Engineering Sciences for Modeling and Simulation-Based Life-Cycle Engineering and Manufacturing

Program Solicitation

NSF 05-616

***Replaces Document* NSF 03-505**

National Science Foundation
Directorate for Engineering
Division of Design and Manufacturing Innovation
Division of Civil and Mechanical Systems
Division of Chemical and Transport Systems

Sandia National Laboratories

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

March 01, 2006

SUMMARY OF PROGRAM REQUIREMENTS

General Information

Program Title:

Engineering Sciences for Modeling and Simulation-Based Life-Cycle Engineering and Manufacturing

Synopsis of Program:

This is a continuation of a collaborative research program between the National Science Foundation (NSF) and Sandia National Laboratories (Sandia) that was started in 1997. The objective of this collaborative program is to fund research projects focused on science-based experimental, computational and theoretical capabilities that enhance our understanding and confidence of the behavior of engineered systems at unprecedented multiple spatial and temporal scales.

Focus areas for this solicitation are 1) thermal transport and fluid mechanics; 2) solid mechanics and structural dynamics; 3) micro/nanoscale phenomenology and metrology; 4) predictive modeling for manufacturing and process optimization; and 5) micro/nanomanufacturing technologies

Cognizant Program Officer(s):

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- Alfonso Ortega, Program Director, Directorate for Engineering, Division of Chemical & Transport Systems, 525 N, telephone: (703) 292-8371, fax: (703) 292-9054, email: aortega@nsf.gov
- Ken P. Chong, Division Director (Acting), Directorate for Engineering, Division of Civil & Mechanical Systems, 545 S,

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- Kevin W. Lyons, Program Director, Directorate for Engineering, Division of Design and Manufacturing Innovation, 510 N, telephone: (703) 292-5365, fax: (703) 292-9056, email: klyons@nsf.gov
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- Wahid Hermina, Sandia National Laboratories, telephone: 505-844-4759, email: wlhermi@sandia.gov
- Ken Wilson, Sandia National Laboratories, telephone: 925-294-2497, email: klwilso@sandia.gov
- Peter Wilson, Sandia National Laboratories, telephone: 505-844-7656, email: pjwilso@sandia.gov
- Mark Kiefer, Sandia National Laboratories, telephone: 505-845-7271, email: mlkiefe@sandia.gov

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

- 47.041 --- Engineering

Eligibility Information

- **Organization Limit:** Colleges, universities and non-profit organizations in the United States.
- **PI Eligibility Limit:** Individual investigators or small groups of 2 to 4 investigators.
- **Limit on Number of Proposals:** One proposal per PI, co-PI or active award participant. Proposals will be returned without review if an individual appears on multiple proposals for this solicitation.

Award Information

- **Anticipated Type of Award:** Standard Grant
- **Estimated Number of Awards:** 8 to 12
- **Anticipated Funding Amount:** $3,000,000 pending availabiity of funds

Proposal Preparation and Submission Instructions

A. Proposal Preparation Instructions

- **Full Proposal Preparation Instructions:** This solicitation contains information that supplements the standard Grant Proposal Guide (GPG) proposal preparation guidelines. Please see the full text of this solicitation for further information.

B. Budgetary Information

- **Cost Sharing Requirements:** Cost Sharing is not required by NSF.
- **Indirect Cost (F&A) Limitations:** Not Applicable.
- **Other Budgetary Limitations:** Not Applicable.

C. Due Dates

- **Full Proposal Deadline Date(s)** (due by 5 p.m. submitter's local time):
  March 01, 2006

Proposal Review Information

- **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:** Additional award conditions apply. Please see the full text of this solicitation for further information.
- **Reporting Requirements:** Standard NSF reporting requirements apply.

TABLE OF CONTENTS

I. INTRODUCTION

This is a solicitation for the continuation of a collaborative research program between the National Science Foundation (NSF) and Sandia National Laboratories (Sandia). Sandia has the responsibility for engineering systems and developing technologies that have profound impact on national security. Engineering systems responsibility includes defining the requirements for a variety of engineered systems, establishing the concepts to meet the requirements, evaluating design options, verifying that a design satisfies the requirements and is fabricatable/manufacturable, manufacturing the system, operating and maintaining the system, and finally dismantling and disposing or recycling of the system. In addition, Sandia is responsible for developing, evaluating, and applying emerging technologies, such as microsystems, to larger engineered systems. With the advent of teraflop-level, massively parallel computers Sandia is becoming more dependent on the synergy between high-fidelity simulation and physical experiments to provide the fundamental understanding of complex engineering phenomena that forms the basis for design, optimization and system qualification.

The NSF mission is to advance the fundamental science and engineering base of the United States, including a commitment to the further development of engineering and manufacturing processes leveraging high-fidelity computer modeling and simulation, and high-fidelity experiments.

The two organizations have entered into a collaborative program to fund research projects that are focused on advancing the fundamental knowledge base needed to support these high-fidelity capabilities for engineering sciences, decision making and manufacturing.

Although significant progress has been made in establishing a leading role for computational simulations in the engineering of systems, additional discovery including better experimental diagnostics, better models of physical phenomena, improved validation of models, multiscale and multiphysics methodologies, methodologies for non-continuum and micro/nanoscale phenomena, improved computational algorithms, and increased emphasis on the treatment of uncertainty are all needed to reach the necessary level of confidence in design, qualification and manufacturing.

Significant advances are required in the fundamental sciences and engineering that form the foundation of all engineering analyses. Sandia and NSF are seeking proposals that address advances in the following focus areas:

- Thermal Transport and Fluid Mechanics
- Solid Mechanics and Structural Dynamics
- Micro/Nanoscale Phenomenology and Metrology
- Predictive Modeling for Manufacturing and Process Optimization
- Micro/Nanomanufacturing Technologies

A growing level of effort at Sandia National Laboratories is being devoted to creating a science-based understanding of micro and nano scale phenomenology as it relates to MEMS and microsystems. Sandia would also like to leverage projects to further educational opportunities for exceptional undergraduate and graduate students. Sandia would like to encourage participation of students in funded research projects and encourage direct collaborations with Sandia staff.

To encourage university interactions in microsystems, Sandia has created the (Microsystems and Engineering Sciences Applications) MESA Institute. It can help to support the labor costs of university faculty and students who come to work on-site with Sandia staff. By working through the MESA Institute with Sandia line organizations, researchers can obtain both supplemental support for project labor costs and access to Sandia's world-class facilities and capabilities in the MEMS area. Projects for which on-site work at Sandia would be beneficial should consider this MESA Institute option as part of their proposal. More information on the MESA Institute can be found at http://www.sandia.gov/MESA-Institute.

Researchers funded under this program may also request access to the Center for Integrated Nanotechnologies (CINT). This user facility is a Department of Energy, Basic Energy Sciences Nanoscale Science Research Center (NSRC) jointly operated by Los Alamos and Sandia National Laboratories. As part of the National nanoscience infrastructure, CINT provides user access to state-of-the-art equipment, facilities and CINT scientific staff for nanoscale science and engineering research through a peer-reviewed competitive process. Information on the capabilities and staff available to prospective CINT users may be found on the CINT web site (http://cint.lanl.gov/).

Other Sandia facilities for collaborative research with Sandia researchers in the areas of microsciences and nanosciences include the Microsystems and Nanotechnology Laboratory (MANTL), situated at Sandia National Laboratories in Livermore CA. Further information on MANTL can be found at http://www.ca.sandia.gov/8700/

Access to CINT, MANTL and MESA are encouraged for relevant work, but are not required for response to this solicitation.

Detailed information of the scope of each of the focus areas is given below.

II. PROGRAM DESCRIPTION

FOCUS AREAS

Proposals may **ONLY** be submitted for the following five (5) focus areas:

1. Thermal Transport and Fluid Mechanics
2. Solid Mechanics and Structural Dynamics
3. Micro/Nanoscale Phenomenology and Metrology
4. Predictive Modeling for Manufacturing and Process Optimization
5. Micro/Nanomanufacturing Technologies

Proposals that are not fully responsive to one of these five (5) focus areas will be returned without review. Therefore, before preparing a proposal, prospective principle investigators are **strongly encouraged** to contact George Hazelrigg (NSF) and Wahid Hermina (Sandia) to assure that their proposed project would be considered responsive to one of these five focus areas. See Section VIII. CONTACTS FOR ADDITIONAL INFORMATION for Dr. Hazelrigg's and Dr. Hermina's email addresses and telephone numbers.

1. Thermal Transport and Fluid Mechanics

This discipline area has, as its focus, the development of advanced constitutive models, experimental and computational capabilities with the objective of enabling validated, predictive scientific simulations for fluid and thermally-dominated

processes. Clearly, fluid and thermal processes play a central role in many engineering applications of importance to Sandia such as in manufacturing and materials processing, power conversion and storage, biological and microelectronic micro-/nano-scale device design and application. This research area extends beyond traditional uncoupled continuum thermal and fluids phenomenology quantification. It also supports improved understanding of non-continuum and reactive processes and is closely tied to the geo-technology (especially single and multiphase reactive transport), and aero-technology (subsonic through hypersonic compressible flows and thermo-physics) focus areas critical to Sandia's mission.

This focus area is particularly interested in proposals that emphasize the development of analytical and computational methods to represent critical fluid/thermal transport phenomena and processes with appropriate resolution, dimensionality, multiphysics and multiscale coupling. Topics suitable for consideration include, but are not limited to research in the areas of:

- transition and turbulence,
- convective heat transfer coupled with moving boundaries,
- participating media radiative heat transfer,
- interfacial phenomena,
- multiphase systems,
- material processing,
- microscale and nanoscale processes and phenomena of importance to the fabrication and performance of microsystems,
- microfluidic devices.

The development and application of advanced spatially and temporally resolved diagnostics and experimental methods, and experiments to better characterize critical transport phenomena and to support the development of analytical and computational methods, are also appropriate.

2. Solid Mechanics and Structural Dynamics

This focus area seeks to improve and expand fundamental computational and material mechanics knowledge in the areas of solid mechanics and structural dynamics. In the area of structural dynamics, methods of treating the nonlinearities associated with energy dissipation in joints and interfaces are needed for systems whose vibrational response is otherwise linear. Advances in nonlinear, large deformation quasistatics and transient dynamics (both explicit and implicit) are also needed. A major area of emphasis is in models for material response and failure. The shift from a test-based to a simulation-based design environment requires accurate, robust and efficient computer codes which model large ranges of loadings, deformation amplitudes and rates, length- (including nano-, micro-, meso-and macro-scales) and multiple time-scale mechanics, and damping of mechanical interfaces and joints. It seeks to develop a basic engineering understanding of numerical solution methods including finite elements, boundary elements, gridless Lagrangian and other methods for challenging simulation problems such as in impact and penetration, thermomechanical aspects of material processing and manufacturing, crack initiation, propagation and arrest, design optimization and uncertainty analysis, including accurate constitutive and/or molecular description of materials. Advanced solution algorithms based upon easy-to-implement meshes, e.g., mesh free or advanced tetrahedral elements, are particularly attractive. Adaptive techniques that automatically improve accuracy are desired. The solution algorithms must be robust, reliable, efficient, and scalable on parallel computing platforms. Carefully designed experimental investigations to validate and otherwise support the above technology areas are also needed.

Another very important issue in the use of computational models to impact design and design qualification is the time it takes to create computational models. It can often take so long to create a computational model for a complex system that the computations are not timely enough to impact design. Therefore, proposals addressing computational model creation issues for complex systems are solicited that cover issues such as improvements in solid geometry technology to defeature geometric models for analysis, methods for detecting and correcting nonphysical attributes in solid models, and improvements in automatic mesh generation, such as hexahedral finite element meshes.

3. Micro/Nanoscale Phenomenology and Metrology

Microscale and nanoscale systems and processes are becoming more viable for use in engineering applications. However, our knowledge of their behavior and our ability to model their performance remains limited. In particular, existing continuum-based computational capabilities are not applicable over the full range of operational conditions. We observe non-continuum behavior in gas dynamic transport, thermal transport and material mechanics as characteristic scales drop towards the micron scale. To support the design and qualification of microscale and future nanoscale systems and processes, we must develop analytical, computational and experimental capabilities that can span the continuum to non-continuum regimes. In the near continuum regimes, we anticipate that we can extend our continuum capabilities through subgrid constitutive models that can capture non-continuum phenomena and that can be integrated into continuum mechanics capabilities. In the non-continuum regimes we anticipate that new formulations of the conservation laws and new constitutive relationships will be required for these capabilities. We seek innovative proposals that enhance our phenomenological understanding and capabilities to compute at the microscale and nanoscale.

Experimentally, we anticipate the need for advanced diagnostics that can provide spatial and temporal resolution with quantifiable uncertainty at the micro and nanoscale, and capabilities that can provide both dimensional and functional metrology at the micro and nanoscale.

4. Predictive Modeling for Manufacturing and Process Optimization

Models that predict the behavior of a system or process are a requisite for essentially all engineering decision making and optimization. And, as all predictions are fraught with uncertainty, valid predictive models are, of necessity, probabilistic models. Current practice, however, is to employ deterministic descriptive models as a basis for prediction, although simple examples illustrate the risks associated with this practice. This task focuses on fundamental research on the theory and application of predictive models in support of manufacturing across product and device size from the nano-scale to the macro-scale. Proposals submitted under this topic area should offer to provide fundamental advances in the underlying mathematics of prediction and their application to manufacturing. Proposals that simply address the modeling of manufacturing systems or processes without accompanying fundamental advances in the mathematics of predictive modeling will not be responsive to this topic.

Proposals submitted to this focus area will likely include multiple PIs, with expertise covering both the relevant mathematics and manufacturing technologies. Accordingly, small team proposals are encouraged. Successful proposals will include advances in predictive modeling of a manufacturing system or process and the application of these advances to manufacturing decision making and optimization across the full range of manufacturing scales. Modeling for process optimization and/or resulting product characteristics at all scales with emphasis at the micro-scale and nano-scale, and manufacturing decision making and optimization under uncertainty and risk.

5. Micro/Nanomanufacturing Technologies

The purpose of this area is to explore innovative ideas relating to manufacturing micro/nano systems that leverage Engineering Sciences phenomenology and nanoscience enabled properties.

We anticipate the development of new engineered systems with pre-designed and controlled features on multiple length scales. For example, the interface plays a critical role in fluid transport, and in the adhesion and tribological properties. Currently, nanoscience has enabled the design and manufacture of nanostructured surfaces and interfaces with precise control of the grain sizes, orientation and the surface chemistry. We envision that such nanostructured surfaces and interfaces will be integrated with microsystems to expand the functionality of engineered systems.

Future advanced engineered systems may also involve revolutionary approaches such as self-assembly for improved efficiency and functionality. Although self-assembly is still at the early stage of development for engineered systems, it has the promise of large scale low cost manufacturing, and has the potential for a whole new generation of engineering systems. We seek to expand our understanding of phenomena pertinent to microscale and nanoscale manufacturing and to develop processes that create engineered systems governed by nanoscience enabled properties.

The preceding topics are not intended to be comprehensive of this focus area. Proposals pertaining to the phenomenology of micro/nano manufacturing will be entertained.

III. ELIGIBILITY INFORMATION

- **Organization Limit:** Colleges, universities and non-profit organizations in the United States.
- **PI Eligibility Limit:** Individual investigators or small groups of 2 to 4 investigators.
- **Limit on Number of Proposals:** 1. One proposal per PI, co-PI or active award participant. Proposals will be returned without review if an individual appears on multiple proposals for this solicitation.

IV. AWARD INFORMATION

Awards may be funded by NSF or Sandia National Laboratories. The NSF awards will be made as standard or continuing grants, funded at a typical annual range of $80,000 to $100,000 per year for individual investigators or up to $133,000 per year for small groups of investigators (two to four). Award duration will be three years. The Sandia awards will be contracts with a duration of three years. NSF and Sandia will determine which organization will fund individual projects. Estimated

program budget, number of awards and award size/duration are subject to availability of funds.

V. PROPOSAL PREPARATION AND SUBMISSION INSTRUCTIONS

A. Proposal Preparation Instructions

Full Proposal Instructions:

Proposals submitted in response to this program announcement/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 pubs@nsf.gov.

A. General Information

Proposals submitted under this solicitation will be reviewed jointly by NSF and Sandia using external merit review via panels. See Section VI, PROPOSAL REVIEW INFORMATION.

B. Project Summary

The first sentence in the Project Summary must identify which of these five (5) focus areas is the topic of the project:

1. Thermal Transport and Fluid Mechanics
2. Solid Mechanics and Structural Dynamics
3. Micro/Nanoscale Phenomenology and Metrology
4. Predictive Modeling for Manufacturing and Process Optimization
5. Micro/Nanomanufacturing Technologies

Proposals that are not fully responsive to one of these five (5) focus areas will be returned without review.

C. Proposal Preparation Instructions

The full proposal must include a separate disclosure authorization page in the supplementary documentation section. This page must state the following:

AUTHORIZATION TO DISCLOSE PROPOSAL AND REVIEW MATERIALS TO SANDIA NATIONAL LABORATORIES:

We acknowledge by submission of this proposal that we understand that the program solicitation "Engineering Sciences for Modeling and Simulation-Based Life-Cycle Engineering and Manufacturing" is a joint initiative of the National Science Foundation and the Sandia National Laboratories, and the submitted proposals and review materials will be shared with the Sandia National Laboratories for the purposes of proposal evaluation. We authorize the National Science Foundation to disclose this proposal and all associated materials and review documents to the Sandia National Laboratories and its representatives for the purpose of evaluation and selection of proposals.

Note that submission of a proposal and consent to disclose are voluntary. However, failure to authorize disclosure will result in ineligibility for an award under this solicitation and return of the proposal without review.

Proposers are reminded to identify the program announcement/solicitation number (05-616) in the program announcement/ solicitation block on the proposal Cover Sheet. Compliance with this requirement is critical to determining the relevant proposal processing guidelines. Failure to submit this information may delay processing.

B. Budgetary Information

Cost Sharing:

Cost sharing is not required by NSF in proposals submitted under this Program Solicitation.

C. Due Dates

Proposals must be submitted by the following date(s):

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

March 01, 2006

D. FastLane Requirements

Proposers are required to prepare and submit all proposals for this announcement/solicitation through the FastLane system. Detailed instructions for proposal 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 announcement/solicitation should be referred to the NSF program staff contact(s) listed in Section VIII of this announcement/solicitation.

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. Proposers are no longer required to provide a paper copy of the signed Proposal Cover Sheet to NSF. Further instructions regarding this process are available on the FastLane Website at: http://www.fastlane.nsf.gov

VI. PROPOSAL REVIEW INFORMATION

A. NSF Proposal Review Process

Reviews of proposals submitted to NSF are solicited from peers with expertise in the substantive area of the proposed research or education project. These reviewers are selected by Program Officers charged with the oversight of the review process. NSF invites the proposer to suggest, at the time of submission, the names of appropriate or inappropriate reviewers. Care is taken to ensure that reviewers have no conflicts with the proposer. Special efforts are made to recruit reviewers from non-academic institutions, minority-serving institutions, or adjacent disciplines to that principally addressed in the proposal.

The National Science Board approved revised criteria for evaluating proposals at its meeting on March 28, 1997 (NSB 97-72). All NSF proposals are evaluated through use of the two merit review criteria. In some instances, however, NSF will employ additional criteria as required to highlight the specific objectives of certain programs and activities.

On July 8, 2002, the NSF Director issued Important Notice 127, Implementation of new Grant Proposal Guide Requirements Related to the Broader Impacts Criterion. This Important Notice reinforces the importance of addressing both criteria in the preparation and review of all proposals submitted to NSF. NSF continues to strengthen its internal processes to ensure that both of the merit review criteria are addressed when making funding decisions.

In an effort to increase compliance with these requirements, the January 2002 issuance of the GPG incorporated revised proposal preparation guidelines relating to the development of the Project Summary and Project Description. Chapter II of the

GPG specifies that Principal Investigators (PIs) must address both merit review criteria in separate statements within the one-page Project Summary. This chapter also reiterates that broader impacts resulting from the proposed project must be addressed in the Project Description and described as an integral part of the narrative.

Effective October 1, 2002, NSF will return without review proposals that do not separately address both merit review criteria within the Project Summary. It is believed that these changes to NSF proposal preparation and processing guidelines will more clearly articulate the importance of broader impacts to NSF-funded projects.

The two National Science Board approved merit review criteria are listed below (see the Grant Proposal Guide Chapter III.A for further information). The criteria include considerations that help define them. These considerations are suggestions and not all will apply to any given proposal. While proposers must address both merit review criteria, reviewers will be asked to address only those considerations that are relevant to the proposal being considered and for which he/she is qualified to make judgments.

What is the intellectual merit of the proposed activity?
How important is the proposed activity to advancing knowledge and understanding within its own field or across different fields? How well qualified is the proposer (individual or team) to conduct the project? (If appropriate, the reviewer will comment on the quality of the prior work.) To what extent does the proposed activity suggest and explore creative and original concepts? How well conceived and organized is the proposed activity? Is there sufficient access to resources?

What are the broader impacts of the proposed activity?
How well does the activity advance discovery and understanding while promoting teaching, training, and learning? How well does the proposed activity broaden the participation of underrepresented groups (e.g., gender, ethnicity, disability, geographic, etc.)? To what extent will it enhance the infrastructure for research and education, such as facilities, instrumentation, networks, and partnerships? Will the results be disseminated broadly to enhance scientific and technological understanding? What may be the benefits of the proposed activity to society?

NSF staff will give careful consideration to the following in making funding decisions:

Integration of Research and Education
One of the principal strategies in support of NSF's goals 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 diversity of learning perspectives.

Integrating Diversity into NSF Programs, Projects, and Activities
Broadening opportunities and enabling the participation of all citizens -- women and men, underrepresented minorities, and persons with disabilities -- 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.

Additional Review Criteria:National Science Board approved criteria apply. In addition, relevance to the mission of Sandia will also be considered.

B. Review Protocol and Associated Customer Service Standard

All proposals are carefully reviewed by at least three other persons outside NSF who are experts in the particular field represented by the proposal. Proposals submitted in response to this announcement/solicitation will be reviewed by 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.

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 Director. In addition, the proposer will receive an explanation of the decision to award or decline funding.

NSF is striving to be able to tell proposers whether their proposals have been declined or recommended for funding within six months. The time interval begins on the closing date of an announcement/solicitation, or the date of proposal receipt,

whichever is later. The interval ends when the Division Director accepts the Program Officer's recommendation.

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 Division 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.A. 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 (NSF-GC-1); * or Federal Demonstration Partnership (FDP) Terms and Conditions * and (5) any announcement or other NSF issuance that may be incorporated by reference in the award letter. Cooperative agreement awards are administered in accordance with NSF Cooperative Agreement Financial and Administrative Terms and Conditions (CA-FATC). Electronic mail notification is the preferred way to transmit NSF awards to organizations that have electronic mail capabilities and have requested such notification from the Division of Grants and Agreements.

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

More comprehensive information on NSF Award Conditions is contained in the NSF *Grant Policy Manual* (GPM) Chapter II, available electronically on the NSF Website at http://www.nsf.gov/publications/pub_summ.jsp?ods_key=gpm. The GPM is also for sale through the Superintendent of Documents, Government Printing Office (GPO), Washington, DC 20402. The telephone number at GPO for subscription information is (202) 512-1800. The GPM may be ordered through the GPO Website at http://www.gpo.gov.

Special Award Conditions:

Awards made under this solicitation may be issued either by the National Science Foundation or by the Sandia National Laboratories. In the event that an award is made by the Sandia National Laboratories, the conditions of the award will be in accordance with the conditions set forth by the Sandia National Laboratories.

C. Reporting Requirements

For all multi-year grants (including both standard and continuing grants), the PI must submit an annual project report to the cognizant Program Officer at least 90 days before the end of the current budget period.

Within 90 days after the expiration of an award, the PI also is required to submit a final project report. Failure to provide final technical reports delays NSF review and processing of pending proposals for the PI and all Co-PIs. 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 FastLane, for preparation and submission of annual and final project reports. This system permits electronic submission and updating of project reports,

including information on project participants (individual and organizational), activities and findings, publications, and other specific products and contributions. PIs will not be required to re-enter information previously provided, either with a proposal or in earlier updates using the electronic system.

VIII. CONTACTS FOR ADDITIONAL INFORMATION

General inquiries regarding this program should be made to:

- George A. Hazelrigg, Group Leader, Directorate for Engineering, Division of Design and Manufacturing Innovation, 550 S, telephone: (703) 292-7068, fax: (703) 292-9056, email: ghazelri@nsf.gov
- Alfonso Ortega, Program Director, Directorate for Engineering, Division of Chemical & Transport Systems, 525 N, telephone: (703) 292-8371, fax: (703) 292-9054, email: aortega@nsf.gov
- Ken P. Chong, Division Director (Acting), Directorate for Engineering, Division of Civil & Mechanical Systems, 545 S, telephone: (703) 292-8360, fax: (703) 292-9053, email: kchong@nsf.gov
- Kevin W. Lyons, Program Director, Directorate for Engineering, Division of Design and Manufacturing Innovation, 510 N, telephone: (703) 292-5365, fax: (703) 292-9056, email: klyons@nsf.gov
- Jian Cao, Program Director, Directorate for Engineering, Division of Design and Manufacturing Innovation, 531, telephone: (703) 292-7088, fax: (703) 292-9056, email: jcao@nsf.gov
- Wahid Hermina, Sandia National Laboratories, telephone: 505-844-4759, email: wlhermi@sandia.gov
- Ken Wilson, Sandia National Laboratories, telephone: 925-294-2497, email: klwilso@sandia.gov
- Peter Wilson, Sandia National Laboratories, telephone: 505-844-7656, email: pjwilso@sandia.gov
- Mark Kiefer, Sandia National Laboratories, telephone: 505-845-7271, email: mlkiefe@sandia.gov

For questions related to the use of FastLane, contact:

- Veronica T. Calvo, Program Technology Specialist, Directorate for Engineering, Division of Design and Manufacturing Innovation, 550 S, telephone: (703) 292-7056, fax: (703) 292-9056, email: vcalvo@nsf.gov

IX. OTHER PROGRAMS OF INTEREST

The NSF *Guide to Programs* is a compilation of funding for research and education in science, mathematics, and engineering. The NSF *Guide to Programs* is available electronically at http://www.nsf.gov/cgi-bin/getpub?gp. General descriptions of NSF programs, research areas, and eligibility information for proposal submission are provided in each chapter.

Many NSF programs offer announcements or solicitations concerning specific proposal requirements. To obtain additional information about these requirements, contact the appropriate NSF program offices. Any changes in NSF's fiscal year programs occurring after press time for the *Guide to Programs* will be announced in the NSF E-Bulletin, which is updated daily on the NSF Website at http://www.nsf.gov/home/ebulletin, and in individual program announcements/solicitations. Subscribers can also sign up for NSF's MyNSF News Service (http://www.nsf.gov/mynsf/) to be notified of new funding opportunities that become available.

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