**EPIC: Engaging People in Cyberinfrastructure**

A collaboration led by the University of Wisconsin-Madison and Boston University

We stand poised at the dawn of NSFís cyberinfrastructure initiative (CI). The promise of cyberinfrastructure for the national academic research community and eventually for the population at large is reported in the Blue Ribbon Advisory Panel on Cyberinfrastructure known as the Atkinsí Report. Untold advances in science and engineering await the implementation of national digital archives and a national computational grid with unparalleled computing power concentrated in a few select centers and connected in a seamless network to local computing resources across the country. All of this will be realized with increased focus and funding by the NSF and other federal agencies and private industry. However the Atkinsí Report also presents challenges. In our proposal, we identify the most important of these challenges with a question, and a plan to address it.

Who will be the ì first beneficiariesî of this cyberinfrastructure initiative? Without a plan to broaden the CI community, they are easy to identify: the talented and self-selected faculty, students and staff at prestigious academic and research institutions where most of the planned CI hardware will reside and the research will be done.

**Intellectual Merit:** Our proposal is to construct a human capacity building infrastructure that extends this select CI community to include a much larger number of talented and diverse people who otherwise would not be first beneficiaries of CI. We will accomplish this with incremental funding beyond the base funding for CI and we will demonstrate a successful approach in one year. This will be achieved by using the proven community building practices of the successful Education, Outreach and Training Partnership for Advanced Computational Infrastructure (EOT-PACI) program and extending these to engage larger and more diverse communities in realizing the vision of CI. We call this one-year initiative EPIC: Engaging People in Cyberinfrastructure. The four strategies of EPIC are: (1) extending the spectrum of successful computational science education and training activities to a national level, (2) enabling access to advanced CI technologies, (3) ensuring diversity through an inclusive community environment and specifically supporting and including diverse populations in our endeavor, and (4) energizing a large CI community. Our proposed activity will consist of representative projects that are interlinked and coordinated by a diverse Leadership Team. EPIC will be independently evaluated to document the keys to our successes and to lay the foundation for major advances in scale-up and sustained systemic change through the use of best practices identified by the EPIC team.

**Broader Impact:** EPIC is itself focused on the broader impact of CI. The nature of CI as an agency-wide initiative makes community building essential to its success. By explicitly introducing our community building activity within CI initiatives, NSF has a natural pathway to inclusive behavior and processes. EPICís focus on diversity will ensure that CI fully engages under-served populations, and accelerates the preparation of Americaís workforce for a global digital society. EPIC will serve NSF and the nation in ways that few projects do.

Additionally, important aspects of the EPIC project have an even broader impact themselves. Interest in human capacity building is not limited to CI. Demonstration and documentation of our practices will serve as a roadmap to other similar efforts by NSF and other federal agencies. The results of the project will lay the foundation for future years as CI accelerates its impact upon every field of science and engineering. We will deliberately create processes that are inclusive of current projects and new projects as they emerge, thus creating an ever-expanding coordinated community.

## EPIC: Engaging People in Cyberinfrastructure

A collaboration led by Boston University and the University of Wisconsin-Madison

The building of cyberinfrastructure as set forth by the National Science Foundationís Blue Ribbon Advisory Panel on Cyberinfrastructure, also known as the Atkinsí Report, is one of the boldest and most far-reaching initiatives ever undertaken by the NSF [Atkins, 2003]. The Atkinsí Report speaks of the ìvast opportunityî the NSF has before it, not only to encourage the development of a ubiquitous, comprehensive, user-friendly cyberinfrastructure, but to build the human capacity necessary to fully exploit these computational resources. Recognizing the critical need to substantially broaden and diversify the user base of high-performance computing tools, the Atkinsí panel laid down three related challenges.

> *Challenge 1: ìEducating non-computer or domain science students in the concepts and tools of cyberinfrastructure.î*
> *Challenge 2: ìMore effectively including Minority Serving Institutions (MSIs) and underserved communities in the development and use of cyberinfrastructure.î*
> *Challenge 3: ìPreventing the ëfragmentation and balkanization of the research communitiesí that currently use or could benefit from cyberinfrastructure.î*

To address these challenges Boston University and the University of Wisconsin-Madison submit this proposal entitled EPIC: Engaging People in Cyberinfrastructure. EPICís overarching goal is ***to build human capacity by creating awareness and by educating and training a diverse group of people in all stages of life from K-12 to professional practice to fully participate in the cyberinfrastructure community as developers, users, and leaders.***

### EPICís Leadership Role

The EPIC teamís past performance on issues of diversity, inclusion, education, outreach, and community building has been cited many times as a success of the Partnership for Advanced Computational Infrastructure (PACI) program [PACI, 2004]. The momentum of this group, and the growing community interested in applying cyberinfrastructure to meet their needs, must continue if we are to improve the education of future generations of mathematicians, scientists and engineers

EPIC partners are enhancing and scaling-up proven programs and are offering fresh, new ideas they are ready to launch to accelerate the adoption of cyberinfrastructure. Established programs will provide resources and experience to new programs, and all of the programs will engage new participants, respond to their needs, and bring energy to the common efforts. EPIC will take the lessons learned from the Education, Outreach, and Training Partnership for Advanced Computational Infrastructure (EOT-PACI) [EOT-PACI, 2004] about (a) educating and training new user groups, (b) working with under-represented groups, and (c) building collaborative communities to create a new and expanded infrastructure to support the growth and expansion of human capacity development under NSFís cyberinfrastructure program.

The time to act is now. The momentum exists, and a large community of new users awaits their participation. As Atkins et al. emphasized, ìThe cost of not acting quickly or at a subcritical level could be high, both in opportunities lost and in increased fragmentation and balkanization of the research communities.î

**Results of Prior and Current NSF Support**

The recently concluded EOT-PACI program unified the two PACI partnerships funded by NSF, and became one of the greatest successes of the PACI program [CISE-9619020, National Partnership for Advanced Computational Infrastructure, PI: Berman (UCSD), $242,649,338, 10/1/97-9/30/04; and CISE ASC 97-19019, National Computational Science Alliance, PI: Pennington (NCSA), $230,201,609, 10/1/97-9/30/04]. Leaders from the National Center for Supercomputing Applications (NCSA), San Diego Supercomputer Center (SDSC), Boston University (BU), Rice University (Rice), and the University of Wisconsin at Madison (U Wisc) formed the EOT-PACI Leadership Team (EOT-PACI-LT), to guide the EOT-PACI program, 1997 ñ 2004. The EOT-PACI collaboration is the exemplary example of the benefit of working together and leveraging resources and expertise.

The mission of EOT-PACI was to develop human resources to understand, formulate, and solve problems through the innovative use of emerging information technologies. A key goal was engagement of people from diverse backgrounds in the development and use of new technologies and applications. The EOT-PACI.LT members, committed to ensuring the collaborative success of the more than 30 PACI partners and affiliates, organized the EOT activities around the themes of Education, Access and Inclusion, Learning Technologies, and Government and New Communities. External evaluations of the EOT-PACI-LT and EOT programs provided formative feedback for the strengthening and scaling-up of EOT programs.

Metrics of Success - Metrics collected from Oct. 2000 to Sept. 2004 indicate that over 50,000 people, including tens of thousands of K-12 students, from all U.S. states and many foreign countries benefited from EOT-PACI. People participated in workshops (172), courses (27), conferences (42), and presentations (123) hosted and attended by EOT-PACI partners. Diverse communities were involved including women (8,809), minorities (8,976), college faculty (1,898), government employees (376), industrial staff (407), and graduate students (573). EOT used or developed about 30 software applications and developed/updated more than 60 resources. The EOT-PACI partners secured over 40 new grants, conservatively estimated at three times the funding level provided by PACI, allowing partners to scale-up successful activities and form collaborations with institutions not funded by PACI.

Developing Human Resources - EOT-PACI partners were committed to mentoring programs to develop human resources, including the California Alliance for Minority Participation (CAMP) at SDSC [CAMP, 2004]; the Computing Research Associationís Committee on the Status of Women in Computing Research (CRA-W) Distributed Mentor Program [CRA-W, 2004]; the Coalition to Diversify Computingís Distributed Rap Sessions [CDC, 2004]; and the CRA-W Collaborative Research Experience for Women. Through the Advanced Networking with Minority Serving Institutions (AN-MSI) grant with EDUCAUSE [AN-MSI, 2004], and the formation of the Minority Serving Institutions Consortium (MSIC) [MSIC, 2004], EOT-PACI collaborated with MSIs on high-performance computing applications. MSI-focused curricula were developed and delivered through projects such as the Education Center on Computational Science and Engineering (EC/CSE) at SDSU [EC/CSE, 2004], and the Shodor Foundation, Inc. Computational Science Education Reference Desk [CSERD, 2004].

Summative Evaluation ñ the LEAD Center [LEAD, 2004] summative evaluation identified these key outcomes [Alexander, 2003]:

1) Increased knowledge of best practices in education, outreach, and training through interactions with diverse communities of researchers and educators.
2) Enriched project and tool development through collaboration with partners.
3) Enhanced dissemination pathways for existing curricula, tools, and projects through connections with other partners.
4) Increased scaling of projects through connections with other partnersí institutions and organizations.
5) Access to computational science researchers at supercomputing centers.
6) Increased likelihood of receiving additional grants through leveraging.
7) Increased professional development opportunities.

Summary - The creation of EOT-PACI was a bold step by NSFís CISE Directorate that has engaged diverse communities of people in making effective use of emerging technology, and involved researchers in significantly improving education programs. Through NSFís vision, and with the support, human networking, resources, grid infrastructure, encouragement, and involvement of the partner institutions, EOT-PACI partners grew in strength, leveraged new grants, spawned 57 community projects, and generated much broader impact than had originally been planned. EOT-PACI created a change in the mindset and level of participation of the researchers and educators that EOT-PACI touched. EPIC will build on the EOT-PACI success to lay the foundation bringing together many more groups to generate benefits in similar ways.

**EPIC: An Integrated Partnership of Organizations and Activities**

EPICís overarching goal is *to build human capacity by creating awareness and by educating and training a diverse group of people in all stages of life from K-12 to professional practice to fully participate in the cyberinfrastructure community as developers, users, and leaders.* To meet this goal that addresses the challenges outlined in the Atkinís Report, EPIC has four strategies:

1: CSE - Providing computational science education and training in the use of tools and resources, for science and math education at all levels.
2: AATT - Enabling access to advanced technologies and tools in education and outreach.
3: DIV - Ensuring diversity by both supporting specific access and inclusion projects and infusing every aspect of EPIC with diversity, access, and inclusion.
4: COMM - Establishing a large, engaged, energized learning community of educators, students, researchers, and citizens who see their role in the creation, development and use of cyberinfrastructure.

Partners in this proposal align well with the overarching goal and strategies of EPIC. The partners cover all levels of education, several professional organizations, and decades of experience in working with local, regional and national communities to support the adoption of emerging technologies to enhance research and education. Specific EPIC activities are described

below in relation to the four strategies above. The projects have a common desire to maximize diversity, and involve multiple partners.

Within each strategy, a number of activities will be used to help educate, train, and build a cyberinfrastructure community. These activities may include, but are not limited to, offering workshops and meetings; activities to ìtrain the trainers;î professional development; mentoring programs; youth programs; programs to address diversity and accessibility; learning material development; software and online information and simulation tools; online dissemination of materials, tools, and resources; and online guides and reports. Cross-fertilization of activities will take place throughout the partnership, allowing participants to make use of best practices while also taking on new endeavors with new colleagues.

Strategy 1: Computational Science Education (CSE) - Providing computational science education and training in the use of tools and resources, for science and math education at all levels.

EPIC plans to implement strategies in all levels of education, from K-12 through graduate school, and to the general public. EPIC will more effectively link education/professional development activities with training that is taking place in the NSF Core Centers and TeraGrid sites. EPIC will make use of common human and technical infrastructure that supports education and training. EPIC will also engage key PACI partners who have been active in developing training to facilitate their continued communication and interaction with professional development in a broader context. This training activity will help provide an important resource for new and under-represented communities. Selected EPIC projects, linking partners, resources, and new communities into the development and use of cyberinfrastructure, are described below.

*K-12 Programs: Training Teachers, Engaging Students, and Resource Development*

TeacherTECH, led by the San Diego Supercomputer Center (SDSC) will build upon the successful TeacherTECH program offered by EOT-PACI in five major cities, by adding new curriculum and resources [TeacherTECH, 2004]. The development of cyberinfrastructure provides a natural, new reason for teachers to become educated, and to engage their students in relevant, focused projects that make use of cyberinfrastructure. TeacherTECH will focus on the educators and students in San Diego County, which is the seventh largest metropolitan area in the US, with a highly diverse population, including 25% Hispanics and 8% African Americans. TeacherTECH will include workshops for K-12 educators that include activities focused on chemistry, bioinformatics, Earth science, and scientific visualization. Each workshop will be Webcast and videotaped for future Web archiving. TeacherTECH will develop ìtrain-the-trainersî sessions for school and district staff to train other educators, and science education sessions to address issues of diversity in the classroom.

Master teachers from Maryland Virtual High School (MVHS), through a train-the-trainers program for use across the U.S., will provide training to middle and high school teachers at summer workshops and Saturday support sessions during the school year at regional sites across the country [MVHS, 2004]. The goal of the MVHS program is to educate and train teachers and to provide them with support to develop their own training programs for their fellow teachers. In collaboration with SDSC and with involvement from other EPIC partners, MVHS will develop an EPIC CD-ROM that includes simulations and instructional materials for

Earth and space science courses, on orbits and hurricane tracking. Master teachers will present workshops at TeacherTECH and at national conferences attended by science and math teachers (National Council of Teachers of Mathematics, National Science Teachers Association, National Educational Computing Conference) to present ìhow toî information on developing ìtrain the trainerî programs based on their experience with EPIC and distribute the EPIC CD-ROM.

EPIC partner Rice University's Center for Excellence and Equity in Education [Rice, 2004] has hosted GirlTECH [GirlTECH, 2004, Foertsch, 1998] and TeacherTECH programs that successfully engaged K-12 teachers in computing workshops and diversity awareness. Past participants in Rice's teacher programs will be invited to the MVHS workshop for current training, and to keep them engaged in the cyberinfrastructure community. Rice will invite middle school teachers as part of the first stages of the development of a middle school Computer Science Computing and Mentoring Partnership (CS-CAMP) program, which provides a female-centric environment where students gain confidence as they learn about computer science [CS-CAMP, 2004]. During previous high school CS-CAMP programs, teachers and girls indicated that a program targeted at middle schools would have an even greater impact on the girls' interests in STEM disciplines and in computing.

In-service and pre-service teachers have limited experience with the applications of technology to science and mathematics instruction. One of the major EOT-PACI projects, developed by the Ohio Supercomputer Center, was the creation of instructional materials that demonstrated the use of computation as a focal point for problem and project-based learning activities. One example is a project aimed at building knowledge of the hydrologic cycle, hurricanes, and flood damage. The exercise meets the criteria for experience-based learning that are parts of the national and many state science standards, as well as mathematics standards. These materials were embedded in a graduate level course for teachers taught at The Ohio State University as both a regular and a distance-learning course. The Ohio Supercomputer Center will work with the Eisenhower National Clearinghouse (ENC) to ensure wider dissemination of these materials to science teachers through presentations at education meetings and via their web site [ENC, 2004].

The Math Forum, a leading center for mathematics and mathematics education on the Internet, provides resources, materials, activities, person-to-person interactions, and educational products and services that enrich and support teaching and learning [MathForum, 2004]. The Forumís online community includes teachers, students, researchers, parents, educators, and citizens who have an interest in math and math education. The Math Forumís community encourages communication throughout the mathematics community, offers model interactive projects, makes math-related Web resources accessible, and provides high-quality math and math education content [Renninger, 2002]. The Math Forum will catalog EPIC tools and materials so that teachers, students, teacher professional development deliverers, and other users can easily find resources that fit their needs; present the tools and materials using content strand portals for K-7 and course subject portals for levels 8-12 including calculus, and facilitate discussions groups and develop communities of users helping each other to use the materials. Through this effort, EPIC will capitalize on the Math Forum's large and active national community to disseminate materials at a broad national level.

*Community College, Undergraduate, Graduate, and Faculty Programs*

Community colleges play a significant role in undergraduate education, with an enrollment of 10.4 million students at 1,173 institutions, making up 44% of all undergraduates and a significant number of minority students. Shodor will lead a national effort to develop a dynamic pathway supporting The Computational Science Education Reference Desk (CSERD) as an integral component of the National Science Digital Library (NSDL) [NSDL, 2004, Searcy, 2004]. Shodorís effort will build upon significant prior work of Shodor and EOT-PACI partners to extend and sustain a digital library of high-quality, effective educational materials for computational STEM disciplines. CSERD incorporates both using models to teach and explore concepts in science and mathematics as well as teaching how to conduct validation, verification and accreditation of those very computational models. CSERD resources benefit undergraduate and community college faculty whose students are future scientists and engineers, future teachers, or both, as well as the undergraduate students themselves. Also, through Shodor's partnerships with Math-Science Partnerships, Advanced Technological Education programs, and Centers for Learning and Teaching, CSERD will have a direct impact on in-service teachers and their students in intermediate and secondary schools, as well as life-long learners. Emphasis will be on identifying materials that help mitigate the digital divide and the cultural chasm in computational science.

EPIC will examine multidisciplinary approaches to undergraduate curriculum models with the help of the BioQUEST Curriculum Consortium, an organization dedicated to collaborative, peer-viewed quantitative problem solving that support educators interested in the reform of undergraduate biology [BioQuest, 2004]. A BioQuest-led workshop will bring together educators and EPIC partners to determine means to make undergraduate education more interdisciplinary, mathematically and computationally intensive, and reflective of contemporary science in terms of dealing with terabytes of data that are generated daily. Results of the workshop will be widely distributed, and participant developed curriculum materials will be made accessible online.

EPIC will begin a Virtual Institute on Computational Science education and training to establish a computational science curriculum base, founded upon common concepts [Yasar, 2003] and instantiated in online courses and materials. These concepts will be unified in concept maps to serve grade levels 9-16. Participants include institutions with computational science degrees: University of Wisconsin-Madison, Oregon State, and SUNY-Brockport, and institutions with significant computational science resources: University of Texas Advanced Computing Center (TACC), Ohio Supercomputer Center (OSC), Boston University, University of Kentucky and NCSA. Very often the first barrier to establishing a computational science program is a complete set of course materials. This multi-institution project will ì fill in the gapsî that would otherwise slow the progress of computational science at institutions with emerging programs.

Two new books authored by R. Landau for undergraduate computational courses are being published, and these will be used to develop new courses at EPIC sites and beyond [Yasar, 2003, Landau, 2004]. TACC partners are developing a comprehensive, four-course scientific computing sequence in computational science and engineering that includes ì Parallel Computing,î ì Visualization,î ì Distributed and Grid Computing,î and ì Databases and Data Analysis.î TACC will capture the courses, including videotaped lectures, Q&A sessions, and slides, and prepare materials for downloading, to provide them asynchronously and synchronously to other institutions. Asynchronous training courses have been developed through

a partnership of the Ohio Supercomputer Center (OSC), Boston University, NCSA, and the University of Kentucky. Courses include ì Introduction to MPI,î ì Introduction to OpenMP,î ëMultilevel Parallel Programming,î Intermediate MPI,î ì Performance Tuning for Clusters,î ì Parallel Numerical Libraries,î Access Grid Tutorials,î and Debugging Computational Programs.î

In cooperation with the above resource partners, Oregon State University, SUNY Brockport, and the University of Wisconsin at Madison will evaluate all such curriculum materials and delivery modalities for their suitability in a larger context of fundamental computational science principles and effective teaching and learning principles to create an accessible online concept map of principles and associated resources. The EPIC Virtual Institute including all of these partners will focus on the development of a national computational science curriculum that will be available online and serve as a resource for institutions that are starting computational science degree programs. A report will be broadly distributed through national conferences and publications to help build momentum for change within computational sciences and education. Visibility of successful new programs will help inspire changes nationwide and improve the countryís overall appreciation for, and interest in, computational sciences.

Strategy 2: Access to Advanced Technologies and Tools (AATT) - Enabling access to advanced technologies and tools in education and outreach.

Several EPIC partners have highly advanced and useful resources, developed over decades of work within their respective areas. Resources include high-performance computers, clusters, advanced networking, visualization laboratories, digital libraries, collaborative environments, software, and of course facilities for meetings and workshops. Human resources are also available through the EPIC partnersó people with highly valuable experiences and knowledge from a wide range of disciplines, professionals who are eager to contribute to EPIC. These resources, tangible and intangible, will be brought to bear on EPICís one-year program. The partners will also focus on specific resource development and distribution, as illustrated in the following collaborative projects.

SDSC will develop a Web-based interface to support broad community access to data collections and databases at SDSC and elsewhere. The NDSL, California Digital Library [CDL, 2004], and Digital Library for Earth System Education [DLESE, 2004] will be integrated with this project, and relevant metadata will be integrated to help ensure broad acceptance and use of these resources. SDSC will leverage its data applications staff expertise, established data collections, and storage resources to quickly bring this project to fruition. SDSC and teachers participating in TeacherTECH will evaluate several large-scale data efforts (Geosciences Cyberinfrastructure Network, Network for Earthquake Engineering Simulation, Biomedical Informatics Research Network, and Protein Data Bank) to identify common access modes to facilitate use by high school and undergraduate teachers. A prototype collection will be selected and a prototype education portal interface will be developed.

NCSA will work with SDSC, the Ohio Supercomputer Center (OSC), and educators to integrate data management, data mining and data analysis into undergraduate and graduate curriculum, while also exploring opportunities for introducing these methods into K-12 classrooms to address national and state learning standards. NCSA and SDSC have developed innovative data tools for management, mining, and analysis that are significantly advancing scientific research and discovery, and OSC has developed courses on data analysis. This team

will determine user requirements on data mining needs in education, develop data mining exemplars in multiple disciplines that augment data mining text books and that address the requirements identified by educators, conduct workshops and seminars to introduce the tools and methods to educators, and raise the awareness of data mining and analysis tools for scientific inquiry among educators through major conferences and workshops, including using the Access Grid [AG, 2004]. The workshops will include undergraduate and graduate faculty, high school teachers, and policy-makers. Tutorials, lesson plans, curricular materials and software will be accessible through the Web and the NSDL.

K-12 and undergraduate students today have sophisticated expectations for the realism of modeling and simulation in their coursework, due to advanced realism found in the media and in computer games. Game development tools and rendering engines may be leveraged within the K-16 curriculum to provide added engagement for learning and increased motivation to better understand the complex systems represented by these realistic simulations. The National Center for Supercomputing Applications (NCSA), Boston University (BU), Cornell University, West Point, East Carolina University (ECU), Shodor Foundation, Inc., the San Diego Supercomputer Center (SDSC), and the Education Center on Computational Science and Engineering (E/CSE) at San Diego State University have formed a Viz-Ed Virtual Institute to advance the adoption of visualization methodologies into K-16 education. The EC/CSE will work with K-16 educators to evaluate six existing "off-the-shelf" development tools as well as leading-edge "pre-alpha" prototypes that exhibit the potential for advanced multi-user simulation-based learning experiences. The tools are Croquet, OGRE, Butterfly, Java3D, Web3D, Visual Studio w, OpenGL libraries, and Python 3D. Based on the evaluations, a subset of the most promising tools will be used in workshops to help K-12 educators and university faculty members use these tools in their curriculum. Faculty at BU, SUNY Brockport, and the University of Wisconsin at Madison will be provided with student interns and/or release time to help with the application of the tools. The EC/CSE will identify a set of areas in need of content development and develop prototypes to demonstrate the important role played by multi-user simulation environments in the classroom.

Strategy 3: Diversity (DIV) - Ensuring diversity by both supporting specific access and inclusion projects and infusing every aspect of EPIC with diversity, access, and inclusion.

The EPIC partners are leaders in addressing diversity. They have started outreach programs, often with very limited funding, working in concert over the years with the Girl Scouts of the USA, Boys and Girls Clubs, the Urban League, and several professional organizations that exist to address issues surrounding the involvement of women, minorities, and persons with disabilities. EPIC partners have also been instrumental in the founding of national meetings focused on the participation of under-represented groups in computer science, computational science, and STEM disciplines. These leaders are committed to seeing the full engagement of a diverse population in the development and use of cyberinfrastructure. Specific programs are described below, but it is important to note that diversity will be at the forefront of every EPIC program, and critical to the management of this effort.

*K-12 through Graduate School and Beyond: Diversity Outreach*

The Science Enrichment Program, which provides informal science education for K-8 girls who are members of groups under-represented in the fields of science and engineering, is currently serving a total of approximately 10,000 girls in the cities of Houston, Atlanta, and San Diego [SEP, 2004, Alexander, 2002]. The program uses weekly hands-on science lessons, Family Science Nights, Science Saturdays, summer day camps, and leveraged meetings with programs such as Sally Rideís Science Festivals to reach the girls and their families, who meet in a variety of settings. The program, part of EOT-PACI, has been evaluated by the LEAD Center, which helped strengthen the activities. The Science Enrichment Program will be launched in Portland, Oregon, where a computer science program will be added. The Atlanta and Portland programs will receive laptop computers, which have proven to be critical to the development of the programs in San Diego and Houston. The computers give urban girls an opportunity to get comfortable with the use of the computer in a supportive environment. Information about the Science Enrichment Program will be presented at EPIC workshops for teachers, as a model for involving girls in STEM disciplines.

EPIC partner and MSIC member Florida International University (FIU) will guide workshops for MSIs. MSIC has worked diligently to establish Access Grid Nodes at MSI institutions, and the Access Grid will be used for a monthly Virtual Institute focused on research at MSIs. Topics will be in the areas of mechanical and materials engineering, biomedical engineering, assistive technologies and neuroscience research, neural networks and digital signal processing, 3-D modeling and visualization, cluster tools, emerging high-performance computing communities, nanofabrication, and shared applications on the Access Grid. This Virtual Institute will be broadly promoted throughout the cyberinfrastructure community, to bring visibility to the work of researchers at MSIs and to further the two-way interactions of researchers across the country. FIU will convene a one-day conference on MSI research, co-located with an annual national conference such as the Richard Tapia Celebration of Diversity in Computing [Tapia, 2004]. A database of all MSI participants and universities will be created to provide information about research going on at the MSIs as well as resources and services available to the MSI community.

MSIs provide a supportive environment that has a positive impact on retention, but retention of minority students at majority institutions remains a critical problem. Rice University, which has a long history of successful minority retention programs, will build a community of minority undergraduate researchers throughout EPIC, combining opportunities and experiences with other minority programs nationwide. Rice will hold a Summit on Scholarly Pursuits for EPIC minority students, including motivational lectures and research presentations from minority scholars. Throughout the year, the minority scholars will participate in EPIC meetings; interact with colleagues in other programs, such as the Alliance for Graduate Education and the Professoriate, and serve in leadership roles on national conferences and committees. Students will be required to provide candid feedback on their experiences within EPIC and academia in general, so that the programs can be improved.

Cyberinfrastructure development must involve persons with disabilities. In EPIC, this community will be represented on the EPIC advisory board, described later, and will be involved in outreach efforts. EPIC will engage leading organizations in the country about assistive and adaptive technologies to infuse the principles of universal design into our activities.

*EPIC and Professional Organizations*

The Coalition to Diversify Computing (CDC) is developing a diverse community of professionals that can effectively meet the computing demands of an evolving society. CDC projects target students and faculty with the expressed intent of increasing the number of minorities successfully transitioning into graduate school or computing-based careers in academia, federal laboratories, and industry. One of the most valuable experiences students can have is having a mentor who works with them throughout the year and who introduces them to the national community of scholars in their field. The CDC will match up minority undergraduate students with an appropriate mentor through CDCís student/faculty conference support program. Mentors and their students will participate in the aforementioned Summit on Scholarly Pursuits hosted by Rice University, and attend the Richard Tapia Celebration of Diversity in Computing, to provide them the opportunity to meet with national leaders who have an interest in their success. CDC has ongoing "Distributed Rap Sessions" that are building a virtual community of minority peers at numerous locations and events, making use of technologies such as the Access Grid. Through the Rap Sessions, CDC students and mentors discuss research projects and issues related to diversity. CDC speakers and participants will be solicited from EPIC partners, and will participate in EPIC Access Grid meetings, including the Virtual Institute focused on research at MSIs organized by Florida International University.

The Computing Research Associationís Committee on the Status of Women in Computing Research (CRA-W) has a proven track record of developing and running programs that aim to increase the participation of women in computer science and engineering research. CRA-W focuses on women undergraduate and graduate students and women researchers in academic and industrial research positions. CRA-Wís programs, which will be integrated throughout the EPIC partnership, include the Distributed Mentor Program (DMP), the Grad Cohort Program, and the Distributed Lecture Series (DLS). For all three programs, participants will be sought from EPIC partners, and will take part in EPIC opportunities, such as an EPIC meeting at SC2005, where students and their mentors will be introduced to national leaders in computing.

CRA-Wís DMP matches undergraduate women who have strong academic records with female faculty members for ten weeks during the summer to participate in a research project at the faculty member's institution. In addition to exposure to research, the student has a close mentoring relationship with a faculty member and sees firsthand what graduate student life is like. CRA-W's Grad Cohort Program will provide networking support for women graduate students, who are frequently a small minority in their departments. CRA-W piloted a program last year that brought together 100 first-year female graduate students to meet women faculty and network. Feedback was very positive, and through EPIC, CRA-W will have a follow-on meeting for last yearís students, and bring in 100 new students to join this community. The meeting will feature speakers from EPIC partners to expose the students to new resources and opportunities, such as internships, summer programs, and possible graduate schools. CRA-Wís DLS aims to increase both the number of women undergraduates who successfully apply to graduate school and the visibility of distinguished women researchers from academia and industrial research labs. Studentsí responses indicate that the DLS program has given them great insights into graduate school, and that the panels have been invaluable.

*Outreach to New Communities*

EPICís interest in diversity extends to a diversity of disciplines, as well. One area with interest in the use of cyberinfrastructure is the humanities and social sciences. The Humanities, Arts, Science, and Technology Advanced Collaboratory has recently been formed to explore opportunities for shared projects and resources, with several members from the PACI community who were instrumental in its creation [HASTAC, 2004]. SDSC will conduct a needs assessment for the HASTAC community to determine what tools might best meet their needs, and what tools need to be developed. Tools such as portals, data collections, and data management will be explored. SDSC will host a weeklong Humanities Summer Institute with lectures on cyberinfrastructure and relevant tools. Attendees will bring information on their project to share and to help SDSC in developing and applying appropriate tools.

Strategy 4: Community Building (COMM) - Establishing a large, engaged, energized learning community of educators, students, researchers, and citizens who see their role in the creation, development and use of cyberinfrastructure.

EPIC will work with leading educators, researchers, and others to build a national network and support community to share information and outcomes and to develop deep understanding of the impact of cyberinfrastructure on our national research and education enterprise and on society at large. The activities will include at least five topical workshops and at least three thematic year-long Virtual Institutes. The Virtual Institutes bring together researchers and educators on a regular basis to develop a deeper understanding of selected overarching topics within cyberinfrastructure. Three topics in this proposal are: MSI Research, Visualization in the Classroom, and Computational Science Curriculum. Others will be chosen as the opportunity arises.

At the grass roots, EPIC will help organize potential partners for future projects into focus areas that allow participants to continuously and informally communicate and share information. EPIC will engage education programs of NSF Science and Technology Centers, Engineering Research Centers and other major NSF research centers. The experience of the EPIC leaders has proven that a strong community, with shared resources and a commitment to the success of all partners, provides unparalleled opportunities for its participants, and to impact the broader community.

*Communications*

Building a community requires communication, by many means and at many levels. EPIC will make certain the accomplishments of its partners and the many people who take part in EPIC programs receive visibility for their work. This visibility is critical, as it will help send a strong message to students, educators, researchers, and the public that the NSF is serious about education, outreach, and engaging a diverse population in the development and use of cyberinfrastructure. EPIC will work in concert with a number of organizations to increase visibility for the welcoming community of cyberinfrastructure builders, including NSF-funded centers, professional organizations, educational centers, informal science learning centers, and the media. Partnersí publications and other communication media will be used to educate and

advise people about EPIC accomplishments and activities. Visibility for EPICís program will help bring more and more people into the fold to help create the future of cyberinfrastructure.

EPICís community will be strengthened through Virtual Institutes, planned meetings, workshops, and presentations, also described in the management section of this proposal. The program will begin with an all-hands meeting in Spring 2005, and be reinforced throughout the year. Partners are already planning joint meetings and activities, many of which were described earlier. EPIC will work with partners to help weave together their programs, building further momentum and involvement. Team building will take place through work on clearly stated goals and strategies and through frequent interactions, via conference calls, email, Access Grid meetings, and in-person conferences. An EPIC Website will include information about EPIC programs, meetings, resources, and people, and will express the interest of the EPIC community in attracting new partners and participants. A second all-hands meeting will provide EPIC partners the opportunity to discuss accomplishments, future plans, and possible collaborations for proposals.

*Innovative Cyber Community Building*

In addition to communicating about the partnership, communication within EPIC will be instrumental in community building. NCSA will foster the creation of an Inquiring Knowledge Networks on the Web (I-KNOW) network for the education/outreach community within cyberinfrastructure, starting with the EPIC partners [I-KNOW, 2004]. I-KNOW knowledge networks help individuals learn ìwho knows who,î ìwho knows what,î and ìwho knows, who knows whatî to facilitate making personal connections among people with common interests. I-KNOW will put in place a mapping, visualization, and measurement system to study the patterns of knowledge and information flow though an organization such as EPICís informal network. NCSA will work with Shodor, the MathForum, and the EC/CSE to make EPIC resources part of NSDL in order to broaden dissemination, and with HASTAC on the social implications of knowledge networks.

**Partnership Leadership, Management, and Reporting**

EPIC is a single overall project submitted jointly by Boston University and the University of Wisconsin-Madison. EPIC will be directed by a leadership team (LT) that will work closely together in a cooperative spirit to build the national community and manage the EPIC project, especially paying attention to inclusiveness, evaluation, dissemination, and national impact. Professor Roscoe Giles of Boston University and Professor Gregory Moses of the University of Wisconsin at Madison will serve as PIs on the two EPIC proposals and will be responsible to NSF for insuring the effectiveness of the leadership team, which they will co-lead, and the successful completion of the EPIC project set forth in this proposal. The leadership team organization, philosophy and membership are influenced by the successful EOT-PACI leadership team experience. The LT will consist of R. Giles (Boston U.), A. Gonzales (FIU), C. Lanius (Math Forum), S. Lathrop (Consultant), S. McLean (NCSA), G. Moses (U. Wisc.), A. Redelfs (Consultant), R. Tapia (Rice U.) and others as required.

The LT will meet bi-weekly via video and teleconference to manage the week-to-week activities and budget of the EPIC project. They will meet at least three times over the course of the project in one-day face-to-face meetings. The EPIC leadership team will be directly

responsible for the overarching programmatic activities such as Virtual Institutes, meetings, workshops, project collaborations, and communications both within the EPIC project and to other organizations such as MRSECs, ERCs, and other NSF programs.

Individual projects will be required to submit three quarterly reports that emphasize their integration into the national EPIC project and the populations that they impact. These reports will be summarized by the LT and sent to NSF program management. A final EPIC report will be submitted to NSF and it will include an independent evaluation of the EPIC project.

Twelve members of the national community, but not involved directly in EPIC will be asked to serve on an external advisory board for this project. Professor Bryant York of Portland State University will chair the advisory board. The advisory board will meet once midway through the project to offer formative advice.

**Action Plan**

The EPIC program has one year to meet its goal. A leadership team and a host of partner institutions will guide it there. Coordinating activities among EPICís diverse community requires that we establish a clear action plan. Throughout the proposal, there are several projects that have ongoing programsó programs that will be developed throughout the year in concert with other EPIC partners. In support of these ongoing projects, EPIC has established a timeline of meetings at which programs will deliver on their promises. The resulting action plan is necessarily driven by deadlines and by leveraging opportunities to co-locate with other meetings, described below. EPICís leaders, experienced through EOT-PACI and other large, multi-partner initiatives, have taken on the responsibility to ensure that EPIC partners will deliver as proposed. At the end of one year, the cyberinfrastructure community will have grown substantially, through the programs described in this proposal.

Action Timeline

Q1 ñ January ñ March 2005

- *Every other Tuesday morning: EPIC Leadership Team meeting*
- *Every month: TeacherTECH workshops*
- *This quarter: NCSA EasyViz and DataBridge workshops for K-12 teachers*
- January - Association for the Education of Teachers of Science (AETS), EPIC Minority Serving Institutions (MSI) Research Virtual Institute
- February - EPIC Virtual Institutes (MSI Research, Viz-Ed, Computational Science), AAAS Meeting
- March ñ EPIC Virtual Institutes, First EPIC all-hands meeting, National Science Teachers Association Annual Meeting

Q2 ñ April ñ June 2005

- *Every other Tuesday morning: EPIC Leadership Team meeting*
- *This quarter: TeacherTECH one-week institute; Maryland Virtual High School master teachers regional training workshops; NCSA EasyViz and DataBridge workshops for K-12 teachers*
- April - NRCEN (NSF Research Center Educators Network) Annual Meeting. Includes education directors from NSF Engineering Research Centers (ERC), Materials Research Science and Engineering Centers (MRSEC), Science and Technology Centers (STC).;

EPIC Virtual Institutes, National Council of Teachers of Mathematics Annual Meeting, TeacherTECH workshop, Q1 report to NSF.
- May - EPIC Virtual Institutes, TeacherTECH workshop
- June - EPIC Virtual Institutes, National Educational Computing Conference

Q3 ñ July ñ September 2005
- *Every other Tuesday morning: EPIC Leadership Team meeting*
- *This quarter: TeacherTECH one-week institute; Maryland Virtual High School master teachers regional training workshops; NCSA EasyViz and DataBridge workshops for K-12 teachers*
- July - EPIC Virtual Institutes, SIGGRAPH 2005, Q2 report to NSF.
- August - EPIC Virtual Institutes
- September - EPIC Virtual Institutes, TeacherTECH workshop

Q4 ñ October ñ December 2005
- *Every other Tuesday morning: EPIC Leadership Team meeting*
- *Every month: TeacherTECH workshops*
- *This quarter: NCSA EasyViz and DataBridge workshops for K-12 teachers*
- October - EPIC Virtual Institutes, EPIC MSI Research Conference, Richard Tapia Celebration of Diversity in Computing Conference, Q3 report to NSF.
- November - EPIC Virtual Institutes, SC2005 Education Program, SC2005 Conference, EPIC all-hands meeting
- December - EPIC Virtual Institutes, EPIC final report.

**Evaluation of EPIC**

Third-party evaluation of the proposed project will be provided by the Learning through Evaluation, Adaptation and Dissemination (LEAD) Center at the University of Wisconsin-Madison. LEAD was chosen to evaluate this project because of their expertise in evaluation of programs in education and outreach, and because they played a key role as the evaluator of the EOT-PACI programs. Professional evaluation was an integral part of the EOT-PACI effort throughout the grant. [Foertsch, 1999, 2000, 2000a, 2002, 2003]

The goal of the EPIC evaluation is to provide both formative and summative data on EPICís progress in meeting its overarching goal of human capacity building in the field of computational science [Foertsch, 2000]. Formative evaluation will play a critical role in this project through providing continuous feedback on how effectively EPIC is achieving its goals and enabling them to make changes that continually redirect the program toward the desired outcomes. The evaluation will attempt to measure the degree to which each collaboration produces outcomes ***above and beyond*** those that the individual projects would have produced in isolation. The evaluation will focus on the key objectives and strategies that the program has developed to promote cross-project communication, collaboration, and more effective development within and between multi-institutional collaborations. This one-year project can serve as a prototype for future collaborative initiatives and the evaluation will provide important information about best practices. The evaluation will utilize a combination of survey instruments and semi-structured interviews to assess the following:

- *Impact of EPIC on Individual Projects:* This assessment involves documenting how the EPIC multi-institutional collaborations helped partners to: (1) improve and expand their

projects in ways that they would not have otherwise; and (2) create new projects and collaborative efforts with other partners.

- *Success of each Multi-institutional Collaboration:* Evaluation will assess the degree to which this nationwide partnership is able to achieve a multiplier effect through the clustering and collaboration of education, outreach, and training projects. This will involve assessing the success of each collaboration in meeting their group goals.
- *Impact of EPIC Projects:* Evaluation will collect documentation from each project on their success in meeting their target goals.

The evaluators will produce a stand-alone final report at the end of the year. The results will be incorporated into the EPIC final report.

**EPICís Broader Impact**

Who will build, use, and benefit from cyberinfrastructure? EPIC will construct a human capacity building infrastructure that extends beyond the faculty, staff, and students at prestigious academic and research institutions where most of the planned hardware will reside and the research will be done. With EPIC, thousands of people that otherwise would not be part of this activity and, in fact, might not now be aware of its existence, will become active members of this diverse and inclusive cyberinfrastructure community. EPIC creates awareness and educates and trains a diverse group of people, including women, minorities, and persons with disabilities, from K-12 to professional practice to fully participate in the cyberinfrastructure community as developers, users, and leaders. EPIC derives its broader impact from its driving strategies to build this human capacity at a national scale. Its driving strategies map directly to components of the NSFís broader impacts criterion. EPIC will engage large and diverse communities to begin to disseminate broad understanding and awareness of cyberinfrastructure to the national audience. At the end of the year, a foundation of processes and structures will be created for future human capacity building.

**Summary**

EPIC is a coordinated, cooperative, national-scale effort in which successful and innovative projects and people are woven together into a fabric that encourages engagement, growth, and dissemination. EPIC plans to participate in the development and use of cyberinfrastructure, and will actively engage its partnership and many others in exploring innovative uses for tools and resources, along with broadening the community of participants far beyond the past participants in the original investments NSF and others have made in supercomputing and high-performance computing endeavors. The Computer and Information Science and Engineering Directorate is leading the NSF and the country in ensuring broad impacts and broad participation in STEM disciplines. EPICís leaders and partners are ready and fully prepared to help develop more diverse cyberinfrastructure, made stronger by the participation of a wide range of people and organizations that are eager to be involved.

[AG, 2004] Access Grid Project, http://www.accessgrid.org/

[Alexander, 2002] Alexander, B. B., Herrera, O. L. (2002). *Engaging Ethnic Minority Girls in Science: An Evaluation of the Girls are G.R.E.A.T. Science Enrichment Program*. Madison: University of Wisconsin-Madison, LEAD Center.

[Alexander, 2003] Alexander, B. B. & Foertsch, J. (2003). *The Impact of the EOT-PACI Program on Partners, Projects, and Participants: A Summative Evaluation.* UW-Madison: LEAD Center.

[AN-MSI, 2004] Advanced Networking with Minority Serving Institutions (AN-MSI), http://www.anmsi.org/

[Atkins, 2003] Revolutionizing Science and Engineering Through Cyberinfrastructure, Report of the National Science Foundation Blue-Ribbon Advisory Panel on Cyberinfrastructure, http://www.communitytechnology.org/nsf_ci_report/, January 2003.

[BioQuest, 2004] BioQuest Curriculum Consortium, http://www.bioquest.org/

[CAMP, 2004] California Alliance for Minority Participation, http://www.camp.uci.edu/

[CDC, 2004] Coalition to Diversify Computing, http://www.ncsa.uiuc.edu/Outreach/CDC/

[CDL, 2004] California Digital Library, http://www.cdlib.org/

[CRA-W, 2004] Computing Research Associationís Committee on the Status of Women in Computing Research (CRA-W), http://www.cra.org/Activities/craw/

[CS-CAMP, 2004] Computer Science Computing and Mentoring Partnership, http://ceee.rice.edu/cs-camp/

[CSERD, 2004] Computational Science Education Reference Desk (CSERD), http://www.shodor.org/refdesk/

[DLESE, 2004] Digital Library for Earth System Education, http://www.dlese.org/dds/index.jsp

[EC/CSE, 2004] Education Center on Computational Science and Engineering (EC/CSE), http://www.edcenter.sdsu.edu/

[ENC, 2004] Eisenhower National Clearinghouse, http://www.enc.org/

[EOT-PACI, 2004] EOT-PACI, http://www.eot.org

[Foertsch, 1998] Foertsch, J., Daffinrud, S., & Alexander, B. B. (1998). *The GirlTECH Workshop: Guidelines for a successful technology training program for K-12 teachers*. UW-Madison: LEAD Center.

[Foertsch, 1999] Foertsch, J. & Alexander, B. B. (1999). *Integrating High Performance Computing into the Undergraduate Curriculum: How PACI and the Education Center on Computational Science & Engineering Can Succeed.* UW-Madison: LEAD Center.

[Foertsch, 2000] Foertsch, J. (2000). *NPACIís Strategies for Connecting High-Performance Technology Developers to Users in Education.* UW- Madison: LEAD Center.

[Foertsch, 2000a] Foertsch, J. & Alexander, B. B. (2000). *Guidelines for Self-Evaluation of EOT-PACI Projects*. A hypertext document at http://www.cae.wisc.edu/~lead/pages/products/self-eval.pdf.

[Foertsch, 2002] Foertsch, J., Moses, G., Strikwerda, J., & Litzkow, M. (2002) Reversing the lecture/homework paradigm using eTEACH web-based streaming video software. *Journal of Engineering Education*, 91 (3), 267-274.

[Foertsch, 2003] Foertsch, J. (2003). *Summative Evaluation of EOT-PACIís Efforts within the Advanced Networking for Minority-Serving Institutions (AN-MSI) Project*. UW-Madison: LEAD Center.

[GirlTECH, 2004] GirlTECH Program, http://teachertech.rice.edu/

[HASTAC, 2004] Humanities, Arts, Science, and Technology Advanced Collaboratory, http://www.stanford.edu/group/shl/HASTAC/

[I-KNOW, 2004] Inquiring Knowledge Networks on the Web (I-KNOW), http://www.spcomm.uiuc.edu/Projects/TECLAB/IKNOW/

[Landau, 2004] R. H. Landau, "Computational Physics for Undergraduates, the CPUG Degree Program at Oregon State University", IEEE Computing in Sci & Engr, 6, 68-75, March/April 2004.

[LEAD, 2004] Learning through Evaluation, Adaptation, and Dissemination (LEAD) Center, http://homepages.cae.wisc.edu/~lead/

[MathForum, 2004] Math Forum, http://www.mathforum.org/

[MSIC, 2004] Minority Serving Institutions Consortium (MSIC), http://www.msihpc.org/

[MVHS, 2004] Maryland Virtual High School, http://mvhs1.mbhs.edu/

[NSDL, 2004] National Science Digital Library, http://www.nsdl.org/

[PACI, 2004] Partnership for Advanced Computational Infrastructure (PACI) program, http://www.paci.org/

[Renninger, 2002] Renninger , K. A. & Shumar, W. (2002). Community Building with and for Teachers at The Math Forum. In K. Ann Renninger & Wesley Shumar (eds.) *Building Virtual Communities*: Learning and Change in Cyberspace, Cambridge University Press

[Rice, 2004] Rice Universityís Center for Excellence and Equity in Education, http://ceee.rice.edu/news/modeling.html

[Searcy, 2004] Searcy, ME and Richie, JT. Investigating the development of a computational science education community. In McDougall, DE and Ross, JA (Eds.) Proceedings of the Twenty-Sixth Annual Meeting of the North American Chapter of the International Group for the Psychology of Mathematics Education Conference, Vol. 2. Toronto: OISE/UT.

[SEP, 2004] SDSC Science Enrichment Program, http://education.sdsc.edu/enrich/cell.html

[Tapia, 2004] Tapia Celebration of Diversity in Computing, http://www.ncsa.uiuc.edu/Conferences/Tapia2003/

[TeacherTECH, 2004] TeacherTECH Programs, http://education.sdsc.edu/teachertech/, http://www.ncsa.uiuc.edu/Divisions/eot/programs/teacherTECH/, http://teachertech.rice.edu/goals.html

[Yaser, 2003] Yaser, O. and R. Landau, "Elements of Computational Science Education," SIAM Review, 45, 787 (2003).