APPENDIX B. HELIOPHYSICS RESEARCH PROGRAM

B.1 OVERVIEW

1. Overview

NASA's Heliophysics Research Program supports research activities that address understanding of the Sun and planetary space environments, including the origin, evolution, and interactions of space plasmas and electromagnetic fields throughout the heliosphere and in connection with the galaxy. Understanding the origin and nature of solar activity and its interaction with the space environment of the Earth is a particular focus. The program seeks to characterize these phenomena on a broad range of spatial and temporal scales, to understand the fundamental processes that drive them, to understand how these processes combine to create space weather events, and to enable a capability for predicting future space weather events.

The program supports investigations of the Sun as a typical dwarf star including processes taking place throughout the solar interior and atmosphere; the evolution and cyclic activity of the Sun; and the origin and behavior of the solar wind, energetic particles, and magnetic fields in the heliosphere and their interaction with the interstellar medium. The program also supports investigations of the physics of magnetospheres, including their formation and fundamental interactions with plasmas, fields, and particles; and the physics of the mesosphere, thermosphere, ionosphere, and aurorae of the Earth, including the coupling of these phenomena to the lower atmosphere and magnetosphere.

The Heliophysics Research Program of 2010 represents a strategic commitment to system science — emphasizing the understanding of fundamental processes and interconnections across the traditional science disciplines. In concert with the other NASA science divisions (Planetary Science, Astrophysics, and Earth Science), the Program shares responsibility for learning about the Earth, our solar system, the universe, and their interrelationships. This kind of comprehensive knowledge is necessary if mankind is to reach beyond the confines of our planet and navigate safely across the vast ocean of space.

The Heliophysics Research Program is formulated to contribute directly and substantially to national priorities:

Leadership in Fundamental Research: The Heliophysics Research Program is the world's leading scientific effort in and across the field of Heliophysics science. Investigations selected for the program address problems of the highest intrinsic science and technical merit that are relevant to NASA's Heliophysics strategic objectives.

Educating the Next Generation and Creating a World-class Workforce: NASA is committed to communicating the new knowledge gained from its programs and to inspiring a new generation of scientists and engineers. Future Heliophysics experimentalists are prepared via intensive internships in the suborbital programs, support for postdoctoral positions, and the SMD-wide NASA Earth and Space Science Fellowship (NESSF) program for graduate students. Science workshops and annual graduate-level summer schools sustain a pipeline of participation.

Driving Technological Innovation: Innovation is the engine that drives scientific progress in Heliophysics research and its prompt transition from basic understanding to advanced applications. Being at the forefront of scientific endeavors necessarily entails the need for new measurement, data analysis, and modeling techniques. Heliophysics technology development projects focus on the rapid development and infusion of new, mission-enabling technologies.

Enhancing Environmental Stewardship: The Earth is embedded in the extended atmosphere of the Sun, and the Sun's magnetic variability drives the Earth and Earth's environment. The physical mechanisms that link the variations seen on the Sun with the variability occurring at the Earth are poorly understood. In addition, it is known that important elements of our society's technological infrastructure are vulnerable to the effects of disturbances in Earth's space environment that are caused by activity at the Sun. However, there has been rapid progress over the past ten years. NASA's Heliophysics research programs are dedicated to understanding these effects, to understand their root cause, and provide the information needed to protect assets critical to our society and economy.

The scientific documentation underlying the Heliophysics Research Program provides the needed background for proposals addressing its objectives. The science carried out must directly address NASA's Strategic Subgoal to study the Sun and its interactions with the Earth and the Solar System (see Section I(a) and Table 1 in the *ROSES Summary of Solicitation*)**.** In particular, proposals must address the more specific Science Outcomes (see Section I(a) and Table 1 in the *ROSES Summary of Solicitation*), which are to achieve:

- Progress in understanding the fundamental physical processes of the space environment—from the Sun to Earth, to other planets, and beyond to the interstellar medium;
- Progress in understanding how human society, technological systems, and the habitability of planets are affected by solar variability interacting with planetary magnetic fields and atmospheres; and
- Progress in maximizing the safety and productivity of human and robotic explorers by developing the capability to predict the extreme and dynamic conditions in space.

NASA's Heliophysics research program is an end-to-end one that starts with the formulation of theories as explanations of the phenomena under study, and the design of experimental studies to test these theories; the development of observational techniques and the instrument technology needed to implement them; experiments in the laboratory and from an appropriate set of balloon-sounding rocket- and/or space-based platforms; uses the results to increase basic knowledge; incorporates results into computational models that can be used to more fully characterize the present state and future evolution of the Heliophysics system; and develops conduits to other national and international agencies that can use the generated knowledge in space weather forecasting and in policy and resource management.

A brief description of each program element offered in the Heliophysics Research Program is given below. The intent of these summary statements is to give the prospective proposer insight into the element's purpose and context within the overall program structure. Detailed descriptions of each element are to be found in Appendices B.2 through B.8.

2. Program Elements

Heliophysics Theory:
Theory investigations are the foundation of the Heliophysics Research Program. They lead the way to new understanding of previous investigations and drive science concepts for future strategic missions. The Heliophysics Theory program element supports large PI-proposed team efforts that require a critical mass of expertise to make significant progress in understanding complex physical processes with broad importance. Competed once every three years, theory investigations will be solicited in 2010 as part of the Heliophysics Theory program element described in Appendix B.2.

Supporting Research and Technology (SR&T):
SR&T investigations are the advanced planning arm of the Heliophysics research program. Results of investigations in the program guide the direction and content of future science missions. This element supports individual research tasks that employ a variety of fundamental research techniques (e.g., theory, numerical simulation, and modeling), analysis and interpretation of space data, development of new measurement concepts, and laboratory measurements of relevant atomic and plasma parameters, all to the extent that they have a clear application to Heliophysics program goals. Geospace SR&T tasks are solicited as part of the Geospace Science element described in Appendix B.3, while solar and heliospheric SR&T tasks are solicited as part of the Solar and Heliospheric Science program element described in Appendix B.4.

Low Cost Access to Space (LCAS):
LCAS investigations have as their objective science investigations that may be completed through suborbital rocket, Commercial Reusable Suborbital Research (CRuSR), or balloon flight of experimental instrumentation, as well as proof-testing new concepts in experimental techniques that may ultimately find application in free-flying Heliophysics space missions. Geospace LCAS investigations are solicited as part of the Geospace Science program element described in Appendix B.3, while solar and heliospheric LCAS investigations are solicited as part of the Solar and Heliospheric Science element described in Appendix B.4.

Instrument Development:
Instrument development investigations have as their objective the development of instrument technologies that show promise for use in scientific investigations on future Heliophysics science missions, including the development of laboratory instrument prototypes, but not of flight hardware. The goal is to define and develop scientific instruments and/or components of such instruments to the point where complete instruments may be proposed in response to future Announcements of Opportunity without significant additional technology development. Geospace instrument development investigations are solicited as part of the Geospace Science program element described in Appendix B.3, while solar and heliospheric instrument development investigations are solicited as part of the Solar and Heliospheric Science element described in Appendix B.4.

Heliophysics Guest Investigators (GI):
Heliophysics GI investigations are focused on maximizing the scientific return from the missions of the Heliophysics System Observatory (HSO). The GI program enables a broad community of heliophysics researchers in universities and other institutions to use the HSO data in innovative scientific investigations to (a) broaden the scientific output of existing missions, or (b) apply the data from existing missions to new scientific goals. The focus of the selected research continuously evolves to ensure that the most important questions identified by the operating mission senior reviews are addressed. The Heliophysics Guest Investigator program element, Appendix B.5, is not competed in ROSES-2010.

LWS Targeted Research and Technology (TR&T):
The goal of NASA's Living With a Star (LWS) Program is to develop the scientific understanding needed for the United States to effectively address those aspects of Heliophysics science that may affect life and society. To ensure this the TR&T program solicits large-scale problems that cross discipline and technique boundaries leading to a physics-based understanding of the integral system linking the Sun to the Solar System both directly and via the heliosphere, planetary magnetospheres, and ionospheres. The proposals must identify how this new understanding will have a direct impact on life and society. In addition, TR&T supports the Sun-Climate objective whose goal is to deliver the understanding of how and to what degree variations in the solar radiative and particulate output contribute to changes in global and regional climate over a wide range of time scales. Development of Tools and Methods that are needed to achieve the LWS goals are also supported. The LWS TR&T program element is described in Appendix B.6.

LWS Targeted Research and Technology (TR&T) Strategic Capability:
A primary goal of NASA's LWS Program is the development of first-principles-based models for the coupled Sun-Earth and Sun-Solar System, similar in spirit to the first-principles models for the lower terrestrial atmosphere. Such models can act as tools for science investigations, as prototypes and test beds for prediction and specification capabilities, as frameworks for linking disparate data sets at vantage points throughout the Sun-Solar System, and as strategic planning aids for enabling exploration of outer space and testing new mission concepts. Strategic Capabilities are the development and integration of such models for all the various components of this system. The LWS Strategic Capability program element is described in Appendix B.7.

Heliophysics Data Environment Enhancements:
Progress in space science is sparked by space observations. It is essential that observations be properly recorded, analyzed, released, documented, and rapidly turned into scientific results. Heliophysics Data Environment Enhancement investigations support and extend data services necessary for the conduct of heliophysics research. Holders of heliophysics data propose for small grants to continue resident archives of data from previously operating missions and to participate in one of the several virtual observatories either in existence or proposed. Aspects to be taken into account are the special needs driven by the increasing complexity of missions, the associated increasing complexity and volume of data, and the need for innovative and enabling technologies. The data environment enhancement program element is described in Appendix B.8.

Education and Public Outreach (EPO):
NASA's founding legislation, the Space Act of 1958, directs the Agency to expand human knowledge of Earth and space phenomena and to preserve the role of the United States as a leader in aeronautics, space science, and technology. High achievement in science, technology, engineering, and mathematics (STEM) education and public scientific literacy is essential to the accomplishment of NASA's mission. Heliophysics EPO investigations typically pertain to and emphasize the system-science approach of Heliophysics research with the aim of encouraging upcoming generations to pursue education and careers in this area. A "multimission" approach is preferred, given the very broad nature of the science regimes studied. Heliophysics education and public outreach investigations are solicited through the Opportunities in Education and Public Outreach for Earth and Space Science program element described in Appendix E.4.

3. General Guidance for Proposals to Heliophysics Programs

Proposals to any of the Heliophysics scientific research program elements are expected to present within their Scientific/Technical/Management section a clear description of a specific scientific problem, of how the attack on this problem will be carried out, and of the relevance of the proposed research to NASA's Heliophysics strategic objectives.

Proposals to any of the Heliophysics scientific research program elements are expected to present clear descriptions of (1) a specific scientific problem, (2) the importance of the problem, (3) the relevance of the problem to NASA's heliophysics strategic objectives, and (4) a complete method of attack on this problem. Principal Investigators (PIs) have the privilege of choosing the science question(s) they wish to address. However, having done so, they are expected to detail a methodology/science plan that clearly and specifically addresses the chosen question(s). Historically, proposals that are focused on a specific science question have been more successful at constructing methodologies than those that propose to address a broad science topic or a large number of science questions.

The development and testing of new instrument concepts, new observing techniques, new models, new data analysis techniques, and/or new supporting infrastructures that are pertinent to discipline goals is also supported. However, proposals for such efforts must provide an explanation of the relationship between such proposed efforts and clearly defined Heliophysics science problems.

Proposals with the intent of duplicating or directly supplementing investigations selected for current approved space flight missions are not appropriate for this ROSES NRA. Investigators who are funded members of the science teams of ongoing missions (including mission PIs and Co-Is) and who propose to use data from these missions in SR&T, Guest Investigator, or other Heliophysics program element's efforts proposed through this ROSES NRA must clearly delineate between their mission responsibilities and the proposed efforts.

It is the overall guiding objective of each of these program elements to contribute as effectively and directly as possible to the achievement of NASA Heliophysics strategic goals. Priority for selection is given to those proposals that most clearly demonstrate the potential for such contributions.