National Aeronautics and Space Administration

June 12, 2000

NRA2-37143

RESEARCH ANNOUNCEMENT

Research in Intelligent Systems

Step 1 Proposals Due – July 11, 2000

OMB Approval No. 2700-0087

RESEARCH IN INTELLIGENT SYSTEMS

NASA Research Announcement
Soliciting Research Proposals
For
Period Ending
July 11, 2000

NRA2-37143
Issued June 12, 2000

National Aeronautics and Space Administration
Ames Research Center
Intelligent Systems Program Office
Moffett Field, CA 94035-1000

Research in Intelligent Systems

This NASA Research Announcement (NRA) solicits proposals from the Computational Sciences research community for new and innovative research, applied research, and pilot projects, which will advance information systems technology required by future NASA missions. In particular, this NRA solicits truly novel approaches to solving future NASA problems, rather than refinements of existing techniques. In the last three years NASA has developed a bold vision for Space Science, Earth Science, Human Exploration, and Aeronautics and Space Transportation for the twenty first century. This vision focuses on robotic exploration of deep space to understand the origin and evolution of life, combined human-robotic exploration of Mars, safe and cost effective operation of the Space Shuttle and follow-on launch vehicles to orbit, the use of Earth-orbiting satellites to establish cause and effect relationships associated with such important phenomena as global warming, and the development of methodologies to enhance the safety and capacity of the U. S. air transportation system. What the elements of this vision have in common is the need for a set of advanced computer science/information technology capabilities associated with system intelligence that do not exist today. The Intelligent Systems (IS) Program was created to address the need for advanced information systems technology in future NASA missions. The Government intends to develop advanced Intelligent Systems technologies by leveraging existing government and university research, and by feeding maturing technologies to ongoing NASA missions and activities, to industry activities, and to other government agencies. IS Program activities are focused on providing advancements in fundamental technologies, methods, and processes in four areas: Automated Reasoning, Intelligent Data Understanding, Human-Centered Computing, and Revolutionary Computing.

Participation in this NRA is open to industry, educational institutions, nonprofit organizations (includes not-for-profit organizations), and U.S. Government agencies (acting independently or as part of a team). Multiple awards are anticipated as a result of this NRA. The range of awards is expected to be from $200K per year for individual PI or small team research to $1M per year for larger team or collaborative efforts. Proposers are encouraged to utilize appropriately ramped funding profiles which will enable them to participate in collaborative activities with other IS Program participants in the second and third year of their research activities.

Proposals will be evaluated in two steps. Step 1 proposals may be submitted at any time during the period ending at 1:30 pm, PDT, on July 11, 2000. Step 2 proposals will be due no later than 2 months following notification from NASA of the Step 1 proposal review results and recommendations.

Step 1 proposals may be up to 5 pages of text, single-spaced, with type no smaller than 12-pt., including abstract and references. Step 2 proposals may be up to fifteen pages of text, single-spaced, with type no smaller than 12-pt., including abstract and references. Detailed information on process as well as proposal format and content is provided in Appendix A.

Proposals will be subjected to peer and/or technical review utilizing either mail evaluation, panel evaluation, or both. A NASA management review for program relevance, technical and logistical

feasibility and cost analysis will also be conducted. The evaluation criteria to be used are listed in Appendix A. Step 1 proposals will be reviewed by a panel. Following the panel review, NASA will place each Step 1 proposal in one of four groups: 1) high priority, 2) medium priority, 3) low priority, and 4) non-responsive..

Proposers will be notified as soon as possible of the categorization of their Step 1 proposals, and will receive summaries of comments from the panel. Proposers will receive specific recommendations concerning the submission of a Step 2 proposal based on the categorization of their proposals (see Appendix A). Step 2 proposals will be reviewed as a group (using both mail and panel review). A proposal that is scientifically and programmatically meritorious, but cannot be accepted during its initial review under an NRA because of funding uncertainties, may be included in subsequent reviews unless the offeror requests otherwise. All or part of a proposal may be selected for negotiations leading to possible award unless the offeror requests otherwise. Selection and award may occur for a period of one year following the release date of this NRA.

Proposals should request up to 3 years of funding to start no sooner than January 1, 2001. Annual review of progress reports will be required for renewal during 2001-2002.

A complete proposal schedule is given below:

Step 1 Proposals Due:	1:30 pm, PDT, July 11, 2000
Step 2 Proposals Due:	2 months after notification of categorization of Step 1 proposal
Announcement of Final Selections:	December 2000

NRA Number:	NRA2-37143
Submit Proposals to:	Ames Research Center ATTN: NRA2-37143, [LMV] Bldg. 241, Room 202 Mail Stop 241-1 Moffett Field, CA 94035-1000
Copies Required:	10 *plus* signed original, plus an electronic copy on a ZIP disk, CDROM, or floppy
Selecting Official:	Dr. Robert J. Hansen Deputy Director for Research Ames Research Center

Obtain additional information from:

Technical:	Dr. Dan Cooke Manager, Intelligent Systems (IS) Program Office (650) 604-3371 dcooke@mail.arc.nasa.gov Dr. Butler Hine Deputy Manager (acting), IS Program Office (650) 604-4756 bhine@mail.arc.nasa.gov Mail Stop 269-3 NASA-Ames Research Center Moffett Field, CA 94035-1000
Administrative and contractual:	Ms. Lupe M. Velasquez, Code JAI Mail Stop 241-1 NASA-Ames Research Center Moffett Field, CA 94035-1000 (650) 604-4522 lvelasquez@mail.arc.nasa.gov

Funds are not currently available for awards under this NRA. The Government's obligation to make award(s) is contingent upon the availability funds from which payment can be made and the receipt of proposals that NASA determines are acceptable for award under this NRA.

Appendix A provides technical information for the general areas for which research proposals are sought. Appendix B provides basic guidance for preparation of solicited proposals in response to this NRA. Appendix C describes policy on foreign participation. Appendix D provides example forms.

Your interest in participating in this effort is appreciated.

Henry McDonald
Director

Four Enclosures:
1. Appendix A-Description of Program Opportunity
2. Appendix B-Instructions for Responding to NASA Research Announcements
3. Appendix C-Policy for the Use of Foreign Technology
4. Appendix D-Examples

APPENDIX A - Description of Program Opportunity
NRA2-37143
RESEARCH IN INTELLIGENT SYSTEMS

NASA supports research in information technologies through sponsorship of technology programs conducted at the NASA Field Centers, other national laboratories, industry, and universities. The Intelligent Systems Program Office at the Ames Research Center sponsors research for the development of intelligent systems technologies to reduce mission operations costs, improve NASA's mission capabilities, and increase the productivity of NASA's science and engineering activities.

This NASA Research Announcement (NRA) solicits research proposals for innovative research, applied research, and pilot projects, which will fulfill the NASA Administrator's vision for next-generation information technology capabilities. The Government's intent is to achieve this vision by developing state of the art and revolutionary Intelligent Systems technologies, by leveraging existing government and university research, and by feeding maturing technologies to ongoing NASA missions and activities, to industry activities, and to other government agencies. IS activities are focused on providing for advancements in fundamental technologies, methods, and processes in four areas: Automated Reasoning, Intelligent Data Understanding, Human-Centered Computing and Revolutionary Computing.

OVERALL SCOPE

Technology development and demonstrations completed under this NRA should address the engineering and science needs of one or more of NASA's four Enterprises. Proposed efforts that show relevance and promise for strategically enabling NASA missions on the ground or in space are preferred. Pilot projects and demonstrations may include ground or flight experiments. The scope of this activity consists of these four IS technology areas:

Automated Reasoning is concerned with advances that result in greater autonomy in the development and operation of computer-based systems, including improved abilities to synthesize, validate, and verify computer software. **Intelligent Data Understanding** is concerned with the advances that improve our ability to extract meaningful information and knowledge from large, diverse databases. **Human-Centered Computing** is concerned with the development of new approaches to the design of problem solutions. Specifically, HCC is concerned with an end-to-end systems perspective that considers how humans and machines interact, taking into account basic human perceptual, cognitive, and social abilities. **Revolutionary Computing** is concerned with the implications of new approaches to technologies that may change the way we think of computation.

TECHNOLOGY RESEARCH AREAS

TA-1 – Automated Reasoning

Automated reasoning enables computers to perform tasks, which have previously required human capabilities. This will allow the extension of a "virtual" human presence into areas where it is not possible or desirable to place humans. Such situations may involve environments too hazardous or expensive for human presence, or operational regimes incompatible with human perceptual and cognitive speeds. NASA's enterprises are planning numerous missions in which these situations occur. These missions range from fleets of highly autonomous cooperating satellites in Earth orbit, to human-robotic communities on Mars, and on to vehicles capable of independently carrying out a science program such as a long-range planetary rover or a Europa Submarine. The capabilities to be developed in this area should be responsive to those needs and will be crucial to mission success. Automated Reasoning will also support virtually all of NASA's far-term missions by creating automated tools for software synthesis, verification and validation of autonomy software, which will radically reduce the resources, time, and specialized expertise required to build the mission software. Similarly, advances in planning scheduling and control methods and tools will enable new applications ranging from on-board health management for Reusable Launch Vehicles and "free-flight" of aircraft within a shared airspace to more efficient ground processing of both vehicles and payloads. In fact, empowering the computer to make complex decisions in ground processing systems might be an essential first step toward automated orbital or extraterrestrial spacecraft processing systems.

Like many organizations, NASA's speed of innovation is often bounded by its speed of software development. No matter how fast we design and build a new vehicle; we cannot do the mission without the software. The best way to speed software development is to automate it. Instead of legions of programmers who do detailed code development, we need to enable non-programmers to specify *what* the code should do, using notations and concepts that are natural to their domain. The detailed decisions on *how* the code should be implemented, validated, and verified to satisfy the specification should be carried out through automated and semi-automated processes. This automated capability is expected to result in one to two orders of magnitude in time and cost savings.

The Automated Reasoning (AR) area intends to encourage basic research in artificial intelligence and advanced problem solving approaches that lead to greater autonomy in future missions. The results obtained from this area should lead to new approaches to the development of component technologies for autonomy as well as insight into how those technologies are to be integrated into autonomous systems, which ultimately can be tested and refined against full-scale real-world problem domains. While the AR area does not intend to develop new robotic platforms as part of this effort, we do encourage participants to take advantage of the knowledge that can be gained from existing platforms and facilities. Proposers intending to work in this area are encouraged to take advantage of simulated and/or hardware autonomy targets such as:

- the AR Mission Simulation Facility (MSF),
- planetary rover testbeds at NASA Ames and JPL,
- rotorcraft testbeds at NASA Ames,
- the Remote Agent,

- underwater vehicles or other robotic platforms at various research institutions, and
- other complex control systems requiring autonomy (e.g. the BIOPlex facility at NASA JSC).

Research areas within automated reasoning includes elements such as:
- Intelligent autonomous operations in uncertain environments.
- Utilizing an explicit representation of the uncertainty in a computationally efficient manner.
- The integration of knowledge-based techniques that leverage an explicit representation of an expert's knowledge with data-driven approaches that allow adaptation over time.
- Flexible and reusable model-based programming paradigms.
- Automated fault anticipation, diagnosis and recovery.
- Techniques that enable the generation of highly robust plans.
- On-board high-level science data analysis.
- Autonomous systems which respond to previously unforeseen science opportunities.
- Techniques that enable the rapid development of highly autonomous systems through the declarative specification of high-level goals and objectives coupled with a description of the device being controlled.
- Tradeoffs between reactive execution and deductive inference within a real-time control loop.
- Anytime algorithms that allow the gradual improvement of an initial solution as additional time and computational resources become available.
- Advanced debugging and model-development environments to facilitate the rapid development of autonomy software by spacecraft engineers.
- Integration of stochastic optimization techniques with more systematic approaches for constraint satisfaction.
- Formal specification languages for describing both conditions that must be satisfied as well as the functionality provided by the software.
- The extension and integration of model checking and theorem proving approaches to automated V&V.
- Automated abstraction for synthesis and verification.
- Verification and validation of autonomous systems, systems that learn, and coupled machine/human systems.

TA-2 – Intelligent Data Understanding

NASA is fundamentally a data-gathering and data-analyzing agency. To answer the basic questions about the origins, composition, and future of the Earth, solar system, and universe, we gather data with telescopes, probes, satellites, and astronauts, and then distribute it to teams of scientists to analyze the data to give us a better understanding of these questions. Data are then managed and archived by a diverse and highly specialized and geographically dispersed community. Furthermore, in support of the science missions, NASA maintains unique platforms and systems (like the Space Shuttle). Engineering data about these platforms is collected as part of maintenance and quality improvement. As with the scientific data, modern technologies can produce volumes of data that are increasingly difficult to fully and efficiently analyze. If NASA is to leverage and fully exploit the vast quantities of data currently available, innovative research is required to transform this distributed data into knowledge and assist in the decision making process.

Central to NASA's need for intelligent data understanding are processing and analysis requirements that result from the agency's unique opportunities for data acquisition through remote sensing. These opportunities lead to the sensing of large amounts of data, where the quantity is based upon the large areas covered (i.e., the spatial dimensions of the data); the periodic routine of data collection (the temporal dimension); and the portions of the electromagnetic spectrum being sensed (a dimension that leads to varying representations of the sensed objects). Most commercial databases are the result of the careful design of a solution to a problem. Database system designers begin with a problem and work towards a design that includes a thorough specification of the many fields that will comprise the many records that complete the database design. As a result, the precise purpose of every field is typically well understood. Future uses of the field, that might be unforeseen at the time of an initial design, are facilitated by the knowledge of the field's original purpose. With NASA's remotely sensed data, the full utility of each field is often not completely known. Furthermore, the accuracy and even the value of a field may require enhancements only possible through the use of ancillary data sources, such as in-situ sensors or spatial data from non-NASA sources. General attributes and intended uses of what is being sensed are understood, but the purposes for which the data may be used, and the general problems that the data may help solve serve, themselves, as the goals for scientific investigations. The current situation can be viewed as one where large numbers of observations have been acquired and stored on distributed databases, resulting in the need for "theories" that distill the information and knowledge content contained therein and between databases. Since the acquisition of data is a continuing process, general tools to assist humans in generating and testing these "theories" are needed. Due to the vast amounts of data involved, automated approaches that limit the need for human assistance are desirable.

The expected advances resulting from this program should result in products that streamline investigations by automating tasks that are best performed by machines while freeing scientists and engineers to focus on the creative process of hypothesis generation and knowledge synthesis. The Intelligent Data Understanding Research area intends to fund research in Data *Mining, Knowledge discovery for scientific understanding and engineering analysis,* and *Machine learning for decision-making and action*.

The Data Mining research efforts are to focus on fundamental techniques that extend our ability to intelligently process the raw data, extract information and detect interesting correlations and patterns. The processing of raw data is responsible for selecting the relevant subset of the data, removing noise or outliers, deciding on a strategy for handling sparse and missing data, extracting discrete features, separating signal from noise, evaluating the quality of the data, and other tasks. The task of detecting correlations generally involves the selection of a representation language for describing the correlations and patterns detected and fitting the data to a model within this representation language.

Various data mining techniques have been developed within the fields of machine learning, pattern recognition, reinforcement learning and statistics. Representative approaches to this problem include decision trees, neural networks, automated knowledge based construction of causal and probabilistic dependency models (e.g. Bayesian networks), non-linear regression, genetic algorithms, inductive logic programming and others. The Data Mining element will support work in many of these fields focussing on those methods that appear to be particularly well-suited to NASA's requirements and needs.

Specific research challenges for Data Mining:

- Techniques for dealing with geographically distributed, large or multidimensional data sets.
- Techniques for finding patterns using data from distributed, heterogeneous data sources.
- On-line techniques for improving the predictive accuracy of a model as additional samples are collected and stored.
- Specialized algorithms or biased sampling for discovering novel patterns.
- Intelligent "polishing" of the data to handle imperfections as opposed to simple filtering.
- Techniques for dealing with highly skewed data that is non-representative of the solution space.
- Active exploration and experimentation when collecting data to ensure adequate coverage.
- Automated techniques for extracting new features that provide better predictive power.
- Methods for assessing statistical significance and adjusting the test statistic as a function of the search (e.g. randomize testing).

The Knowledge Discovery for Scientific Understanding and Engineering Analysis area is concerned with the integration of multiple data streams using automated and interactive data analysis techniques to create a semi-automated environment for the discovery of causal relationships, hypothesis testing and theory formation. Efforts focus on advances that lead to tools and techniques to assist in the process of *interpreting* the patterns and correlations extracted from the data to generate *knowledge*. Knowledge discovery is the non-trivial process of identifying valid, novel, potentially useful, and ultimately understandable patterns in data. Knowledge discovery is often a mixed-initiative process that intimately involves the human as well as domain specific information to help guide the search for new models and theories. Research within the Knowledge Discovery element includes automated interpretation, model construction, hypothesis generation, and model revision. Another fundamental issue of interest is the detection of causal links from correlational data that can be used to predict the outcome of certain actions and events within regions for which there is limited data. Knowledge Discovery also covers work such as advanced data visualization techniques, explanation, and other approaches for communicating the information extracted from the data to the user as well as integrated systems that demonstrate the whole knowledge discovery process within the context of a focused task, including constraint-based approaches to causal discovery, representations for assisting in human understanding of discoveries, intelligent techniques for indexing, storing and retrieving instances from a large corpus of distributed data, and techniques for incorporating prior domain, common sense and even statistical knowledge possessed by the scientist into the discovery process. Techniques and methods for the specification of user knowledge in knowledge discovery environments will be a focus of attention of this area.

Pacing research challenges for Knowledge Discovery for Scientific Understanding and Engineering Analysis:

- Generalizing intelligently from statistical data and represented knowledge.
- Methods that incorporate significant user input in an integrated fashion.
- Inductive inference making use of background knowledge.
- Methods for inferring causation from associations and background knowledge.
- Novel methods of inductive or nonmonotonic or fallibistic inference that are both rationally defensible and correspond to human inferential procedures.

- Comprehensive theories of causality and how they apply to the analysis of data.
- Discovery of classification rules in domains (such as Earth Science) where the variables have complex interactions.
- Development of methods that exploit significant amounts of background or commonsense knowledge and combine this formalized background knowledge with data to yield approximate probabilities.

The Machine Learning for Decision Making and Action component focuses on developing data-driven techniques that can assist NASA engineers and scientists in the decision making process and suggest actions that lead to desired outcomes. The results developed within this element are applicable when monitoring, controlling and maintaining complex devices as well as when analyzing scientific data to make decisions.

An important issue to be addressed is the transition from *predicting* the value of a feature to the *selection* of an action that optimally achieves a desired outcome. This task requires the ability to develop predictive models and autonomously learn their behavior in order to determine how alternative actions perturb the system. Recent research in statistics and artificial intelligence has developed a theoretical understanding of when partial models of the structure of a system can be used to predict the effects of actions, and, conversely, when there is insufficient information for predictions. These algorithms have been implemented in limited and special cases, and their development, improvement, implementation and testing is an important research area.

Pacing research challenges for the Machine Learning for Decision Making and Action are:

- Learning *causal relations* that can be used to evaluate alternative actions when attempting to achieve a desired outcome.
- How to incorporate conjectures by human experts about the effects of the various potential actions the decision maker might make.
- Integrating data-driven decision routines into a knowledge-based intelligent assistant.
- Measuring the relevance and interestingness of a new sample.
- Algorithms to detect changes and to support learning from *time-series data*.
- Handling *non-representative data sets* such as maintenance records for the shuttle containing limited failure information.
- Integrating data-driven decision routines into a knowledge-based intelligent assistant.
- Unsupervised, learning techniques, including reinforcement learning techniques that can learn a classification using delayed reward.
- Theories of causality and how they apply to the analysis of data.
- Active exploration and experimentation when collecting data to ensure adequate coverage
- Algorithms for learning from *semi-structured* databases, such as vehicle maintenance records or meta-data.
- Algorithms to support *prognosis*, such as analyzing science data or maintenance records to predict failures before they occur and to predict the effects of actions.
- Methods for supporting the inference of causation from association.

TA-3 - Human-Centered Computing

Human-Centered Computing (HCC) is an interdisciplinary effort designed to integrate computer hardware and software with teams of experts, in order to build systems that make best use of all available resources. HCC focuses on the design of distributed systems of human and software agents. NASA seeks to invent and deploy intelligent systems designed to enhance and extend human cognitive and perceptual capabilities. In designing such intelligent collaborative systems, we are always aiming for a future work system in which large, diverse, distributed teams of intelligent agents will work together with orders of magnitude improvements in safety and effectiveness.

Efforts that extend the knowledge required to design flexible, robust performance enhancement systems are encouraged. One problem is the lack of understanding of the differences between the cognitive and computational abilities of human and machine. Better models of attention, concentration, memory, conceptual structure, decision-making, learning, and higher-level perception will provide the basis for the principled design of these capabilities. Furthermore, in order to enhance human performance in complex work systems, NASA must advance computational theory, models, simulations, and other enhancements of human-computer systems, leading to revolutionary approaches to specific and generalized problem solving that fully exploit human-machine abilities.

An important goal of much HCC research is to provide the understanding required to design and model entire work environments in which teams of humans and networks of machines are effectively integrated. Work system design requires articulating, simulating, and testing our understanding of how interactions develop in a system of humans, technologies, and the environment. Research in design tool software, human information flow modeling, cognitive task/work analysis, decision making under stress, psychophysiological reactivity, multi-person performance modeling, and work process modeling is needed. One representative application for these system design methodologies will be the design and construction of an automated mission-planning tool. Such a tool would be utilized in the design and simulation of complex endeavors such as manned or robotic missions to Mars. Unlike current simulation tools, human roles and activities, as well as those of smart machines, will be firmly embedded in the simulation framework, e.g. as software agents. The tool will be deployed to uncover mission design flaws, bottlenecks in decision-making, or gaps in expertise.

HCC will include elements such as:

- Innovative research on the nature, modeling, and sharing of human expertise.
- Methods and models for knowledge management and institutional knowledge capture.
- Engineering and mission-design knowledge capture research.
- Models and system-design methods for mixed-initiative systems.
- Technologies for supporting synchronous and asynchronous collaboration in science, engineering, and operations.
- Research on mediating representations intended to facilitate communication and understanding.
- Knowledge organization and representation technologies for distributed team training.

- Technologies for embedded (on-board) training/aiding systems.
- Model-based metrics for multi-agent performance assessment.
- Models of cognition and collaboration capable of facilitating effective "teamwork" between humans and software agents.
- Methodologies for integrating cognitive task and work-systems analysis into mission design.
- Models for effective operator interfaces to portable and wearable computational systems.
- Innovative designs for human/machine interfaces that communicate integrated task-relevant knowledge.
- Research on information overload and associated countermeasures.
- Software agent mobility, security, and behavior.
- Innovative human/machine interfaces and displays.
- Tools for enabling effective distributed scientific collaboration.
- Tools, methods, and metrics for multi-person performance modeling.
- Human-centered internet tools and applications (e.g., advanced browsers).

TA-4 – Revolutionary Computing

Increased computing capacity is a recurring theme in stated mission requirements across all NASA enterprises. Likewise, progress in the other IS program areas (Automated Reasoning, Human-Centered Computing, and Intelligent Data Understanding) will be hampered by computational complexity requirements that are currently considered intractable for classical computers. Increased computing capacity implies faster processing speeds and larger memory capacities, to handle a larger number of and more complex tasks. Increased computing capacity may also be achieved with novel approaches to problem solving.

Computers for space-based processing include systems carried on board satellites, spacecraft, rovers, or other robots performing earth observation or planetary missions. In this category, application of technology that provides faster processors and more memory is severely constrained by power and weight requirements. In addition, the operating environment involving radiation and thermal cycles severely impacts the robustness of systems and imposes additional penalties on weight and power. Robustness in the operating environment, power, and weight constraints are limiting factors in the adoption of commercial technology.

Space computing has generally not been the focus of computing technology developments. Consequently, space computing has adapted existing conventional computing technologies to work in the constraints of a space mission. This adaptation has had the consequence that space-based computing systems are one to two orders of magnitude less capable than their state-of-the-practice counterparts for ground-based systems.

The computing requirements of NASA space missions combined with the limitations of adapting conventional computing technology to fulfill these requirements provides a need and opportunity to look for solutions “outside the box.” Example missions in this category are those to Mars, Europa, and interstellar probes. Computing models based on quantum physics, statistical physics, and biology offer revolutionary concepts that could provide true breakthroughs that will increase the memory capacity and speed of computation in ways that classical approaches can not imagine. The advances being considered by these areas of research may allow one to address

some problems currently being viewed as intractable. The development of the models of computation that could guide technology development and the development of algorithms based on the underlying physics and biology is the focus of this activity.

4.1 Physics-Inspired Approaches to Computing.

Quantum Computing as an example of physics inspired approach to computing is a revolutionary approach to computing in which quantum effects, such as superposition, interference, and non-determinism, are exploited in the service of a new approach to computation enabling efficient solutions to problems heretofore deemed intractable.

Although quantum computing is now in its infancy, success in this research area could have a revolutionary direct impact on NASA's missions of aeronautics and space exploration. For example, future deep space missions will be conducted largely by sophisticated, autonomous spacecraft operating in harsh environments and under extreme constraints on permitted mass, time to respond, and available electrical power. These robotic explorers will need massive computational power to endow them with capabilities such as on-the-fly mission re-planning, real-time onboard data analyses, and autonomous diagnosis, repair, and reconfiguration to name but a few.

Physics-Inspired Approaches to Computing will focus on the following areas:

- Develop novel and efficient quantum and other physics based algorithms that address NASA relevant problems.
- Explore and expand the scope of problems that are known to be efficiently solvable using physics based models.
- Devise and study networks of quantum gates that can solve interesting problems.
- Study, develop, and assess methods to improve the reliability of a quantum computer that operates under realistic NASA conditions (e.g., noisy, Rad-hard, low power).
- Conduct computational complexity research in the context of quantum computation.
- New computer languages capable of producing, automatically, the massively parallel problem solutions that could run on quantum computers.
- Develop useful computational simulations of proposed models.
- Examine physical realization and robustness by modeling and simulation.
- Identify and characterize potential applications of quantum computers that would strategically enable future NASA missions.
- Characterize the extent proposed concepts can speed up the solution of NP-complete problems.
- Develop methodologies and methods for automating the discovery of novel algorithms from a description of physics.

4.2 Biology-Inspired Approaches to Computing

A biological system can be viewed as being composed of interacting elements that exchange and process information. In this context, these systems may provide a rich source of computation

models for the Automated Reasoning, Human-Centered Computing, and Intelligent Data Understanding program areas. For example, many of the autonomy problems faced by NASA have already been solved by biological systems. The basic idea motivating this endeavor is to learn how biological systems address the apparent complexity of autonomous activities and then exploit that knowledge to develop advanced computational systems. This approach could be particularly useful in enhancing the *problem solving* capabilities of autonomous agents.

Neural computing research has led to approaches to learning, adaptation, and control that may result in significant advances in our understanding about how to solve related problems. Much of the current work in neural computing deals with recognition of instantaneous patterns (e.g. face recognition in a static image). Biological systems, however, exist in environments rich with temporal information. The autonomous systems envisioned in this program will need to take advantage of this additional information. Thus, understanding neural systems that store, process, and retrieve, temporal information will be a central research issue.

Genetic and evolutionary algorithms use biological-inspired mechanisms, selective reproduction, mutation, and genome crossover, to search for optimal structures. Genetic and evolutionary programming applies these techniques to the task of automatic programming. One major difficulty in this area that will need to be addressed in the near future is the encoding of problems so that these biology-inspired search techniques can uncover satisfactory solutions.

As we learn how genetic information is encoded, stored, retrieved - particularly if new levels of information primitives are discovered - new models of computation may result. One example of the class of models that could ensue is the "DNA Computer." This approach, like Quantum Computing, might revolutionize our approach to computing.

Biologically-Inspired Approaches to Computing will focus on the following areas:

- Understand how organisms organize the complexity of their environments in order to survive and prosper.
- Examine biologically inspired approaches to sensor fusion and action selection.
- Neural computing techniques for adaptation of control systems.
- Formalize strategies for organizing problems to maximize the effectiveness of evolutionary search strategies.
- Extract algorithms from existing biochemical knowledge of the storage, processing, retrieval, of genetic information.
- Enhance fault tolerance based on immune systems.
- Explore biologically inspired computational substrates such as DNA computation and neural circuitry.
- Understand and exploit how recurrent neural networks recognize and act upon temporal patterns in data.
- Construct systems capable of carrying out biologically inspired computation at very large scales.

FUNDING

The following budget information is provided for planning purposes only. Any award will be subject to the availability of funds.

The Government anticipates multiple awards in each technology area within the available funding. Expected real year funding in millions of dollars, by government fiscal year (FY), is as follows:

		FY01	FY02	FY03
747-10	Automated Reasoning	4.7	8.3	8.2
747-20	Human-Centered Computing	3.3	6.0	5.9
747-30	Intelligent Data Understanding	3.7	6.6	6.4
747-40	Revolutionary Computing	1.5	2.8	2.8
	Totals (NRA)	**13.2**	**23.7**	**23.3**

This profile includes funding for all of the following:

a. Funds provided directly to the selected offerors.

b. Funds required to pay for charges relating to the performance of Government responsibilities under resulting grants, cooperative agreements or contracts. These may include charges for program support, materials, facility modifications, etc., but do not include salaries or travel for Government personnel. Payment of these charges will be made internal to the Government out of the available program funding. Charges will be consistent with agency wide full-cost accounting practices.

SUPPLEMENTAL PROPOSAL INSTRUCTIONS

Proposals shall conform to the guidelines in Appendix B, "Instructions for Responding to NASA Research Announcements." The following supplemental instructions are provided in addition to Appendix B:

Proposal Content, Format / Length, and Evaluation Process

Proposals should be written concisely in English. Step 1 proposals may be up to 5 pages of text, single-spaced, with type no smaller than 12-pt., including abstract and references. Full proposals may be up to fifteen pages of text, single-spaced, with type no smaller than 12-pt., including abstract and references.

In addition to paper copies of the proposal (see NRA letter), an electronic copy of the proposal shall be submitted in a format readable with Microsoft Word 2000. Text, tables and graphics shall allow for copy and paste into other applications. In addition, supporting cost information

shall be provided in Microsoft Excel 2000 – compatible spreadsheets. All electronic information shall be provided on either a Zip (100 MB), CDROM, or floppy for PC platforms.

The proposal process will involve two stages: Step 1, requiring brief, summary proposals, and Step 2, requiring full proposals. All investigators interested in being considered for funding through this NRA must submit a Step 1 proposal. Note: If the Government finds sufficient merit from the initial Step 1 abbreviated proposals, the Government reserves the right to request detailed budget information and required certifications and may award off of initial summary submittals.

A. Step 1 Proposals.

Step 1 proposals may be up to 5 pages of text, single-spaced, with type no smaller than 12-pt., including abstract and references. The text should describe concisely the research to be conducted, emphasizing the research objectives, technical approach, and expected results. Not included in this page total is the cover page. The Step 1 proposal cover page should contain the following: a short, descriptive title for the proposed effort; the name of the proposing organization(s); names, addresses, telephone numbers, FAX number, electronic mail addresses, and affiliations of the Principal Investigator and all Co-Investigators; and a total cost estimate by year. The Step 1 proposal should bear official institutional signatures. Any additional material submitted with the Step 1 proposal will be discarded.

Step 1 proposals will be reviewed by a technical review panel on the basis of their intrinsic merit, relevance to NASA's objectives, and cost. The criteria listed below will be used in evaluating individual Step 1 proposals:

1. The relevance and responsiveness of the proposed research to the goals and objectives of the Intelligent Systems (IS) Program and the particular Technology Research Areas, as described in this announcement.
2. The innovativeness of the technical approach.
3. The qualifications, capabilities, and related experience of the proposed principal investigator and key personnel.
4. The relevance of the proposed research to future NASA missions.
5. The proposed cost of the investigation in relation to the available funds.

Following the panel review, NASA will place each Step 1 proposal in one of four groups:

- **high priority** (well-conceived proposals of high scientific and technical merit and strongly relevant to the goals of the IS Program)
- **medium priority** (relevant proposals of sound scientific and technical merit, but of lower priority than those categorized as high priority)
- **low priority** (proposals of lesser relevance, and/or containing major scientific or technical deficiencies, and/or with high costs relative to their projected scientific returns)
- **non-responsive/unimplementable** (proposals not relevant to the goals of the IS Program, or proposals so scientifically or technically flawed that they appear to be unimplementable, or proposals with cost estimates exceeding the resource levels available for this NRA)

Note: If the Government finds sufficient merit from the initial abbreviated proposal, the Government reserves the right to request detailed budget information and certifications, and may award off of the initial summary submittals.

Proposers will be notified as soon as possible of the categorization of their Step 1 proposal, and will receive summaries of comments from the panel.

- Proposers whose Step 1 proposals were categorized as **high priority** will receive a specific recommendation encouraging submission of a Step 2 proposal.
- Proposers whose Step 1 proposals were categorized as **medium priority** will receive a recommendation that Step 2 proposals from them will be acceptable, but not specifically encouraged.
- Proposers whose Step 1 proposals were categorized as **low priority** will receive a recommendation that Step 2 proposals from them will be considered, but are discouraged.
- Proposers whose Step 1 proposals were categorized as **non-responsive/ unimplementable** will receive a specific recommendation strongly discouraging submission of a Step 2 proposal.

Step 2 proposals will be due within 2 months after the date of notification of the results of the Step 1 proposal review. The letter notification will establish the exact due date.

B. Step 2 Proposals

The content of the Step 2 proposal should provide sufficient detail to enable a reviewer to assess the value of the proposed research, its relation to IS Program objectives, and the probability that the investigators will be able to accomplish the stated objectives within the requested resources and schedule. The technical part of the proposal should be limited to the equivalent of 15 pages of text, single-spaced, with type no smaller than 12 pt., including abstract and references. The cover page, table of contents, management plan, data plan, cost plan, and short resumes do not count in this total. Additional pertinent information may be added as appendices.

Each proposal should contain the following materials assembled in the order given.

1. Cover Letter. Each proposal should be prefaced by a cover letter signed by an official of the investigator's institution who is authorized to legally bind the organization to the proposal and its content (unless the signature appears on the proposal itself). The cover letter should refer to the Intelligent Systems Program.

2. Proposal Cover Page. The proposal cover page should contain the following: a short, descriptive title for the proposed effort; the name of the proposing organization(s); names, addresses, telephone numbers, FAX numbers, electronic mail addresses, and affiliations of the Principal Investigator and all Co-Investigators; and a year by year budget summary, including a total for all years. An example cover page is provided in Appendix D.

3. Table of Contents (recommended length: 1 page). A table of contents listing the page numbers for key sections of the proposal, including the data, management, and cost plans, should be provided.

4. Abstract and Technical Plan (not to exceed 15 pages). The abstract should summarize the research proposed in one page or less. It should contain a simple, concise overview of the investigation, its objectives, its scientific approach, expected results, and the value of its results to the IS Program. It is very important that this abstract be specific and accurately represent the research to be conducted.

The main body of the proposal should contain a full statement of the research to be undertaken and should describe objectives, scientific relevance, technical approach, and expected significance of the work. The key elements of the project should be clearly identified and related to each other. The methods or approaches to be used should be described, and, as appropriate, the advantages of the selected methods or approaches over alternatives should be discussed. The anticipated results should be identified and their relation to the proposal's stated objectives and the objectives of the IS Program should be discussed. The research should be described in sufficient detail that peer reviewers can adequately assess the scientific methods and quality of the work proposed.

A list of references used in the Technical Plan should be provided.

5. Management Plan (recommended length: 1/2 - 2 pages, depending on complexity). The Management Plan should outline the roles and responsibilities of all investigators and collaborators and indicate the relationships among these roles and responsibilities within the group. The management plan should also identify what contractor and/or non-institutional support is anticipated and who will be providing it.

6. Cost Plan for U.S. Proposals Only (recommended length: 1 page per budget year, 1 budget summary page, 1/2 - 2 pages of explanation/justification, 1/2 - 2 pages detailing other funded projects). A detailed cost plan must be provided. Costs should be broken down into all of the following categories that apply: salaries and wages, including staff-months and rates for all personnel; benefits; supplies; services; equipment purchases; data purchases; computer services; publication costs; communications; travel; overhead; and other. Proposers are encouraged to utilize appropriately ramped funding profiles which will enable them to participate in collaborative activities with other IS Program participants in the second and third year of their research activities.

Contributions from any cost-sharing plan or other support for the proposed research should be detailed.

Current funding from other sources, including the level of funding and the title or brief description of the supported research, should be listed.

7. Resumes. Brief resumes (1-2 pages) for all named investigators should be appended to the proposal.

8. Declarations and Certifications. Certifications bearing official institutional signatures regarding drug-free workplace requirements, debarment and suspension, and lobbying must be appended. Example forms are provided in Appendix D.

If the proposal requires the use of NASA or other government facilities in performing the research, then appropriate letters or support and/or MOU's should be appended stating that the facilities will be available (see "Government Installation Support" below).

9. Other Enclosures. Any other material pertinent to the consideration of the proposal may be attached as an Appendix. This might include preprints or reprints of relevant publications, background on new measurement or analysis approaches, or letters of support and/or participation by scientists and/or agencies in other countries. Inclusion of general materials that will not aid in the evaluation of the proposal is specifically discouraged.

C. Selection Process and Evaluation Criteria for Step 2 Proposals

Step 2 proposals will be reviewed by a technical review panel on the basis of their intrinsic merit, relevance to NASA's objectives, and cost. The criteria listed below will be used in evaluating individual Step 2 proposals:

1. The relevance and responsiveness of the proposed research to the goals and objectives of the Intelligent Systems (IS) Program and the particular Technology Research Areas, as described in this announcement.
2. The innovativeness of the technical approach.
3. The qualifications, capabilities, and related experience of the proposed principal investigator and key personnel.
4. The relevance of the proposed research to future NASA missions.
5. The proposed cost of the investigation in relation to the available funds.

Step 2 proposals will also be reviewed by NASA managers to identify any logistical, implementation, cost, and/or management concerns. Under Step 2, NASA will only consider those proposals that had their scientific objectives and technical approach evaluated in Step 1.

NASA may desire to accept only a portion of a proposer's investigation, in which case the investigator will be given the opportunity to accept or decline such partial acceptance. In cases in which two or more proposals address similar problems and/or adopt complementary approaches to a larger problem, NASA may desire joint participation on the part of two or more proposers in a single project. If such overlap involves more than one funding organization, NASA and those organizations will confer and mutually agree to the disposition of those proposals.

Period of Performance

Technology development and demonstrations must be completed after the proposed award date and no later than September 30, 2003.

Number of proposals

Interested responders may propose on any or all of the areas being solicited. Each offeror is encouraged to submit one integrated proposal.

Government Installation Support

Government installations may propose to provide non-cash resources (including analysis, design, test, fabrication, facilities, and other resources) within the capabilities and resources of the various field centers to support the proposed activities of non-governmental organizations. The proposal must include documentation of the installation's agreement to provide the planned services in the form of a letter of commitment from the installation's director or designee. This letter of commitment must describe the tasks to be performed, key milestones, assumptions made and a cost summary broken down by civil service labor, support contractor labor, materials and other costs by FY. Offerors should propose the use of only Government installation resources they believe are necessary for the successful completion of the project.

Management

The offeror's proposal shall include support of annual reviews to the Intelligent Systems Program Office and an independent annual NASA review team.

All reports generated under proposed activities shall be submitted electronically to NASA via a secure website maintained by the offeror. Reports shall be accessible by both Macintosh and PC platforms.

Teaming

Teaming between multiple organizations is encouraged where it benefits the development of low cost technologies. Teaming with NASA researchers and technologists is especially encouraged.

Deviations

If applicable, the Offeror's proposal shall describe any deviations proposed to the model cooperative agreement included in the NASA Grant and Cooperative Agreement Handbook (NHB 5800.1).

Restrictions on Data Produced

This activity will produce data to support future NASA information systems development. It is the goal of this NRA to develop technologies in cooperation with U.S. industry for use in the development of intelligent systems. Therefore, proposals requiring restrictions on distribution of any aspect of the completed and resulting technology must include a justification for the restriction and the time period for which the restriction would apply. It is anticipated that the data generated will be subject to applicable export control laws.

Cost

In general, cost sharing is permitted under contracts in which there is no profit. Cost sharing is required for cooperative agreements. Cooperative agreements with for-profit companies are governed by the final rule on Cooperative Agreements with Commercial Firms, NASA Grant and Cooperative Agreement Handbook (NHB 5800.l). Criteria and procedures for the allowability and allocability of cash and non-cash contributions shall be governed by Section 23, "Cost Sharing or Matching," of OMB Circular A-110.

Foreign Participation

Policy on use of foreign technology is attached in Appendix C. This policy applies to all proposals submitted under this NRA. In general, foreign participation is permitted on a no-cost basis when the foreign company or institution is teamed with a US partner.

NRA Access

A digital copy of this NRA and related documents may be obtained over the Internet. These documents will be in Microsoft Office 2000 format and will reside on a World Wide Web (WWW) server, which may be accessed using a WWW browser application. The WWW address, or URL for more information regarding this NRA is http://procurement.nasa.gov/cgi-bin/NAIS/link_syp.cgi or http://ic.arc.nasa.gov/ic/nra.

APPENDIX B

INSTRUCTIONS FOR RESPONDING TO NASA RESEARCH ANNOUNCEMENTS

1. Foreword

a. These instructions apply to "NASA Research Announcements." The "NASA Research Announcement (NRA)" permits competitive selection of research projects in accordance with statute while preserving the traditional concepts and understandings associated with NASA sponsorship of research.

b. These instructions incorporate 1852.235-72 of the NASA Federal Acquisition Regulation Supplement.

INSTRUCTIONS FOR RESPONDING TO NASA RESEARCH ANNOUNCEMENTS (JANUARY 2000)

(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 *[<u>insert page numbers or other identification</u>]* 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 (U.S. Proposals Only).**

(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).

(iv) Use of NASA funds--NASA funding may not be used for foreign research efforts at any level, whether as a collaborator or a subcontract. The direct purchase of supplies and/or services, which do not constitute research, from non-U.S. sources by U.S. award recipients is permitted. Additionally, in accordance with the National Space Transportation Policy, use of a non-U.S. manufactured launch vehicle is permitted only on a no-exchange-of-funds basis.

(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.** Proposals or proposal modifications received after the latest date specified for receipt may be considered if a significant reduction in cost to the Government is probable or if there are significant technical advantages, as compared with proposals previously received.

(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) **Additional Guidelines Applicable to Foreign Proposals and Proposals Including Foreign Participation.**

(1) NASA welcomes proposals from outside the U.S. However, foreign entities are generally not eligible for funding from NASA. Therefore, unless otherwise noted in the NRA, proposals from foreign entities should not include a cost plan unless the proposal involves collaboration with a U.S. institution, in which case a cost plan for only the participation of the U.S. entity must be included. Proposals from foreign entities and proposals from U.S. entities that include foreign participation must be endorsed by the respective government agency or funding/sponsoring institution in the country from which the foreign entity is proposing. Such endorsement should indicate that the proposal merits careful consideration by NASA, and if the proposal is selected, sufficient funds will be made available to undertake the activity as proposed.

(2) All foreign proposals must be typewritten in English and comply with all other submission requirements stated in the NRA. All foreign proposals will undergo the same evaluation and selection process as those originating in the U.S. All proposals must be received before the established closing date. Those received after the closing date will be treated in accordance with paragraph (g) of this provision. Sponsoring foreign government agencies or funding institutions may, in exceptional situations, forward a proposal without endorsement if endorsement is not possible before the announced closing date. In such cases, the NASA sponsoring office should be advised when a decision on endorsement can be expected.

(3) Successful and unsuccessful foreign entities will be contacted directly by the NASA sponsoring office. Copies of these letters will be sent to the foreign sponsor. Should a foreign proposal or a U.S. proposal with foreign participation be selected, NASA's Office of External Relations will arrange with the foreign sponsor for the proposed participation on a no-exchange-of-funds basis, in which NASA and the non-U.S. sponsoring agency or funding institution will each bear the cost of discharging their respective responsibilities.

(4) Depending on the nature and extent of the proposed cooperation, these arrangements may entail:

(i) An exchange of letters between NASA and the foreign sponsor; or

(ii) A formal Agency-to-Agency Memorandum of Understanding (MOU).

(m) **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.

(End of provision)

APPENDIX C - POLICY FOR THE USE OF FOREIGN TECHNOLOGY

The National Space Transportation Policy directs that the U.S. Government will seek to take advantage of foreign components or technologies in developing U.S. next-generation space transportation systems. Such activities will be consistent with U.S. nonproliferation, national security, and foreign policy goals and commitments, as well as the commercial-sector guidelines contained in the National Space Transportation Policy. They will be conducted in a manner consistent with U.S. obligations under the Missile Technology Control Regime and with due consideration given to dependence on foreign sources and national security.

The Intelligent Systems program may seek to take advantage of all beneficial components and technologies, both foreign and domestic, in developing information systems for U.S. next-generation space transportation systems and other NASA missions. Foreign participation in the Intelligent Systems Program will be undertaken on a institution-to-institution contractual basis with a US partner, and will be conducted consistent with the policy and guidelines in this document.

NASA will make available expertise and resources as appropriate to assist U.S. companies in identifying and analyzing potential foreign participation that could clearly advance the interests of the development and demonstration program.

The National Space Transportation Policy also provides that, for the foreseeable future, U. S. Government payloads will be launched on space launch vehicles manufactured in the United States, unless exempted by the President or his designated representative, or unless foreign launch vehicles are used on a no-exchange-of-funds basis to support the following: flight of scientific instruments on foreign spacecraft, international scientific programs, or other cooperative government-to-government programs. Such use will be subject to interagency coordination procedures.

GUIDELINES

Any U.S. companies or other organizations that decide to utilize foreign components or technologies in IS projects should be cognizant that NASA's participation, both as the major provider of research funding and as a major potential customer of future intelligent systems, will be subject to the following criteria:

1. Foreign participation must provide clear net benefits to the achievement of the program's technical and business objectives, and further NASA's goal of establishing itself as a world-class developer of information technology.

2. Federal funds may be used for manufacture or acquisition of off-the-shelf foreign component technology, but may not be used for foreign-based development of foreign technology unless specifically exempted by the NASA Administrator.

3. Incorporation of foreign technology must not threaten the successful execution of the program, both in its developmental and operational phases.

4. Due consideration is given to fostering U.S. competitiveness and safeguarding national security interests throughout the life of the program.

5. Close consultation is maintained with NASA and other appropriate U.S. Government agencies on all aspects of foreign participation.

NASA will consult with executive agencies, including the Office of Science and Technology Policy, the National Security Council, and the Office of Management and Budget, to ensure that all national interests are sufficiently reflected in ongoing IS program activities.

APPENDIX D

EXAMPLES OF REQUIRED DECLARATIONS AND PROPOSAL COVER PAGE

Certification Regarding
Debarment, Suspension, and Other Responsibility Matters
Primary Covered Transactions

This certification is required by the regulations implementing Executive Order 12549, Debarment and Suspension, 34 CFR Part 85, Section 85.510, Participant's responsibilities. The regulations were published as Part VII of the May 26, 1988 Federal Register (pages 19160-19211). Copies of the regulation may be obtained by contracting the U.S. Department of Education, Grants and Contracts Service, 400 Maryland Avenue, S.W. (Room 3633 GSA Regional Office Building No. 3), Washington, DC. 20202-4725, telephone (202) 732-2505.

(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 from covered transactions 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 statues 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 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.

Organization Name PR/Award Number or Project Name

Name and Title of Authorized Representative

Signature Date

Certification Regarding Drug-Free Workplace Requirements
Grantees Other Than Individuals

This certification is required by the regulations implementing the Drug-Free Workplace Act of 1988, 34 CFR Part 85, Subpart F. The regulations, published in the January 31, 1989 Federal Register, require certification by grantees, prior to award, that they will maintain a drug-free workplace. The certification set out below is a material representation of fact upon which reliance will be placed when the agency determines to award the grant. False certification or violation of the certification shall be grounds for suspension of payments, suspension or termination of grants, or government wide suspension or debarment (see 34 CFR Part 85, Sections 85.615 and 85.620).

This grantee certifies that it will provide a drug-free workplace by:

(a) Publishing a statement notifying employees that the unlawful manufacture, distribution, dispensing, possession or use of a controlled substance is prohibited in the grantee's workplace and specifying the actions that will be taken against employees for violation of such prohibition;

(b) Establishing a drug-free awareness program to inform employees about -
(1) The dangers of drug abuse in the workplace;
(2) The grantee's policy of maintaining a drug-free workplace;
(3) Any available drug counseling, rehabilitation, and employee assistance programs, and
(4) The penalties that may be imposed upon employees for drug abuse violations in the workplace;

(c) Making it a requirement that each employee to be engaged in the performance of the grant be given a copy of the statement required by paragraph (a);

(d) Notifying the employee in the statement required by paragraph (a) that, as a condition of employment under the grant, the employee will -
(1) Abide by the terms of the statement; and
(2) Notify the employer of any criminal drug statute conviction for a violation occurring in the workplace no later than
five days after such conviction;

(e) Notifying the agency within ten days after receiving notice under subparagraph (d)(2) from an employee or otherwise receiving actual notice of such conviction;

(f) Taking one of the following actions, within 30 days of receiving notice under subparagraph (d)(2), with respect to any employee who is so convicted -
(1) Taking appropriate personnel action against such an employee, up to and including termination; or
(2) Requiring such employee to participate satisfactorily in a drug abuse assistance or rehabilitation program approved
for such purposes by a Federal, State, or local health, law enforcement, or other appropriate agency;

(g) Making a good faith effort to continue to maintain a drug-free workplace through implementation of paragraph (a), (b), (c), (e), and (f).

Organization Name PR/Award Number or Project Name

Name and Title of Authorized Representative

Signature Date

ED 80-0004

CERTIFICATION REGARDING LOBBYING

Certification for Contracts, Grants, Loans, and Cooperative Agreements.

The undersigned certifies, to the best of his or her knowledge and belief, 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 any 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 entering into of any cooperative agreement, and the extension, continuation, renewal, amendment, or modification of any Federal contract, grant, loan, or cooperative agreement.

(2) If any funds other than Federal 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 this Federal contract, grant, loan, or cooperative agreement, the undersigned shall complete and submit 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.

This certification is a material representation of fact upon which reliance was placed when this transaction was made or entered into. Submission of this certification is a prerequisite for making or entering into this transaction imposed by section 1352, title 31, U.S. Code. Any person who fails to file the required certification shall be subject to a civil penalty of not less than $10,000, and not more than $100,000 for each such failure.

_____

Signature and Date

_____

Name and Title of Authorized Representative

_____

Organization Name

INTELLIGENT SYSTEMS: NRA2-37143

Title: _____

Principal Investigator Name:_____

Department:_____

Institution:_____

Address: _____

City: _____ State: _____ Zip: _____

Country: _____ E-mail: _____

Telephone: _____ Fax:_____

Co-Investigators:

Name	Institution	Telephone	Electronic Mail
_____	_____	_____	_____
_____	_____	_____	_____
_____	_____	_____	_____
_____	_____	_____	_____
_____	_____	_____	_____
_____	_____	_____	_____

Budget (in $K):

1st Yr.: _____ 2nd Yr.: _____ 3rd Yr.: _____

Total: _____

Requested Start Date: _____ Requested Duration:_____

Technical Area Proposing Under:_____

(TA choices: 1) TA-1 Automated Reasoning, 2) TA-2 Intelligent Data Understanding, 3) TA-3 Human-Centered Computing, or 4) TA-4 Revolutionary Computing.

Authorizing Official: _____ _____

(Name) (Institution)