A.4.2 CALL FOR MISSION STUDIES: SPACE SCIENCE VISION MISSIONS

1. Scope of Program

1.1 Overview

NASA's Office of Space Science's (OSS) research program encompasses a broad range of investigations that includes astrophysics and cosmology, origins of other planetary systems, solar and heliospheric physics, and planetary science in the solar system (including Mars exploration). In order to focus near term mission development activities, technology investments, and long term planning, OSS commissions decadal surveys from the National Research Council (NRC) and conducts a triennial roadmapping process in its scientific theme areas. These theme areas are Sun-Earth Connection (SEC), Solar System Exploration (SSE), Mars Exploration Program (MEP), Structure and Evolution of the Universe (SEU), and Astronomical Search for Origins (ASO). Decadal surveys and "roadmaps" have recently been completed and have identified key science objectives for OSS, as well as the highest priority flight missions for the next decade. These processes have also identified other challenging candidates, referred to here as "vision missions," for possible implementation beyond 2013. This solicitation will fund additional scientific and technical study of a subset of these vision missions. This subset of conceptual missions spans the full scope of OSS research and is provided below in Sections 1.2-1.6. Respondents should propose to study one of these missions, the Study Cases enumerated below.

The goals of this solicitation are two-fold:

The first goal is to sharpen understanding of a subset of possible future missions for scientific and programmatic planning within OSS. The OSS flight program is premised on scientific objectives, and these vision missions represent approaches to extending the current and near term flight programs to future, more advanced capabilities. It is expected that the results of these studies will help define OSS's long term technology investment.

A second and equally important goal for improving our understanding of implementation of long term objectives is to support integration of long range Agency-wide planning. The *NASA 2003 Strategic Plan* provides that "NASA will continue to expand its human presence in space—not as an end in itself, but as a means to further the goals of exploration, research, and discovery." In support of this goal, proposals responding to this solicitation that consider astronauts performing in-space assembly or servicing tasks (e.g., for telescopes or other observing systems) or conducting planetary surface operations are welcome. That is, proposers may choose to premise their submission on astronaut involvement, particularly the role of human-robotic cooperation, or propose a purely automated approach. Note that if an astronaut-assisted approach is proposed and analyzed, the study should focus on the implementation of the science mission and identify resulting requirements for the human role and should not address implementation of the systems needed to deliver humans to the location of science-related work or to support them while there.

Proposers should also assume the availability of a variety of nuclear power sources, both radioisotope thermal generators and space fission reactors. While not necessarily applicable to every mission, these elements may be incorporated in mission concepts proposed for study as determined to be appropriate by the proposer. Parameters of the systems and capabilities currently being contemplated are provided in the references in Section 2.4 below.

1.2 Structure and Evolution of the Universe Vision Missions

1.2.1 Beyond Einstein Missions

In addition to nearer term missions such as Constellation-X, Laser Interferometer Space Antenna (LISA), and the new Einstein Probes, the OSS Structure and Evolution of the Universe (SEU) 2002 roadmap (website in Section 2.4) identified two Beyond Einstein vision mission concepts, the Big Bang Observer and the Black Hole Imager, for which studies are solicited.

> Big Bang Observer (BBO; Study Case 1)—Gravitational waves carry information undisturbed from the earliest moments of the Universe when it was so dense that neither light nor neutrinos could escape. Understanding the expansion history of the Universe at the moments when quantum foam was becoming our familiar space and time requires measuring the gravitational wave relics from this era. The Big Bang Observer has the goal of direct detection of quanta of the gravitational field created during inflation. Such data could provide a direct view of the creation of space and time and, in combination with results from the Inflation Probe (one of the Einstein Probes), determine the nature of the vacuum at energies far higher than can be reached with ground-based accelerators. The Big Bang Observer will seek a direct detection of gravitational waves, perhaps at periods of 0.1-10 sec. In this frequency range, the primary source of foreground signals is expected to be neutron star binaries several months before coalescence, and these are few enough that they can be identified and removed. Measurement of these merger signals will also directly determine the rate of expansion of the Universe as a function of time, extending the results of the Dark Energy Probe (another of the Einstein Probes).

> Black Hole Imager (BHI; Study Case 2)—A simple image of space-time near the event horizon of a black hole, while exciting in concept, is not sufficient to study the dynamics of the closest regions. To better disentangle the complicated dynamics near the black hole will require spectroscopy to map the speed as well as position of gas as it nears the event horizon. This information could be obtained from spectroscopically resolved imaging at the wavelengths of X-ray lines. Therefore, the science objectives for a black hole imaging mission are to: (i) map the motions of gas in the vicinity of a black hole event horizon and compare them to predictions based on the general theory of relativity; (ii) map the release of energy in black hole accretion disks; and (iii) determine how relativistic jets are produced and the role of black hole spin in this process.

1.2.2 Cycles of Matter and Energy Missions

The OSS Structure and Evolution of the Universe (SEU) 2002 roadmap identified the following vision missions for understanding the cycles of matter and energy that govern the Universe and how these cycles created the conditions for our own existence:

Advanced Compton Telescope (ACT; Study Case 3)—Observations in the energy range from 500 eV to 30 MeV explore a variety of astrophysical questions of fundamental importance. The continuum emission and nuclear line astrophysics involved provide unique information on galactic chemical evolution and supernova physics as well as important measurements for active galaxies, pulsars, and diffuse emission processes. Previous instruments operating in this energy range have provided detailed maps of galactic positron and ^{26}A1 emission, as well as line emission detections from objects like SN 1987A (^{56}Co) and Cas A (^{44}Ti). Breakthroughs in this area will require large improvements in sensitivity and spatial resolution. The Advanced Compton Telescope (ACT) is a mission concept to achieve these improvements utilizing solid state detector technologies to provide the necessary energy and spatial resolution as well as background reduction.

Generation-X (Gen-X; Study Case 4)—To observe the birth of the first black holes and their effect on the formation of galaxies and to probe the behavior of matter in extreme environments will require a very large aperture, arcsecond x-ray imaging telescope called Generation-X. As a major x-ray mission following Chandra, XMM-Newton, and Constellation-X, a mission with more than 100 square meters of collecting area will address a very broad spectrum of scientific objectives, from flares of stars in the solar neighborhood, to galactic star formation regions, compact objects, supernova remnants, accretion disks, to active galactic nuclei, quasars, clusters of galaxies, and to the large scale structures of the Universe. For instance, in order to effectively study the fluctuations in the early Universe that gave rise to the formation of galaxies and clusters of galaxies and other large scale structures, Gen-X needs to be able to detect the typical normal galaxy out to $z = 10$. Such a mission will be capable of spectroscopic studies of the same galaxy at $z = 5$. Similarly, such an amount of effective area will facilitate studies of starburst galaxies and the formation and evolution of quasars. Perhaps $z=6$ luminous quasars result from stellar-sized black holes that have accreted mass from their environment over the life time of the Universe to become supermassive black holes. Detecting and studying these quasars in the x-ray band and comparing their properties with other black holes in nearby galaxies will be extremely important to fully understand the origin and evolution of quasars.

1.3 Sun-Earth Connection Vision Missions

The 2002 Sun-Earth Connection (SEC) roadmap (web site in Section 2.4) describes a number of near, mid, and long range missions that fall into three categories, aligned with the major science objectives of the SEC theme. This solicitation seeks additional study of missions considered to be candidates for implementation in the 2015-2028 timeframe that are identified in the first and third categories. These categories are the missions to study the changing flow of energy throughout the heliosphere and missions to define the origins and societal impacts of variability in the Sun-Earth connection (SEC roadmap, Sections 3.1 and 3.3). The solicitation does not solicit proposals for missions focusing on fundamental physical processes of plasma systems in the solar system that are described in SEC roadmap Section 3.2.3.

1.3.1 Missions to Study the Changing Flow of Energy Throughout the Heliosphere

Understanding the changing flow of energy and matter throughout the Sun, heliosphere, and planetary environments depends critically on an understanding of the strong and complex linkages between regions. Consequently, this science objective requires a linked set of missions to systematically establish the flows from their source (or sources), through the regions where they evolve, to their ultimate destinations. Vision missions of interest for this solicitation are the following:

> Solar Polar Imager (Study Case 5)—Solar Polar Imager will define a critical missing component in the understanding of the solar cycle. It is a single spacecraft mission that uses solar sails to achieve a final 0.48 AU circular orbit around the Sun with a 60° inclination to the ecliptic. This orbit is in 3:1 resonance with that of the Earth. The spacecraft carries a Doppler imager for high resolution helioseismology measurements, a solar magnetic field imager, *in situ* particles and fields instrumentation and a solar irradiance monitor. The 3:1 resonance permits this mission to obtain helioseismology measurements on the far side of the Sun from the Earth. This combined imaging and *in situ* instrument suite could make high resolution helioseismology measurements of the Sun's polar regions down to the equator, tracing the complete life cycle of active regions and coronal holes on the Sun and placing sharper constraints on the deep structure of the Sun.
>
> Interstellar Probe (Study Case 6)—Interstellar Probe will be the first mission to pass through the heliopause and into interstellar space. It is a single spacecraft that will use an advanced in-space propulsion system such as a solar sail or nuclear electric propulsion to reach the upstream interstellar medium at a distance of at least 200 AU within about 15 years. Its payload will be specifically designed to determine the characteristics of the local interstellar medium, including dust, plasma, neutral gas, energetic particles, and electromagnetic fields. On its way, it will provide only the second opportunity after Voyager to directly observe the thick interaction region between the heliosphere and the interstellar medium extending from the termination shock to the heliopause. Eventually, Interstellar Probe may cross an external bow shock, should it exist. Additional advanced instrumentation will determine the nature and chemical evolution of organic molecules in the outer solar system and interstellar medium and perhaps expose the cosmic infrared background (CIRB) radiation normally hidden by the Zodiacal dust.

1.3.2 Missions to Define the Origins and Societal Impacts of Variability in the Sun-Earth Connection

Solar variability has significant short term and long term impact on society. The Living With A Star (LWS) program is a long term effort to determine the physics behind those aspects of the connected Sun-Earth system that directly affect life and society. It advances the understanding of the network of processes that couple the activity-generating processes within the Sun to the responses within geospace, down to the Earth's atmosphere. The magnitude of the problem requires dedicated NASA LWS missions, comprehensive modeling and data assimilation, as well as intraagency, interagency, and international collaboration. In the long term, these missions lay the groundwork for an operational capability by investigating the ability to extend forecasting of solar disturbances, completing an understanding of the full, end-to-end links of the Sun-heliosphere-Earth system, and investigating long term solar variability. Missions of interest for the present solicitation are the following:

Solar Imaging Radio Array (SIRA; Study Case 7)—SIRA will determine the global structure of coronal mass ejections and other transient and corotating structures in the outer corona and consists of 10-16 identical microsat spacecraft in a quasi-spherical constellation about 100 km in diameter in a nearly retrograde orbit approximately 10^6 km from the Earth. These spacecraft will carry radio receivers with frequency and time resolution optimized for solar radio burst detection and analysis. The constellation will make it possible to track coronal mass ejections from the Sun to 1 AU, significantly improving the accuracy of space weather forecasting. In addition, imaging of type III (fast drift) radio bursts will permit the mapping of interplanetary magnetic field topology and density structures in the solar wind.

Stellar Imager (SI; Study Case 8)—Stellar Imager will determine the long term variability of the Sun by imaging other solar-like stars for the purpose of developing and testing a solar dynamo model with predictive capabilities. Developing that dynamo model and testing it for long term predictions of solar activity is impractical if only the Sun is used, as it would take centuries to see the Sun go through only a limited part of the possible states of the nonlinear dynamo. SI will image dozens of Sun-like, magnetically active stars with sufficient resolution to see the patterns of field emergence and evolution, revisiting stars frequently over up to a decade to map out the patterns in the dynamo, and to test and validate dynamo models. It will make use of astroseismic methods to image the internal rotation profiles of stars. The ultimate SI mission is a multispacecraft space-based interferometer working in the visible and ultraviolet. It would involve at least nine meter-class light collectors and a central beam-combining module, with a maximum baseline of up to 250 m, capable of frequent reconfigurations on a time scale of order 10 hrs and operating in a very stable region of space such as the Sun-Earth L2 point outside the Earth's orbit. A pathfinder mission of two or three free flying spacecraft would be able to study the least active stars (rotating slowly with few active regions) and form a logical successor to the boom-based Space Interferometry Mission. Ideally, the SI would be a multidisciplinary mission, as its imaging capabilities are of direct interest to studies of stars in particular and the universe in general.

1.4 Astronomical Search for Origins Vision Missions

Near and midterm missions scheduled for implementation in the Astronomical Search for Origins (ASO) theme include the Space Interferometry Mission (SIM), the James Webb Space Telescope (JWST), and the Terrestrial Planet Finder (TPF). This solicitation seeks proposals for scientific and technical studies of four follow-on missions, namely a Far-Infrared Telescope, an Optical and Ultraviolet Telescope, a Life Finder follow-on to TPF, and a Far Infrared and Submillimeter Interferometer.

Far-Infrared Telescope (Study Case 9)—This mission, consisting of a single 8 to 10 m telescope operating in the far infrared, could serve as a building block for the Life Finder (described below) while carrying out a range of scientific programs beyond the capabilities of the Space Infrared Telescope Facility (SIRTF) and the JWST. These programs include probing the epoch of energetic star formation in the redshift range $1<z<10$ at a wavelength regime that can easily detect continuum and cooling line emission from dust enshrouded primeval galaxies with an angular resolution capable of isolating individual objects at or below the limits of the Hubble Deep Field; investigating the physical processes that control the collapse and fragmentation of molecular clouds to produce stars of various masses by mapping cold, dense cores at better than 100 AU resolution at the peak of their dust emission and using gas phase tracers such as H_2, H_20, CO, OI, and NII; learning about the era of cometary bombardment that may have determined the early habitability of Earth by making high spatial resolution maps of the distribution of ices and minerals in the Kuiper Belts surrounding nearby stars; and studying the nature of the recently discovered objects in the Kuiper Belt of the solar system that may be remnants of the planet formation process.

Optical and Ultraviolet Telescope (Study Case 10)—A successor to Hubble Space Telescope (HST) operating at ultraviolet and optical wavelengths, this telescope could enable forefront science in all areas of modern astronomy, focusing on the era from redshifts $0<z<3$ that occupies over 80% of cosmic time, beginning after the first galaxies, quasars, and stars emerged into their present form. Research to be conducted in the post-HST era will include studies of dark matter and baryons, the origin and evolution of the elements, and the major formation phase of galaxies and quasars. A large aperture optical-ultraviolet telescope in space would provide a major facility in the second quarter of the century for addressing scientific problems such as: Where is the rest of the unseen universe? What is the interplay of the dark and luminous universe? How did the intergalactic medium collapse to form the galaxies and clusters? When were galaxies, clusters, and stellar populations assembled into their current form? What is the history of star formation and chemical evolution? Are massive black holes a natural part of most galaxies?

Life Finder (Study Case 11)—A long term goal of the ASO science theme is the detailed study of life and its evolution in ecosystems beyond the solar system. Achieving that goal will require observations beyond those possible with the Terrestrial Planet Finder (TPF). For example, searching the atmospheres of distant planets for unambiguous tracers of life such as methane (in terrestrial concentrations) and nitrous oxide would require a spectral resolving power of about 1,000, by utilizing a version of TPF with greatly increased sensitivity. The Life Finder would provide high resolution spectroscopy on habitable planets identified by TPF. This information would extend the reach of biologists, geophysicists, and atmospheric chemists to ecosystems far beyond Earth.

Far-Infrared and Submillimeter Interferometer (Study Case 12)—This space-based interferometer would be capable of detecting the far infrared and submillimeter light from stars forming in the youngest galaxies. JWST will study the visible starlight from forming galaxies that has been red-shifted into the near infrared by the expansion of the universe. However, typically half, and sometimes more than 99% of the starlight of a galaxy is absorbed by dust in that galaxy and reradiated in the far infrared. This emission is red-shifted further into infrared or into the submillimeter bands. An interferometer consisting of three 15 to 25 m telescopes with a 1 km baseline would have the sensitivity and angular resolution (0.02 arcsec at a wavelength of 100 micrometers) needed to study the physical conditions in these young galaxies. In addition to cosmological studies, the interferometer would be able to observe collapsing protostars deeply embedded in their parental molecular clouds, providing valuable constraints on models for star formation.

1.5 Mars Exploration Program Vision Missions

The current Mars Exploration Program (MEP) consists of missions in operation (Mars Global Surveyor and Mars Odyssey), under development (Mars Exploration Rovers [MER] and Mars Reconnaissance Orbiter [MRO]), and in preproject planning (2007 Mars Scout and 2009 Mars Science Laboratory [MSL]). In addition, preproject planning for a 2009 Mars Telesat is also underway, including a possible optical telecommunication demonstration experiment.

Specific details of future MEP missions will depend on the findings and technological developments of the missions approved and in flight during the present decade (2001-2010). Follow-on missions will respond to discoveries made by MGS, Odyssey, the MER rovers, detailed reconnaissance of the 2005 MRO, and choices made in the next several years about the implementation of the 2009 MSL.

As part of ongoing planning for the next decade (2010-2020), potential science findings, programmatic constraints, and technological development have been analyzed to produce a set of possible science "pathways," including conceptual mission architectures. Each pathway depends on future understanding about whether persistent surficial liquid water has left its record on Mars (primarily MER, MRO, Mars Scout). In addition, each pathway addresses the central issue of the "habitability" of Mars from different vantage points and measurement systems. The detailed reconnaissance to be provided by the 2005 MRO mission, including assessment of submeter scale features on Mars, mineralogies associated with the action of liquid water, transport processes in the present day atmosphere, and shallow subsurface layering and potential reservoirs of liquid water, is a keystone to each of the pathway strategies for the next decade. In one case, MER and MRO could drive Mars exploration to intensify *in situ* and sample return measurements of deposits associated with standing bodies of liquid water from the Martian past, while in other cases, discoveries by MRO would favor a comprehensive focus upon recent or active hydrothermal vent sites as possible habitats.

Mission concept proposals submitted should address one of three pathways, each of which is premised on one of three distinct possible 2001-2010 MEP scientific outcomes. (Note that, while there is widespread sentiment that return of samples to Earth may ultimately be required for definitive analysis, proposed studies that include sample return should be limited to activities in Mars orbit or on the Mars surface and relevant sample analysis activities on the Earth, and should not address in detail transportation systems or operations required to return the samples to Earth.)

> <u>Search for Evidence of Past Life (Study Case 13)</u>—This pathway is based on the possible 2001-2010 outcome that persistent liquid water has played a significant role in shaping the environments and geological evolution of ancient Mars, suggesting intensified analysis of preserved deposits from water-related sediments in search of evidence of ancient life.

On this pathway, primary goals include definitive analysis of water-lain sedimentary rocks and understanding of their preservation potential for any indicators of past biological activity, or even of prebiotic chemistry. In this case, studies of mission scenarios that would enable highly informed *in situ* sample identification, acquisition, and analysis as a precursor to return of the most scientifically valuable samples to Earth for subsequent analysis are solicited, including mission concepts in which human-based sample selection, collection, and triage are an element of the strategy. Alternatively, proposals advancing highly autonomous *in situ* explorers with advanced sample selection, acquisition, and preparation capabilities are also welcome.

<u>Exploration of Hydrothermal Habitats (Study Case 14)</u>—This pathway is based on the possible 2001-2010 outcome that scientific results from the Mars Reconnaissance Orbiter (and perhaps from the Mars Odyssey orbiter presently in flight) confirm the existence of either active or very recent hydrothermal vent systems at the surface of Mars.

On this pathway, the next decade's exploration would directly focus scientific attention on one or more of these hydrothermal vent sites, culminating in direct life detection experiments at either active or fossil examples of such biologically favored settings. For this scenario, specific studies of advanced, *in situ* astrobiological field laboratories, tailored to the exploration issues associated with hydrothermal vents, are solicited. In particular, autonomous and mobile robotic laboratories with intelligent sample selection, preparation, and analysis facilities, as well as adaptable sample collection capabilities, are invited. Alternatively, proposals that assume human "on site" exploration to intelligently sample such vent localities are welcome.

<u>Search for Present Life (Study Case 15)</u>—This pathway is based on the possibility that the 2001-2010 missions point to the existence of liquid water zones on present day Mars, or active hydrothermal systems with circulating fluids.

For this case, mission concepts that enable access to potentially hospitable liquid water sites on Mars today are solicited, with particular emphasis on approaches for exploration of potential habitats beneath the permanent water ice caps of Mars or for deep subsurface access in hydrothermal vent sites. Mission approaches utilizing either humans as surface explorers to enable complex sampling schemes or highly autonomous robotic approaches are welcome.

1.6 Solar System Exploration Vision Missions

The recent NRC decadal survey of Solar System Exploration (SSE), *New Frontiers in the Solar System—An Integrated Exploration Strategy* (website in Section 2.4), identified two high priority candidates for flagship-class vision missions to be implemented in the decade beyond 2012. These were Titan Explorer and Neptune Orbiter with Probes. Studies are solicited for these two missions.

<u>Titan Explorer (Study Case 16)</u>—The atmosphere and surface of Titan are inferred to be rich in organic materials and may, therefore, provide a natural environment for studying organic chemistry at temporal and spatial scales unattainable in terrestrial laboratories. Understanding the pathways of organic synthesis on Titan might yield important insights

into the evolution of prebiotic chemistry that led to the origin of life on Earth. The Cassini mission and Huygens probe, now en route to the Saturn system, will return data on Titan's surface state, atmospheric composition, and chemical processes. A follow-on Titan Explorer mission might include a mobile platform capable of obtaining samples and conducting a variety of experiments at multiple locations.

Neptune Orbiter with Probes (Study Case 17)—The giant planets of the outer solar system divide into two distinct classes: the "gas giants" Jupiter and Saturn, which consist mainly of hydrogen and helium, the lightest elements in the universe; and the "ice giants" Uranus and Neptune, which contain significant amounts of the heavier elements oxygen, carbon, nitrogen, and sulfur. Detailed comparison of the internal structures and compositions of the gas giants with those of the ice giants will yield valuable insight into the processes that formed the solar system and, perhaps, other planetary systems. By 2012, Galileo, Cassini, and possibly a Jupiter Orbiter with Probes mission in the New Frontiers line, will have yielded significant information on the chemical and physical properties of Jupiter and Saturn. A Neptune Orbiter with Probes mission would deliver the corresponding key data for an ice giant planet.

2. Programmatic Information

2.1 Proposal Evaluation and Awards

Approximately $3M will be available to support about a dozen mission concept studies, each for a period of 12 months. Subject to the distribution and quality of proposals received, NASA intends to make a comparable number of awards in each of the five broad areas above (Sections 1.2 through 1.6). Proposals will be assessed by one or more panels of individuals who are peers of the proposal teams in the relevant scientific and technical areas.

The scope of each study is expected to encompass both scientific and technical aspects of the mission analyzed and should address the architecture and implementation elements in Section 2.2 below. It is recognized that the depth of penetration that is realistically achievable in individual missions offered for study may vary from case to case. Within this framework, the primary evaluation criteria will be intrinsic merit, including scientific and technical merit, as stated in Section C.2 of Appendix C of the *Guidebook for Proposers—2003*, as follows:

- Scientific merit will be judged on the alignment of the proposed concept with stated science objectives in the *NASA 2003 Strategic Plan* and *Space Science 2003 Strategy* (draft) (websites below in Section 2.4) and the breadth and depth of the expected science return, which should be explicitly discussed in the proposal. This science return should be quantified to the extent possible and contrasted with the anticipated yield of OSS missions now flying or to be launched in the 2003-2013 time frame.

- Technical merit will be judged on the proposed implementation approach to the science objectives and its balance between innovation and the likelihood of the mission's feasibility as proposed. The proposal should address the technical risk analysis approach and methodology to be used, including identification of sources of risk and comparison to alternative mission approaches.

A selection factor that will be used to discriminate between proposals of otherwise equal merit will be the inclusion of a clear and convincing plan for the involvement of undergraduate and/or graduate students in the proposed work. Plans for this involvement should describe the role of the student(s) and how it benefits both the student(s) and the study objectives.

As noted in Section 1.1, proposals that analyze potential roles for astronauts and/or nuclear power systems are welcome. However, evaluation will be based on scientific and technical merit of the proposal and the appropriateness of the approach proposed and will be otherwise neutral with respect to the inclusion or absence of these features.

2.2 Proposal Guidelines

A proposal may not propose actual fabrication of hardware, even at the laboratory concept level.

The proposal must discuss the relationship of the proposed mission to the present and anticipated state of knowledge in the field, to the anticipated readiness of needed technologies, and to any related planned missions.

Any proposed involvement of undergraduate and/or graduate students in the study should be presented in such a way that its value and efficacy, both for the study and for the participant(s), can be assessed.

If a proposal includes taking advantage of the services of one of the two NASA Design Centers offered (Section 2.3 below), it <u>must</u> state which of the two will be used, what design capabilities will be used, objectives of this utilization, and how Design Center study results will fit in with the rest of the proposed study.

The proposal must provide a detailed statement of the work to be undertaken over the 12 month period of performance to develop the mission concept and deliver a comprehensive Final Report that NASA will make publicly available through an appropriate venue. The Final Report of each study will provide findings on the following major characteristics of the concept:

1. Science rationale
    a. key objectives
    b. relation to NASA and OSS strategic plans
    c. uniqueness or scientific advantages of the proposed approach compared to alternatives
2. Architecture and Implementation Approach
    a. space systems architecture
    b. science instrumentation
    c. infrastructure and constraints assumed in place for the time of implementation
    d. role of humans (if proposed)

3. Technology
    a. unique requirements, their priority, and sensitivity of design to each
    b. key technology risks and uncertainties, quantified where possible
    c. development roadmap, with alternative approaches where applicable
    d. validation and/or demonstration approachDeployment
    a. transportation to operational locationb. assembly (if applicable) or deploymentOperations
    a. space segment
    b. communications
    c. ground segment
6. Operations Assurance
    a. system resilience (e.g., redundancy or adaptability)
    b. maintenance or servicing (if applicable)
7. Safetylaunch and near-Earth operationsb. planetary protection (if applicable)end of mission safety issues (if applicable)

As a modification to the material in Section 2.3.5 of the *Guidebook for Proposers—2003* (web site provided in Section 2.4), the Scientific/Technical/Management section of proposals for this program element must address the proposer’s approach to analyzing and documenting findings on the above major characteristics in the Final Report, which must be submitted in a narrative form. Final reports from work performed under this solicitation may be bound together by NASA to document the results of the program. Participation in a workshop and/or a final briefing at NASA Headquarters at the end of the study shall also be required.

NASA recognizes that cost estimation for vision missions is premature. Therefore, as a surrogate for cost estimates, the final report should estimate the major physical properties and resources entailed, including system mass, power, volume, communications, etc. For concepts that incorporate astronaut participation, these estimates should be limited to scientific components of the mission concept and exclude any systems generally devoted to delivering or maintaining human presence. For example, for a mission that involves astronaut activities on Mars, the analysis should not include systems for delivering them to Mars, habitats to support long term safe and healthy residence on the surface, or vehicles for returning them to Earth. Likewise, studies directed at robotic sample return should focus on sample identification, collection, preservation, and planetary protection, and omit analysis of launch from the Mars surface and other space systems required to return the samples from Mars to the Earth.

Mission concepts may incorporate unmanned launch vehicles not in the currently available inventory, if none of these are suitable. However, if a required capability (e.g., launch mass to orbit or escape trajectory, shroud size, etc.) is not available, the performance required must be stated and justified. If an existing launch system can meet concept requirements, it should be identified.

For concepts that incorporate nuclear systems, the web site in Section 2.4 provides the parameters to be assumed for these components in conducting the study and developing the above estimates.

2.3 Support for Mission Concept Development

During the period of performance, a selected investigator may wish to utilize instrument and mission design capabilities provided by NASA to help develop the implementation approach, make trade-off studies, and/or evaluate overall feasibility.

OSS believes it will be particularly useful for these studies to be based at least in part on a shared platform of tools and methodologies. As a result, to simultaneously increase the depth of analysis possible while promoting the desired commonality, OSS will make available to each successful proposer additional resources for support at either the NASA Jet Propulsion Laboratory's Project Design Center (Team-X) or the NASA Goddard Space Flight Center's Integrated Design Capability (IDC). Note that costs for this support, which are projected to amount for each selected proposer to approximately $60K, are not to be included in the proposed cost of the proposal. This support is offered as a "voucher" to be exercised with one of these two sources only and may not be transferred to other uses within a proposer's plan of study. The proposal must state which of the two Design Centers will be used. Proposers who intend to use these capabilities are encouraged to contact their chosen Design Center representative during proposal preparation.

- Further information about the GSFC Integrated Design Capability can be found at http://idc.gsfc.nasa.gov/ or from Ms. Ellen Herring *(Ellen.L.Herring@nasa.gov)*.

- Further information about the JPL Project Design Center can be found at http://pdcteams.jpl.nasa.gov or from Mr. Stephen Prusha *(Stephen.L.Prusha@jpl.nasa.gov)*.

2.4 Supplemental Information

The *NASA Strategic Plan* is available in final form at:
http://ifmp.nasa.gov/codeb/docs/2003_Strategic_Plan.pdf (case sensitive)

The *Space Science 2003 Strategy* (draft) and theme roadmaps are available at:
http://spacescience.nasa.gov/admin/pubs/strategy/2003/
(A table of OSS science objectives and component Research Focus Areas is contained in the *Space Science 2003 Strategy*).

Further information on Mars Exploration strategy options is available at:
http://mars.jpl.nasa.gov/plan/Mars_Preliminary_Exploration_Options.doc (case sensitive)

Information on nuclear systems for analysis purposes is provided at:
http://spacescience.nasa.gov/missions/npsfactsheet.pdf

Information on the current launch vehicle inventory is provided at:
http://www.ksc.nasa.gov/elvnew/vehicles.htm
http://elvperf.ksc.nasa.gov

Proposers may also wish to consult the following recent NRC reports:
Astronomy and Astrophysics in the New Millennium (2001), available at:
http://books.nap.edu/catalog/9839.html
Connecting Quarks with the Cosmos (2002), available at:
http://www.nap.edu/catalog/10079.html

New Frontiers in the Solar System (prepublication draft 2002), available at:
http://www.nap.edu/catalog/10432.html
The Sun to the Earth—and Beyond (prepublication draft, 2002), available at:
http://www.nap.edu/catalog/10477.html

IMPORTANT INFORMATION

As discussed in the Summary of Solicitation of this NRA, the Office of Space Science (OSS) now uses a single, unified set of instructions for the submission of proposals given in the document entitled *NASA Guidebook for Proposers Responding to NASA Research Announcement—2003* (or *NASA Guidebook for Proposers* for short) that may be accessed at http://www.hq.nasa.gov/office/procurement/nraguidebook/ (note that the updated 2003-edition of the *Guidebook* is to be used for this solicitation). This NRA's Summary of Solicitation also contains the instructions relevant to the electronic submission of a *Notice of Intent* (NOI) to propose and a proposal's *Cover Page/Proposal Summary/Budget Summary*, as well as the mailing address for the submission of the hard copies of a proposal.

Notices of Intent (NOI's) to propose, which are not required but are strongly encouraged, should indicate (1) which one of the 17 Study Cases the proposal will address, (2) whether or not the proposed concept will include participation of astronauts, and (3) whether or not nuclear power sources will be included. The schedule for submission of NOI's and hard copies of the proposals is:

- Release Date: June 13, 2003
- NOI Due Date: July 11, 2003
- Proposal Due Date (4:30 p.m. ET): Sept. 12, 2003

The Selection Official for this program will be the OSS Deputy Associate Administrator for Science.

Further information about this program may be obtained from:

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