

**National Aeronautics and
Space Administration**

September 16, 1999

NRA-99-OES-07

RESEARCH ANNOUNCEMENT

**ADVANCED TECHNOLOGY INITIATIVES PROGRAM
CORE INSTRUMENT TECHNOLOGY**

**Letters of Intent due October 15, 1999
Proposals due November 1, 1999**

OMB Approval No. 2700-0087

**ADVANCED TECHNOLOGY INITIATIVES
PROGRAM
CORE INSTRUMENT TECHNOLOGY**

**NASA Research Announcement
Soliciting Research Proposals
For
Period Ending
November 1, 1999**

**NRA 99-OES-07
Issued September 16, 1999**

**Office of Earth Science
National Aeronautics and Space Administration
Washington, DC 20546**

**EARTH SCIENCE ENTERPRISE
ADVANCED TECHNOLOGY INITIATIVES PROGRAM (ATIP)
CORE INSTRUMENT TECHNOLOGY**

The National Aeronautics and Space Administration (NASA) announces the solicitation of proposals for a new technology development program in support of the Earth Science Enterprise (ESE). The Advanced Technology Initiatives Program (ATIP) seeks proposals for core component and subsystem technology developments that support the ESE science research.

I. Introduction

Office of Earth Science

(a) Objectives

NASA's ESE is studying how our global environment is changing. Using the unique perspective available from space and airborne platforms, NASA is observing, documenting, and assessing large-scale environmental processes, with emphasis on:

- Biology and biogeochemistry of ecosystems and the global carbon cycle
- Global water and energy cycle
- Climate variability and prediction
- Atmospheric chemistry
- Solid Earth and natural hazards

In addition, NASA is carrying out studies of the solid earth related to the monitoring and prediction of natural hazards in order to minimize the loss of human life and mitigate property damage. ESE satellite data, complemented by aircraft and ground data, are enabling us to better understand environmental changes, to determine how human activities may have contributed to these changes and to understand the consequences of such changes.

A major objective of the ESE space flight program is to implement the program with small and affordable spacecraft leading to greater program flexibility. A major part of this enabling process is the rapid development of small, low cost remote sensing instruments.

The ESE program is and will continue to operate in a restrictive budget environment for the foreseeable future. It is anticipated that commercial rather than custom spacecraft will be used for many missions. These commercial spacecraft will only support smaller payloads. Large, expensive scientific instruments are not affordable in this new environment. Technological innovation in reducing the size, mass and/or power requirements for the current instruments and development of future remote sensing instruments are essential to the future success of ESE.

(b) Advanced Technology Initiatives Program

Objectives

The objective of the ATIP is to develop and demonstrate component and subsystem technologies which:

- reduce the risk, cost, size, and development time of three areas of importance to the Earth Science Enterprise:
 1. Earth observing instruments
 2. platforms and
 3. information systems
- enable new Earth observation measurements.

This NRA concerns itself only with Item 1, Earth observing instruments, limited to space-borne and airborne remote sensing measurements.

Description

The ATIP is designed to bring instrument, platform and information system components and subsystems to a demonstrated technology readiness level in order to allow integration into an on-going technology development program, such as the Instrument Incubator Program (IIP), the New Millennium Program (NMP), or directly into other programs for infusion into an instrument design. This is consistent with a successful science Announcement of Opportunity (AO) competition in a three year development environment.

Critical to this design is the relationship between the various technology development programs that the ESE has available to enable missions. Within this development environment, the ATIP will rely heavily upon the Instrument Incubator Program (IIP) and the New Millennium Program (NMP) for instrument, information systems and platform technology development and space flight validation. Technology Readiness Levels (TRLs) are a systematic metric/measurement system that supports assessments of the maturity of a particular technology and the consistent comparison of maturity between different types of technology. The listing below summarizes the technology development requirements for TRL levels 1 through 9. Appendix F contains additional discussion on this topic.

Technology Readiness Levels Summary

TRL 1 Basic principles observed and reported

TRL 2 Technology concept and/or application formulated

- TRL 3** Analytical and experimental critical function and/or characteristic proof-of-concept
- TRL 4** Component and/or breadboard validation in laboratory environment
- TRL 5** Component and/or breadboard validation in relevant environment
- TRL 6** System/subsystem model or prototype demonstration in a relevant environment (ground or space)
- TRL 7** System prototype demonstration in a space environment
- TRL 8** Actual system completed and “flight qualified” through test and demonstration (ground or space)
- TRL 9** Actual system “flight proven” through successful mission operations

Figure 1 shows the range of technology readiness level (TRL, see Appendix F for TRL definitions) for each of these programs and future science missions.

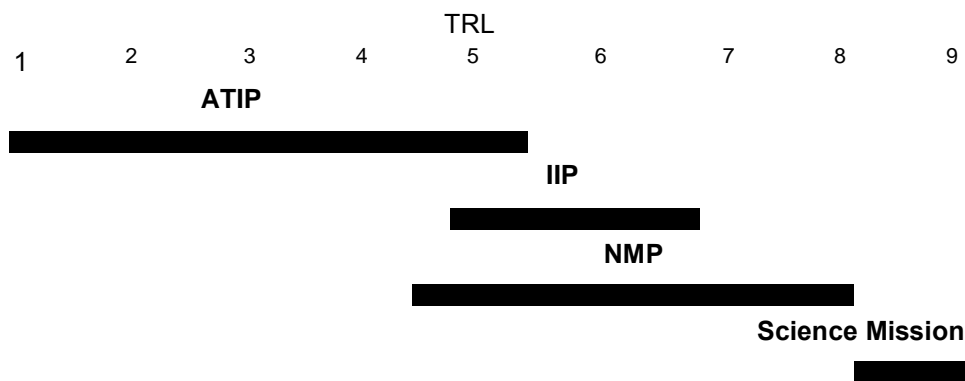


Figure 1

The ATIP is envisioned to be flexible enough to accept technology developments at various stages of maturity, and through appropriate risk reduction activities (such as requirements analysis, conceptual design, laboratory breadboards and pre-engineering models), advance the TRL of the component or subsystem.

II. NASA Research Announcement:

(a) Goals

This NASA Research Announcement solicits a range of proposals for instrument component and subsystem technology developments that have the highest potential to meet the goals of the ATIP and the measurement capability requirements of ESE. Included in this range are requirements analyses, laboratory development and demonstration, and breadboard and/or pre-engineering model construction for instrument component and subsystem technologies. Information systems and platform technologies will be solicited in a later announcement.

(b) Proposal Research Topics

This NRA solicits three classes of instrument component and subsystem development activities:

1. innovative component and subsystem developments that enable new measurement implementations and science investigations,
2. component and subsystem developments that improve current implementations in order to reduce life cycle cost and development risk, and
3. development of selected technologies that advance the state-of-the-art in the selected domain and that have the potential to impact a broad set of future missions which are relevant to ESE strategy.

The ESE has adopted an integrated planning process with the goal of ensuring effective use of NASA resources for technology development. In this process, system capability drivers are derived directly from the ESE fundamental and applied research priorities. Priorities for technology development are then generated through trade and system studies that compare the relative merits of different implementation options in terms of life-cycle cost reduction and improved or enabled capability to perform priority science investigations. Figure 2 depicts a schematic of this process. The focus of this NRA is the element entitled Technology Developments.

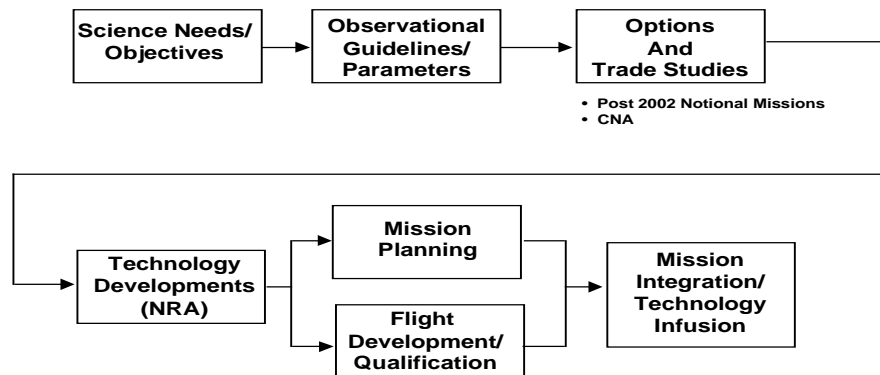


Figure 2

Within this requirements-driven framework, the objective of this NRA is to fund development activities that will assist the ESE in development of an investment portfolio that will reduce the risk, cost, and development time of Earth observing instruments or enable new Earth observation measurements.

To guide the development of ESE scientific mid-term missions (i.e., missions to be conducted in the 2003-2010 timeframe), the ESE conducted a Request for Information

(RFI) on Concepts for Science and Applications Missions in the Post-2002 Era (available on the World Wide Web (WWW) at <http://www.hq.nasa.gov/office/ese/nra/RFIdodge/index.html>). With this RFI, the ESE began the implementation of the new paradigm for mission planning which calls for selection of science missions if and only if required technologies are mature and available. Using the information from the RFI response, the ESE has formulated a nominal flight mission profile that will guide Earth Science Enterprise technology program to support implementation of its scientific missions beyond the current series of EOS satellites. This nominal multi-mission profile for Earth observation satellite missions in the 2003-2010 time frame was based on the results of a science and applications workshop at Easton, MD. The results of the workshop are available on the WWW at <http://www.hq.nasa.gov/office/ese/nra/RFIdodge/Panelrev.html>.

The Earth Science Technology Office (ESTO) developed a technology Capability/Needs Assessment (CNA) that captures the key technologies required to support ESE scientific objectives in mid- to long-term. The assessment relates ESE science disciplines to specific Earth-system quantities, to the detection approach, and to implementation options. The CNA will serve as the top-level document that guides selection and development of technologies required by ESE. The CNA can be found on the WWW at <http://esto.gsfc.nasa.gov/EarthScience/>, by selecting "Capability & Need Matrix".

For the purposes of the NRA, representative candidate technology developments include:

- UV DIAL laser transmitters with wall-plug efficiency greater than 10%
- Lightweight, deployable telescope technologies with apertures approaching three meters
- Conductively cooled, 2-micron laser transmitter technologies
- Compact, extendible, parallel processing delay-Doppler mapping GPS receivers
- Monolithic microwave integrated circuit (MMIC) receiver technologies for microwave sensing instruments
- Highly integrated RF electronics
- Advanced correlator devices for microwave radiometers
- Lightweight, high packing density, deployable antenna technology for microwave radiometers
- Lightweight microstrip antenna technology for microwave radiometers
- Advanced, compact, high resolution Fourier Transform Spectrometers with minimal moving parts
- Low noise, high temperature visible-near infrared and short-wave infrared detectors in large format arrays
- Room temperature mid and far infrared sensing detectors, including large format arrays approaching 2048x2048 elements
- High resolution optical filters

This list is not a comprehensive list and is only meant to indicate the level of components and subsystems being solicited from this NRA. The list is not prioritized.

Innovative proposals are encouraged for instrument components and subsystem technologies that address ESE science themes, candidate future missions, and all areas of the CNA. This includes systematic and process measurements already planned as part of the ESE science program, including the Earth Observing System (EOS) and Earth Probes Programs, and new measurements for which no current capability exists. Proposals must indicate which, science question(s), notional mission(s) and finally, which entry(s) of the CNA is the focus of proposed research/development.

(c) Objectives & Guidance

The proposer must define the starting point for the component or subsystem and the exit or success criteria for their proposal activity. Past and ongoing work on the component development should determine the entry point. For this solicitation, entry TRL is approximately 3 with an exit TRL approximately 5 (see Appendix F for a definition of TRL). Proposals approaching TRL 3 may be considered provided they describe the prior basic research accomplished and demonstrate achievement of approximate TRL 5 within the maximum performance period of 36 months. A responsive proposal will demonstrate advancement of at least one TRL within the proposed performance period. These limitations naturally preclude space qualification or end-to-end instrument designs from being performed in the ATIP. However, an instrument concept must be defined for which the components or subsystems will be a part.

Proposals that include partnering with other research and technology development programs are acceptable. The proposer should seek an alternate technology program for developments that exceed TRL 5.

The results at the exit point must provide convincing evidence that the components or subsystems can be integrated into an on-going technology development program, such as IIP, NMP, or directly into other flight validation programs for infusion into an instrument design.

As appropriate, each proposed development must include an evaluation of feasibility, requirements analysis, construction of component or subsystem breadboards, and/or construction of component or subsystem pre-prototypes. All proposed efforts must include evaluation of anticipated performance, an estimate of the entry and exit TRLs, cost and schedule to achieve TRL 6, and documentation of technology dependencies. These items will be documented as contract deliverables.

Laboratory demonstrations may be funded and are expected to produce working components or subsystems and data documenting performance measured in the laboratory.

Quarterly reports that document technical progress and financial status will be required as deliverables for awarded proposals. In addition, a final report will be required to

document the detailed component or subsystem designs, performance, and remaining risks.

(d) Relationship to Other Programs

For technology infusion to take place according to some predetermined timetable, appropriate funding must be applied at each stage or readiness level associated with the development of a specified end item. The ESE is responsible for planning technology development activities to ensure that sufficient funding exists in the various development programs so that all technological risk is retired prior to the selection of its scientific missions. There are two ESE-specific programs whose charter is to promote new ideas or technology development intended to lead to issuance of future science mission solicitations: the Instrument Incubator Program and the New Millennium Program.

Instrument Incubator Program

The objectives of the Instrument Incubator Program (IIP) are to identify, develop and (where appropriate) demonstrate new measurement technologies that reduce the risk, cost, size, and development time of Earth-observing instruments, and enable new Earth-observation measurements. The IIP is designed to bring instrument systems to a demonstrated technology readiness level consistent with successful science AO competition in today's fast track (3 year) development environment. The Instrument Incubator may depend on NMP for space flight validation, if necessary, of instruments developed in the IIP which were selected during an open solicitation and peer review process.

New Millennium Program

NASA created the New Millennium Program (NMP) to enable new missions by the identification, development, and flight validation of emerging technologies. In order to fulfill program goals, affordable missions with highly focused technological objectives are chosen to enable future scientific missions. The program encourages revolutionary and breakthrough technologies that traditionally have been difficult to incorporate into a science mission because of the inherently high risk associated with their first use. Key areas include lower mass systems to reduce launch costs, greater autonomy in space and on the ground to cut operations overhead, and shorter project life cycles to increase mission frequency, and/or extended lifetime to achieve long-term (decade scale) scientific objectives.

Other NASA programs can serve as sources of technology developments for the ATIP, including the Small Business Innovation Research (SBIR) Program and the Cross-Enterprise Technology Development Program (CETDP).

Small Business Innovation Research (SBIR) Program.

The SBIR program is a broad, government wide initiative managed by the Small Business Administration. It seeks to foster cooperative research and development through a three-phase process: phase 1 is intended as a study or conceptual design phase; phase 2 is the prototyping or proof of phase; and phase 3 infuses new technologies into commercial markets.

Cross-Enterprise Technology Development Program (CETDP)

The objectives of the NASA Cross-Enterprise Technology Development Program are to:

- Develop new critical crosscutting technologies to enable innovative and less costly missions and research concepts for the Earth Science, Space Science, and Human Exploration and Development communities, and
- Improve performance orders of magnitude through revolutionary long-term, high-risk, high pay-off technology advances.

Crosscutting technologies are defined as those that clearly benefit programs and projects across more than one enterprise. The primary focus of the program is to develop low TRL technologies capable of supporting revolutionary advances. Maturing technologies, TRL 4 and higher, will be supported in cost-sharing partnerships with the ESE and other NASA Enterprises.

(e) Period of Performance

The minimum period of performance is twelve months. The total proposed period of performance should not exceed 36 months. Proposals covering more than twelve months must define clear measurable milestones (two per year minimum) to be achieved in order to warrant continuation of funding. It is expected that awards covering more than twelve months will be handled as contract options with continuation based on performance and no guarantee that all options will be funded.

(f) International Participation

This announcement is open to the international technology community. International cooperative proposals, with co-investigators from U.S. institutions participating in foreign-led proposals or with co-investigators from non-U.S. institutions on the teams of proposals from U.S. institutions, are also acceptable. These proposals must be on a "no-exchange-of-funds" basis for their non-U.S. elements and should identify any requirements for NASA financial support for U.S. participants. Proposals from non-U.S. institutions are acceptable, but only on a "no-exchange-of-funds" basis. Specific instructions for proposals from non-U.S. institutions are included in Appendix C.

(g) Funding

The U.S. Government obligation to make awards is contingent upon the availability of appropriated funds from which payment for award purposes can be made and the receipt of proposals which are determined to be acceptable by the Government for award under

this announcement. Funding of the successful proposals will typically be via a contract. Interagency agreements will be considered, though grants will not be considered for this solicitation. Proposals also are encouraged that take advantage of cost-sharing arrangements. Cost-sharing proposals must include a discussion on the data-rights requested by the offerer.

Funding for this NRA will limit the number and magnitude of the proposals awarded. The ESE expects that 10 to 15 proposals will be awarded, with values in the approximate range of \$150,000 to \$300,000 per year cast in full-cost equivalent dollars.

(h) Rights to Data

In the event that a cost sharing arrangement is proposed, appropriate data rights that recognize the offerer's contributions as well as the Government's rights to access will be negotiated prior to awarding a contract.

(i) World Wide Web Links

This announcement and appendices are available on the Earth Science home page at: <http://www.earth.nasa.gov> (look under "Research Opportunities")

The Capability/Needs Assessment (CNA) is available at: <http://esto.gsfc.nasa.gov/EarthScience/>, by selecting "Capability & Need Matrix".

References to Earth Science far-term and strategic visions are available at: <http://www.earth.nasa.gov/visions/index.html>.

A source of information on planned measurements in the post-EOS era is available in the "Request for Information (RFI) on Concepts for Science and Applications Missions in the Post-2002 Era", available at: <http://www.hq.nasa.gov/office/ease/nra/RFIdodge/index.html>.

The results of the RFI workshop are available at: <http://www.hq.nasa.gov/office/ease/nra/RFIdodge/Panelrev.html>.

The summary of the Science Implementation Plan is available at:
<http://www.hq.nasa.gov/office/ease>

(j) Guidance to proposers; Procedures

Participation in this NRA or a subsequent similar NRA is not a prerequisite to selection as a science investigation as part of any future ESE solicitations. Similarly, participation in this NRA does not guarantee continued participation in ATIP or success in any future ESE competition. Successful participation in this NRA is intended to give innovative component and subsystems the technical pedigree they need to compete in future relevant ESE solicitations. Solicitations similar to this announcement will be issued periodically

to select additional components and subsystems for development and to continue the promotion of promising technological developments.

All prospective proposers are strongly encouraged to submit a letter of intent to propose to NASA in response to this announcement as per the schedule below. This letter will help to scope NASA's planning for the peer review process. The letter of intent may be submitted electronically through the Internet by completing the forms at URL: <http://bhuma.earth.nasa.gov/loi/form.cfm>. Use the electronic letter of intent forms unless you do not have access to the Internet. In that case, we will accept a FAX copy sent to 202-554-3024 with the following information:

- Technologist Name
- Proposal Title
- Organization
- Department
- Street Address
- City
- State
- Zip Code
- Country
- Telephone
- Fax
- Email
- Cognizant Principal Investigator Name
- PI Organization
- PI Telephone
- PI Email
- NRA Number
- A brief summary of proposal (1 page maximum)

Note that the electronic form for the letter of intent does not support the notion of different Technologists and PIs (see Appendix A for a definition of technologist vis-à-vis PI). Please substitute the Technologist's name and contact information for the references to PI in the form and submit the PI's name and contact information within the body of the letter. Proposals must be prepared and submitted in accordance with specific information provided in Appendices A-G of this Announcement. Appendix A provides additional instructions for proposers to this announcement. Appendix B contains the general instructions needed for preparation of solicited proposals in response to NASA Research Announcements. Appendix C provides guidance for international participation. Appendix D provides the list of required declarations, the proposal cover sheet and information on requisite certifications and disclosures. Appendix E contains a budget summary worksheet with instructions for its use. Appendix F contains a definition of Technology Readiness Levels. Appendix G contains a list of acronyms used. All proposals submitted to NASA in response to this announcement must have a completed cover-sheet-form and information on current and pending research support from all other sources (see Appendix D) attached. All proposals from investigators from the U.S. and other countries will be reviewed and evaluated by NASA.

Submit proposals to: ESE ATIP NRA
Code Y
400 Virginia Avenue, SW
Suite 700
Washington, DC 20024
(For overnight delivery purposes only,
The recipient telephone number is 202-554-2775)

Selecting Official: Associate Administrator, Office of Earth Science
NASA Headquarters

Point of Contact for Program Planning and Solicitation:
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(k) Selection Schedule

All proposals submitted in response to this announcement are due in accordance with the schedule shown below. Late proposals will not be considered for review and funding, unless it is judged to be in the interest of the U.S. Government.

A complete proposal schedule is given below:

Pre-proposal / Bidders Conference	September 23, 1999
Letter of Intent to Propose due	October 15, 1999
Proposals due	November 1, 1999
Peer Review	November 8 – 24, 1999

Announcement of Final Selections

January 2000

Your interest in participating in this opportunity is heartily welcomed.

Ghassem R. Asrar
Associate Administrator for Earth Science

Enclosures:

- Appendix A. Specific Guidelines for Proposers
- Appendix B. Instructions for Responding to NASA Research Announcements
- Appendix C. Guidelines for International Proposals
- Appendix D. Proposal Cover Sheet, Forms, And Required Declarations, Certifications, Disclosures, and Assurances
- Appendix E. Budget Summary
- Appendix F. Definition of Technology Readiness Level
- Appendix G. List of Acronyms used in this Research Announcement

Appendix A

Specific Guidelines for Proposers

Evaluation Factors

The following evaluation factors will be used to evaluate the proposals; they replace and supersede those contained in Appendix B, paragraph (i) Evaluation Factors. Evaluation Criterion 1 has greater weighting than Criterion 2, which has greater weighting than Criterion 3. The sum of the weightings for Criterion 2 and Criterion 3 are approximately equal to the weighting of Criterion 1.

Criterion 1 Applicability to NASA ESE Science Measurements and Technology Needs

- a. The proposed component or subsystem's relevance to the ESE science theme(s) that it addresses, its potential contribution to enabling future Post-2002 notional missions or other science measurements.
- b. The proposed component or subsystem's technology relevance (refer to the Implementation/Instrument Option field of the relevant CNA entry).
- c. The extent the component or subsystem provides performance benefits over existing or currently planned components or subsystems.
- d. The potential of the component or subsystem to be integrated, once matured, into an operational instrument and/or commercial use.
- e. The extent the component or subsystem enables a new measurement(s) and/or reduces the risk, cost, size, and development time of Earth observing instruments.

Criterion 2 Maturity of the Technology

- a. Substantiated justification that the component or subsystem is at the appropriate level of readiness for the ATI Program. Failure to report TRL assessments may be a cause for non-selection.
- b. Feasibility of obtaining the required measurement or reduction in risk, cost, size, and development time with the proposed component or subsystem.

Criterion 3 Proposer's Capability of Providing the Technology

- a. Historical performance and related experience in the proposed area of technology development.
- b. Commitment of the organization's management to the proposed technology development (evidenced by cost and resource sharing, prior teaming arrangements, etc.). Proposers must identify any previous investment by the organization and/or program and provide supporting documentation.
- c. Proposer's Cost Credibility. Proposers must include rationale and basis for the cost proposal to complete the effort.

ESE selection priorities will be focused on technologies that can support the next generation of missions which follow the current EOS first series (Terra, PM, and CHEM). Examples are included in the post-2002 notional mission set and in the complementary Science Implementation Plan both of which are summarized in reference in Section II, (i) World Wide Web Links, in the main body of the NRA.

Project Description

Appendix B, paragraph (c) (4) (i), Project Description, is amended to include the following:

- the CNA entry(s) that identifies the relevant technology requirement.
- the Post-2002 RFI science question(s) and notional mission(s) that are enabled by the proposed components or subsystems,
- the anticipated resolutions, accuracy, etc., of the enabled measurements, and a comparison to corresponding requirements driven by the science questions addressed,
- the anticipated benefits of this component versus existing or currently planned components, e.g., reduction of size, mass, power, volume, data rate, cost, improved resolution, or enabling of a new measurement not previously possible,
- a discussion of any possible commercial benefits.

Definition of Principal Investigator

For the purposes of this technology-driven solicitation, prospective proposers are expected to be technologists and a Principal Investigator (PI) who represents the science concerns of the development is expected to participate in the development activity. All references to “proposer”, “offerer” or “awardee” are directed at the technologist that will be leading the development activity. The traditional use of the term PI is meant to apply to the lead technologist for this solicitation.

Statement of Work

A draft Statement of Work must be delivered with the proposal. The Statement of Work will be used to establish a contract in the event that the proposal is awarded. The text must include the scope of the work proposed, the specific tasks to be performed with key milestones (at least two per 12 months), with no task exceeded 12 months in duration, and a draft monthly spending plan.

Required Deliverables

The following deliverables will be required of awarded proposals. In this context, the word “Phase” refers to an approximate 12-month effort, or a duration that achieves a significant milestone (not to exceed 12 months).

Bimonthly Report:

The initial bimonthly report must include a plan for technical, schedule and resource activities for the entire phase. Bimonthly reports must be submitted in Microsoft (MS) Word or Powerpoint compatible formats every other month on a schedule to be determined by the Earth Science Technology Office (ESTO). Any electronically

incompatible material shall be submitted as paper copy. A teleconference will be conducted between the ESTO and the awardee to review and discuss each report. These reports must include:

Technical status: The awardee must summarize accomplishments for the preceding two months including technical accomplishments (trade study results, requirements analysis, design, etc), technology development results, results of tests and/or demonstrations.

Schedule status: The awardee must address the status of major tasks and the variance from planned versus actual including tasks completed, tasks in process and expected to complete later than planned, tasks that are delayed starting with rationale for each, and recovery plans as appropriate.

Financial status: The financial status must be cumulative and focus on the proceeding two-month's efforts. The awardee must address:

- the variance of planned versus actual costs and include work that has been completed and cost incurred from the project (must be traceable to the schedule)
- status of major procurements:
 - that have been incurred to date and
 - amounts obligated to suppliers and subcontractors, including open purchase orders against which materials have not been received nor services rendered

Technology Readiness Level Assessment:

The awardee must provide an assessment of the entry Technology Readiness Level (TRL) and the basis for that assessment for the critical technology developments of the activity. The first TRL assessment is to be provided with the first report. An updated TRL assessment must be provided with the mid-phase report and with the end-of-phase report.

Mid-Phase Review and Report:

The awardee must provide a report summarizing the work accomplished and results leading up to this milestone review and must:

- Describe the primary findings, technology development results, technical status, status of construction of breadboards, and/or construction of a pre-engineering model, and results of tests and/or demonstrations. The PI may provide a laboratory demonstration, if appropriate, to show technical results and status.
- Describe the work planned for the remainder of the phase and critical issues that need to be resolved to successfully complete the remaining planned work.
- Summarize the cost and schedule status of the project including any schedule slippage/acceleration.

- Summarize the status of project reserve and planned use to meet critical milestones remaining in the phase.

The text report must be submitted in either electronic (MS-Word or Powerpoint compatible format) or paper copy 10 days prior to the review. Any electronically incompatible material shall be submitted as paper copy. The ESTO will conduct a one day (approximately) review at the PI's facility or at a mutually agreed upon location. The presentation at the review will constitute the final mid-phase report.

End-of-Phase Review and Report:

The awardee must provide a report summarizing the work accomplished and anticipated results at the end of this phase.

This report must include:

- A description of the work accomplished and the results leading up to this review.
- A summary of the primary findings, technology development results, and technical status, status of breadboards and/or pre-engineering models, and results of tests and/or demonstrations. The PI may provide a laboratory demonstration, if appropriate, to show technical results and status.

The review presentation must be submitted in electronic (MS-Word or Powerpoint) format and paper copy 10 days prior to the review. Any electronically incompatible material must be submitted as paper copy. The ESTO will conduct a one day review at the PI's facility or at a mutually agreed upon location. The presentation material at this review will constitute the deliverable for the review.

This written report must include the following:

- Results of all analyses, component or subsystem designs, breadboards and/or pre-engineering model designs.
- Performance analysis results of tests and/or demonstrations; estimation of reduction of size, mass, power, volume, data rate, cost, improved resolution, or description of enabled measurement not previously possible; and documentation of technology dependencies.
- Tables, graphs, diagrams, curves, sketches, photographs and drawings in sufficient detail to explain comprehensively the results achieved.
- A rough order of magnitude cost and a description of, and estimate of the duration of the follow-on activities necessary to achieve TRL 6 for technologies that remain at less than TRL 6 at the completion of the (final) phase.

The end-of-phase text report must be submitted in electronic (MS-Word) format and paper copy within 10 days following the end of phase review. Any electronically incompatible material must be submitted as paper copy.

Proposal Length

The length section of Appendix B is revised as follows:

The maximum length of each proposal is limited to 8 non-reduced, single-space typewritten pages for the total of the project description, management approach, personnel, and facilities and equipment sections (that is, the whole proposal, excluding the forms in Appendix D and cost information, is limited to 8 pages). Each side of a sheet of paper containing text or figures is considered a page. Use type font 10 point or larger, minimum one-inch margins and standard 8.5 x 11 inch paper.

The proposer must submit 10 paper copies and one 3 1/2" magnetic disk (Macintosh or IBM PC compatible format) with the proposal in MS-Word or comparable word processor format.

Appendix B

INSTRUCTIONS FOR RESPONDING TO NASA RESEARCH ANNOUNCEMENTS

Part 1852.235-72

**NASA Federal Acquisition Regulations (FAR) Supplement (NFS) Version 89.90,
Effective March 11, 1997.**

**Accessible at URL <http://www.hq.nasa.gov/office/procurement/regs/nfstoc.htm>,
open**

Part 1852.228 to 1852.241 from menu.

(JANUARY 1997)

(a) General.

(1) Proposals received in response to a NASA Research Announcement (NRA) will be used only for evaluation purposes. NASA does not allow a proposal, the contents of which are not available without restriction from another source, or any unique ideas submitted in response to an NRA to be used as the basis of a solicitation or in negotiation with other organizations, nor is a pre-award synopsis published for individual proposals.

(2) A solicited proposal that results in a NASA award becomes part of the record of that transaction and may be available to the public on specific request; however, information or material that NASA and the awardee mutually agree to be of a privileged nature will be held in confidence to the extent permitted by law, including the Freedom of Information Act.

(3) NRAs contain programmatic information and certain requirements which apply only to proposals prepared in response to that particular announcement. These instructions contain the general proposal preparation information which applies to responses to all NRAs.

(4) A contract, grant, cooperative agreement, or other agreement may be used to accomplish an effort funded in response to an NRA. NASA will determine the appropriate instrument. Contracts resulting from NRAs are subject to the Federal Acquisition Regulation and the NASA FAR. Supplement. Any resultant grants or cooperative agreements will be awarded and administered in accordance with the NASA Grant and Cooperative Agreement Handbook (NPG 5800.1).

(5) NASA does not have mandatory forms or formats for responses to NRAs; however, it is requested that proposals conform to the guidelines in these instructions. NASA may accept proposals without discussion; hence, proposals should initially be as complete as possible and be submitted on the proposers' most favorable terms.

(6) To be considered for award, a submission must, at a minimum, present a specific project within the areas delineated by the NRA; contain sufficient technical and cost information to permit a meaningful evaluation; be signed by an official authorized to legally bind the submitting organization; not merely offer to perform standard services or to just provide computer facilities or services; and not significantly duplicate a more specific current or pending NASA solicitation.

(b) NRA-Specific Items. Several proposal submission items appear in the NRA itself: the unique NRA identifier; when to submit proposals; where to send proposals; number of copies required; and sources for more information. Items included in these instructions may be supplemented by the NRA.

(c) The following information is needed to permit consideration in an objective manner. NRAs will generally specify topics for which additional information or greater detail is desirable. Each proposal copy shall contain all submitted material, including a copy of the transmittal letter if it contains substantive information.

(1) Transmittal Letter or Prefatory Material.

(i) The legal name and address of the organization and specific division or campus identification if part of a larger organization;

(ii) A brief, scientifically valid project title intelligible to a scientifically literate reader and suitable for use in the public press;

(iii) Type of organization: e.g., profit, nonprofit, educational, small business, minority, women-owned, etc.;

(iv) Name and telephone number of the principal investigator and business personnel who may be contacted during evaluation or negotiation;

(v) Identification of other organizations that are currently evaluating a proposal for the same efforts;

(vi) Identification of the NRA, by number and title, to which the proposal is responding;

(vii) Dollar amount requested, desired starting date, and duration of project;

(viii) Date of submission; and

(ix) Signature of a responsible official or authorized representative of the organization, or any other person authorized to legally bind the organization (unless the signature appears on the proposal itself).

(2) **Restriction on Use and Disclosure of Proposal Information.** Information contained in proposals is used for evaluation purposes only. Offerors or quoters should, in order to maximize protection of trade secrets or other information that is confidential or privileged, place the following notice on the title page of the proposal and specify the information subject to the notice by inserting an appropriate identification in the notice. In any event, information contained in proposals will be protected to the extent permitted by law, but NASA assumes no liability for use and disclosure of information not made subject to the notice.

Notice

Restriction on Use and Disclosure of Proposal Information

The information (data) contained in [insert page numbers or other identification] of this proposal constitutes a trade secret and/or information that is commercial or financial and confidential or privileged. It is furnished to the Government in confidence with the understanding that it will not, without permission of the offeror, be used or disclosed other than for evaluation purposes; provided, however, that in the event a contract (or other agreement) is awarded on the basis of this proposal the Government shall have the right to use and disclose this information (data) to the extent provided in the contract (or other agreement). This restriction does not limit the Government's right to use or disclose this information (data) if obtained from another source without restriction.

(3) **Abstract.** Include a concise (200-300 word if not otherwise specified in the NRA) abstract describing the objective and the method of approach.

(4) Project Description.

(i) The main body of the proposal shall be a detailed statement of the work to be undertaken and should include objectives and expected significance; relation to the present state of knowledge; and relation to previous work done on the project and to related work in progress elsewhere. The statement should outline the plan of work, including the broad design of experiments to be undertaken and a description of experimental methods and procedures. The project description should address the evaluation factors in these instructions and any specific factors in the NRA. Any substantial collaboration with individuals not referred to in the budget or use of consultants should be described. Subcontracting significant portions of a research project is discouraged.

(ii) When it is expected that the effort will require more than one year, the proposal should cover the complete project to the extent that it can be reasonably anticipated. Principal emphasis should be on the first year of work, and the description should distinguish clearly between the first year's work and work planned for subsequent years.

(5) **Management Approach.** For large or complex efforts involving interactions among numerous individuals or other organizations, plans for distribution of responsibilities and arrangements for ensuring a coordinated effort should be described.

(6) **Personnel.** The principal investigator is responsible for supervision of the work and participates in the conduct of the research regardless of whether or not compensated under the award. A short biographical sketch of the principal investigator, a list of principal publications and any exceptional qualifications should be included. Omit social security number and other personal items which do not merit consideration in evaluation of the proposal. Give similar biographical information on other senior professional personnel who will be directly associated with the project. Give the names and titles of any other scientists and technical personnel associated substantially with the project in an advisory capacity. Universities should list the approximate number of students or other assistants, together with information as to their level of academic attainment. Any special industry-university cooperative arrangements should be described.

(7) **Facilities and Equipment.**

(i) Describe available facilities and major items of equipment especially adapted or suited to the proposed project, and any additional major equipment that will be required. Identify any Government-owned facilities, industrial plant equipment, or special tooling that are proposed for use. Include evidence of its availability and the cognizant Government points of contact.

(ii) Before requesting a major item of capital equipment, the proposer should determine if sharing or loan of equipment already within the organization is a feasible alternative. Where such arrangements cannot be made, the proposal should so state. The need for items that typically can be used for research and non-research purposes should be explained.

(8) **Proposed Costs.**

(i) Proposals should contain cost and technical parts in one volume: do not use separate "confidential" salary pages. As applicable, include separate cost estimates for salaries and wages; fringe benefits; equipment; expendable materials and supplies; services; domestic and foreign travel; ADP expenses; publication or page charges; consultants; subcontracts; other miscellaneous identifiable direct costs; and indirect costs. List salaries and wages in appropriate organizational categories (e.g., principal investigator, other scientific and engineering professionals, graduate students, research assistants, and technicians and other non-professional personnel). Estimate all staffing data in terms of staff-months or fractions of full-time.

(ii) Explanatory notes should accompany the cost proposal to provide identification and estimated cost of major capital equipment items to be acquired; purpose and

estimated number and lengths of trips planned; basis for indirect cost computation (including date of most recent negotiation and cognizant agency); and clarification of other items in the cost proposal that are not self-evident. List estimated expenses as yearly requirements by major work phases.

(iii) Allowable costs are governed by FAR Part 31 and the NASA FAR Supplement Part 1831 (and OMB Circulars A-21 for educational institutions and A-122 for nonprofit organizations).

(9) **Security.** Proposals should not contain security classified material. If the research requires access to or may generate security classified information, the submitter will be required to comply with Government security regulations.

(10) **Current Support.** For other current projects being conducted by the principal investigator, provide title of project, sponsoring agency, and ending date.

(11) Special Matters.

(i) Include any required statements of environmental impact of the research, human subject or animal care provisions, conflict of interest, or on such other topics as may be required by the nature of the effort and current statutes, executive orders, or other current Government-wide guidelines.

(ii) Proposers should include a brief description of the organization, its facilities, and previous work experience in the field of the proposal. Identify the cognizant Government audit agency, inspection agency, and administrative contracting officer, when applicable.

(d) Renewal Proposals

(1) Renewal proposals for existing awards will be considered in the same manner as proposals for new endeavors. A renewal proposal should not repeat all of the information that was in the original proposal. The renewal proposal should refer to its predecessor, update the parts that are no longer current, and indicate what elements of the research are expected to be covered during the period for which support is desired. A description of any significant findings since the most recent progress report should be included. The renewal proposal should treat, in reasonable detail, the plans for the next period, contain a cost estimate, and otherwise adhere to these instructions.

(2) NASA may renew an effort either through amendment of an existing contract or by a new award.

(e) Length. Unless otherwise specified in the NRA, effort should be made to keep proposals as brief as possible, concentrating on substantive material. Few proposals need exceed 15-20 pages. Necessary detailed information, such as reprints, should be

included as attachments. A complete set of attachments is necessary for each copy of the proposal. As proposals are not returned, avoid use of "one-of-a-kind" attachments.

(f) Joint Proposals.

(1) Where multiple organizations are involved, the proposal may be submitted by only one of them. It should clearly describe the role to be played by the other organizations and indicate the legal and managerial arrangements contemplated. In other instances, simultaneous submission of related proposals from each organization might be appropriate, in which case parallel awards would be made.

(2) Where a project of a cooperative nature with NASA is contemplated, describe the contributions expected from any participating NASA investigator and agency facilities or equipment which may be required. The proposal must be confined only to that which the proposing organization can commit itself. "Joint" proposals which specify the internal arrangements NASA will actually make are not acceptable as a means of establishing an agency commitment.

(g) Late Proposals. A proposal or modification received after the date or dates specified in an NRA may be considered if doing so is in the best interests of the Government.

(h) Withdrawal. Proposals may be withdrawn by the proposer at any time before award. Offerors are requested to notify NASA if the proposal is funded by another organization or of other changed circumstances which dictate termination of evaluation.

(i) Evaluation Factors

(1) Unless otherwise specified in the NRA, the principal elements (of approximately equal weight) considered in evaluating a proposal are its relevance to NASA's objectives, intrinsic merit, and cost.

(2) Evaluation of a proposal's relevance to NASA's objectives includes the consideration of the potential contribution of the effort to NASA's mission.

(3) Evaluation of its intrinsic merit includes the consideration of the following factors of equal importance:

(i) Overall scientific or technical merit of the proposal or unique and innovative methods, approaches, or concepts demonstrated by the proposal.

(ii) Offeror's capabilities, related experience, facilities, techniques, or unique combinations of these which are integral factors for achieving the proposal objectives.

(iii) The qualifications, capabilities, and experience of the proposed principal investigator, team leader, or key personnel critical in achieving the proposal objectives.

(iv) Overall standing among similar proposals and/or evaluation against the state-of-the-art.

(4) Evaluation of the cost of a proposed effort may include the realism and reasonableness of the proposed cost and available funds.

(j) Evaluation Techniques. Selection decisions will be made following peer and/or scientific review of the proposals. Several evaluation techniques are regularly used within NASA. In all cases proposals are subject to scientific review by discipline specialists in the area of the proposal. Some proposals are reviewed entirely in-house, others are evaluated by a combination of in-house and selected external reviewers, while yet others are subject to the full external peer review technique (with due regard for conflict-of-interest and protection of proposal information), such as by mail or through assembled panels. The final decisions are made by a NASA selecting official. A proposal which is scientifically and programmatically meritorious, but not selected for award during its initial review, may be included in subsequent reviews unless the proposer requests otherwise.

(k) Selection for Award.

(1) When a proposal is not selected for award, the proposer will be notified. NASA will explain generally why the proposal was not selected. Proposers desiring additional information may contact the selecting official who will arrange a debriefing.

(2) When a proposal is selected for award, negotiation and award will be handled by the procurement office in the funding installation. The proposal is used as the basis for negotiation. The contracting officer may request certain business data and may forward a model award instrument and other information pertinent to negotiation.

(l) Cancellation of NRA. NASA reserves the right to make no awards under this NRA and to cancel this NRA. NASA assumes no liability for canceling the NRA or for anyone's failure to receive actual notice of cancellation.

Appendix C

GUIDELINES FOR FOREIGN PARTICIPATION

NASA accepts proposals from entities located outside the U.S. in response to this NRA. Proposals from non-U.S. entities should not include a cost plan as they are made on a no-exchange-of-funds basis. Non-U.S. proposals, and U.S. Proposals that include non-U.S. participation, must be endorsed by the respective government agency or funding/sponsoring institution in the country from which the non-U.S. participant is proposing. Such endorsement should address the following points: (1) The proposal merits careful consideration by NASA; and (2) If the proposal is selected, sufficient funds will be made available by the sponsoring foreign agency to undertake the activity as proposed.

Proposals, along with the requested number of copies and Letter of Endorsement must be forwarded to NASA in time to arrive before the deadline established for this NRA. In addition, one copy of each of these documents should be sent to:

NASA Headquarters
Office of External Relations
Earth Science Division, Code IY
Washington, DC 20546
USA

Any materials sent by courier or express mail should include the street address 300 E Street, S. W., and substitute 20024 for the indicated ZIP code.

All proposals must be typewritten in English. All non-U.S. proposals will undergo the same evaluation and selection process as those originating in the U.S. Non-U.S. proposals and U. S. Proposals that include non-U.S. participation, must follow all other guidelines and requirements described in this NRA. Sponsoring non-U.S. agencies may, in exceptional situations, forward a proposal without endorsement to the above address, if review and endorsement are not possible before the announced closing date. In such cases, however, NASA's Earth Science Division of the Office of External Relations should be advised when a decision on the endorsement is to be expected.

Successful and unsuccessful proposers will be contacted directly by the NASA Program Office coordinating the NRA. Copies of these letters will be sent to the sponsoring government agency.

Appendix D

Proposal Cover Sheet, Forms, and Required Certifications

Proposal Cover Sheet

NASA Research Announcement 99-OES-07

Proposal No. _____ (Leave Blank for NASA Use)

Title: _____

Principal Investigator: _____

Department: _____

Institution: _____

Street/PO Box: _____

City: _____ State: _____ Zip: _____

Country: _____ E-mail: _____

Telephone: _____ Fax: _____

Co-Investigators:

Name	Institution & Address	Telephone & E-mail
_____	_____	_____
_____	_____	_____
_____	_____	_____

Budget:

1st Year: _____ 2nd Year: _____ 3rd Year: _____ Total: _____

Certification of Compliance with Applicable Executive Orders and U.S. Code

By submitting the proposal identified in this *Cover Sheet/Proposal Summary* in response to this Research Announcement, the Authorizing Official of the proposing institution (or the individual proposer if there is no proposing institution) as identified below:

- certifies that the statements made in this proposal are true and complete to the best of his/her knowledge;
- agrees to accept the obligations to comply with NASA award terms and conditions if an award is made as a result of this proposal; and
- confirms compliance with all provisions, rules, and stipulations set forth in the two Certifications contained in this NRA [namely, (i) *Certification of Compliance with the NASA Regulations Pursuant to Nondiscrimination in Federally Assisted Programs*, and (ii)

Certifications, Disclosures, And Assurances Regarding Lobbying and Debarment & Suspension].

Willful provision of false information in this proposal and/or its supporting documents, or in reports required under an ensuing award, is a criminal offense (U.S. Code, Title 18, Section 1001).

Title of Authorizing Institutional Official: _____

Signature: _____ Date: _____

Name of Proposing Institution: _____

Telephone: _____ E-mail: _____ Facsimile: _____

Current And Pending Research Support From All Other Sources

All proposals must include this information. This list must include all current and pending research support from the following sources:

1. Any proposal for which the Technologist of this proposal is also the Technologist or Principal Investigator.
2. Any proposal, regardless of the Technologist or PI, which accounts for more than 20% of the time of the Technologist of this proposal and other personnel essential to this proposal.

Please provide this information in the following format:

I. Technologist

A. Current Fiscal Year Support

1. Source of Support and Technologist or Principal Investigator
2. Award Amount and Period of Performance
3. Person-Months and Level of Effort
4. Project Title and Short Abstract (50 words or less)

B. Pending Proposals (Excluding this proposal but including other proposals).

1. Source of Support and Technologist or Principal Investigator
2. Award Amount and Period of Performance
3. Person-Months and Level of Effort
4. Project Title and Short Abstract (50 words or less)

For both current and pending support provide information on:

II. Co-Investigators

As outlined above, provide information on all Current and Pending Support. Disclosure of current and pending research support is not required for collaborators.

III. Other agencies to which this proposal, or parts thereof, has been submitted.

**Certification of Compliance with the NASA Regulations Pursuant to
Nondiscrimination in Federally Assisted Programs**

The (*Institution, corporation, firm, or other organization on whose behalf this assurance is signed, hereinafter called "Applicant "*) hereby agrees that it will comply with Title VI of the Civil Rights Act of 1964 (P.L. 88-352), Title IX of the Education Amendments of 1962 (20 U.S.C. 1680 et seq.), Section 504 of the Rehabilitation Act of 1973, as amended (29 U.S.C. 794), and the Age Discrimination Act of 1975 (42 U.S.C. 16101 et seq.), and all requirements imposed by or pursuant to the Regulation of the National Aeronautics and Space Administration (14 CFR Part 1250) (hereinafter called "NASA") issued pursuant to these laws, to the end that in accordance with these laws and regulations, no person in the United States shall, on the basis of race, color, national origin, sex, handicapped condition, or age be excluded from participation in, be denied the benefits of, or be otherwise subjected to discrimination under any program or activity for which the Applicant receives federal financial assistance from NASA; and hereby give assurance that it will immediately take any measure necessary to effectuate this agreement.

If any real property or structure thereon is provided or improved with the aid of federal financial assistance extended to the Applicant by NASA, this assurance shall obligate the Applicant, or in the case of any transfer of such property, any transferee, for the period during which the real property or structure is used for a purpose for which the federal financial assistance is extended or for another purpose involving the provision of similar services or benefits. If any personal property is so provided, this assurance shall obligate the Applicant for the period during which the federal financial assistance is extended to it by NASA.

this assurance is given in consideration of and for the purpose of obtaining any and all federal grants, loans, contracts, property, discounts, or other federal financial assistance extended after the date hereof to the Applicant by NASA, including installment payments after such date on account of applications for federal financial assistance which were approved before such date. The Applicant recognized and agrees that such federal financial assistance will be extended in reliance on the representations and agreements made in this assurance, and that the United States shall have the right to seek judicial enforcement of this assurance. This assurance is binding on the Applicant, its successors, transferees, and assignees, and the person or persons whose signatures appear below are authorized to sign on behalf of the Applicant.

**Certifications, Disclosures, and Assurances
Regarding Lobbying and Debarment & Suspension**

1. LOBBYING

As required by Section 1352, Title 31 of the U.S. Code, and implemented at 14 CFR Part 1271, as defined at 14 CFR Subparts 1271.110 and 1260.117, with each submission that initiates agency consideration of such applicant for award of a Federal contract, grant, or cooperative agreement exceeding \$ 100,000, the applicant must **certify** that:

(1) No Federal appropriated funds have been paid or will be paid, by or on behalf of the undersigned to any person for influencing or attempting to influence an officer or employee of an agency, a Member of Congress, an officer or employee of Congress, or an employee of a Member of Congress in connection with the awarding of any Federal contract, the making of any Federal grant, the making of any Federal loan, the continuation, renewal, amendment, or modification of any Federal contract, grant, loan, or cooperative agreement.

(2) If any funds other than appropriated funds have been paid or will be paid to any person for influencing or attempting to influence an officer or employee of any agency, a Member of Congress, an officer or employee of Congress, or an employee of a Member of Congress in connection with the Federal contract, grant, loan, or cooperative agreement, the undersigned shall complete and submit a Standard Form-LLL, "Disclosure Form to Report Lobbying," in accordance with its instructions.

(3) The undersigned shall require that the language of this certification be included in the award documents for all subawards at all tiers (including subcontracts, subgrants, and contracts under grants, loans, and cooperative agreements) and that all subrecipients shall certify and disclose accordingly.

2. GOVERNMENTWIDE DEBARMENT AND SUSPENSION

As required by Executive Order 12549, and implemented at 14 CFR 1260.510, for prospective participants in primary covered transactions, as defined at 14 CFR Subparts 1265.510 and 1260.117—

(1) The prospective primary participant **certifies** to the best of its knowledge and belief, that it and its principals:

(a) Are not presently debarred, suspended, proposed for debarment, declared ineligible, or voluntarily excluded by any Federal department or agency.

(b) Have not within a three-year period preceding this proposal been convicted of or had a civil judgment rendered against them for commission of fraud or a criminal offense in connection with obtaining, attempting to obtain, or performing a public (Federal, State or local) transaction or contract under a public transaction; violation of Federal or State antitrust statutes or commission of embezzlement, theft, forgery, bribery, falsification or destruction of records, making false statements, or receiving stolen property;

(c) Are not presently indicted for or otherwise criminally or civilly charged by a governmental entity (Federal, State or local) with commission of any of the offenses enumerated in paragraph 1(b) of this certification; and

(d) Have not within a three-year period preceding this application/proposal had one or more public transactions (Federal, State or local) terminated for cause or default.

(2) Where the prospective primary participant is unable to certify to any of the statements in this certification, such prospective participant shall attach an explanation to this proposal.

• **Appendix E**

BUDGET SUMMARY

For period from _____ to _____

- Provide a complete Budget Summary for year one and separate estimated for each subsequent year.
- Enter the proposed estimated costs in Column A (Columns B & C for NASA use only).
- Provide as attachments detailed computations of all estimates in each cost category with narratives as required to fully explain each proposed cost. See *Instructions For Budget Summary* on following page for details.

	A	<u>NASA USE ONLY</u>	
		B	C
1. <u>Direct Labor</u> (salaries, wages, and fringe benefits)	_____	_____	_____
2. <u>Other Direct Costs:</u>			
a. Subcontracts	_____	_____	_____
b. Consultants	_____	_____	_____
c. Equipment	_____	_____	_____
d. Supplies	_____	_____	_____
e. Travel	_____	_____	_____
f. Other	_____	_____	_____
3. <u>Facilities and Administrative Costs</u>	_____	_____	_____
4. <u>Other Applicable Costs:</u>	_____	_____	_____
5. <u>SUBTOTAL--Estimated Costs</u>	_____	_____	_____
6. <u>Less Proposed Cost Sharing</u> (if any)	_____	_____	_____
7. <u>Carryover Funds</u> (if any)			
a. Anticipated amount : _____			
b. Amount used to reduce budget	_____	_____	_____
8. <u>Total Estimated Costs</u>	_____	_____	XXXXXXXX
9. APPROVED BUDGET	XXXXXXXX	XXXXXXXX	_____

INSTRUCTIONS FOR BUDGET SUMMARY

1. Direct Labor (salaries, wages, and fringe benefits): Attachments should list the number and titles of personnel, amounts of time to be devoted to the grant, and rates of pay.
2. Other Direct Costs:
 - a. Subcontracts: Attachments should describe the work to be subcontracted, estimated amount, recipient (if known), and the reason for subcontracting.
 - b. Consultants: Identify consultants to be used, why they are necessary, the time they will spend on the project, and rates of pay (not to exceed the equivalent of the daily rate for Level IV of the Executive Schedule, exclusive of expenses and indirect costs).
 - c. Equipment: List separately. Explain the need for items costing more than \$5,000. Describe basis for estimated cost. General purpose equipment is not allowable as a direct cost unless specifically approved by the NASA Grant Officer. Any equipment purchase requested to be made as a direct charge under this award must include the equipment description, how it will be used in the conduct of the basic research proposed and why it cannot be purchased with indirect funds.
 - d. Supplies: Provide general categories of needed supplies, the method of acquisition, and the estimated cost.
 - e. Travel: Describe the purpose of the proposed travel in relation to the grant and provide the basis of estimate, including information on destination and number of travelers where known.
 - f. Other: Enter the total of direct costs not covered by 2a through 2e. Attach an itemized list explaining the need for each item and the basis for the estimate.
3. Facilities and Administrative (F&A) Costs: Identify F&A cost rate(s) and base(s) as approved by the cognizant Federal agency, including the effective period of the rate. Provide the name, address, and telephone number of the Federal agency official having cognizance. If unapproved rates are used, explain why, and include the computational basis for the indirect expense pool and corresponding allocation base for each rate.
4. Other Applicable Costs: Enter total explaining the need for each item.
5. Subtotal-Estimated Costs: Enter the sum of items 1 through 4.
6. Less Proposed Cost Sharing (if any): Enter any amount proposed. If cost sharing is based on specific cost items, identify each item and amount in an attachment.
7. Carryover Funds (if any): Enter the dollar amount of any funds expected to be available for carryover from the prior budget period. Identify how the funds will be used if they are not used to reduce the budget. NASA officials will decide whether to

use all or part of the anticipated carryover to reduce the budget (not applicable to 2nd-year and subsequent-year budgets submitted for award of a multiple year award).

8. Total Estimated Costs: Enter the total after subtracting items 6 and 7b from item 5.

Appendix F

Definition of Technology Readiness Level

TECHNOLOGY READINESS LEVELS

A White Paper
April 6, 1995

John C. Mankins
Advanced Concepts Office
Office of Space Access and Technology
NASA

Introduction

Technology Readiness Levels (TRLs) are a systematic metric/measurement system that supports assessments of the maturity of a particular technology and the consistent comparison of maturity between different types of technology. The TRL approach has been used on-and-off in NASA space technology planning for many years and was recently incorporated in the NASA Management Instruction (NMI 7100) addressing integrated technology planning at NASA. Figure 1 (attached) provides a summary view of the technology maturation process model for NASA space activities for which the TRL's were originally conceived; other process models may be used. However, to be most useful the general model must include: (a) 'basic' research in new technologies and concepts (targeting identified goals, but not necessary specific systems), (b) focused technology development addressing specific technologies for one or more potential identified applications, (c) technology development and demonstration for each specific application before the beginning of full system development of that application, (d) system development (through first unit fabrication), and (e) system 'launch' and operations.

Technology Readiness Levels Summary

- TRL 1** Basic principles observed and reported
- TRL 2** Technology concept and/or application formulated
- TRL 3** Analytical and experimental critical function and/or characteristic proof-of-concept
- TRL 4** Component and/or breadboard validation in laboratory environment
- TRL 5** Component and/or breadboard validation in relevant environment
- TRL 6** System/subsystem model or prototype demonstration in a relevant environment (ground or space)
- TRL 7** System prototype demonstration in a space environment

TRL 8 Actual system completed and “flight qualified” through test and demonstration (ground or space)

TRL 9 Actual system “flight proven” through successful mission operations

Discussion of Each Level

The following paragraphs provide a descriptive discussion of each technology readiness level, including an example of the type of activities that would characterize each TRL.

TRL 1

Basic principles observed and reported

This is the lowest “level” of technology maturation. At this level, scientific research begins to be translated into applied research and development. Examples might include studies of basic properties of materials (e.g., tensile strength as a function of temperature for a new fiber).

Cost to Achieve: Very Low ‘Unique’ Cost (investment cost is borne by scientific research programs)

TRL 2

Technology concept and/or application formulated

Once basic physical principles are observed, then at the next level of maturation, practical applications of those characteristics can be ‘invented’ or identified. For example, following the observation of high critical temperature (H_{tc}) superconductivity, potential applications of the new material for thin film devices (e.g., SIS mixers) and in instrument systems (e.g., telescope sensors) can be defined. At this level, the application is still speculative: there is not experimental proof or detailed analysis to support the conjecture.

Cost to Achieve: Very Low ‘Unique’ Cost (investment cost is borne by scientific research programs)

TRL 3

Analytical and experimental critical function and/or characteristic proof-of-concept

At this step in the maturation process, active research and development (R&D) is initiated. This must include both analytical studies to set the technology into an appropriate context and laboratory-based studies to physically validate that the analytical predictions are correct. These studies and experiments should constitute “proof-of-concept” validation of the applications/concepts formulated at TRL 2. For example, a concept for High Energy Density Matter (HEDM) propulsion might depend on slush or super-cooled hydrogen as a propellant: TRL 3 might be attained when the concept-enabling phase/temperature/pressure for the fluid was achieved in a laboratory.

Cost to Achieve: Low ‘Unique’ Cost (technology specific)

TRL 4

Component and/or breadboard validation in laboratory environment

Following successful “proof-of-concept” work, basic technological elements must be integrated to establish that the “pieces” will work together to achieve concept-enabling levels of performance for a component and/or breadboard. This validation must be devised to support the concept that was formulated earlier, and should also be consistent with the requirements of potential system applications. The validation is relatively “low-fidelity” compared to the eventual system: it could be composed of ad hoc discrete components in a laboratory. For example, a TRL 4 demonstration of a new ‘fuzzy logic’ approach to avionics might consist of testing the algorithms in a partially computer-based, partially bench-top component (e.g., fiber optic gyros) demonstration in a controls lab using simulated vehicle inputs.

Cost to Achieve: Low-to-moderate ‘Unique’ Cost (investment will be technology specific, but probably several factors greater than investment required for TRL 3)

TRL 5

Component and/or breadboard validation in relevant environment

At this, the fidelity of the component and/or breadboard being tested has to increase significantly. The basic technological elements must be integrated with reasonably realistic supporting elements so that the total applications (component-level, sub-system level, or system-level) can be tested in a ‘simulated’ or somewhat realistic environment. From one-to-several new technologies might be involved in the demonstration. For example, a new type of solar photovoltaic material promising higher efficiencies would at this level be used in an actual fabricated solar array ‘blanket’ that would be integrated with power supplies, supporting structure, etc., and tested in a thermal vacuum chamber with solar simulation capability.

Cost to Achieve: Moderate ‘Unique’ Cost (investment cost will be technology dependent, but likely to be several factors greater than cost to achieve TRL 4)

TRL 6

System/subsystem model or prototype demonstration in a relevant environment (ground or space)

A major step in the level of fidelity of the technology demonstration follows the completion of TRL 5. At TRL 6, a representative model or prototype system or system — which would go well beyond ad hoc, ‘patch-cord’ or discrete component level breadboarding — would be tested in a relevant environment. At this level, if the only ‘relevant environment’ is the environment of space, then the model/prototype must be demonstrated in space. Of course, the demonstration should be successful to represent a true TRL 6. Not all technologies will undergo a TRL 6 demonstration: at this point the maturation step is driven more by assuring management confidence than by R&D requirements. The demonstration might represent an actual system application, or it might only be similar to the planned application, but using the same technologies. At this level, several-to-many new technologies might be integrated into the demonstration. For example, an innovative approach to high temperature/low mass radiators, involving liquid droplets and composite materials, would be demonstrated to TRL 6 by actually flying a working, sub-scale (but scaleable) model of the system on a Space Shuttle or International Space Station ‘pallet’. In this example, the reason space is the ‘relevant’ environment is that microgravity plus vacuum plus thermal environment effects will dictate the success/failure of the system — and the only way to validate the technology is in space.

Cost to Achieve: Technology and demonstration specific; a fraction of TRL 7 if on ground; nearly the same if space is required

TRL 7

System prototype demonstration in a space environment

TRL 7 is a significant step beyond TRL 6, requiring an actual system prototype demonstration in a space environment. It has not always been implemented in the past. In this case, the prototype should be near or at the scale of the planned operational system and the demonstration must take place in space. The driving purposes for achieving this level of maturity are to assure system engineering and development management confidence (more than for purposes of technology R&D). Therefore, the demonstration must be of a prototype of that application. Not all technologies in all systems will go to this level. TRL 7 would normally only be performed in cases where the technology and/or subsystem application is mission critical and relatively high risk. Example: the Mars Pathfinder Rover is a TRL 7 technology demonstration for future Mars micro-rovers based on that system design. Example: X-vehicles are TRL 7, as are the demonstration projects planned in the New Millennium spacecraft program.

Cost to Achieve: Technology and demonstration specific, but a significant fraction of the cost of TRL 8 (investment = “Phase C/D to TFU” for demonstration system)

TRL 8

Actual system completed and “flight qualified” through test and demonstration (ground or space)

By definition, all technologies being applied in actual systems go through TRL 8. In almost all cases, this level is the end of true ‘system development’ for most technology elements. Example: this would include DDT&E through Theoretical First Unit (TFU) for a new reusable launch vehicle. This might include integration of new technology into an existing system. Example: loading and testing successfully a new control algorithm into the onboard computer on Hubble Space Telescope while in orbit.

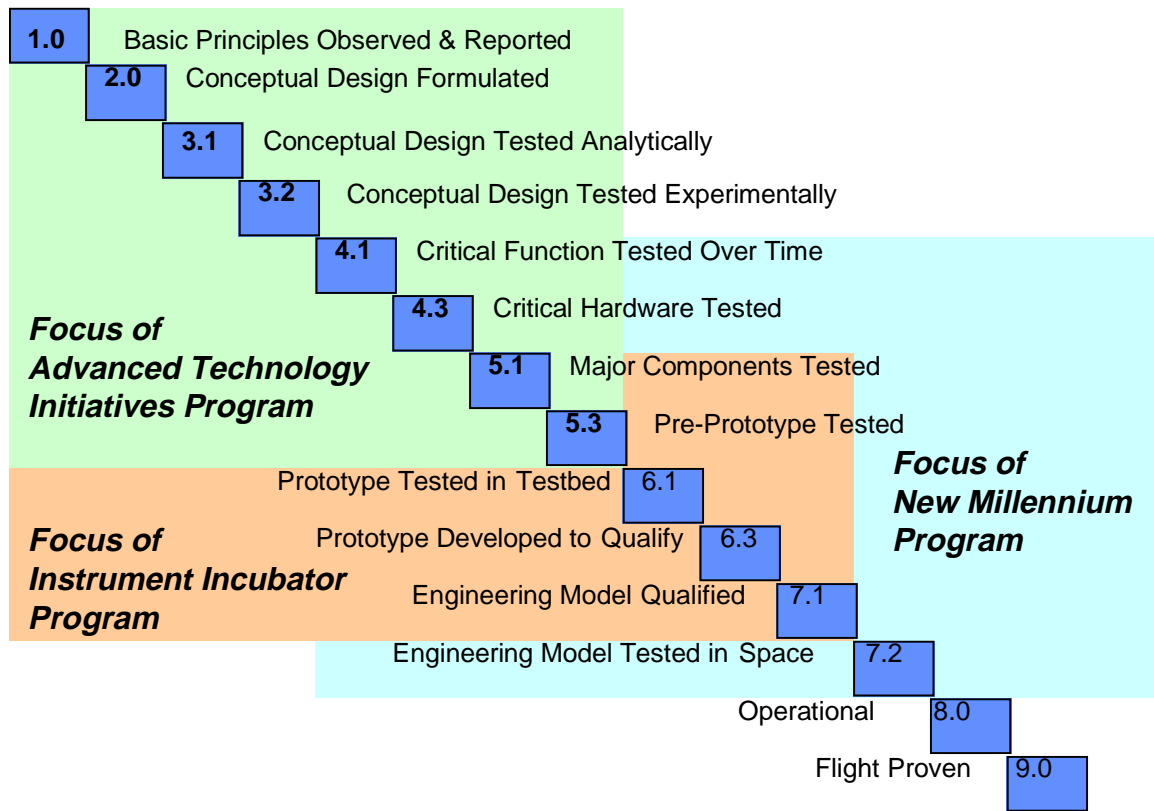
Cost to Achieve: Mission specific; typically highest unique cost for a new technology (investment = “Phase C/D to TFU” for actual system)

TRL 9

Actual system “flight proven” through successful mission operations

By definition, all technologies being applied in actual systems go through TRL 9. In almost all cases, the end of last ‘bug fixing’ aspects of true ‘system development’. For example, small fixes/changes to address problems found following launch (through ‘30 days’ or some related date). This might include integration of new technology into an existing system (such operating a new artificial intelligence tool into operational mission control at JSC). This TRL does not include planned product improvement of ongoing or reusable systems. For example, a new engine for an existing RLV would not start at TRL 9: such ‘technology’ upgrades would start over at the appropriate level in the TRL system.

Cost to Achieve: Mission Specific; less than cost of TRL 8 (e.g., cost of launch plus 30 days of mission operations)



Appendix G

List of Acronyms used in this Research Announcement

AO	Announcement of Opportunity
ATIP	Advanced Technology Initiatives Program
CNA	Capability/Needs Assessment
EOS	Earth Observing System
FAR	Federal Acquisition Regulation
FY	Fiscal Year
GSFC	Goddard Space Flight Center
IIP	Instrument Incubator Program
MS	Microsoft
NASA	National Aeronautics and Space Administration
NFS	NASA FAR Supplement
NRA	NASA Research Announcement
OES	Office of Earth Science
OMB	Office of Management and Budget
PI	Principal Investigator
URL	Uniform Resource Locator
WWW	World Wide Web