Expeditions in Training, Research, and Education for Mathematics and Statistics through Quantitative Explorations of Data (EXTREEMS-QED)

PROGRAM SOLICITATION
NSF 12-606

National Science Foundation

Directorate for Mathematical & Physical Sciences
Division of Mathematical Sciences
Office of Multidisciplinary Activities

Directorate for Computer & Information Science & Engineering
Division of Advanced Cyberinfrastructure

Full Proposal Deadline(s) (due by 5 p.m. proposer's local time):

January 31, 2013

November 06, 2013

First Wednesday in November, Annually Thereafter

IMPORTANT INFORMATION AND REVISION NOTES

A revised version of the ***NSF Proposal & Award Policies & Procedures Guide*** (PAPPG), NSF 13-1, was issued on October 4, 2012 and is effective for proposals submitted, or due, on or after January 14, 2013. Please be advised that the guidelines contained in NSF 13-1 apply to proposals submitted in response to this funding opportunity.

Please be aware that significant changes have been made to the PAPPG to implement revised merit review criteria based on the National Science Board (NSB) report, National Science Foundation's Merit Review Criteria: Review and Revisions. While the two merit review criteria remain unchanged (Intellectual Merit and Broader Impacts), guidance has been provided to clarify and improve the function of the criteria. Changes will affect the project summary and project description sections of proposals. Annual and final reports also will be affected.

A by-chapter summary of this and other significant changes is provided at the beginning of both the *Grant Proposal Guide* and the *Award & Administration Guide*.

Please note that this program solicitation may contain supplemental proposal preparation guidance and/or guidance that deviates from the guidelines established in the Grant Proposal Guide.

SUMMARY OF PROGRAM REQUIREMENTS

General Information

Program Title:

Expeditions in Training, Research, and Education for Mathematics and Statistics through Quantitative Explorations of Data (EXTREEMS-QED)

Synopsis of Program:

The long-range goal of EXTREEMS-QED is to support efforts to educate the next generation of mathematics and statistics undergraduate students to confront new challenges in computational and data-enabled science and engineering (CDS&E). EXTREEMS-QED projects must enhance the knowledge and skills of most, if not all, the institution's mathematics and statistics majors through training that incorporates computational tools for analysis of large data sets and for modeling and simulation of complex systems.

Funded activities are expected to provide opportunities for undergraduate research and hands-on experiences centered on CDS&E; result in significant changes to the undergraduate mathematics and statistics curriculum; have broad institutional support and department-wide commitment that encourage collaborations within and across disciplines; and include professional development activities for faculty or for K-12 teachers.

EXTREEMS-QED is a joint effort of the Directorate of Mathematical and Physical Sciences and the Office of Cyberinfrastructure at the National Science Foundation. The Office of Cyberinfrastructure is interested in supporting educational activities that incorporate cyberinfrastructure considerations at a fundamental level, and in efforts that leverage and advance major NSF investments in cyberinfrastructure. Cyberinfrastructure consists of advanced computing systems, data storage systems, instruments and data repositories, visualization environments, and people, all linked together by software and high performance networks to improve research productivity and enable breakthroughs not otherwise possible. Examples of NSF investments in cyberinfrastructure can be found at

[http://www.nsf.gov/od/oci/cif21/cybinf_list.jsp].

Cognizant Program Officer(s):

Please note that the following information is current at the time of publishing. See program website for any updates to the points of contact.

- Sujit Ghosh, MPS/DMS, telephone: (703) 292-8039, email: sghosh@nsf.gov
- Jennifer Pearl, MPS/DMS, telephone: (703) 292-4492, email: jslimowi@nsf.gov

Applicable Catalog of Federal Domestic Assistance (CFDA) Number(s):

- 47.049 --- Mathematical and Physical Sciences
- 47.070 --- Computer and Information Science and Engineering

Award Information

Anticipated Type of Award: Standard Grant or Continuing Grant

Estimated Number of Awards: 4 to 6 NSF anticipates making 4-6 awards, with some projects having 5 year duration and some having 2-3 year duration. It is not anticipated that particular projects will receive support from the EXTREEMS-QED program for longer than five years in total.

Anticipated Funding Amount: $4,000,000 subject to the availability of funds

Eligibility Information

Organization Limit:

Proposals may only be submitted by the following:

- Universities and Colleges -- Universities and four-year colleges accredited in and having a campus located in the US, acting on behalf of their faculty members. Two-year colleges or community colleges may serve as non-lead organizations in collaborative proposals or receive support via subcontracts.

PI Limit:

None Specified

Limit on Number of Proposals per Organization:

None Specified

Limit on Number of Proposals per PI:

None Specified

Proposal Preparation and Submission Instructions

A. Proposal Preparation Instructions

- Letters of Intent: Not Applicable
- Preliminary Proposal Submission: Not Applicable
- Full Proposals:
  - Full Proposals submitted via FastLane: NSF Proposal and Award Policies and Procedures Guide, Part I: Grant Proposal Guide (GPG) Guidelines apply. The complete text of the GPG is available electronically on the NSF website at: http://www.nsf.gov/publications/pub_summ.jsp?ods_key=gpg.
  - Full Proposals submitted via Grants.gov: NSF Grants.gov Application Guide: A Guide for the Preparation and Submission of NSF Applications via Grants.gov Guidelines apply (Note: The NSF Grants.gov Application Guide is available on the Grants.gov website and on the NSF website at: http://www.nsf.gov/publications/pub_summ.jsp?ods_key=grantsgovguide)

B. Budgetary Information

- Cost Sharing Requirements: Inclusion of voluntary committed cost sharing is prohibited.
- Indirect Cost (F&A) Limitations: Not Applicable
- Other Budgetary Limitations: Not Applicable

C. Due Dates

- Full Proposal Deadline(s) (due by 5 p.m. proposer's local time):

  January 31, 2013

  November 06, 2013

  First Wednesday in November, Annually Thereafter

Proposal Review Information Criteria

Merit Review Criteria: National Science Board approved criteria. Additional merit review considerations apply. Please see the full text of this solicitation for further information.

Award Administration Information

Award Conditions: Standard NSF award conditions apply.

Reporting Requirements: Additional reporting requirements apply. Please see the full text of this solicitation for further information.

TABLE OF CONTENTS

I. INTRODUCTION

The new field of computational and data-enabled science and engineering (CDS&E) has emerged as a third pillar of scientific investigation that complements theory and experimentation. CDS&E is now clearly recognizable as a distinct intellectual and technological discipline lying at the intersection of applied mathematics, statistics, computer science, core science and engineering disciplines. It is dedicated to the development and use of computational methods, data mining, and management systems to enable scientific discovery and engineering innovation. In particular, CDS&E is exerting a transformational influence on research and learning through the use of computers to model, simulate, measure, and visualize complex scientific and engineering concepts; to create resources for scientific investigation and education both formal and informal; and to foster interdisciplinary collaborations.

Examples of mathematical and statistical research in CDS&E include, but are not limited to:

- Sophisticated computational/statistical modeling for simulation, prediction, and assessment in computationally intensive, data-intensive scientific problems (arising, for example, in astronomy, health sciences, energy, economics, climate modeling, genetics, finance, social networks, etc.).
- State-of-the-art tools and theory for knowledge discovery from massive, complex, and dynamic data sets.
- General theory and algorithms for advancing large-scale modeling of problems that present particular computational difficulties, such as strong heterogeneities and anisotropies, multi-physics coupling, multi-scale behavior, stochastic forcing, uncertainty parameters or dynamic data, and long-time behavior.
- Novel end-to-end scientific scenarios to exploit cutting edge cyberinfrastructure (e.g., advanced computing and data systems, software frameworks, middleware, workflow systems, visualization capabilities, and networks) that are driven by mathematical and statistical challenges.
- Computational and data-enabled approaches to the study of mathematical, statistical, and stochastic properties of networks.
- Computational and data-enabled approaches to the study of analytical, topological, algebraic, geometric and number-theoretic structures.
- Computational and data-enabled approaches to the mathematical and statistical challenges of uncertainty quantification.

Unfortunately, the interdisciplinary demands of CDS&E training often lead it to be under-developed within the current structure of U.S. educational institutions. The long-range goal of EXTREEMS-QED is to enhance the ability of the mathematics and statistics community within universities and colleges to educate the next generation of undergraduate students to confront new challenges in CDS&E. EXTREEMS-QED projects must enhance the knowledge and skills of most, if not all, the institution's mathematics and statistics majors through training that incorporates computational tools for analysis of large data sets and for modeling and

simulation of complex systems. EXTREEMS-QED projects may have components that enhance the knowledge and skills of non-majors as well. Strongly competitive proposals will have the potential to transform both departmental and institutional culture.

The program posits the importance of early interdisciplinary research experiences and innovative curricula in CDS&E. EXTREEMS-QED challenges institutions to create new learning environments and experiences that immerse students in CDS&E while energizing and sustaining the professional growth of faculty in CDS&E.

II. PROGRAM DESCRIPTION

Funded activities are expected to:

- Provide opportunities for undergraduate research and hands-on experiences centered on CDS&E;
- Result in significant changes to the undergraduate mathematics and statistics curriculum;
- Have broad institutional support and department-wide commitment that encourage collaborations within and across disciplines;
- Include professional development activities for faculty or for K-12 teachers;
- Where appropriate leverage and advance the use of existing cyberinfrastructure resources (e.g. data archives, networks) for data exploration.

The duration of projects may be up to five years. In general, projects of five-year duration are encouraged; however, institutions may submit proposals for shorter terms (for example, smaller projects of two to three years).

Long-term projects will be reviewed in the third year and fourth- and fifth-year funding will be contingent upon the outcome of the review. A site visit and/or a PI meeting are possible mid-term review mechanisms.

A. PROJECT COMPONENTS

All EXTREEMS-QED proposals must include objectives and detailed plans for (1) Research, (2) Education and Training, and (3) Faculty Professional Development or Outreach. Projects may choose to place more emphasis on one (or more) of the components. A description of the three components is provided below:

- Research. CDS&E-centered undergraduate research and hands-on activities. These activities should be of longer duration than summer research experiences, resulting in long-term engagement in research and allowing mutual reinforcement between the research and classroom components. Team research experiences, partnerships with other academic and non-academic institutions, and inter- and multi-disciplinary activities are encouraged and are a priority for EXTREEMS-QED.

Examples include, but are not limited to:

- Exploring the mathematical, statistical, or computational foundations of CDS&E;
- Understanding the role of computational and statistical tools in advancing mathematics and statistics theory;
- Applying CDS&E-related tools to other fields of knowledge;
- Exploration of existing, ideally remote, data sets using new mathematical and statistical tools and cyberinfrastructure.

Here, research is interpreted broadly to include all forms of discovery learning, at levels appropriate to the students, through which students are introduced to the excitement of the scientific research process. These should motivate students to pursue and persist in what can be challenging aspects of scientific endeavor. For the purposes of this program, it is not necessary that research topics be original or that student research experiences lead to publishable results, but the content should be substantial and intellectually stimulating.

1. Education and Training. Enhancements to the undergraduate curriculum that contribute to the training of the next-generation of mathematics and statistics majors grounded in CDS&E. Training activities, centered on CDS&E, for students pursuing minors in mathematics and statistics are encouraged.

   Examples include, but are not limited to:
   - Developing minors/majors, certificate programs, or joint programs in CDS&E;
   - Incorporating CDS&E content in existing courses or developing new courses in CDS&E areas (e.g., data structures, algorithms, and software for science and engineering, scientific computation, and analysis and visualization of big data sets);
   - Creating CDS&E capstone experiences, such as practica, internships, or multidisciplinary projects;
   - CDS&E training activities, designed as part of existing courses or as components of teacher training, for mathematics and statistics undergraduates pursuing a teaching career.
   - Engaging students in quantitative explorations with data through innovations in general education courses in STEM fields.
   - Interdepartmental curricular initiatives are encouraged.
   - Faculty Professional Development or Outreach. CDS&E-centered training activities for college faculty or K-12 teachers.

   Examples include, but are not limited to:

2. CDS&E-specific training for faculty and mentors;
3. Lectures/workshops on current and emerging challenges in CDS&E;
4. Collaboration with CDS&E experts from other universities, institutes, national laboratories, or industry;
5. Workshops on integrating CDS&E content in the curriculum;
6. Pedagogical strategies for CDS&E content;
7. Developing CDS&E-driven student activities at the K-12 level (e.g., competitions, group projects, science fairs).

B. IMPORTANT PROJECT FEATURES

All EXTREEMS-QED projects should strengthen the educational capacity, infrastructure, and culture at participating institutions, as reflected by the number and inclusiveness of participating mentors and students, the quality of their research experiences, the effectiveness of department-wide curricular initiatives, and the impact of outreach and faculty professional development activities. Projects should foster student learning and professional development and an appreciation for the integration of research and education. EXTREEMS-QED projects should contribute substantially to an enhanced and sustainable undergraduate educational

enterprise that strengthens CDS&E training and education for mathematics and statistics students.

The use of evidence-based proven instructional practices is encouraged and should be documented. Please see Section IX for some examples of references that discuss proven practices.

EXTREEMS-QED encourages collaborations that bring together scientists from baccalaureate, masters, or PhD granting institutions. Collaborative involvement of minority-serving institutions, two-year colleges, industrial partners, or government laboratories is strongly encouraged.

Although projects may vary in the approaches they take, the number and type of academic institutions involved, and the number of participating faculty members, all competitive projects will have certain common features:

1. Student Activities and Mentoring: Instruction in effective oral and written communication (e.g. seminars, posters, research papers, project and consulting reports, and documentation of computer programs) should be an important component of the proposed student experience. Projects must include a description of the mentors' qualifications or plans for training of mentors. Broad participation of department faculty is encouraged. A schedule of the year-round long-term activities should be provided.
2. Recruitment: Describe in detail the recruitment plan for all participants. NSF is particularly interested in increasing the participation of women, underrepresented minorities, and persons with disabilities in the STEM disciplines. Underrepresented minorities are African-Americans, Hispanics, Native Americans, and Native Pacific Islanders. In EXTREEMS-QED awards, only those undergraduate students who are citizens or permanent residents of the United States or its possessions can be supported with NSF funds.
3. Post EXTREEMS-QED Plan: One of the main goals of the program is to facilitate lasting changes in the education and training of the next generation of mathematics and statistics undergraduate students, so that they are well-equipped to confront the new challenges in CDSE either in the workforce or in graduate school. Proposals should address the potential long-term effects of the proposed activities, including changes to the curriculum, development of new programs, and establishment of collaborations within and/or outside the institution. A clear plan for sustaining the program goals beyond the grant duration must be included.
4. Dissemination/CDSE Community-Building: Proposals should clearly address dissemination of information about project outcomes. Investigators of EXTREEMS-QED projects are expected to share the knowledge and experience gained in developing and assessing CDS&E educational innovations with the mathematics and statistics community. EXTREEMS-QED aims to create new models of education and training in CDS&E: dissemination to the mathematics and statistics community as well as a broader audience is therefore critical to the success of the program. This may be achieved in a number of ways, including websites, publications, publicly accessible databases, presentations, and workshops.
5. Project Assessment, Evaluation and Reporting: All projects should include an evaluation plan that describes both a strategy for continuous monitoring of the project to provide feedback for improvement (formative evaluation) and a strategy for evaluating the effectiveness of the project in achieving its goals and identifying positive and negative findings upon completion (summative evaluation). Proposals should identify specific goals and related expected measurable outcomes that will be used to track progress, guide the project, and evaluate its impact. Expected measurable outcomes must address student learning, contributions to CDS&E research and training, and community building.

   The proposal must describe ways of assessing students' foundational knowledge in CDS&E and their ability to apply computational and statistical methods. The proposal must address the effect of curricular changes on student learning and performance, and the impact of faculty professional development or outreach activities on the department and institution. Please see Additional Reporting Requirements in Section VII.C.

   More extensive projects may require experienced evaluators to conduct a comprehensive evaluation. Although not required, the principal investigator(s) may wish to engage educational research specialists in planning and implementing the project evaluation. Additionally, it is highly desirable to have a mechanism for tracking participating students beyond graduation in order to assess the impact of the CDS&E research, education and training on their career paths. For guidance, proposers may wish to consult the NSF on-line document, "User-Friendly Handbook for Project Evaluation" (NSF 02-57), [http://www.nsf.gov/pubsys/ods/getpub.cfm?nsf02057].

III. AWARD INFORMATION

Anticipated Type of Award: Continuing Grant or Standard Grant

Estimated Number of Awards: 4 to 6 NSF anticipates making 4-6 awards, with some projects having 5 year duration and some having 2-3 year duration. It is not anticipated that particular projects will receive support from the EXTREEMS-QED program for longer than five years in total.

Anticipated Funding Amount: $4,000,000, subject to the availability of funds

IV. ELIGIBILITY INFORMATION

Organization Limit:

Proposals may only be submitted by the following:

- Universities and Colleges -- Universities and four-year colleges accredited in and having a campus located in the US, acting on behalf of their faculty members. Two-year colleges or community colleges may serve as non-lead organizations in collaborative proposals or receive support via subcontracts.

PI Limit:

None Specified

Limit on Number of Proposals per Organization:

None Specified

Limit on Number of Proposals per PI:

None Specified

V. PROPOSAL PREPARATION AND SUBMISSION INSTRUCTIONS

A. Proposal Preparation Instructions

Full Proposal Preparation Instructions: Proposers may opt to submit proposals in response to this Program Solicitation via Grants.gov or via the NSF FastLane system.

- Full proposals submitted via FastLane: Proposals submitted in response to this program solicitation should be prepared and submitted in accordance with the general guidelines contained in the NSF Grant Proposal Guide (GPG). The complete text of the GPG is available electronically on the NSF website at: http://www.nsf.gov/publications/pub_summ.jsp?ods_key=gpg. Paper copies of the GPG may be obtained from the NSF Publications Clearinghouse, telephone (703) 292-7827 or by e-mail from nsfpubs@nsf.gov. Proposers are reminded to identify this program solicitation number in the program solicitation block on the NSF Cover Sheet For Proposal to the National Science Foundation. Compliance with this requirement is critical to determining the relevant proposal processing guidelines. Failure to submit this information may delay processing.

- Full proposals submitted via Grants.gov: Proposals submitted in response to this program solicitation via Grants.gov should be prepared and submitted in accordance with the NSF Grants.gov Application Guide: A Guide for the Preparation and Submission of NSF Applications via Grants.gov. The complete text of the NSF Grants.gov Application Guide is available on the Grants.gov website and on the NSF website at: (http://www.nsf.gov/publications/pub_summ.jsp?ods_key=grantsgovguide). To obtain copies of the Application Guide and Application Forms Package, click on the Apply tab on the Grants.gov site, then click on the Apply Step 1: Download a Grant Application Package and Application Instructions link and enter the funding opportunity number, (the program solicitation number without the NSF prefix) and press the Download Package button. Paper copies of the Grants.gov Application Guide also may be obtained from the NSF Publications Clearinghouse, telephone (703) 292-7827 or by e-mail from nsfpubs@nsf.gov.

In determining which method to utilize in the electronic preparation and submission of the proposal, please note the following:

Collaborative Proposals. All collaborative proposals submitted as separate submissions from multiple organizations must be submitted via the NSF FastLane system. Chapter II, Section D.4 of the Grant Proposal Guide provides additional information on collaborative proposals.

Important Proposal Preparation Information: FastLane will check for required sections of the full proposal, in accordance with *Grant Proposal Guide* (GPG) instructions described in Chapter II.C.2. The GPG requires submission of: Project Summary; Project Description; References Cited; Biographical Sketch(es); Budget; Budget Justification; Current and Pending Support; Facilities, Equipment & Other Resources; Data Management Plan; and Postdoctoral Mentoring Plan, if applicable. If a required section is missing, FastLane will not accept the proposal.

Please note that the proposal preparation instructions provided in this program solicitation may deviate from the GPG instructions. If the solicitation instructions do not require a GPG-required section to be included in the proposal, insert text or upload a document in that section of the proposal that states, "Not Applicable for this Program Solicitation." Doing so will enable FastLane to accept your proposal.

The following instructions supplement the GPG or NSF Grants.gov Application Guide guidelines.

1. Cover Sheet. The title of the project should begin "EXTREEMS-QED: ...."
2. Project Summary. The project summary must clearly state the objectives of the proposed EXTREEMS-QED project in each of the three categories: Research, Education and Training, and Faculty Professional Development/Outreach.
3. Project Description. The project description is not to exceed 15 pages in length and must contain the following items:
   a) Results from Prior NSF Support (if applicable).
   b) Overview. Provide a brief description of the objectives of the proposed EXTREEMS-QED project in each of the three categories: Research, Education and Training, and Faculty Professional Development/Outreach. The proposal should describe student, faculty, and outreach participation, the organizational structure and timetable, and evidence of organizational endorsement. *Letters of commitment from appropriate institutional administrators should be included as supplementary documents.*
   c) Project Components and Important Features. Provide a detailed plan for the Research, Education and Training, and Faculty Professional Development/Outreach activities. See Section II.A of this solicitation for a list of examples. Describe key features of the project including Student Activities and Mentoring, Recruitment, Post EXTREEMS-QED Plan, Dissemination, and Assessment and Evaluation. See II.B for details. If appropriate, provide a clear list of cyberinfrastructure resources which will be leveraged through the project activities.
   d) Project Management. Describe a clear management plan that includes mechanisms for dealing with possible changes in faculty participation over the course of the project.
4. Biographical Sketches. The standard guidelines for biographical material apply; however, senior personnel are encouraged to include publications with undergraduate co-authors (with the student labeled by an asterisk) and other activities or accomplishments relevant to a successful CDS&E activity. Senior personnel are the principal investigator, any co-principal investigators, and any other faculty/professionals who are anticipated to serve as research mentors. Postdoctoral scholars and graduate students are not senior personnel.
5. Project Budget. The proposal should include a detailed project budget and budget justification, as described in the GPG or NSF Grants.gov Application Guide. The budget justification should explain and justify major cost items and any unusual situations/inclusions and address the cost-effectiveness of the project. The budget may include items such as faculty salaries (including course buy-outs), support for coordination activities, equipment, and other direct costs (e.g., materials, publication costs). The budget may include funds for student stipends. Funds for organizing/attending workshops for faculty professional development may also be included. In projects of duration three years or greater, funds should also be budgeted for the PI and an additional faculty member to travel to an awardees meeting in the third year of the award.
6. Supplementary Documentation. While all material relevant to determining the quality of the proposed work must be included within the 15-page Project Description or as part of the budget justification, proposers may, as a part of the Supplementary Documentation, include letters showing collaborator commitments and organizational endorsement. In addition, for those projects whose deliverables include a final product, samples of these products (such as screen shots of

software, sample teaching modules and other project deliverables) may be placed within the Supplementary Documentation section. These sample materials should be concise and relevant.

B. Budgetary Information

Cost Sharing: Inclusion of voluntary committed cost sharing is prohibited

Budget Preparation Instructions:

Other Budgetary Limitations:

NSF funds may not be used to support expenditures that would normally be made in the absence of an award, such as costs for routine teaching activities.

Total award sizes are limited to an average of $200,000 per year (or $250,000 per year when four-year colleges or universities collaborate with two-year colleges).

C. Due Dates

- Full Proposal Deadline(s) (due by 5 p.m. proposer's local time):

  January 31, 2013

  November 06, 2013

  First Wednesday in November, Annually Thereafter

D. FastLane / Grants.gov Requirements

- For Proposals Submitted Via FastLane:

  Detailed technical instructions regarding the technical aspects of preparation and submission via FastLane are available at: https://www.fastlane.nsf.gov/a1/newstan.htm. For FastLane user support, call the FastLane Help Desk at 1-800-673-6188 or e-mail fastlane@nsf.gov. The FastLane Help Desk answers general technical questions related to the use of the FastLane system. Specific questions related to this program solicitation should be referred to the NSF program staff contact(s) listed in Section VIII of this funding opportunity.

  Submission of Electronically Signed Cover Sheets. The Authorized Organizational Representative (AOR) must electronically sign the proposal Cover Sheet to submit the required proposal certifications (see Chapter II, Section C of the Grant Proposal Guide for a listing of the certifications). The AOR must provide the required electronic certifications within five working days following the electronic submission of the proposal. Further instructions regarding this process are available on the FastLane Website at: https://www.fastlane.nsf.gov/fastlane.jsp.

- For Proposals Submitted Via Grants.gov:

  Before using Grants.gov for the first time, each organization must register to create an institutional profile. Once registered, the applicant's organization can then apply for any federal grant on the Grants.gov website. Comprehensive information about using Grants.gov is available on the Grants.gov Applicant Resources webpage: http://www07.grants.gov/applicants/app_help_reso.jsp. In addition, the NSF Grants.gov Application Guide provides additional technical guidance regarding preparation of proposals via Grants.gov. For Grants.gov user support, contact the Grants.gov Contact Center at 1-800-518-4726 or by email: support@grants.gov. The Grants.gov Contact Center answers general technical questions related to the use of Grants.gov. Specific questions related to this program solicitation should be referred to the NSF program staff contact(s) listed in Section VIII of this solicitation.

  Submitting the Proposal: Once all documents have been completed, the Authorized Organizational Representative (AOR) must submit the application to Grants.gov and verify the desired funding opportunity and agency to which the application is submitted. The AOR must then sign and submit the application to Grants.gov. The completed application will be transferred to the NSF FastLane system for further processing.

VI. NSF PROPOSAL PROCESSING AND REVIEW PROCEDURES

Proposals received by NSF are assigned to the appropriate NSF program for acknowledgement and, if they meet NSF requirements, for review. All proposals are carefully reviewed by a scientist, engineer, or educator serving as an NSF Program Officer, and usually by three to ten other persons outside NSF either as *ad hoc* reviewers, panelists, or both, who are experts in the particular fields represented by the proposal. These reviewers are selected by Program Officers charged with oversight of the review process. Proposers are invited to suggest names of persons they believe are especially well qualified to review the proposal and/or persons they would prefer not review the proposal. These suggestions may serve as one source in the reviewer selection process at the Program Officer's discretion. Submission of such names, however, is optional. Care is taken to ensure that reviewers have no conflicts of interest with the proposal. In addition, Program Officers may obtain comments from site visits before recommending final action on proposals. Senior NSF staff further review recommendations for awards. A flowchart that depicts the entire NSF proposal and award process (and associated timeline) is included in the GPG as Exhibit III-1.

A comprehensive description of the Foundation's merit review process is available on the NSF website at: http://nsf.gov/bfa/dias/policy/merit_review/.

Proposers should also be aware of core strategies that are essential to the fulfillment of NSF's mission, as articulated in *Empowering the Nation Through Discovery and Innovation: NSF Strategic Plan for Fiscal Years (FY) 2011-2016*. These strategies are integrated in the program planning and implementation process, of which proposal review is one part. NSF's mission is

particularly well-implemented through the integration of research and education and broadening participation in NSF programs, projects, and activities.

One of the core strategies in support of NSF's mission is to foster integration of research and education through the programs, projects and activities it supports at academic and research institutions. These institutions provide abundant opportunities where individuals may concurrently assume responsibilities as researchers, educators, and students, and where all can engage in joint efforts that infuse education with the excitement of discovery and enrich research through the variety of learning perspectives.

Another core strategy in support of NSF's mission is broadening opportunities and expanding participation of groups, institutions, and geographic regions that are underrepresented in STEM disciplines, which is essential to the health and vitality of science and engineering. NSF is committed to this principle of diversity and deems it central to the programs, projects, and activities it considers and supports.

A. Merit Review Principles and Criteria

The National Science Foundation strives to invest in a robust and diverse portfolio of projects that creates new knowledge and enables breakthroughs in understanding across all areas of science and engineering research and education. To identify which projects to support, NSF relies on a merit review process that incorporates consideration of both the technical aspects of a proposed project and its potential to contribute more broadly to advancing NSF's mission "to promote the progress of science; to advance the national health, prosperity, and welfare; to secure the national defense; and for other purposes." NSF makes every effort to conduct a fair, competitive, transparent merit review process for the selection of projects.

1. Merit Review Principles

These principles are to be given due diligence by PIs and organizations when preparing proposals and managing projects, by reviewers when reading and evaluating proposals, and by NSF program staff when determining whether or not to recommend proposals for funding and while overseeing awards. Given that NSF is the primary federal agency charged with nurturing and supporting excellence in basic research and education, the following three principles apply:

- All NSF projects should be of the highest quality and have the potential to advance, if not transform, the frontiers of knowledge.
- NSF projects, in the aggregate, should contribute more broadly to achieving societal goals. These "Broader Impacts" may be accomplished through the research itself, through activities that are directly related to specific research projects, or through activities that are supported by, but are complementary to, the project. The project activities may be based on previously established and/or innovative methods and approaches, but in either case must be well justified.
- Meaningful assessment and evaluation of NSF funded projects should be based on appropriate metrics, keeping in mind the likely correlation between the effect of broader impacts and the resources provided to implement projects. If the size of the activity is limited, evaluation of that activity in isolation is not likely to be meaningful. Thus, assessing the effectiveness of these activities may best be done at a higher, more aggregated, level than the individual project.

With respect to the third principle, even if assessment of Broader Impacts outcomes for particular projects is done at an aggregated level, PIs are expected to be accountable for carrying out the activities described in the funded project. Thus, individual projects should include clearly stated goals, specific descriptions of the activities that the PI intends to do, and a plan in place to document the outputs of those activities.

These three merit review principles provide the basis for the merit review criteria, as well as a context within which the users of the criteria can better understand their intent.

2. Merit Review Criteria

All NSF proposals are evaluated through use of the two National Science Board approved merit review criteria. In some instances, however, NSF will employ additional criteria as required to highlight the specific objectives of certain programs and activities.

The two merit review criteria are listed below. Both criteria are to be given full consideration during the review and decision-making processes; each criterion is necessary but neither, by itself, is sufficient. Therefore, proposers must fully address both criteria. (GPG Chapter II.C.2.d.i. contains additional information for use by proposers in development of the Project Description section of the proposal.) Reviewers are strongly encouraged to review the criteria, including GPG Chapter II.C.2.d.i., prior to the review of a proposal.

When evaluating NSF proposals, reviewers will be asked to consider what the proposers want to do, why they want to do it, how they plan to do it, how they will know if they succeed, and what benefits could accrue if the project is successful. These issues apply both to the technical aspects of the proposal and the way in which the project may make broader contributions. To that end, reviewers will be asked to evaluate all proposals against two criteria:

- Intellectual Merit: The Intellectual Merit criterion encompasses the potential to advance knowledge; and
- Broader Impacts: The Broader Impacts criterion encompasses the potential to benefit society and contribute to the achievement of specific, desired societal outcomes.

The following elements should be considered in the review for both criteria:

1. What is the potential for the proposed activity to
    a. Advance knowledge and understanding within its own field or across different fields (Intellectual Merit); and
    b. Benefit society or advance desired societal outcomes (Broader Impacts)?
2. To what extent do the proposed activities suggest and explore creative, original, or potentially transformative concepts?
3. Is the plan for carrying out the proposed activities well-reasoned, well-organized, and based on a sound rationale? Does the plan incorporate a mechanism to assess success?
4. How well qualified is the individual, team, or organization to conduct the proposed activities?
5. Are there adequate resources available to the PI (either at the home organization or through collaborations) to carry out the proposed activities?

Broader impacts may be accomplished through the research itself, through the activities that are directly related to specific research projects, or through activities that are supported by, but are complementary to, the project. NSF values the advancement of scientific knowledge and activities that contribute to achievement of societally relevant outcomes. Such outcomes include, but are not limited to: full participation of women, persons with disabilities, and underrepresented minorities in science, technology, engineering, and mathematics (STEM); improved STEM education and educator development at any level; increased public scientific literacy and public engagement with science and technology; improved well-being of individuals in society; development of a diverse, globally

competitive STEM workforce; increased partnerships between academia, industry, and others; improved national security; increased economic competitiveness of the United States; and enhanced infrastructure for research and education.

Proposers are reminded that reviewers will also be asked to review the Data Management Plan and the Postdoctoral Researcher Mentoring Plan, as appropriate.

Additional Solicitation Specific Review Criteria

Transformative nature of the project: The potential to contribute to a paradigm-shifting integration of CDS&E into undergraduate STEM research, education and training. Development of model programs that enhance student learning and may be adapted easily by other sites. Impact on the training of faculty or K-12 teachers.

B. Review and Selection Process

Proposals submitted in response to this program solicitation will be reviewed by Ad hoc Review and/or Panel Review.

Reviewers will be asked to formulate a recommendation to either support or decline each proposal. The Program Officer assigned to manage the proposal's review will consider the advice of reviewers and will formulate a recommendation.

After scientific, technical and programmatic review and consideration of appropriate factors, the NSF Program Officer recommends to the cognizant Division Director whether the proposal should be declined or recommended for award. NSF is striving to be able to tell applicants whether their proposals have been declined or recommended for funding within six months. The time interval begins on the deadline or target date, or receipt date, whichever is later. The interval ends when the Division Director accepts the Program Officer's recommendation.

A summary rating and accompanying narrative will be completed and submitted by each reviewer. In all cases, reviews are treated as confidential documents. Verbatim copies of reviews, excluding the names of the reviewers, are sent to the Principal Investigator/Project Director by the Program Officer. In addition, the proposer will receive an explanation of the decision to award or decline funding.

In all cases, after programmatic approval has been obtained, the proposals recommended for funding will be forwarded to the Division of Grants and Agreements for review of business, financial, and policy implications and the processing and issuance of a grant or other agreement. Proposers are cautioned that only a Grants and Agreements Officer may make commitments, obligations or awards on behalf of NSF or authorize the expenditure of funds. No commitment on the part of NSF should be inferred from technical or budgetary discussions with a NSF Program Officer. A Principal Investigator or organization that makes financial or personnel commitments in the absence of a grant or cooperative agreement signed by the NSF Grants and Agreements Officer does so at their own risk.

VII. AWARD ADMINISTRATION INFORMATION

A. Notification of the Award

Notification of the award is made to *the submitting organization* by a Grants Officer in the Division of Grants and Agreements. Organizations whose proposals are declined will be advised as promptly as possible by the cognizant NSF Program administering the program. Verbatim copies of reviews, not including the identity of the reviewer, will be provided automatically to the Principal Investigator. (See Section VI.B. for additional information on the review process.)

B. Award Conditions

An NSF award consists of: (1) the award letter, which includes any special provisions applicable to the award and any numbered amendments thereto; (2) the budget, which indicates the amounts, by categories of expense, on which NSF has based its support (or otherwise communicates any specific approvals or disapprovals of proposed expenditures); (3) the proposal referenced in the award letter; (4) the applicable award conditions, such as Grant General Conditions (GC-1); * or Research Terms and Conditions * and (5) any announcement or other NSF issuance that may be incorporated by reference in the award letter. Cooperative agreements also are administered in accordance with NSF Cooperative Agreement Financial and Administrative Terms and Conditions (CA-FATC) and the applicable Programmatic Terms and Conditions. NSF awards are electronically signed by an NSF Grants and Agreements Officer and transmitted electronically to the organization via e-mail.

*These documents may be accessed electronically on NSF's Website at http://www.nsf.gov/awards/managing/award_conditions.jsp?org=NSF. Paper copies may be obtained from the NSF Publications Clearinghouse, telephone (703) 292-7827 or by e-mail from nsfpubs@nsf.gov.

More comprehensive information on NSF Award Conditions and other important information on the administration of NSF awards is contained in the NSF *Award & Administration Guide* (AAG) Chapter II, available electronically on the NSF Website at http://www.nsf.gov/publications/pub_summ.jsp?ods_key=aag.

C. Reporting Requirements

For all multi-year grants (including both standard and continuing grants), the Principal Investigator must submit an annual project report to the cognizant Program Officer at least 90 days prior to the end of the current budget period. (Some programs or awards require submission of more frequent project reports). Within 90 days following expiration of a grant, the PI also is required to submit a final project report, and a project outcomes report for the general public.

Failure to provide the required annual or final project reports, or the project outcomes report, will delay NSF review and processing of any future funding increments as well as any pending proposals for all identified PIs and co-PIs on a given award. PIs should examine the formats of the required reports in advance to assure availability of required data.

PIs are required to use NSF's electronic project-reporting system, available through Research.gov, for preparation and submission of annual and final project reports. Such reports provide information on accomplishments, project participants (individual and organizational), publications, and other specific products and impacts of the project. Submission of the report via Research.gov constitutes certification by the PI that the contents of the report are accurate and complete. The project outcomes report also must be prepared and submitted using Research.gov. This report serves as a brief summary, prepared specifically for the public, of the nature and outcomes of the project. This report will be posted on the NSF website exactly as it is submitted by the PI.

More comprehensive information on NSF Reporting Requirements and other important information on the administration of NSF awards is contained in the NSF *Award & Administration Guide* (AAG) Chapter II, available electronically on the NSF Website at http://www.nsf.gov/publications/pub_summ.jsp?ods_key=aag.

In addition to the FastLane reporting requirements, awardees will be required to report data relevant to the proposed measurable outcomes of the project annually for the duration of the grant. In particular, the awardee must include the following items in annual reports:

1. Number of undergraduate students engaged in EXTREEMS-QED research.

2. List of new courses and new programs developed, with number of students enrolled in each.

3. Number of individuals impacted by professional development and outreach activities, broken down by home institution.

4. List of cyberinfrastructure resources (if appropriate) created or leveraged through the project activities.

Grantees whose awards are of duration three years or longer will be required to report results of the project efforts during a site visit and/or at a third-year PI meeting held to share information on effective practices. Fourth- and fifth- year funding is contingent upon demonstration of satisfactory progress towards meeting the project goals.

VIII. AGENCY CONTACTS

Please note that the program contact information is current at the time of publishing. See program website for any updates to the points of contact.

General inquiries regarding this program should be made to:

- Sujit Ghosh, MPS/DMS, telephone: (703) 292-8039, email: sghosh@nsf.gov
- Jennifer Pearl, MPS/DMS, telephone: (703) 292-4492, email: jslimowi@nsf.gov

For questions related to the use of FastLane, contact:

- FastLane Help Desk, telephone: 1-800-673-6188; e-mail: fastlane@nsf.gov.

For questions relating to Grants.gov contact:

- Grants.gov Contact Center: If the Authorized Organizational Representatives (AOR) has not received a confirmation message from Grants.gov within 48 hours of submission of application, please contact via telephone: 1-800-518-4726; e-mail: support@grants.gov.

Important submission information:

If you submit your proposal prior to January 14, 2013, you must prepare your proposal in accordance with the Proposal & Award Policies & Procedures Guide (PAPPG) (NSF 13-1), which requires that the one-page Project Summary include 1) an overview; 2) a statement on intellectual merit of the proposed activity; and 3) a statement on the broader impacts of the proposed activity. (See GPG, Chapter II.C.2b)

If you prepare your proposal prior to January 14, 2013, with the intention of submitting it on or after January 14, 2013, the information that you included in the Project Summary in FastLane will be inserted into the overview text box of the Project Summary. Per PAPPG guidelines, you will need to include this information in the three text boxes (overview; statement on intellectual merit; statement on broader impacts) or FastLane will not accept your proposal. (See GPG, Chapter II.C.2b)

IX. OTHER INFORMATION

The NSF website provides the most comprehensive source of information on NSF Directorates (including contact information), programs and funding opportunities. Use of this website by potential proposers is strongly encouraged. In addition, "My NSF" is an information-delivery system designed to keep potential proposers and other interested parties apprised of new NSF funding opportunities and publications, important changes in proposal and award policies and procedures, and upcoming NSF Grants Conferences. Subscribers are informed through e-mail or the user's Web browser each time new publications are issued that match their identified interests. "My NSF" also is available on NSF's website at http://www.nsf.gov/mynsf/.

Grants.gov provides an additional electronic capability to search for Federal government-wide grant opportunities. NSF funding opportunities may be accessed via this new mechanism. Further information on Grants.gov may be obtained at http://www.grants.gov.

Related Programs:

Two NSF programs that are related to EXTREEMS-QED are

Transforming Undergraduate Education in Science, Technology, Engineering and Mathematics and

Computational and Data-Enabled Science and Engineering (CDS&E).

The following resources are but a sample of the literature that provide information concerning evidence-based proven instructional practices in STEM fields:

"Engage to Excel: Producing One Million Additional College Graduates with Degrees in Science, Technology, Engineering, and Mathematics," President's Council of Advisors on Science and Technology, 2012. http://www.whitehouse.gov/sites/default/files/microsites/ostp/pcast-engage-to-excel-final_feb.pdf.

"Discipline-Based Education Research: Understanding and Improving Learning in Undergraduate Science and Engineering," edited by Susan R. Singer, Natalie R. Nielsen, and Heidi A. Schweingruber, National Academies Press, 2012. http://www.nap.edu/catalog.php?record_id=13362

"Five High Impact Practices: Research on Learning Outcomes, Completion, and Quality," by Jayne E. Brownell and Lynn E. Swaner, Association of American Colleges and Universities, 2010.

Reports published by the American Association for the Advancement of Science which emanate from the "Understanding Interventions that Broaden Participation in Research Careers" workshops, 2007-2009. http://understanding-interventions.org/

"New Challenges, New Strategies: Building Excellence in Undergraduate STEM Education", American Association for the Advancement of Science, 2009. http://ccliconference.org/files/2010/02/2009.pdf

ABOUT THE NATIONAL SCIENCE FOUNDATION

The National Science Foundation (NSF) is an independent Federal agency created by the National Science Foundation Act of 1950, as amended (42 USC 1861-75). The Act states the purpose of the NSF is "to promote the progress of science; [and] to advance the national health, prosperity, and welfare by supporting research and education in all fields of science and engineering."

NSF funds research and education in most fields of science and engineering. It does this through grants and cooperative agreements to more than 2,000 colleges, universities, K-12 school systems, businesses, informal science organizations and other research organizations throughout the US. The Foundation accounts for about one-fourth of Federal support to academic institutions for basic research.

NSF receives approximately 55,000 proposals each year for research, education and training projects, of which approximately 11,000 are funded. In addition, the Foundation receives several thousand applications for graduate and postdoctoral fellowships. The agency operates no laboratories itself but does support National Research Centers, user facilities, certain oceanographic vessels and Arctic and Antarctic research stations. The Foundation also supports cooperative research between universities and industry, US participation in international scientific and engineering efforts, and educational activities at every academic level.

Facilitation Awards for Scientists and Engineers with Disabilities provide funding for special assistance or equipment to enable persons with disabilities to work on NSF-supported projects. See Grant Proposal Guide Chapter II, Section D.2 for instructions regarding preparation of these types of proposals.

The National Science Foundation has Telephonic Device for the Deaf (TDD) and Federal Information Relay Service (FIRS) capabilities that enable individuals with hearing impairments to communicate with the Foundation about NSF programs, employment or general information. TDD may be accessed at (703) 292-5090 and (800) 281-8749, FIRS at (800) 877-8339.

The National Science Foundation Information Center may be reached at (703) 292-5111.

The National Science Foundation promotes and advances scientific progress in the United States by competitively awarding grants and cooperative agreements for research and education in the sciences, mathematics, and engineering.

To get the latest information about program deadlines, to download copies of NSF publications, and to access abstracts of awards, visit the NSF Website at http://www.nsf.gov

- Location: 4201 Wilson Blvd. Arlington, VA 22230
- For General Information (NSF Information Center): (703) 292-5111
- TDD (for the hearing-impaired): (703) 292-5090
- To Order Publications or Forms:

  Send an e-mail to: nsfpubs@nsf.gov

  or telephone: (703) 292-7827
- To Locate NSF Employees: (703) 292-5111

PRIVACY ACT AND PUBLIC BURDEN STATEMENTS

The information requested on proposal forms and project reports is solicited under the authority of the National Science Foundation Act of 1950, as amended. The information on proposal forms will be used in connection with the selection of qualified proposals;

and project reports submitted by awardees will be used for program evaluation and reporting within the Executive Branch and to Congress. The information requested may be disclosed to qualified reviewers and staff assistants as part of the proposal review process; to proposer institutions/grantees to provide or obtain data regarding the proposal review process, award decisions, or the administration of awards; to government contractors, experts, volunteers and researchers and educators as necessary to complete assigned work; to other government agencies or other entities needing information regarding applicants or nominees as part of a joint application review process, or in order to coordinate programs or policy; and to another Federal agency, court, or party in a court or Federal administrative proceeding if the government is a party. Information about Principal Investigators may be added to the Reviewer file and used to select potential candidates to serve as peer reviewers or advisory committee members. See Systems of Records, NSF-50, "Principal Investigator/Proposal File and Associated Records," 69 Federal Register 26410 (May 12, 2004), and NSF-51, "Reviewer/Proposal File and Associated Records," 69 Federal Register 26410 (May 12, 2004). Submission of the information is voluntary. Failure to provide full and complete information, however, may reduce the possibility of receiving an award.

An agency may not conduct or sponsor, and a person is not required to respond to, an information collection unless it displays a valid Office of Management and Budget (OMB) control number. The OMB control number for this collection is 3145-0058. Public reporting burden for this collection of information is estimated to average 120 hours per response, including the time for reviewing instructions. Send comments regarding the burden estimate and any other aspect of this collection of information, including suggestions for reducing this burden, to:

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Reports Clearance Officer
Office of the General Counsel
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