Program Announcement
To DOE National Laboratories
LAB 07-04

Basic Research
for Advanced Nuclear Energy Systems

SUMMARY: The Office of Basic Energy Sciences (BES) of the Office of Science (SC), U.S. Department of Energy (DOE), in keeping with its mission to strengthen the Nation's scientific research enterprise through the support of fundamental science and the experimental tools to perform basic research, announces its interest in receiving proposals for basic research for Advanced Nuclear Energy Systems. Areas of focus include understanding of nanoscale interactions under extreme conditions, mastering the behavior of actinides and of fission products, solution behavior under extreme conditions of radiation and temperature, and interfacial behavior under extreme environmental conditions. Research funded under this initiative will pursue breakthroughs in scientific understanding that will advance materials design, will improve characterization of materials and processes, will enhance chemical processes under the extreme conditions present in nuclear energy systems, and will extend interdisciplinary theory-modeling-simulation-experimentation methodology to surmount the existing scientific and technical barriers for nuclear energy systems of the future. More information on these focus areas is provided in the SUPPLEMENTARY INFORMATION section below.

DATES: Potential researchers are **REQUIRED** to submit a brief preproposal through appropriate Laboratory channels. Preproposals referencing Program Announcement LAB 07-04 must be received by DOE by 8:00 pm, Eastern Time, **November 22, 2006.** An electronic acknowledgement of preapplications receipt will be sent to all preapplicants by December 4, 2006. If you receive no such acknowledgement, contact us after that date through nuclear@science.doe.gov. Preproposals will be reviewed for conformance with the guidelines presented in this notice and suitability in the technical areas specified in this notice. A response to the preproposals encouraging or discouraging formal proposals will be communicated to the applicants by January 4, 2007. **Complete guidance on the content and format of the preproposal is provided in the SUPPLEMENTARY INFORMATION section below.**

Only those researchers that receive notification from DOE encouraging a formal proposal may submit a full proposal. **No other formal proposals will be considered.** Formal proposals in response to this notice must be received by **March 14, 2007, 8:00 pm Eastern Time.**

NUMBER OF PREPROPOSALS: Each Federally Funded Research and Development Center (FFRDC) may submit up to four preproposals as lead institution. The first four preproposals received from an FFRDC as lead institution will be considered to be that institution's official submission. BES reserves the right to encourage, in whole or in part, any, all, or none of the preproposals submitted, and may issue further guidance on the scope of the full proposal submissions of those encouraged.

ADDRESSES: Preproposals referencing Program Announcement LAB 07-04 should be sent as PDF file attachments via e-mail to: nuclear@science.doe.gov with Subject line specifying "Program Announcement LAB 07-04" and the primary submission category, i.e., "Understanding nanoscale interactions under extreme conditions," "Mastering the behavior of actinides and fission products," "Solution behavior under extreme conditions of radiation and temperature," or "Interfacial behavior under extreme environmental conditions." No FAX or mail submission of preproposals will be accepted.

FORMAL PROPOSALS: Refer to Full Proposals section under SUPPLEMENTARY INFORMATION below.

This section pertains only to those proposers who have been encouraged to submit a full proposal. A complete formal FWP in a single Portable Document Format (PDF) file must be submitted through the DOE ePMA system (https://epma.doe.gov) as an attachment. The formal application should follow the preapplication with regard to scope and budget to the fullest extent possible. To identify that the FWP is responding to this program announcement, please fill in the following fields in the "ePMA Create Proposal Admin Information" screen as shown:

Proposal Short Name:
Fiscal Year:
Proposal Reason:
Program Announcement Number: LAB 07-04 *
Program announcement Title: Basic Research for Advanced Nuclear Energy Systems, DOE Research Program Announcement * **Proposal Purpose:**
Estimated Proposal Begin Date:
HQ Program Manager Organization:

* Please use the wording shown when filling in these fields to identify that the FWP is responding to this Program Announcement.

For Further Information Contact: Dr. Lester Morss, Chemical Sciences, Geosciences and Biosciences Division, SC-22.1, telephone: 301-903-9311, e-mail: lester.morss@science.doe.gov or Dr. Tim Fitzsimmons, Materials Sciences and Engineering Division, SC-22.2, telephone: 301-903-9830, e-mail: tim.fitzsimmons@science.doe.gov.

SUPPLEMENTARY INFORMATION: A workshop was held July 31-August 3, 2006 by the Office of Basic Energy Sciences (BES) to identify basic research needs for advanced nuclear energy systems. The workshop report, entitled *Basic Research Needs for Advanced Nuclear Energy Systems* http://www.science.doe.gov/bes/reports/files/ANES_rpt.pdf, detailed scientific grand challenges and a broad array of priority research directions. These challenges depicted the gap between present-day scientific knowledge/technology capabilities and what would be required for the practical realization of advanced closed-cycle nuclear reactors. The workshop report is a current source of information and summarizes the interests of the BES.

This Notice solicits innovative basic research proposals to significantly strengthen the scientific basis that will allow comprehensive understanding of the physical and chemical processes that

lead to reliable, affordable and clean nuclear energy, in a safe as well as economically and environmentally sustainable manner. We seek to support outstanding fundamental research programs potentially leading to discoveries and breakthroughs, focused on these broad areas:

(1) Understanding nanoscale interactions under extreme conditions
(2) Mastering the behavior of actinides and of fission products
(3) Solution behavior under extreme conditions of radiation and temperature (4) Interfacial behavior under extreme environmental conditions

The following topics exemplify, but do not provide an exclusive listing of, areas where advances in fundamental understanding are required.

1. Understanding nanoscale interactions under extreme conditions

Nanoscale design of materials and interfaces that radically extend performance limits in extreme radiation environments

Understanding the interaction of defects with nanostructures, and controlling defect behavior, can facilitate the design of materials and interfaces that mitigate radiation damage. New research is needed in the design and synthesis of tailored nanostructured materials. Nanoscale characterization and time-resolved study of interactions are needed to control behavior such as defect production and trapping under extreme conditions.

Developing and verifying a first-principles, multiscale description of properties in complex materials under extreme conditions

The predictive understanding of microstructural evolution and property changes under extreme conditions is essential for the design of structural materials, nuclear fuels, and wasteforms. A first-principles understanding of the relationship of defect properties and microstructural evolution to mechanical behavior and phase stability must be developed. This will require a closely coupled approach of *in situ* studies of nanoscale and mechanical behavior with multiscale theory.

2. Mastering the behavior of actinides and fission products

Behavior of actinide-bearing materials

A robust theory of the electronic structure of actinides will provide an improved understanding of their physical and chemical properties and behavior, leading to opportunities for advances in fuels and waste forms. Advances are needed in the application of new electronic structure methods for f-element-containing molecules and solids to calculate the properties of defects in multi-component systems, and in the fundamental understanding of related chemical and physical properties at high temperature. Advances in basic science of 4f- and 5f-electron systems in solutions will extend understanding of reaction chemistry in order to improve separations technologies.

Understanding and designing new molecular systems to gain unprecedented control of chemical selectivity during reprocessing

Innovations in chemical selectivity in multicomponent separations matrices require the design, synthesis, and optimization of molecular systems to trap and release target molecules and ions efficiently and economically. The bonding, reactivity, and mechanisms of molecular and nanophase separations systems must be modeled by computation and characterized by macroscopic thermodynamic and kinetics measurements and by microscopic techniques such as electronic and X-ray spectroscopy.

Mastering actinide and fission product chemistry under all conditions

A more accurate understanding of the electronic structure of the complexes of actinide and fission products will expand our ability to predict their behavior quantitatively under conditions relevant to all stages in fuel reprocessing (separations, dissolution, and stabilization of waste forms) and in new media that are proposed for advanced processing systems. This knowledge must be supplemented by accurate prediction and manipulation of solvent properties and chemical reactivities in nontraditional separation systems such as modern "tunable" solvent systems. This will require quantitative, fundamental understanding of the mechanisms of solvent tunability, the factors limiting control over solvent properties, the forces driving chemical speciation, and modes of controlling reactions.

Exploiting organization to achieve selectivity at multiple length scales

Harnessing the complexity of organization that occurs at the mesoscale in solution will lead to new separation systems that provide for greatly increased selectivity in recovery of target species and reduce formation of secondary waste streams through ligand degradation. Research directions include design of ligands and other selectivity agents, expanding the range of selection/release mechanisms, fundamental understanding of phase phenomena and self-assembly in separations, and aqueous separations systems.

Understanding fundamental thermodynamics and kinetic processes in multi-component systems

The behavior of the minor actinides is a significant challenge that requires a fundamental understanding of the thermodynamics, transport, and chemical behavior of complex materials. Global thermochemical models of complex phases that are informed by ab initio calculations of materials properties and high-throughput predictive models of complex transport and phase segregation will be required for full fuel fabrication calculations. These models, when coupled with appropriate experimental efforts, will lead to significantly improved fuel performance by creating novel tailored fuel forms.

3. Solution behavior under extreme conditions of radiation and temperature

Fundamental effects of radiation and radiolysis in chemical processes

The reprocessing of nuclear fuel and the storage of nuclear waste present an environment that includes substantial radiation fields. A predictive understanding of the chemical processes resulting from intense radiation, high temperatures, and extremes of acidity and redox potential on chemical speciation is required to enhance efficient, targeted separations processes and effective storage of nuclear waste. In particular, the effect of radiation on the chemistries of ligands, ionic liquids, polymers, and molten salts is poorly understood. There is a need for an improved understanding of the fundamental processes that affect the formation of radicals and ultimately control the accumulation of radiation-induced damage to separation systems.

4. Interfacial behavior under extreme environmental conditions

Exploiting organization to achieve selectivity at multiple length scales

Control of mesoscale complexity in solution or at interfaces will lead to new separation systems that provide for greatly increased selectivity in recovery of target species and reduce formation of secondary waste streams through ligand degradation. Research directions include design of ligands and other selectivity agents, expanding the range of selection/release mechanisms, fundamental understanding of phase phenomena and self-assembly in separations, and aqueous separations systems.

Adaptive material-environment interfaces for extreme conditions

Revolutionary advances in the understanding of interfacial behavior through new modeling and *in situ* experimental techniques are needed to support the control of interfaces that can provide dynamic stability over a wide range of conditions and with much greater "self-healing" capabilities. Achieving the necessary scientific advances will require moving beyond interfacial chemistry and physics in ultra high vacuum environments to the development of *in situ* techniques to monitor the processes at fluid/solid and solid/solid interfaces under conditions of high pressure and temperature, and harsh environments.

Predictive multiscale modeling of materials and chemical phenomena in multi-component systems under extreme conditions

The advent of large-scale simulations will significantly enhance the prospect of probing important molecular-level mechanisms underlying the macroscopic phenomena of solution and interfacial behavior in actinide-bearing systems and structural components, performance and failure under extreme conditions. There is an urgent need to develop multiscale algorithms capable of efficiently treating systems whose time evolution is controlled by activated processes and rare events.

The workshop report provides further information under each of the focus areas to illustrate the scope of proposals that are solicited under this Notice. In particular, section II of the workshop describes scientific grand challenges and section IV lists priority research directions and scientific challenges.

Program Funding

It is anticipated that up to $8 million annually starting in Fiscal Year 2007 (subject to appropriations) will be available for multiple awards for this notice. Proposers may request project support for up to three years. All awards are contingent on the availability of funds and programmatic needs.

Preproposals

Each FFRDC may submit up to four preproposals as lead institution. The preproposals should consist of a description of the research proposed to be undertaken by the proposer and a clear explanation of its importance to the advancement of basic research for advanced nuclear energy systems. The preproposals must be submitted electronically to nuclear@science.doe.gov as two files: <P<

(1) A cover page in Excel format downloadable from: http://www.science.doe.gov/bes/nuclear_preapp_cover.xls. The information to be entered on the cover page worksheet includes: Program Announcement Number; Lead Principal Investigator name, address, email address, telephone number, and fax number; project title; selection of one submission category (see below); budget request for each project year; total budget request for the project; and the names and institutions of all co-Principal Investigators and/or senior collaborators (excluding postdoctoral associates and graduate students). Do not alter the overall format of the cover- page Excel file, i.e., do not move or merge cells, as this will significantly slow the processing of the preproposal.

(2) A PDF file containing a narrative section not to exceed 3 pages (including text, minimum font size 10, references, and figures) describing the research objectives, approaches to be taken, the institutional setting, and a description of any research partnership if applicable. In addition, include a brief, one-page, curriculum vita from each Principal Investigator.

As noted above, the preapplication must also identify the primary submission topic:

(1) Understanding nanoscale interactions under extreme conditions
(2) Mastering the behavior of actinides and fission products
(3) Solution behavior under extreme conditions of radiation and temperature (4) Interfacial behavior under extreme environmental conditions

The purpose of this self-identification into a research topic is primarily for the purposes of grouping similar applications for peer review.

Full Proposals

The Department of Energy will accept Full Proposals by invitation only, based upon the evaluation of the preproposals. After receiving notification from DOE concerning successful preproposals, researchers may prepare formal proposals. DOE is under no obligation to pay for any costs associated with the preparation or submission of proposals.

Full proposals adhering to DOE Field Work Proposal format are to be prepared and submitted consistent with policies of the investigator's laboratory and the local DOE Operations Office.

The instructions and format described below should be closely followed. Laboratories must submit proposals directly to the SC Program Office listed below under "2. How to Submit". A copy should also be provided to the appropriate DOE Operations Office. Program Announcement LAB 07-04 must be referenced on all submissions and inquiries about this program.

OFFICE OF SCIENCE
GUIDE FOR PREPARATION OF SCIENTIFIC/TECHNICAL PROPOSALS TO BE SUBMITTED BY NATIONAL LABORATORIES

Proposals from National Laboratories submitted to SC as a result of this program announcement will follow the Department of Energy Field Work Proposal process with additional information requested to allow for scientific/technical merit review. The following guidelines for content and format are intended to facilitate an understanding of the requirements necessary for SC to conduct a merit review of a proposal. Please follow the guidelines carefully, as deviations could be cause for declination of a proposal without merit review.

1. Evaluation Criteria

Proposals will be subjected to formal merit review (peer review) and will be evaluated against the following evaluation criteria listed below in descending order of importance.

Scientific and/or technical merit of the project;
Appropriateness of the proposed method or approach;
Competency of the personnel and adequacy of the proposed resources;
Reasonableness and appropriateness of the proposed budget;

Basic research that is relevant to advanced nuclear energy systems The external peer reviewers are selected with regard to both their scientific expertise and the absence of conflict-of-interest issues. Federal and Non-federal reviewers may be used, and submission of a proposal constitutes agreement that this is acceptable to the investigator(s) and the submitting institution.

2. How to Submit

The deadline for receipt of formal proposals refers to receipt of the proposal by BES. For DOE national laboratories, a complete FWP in a single Portable Document Format (PDF) file also must be submitted through the DOE ePMA system (https://epma.doe.gov) as an attached file. To identify that the FWP is responding to this program announcement, please fill in the following fields in the "ePMA Create Proposal Admin Information" screen as shown:

Proposal Short Name:
Fiscal Year:
Proposal Reason:
Program Announcement Number: LAB 07-04 *
Program announcement Title: Basic Research for Advanced Nuclear Energy Systems, DOE Research Program Announcement * **Proposal Purpose:**
Estimated Proposal Begin Date:
HQ Program Manager Organization:

* Please use the wording shown when filling in these fields to identify that the FWP is responding to this Program Announcement.

In order to expedite the review process, please submit a CD and two copies of the proposal using the following address, by U.S. Postal Service Express Mail, a commercial mail delivery service, or when hand-carried to:

U.S. Department of Energy
Office of Science
Office of Basic Energy Sciences, SC-22
19901 Germantown Road
Germantown, MD 20874-1290
ATTN: Program Announcement LAB 07-04

3. Proposal Contents

Summary

3.1 Field Work Proposal (FWP) Format (Reference DOE O 412.1A) (DOE ONLY)
3.2 Proposal Cover Page
3.3 Proposal Abstract
3.4 Table of Contents
3.5 Management Plan

Sections 3.6-3.13 are to be completed for each subtask in the proposal.
Up to 4 tightly integrated subtasks are allowed in each proposal.
Multiple subtasks should be presented as follows:
First Subtask: Sections 3.6.1, 3.7.1,..., 3.12.1, 3.13.1
Second Subtask: Sections 3.6.2, 3.7.2, ..., 3.12.2, 3.13.2 .....

3.6 Subtask Title and Abstract
3.7 Budget and Budget Explanation
3.8 Narrative
3.9 Literature Cited
3.10 Other Support of Investigators and Collaborations
3.11 Biographical Sketches

3.12 Description of Facilities and Resources
3.13 Appendix (All appended material must be separate from the proposal, e.g., in electronic folders containing multiple PDF files of publications.)

Detailed Contents of the Proposal

Proposals must be readily legible, when printed and must conform to the following requirements: the height of the letters must be no smaller than 10 point with at least 2 points of spacing between lines (leading); the type density must average no more than 17 characters per inch; the margins must be at least one-half inch on all sides. Figures, charts, tables, figure legends, etc., may include type smaller than these requirements so long as they are still fully legible.

Number pages consecutively at the bottom of each page throughout the document. Start each major section at the top of a new page with the section number and title, for example, "2.0 Table of Contents." Do not use unnumbered pages.

3.1 Field Work Proposal Format (Reference DOE O 412.1A) (DOE ONLY)

The Field Work Proposal (FWP) is to be prepared and submitted consistent with policies of the investigator's laboratory and the local DOE Operations Office. The format described below should be closely followed. Additional information is also requested to allow for scientific/technical merit review.

Laboratories may submit proposals directly to the SC Program office listed above. A copy should also be provided to the appropriate DOE operations office.

3.2 Proposal Cover Page (No special form is required.)

Title of proposed project
FWP Number(s) corresponding to the proposed project (if available for new proposals)
BES Program announcement title: Basic Research for Advanced Nuclear Energy Systems
Name of laboratory
Name of principal investigator (PI) (one Lead PI only)
Position title of PI
Mailing address of PI
Telephone of PI
Fax number of PI
Electronic mail address of PI
Name of official signing for laboratory*
Title of official
Fax number of official
Telephone of official

Electronic mail address of official
Requested funding for each year; total request

If other institutions are participating in the project, include a table listing institutions, lead investigator at each institution, and requested funding for each institution at this point on the cover page. Collaborations in which the lead institution is an FFRDC and other institutions are FFRDCs or academic institutions are acceptable. For further information contact one of the persons listed above.

Use of human subjects in proposed project:

If activities involving human subjects are not planned at any time during the proposed project period, state "No"; otherwise state "Yes", provide the IRB Approval date and Assurance of Compliance Number and include all necessary information with the proposal should human subjects be involved.

Use of vertebrate animals in proposed project:

If activities involving vertebrate animals are not planned at any time during this project, state "No"; otherwise state "Yes" and provide the IACUC Approval date and Animal Welfare Assurance number from NIH and include all necessary information with the proposal.

Signature of PI, date of signature
Signature of official, date of signature*

*The signature certifies that personnel and facilities are available as stated in the proposal, if the project is funded.

3.3 Proposal Abstract

Provide an abstract to convey an overall vision and the long-term goals and objectives of the proposed research. Describe what the specific research proposed is intended to accomplish, the approach to be taken, and the integration and synergy of the various subtasks. Discuss the potential scientific impact and significance of the proposed research. Indicate how the proposed research addresses the scientific/technical areas specifically described in the call. The maximum length for the abstract is one page.

Proposals must contain one paragraph addressing how the proposed research will address one or more of the four BES long-term program measures used by the Office of Management and Budget to rate the BES program annually; these measures may be found at http://www.science.doe.gov/bes/BES_PART_Performance_Measures.pdf.

3.4 Table of Contents

Provide the initial page number for each of the sections of the proposal.

3.5 Management Plan

The plan, up to 5 pages, needs to describe the overall strategy in developing and managing the proposed research program. Describe the overarching scientific goals that

link the groups and researchers together. Include an overview of the functions and responsibilities of key personnel and the relationships among the subtasks. Clearly illustrate the integration, synergy, and coordination among the subtasks.

Describe any distinguishing strengths of conducting this particular research at your DOE laboratory, such as the synergisms among the investigators of a large interdisciplinary team; the ability to utilize unique DOE facilities at the laboratory; the benefits of collocation with researchers from other DOE programs; the ability to rapidly reconfigure your research thrust to respond to new challenges; and your successes at working with other research performers on transferring results to targeted research and development. Cite specific examples to illustrate such distinguishing strengths.

As appropriate for the research described in the proposal, describe the role of any advisory committee, executive committee, program committee, or their equivalent. Identify any plans for administering educational programs and outreach activities associated with the proposed research. Plans for administering shared facilities should be described under Section 3.12, Description of Facilities and Resources.

If the proposal consists of multiple subtasks, an overall budget summary should be provided here, which is the sum of the individual budgets for each subtask (see Section 3.7 for details)

Sections 3.6-3.13 are to be completed for each subtask in the proposal.
Up to 4 tightly coordinated subtasks are allowed in a proposal.
Multiple subtasks should be presented as follows:
First Subtask: Sections 3.6.1, 3.7.1,..., 3.12.1, 3.13.1
Second Subtask: Sections 3.6.2, 3.7.2, ..., 3.12.2, 3.13.2 ...

3.6 Subtask Title and Abstract

Provide an abstract for the subtask that is no more than 250 words. No more than 4 subtasks are allowed in the proposal. Give the broad, long-term objectives and what the specific research proposed is intended to accomplish. Indicate how the proposed research addresses the BES scientific/technical area specifically described in the announcement.

3.7 Budget and Budget Explanation

A budget, conforming to the guidelines given below, is required for the entire project period, which normally will be three years, and for each Fiscal Year. You optionally may utilize DOE's budget page, Form 4620.1, for providing the equivalent budget information (Form 4620.1 is available at the following web site: http://www.science.doe.gov/grants/budgetform.pdf). Modifications of this form are permissible to comply with institutional practices. A written justification of each subtask is to follow the budget pages. For personnel, this should take the form of a one-sentence

statement of the role of the person in the project. Provide a justification of the need for each item of permanent equipment. Budgets should include an estimate for travel to one contractors' meeting each year. Budgets should also be provided for each research partner from a different institution who is funded under the FWP. Any other significant support received should be shown in
Section 3.10.

Total Budget and Level of Effort: Provide the total budget for the project, not counting equipment requests. List the names of the principal investigator and other key personnel and the estimated number of person-months or percentage of time for which DOE funding is requested. Proposers should list the number of postdoctoral associates and other professional positions included in the proposed work and indicate the number of full-time-equivalent (FTE) person-months. For graduate and undergraduate students and all other personnel categories such as secretarial, clerical, technical, etc., show the total number of people needed in each job title and their level of effort. The budget explanation should define concisely the role of each position in the overall project.

Equipment: Provide the total equipment budget requested. DOE defines equipment as "an item of tangible personal property that has a useful life of more than two years and an acquisition cost of $25,000 or more." Special purpose equipment means equipment that is used only for research, scientific or other technical activities. Items of needed equipment should be individually listed by description and estimated cost, including tax, and adequately justified. Allowable items ordinarily will be limited to scientific equipment that is not already available for the conduct of the work.

3.8 Narrative

The narrative comprises the research plan for the FWP subtask. Each proposal is allowed up to four tightly coordinated subtasks. The narrative for each subtask should not exceed 15 pages. The majority of the narrative should address the *Proposed Work*. At the beginning of each subtask section, name the senior personnel who will participate, and state the proposed number of postdoctoral and undergraduate and graduate student participants. The narrative should contain the following subsections:

***Background and Significance*:** Briefly sketch the background leading to the present proposal, critically evaluate existing knowledge, and specifically identify the gaps that the project is intended to fill. State concisely the importance of the research described in the proposal. Explain the relevance of the project to the research needs identified by BES. The section must also contain one paragraph addressing how the proposed research will address one or more of the four BES long-term program measures used by the Office of Management and Budget to rate the BES program annually; these measures may be found at http://www.science.doe.gov/bes/BES_PART_Performance_Measures.pdf. Describe the role and intellectual contribution of each senior researcher in the

subtask, and briefly outline the resources available or planned to accomplish the research goals. The need for a collaborative/laboratory approach involving several investigators and the means of achieving this should be clearly established. Include references to relevant published literature, both to work of the investigators and to work done by other researchers.

***Preliminary Studies (Optional)*:** Use this section to provide an account of any preliminary studies that may be pertinent to the proposal. Include any other information that will help to establish the experience and competence of the investigators to pursue the proposed project. References to appropriate publications and manuscripts submitted or accepted for publication may be included. Copies of such publications or manuscripts may be included in the Appendix (Section 3.13).

***Proposed Work*:** This section should constitute the major portion of the narrative, and should reflect a well-integrated vision for the project. A clear statement of the work to be undertaken is needed and must include: objectives for the period of the proposed work and expected significance; relation to longer-term goals of the project; and relation to the present state of knowledge in the field, to work in progress by the PIs under other support and to work in progress elsewhere. The Proposed Work should outline the general plan of the proposed work, including the broad design of activities to be undertaken, and, where appropriate, provide a clear description of experimental methods and procedures needed to accomplish the Proposed Work. In addition, it should describe new techniques and methodologies and explain their advantages over what currently exists.

***Subcontract or Consortium Arrangements*:** If any portion of the project is to be done in collaboration with another institution listed on the cover page or subsequent pages, provide information on the institution and why it is to do the specific component of the project. Further information on any such arrangements is to be given in the sections "Budget and Budget Explanation," "Biographical Sketches," and "Description of Facilities and Resources."

3.9 Literature Cited

List all references cited in the narrative, including titles. Limit citations to current literature relevant to the proposed research. Information about each reference should be sufficient for it to be located by a reviewer of the proposal.

3.10 Other Support of Investigators and Collaborations

Other support is defined as all financial resources, whether Federal, non-Federal, commercial or institutional, available in direct support of an individual's research endeavors. Information on significant levels of active and pending other support is required for all personnel, including investigators at collaborating institutions to be funded by a subcontract. For each item of other support, give the organization or agency,

inclusive dates of the project or proposed project, annual funding, level of effort devoted to the project, and a one paragraph scope statement for each such project.

Describe any proposed interactions and collaborations with other institutions and sectors, such as universities, other national laboratories, and industrial institutions. Define the goals of the collaboration, and describe the planned activities. Describe the roles of the senior participants, the mechanisms planned to stimulate and facilitate knowledge transfer, and the potential long- term impact of the collaborations.

3.11 Biographical Sketches

This information is required for each senior personnel at the laboratory submitting the proposal and at all subcontracting institutions. Provide concise vitae, listing professional and academic essentials and complete contact information. List up to ten publications most pertinent to the research. Reference to the information already provided in Section 3.9 may be appropriate. This portion of the biographical sketches is limited to a maximum of two pages for each investigator.

Each biographical sketch should also include the following information on collaborators and other affiliations to help identify potential conflicts or bias in the selection of reviewers:

> ***Collaborators*:** A list of all persons in alphabetical order (including their current organizational affiliations) who are currently or who have been collaborators or co-authors with the individual on a project, book, article, report, abstract or paper during the 48 months preceding the submission of this proposal. Include collaborators on this proposal. If there are no collaborators, this should be so indicated.
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> ***Graduate and Postdoctoral Advisors*:** A list of the names of the individual's own graduate advisor(s) and principal postdoctoral sponsor(s), and their current organizational affiliations.
>
> ***Thesis Advisor and Postgraduate-Scholar Sponsor*:** A list of all persons (including their organizational affiliations), over the last five years with whom the individual has had an association as thesis advisor or postgraduate-scholar sponsor. The total number of graduate students advised and postdoctoral scholars sponsored also must be identified.

3.12 Description of Facilities and Resources

Describe briefly the facilities to be used for the conduct of the proposed research. Indicate the performance sites and describe pertinent capabilities, including support facilities (such as machine shops) that will be used during the project. List the most important equipment items already available for the project and their pertinent capabilities. Include this information for each subcontracting institution, if any. Describe

any shared facilities and infrastructure to be established, including specific major instrumentation, and plans for the development of instrumentation. Describe plans for maintaining and operating new facilities, including staffing, and plans for ensuring access to outside users. Distinguish clearly between existing facilities and those still to be acquired or developed.

3.13 Appendix

All appended material must be submitted as separate PDF files from the proposal PDF file, e.g., in electronic folders containing multiple PDF files of publications. However, reviewers are not required to consider information in the Appendix. Do not use the appendix to circumvent the page limitations of the proposal. Reviewers may not have time to read extensive appendix materials with the same care as they will read the proposal proper. Only information that may not be easily accessible to a reviewer should be included, such as publications in print or manuscripts accepted for publication. The appendix may also include letters from investigators at other institutions stating their agreement to *participate* in the project. Do not include letters of endorsement of the project.