HELIOPHYSICS EXPLORERS PROGRAM
2019 MEDIUM-CLASS EXPLORER (MIDEX)

GUIDELINES AND CRITERIA FOR THE PHASE A CONCEPT STUDY

October 6, 2020

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HELIOPHYSICS EXPLORERS PROGRAM
2019 MEDIUM-CLASS EXPLORER (MIDEX)

GUIDELINES AND CRITERIA FOR THE PHASE A CONCEPT STUDY

INTRODUCTION

As the outcome of the Heliophysics Explorers Program 2019 Medium-Class Explorer (MIDEX) Announcement of Opportunity (NNH19ZDA013O, also the "2019 Heliophysics MIDEX AO") Step-1 competition, NASA Science Mission Directorate (SMD) has selected five investigations that the Agency will fund to perform concept studies. The concept study for each selected investigation (or mission) will constitute its Concept and Technology Development Phase (Phase A) of the Formulation process as outlined in NPR 7120.5E, *NASA Space Flight Program and Project Requirements*.

NPR 7120.5E and other documents available through the 2019 Heliophysics MIDEX AO Program Library at https://explorers.larc.nasa.gov/HPMIDEX/programlibrary.html are intended to provide guidance for investigations selected. This website is hereafter referred to as the Program Library. Note that new documents have been added to the Program Library for this Step-2 evaluation.

NASA recognizes and supports the benefits of having diverse and inclusive scientific, engineering, and technology communities and fully expects that such values will be reflected in the composition of all proposal teams as well as peer review panels (science, engineering, and technology), science definition teams, and mission and instrument teams.

Concept studies are intended to provide NASA with more definitive information regarding the cost, risk, and feasibility of the investigations, as well as small business subcontracting plans; optional Student Collaborations (SCs); Science Enhancement Options (SEOs), if proposed; Principal Investigator (PI) Team-developed Enhancing Technology Demonstration Opportunities (TDOs), if proposed; and Engineering Science Investigations (ESIs), if required, before final selection for implementation.

The product of a concept study is a Concept Study Report (CSR), to be delivered to NASA approximately nine months after the Concept Study Kick-Off Meeting (see below). The present document provides guidelines and requirements for preparing a CSR. All program constraints, guidelines, definitions, and requirements specified in the AO are applicable to the CSR, except as noted herein; key examples of these include:

- PIs will propose Level 1 Science requirements in their CSRs, including draft criteria for mission success satisfying the Threshold Science Mission. (see AO Section 7.4.4)

- The PI-Managed Mission Cost (PIMMC) may not increase by more than 20% from that in the Step-1 proposal to that in the CSR, with adjustments as applicable, and in any case may not exceed the Cost Cap specified in the AO. (see AO Section 7.4.4)
- NASA intends investigations to be implemented as Category 2 missions (per NPR 7120.5E) with Class C payloads (per NPR 8705.4, *Risk Classification for NASA Payloads*). NPR 7120.5E and NPR 8705.4 are available in the Program Library. (see AO Section 5.2.8)
- The *Explorers & Heliophysics Projects Division (EHPD) Mission Assurance Requirements (MAR) Mission Risk Classification – NPR 7120.5 Class C* document, available in the Program Library, will apply to investigations that are selected for concept studies. (see AO Section 4.1.2 and Section 5.2.9)

Several items that were deferred from Step 1 that must be provided in the CSR include:

- Independent Verification and Validation (IV&V) of software. (see AO Section 4.6.1)
- Conjunction Analysis Risk Assessment. (see AO Section 4.6.4)
- Updated planetary protection plans; note that the baseline Planetary Protection Plan is due at PDR. (see Appendix L.9 of this document, and AO Section 5.1.5)
- Updated Curation Plan elements. (see Appendix L.10 of this document, and AO Requirement 4, Requirement 7, and Requirement B-62)
- Detailed End-Of-Mission Plan. (see Appendix L.11 of this document)
- SEOs. (see Requirement CS-25, Requirement CS-42, Section E, and Section K of this document, and AO Section 5.1.6)
- Enhancing TDOs. (see Requirement CS-42, Section E, and Section K of this document, and AO Section 5.2.3.1)
- SCs. (see Requirement CS-4, Requirement CS-42, Requirement CS-55, and Section H of this document, and AO Section 5.5.3)
- Schedule-based, end-to-end Data Management Plan. (see Requirement CS-23, Section E.5 , and Appendix L.5 of this document, and AO Requirement B-24)
- Requirements for Real Year dollars. (see Requirement CS-13, Requirement CS-64, and Requirement CS-66 of this document)

Electronic versions of CSRs and all required files, along with images of the original signatures of the PI and an official of the PI's institution who is authorized to commit its resources are due to Dr. Dan Moses (email dan.moses@nasa.gov), the Heliophysics MIDEX Program Scientist, via the NASA NOMAD Large File Transfer (LFT) service by 4 p.m. Eastern Time, July 7, 2021.

Electronic submission requires the utilization of the NASA NOMAD Large File Transfer (LFT) service, which is Federal Information Processing Standards (FIPS) 140-2 certified for Data-in-Transit (DIT) and Data-at-Rest (DAR).

To submit CSRs through LFT, investigation teams must provide an email list of no more than three (3) individuals requiring access to LFT to submit proposals. This email list must be provided to the Program Scientist no more than five calendar days before the CSRs are due. Individuals on the list will then receive an emailed invitation to LFT from NASA. Upon logging into LFT, the "Send File" tab will give these individuals the ability to send an LFT email –

including multiple secured attachments. Investigation teams are encouraged to send a test email with attachments via LFT to ensure functionality prior to CSR submittal.

PART I of this document describes the evaluation criteria for CSRs. PART II provides guidelines for preparing CSRs; every requirement in these guidelines must be addressed in the section in which the requirement appears. An explanation and justification must be provided for any requirement that is not fully addressed in the CSR. PART III describes other factors that are not required and will not be evaluated in the CSR, but will need to be provided by the project shortly after a down-selection decision.

Since evaluation of CSRs is a major part of Step 2 in the acquisition process, NASA will assemble an evaluation team of scientific and technical peers to carefully consider each CSR. Because members of this evaluation team may not have reviewed, nor will be provided access to, Step-1 proposals, each CSR must be a self-contained document.

The CSR evaluation process will include visits, either virtual or in person, by the evaluation team to each investigation team's chosen site, to hear oral briefings and, if needed, to receive updates and clarification of material in the CSRs. These briefings will be conducted approximately two months following submission of the CSRs. NASA may identify potential weaknesses and questions and ask that the investigation team respond to these before, during, and/or after the Site Visit. Any additional information provided to NASA by the investigation team will be considered during the evaluation and treated as updates and clarifications to the CSR.

Investigation teams are responsible for the content and quality of their CSRs, Site Visit presentations, and responses to potential weaknesses and questions, including parts that may be prepared by partner organizations or by any other individual. All assumptions and calculations should be carefully documented in the CSR and agreed to by the PI and his/her team, to both ensure that they are accurate and that they will satisfy NASA requirements. Investigation teams are also responsible for assuring that all requirements specified in PART II of this document are addressed.

As the outcome of Step 2, it is anticipated that the Selection Official, the Associate Administrator of the Science Mission Directorate (SMD) at NASA Headquarters or their designee, plans to continue at least one of the investigations into the subsequent phases of mission development for flight and operation. The target date for this continuation decision (*i.e.,* "down-selection") is March 15, 2022 (TBR).

Upon a continuation decision, NASA will execute the two-month priced option for a First Bridge Phase and begin to provide Phase B funding for the project(s) that are continued beyond the Phase A concept study. The focus of the First Bridge Phase is: 1) participation in the Explorers Program Office project kick-off meeting; 2) work with the Explorers Program Office to negotiate and award the balance of the Bridge Phase; and 3) other interactions with the Explorers Program Office as necessary. A Second Bridge Phase will be negotiated during implementation of the First Bridge Phase in the first two months of Phase B to cover the remainder of that mission phase. The Second Bridge Phase is intended to cover the remainder of Phase B and to provided continuity while negotiations are underway to modify the contract to include Phases C/D and

E/F. Institutions awarded a Phase A contract are required to provide the First Bridge Phase proposal at the time of the CSR submission (*e.g.,* Sections I, J, and L.4).

For those investigations that are not continued, the contracts will be allowed to terminate without further expense to NASA.

Every investigation team will be offered a debriefing of the evaluation of its CSR.

PART I - EVALUATION CRITERIA

The Step-2 evaluation of Concept Study Reports is very similar to the evaluation of Step-1 proposals, as described in AO Section 7.1.1. The evaluation criteria and their factors, specified in AO Sections 7.2.1 through 7.2.4, apply fully to CSRs. However, all factors related to the probability of mission success and to the realism of the proposed costs to NASA will be considered in greater depth of detail. Additional factors, such as implementation plans for student collaboration and small business subcontracting, will also be evaluated. In case of conflict between the AO and the CSR Guidelines, the CSR Guidelines take precedence.

All information relevant to the evaluation will be considered during the evaluation of Step-2 proposals, including information contained in the CSR, information presented during the Site Visit, and information provided in response to weaknesses and questions.

Each CSR must be a self-contained document and must not refer to information contained in the Step-1 proposal. Except for compliance checking by NASA (*e.g.*, that the PIMMC has not grown by more than 20%) and for determining if re-evaluation of Scientific Merit of the Proposed Investigation is required (as described below), the Step-1 proposals will not be used in the Step-2 evaluation.

Definition of Heritage

Heritage is not a separate evaluation factor. However, it is an aspect of multiple evaluation criteria, factors, and subfactors.

In considering the heritage of any aspect of the mission, the evaluation team will consider the design, manufacture, software, provider, use, operating environment, referenced mission, and other factors. The evaluation team will consider the degree of difference between the proposed use and the referenced (heritage) use. The evaluation team will assess whether the degree of modification is consistent with any risk mitigation claimed, and whether the degree of modification is consistent with any cost savings claimed. The following table provides a guide as to how the evaluation team will consider the spectrum of claimed heritage.

	Full heritage	**Partial heritage**	**No heritage**
Design	Identical	Minimal modifications	Major modifications
Manufacture	Identical	Limited update of parts and processes necessary	Many updates of parts or processes necessary
Software	Identical	Identical functionality with limited update of software modules (< 50%)	Major modifications (≥ 50%)
Provider	Identical provider and development team	Different however with substantial involvement of original team	Different and minimal or no involvement of original team

Use	Identical	Same interfaces and similar use within a novel overall context	Significantly different from original
Operating Environment	Identical	Within margins of original	Significantly different from original
Referenced Prior Use	In operation	Built and successfully ground tested	Not yet successfully ground tested

The five evaluation criteria for the Step-2 evaluation are:

- Scientific Merit of the Proposed Investigation;
- Scientific Implementation Merit and Feasibility of the Proposed Investigation;
- Technical, Management, and Cost (TMC) Feasibility of the Proposed Mission Implementation;
- Quality and Merit of the Student Collaborations; and
- Quality and Merit of Small Business Subcontracting Plans.

Scientific Merit of the Proposed Investigation

The Heliophysics MIDEX Program Scientist will determine whether any issues that may have emerged in the course of the concept study have effected significant changes to the science objectives or other aspects of the proposed Baseline and Threshold Science Missions (see Requirement CS-17 in PART II of this document) in such a manner as to have impacted the basis for the evaluation of the scientific merit of the investigation as determined by the peer review panel for the Step-1 proposal. If there are no significant changes to the proposed investigation that undermine the basis of this rating, the peer review panel rating for scientific merit of the Step-1 proposal will be the rating for scientific merit of the CSR. If there are significant changes, the Program Scientist will convene a peer review panel to re-evaluate the scientific merit of the objectives in light of these changes. The factors for re-evaluating this criterion will be the same as those used for the Step-1 proposal review (see AO Section 7.2.2).

Scientific Implementation Merit and Feasibility of the Proposed Investigation

All of the factors defined in AO Section 7.2.3 also apply to the evaluation of the CSR. Note that details have been added to one of the subfactors of Factor B-1, Merit of the instruments and mission design. An additional subfactor has also been added to Factor B-2, Probability of technical success. *Italicized details are added to several factor definitions below for the evaluation of the CSR*.

- Factor B-1. Merit of the instruments and mission design for addressing the science goals and objectives. This factor includes the degree to which the proposed mission will address the goals and objectives; the appropriateness of the selected instruments and mission design for addressing the goals and objectives; the degree to which the proposed instruments and mission can provide the necessary data, *including details on data collection strategy and plans*; and the sufficiency of the data gathered to complete the scientific investigation.

- Factor B-2. Probability of technical success. This factor includes the maturity and technical readiness of the instruments or demonstration of a clear path to achieve necessary maturity; the adequacy of the plan to develop the instruments within the proposed cost and schedule; the robustness of those plans, including recognition of risks and mitigation plans for retiring those risks; the likelihood of success in developing any new technology that represents an untested advance in the state of the art; the ability of the development team—both institutions and individuals—to successfully implement those plans; and the likelihood of success for both the development and the operation of the instruments within the mission design. *This factor includes assessment of technology readiness, heritage, environmental concerns, accommodation, and complexity of interfaces for the instrument design*.
- Factor B-3. Merit of the data analysis, data availability, data archiving plan, and/or sample analysis plan. This factor includes the merit of plans for data and/or sample analysis, curation, and data archiving to meet the goals and objectives of the investigation; to result in the publication of science discoveries in the professional literature; and to preserve data, analysis, and samples of value to the science community. Considerations in this factor include assessment of planning and budget adequacy and evidence of plans for well-documented, high-level data products and software usable to the entire science community; assessment of adequate resources for physical interpretation of data; an assessment of the planning and budget adequacy and evidence of plans for the preliminary evaluation and curation of any returned samples; reporting scientific results in the professional literature (*e.g.*, refereed journals); and assessment of the proposed plan for the timely release of the data to the public domain for enlarging its science impact.
- Factor B-4. Science resiliency. This factor includes both developmental and operational resiliency. Developmental resiliency includes the approach to descoping the Baseline Science Mission to the Threshold Science Mission in the event that development problems force reductions in scope. Operational resiliency includes the ability to withstand adverse circumstances, the capability to degrade gracefully, and the potential to recover from anomalies in flight.
- Factor B-5. Probability of science team success. This factor will be evaluated by assessing the experience, expertise, and organizational structure of the science team and the mission design in light of any proposed instruments. The role of each Co-Investigator (Co-I) will be evaluated for necessary contributions to the proposed investigation; the inclusion of Co-Is who do not have a well-defined and appropriate role may be cause for downgrading during evaluation. The inclusion of career development opportunities to train the next generation science leaders will also be evaluated.

The AO Factor A-3 will be re-evaluated as Factor B-6 of Scientific Implementation Merit and Feasibility, as presented below.

- Factor B-6. Likelihood of scientific success. This factor includes how well the anticipated measurements support the goals and objectives; the adequacy of the anticipated data to complete the investigation and meet the goals and objectives; and the appropriateness of the mission requirements for guiding development and ensuring scientific success.

Three new evaluation factors that are not described in the AO, and therefore were not evaluated for Step-1 proposals, will also be considered. Factors B-7 to B-9 below will be evaluated for the CSRs in addition to the factors in AO Sections 7.2.2 and 7.2.3 (repeated or updated above as Factors B-1 through B-6).

- Factor B-7. Scientific Implementation Merit and Feasibility of any Science Enhancement Options (SEOs), if proposed. This factor includes assessing the appropriateness of the selected activities to enlarge the science impact of the mission and the costing of the selected activities. Although evaluated by the same panel as the balance of Scientific Implementation Merit and Feasibility factors, this factor will not be considered in the overall criterion rating.
- Factor B-8. Scientific Implementation Merit and Feasibility of any PI-Team-developed Enhancing Technology Demonstration Opportunities (TDOs), if proposed. This factor includes assessing the appropriateness of the TDO to enlarge the impact of the investigation and/or add value to future investigations. There will be no penalty for potential low inherent maturity of the TDO itself. Although evaluated by the same panel as the balance of Scientific Implementation Merit and Feasibility factors, this factor will not be considered in the overall criterion rating.
- Factor B-9. Maturity of proposed Level 1 science requirements and Level 2 project requirements. This factor includes assessment of whether the Level 1 science requirements are mature enough to guide the achievement of the objectives of the Baseline Mission and the Threshold Mission, and whether the Level 2 requirements are consistent with the Level 1 requirements. The Levels 1 and 2 requirements will be evaluated for whether they are stated in unambiguous, objective, quantifiable, and verifiable terms that do not conflict and for whether they are traceable to the science objectives. They will be evaluated for the adequacy, sufficiency, and completeness, including their utility for evaluating the capability of the instruments and other systems to achieve the mission objectives.The stability of the Level 1 science requirements and Level 2 project requirements will be assessed including whether the requirements are ready, upon initiation of Phase B, to be placed under configuration control with little or no expected modifications for the lifecycle of the mission.

TMC Feasibility of the Proposed Mission Implementation

All of the factors defined in AO Section 7.2.4 apply to the evaluation of the CSR. All of these factors are interpreted as including an assessment as to whether technical, management, and cost feasibility are at least at a Phase A level of maturity. Note that details have been added to subfactors of Factor C-2, Adequacy and robustness of the mission design and plan for mission operations, and Factor C-4, Adequacy and robustness of the management approach and schedule, including the capability of the management team. *Italicized details are added to several factor definitions below for the evaluation of the CSR.*

Note that the ground systems and facilities aspects of the Step-1 evaluation's Factor C-2, Adequacy and robustness of the mission design and plan for mission operations, have been deleted from Factor C-2 and included in a new evaluation factor, Factor C-7, Ground systems. The deleted ground systems subfactor in Factor C-2 is indicated by the struck-through text in that factor definition.

Note that the risk management aspects of the Step-1 evaluation's Factor C-4, Adequacy and robustness of the management approach and schedule, including the capability of the management team, have been removed from Factor C-4 and included in a new evaluation factor, Factor C-6, Adequacy of the risk management plan.

- Factor C-1. Adequacy and robustness of the instrument implementation plan. The maturity and technical readiness of the instrument complement will be assessed, as will the ability of the instruments to meet mission requirements. This factor includes an assessment of the instrument design, accommodation, interface, heritage, and technology readiness. This factor includes an assessment of the instrument hardware and software designs, heritage, and margins. This factor includes an assessment of the proposer's understanding of the processes, products, and activities required to accomplish development and integration of the instrument complement. This factor also includes adequacy of the plans for instrument systems engineering and for dealing with environmental concerns. This factor includes an assessment of plans for the development and use of new instrument technology, plans for advanced engineering developments, and the adequacy of backup plans to mature systems within the proposed cost and schedule when systems having a Technology Readiness Level (TRL) less than 6 are proposed.
- Factor C-2. Adequacy and robustness of the mission design and plan for mission operations. This factor includes an assessment of the overall mission design and mission architecture, the spacecraft design and design margins (including margins for launch mass, ΔV, and propellant), the concept for mission operations (including ~~communication,~~ *operational scenarios, timelines and team responsibilities),* navigation/tracking/trajectory analysis, ~~and ground systems and facilities),~~ *an operations plan,* and the plans for launch services. This factor includes mission resiliency—the flexibility to recover from problems during both development and operations—including the technical resource reserves and margins, system and subsystem redundancy, and reductions and other changes that can be implemented without impact to the Baseline Science Mission.
- Factor C-3. Adequacy and robustness of the flight systems. This factor includes an assessment of the flight hardware and software designs, heritage, and margins. This factor includes an assessment of the proposer's understanding of the processes, products, and activities required to accomplish development and integration of all elements (flight systems, ground and data systems, *etc*.). This factor includes an assessment of the adequacy of the plans for spacecraft systems engineering, qualification, verification, mission assurance, launch operations, and entry/descent/landing. This factor includes the plans for the development and use of new technology, plans for advanced engineering developments, and the adequacy of backup plans to ensure success of the mission when systems having a TRL less than 6 are proposed. The maturity and technical readiness of the spacecraft, subsystems, and operations systems will be assessed. The adequacy of the plan to mature systems within the proposed cost and schedule, the robustness of those plans, including recognition of risks and mitigation plans for retiring those risks, and the likelihood of success in developing any new technologies will be assessed.
- Factor C-4. Adequacy and robustness of the management approach and schedule, including the capability of the management team. This factor includes: the adequacy of the proposed organizational structure and WBS; the management approach including project level systems engineering; the roles, qualifications, and experience of the PI,

Project Manager (PM), Project Systems Engineer (PSE), other named Key Management Team members, and implementing organization, mission management team, and known partners; the commitment, spaceflight experience, and relevant performance of the PI, PM, PSE, other named Key Management Team members, and implementing organization, mission management team, and known partners against the needs of the investigation; the prior working relationships of the implementing organization and known partners; the commitments of partners and contributors; and the team's understanding of the scope of work covering all elements of the mission, including contributions. This factor also includes assessment of elements such as the relationship of the work to the project schedule, the project element interdependencies, the associated schedule margins, and an assessment of the likelihood of meeting the proposed launch readiness date. Also evaluated under this factor are the proposed project and schedule management tools to be used on the project, *along with the small business subcontracting plan including small disadvantaged businesses*. The inclusion of career development opportunities to train the next generation of engineering and management leaders will also be evaluated.

- Factor C-5. Adequacy and robustness of the cost plan, including cost feasibility and cost risk. This factor includes elements such as cost, cost risk, cost realism, and cost completeness including assessment of the basis of estimate, the adequacy of the approach, the methods and rationale used to develop the estimated cost, the discussion of cost risks, the allocation of cost reserves by phase, and the team's understanding of the scope of work (covering all elements of the mission, including contributions. The adequacy of the cost reserves will be evaluated; understanding of the cost risks will be assessed. This factor also includes an assessment of the proposed cost relative to estimates generated by the evaluation team using parametric models and analogies. Also evaluated under this factor are the proposed cost management tools to be used on the project.

When appropriate, Factor C-2 will include an assessment of proposed planetary protection provisions to avoid potential biological contamination (forward and backward) that may be associated with the mission. An evaluation of the implementation of these provisions in the preparation or processing of proposed instruments, the development of the flight system, in project management and to proposed costs will be included in the evaluations of Factors C-1, C-3, C-4, and C-5, as appropriate.

The risk management subfactors of AO Factor C-4 are removed and expanded as a new Factor C-6, as presented below. *Expanded text is italicized below for the evaluation of the CSR.*

- Factor C-6. Adequacy of the risk management plan. The adequacy of the proposed risk management approach will be assessed, including any risk mitigation plans for new technologies*;* any long-lead items; and the adequacy and availability of any required manufacturing, test, or other facilities. The approach to any proposed descoping of mission capabilities will be assessed against the potential science impact to the proposed Baseline Science Mission. The plans for managing the risk of contributed critical goods and services will be assessed, including the plans for any international participation, the commitment of partners and contributors, as documented in Letters of Commitment, and the technical adequacy of contingency plans, where they exist, for coping with the failure

of a proposed cooperative arrangement or contribution; *when no mitigation is possible, this should be explicitly acknowledged. The stability and reliability of proposed partners, and the appropriateness of any proposed contribution, is not assessed as a management risk but will be assessed by SMD as a programmatic risk element of the investigation*.

Two new evaluation factors that are not described in the AO, and therefore were not evaluated for Step-1 proposals, will also be considered. Factors C-7 and C-8 below will be evaluated for the CSRs in addition to the factors in AO Section 7.2.4 (repeated or updated above as Factors C-1 through C-6).

- Factor C-7. Ground systems. This factor includes an assessment, including heritage and planned new development, of the proposed operations facilities, hardware, and software (*i.e.*, those for mission operations and science operations), and a telecommunications analysis, ground network capability and utilization plan, and navigation plans.
- Factor C-8. Approach and feasibility for completing Phase B. The completeness of Phase B plans and the adequacy of the Phase B approach will be assessed. This assessment will include evaluation of the activities/products, the organizations responsible for those activities/products, and the schedule to accomplish the activities/products.

Except for any impact to the primary mission due to inclusion of Enhancing TDO(s) and/or SEO(s), which will be included in the factors above, TMC feasibility of Enhancing TDO(s) and SEO(s) will be evaluated using the same criteria as the primary mission on a separate form. The Enhancing TDO and/or SEO evaluation will be provided to the Selection Official separate from the primary mission evaluation and will not be included in the determination of the primary mission risk.

Merit of the Student Collaboration and Small Business Subcontracting Plans

The following are new evaluation factors that are not described in the AO and therefore were not evaluated for Step-1 proposals. These factors will be evaluated for CSRs.

There is no minimum and no maximum allowable cost for a SC. NASA is providing a student collaboration incentive that is defined to be 1% of the PIMMC. The proposed cost of the SC, up to the student collaboration incentive, is considered outside of the PIMMC. If the SC costs more than the student collaboration incentive, then the rest of the cost of the SC must be within the PIMMC. The SC incentive shall not be used for the investigation's implementation, nor to solve cost overrun issues. The SC provides no cost savings to a NASA investigation.

Merit of the Student Collaboration (SC), if proposed. This factor will include an assessment of whether the scope of the SC follows the guidelines in AO Section 5.5.3. The criteria to be used to evaluate the SC component and a discussion of those criteria are described in the document SPD-31, available in the Program Library.

A proposed SC will be evaluated for its impact on investigation feasibility and merit; see the SMD Student Collaboration document in the Program Library. The three SC review criteria are:

- *Quality, Scope, Realism, and Appropriateness*. Student level and the project's SC research objectives are both clearly defined. SC mentors and supervisors are identified

and have clear lines of responsibilities. A description of what constitutes, to the proposer, a successful SC effort.

- *Diversity*. SC participant recruitment and retention (R&R) practices or proposed inclusion strategies are described. Proposed R&R likely to reach disadvantaged individuals and/or those from groups underrepresented in STEM.
- *Evaluation*. The SC has proposed evaluation methodology based on techniques appropriate to the SC activities proposed. The evaluative processes will document outputs and intended outcomes and use metrics to demonstrate progress or explain the lack of achievement by the SC component.

Merit of the Small Business Subcontracting Plans. This factor will be evaluated on the participation goals and quality and level of work performed by small business concerns overall, as well as that performed by the various categories of small business concerns listed in FAR 52.219-9.

Weighting of Criteria

The percent weighting indicates the approximate significance of each evaluation criterion in the Selection Official's consideration:

- Scientific Merit of the Proposed Investigation: approximately 20%;
- Scientific Implementation Merit and Feasibility of the Proposed Investigation: approximately 30%;
- TMC Feasibility of the Proposed Mission Implementation: approximately 45%; and
- Quality of plans for Small Business Subcontracting, and for an optional Student Collaboration, if proposed: combined approximately 5%.

Additional Selection Factors

At the continuation decision (*i.e.,* the final down-selection), it may be necessary for the Selection Official to consider NASA budget changes and/or other programmatic factors, including but not limited to changes in scientific mandates, national priorities, and budgetary forecasts, that were not evident when the AO was issued. The PIMMC, as well as other programmatic factors, may be additional selection factors.

PART II - CONCEPT STUDY REPORT REQUIREMENTS

Successful implementation of an Explorer investigation demands that the investigation be achievable within established constraints on cost and schedule. The information requested in PART II of this document will enable the evaluation team to assess how well each investigation team understands the complexity of its proposed investigation, its technical risks, and any weaknesses that will require specific action during Phase B. *Investigation teams are cautioned that omissions or inaccurate or inadequate responses to any of the following requirements will negatively affect the overall evaluation.*

Requirement CS-1. A CSR shall consist of two volumes: one volume divided into readily identifiable sections that correspond and conform to Sections A through L of the following guidelines; and a second volume containing the cost proposal (Section J) and any cost appendices (*e.g.*, L.4, L.17). It shall be typewritten in English and shall employ metric (SI) and/ or standard astronomical units, as applicable. It shall contain all data and other information that will be necessary for scientific and technical evaluations; provision by reference to external sources, such as Internet websites, of additional material that is required for evaluation of the CSR is prohibited.

Requirement CS-2. Page size shall be either American standard 8.5 x 11 inches or European standard A4. Foldout pages (11 x 17 inches or A3) may be employed at the proposer's discretion, but see Requirement CS-4 for assessment of foldout pages against the page limit.

Requirement CS-3. Text may not have more than 5.5 lines per vertical inch. Margins at the top, both sides, and bottom of each page shall be no less than 1 inch if printed on 8.5 x 11 inch paper; or no less than 2.5 cm at the top and both sides, and 4 cm at the bottom, if printed on A4 paper. Single-column or double-column formats are acceptable for text pages. Type fonts for text and figure captions shall be no smaller than 12-point (*i.e.,* no more than 15 characters per inch; six characters per centimeter). All text in figures and tables shall be legible; fonts smaller than 8-point are often illegible.

Requirement CS-4. CSRs shall conform to the page limits specified in the *CSR Structure and Page Limits* table below. A page quota higher than that in the Step-1 proposal has been allotted to accommodate an expected greater maturity of detail. As specified in the CSR *Structure and Page Limits* table below, two extra pages each are allotted for each additional, separate, non-identical science instrument, and two extra pages each are allotted for each additional, separate, non-identical flight element (*e.g.,* additional non-identical spacecraft are allotted two extra pages). Five extra pages are allotted for the Student Collaboration (SC) if one is proposed. Pages allocated for the proposed SC shall not be used for any other purpose. Every side of a page upon which printing would appear will count against the page limits unless specifically exempted. Each foldout page will count as two pages against the page limits unless specifically exempted (*e.g.,* cost tables required in Sections J and K).

CSR Structure and Page Limits

Section	Page Limits
A. Cover Pages and Investigation Summary	No page limit, but be brief
B. Fact Sheet	2
C. CSR Table of Contents	No page limit
D. Science Investigation (changes from Step 1 highlighted)	30
E. Science Implementation (including SEOs and/or Enhancing TDOs, if proposed) F. Mission Implementation G. Management H. Other Factors to be Evaluated, including SCs and Small Business Subcontracting I. Preliminary Design and Technology Completion (Phase B) Plan	98 pages; plus 2 pages for each additional, separate, nonidentical instrument or flight element; plus 5 pages for SC if one is proposed; not including schedule foldouts
J. Cost Proposal K. Justification and Cost Proposal for optional SEO and/or Enhancing TDO Activities, if applicable	No page limit, but data must be presented in formats described; be brief
L. Appendices (no other appendices permitted) L.1 Letters of Commitment* L.2 Relevant Experience and Past Performance L.3 Resumes* L.4 Phase B Contract Implementation Data* L.5 Data Management Plan L.6 Incentive Plan(s)* L.7 Technical Content of any International Agreement(s)* L.8 International Participation Plans - Discussion of Compliance with U.S. Export Laws and Regulations (Update from Proposal)* L.9 Planetary Protection Plan L.10 Curation Plans. L.11 End-of-Mission Plan L.12 Compliance with Procurement Regulations by NASA PI Proposals* L.13 Master Equipment List L.14 Heritage L.15 Classified Materials** L.16 Small Business Subcontracting Plan* L.17 Additional Cost Data to Assist Validation (Optional)* L.18 Science Change Matrix L.19 Communications Design Data* L.20 Space Systems Protection* L.21 Description of Engineering Science Investigation (ESI) L.22 Draft Mission Definition Requirements Agreement L.23 Draft MAIP and MAR Compliance Matrix* L.24 Launch Readiness Date Slip L.25 LRD Preference L.26 Acronyms and Abbreviations L.27 References and Management Standards List*	No page limit, but small size encouraged. * Include appendix in the PDF of the CSR. ** Submitted separately.

Requirement CS-5. The electronic submission of the CSR shall contain images of the original signatures of the Principal Investigator and an official of the PI's institution who is authorized to commit its resources.

Requirement CS-6. An electronic submission via LFT containing unlocked, bookmarked, searchable PDF file(s) of the CSR—limited to the main body of the CSR, all tables, all appendices, and the Master Equipment List (MEL)—as well as a separate PDF of the Fact Sheet, Microsoft Excel files of cost tables and the MEL, and other documents specified in Requirements CS-7, CS-8, and CS-9, shall be provided. Animations shall not be included in these PDFs. Additionally, materials identified as subject to U.S. export laws and regulations, in accordance with the AO Section 5.8.3, shall be redacted into separate versions of files that are collected in a Redacted folder. In addition, file size limits from Step 1 are removed. There is no total CSR size limit; however, each PDF file should be no larger than 60MB for ease of display and navigation. If necessary, a PDF file that is larger than 60MB can be divided into more than one file. Limits on number of pages, font sizes, and number of lines per page still apply to the CSR as stated in Requirement CS-4 and the CSR Structure and Page Limit table above, regardless of file size.

Requirement CS-7. The electronic submission shall also contain an electronic version of the schedule in a Microsoft Project format. The tasks in the schedule must follow the standard WBS defined in NPR 7120.5E. The detail on the schedule is requested to go to at least Level 3 for the spacecraft elements (one level below the spacecraft level) and Level 4 for the payload developments (one level below each instrument) where the data are available. When applicable, the electronic submission shall also contain the trajectory information defined in Requirement CS-30 and the references specified according to Requirement CS-115. The electronic submission may contain cost files associated with Appendices L.4 and L.17.

Requirement CS-8. Provide a list of the individuals who have participated in the concept study (*e.g.*, individuals who worked on the CSR, any CSR contributor, Red Team member, reviewer, *etc.*) and/or whom you are proposing to provide work should the mission be down-selected. Additionally, provide a list of all organizations named in the CSR, or providing developmental or research services, including the lead organization, subcontractors, vendors and contributing organizations who have an interest in the mission. Provide an estimate of the total funds for the organizations listed, over the life of the baseline mission as proposed. Provide a draft list of the participants as a Microsoft Excel spreadsheet document to the AO point-of-contact (AO Section 6.1.5) three months prior to the due date of the CSR. Use the Microsoft Excel spreadsheet template that has been posted to the Program Library. This list is to be updated and a final revision shall be included in a separate electronic file at the time of CSR submission.

The purpose of this requirement is to avoid placing people on the CSR evaluation team who have conflicts of interest. One of the objectives of this requirement is to obtain a list of organizations and individuals who would otherwise be unknown to NASA as having or causing a conflict, *e.g.*, independent consultants or consulting organizations who helped with the CSR, or academic colleagues who were Red Team members for the CSR.

Requirement CS-9. Create a separate document that contains a table with all of the requirements (Requirement CS-1 through Requirement CS-115) and the page, section, or table

number that is the main place in the CSR where the requirement is addressed. Provide this table as a PDF document to the AO point-of-contact by email no later than seven days after the CSRs are due**.**

Each electronic submission must include the required files. These files must be compatible with both Microsoft Windows and Apple macOS.

Requirement CS-10. If the science investigation (including but not limited to the science goals and objectives) provided with the Step-1 proposal has changed as a result of the concept study, the changes from the original proposal's science investigation section shall be clearly identified in the CSR.

The required uniform format and contents are summarized below. Failure to follow this outline may result in reduced ratings during the evaluation process.

A. COVER PAGES AND INVESTIGATION SUMMARY

Requirement CS-11. A Graphic Cover Page and Summary Information, prepared as directed below, shall preface every CSR. These pages shall be publically releasable, and will not be counted against the page limits.

Requirement CS-12. The Graphic Cover Page shall contain the following information and elements displayed on the cover page of the CSR:

- The investigation title;
- The name of the proposing organization;
- The name of the PI;
- The name and title of an official who is authorized to commit the proposing organization through the submission of the CSR;
- Images of the signatures of the PI and the authorizing official (unless these signatures appear on the CSR Summary Information) on the electronic submission of the CSR, per Requirement CS-5;
- Names and institutions of all participants in the investigation;
- The total NASA – SMD cost of the investigation;
- The proposed contributions and contributing organizations; and
- A summary of the investigation, not to exceed 300 words.

Per Requirement 86 in AO Section 5.8.3, if the proposal contains export controlled material, the following Export Controlled Material Statement shall be prominently displayed in Section A of the proposal (following the Proposal Summary Information):

> "The information (data) contained in [insert page numbers or other identification] of this proposal is (are) subject to U.S. export laws and regulations. It is furnished to the Government with the understanding that it will not be exported without the prior approval of the proposer under the terms of an applicable export license or technical assistance agreement. The identified information (data) is (are) printed in a red font and figure(s) and table(s) containing the identified information (data) is (are) placed in a red-bordered box."

B. FACT SHEET AND EXECUTIVE SUMMARY

Requirement CS-13. Every CSR shall include a Fact Sheet that provides a brief summary of the investigation. The Fact Sheet shall be publically releasable, and shall not exceed 2 pages in length. Information conveyed on this Fact Sheet shall include:

- Science objectives (including the importance of the science to the program science goals);
- Mission overview;
- Instrument complement;
- Key spacecraft characteristics;
- Mission management and participating organizations (including all named key teaming arrangements);
- Anticipated need for curatorial services for returned samples, as applicable;
- Schedule summary;
- The proposed PI-Managed Mission Cost in Real Year dollars (RY$) and in Fiscal Year 2019 dollars (FY19$) from Cost Table Template 1; and
- The proposed Total Cost, including a breakdown of any contributed costs by contributing organization, in RY$ and in FY19$.

Requirement CS-14. The Executive Summary shall summarize the contents of the CSR and shall include an overview of the proposed baseline investigation, including its scientific objectives, technical approach, management plan, cost estimate, and SC, and small business subcontracting plans. The Executive Summary shall not exceed 5 pages in length.

C. CSR TABLE OF CONTENTS

Requirement CS-15. The CSR shall contain a Table of Contents that parallels the outline provided in Sections D through L below. Figures and tables shall also be included.

See the *CSR Structure and Page Limits* table above for page limits on Sections D through L, inclusive.

D. SCIENCE INVESTIGATION

Requirement CS-16. The Science Investigation section shall describe the science investigation as specified by Requirements B-15 through B-18 in AO Appendix B. If there are no changes from the Step-1 proposal, this section shall be reproduced identically from the Step-1 proposal, with a statement that there have been no changes. Such a statement may be inserted before the first page of this section or it may be included in Appendix L.18 . The Science Investigation section shall not exceed 30 pages in length.

Requirement CS-17. Any changes to the Baseline and Threshold Science Missions defined in the Step-1 proposal shall be identified and the rationale for the change(s) provided. Such changes to the science mission shall be highlighted in bold or a color with column marking for easy identification. In addition, a change matrix showing the original (proposed) science objective(s),

any new or revised science objective(s), rationale for the change(s), and location(s) within the CSR is required as an appendix (see Section L.18). Corrections (*e.g.,* typos and errors) and nominal updates (*e.g.,* revised references, clarified sentences) to this section, that do not constitute a change to the proposed science mission (*i.e.,* no change to science mission objectives, requirements, implementation details, measurements and data, *etc.*) are not required to be individually identified and tracked; however, a summary of such changes shall be provided.

E. SCIENCE IMPLEMENTATION (including Science Enhancement Options if proposed)

E.1 Level 1 Science Requirements and Level 2 Project Requirements

Consistent with NPR 7120.5E, both baseline and threshold requirements are to be described. Baseline science requirements are the mission performance requirements necessary to achieve the full science objectives of the mission. Threshold science requirements are those mission performance requirements necessary to achieve the minimum science acceptable for the investment.

Level 1 requirements should be robust enough (*i.e.*, have sufficient margin) to ensure the system's detailed design could be manufactured, built and tested to achieve the mission success. Ideally, mission success criteria would be defined before Level 1 requirements are written. However, this is not a requirement for the CSR. To the extent that they are known at the end of Phase A, identify the draft mission success criteria in the CSR.

The Level 1 science requirements (referred to as program level requirements in NPR 7120.5E) specify requirements and constraints on science data collection, mission and spacecraft performance, prime mission lifetime, budget, schedule, launch vehicle (LV), and any other requirements or constraints that need to be controlled. The Level 2 requirements flow down from the Level 1 requirements; for example, Level 2 science requirements must describe the data products that would be needed to complete the Level 1 science requirements. The Level 1 requirements provide the criteria to be used to evaluate whether a project should be called for a termination review if it appears it might fail to meet its requirements.

Note that the NPR 7120.5E requires the mission success criteria to be baselined during Phase A at the Systems Requirements Review (SRR). If the mission success criteria are not included in the CSR, they will need to be baselined after down-selection when the project falls under NPR 7120.5E.

Requirement CS-18. A set of proposed Level 1 science requirements that will achieve the objectives of the Baseline Science Mission shall be provided. State both baseline science requirements and threshold science requirements. To the extent that they are known, identify the draft mission success criteria based on the threshold science requirements. The Level 1 science requirements of the investigation, as agreed to by the PI, PM, PSE and other key personnel, must be clearly identified in this section; they must be quantified, verifiable, and clearly tied to the science objectives. Examples of Level 1 science requirements can be found within the Program Level Requirements Appendix (PLRA) documents in the Program Library, along with presentation slides on Level 1 and Level 2 requirements presented at the Concept Study Kickoff meeting. A set of Level 2 requirements that flow down from the Level 1 requirements to guide

the design and development of the mission shall be provided. Lower level requirements shall be provided to the extent that they are known and necessary to explain and justify the design concept including instrument capability, instrument performance, and other aspects of the system architecture that enable the accomplishment of the mission science objectives. State each requirement in unambiguous, objective, quantifiable, and verifiable terms. Requirements shall not conflict with each other. The Level 2 requirements shall be listed in Appendix L.22, Draft Mission Definition Requirements Agreement (MDRA).

E.2 Science Mission Profile

Requirement CS-19. This section shall discuss the science observing profile, including all mission-relevant parameters, such as orbit, navigation accuracy, operational time lines including observing periods, data transmission periods and techniques, and time-critical events. The science observation strategy shall also be described in sufficient detail to understand the complexity of science operations, *i.e.,* are the operations regular re-iteration of data collection sequences, thereby establishing a routine flow, or are there numerous, uniquely planned events thereby requiring repeated planning, testing, and upload cycles. The observation planning and decision-making processes shall be outlined including any priorities assigned to specific observations or measurements and any plans to update the observing strategy based on early observations. The schedule and workforce associated with science planning shall also be described. If science operations involve an ebb and flow of personnel to reduce costs during cruise or "quiet" phases, describe plans for maintaining sufficient trained personnel and for how they will be moved off and then back on the project. The manner in which the proposed investigation objectives, selected instruments, and measurement requirements drive the proposed mission design and operations plan should be apparent from this discussion.

E.3 Instrumentation

Requirement CS-20. This section shall describe the instrumentation and the rationale for its selection. It shall identify instrument systems (*i.e.*, individual instruments), instrument subsystems, and instrument components, including their characteristics and requirements, and indicate items that are proposed for development, as well as any existing instrumentation or design/flight heritage. It shall provide a clear understanding of how the concept will provide the required data, show how it can be accommodated by the spacecraft, demonstrate that instruments have the necessary unobstructed fields-of-view over the measurement period required, describe the technology readiness levels and the approach to bring each instrument to TRL 6 at Preliminary Design Review (PDR). If no development plan is needed, the reasons for this shall be explicitly stated and the rationale shall be described. A preliminary description of each instrument design, with a block diagram showing the instrument subsystems and components, and their interfaces, along with a description of the estimated performance of the instrument, shall be included. These performance characteristics (which shall be considered as requirements on the flight system) shall include mass, power, volume, data rate(s), thermal, pointing (such as control, stability, jitter, drift, accuracy, *etc*.), spatial and spectral resolution, observable precision, retrieved parameter sensitivity and accuracy, and calibration requirements. This section shall demonstrate that the instrumentation can meet the measurement requirements, including factors such as retrieval results for each remote sensor, error analysis of the information in all sensors, vertical and horizontal resolution, signal-to-noise (S/N) calculations, *etc*. It shall also discuss

environmental effects, such as radiation, temperature, and contamination, on each instrument's measurement capabilities as a function of mission time.

Requirement CS-21. The following information shall be provided for each science instrument proposed:

- Mass (include lower level breakouts);
- Viewing direction(s) in body coordinates;
- Pointing accuracy and stability requirements;
- Operational modes;
- Operational mode timeline;
- Data demand for each instrument operational mode;
- Onboard data processing and storage required from spacecraft;
- Power demand for each instrument operational mode including peak, average, and stand-by power; and
- Instrument thermal control capability.

E.4 Data Sufficiency

Requirement CS-22. This section shall discuss the quality and quantity of data to be generated by each instrument, as they relate to the proposed science investigation goals and objectives. The flow-down from science investigation goals to measurement objectives and instrument performance shall be stated clearly and supported by quantitative analysis. If your mission requires NASA High-End Computing (HEC) resources, in your CSR, state your: 1) requirements, by year, for computing in the "standard billing units" (SBUs); 2) data storage need in Terabytes, by year; and 3) explanation of the need to use this capability. You do not need to submit a letter of support. The general HEC webpage is at https://hec.gsfc.nasa.gov/index.html, and SBU Conversion Factors may be found at https://www.hec.nasa.gov/user/policies/sbus.html. Costs associated with HEC utilization will not count against the PIMMC.

E.5 Data Plan

As a Federal agency, NASA requires prompt public disclosure of the results of its sponsored research to generate knowledge that benefits the Nation. Thus, it is NASA's intent that all knowledge developed under awards resulting from this solicitation be shared broadly. In keeping with the *NASA Plan: Increasing Access to the Results of Scientific Research*, available in the Program Library, new terms and conditions about making manuscripts and data publically accessible may be attached to awards that derive from this solicitation. CSRs are required to include a data management plan in accordance with terms and conditions stated in the *NASA Plan: Increasing Access to the Results of Scientific Research* or to justify that one is not necessary given the nature of the work proposed (see AO Requirement B-24). The kind of data that requires a data management plan is described in the *NASA Plan: Increasing Access to the Results of Scientific Research*.

Requirement CS-23. In accordance with the *NASA Plan: Increasing Access to the Results of Scientific Research,* a schedule-based end-to-end Data Management Plan, including approaches

for data retrieval, validation, preliminary analysis, image processing, calibration, correction, and archiving shall be described. The plan shall:

- Identify science products (*e.g.,* flight data, ancillary or calibration data, theoretical calculations, higher order analytical or data products, returned samples, witness samples, and laboratory data), including a list of the specific data products, and the individual team members responsible for the data products;
- Identify the appropriate data archive and the formats and standards to be used. If a NASA archive is not identified, discuss how the mission will satisfy NASA's obligation to preserve data for future researchers;
- Include an estimate of the raw data volume and a schedule for the submission of raw and reduced data, in physical units accessible to the science community, to the data archive, as well as required calibration information to the data archive; and
- Demonstrate allocation of sufficient resources (cost, schedule, workforce, computational) for archiving as well as for preliminary analysis of the data by the Project Science Team, publication of the results in refereed scientific journals, as well as for the development of any new algorithms, software, or other tools.

E.6 Science Team

Requirement CS-24. This section shall identify each key member of the Science Team (*i.e.,* someone whose participation is essential to the success of the investigation) and his/her roles and responsibilities. Resumes or curricula vitae of Science Team members shall be included as appendices to the CSR. The role of the PI and each Co-I shall be explicitly defined, the necessity of that role shall be justified, and the funding source (NASA or contributed) for the PI and each Co-I shall be noted. A summary table shall be included, with columns for 1) PI or Co-I name; 2) their roles and responsibilities on the mission; and 3) their time commitment, in Full-Time Equivalents (FTE) or Work Year Equivalents (WYE), for each mission Phase, A through F (as specified in Requirement CS-72 to Requirement CS-75). Collaborator roles may be defined and justified as done for Co-Is.

E.7 Plan for SEO

Requirement CS-25. If applicable, this section shall describe plans for Science Enhancement Option (SEO) activities (see AO Section 5.1.6). The SEO shall be directly related to the mission (*i.e.*, analyze mission data, not enhance theory). Additionally, a justification and a cost plan for SEO activities are required in Section K of this document.

F. MISSION IMPLEMENTATION

F.1 General Requirements and Mission Traceability

Requirement CS-26. This section shall provide a description of the proposed spaceflight mission that will enable the science investigation. In some areas (*e.g.,* instruments), the data requested may have already been presented in another section of the CSR (*e.g.,* the Science Implementation section). In such a case, a CSR may provide a reference to that section and need not repeat the data in this section.

Requirement CS-27. The mission functional requirements that the science goals and objectives impose on the mission design elements, including mission design, instrument accommodation, spacecraft design, required LV capability, ground systems, communications approach, and mission operations plan, shall be provided in tabular form and supported by narrative discussion. Table B2 in the Program Library, or in AO Appendix B, provides an example of a tabular Mission Traceability Matrix, with examples of matrix elements. Specific information that describes how the science investigation imposes unique requirements on these mission design elements shall be included.

F.2 Mission Concept Descriptions

Requirement CS-28. Designs for all elements of the mission shall be described in sufficient detail to demonstrate that the mission concept meets all of the basic requirements for a space flight mission, including mission design, spacecraft design, and supporting ground systems, as provided in the evaluation factors defined in TMC Feasibility of the Proposed Mission Implementation in PART I above. Discussion of how the various mission elements meet the Mission Functional Requirements shall be included.

Requirement CS-29. This section shall address all elements of the mission design architecture, including the following elements to the extent that they are applicable to the mission. Any additional elements that are applicable to explaining the mission and demonstrating its feasibility shall also be addressed.

- Proposed launch date, launch window, and launch date flexibility;
- Mission duration;
- Orbit type (Earth orbit, heliocentric, *etc*.) and orbit parameters (semi-major axis, eccentricity, inclination, node time of day, argument of perigee, altitude, allowable dispersions) for all orbits, and trajectory design and trajectory parameters for ballistic and low-thrust trajectories to permit independent validation, as applicable to the proposed investigation;
- All critical events, which includes LV separation real-time telemetry;
- Telecomm link summary for all communication modes (based on requirements identified in Appendix L.19, Communications Design Data);
- All ground station(s) usage (*e.g.,* location(s), and transmitting and receiving communication parameters); and
- Space system's fault management approach and design.

Requirement CS-30. Additionally, the following information shall be provided in the CSR for missions whose Phase E operations are beyond Earth orbit. Any graphical references, tables, figures, *etc*. must be presented in a minimum of 150 dots per inch (dpi).

- Checkout Duration: The minimum duration allocated after launch before the primary propulsion system will be commanded to provide required ΔV.
- Initial Mass Assumptions: Provide the initial mass used for generation of the trajectories including propellant loading assumptions.
- Event Basics: Provide the date/time of each trajectory event with a brief event description (*e.g.*, Launch, Gravity Assist, Fly-by, Rendezvous, Mid-Course Burn) and the appropriate data for the event (*e.g.*, flyby altitude, flyby angle, flyby/intercept velocity, ΔV

magnitude). These data should be included for three different scenarios corresponding to the Open, Middle, and Closing Time of the proposed launch window.

- Event Body Ephemeris: Provide ephemeris data for all event bodies (fly-by planet, asteroid fly-by, comet rendezvous, *etc*.). Include the source of the ephemeris data and the epoch for the actual ephemeris point used for a particular event.

For investigations using solar-electric propulsion, the following information should also be included:

- Power model for performance based on solar distance: Provide the functional relationship showing the performance of the solar arrays as a function of the spacecraft's distance from the Sun.
- EP Throttling Model: Provide the throttling model used to generate EP engine performance at any point during the trajectory and a brief explanation of the approach.
- Assumed Engine Duty Cycle: Provide the overall Duty Cycle for the EP engines and if applicable provide the duty cycle over each trajectory segment.
- Number of Engines: Provide the maximum number of engines on the spacecraft that could be operating simultaneously. In addition, provide the number of engines operating throughout each phase of the trajectory.

Any other trajectory specific information not called out above that would be relevant to reviewers attempting to validate the trajectory should also be included.

Requirement CS-31. This section shall demonstrate compatibility with the proposed LV performance level as defined in the AO and the Program Library by providing the launch site, fairing size, spacecraft mass, launch mass margin, and mission orbit characteristics such as altitude (km – circular or apogee/perigee), eccentricity, inclination, C_3, heliocentric, and/or declination. Any non-standard requirements such as additional fairing doors, cleanliness and purge requirements, *etc*., shall be described. The packaged flight system in the proposed fairing, with critical clearance dimensions, and preliminary estimates of launch loads and structural margins shall be included.

Explorer Phase A concept study teams are to continue to use the LV performance classes described in AO Section 5.9.2 and in the Program Library. Explorer Phase A concept study teams should work with Mr. Hamilton Fernandez, 757-817-7709, hamilton.fernandez@nasa.gov, for Launch Services Program support.

Requirement CS-32. This section shall address all aspects of the flight system including the following flight system capabilities to the extent that they are applicable to the mission. Any additional elements that are applicable to explaining the mission and demonstrating its feasibility shall also be addressed. Note that the heritage of the components and subsystems are to be discussed in Appendix L.14.

- Spacecraft parameters:
  (a) Figure of the complete spacecraft/instrument system, on the LV and in flight, with major components labeled and approximate overall dimensions.
  (b) Block diagram of the spacecraft subsystems and their components.
- Subsystem descriptions including structure, telecommunications, thermal, power, propulsion, attitude determination and control, command and data handling, and flight software, to include their interface and interaction with the fault management design.

(Note that the discussion of the telecommunications subsystem should be limited to specifications, design, and proposed component hardware – discussion of the link performance is addressed as part of Appendix L.19). Subsystem detail shall include the following information:

(a) Propulsion, including: (i) a list of all specific events of the proposed ΔV budget (including 3-sigma values for stochastic maneuvers); (ii) for each propulsion type (*e.g.*, monoprop, biprop, dual-mode, solar electric, *etc.*) identify engines and thrust levels, specific impulse, and propellant allocation (*e.g.*, impulse vs. attitude control system); and (iii) propellant margins.

(b) Command and data handling, including: (i) spacecraft housekeeping data rates for nominal and safing strategy; (ii) data storage unit size (Mbits); and (iii) maximum storage record and playback rate.

(c) Power. As appropriate, identify: (i) type of array structure (rigid, flexible, body mounted); (ii) solar array axes of rotation (vector projected in spacecraft coordinates); (iii) array size; (iv) solar cell type and efficiency; (v) expected power generation at beginning of life (BOL) and end of life (EOL); (vi) worst case Sun incidence angle to solar panels during science mission; (vii) battery type and storage capacity; (viii) worst case battery depth of discharge (DOD); (ix) spacecraft bus voltage; and (x) power profiles and margins for all power modes.

(d) Attitude determination and control, including system pointing requirements and capabilities. Describe or define the following: (i) each spacecraft operational mode including the sensors and actuators used, control method, and safing and/or contingency modes; (ii) attitude determination methodology and estimate of accuracy including identifying whether ground post-processing is required to meet science needs; (iii) agility requirements for slews or scanning; (iv) appendage pointing requirements including articulation control methods and deployment accommodations; (v) sensor selection and performance including identifying mounting location and field-of-view (FOV); (vi) actuator selection and sizing including identifying mounting location(s); (vii) translational maneuver (ΔV) control and accuracy; (viii) momentum management approach and mitigation of impacts on navigation accuracy, if applicable; (ix) on-orbit calibrations, if required, including expected accuracy; and (x) attitude control requirements for the spacecraft pointing control, pointing knowledge (at the instrument interface), and pointing stability or jitter.

(e) Thermal control, including: (i) temperature requirements including allowable variations from nominal; (ii) temperature control approach (*i.e.,* passive *vs.* active); (iii) cooling loads; and (iv) special thermal design considerations (*e.g.,* cryogenic instrument requirements).

(f) Structures, including: (i) requirements; (ii) governing load cases and margins; (iii) chosen materials; and (iv) their qualification testing.

(g) Flight software: (i) provide a description of the software architecture including the operating system, development language, and the major software modules to a sufficient depth to demonstrate how this software architecture supports the proposed mission functions; (ii) provide the logical lines of code by Computer Software Configuration Item (CSCI) and the basis for these estimates; a description of the functionality for each CSCI; code counts categorized as either New, Modified, Full Reuse, or Autogenerated; and development method (spiral, waterfall, agile, *etc*.); and

(iii) address the development approach for any major new algorithms to be incorporated in the flight software including the approach for interface management and software verification.

Requirement CS-33. This section shall summarize contingencies and margins of all key flight systems resources. For the driving mission element requirements derived from the Mission Functional Requirements, it shall provide estimates of implementation performance and design margins with respect to the required performance. It shall include the following:

- Dry mass;
- Launch mass not available to the proposed mission;
- Propellants;
- Power;
- CPU utilization;
- Data storage; and
- Attitude control.

For any other driving mission element requirements derived from the Mission Functional Requirements, provide estimates of implementation performance and design margins with respect to the required performance (see the table following Requirement B-35 in AO Appendix B for definitions of contingency and margin).

Requirement CS-34. This section shall address the following elements of mission operations and communication to the extent they are applicable to the mission. Any additional elements that are applicable to explaining the mission operations and demonstrating their feasibility shall also be addressed. This section shall provide:

- Description of ground systems and facilities including supporting ground software at the Mission Operations Center (MOC) and the Science Operations Center (SOC) required for development and testing and operations;
- Telecommunications, Tracking, and Navigation (Deep-Space/Lunar and Earth Orbital missions, as well as missions that utilize telecom relay orbiters) including downlink information and data volume, uplink information, and for all transmit and receive modes, provide mode timeline, data rate(s), and durations, and the ground network utilization plan including ground stations, downlink frequencies/periods/capacities/margins, *etc*., and retransmission capability;
- Plan for acquiring and returning critical event data, including clear identification of procurement and costing for supplemental resources (*e.g.,* mobile ground stations), if such are needed;
- Operations plan, including a quantitative discussion of nominal sequence planning and commanding showing the ability of the Mission Operations and Ground Data System to analyze the spacecraft and payload data and to generate the necessary sequences to enable the spacecraft to meet the planned mission timelines, team training, and availability of spacecraft experts for operations, operations center development; and
- Operational concept that includes the following. Operational Scenarios with a description of each mission phase from launch through end of mission and an integrated description of the ground events and spacecraft/payload events for key mission phases. Timelines for each key mission phase; containing spacecraft, payload, and ground events and processing and identifying margin for each phase if available. Data Flow Diagrams which

clearly show the major operational facilities and key software components utilized for both the uplink and downlink processes. A Phase E Organization diagram and Team Responsibilities clearly indicating the key manager for each of the project facilities in the data flow diagram. An identification of the heritage of each project facility including: the software and hardware within that facility and the identification of the percentage of new, modified or no changes for each major software element. A plan for required maintenance and refresh of vendor supplied ground systems (hardware and software) during extended cruise operations. A plan for retention of adequate development and test resources, spacecraft and Ground Support Equipment (GSE) test beds, *etc*. during Phase E that addresses the impact of operations development and testing on routine and contingency mission operations.

Where the use of NASA's network services may not be within the capabilities and capacities described in the NASA's *Mission Operations and Communications Services* document, discussions should be initiated with the POC named in that document. A Letter of Commitment to be included in Section L.1 is required from the NASA network provider describing the network's ability to deliver the required capabilities and capacities and the cost for doing so.

Requirement CS-35. This section shall provide a clear statement of NASA SCaN network (DSN, NEN, SN) support requirements, preferably in tabular format. Show all mission phases (*e.g.*, launch and early orbital operations, cruise, flybys, orbit insertion, orbital operations, data return), the year in which support is needed, station(s) required, pass lengths in hours, number of passes each week, and the number of weeks for which this support is required.

Requirement CS-36. Missions that employ Multiple Spacecraft Per Aperture (MSPA) on the DSN may reduce costs by using shorter track lengths and operating in non-coherent one-way mode, provided that they do not require an uplink. Investigation teams who plan to avail themselves of such savings shall provide a letter of agreement from each of the other projects with whom they will be sharing the MSPA capability, stating how the uplink services (*e.g.*, commanding, coherent radiometric data capture, *etc.*) will be shared.

F.3 Development Approach

Investigation teams shall describe how all development challenges, including those associated with new technology, will be addressed.

Requirement CS-37. This section shall describe the development plan. This description shall include the following items:

- The systems engineering approach shall be specifically discussed, including the definition, flow-down, tracking, control, and verification of design requirements; resource allocation and control; interface requirements; and hardware and software configuration control. This discussion of the systems engineering approach shall include roles and responsibilities and any unique aspects of the proposed mission that pose unusual system engineering challenges;
- Identification of instrument to spacecraft interfaces;
- Discussion of fault management approach and design;

- Identification of any special or unique implementation/interfaces for supplemental resources that may have been added for critical event coverage;
- Essential trade studies;
- Management and closure of action items, hardware discrepancies, test anomalies, *etc*.; and
- Plan for handling special processes (*e.g.,* if radioactive sources are proposed, the approach to supporting the development, submittal, and approval of the necessary National Environmental Policy Act (NEPA) process and the Nuclear Launch Safety Approval (NLSA) process).

Requirement CS-38. This section shall describe the plan for mission assurance. Plans for using reliability tools, such as fault tree analysis, probabilistic risk assessments, and failure modes and effects analyses, shall be described. Other mission assurance activities such as fault tolerance, reliability (*e.g.*, use or non-use of redundancy, requirements for burn-in of parts, and requirements for total operating time without failure prior to flight) shall be described. Processes for identifying and tracking the correction of failures, both hardware and software, from the piece part to the system level shall be described.

F.4 New Technologies/Advanced Engineering Developments

Requirement CS-39. This section shall describe any proposed new technologies and/or advanced engineering developments – excluding any NASA-developed infusion technologies – and the approaches that will be taken to reduce associated risks. Descriptions shall address, at a minimum, the following topics:

- Identification and justification of the TRL for each proposed system (Level 3 WBS payload developments and Level 3 WBS spacecraft elements) incorporating new technology and/or advanced engineering development at the time the CSR is submitted (for TRL definitions, see NPR 7123.1B, *NASA Systems Engineering Processes and Requirements*, Appendix E, in the Program Library);
- Rationale for combining the TRL values of components and subsystems to derive each full system TRL as proposed, appropriately considering TRL states of integration (see NASA/SP-2016-6105 Rev. 2, *NASA Systems Engineering Handbook,* in the Program Library);
- Rationale for the stated TRL value of an element that is an adaptation of an existing element of known TRL;
- The approach for maturing each of the proposed systems to a minimum of TRL 6 by PDR:
  (a) Demonstration (testing) in a relevant environment can be accomplished at the system level or at lower level(s).
  (b) If applicable, justify what demonstration(s) in a relevant environment at lower level(s) (subsystem and/or subsystem-to-subsystem) would be sufficient to meet system level TRL 6, considering: (i) where any new technology is to be inserted, (ii) the magnitude of engineering development to integrate elements, (iii) any inherent interdependencies between elements (*e.g.*, critical alignments), and/or (iv) the complexity of interfaces. See the Program Library for examples.

(c) Include discussion of simulations, prototyping, demonstration in a relevant environment, life testing, *etc*., as appropriate.

- An estimate of the resources (*e.g.*, manpower, cost, and schedule) required to complete the technology development; and
- Fallbacks/alternatives that exist and are planned, a description of the cost, decision date(s) for fallbacks/alternatives, relevant development schedules, and performance liens they impose on the baseline design, and the decision milestones for their implementation.

If no new technologies or advanced engineering development is required, system TRL 6 or above at the time of CSR submission shall be clearly demonstrated.

F.5 Assembly, Integration, Test, and Verification

Requirement CS-40. An illustration and discussion of the time-phased flow of the Assembly, Integration, and Test (AI&T) Plan shall be presented. Additionally, the key facilities, testbeds, and team members involved in the AI&T Plan shall be summarized.

Requirement CS-41. The project's verification approach shall be described in this section. Flow diagrams, narrative text, and/or other relevant data may be used to convey this information. Elements of the approach that pose special challenges for the project (*e.g.,* mission critical performance or functional requirements that cannot be tested on the ground, special facilities that may be required for testing, large scale simulation tools that must be developed and how they will be validated, critical path items, *etc*.) shall be highlighted. The description of testing and verification shall demonstrate the credibility of the overall approach as reflected by consistency between the described test plans and the schedule, cost, and other resources needed to carry them out. The testing and verification of the space system's fault management approach and implementation shall be discussed.

F.6 Schedule

Requirement CS-42. A project schedule foldout (or foldouts) covering all phases of the investigation shall be provided. This foldout will not be counted against the page limits. The schedule format shall indicate the month and year of each milestone, have a corresponding table of dates, and follow standard NASA WBS elements for task descriptions as prescribed in NPR 7120.5E. The schedule foldout and accompanying narrative shall address major milestones, including the following items:

- Spacecraft development, integration and test, and major review dates;
- Instrument development and major review dates including instrument-to-spacecraft/host integration and test;
- Ground systems development and major review dates (*e.g.*, mission operations and data analysis development schedule);
- Major deliverables (*e.g.*, Interface Control Documents, simulators, engineering modules, flight modules, *etc.*);
- Spacecraft-to-LV integration and launch readiness;
- Long-lead item specifications, development paths, and their impacts to schedule;

- Development schedule for Student Collaborations (SCs); Science Enhancement Options (SEOs), if proposed; Enhancing Technology Demonstration Options (TDOs), if proposed; or Engineering Science Investigators (ESIs), if required;
- Schedule critical path identification, including any significant secondary critical paths; and
- Funded schedule reserve, with indications of appropriate reserves associated with major milestones and deliverables, including allocated critical path reserves.

G. MANAGEMENT

Requirement CS-43. This section shall describe the management approach, including essential management functions and the overall integration of these functions:

- The organizational structure, including:
  (a) An organization chart that clearly indicates how the investigation team is structured.
  (b) The internal operations and lines of authority with delegations, together with internal interfaces.
  (c) Relationships with NASA, major subcontractors, and associated investigators.
  (d) The names of the primary team members, their organizations, and their reporting relationships in the program.
- The commitments and the roles and responsibilities of all institutional team members, including team members responsible for SC (as applicable).

Requirement CS-44. This section shall demonstrate how the proposer's plans, decision-making processes, tools (including performance measurement and reporting), and organization will be applied to manage and control the project during development and operation. The decision-making processes that the team will use shall be described, focusing particularly on the roles of the PI, PM, PSE, and the balance of the Key Management Team in those processes. In particular, the management processes as they apply to the relationships among organizations and key personnel shall be described, including systems engineering and integration; requirements development; configuration management; schedule management; team member coordination and communication; progress reporting (both internal and to NASA); performance measurement; and resource management. This discussion shall include all phases of the mission, including preliminary analysis, technical definition, design and development, and operations phases, as well as products and results expected from each phase. Include a clear description of the methods and frequency of planned communication within the project team.

Requirement CS-45. This section shall summarize the relevant institutional experience and refer to supporting detail included in Section L.2, Relevant Experience and Past Performance. If experience for a partner organization is not equivalent to, or better than, the requirements for the proposed mission, explain how confidence can be gained that the mission can be accomplished within cost and schedule constraints.

Requirement CS-46. Each key position, including its roles and responsibilities, how each key position fits into the organization, and the basic qualifications required for each key position, shall be described. A discussion of the unique or proprietary capabilities that each partner organization brings to the team, along with a description of the availability of personnel at each

partner organization to meet staffing needs shall be included. The contractual and financial relationships between team partners shall be described.

Requirement CS-47. This section shall name all of the team members who will occupy the key project management positions identified in Requirement CS-46. It shall, in addition:

- Describe the previous work experience of each of these key individuals, including the outcomes and complexity of the work they did, and it shall explain the relevance of these experiences to the responsibilities of the key project management positions they will occupy;
- Provide any program/project management certifications held by or planned to be obtained by the PM; and
- Address the role(s), responsibilities, commitments by phase, and percentage of time devoted to the mission for the PI, PM, PSE, and all other named key management individuals, and shall provide reference points of contact, including address and phone number, for each of these individuals.

Requirement CS-48. This section shall describe plans for risk management, both in the overall mission design and in the individual systems and subsystems. NASA's required risk management procedures are provided in NPR 8000.4B, Agency *Risk Management Procedural Requirements*, available in the Program Library. The *Explorers & Heliophysics Projects Division (EHPD) Mission Assurance Requirements (MAR) Mission Risk Classification – NPR 7120.5 Class C* document, available in the Program Library, will also apply. Note that the MAR requires a draft Mission Assurance Implementation Plan (MAIP) and Compliance Matrix to be submitted with the CSR (see Section L.22). Plans for using standard risk management tools, including probability and impact charts, risk lists, mitigation plans and triggers shall be described. The role(s) in the risk management process of each of the key management personnel shall be discussed.

Provide quantitative risk assessments, where the probability and impact of occurrence are independently and numerically specified prior to mitigation; specification of probability and impact after mitigation is encouraged but not required. Where appropriate, an impact may be specified in terms of any resource that is quantified in the CSR. Furthermore, individual quantitative risk assessments may address multiple resources, as well as temporal increments (*e.g.*, mitigation followed by post-mitigation). In order to determine the cumulative effect of risks on resources, each impact must be paired with a probability. The cumulative effect of the products of probabilities and impacts must not reduce the resource below that necessary to achieve baseline science. In the case of cost, the products of pre-mitigation probabilities and impacts shall be included as encumbered cost reserves or explicitly identified in the basis of estimate, including cost validations.

Requirement CS-49. A summary of reserves in cost and schedule shall be identified by mission phase, project element, and year, and the rationale for each shall be discussed. The specific means by which integrated costs, schedule, and technical performance will be tracked and managed must be defined. Specific reserves and the timing of their application must be described. Management of the reserves and margins, including who in the management organization manages the reserves and when and how the reserves are released, must be discussed. This must include the strategy for maintaining reserves as a function of cost-to-

completion. All funded schedule margins shall be identified. The relationship between the use of such reserves, margins, potential descope options, and their effect on cost, schedule, and performance must be fully discussed. When considering potential descope options, consider the investigation as a total system including instrument(s), spacecraft, ground system, launch services, and operations.

Requirement CS-50. This section shall clearly delineate the Government-furnished property, services, facilities, *etc*. required to accomplish all phases of the mission.

Requirement CS-51. This section shall list the major project reviews expected to be conducted during the project's life cycle consistent with NPR 7120.5E and the approximate time frame in the Project Schedule for each review.

NASA NPR 7120.5E establishes the requirements by which NASA formulates and implements space flight programs and projects. This document emphasizes program and project management based on life cycles, Key Decision Points (KDPs), and evolving products during each life-cycle phase.

Tailoring to NASA requirements described in NPR 7120.5E may be proposed by missions at any risk classification. Proposers must identify any tailorable requirements that are proposed to be adjusted, provide a rationale for each adjustment, and describe the cost, schedule, and/or other benefits that would be realized should one or more of the adjustments be accepted by NASA. Note that these adjustments reflect potential modifications to the baseline investigation, to be addressed after down-selection.

The panel evaluating the third evaluation criterion, TMC Feasibility of the Proposed Investigation Implementation, will provide comments to the Selection Official on the proposed tailoring of the requirements and their justifications. These comments will not be considered for the TMC Feasibility of the Proposed Investigation Implementation risk rating but may be considered in the selection decision.

Requirement CS-52. CSRs shall identify any tailorable NASA requirements that are proposed to be adjusted, include the rationale for the adjustment, and describe the cost, schedule, and/or other benefits that would be realized should one or more of the adjustments be accepted by NASA.

Requirement CS-53. This section shall clearly describe the approach to reporting progress to the Government, and indicate the progress reviews the Government is invited to attend to provide independent oversight. The process, including the individual or organization responsible, for reporting integrated cost, schedule, and technical performance must be discussed. A description of the information to be presented must be included.

Requirement CS-54. This section shall describe plans to retire risk due to uncertainty associated with contributions by the end of Phase A. It shall address:

- Commitments for contributions from implementing organizations and/or other funding agencies. Letters of commitment from all organizations involved in a contribution, particularly including the implementing organization (*e.g.*, laboratory or institute) and if

external funding is required the funding agency (*e.g.*, national space agency), shall be provided as an appendix (see Appendix L.1, Requirement CS-79 and Requirement CS-80 of this document);

- Mitigation plans, where possible, for the failure of funding and/or contributions to be provided when that funding and/or contributions are outside the control of the PI. Mitigation may include, but is certainly not limited to, descoping the contributed items and holding reserves to develop the contribution directly. Note that reserves held for this purpose should be weighted by likelihood and are considered encumbered. When no mitigation is possible, this must be explicitly acknowledged, and the stability and reliability of proposed partners, as well as the appropriateness of any proposed contribution, should be addressed; and
- Acknowledgement of the complexities and risks involved with contributions, and plans to handle those complexities or risks. This includes the schedule risk for implementing technical assistance agreements and international agreements. An adequate and realistic schedule must be allocated for having international agreements executed. NASA will not begin working on any international agreements until after the continuation decision is made.

H. OTHER FACTORS TO BE EVALUATED, INCLUDING STUDENT COLLABORATIONS AND SMALL BUSINESS SUBCONTRACTING

CSRs may define a Student Collaboration (SC) that is a separate part of the proposed investigation. A SC can take the form of an instrument development, an investigation of scientific questions, development of supporting hardware or software, or other aspects of the investigation. The SC must be incorporated into the mission on a nonimpact basis. That is, the SC may not increase the mission development risk or impact the development or performance of the baseline or threshold science investigation in any way that would cause the baseline or threshold mission to be compromised in the event that the SC component is not funded; encounters technical, schedule, or cost problems; or fails in flight. A SC must be dependent upon the proposed mission being implemented, *e.g.*, require the provision of flight elements and/or access to science/engineering data generated by the mission. SC elements that involve only analysis of data may not be proposed. A SC may, but is not required to, have the potential to add value to the science or engineering of the mission. A SC must include appropriate plans for the mentoring and oversight of students to maximize the opportunity for teaching, learning, and success in contributing to the mission.

If a proposed investigation is selected, NASA retains the option to fund or not to fund the proposed SC in full or in part. There is no minimum and no maximum allowable cost for a SC. NASA is providing a SC option that is defined to be 1% of the PI-Managed Mission Cost. Contributions to the SC are permitted. The proposed NASA cost of the SC, up to the SC incentive, will be outside of the PI-Managed Mission Cost. If the SC costs NASA more than the SC incentive, then the balance of the NASA cost of the SC must be within the PI-Managed Mission Cost. SC resources, as an addition to a mission's implementation, are not available to solve mission cost overrun issues. SC provides no cost-savings to a NASA mission.

A proposed SC will be evaluated for overall merit as outlined in the SMD document on Student Collaboration SPD-31, which lists evaluation criteria in Section IV. This document can be found in the Program Library.

Requirement CS-55. If a Student Collaboration is proposed, this section shall describe a detailed plan. This plan shall include:

- A summary description of the planned SC;
- A development schedule for the SC, including decision points for determining readiness for flight;
- A demonstration of how the SC will be incorporated into the mission investigation on a non-impact basis;
- A demonstration of how the SC will be clearly separable from the rest of the mission investigation;
- A plan for recruiting student participants;
- A plan for the mentoring and oversight of students to maximize the opportunity for teaching, learning, and success in contributing to the mission;
- An appropriate plan for evaluation; and
- Identification of the cost of the SC separately from the investigation.

Requirement CS-56. A Small Business Subcontracting Plan, covering Phases B through F, shall be provided as an appendix; see Appendix L.16, Requirement CS-103.

I. PRELIMINARY DESIGN AND TECHNOLOGY COMPLETION (PHASE B) PLAN

Once entering Phase B, Heliophysics Explorer projects will be subject to the same requirements as all other NASA missions. Note that the CSR only satisfies some of the KDP-B deliverable requirements, and that the balance will have to be developed early in Phase B (consistent with Section 2.2.7.1 in NPR 7120.5E: "In a two-step AO process, projects are down-selected following evaluation of concept study reports and the down-selection serves as KDP B. Following this selection, the process becomes conventional with the exception that products normally required at KDP B that require Mission Directorate input or approval will be finished as early in Phase B as feasible.").

Requirement CS-57. This section shall address plans and products for the Preliminary Design and Technology Completion Phase (Phase B). It shall identify the key mission tradeoffs to be performed and options to be investigated during Phase B that could lead to reductions in risk of implementation, including those issues, technologies, and decisions points critical to mission success. This section shall also describe and provide the rationale for any anticipated long-lead acquisitions.

Requirement CS-58. The Phase B Plan shall include a detailed schedule, and shall define the products to be delivered and the schedule for their delivery. The schedule shall include the PDR and delivery dates of the following required products:

- A detailed descope plan including the criteria, impact and savings of descope options;
- A complete set of baseline Level 1 requirements including mission success criteria; and
- The baseline project plan.

Requirement CS-59. If more than one contractual arrangement is needed, a separate Statement of Work (SOW) and budget breakout shall be provided for each organization. Subsequent phases will be added to the contract after each phase has been approved through the confirmation review process.

J. COST PROPOSAL

Requirement CS-60. A WBS as defined in NPR 7120.5E and NASA/SP-2016-3404/REV1, *NASA Work Breakdown Structure (WBS) Handbook*, available in the Program Library, shall be provided and used to describe how all project costs are accounted in the cost proposal.

Requirement CS-61. This section shall detail the estimated cost of the proposed investigation. The estimated cost shall encompass all proposed activities, including all applicable mission phases, mission unique or special launch services, flight systems, ground systems, ground network fees, contributions, any other AO-specific activities (*e.g.,* SC), and all cost reserves. Cost for ground network fees, data archive, and other mission-unique elements shall be clearly described. These costs shall be consistent with the policies and requirements in AO Sections 4 and 5.

Requirement CS-62. This section shall describe the methodologies used to develop the cost estimate and provide an overview of the cost estimate development process. Any additional cost estimates or other validation efforts shall be described, the results presented, and any significant discrepancies discussed. The rationale for the proposed cost reserve levels shall be presented. Additional basis of estimate data shall be provided to assist the validation of the costs estimates. Examples of useful basis of estimate data include cost comparisons to analogous items/missions, vendor quotes, and parametric model results.

Requirement CS-63. This section shall discuss cost risks and mitigation strategies.

Requirement CS-64. This section shall provide a foldout cost table, using the template of Cost Table Templates 3a and 3b. The table shall identify the proposed cost required in each mission phase and in each NASA fiscal year; the costs shall be in Real Year dollars (RY$). The top portion of the table shall contain cost data relevant to the PI-Managed Mission Cost. The lower portion shall contain cost data for contributions and mission enhancement costs. The rows in the table shall be the NASA standard WBS elements as defined in NASA/SP-2016-3404/REV1. The costs for most elements shall be provided to WBS Level 3. It is requested that instruments be shown to WBS Level 4 where the data is available. Exceptions are the costs of individual instruments and any unique flight system elements such as landers or sample return capsules, which shall be explicitly shown. The columns in the table shall be grouped and subtotaled by mission phase and shall be labeled with the appropriate fiscal years. Fiscal years that span more than one mission phase shall be split into two columns by mission phase. The table includes totals by phase and life cycle in both RY$ and Fiscal Year 2019 dollars (FY19$). Investigation teams shall use their own forward pricing rates to translate between RY$ and FY19$. For organizations that are without approved forward pricing rates, investigation teams may use the NASA inflation/deflation indices available in the Program Library to translate between RY$ and FY19$.

Requirement CS-65. The CSR cost proposal shall provide information on the anticipated costs for all mission phases. A detailed cost proposal is required for Phase B. Cost estimates are also required for the follow-on phases (*i.e.*, Phases C/D, E, and F), including a description of the estimating techniques used to develop the cost estimates. See Section L for requirements for any SEO costs. A discussion of the basis of estimate shall be provided, with a discussion of heritage and commonality with other programs. Quantify and explain any cost savings that result from heritage. All costs, including all contributions made to the investigation, shall be included. Specific information that would better enable NASA to validate costs (*e.g.*, WBS Level 3 data) may be provided in Appendix L.17 . This will include cost by NASA fiscal year to the lowest level of detail the project is working with, in Microsoft Excel format.

Requirement CS-66. Provide a table with the new obligation authority (NOA) required in RY$ by fiscal year using the format of Cost Table Template 6. If the mission is selected for flight, SMD will use this information to prepare its budget request.

Requirement CS-67. For Phase B only, a time-phased cost breakdown for each WBS element, using the template of Cost Table Template 2, shall be completed. Use only the line items shown in Cost Table Template 2 that are relevant for each phase of the project. The purpose of this set of tables is to provide detailed insight into how the project allocates funding during each phase of work.

Requirement CS-68. The cost of the entire project shall be summarized on two pages—presented using each of the Cost Table Templates 3a and 3b. The purpose of the tables is to (1 provide detailed insight into project costs by cost element and (2 provide a basis for comparison of the project proposed cost with the evaluation team's independent cost analysis. Identify each reserve amount to the lowest level consistent with the proposed reserve management strategy. For example, if each subsystem manager will have spending authority over a reserve for the subsystem, each such amount shall be identified separately. If more convenient, the reserve details may be shown in a separate table, with totals reported using each of Cost Table Templates 3a and 3b. Show costs (NASA SMD and contributed) associated with each Co-I and collaborator using Cost Table Template 4a and 4b respectively**,** on one page each; all Co-Is and collaborators shall be identified in the applicable table.

Requirement CS-69. All contributions provided by NASA Centers, including Civil Servant services, as well as the cost for the use of Government facilities and equipment on a full-cost accounting basis, shall be included. All direct and indirect costs associated with the work performed at NASA Centers shall be fully costed and accounted for in the CSR, and summarized in one page using the template provided in Cost Table Template 5. The purpose of this data is twofold: 1) to determine those costs that are included in the NASA SMD cost but are not funded out of the Explorer program, and 2) to determine Civil Servant contributions that are not included in the NASA SMD cost. Teams should work with their respective NASA Centers to develop estimates for these costs. Contributions by NASA Centers should be documented by a Letter of Commitment, provided as an appendix (see Appendix L.1, Requirement CS-79 and Requirement CS-80).

Definitions for cost element terms shown in the cost tables are provided in AO Appendix C.2.

Requirement CS-70. The inflation index provided in the tables found AO Table B4 and in the Program Library shall be used to calculate all real-year dollar amounts, if an industry forward pricing rate is not available. If something other than the provided inflation index is used, the rates used must be documented.

Requirement CS-71. All costs shall include all burdens and profit/fee in real-year dollars by fiscal year, assuming the inflation rates used by NASA in AO Table B4 and the Program Library, or specifically documented industry forward pricing rates.

Requirement CS-72. This section shall provide a detailed cost proposal for performing Phase B. The cost proposal should correlate with the plans set forth in the concept study. This cost proposal shall include the following elements:

- Contract Pricing Proposal. Complete cost and pricing data for Phase B shall be included with the CSR as an appendix (see Appendix L.4 and Requirement CS-83).
- Work Breakdown Structure. A WBS shall be provided for Phase B. The structure of the WBS should be consistent with the plans set forth in the Science Implementation, Mission Implementation, and Management sections of the concept study and the Statement of Work provided as an appendix to the concept study. The WBS shall be described to the subsystem level (*e.g.*, Attitude Control System, Propulsion, Structure and Mechanisms) for the spacecraft, to at least the instrument level for simple instruments, and to the major component level for more complicated instruments. All other WBS elements shall be at least to the major task level (*e.g.*, Project Management, Systems Engineering, GSE).
- Workforce Staffing Plan. A workforce staffing plan that is consistent with the WBS shall be provided. This plan shall include all team member organizations and must cover all management, technical (scientific and engineering), and support staff. The workforce staffing plan shall be phased by month. Time commitments for the PI, PM, PSE, Co-Is, and other key personnel must be clearly shown.
- Proposal Pricing Technique. The process and techniques used to develop the cost proposal for Phase B shall be described. For portions of the cost proposal developed with a grass-roots methodology, the bases from which the estimates were derived and details on how the estimates were extrapolated from the bases shall be provided. For portions of the cost proposal derived from vendor quotes/historical actuals/catalogue prices/*etc*., information sufficient to understand the fidelity of the values shall be provided. For portions of cost the proposal derived from analogies, the value of and the methodology for extrapolating the analogy shall be described. For portions of the cost proposal derived parametrically, the cost-estimating model(s) and techniques used in the cost estimate for Phase B shall be described. The heritage of the models and/or techniques applied to this estimate, including any differences between missions contained in the model's data base and key attributes of the proposed mission shall be described. Assumptions used as the basis for the cost for Phase B shall be included, and those that are critical to cost sensitivity in the investigation shall be identified. If any "discounts" were assumed in the cost estimates for business practice initiatives or streamlined technical approaches, a description of how these have been incorporated in the cost estimate and will be managed by the investigation team shall be provided.

- Phase B Time-Phased Cost Summary. A summary of the total costs for Phase B consistent with the table created for Requirement CS-67 (Cost Table Template 2) shall be provided. The cost summary for Phase B shall be developed consistent with the WBS and include all costs to NASA SMD along with all contributed costs. The cost summary for Phase B shall be phased by month.
- Elements of Cost Breakdown. Cost or pricing data as defined in FAR 15.401 and supporting evidence stating the basis for the estimated costs by the WBS levels used in the table created for Requirement CS-67 (Cost Table Template 2) shall be provided. This information is in addition to that provided in Requirement CS-64 through Requirement CS-68 (Cost Table Templates 1 through 5). The cost proposal shall include, but is not limited to, the following cost elements:
  (a) Direct Labor. (i) The basis of labor-hour estimates for each of the labor classifications; (ii) the number of productive work-hours per month; (iii) a schedule of the direct labor rates used in the proposal, with a discussion of the basis for developing the proposed direct labor rates for the team member organizations involved; the forward-pricing method (including midpoint, escalation factors, anticipated impact of future union contracts, *etc*.); and elements included in the rates, such as overtime, shift differential, incentives, and allowances; (iv) if available, evidence of Government approval of direct labor rates for proposal purposes for each labor classification for the proposed performance period; and (v) if Civil Servant labor is to be used in support of the Phase B study, but is not to be charged directly to the investigation, this labor shall be considered as a contribution by a domestic partner, subject to the same restrictions as other contributions by domestic or foreign partners, and a discussion of the source of funding for the Civil Servant contributions shall be provided.
  (b) Direct Material. A summary of material and parts costs for each element of the WBS shall be provided.
  (c) Subcontracts. Each effort (task, item, *etc*., by WBS element) to be subcontracted, and list the selected or potential subcontractors, locations, amount budgeted/proposed, and types of contracts shall be identified. Explain the adjustments, if any, and the indirect rates (or burdens) applied to the subcontractors' proposed or anticipated amounts. Describe fully the cost analysis or price analysis and the negotiations conducted regarding the proposed subcontracts.
  (d) Other Direct Costs. (i) A summary of travel and relocation costs, including the number of trips, their durations, and their purposes; (ii) a summary of all unique computer related costs; (iii) specific task areas of problems that require consultant services, including the quoted daily rate, the estimated number of days, associated costs (*e.g.,* travel) if any, and a statement of whether the consultant has been compensated at the quoted rate for similar services performed with Government contracts; and (iv) any other direct costs included in the proposal for Phase B, provided in a manner similar to that described above.
  (e) Indirect Costs. (i) all indirect expense rates for the team member organizations (in the context of the AO, indirect expense rates include labor overhead, material overhead, general and administrative [G&A] expenses, and any other cost proposed as an allocation to the proposed direct costs); (ii) a schedule of off-site burden rates, including a copy of the company policy regarding off-site vs. on-site effort, if applicable; (iii) evidence of Government approval of any/all projected indirect rates

for the proposed period of performance, including the status of rate negotiations with the cognizant Government agency, and a comparative listing of approved bidding rates and negotiated actual rates for the past five fiscal years; and (iv) fee arrangements for the major team partners.

Requirement CS-73. This section shall provide a cost estimate for performing the Final Design and Fabrication/System Assembly, Integration and Test, and Launch (Phase C/D) portion of the mission. The Phase C/D cost estimates shall correlate with the plans set forth in the concept study. In completing this section, the following guidelines will apply:

- Work Breakdown Structure. A WBS shall be included for Phase C/D. The WBS shall be described to the subsystem level (*e.g.*, Attitude Control System, Propulsion System, Structure and Mechanisms) for the spacecraft and to the instrument level for the payload. All other elements of the WBS should be to the major task level (Project Management, Systems Engineering, GSE, *etc*.).
- Cost Estimating Techniques. The process and techniques used to develop the Phase C/D cost estimate shall be described and a description of the cost estimating model(s) and techniques used in the Phase C/D cost estimate shall be provided. The heritage of the models applied to this estimate including any differences between missions contained in the model's database and key attributes of the proposed mission shall be discussed. Include the assumptions used as the basis for the Phase C/D cost and identify those that are critical to the cost sensitivity in the investigation. Identify any "discounts" assumed in the cost estimates for business practice initiatives or streamlined technical approaches and the basis for these discounts. Describe how these have been incorporated in the cost estimate and will be managed by the investigation team.
- Workforce Staffing Plan. A workforce-staffing plan (including Civil Servants) that is consistent with the WBS shall be provided. This workforce-staffing plan shall include all team member organizations and should cover all management, manufacturing, technical (scientific and engineering), and support staff. The workforce-staffing plan shall be phased by fiscal year. Time commitments for the PI, PM, PSE, and other key personnel shall be clearly shown.
- Phase C/D Time-Phased Cost Summary. A summary of the total Phase C/D costs consistent with the WBS in Requirement CS-67 (Cost Table Template 2) shall be provided. The Phase C/D cost summary shall be consistent with the WBS and shall include all costs to NASA, along with all contributed costs. The Phase C/D cost summary shall be phased by fiscal year. Phase C/D extends 30 days beyond launch so be sure to account for all costs for this period, including tracking support and mission operations.

Requirement CS-74. This section shall provide a cost estimate for performing the Operations and Sustainment Phase (Phase E) of the mission. The Phase E cost estimates shall correlate with the plans set forth in the concept study. In completing this section, the following guidelines will apply:

- Work Breakdown Structure. A WBS must be included for the Mission Operations and Data Analysis Phase of the mission. The WBS should be consistent with the plans set forth in the concept study and the Statement of Work that is provided as an appendix.
- Cost Estimating Technique. Describe the process and techniques used to develop the Phase E cost estimate. For portions of the cost proposal developed using a grass-roots

methodology, provide the bases from which the estimates were derived and details on how the estimates were extrapolated from the bases. For portions of the cost proposal derived from vendor quotes/historical actuals/catalogue prices/*etc*. include sufficient information to understand the fidelity of the values. For portions of cost in the CSR derived from analogies, describe the value of and the methodology for extrapolating the analogy. For portions of the cost proposal derived parametrically, provide a description of the cost-estimating model(s) and techniques used in the Phase E cost estimate. Discuss the heritage of the models applied to this estimate including any differences between missions contained in the model's database and key attributes of the proposed mission. Include the assumptions used as the basis for the Phase E cost and identify those which are critical to cost sensitivity in the investigation. If any "discounts" were assumed in the cost estimates for business practice initiatives or streamlined technical approaches, describe how these have been incorporated in the cost estimate and will be managed by the investigation team.

- Workforce Staffing Plan. Provide a workforce staffing plan (including Civil Servants) which is consistent with the WBS. This workforce staffing plan must include all team member organizations and must cover all management, manufacturing, technical (scientific and engineering), and support staff. The workforce staffing plan must be phased by fiscal year. Time commitments for the PI, Co-Is, PM, PSE, and other key personnel must be clearly shown.
- Phase E Time-Phased Cost Summary. Provide a summary of the total Phase E costs consistent with the WBS in Requirement CS-67 (Cost Table Template 2). The Phase E cost summary should be developed consistent with the WBS and must include all costs to NASA SMD, along with all contributed costs. The Phase E cost summary must be phased by fiscal year.

Requirement CS-75. This section shall provide a cost estimate for performing the Closeout Phase (Phase F) of the mission. The Phase F cost estimates should correlate with the plans set forth in the Science Investigation, Science Implementation, Mission Implementation, and Management sections. In completing this section, the following guidelines will apply:

- Work Breakdown Structure. A WBS must be included for the Closeout of the mission. The WBS should be consistent with the plans set forth in the Science Implementation, Mission Implementation, and Management sections and the Statement of Work that is provided as an appendix.
- Cost Estimating Technique. Describe the process and techniques used to develop the Phase F cost estimate. For portions of the cost proposal developed using a grass-roots methodology, provide the bases from which the estimates were derived and details on how the estimates were extrapolated from the bases. For portions of the cost proposal derived from vendor quotes/historical actuals/catalogue prices/*etc*. include sufficient information to understand the fidelity of the values. For portions of cost the proposal derived from analogies, describe the value of and the methodology for extrapolating the analogy. For portions of the cost proposal derived parametrically, provide a description of the cost-estimating model(s) and techniques used in the Phase F cost estimate. Discuss the heritage of the models applied to this estimate including any differences between missions contained in the model's database and key attributes of the proposed mission. Include the assumptions used as the basis for the Phase F cost and identify those which are critical to cost sensitivity in the investigation. If any "discounts" were assumed in the

cost estimates for business practice initiatives or streamlined technical approaches, describe how these have been incorporated in the cost estimate and will be managed by the investigation team.

- Workforce Staffing Plan. Provide a workforce staffing plan (including Civil Servants) which is consistent with the Work Breakdown Structure. This workforce staffing plan must include all team member organizations and must cover all management, manufacturing, technical (scientific and engineering), and support staff. The workforce staffing plan must be phased by fiscal year. Time commitments for the PI, Co-Is, PM, PSE, and other key personnel must be clearly shown.
- Phase F Time-Phased Cost Summary. Provide a summary of the total Phase F costs consistent with Requirement CS-67 (Cost Table Template 2). The Phase F cost summary should be developed consistent with the Work Breakdown Structure and must include all costs to NASA SMD, along with all contributed costs. The Phase F cost summary must be phased by fiscal year.

Requirement CS-76. This section shall summarize the estimated costs to be incurred in Phases A through F, including: Concept and Technology Development (Phase A), Preliminary Design and Technology Completion (Phase B); Final Design and Fabrication (Phase C); System Assembly, Integration and Test, and Launch, extending through in-orbit checkout, usually launch plus 30 days (Phase D); Operations and Sustainment (Phase E); Closeout (Phase F); LV, upper stages, or launch services; ground system costs; and cost of activities associated with social or educational benefits (if not incorporated in any of Phases A through F). The table in Cost Table Template 1 shall be used to summarize these costs. The total mission cost estimate shall be consistent with the Work Breakdown Structure. Detailed plans for any aspects of the mission not discussed elsewhere in the CSR shall be discussed here. The funding profile shall be optimized for the mission. Contributions not included in the NASA SMD cost shall be clearly identified as separate line items.

Immediately following the continuation decision (*i.e.,* down-selection), the contractor will be requested to submit a formal cost proposal based upon the Federal Acquisition Regulation (FAR) Part 15. The instruction and format for submission of this formal cost proposal are found in FAR Part 15.403-5 and Table 15.2. The definitive contract will include an option provision for Phases B, C/D, E, and F with a not-to-exceed amount for each phase.

Requirement CS-77. The cost elements proposed in the formal proposal for contract award shall be traceable to the cost proposal provided in the CSR. Any changes in cost from the CSR shall be described in detail.

K. JUSTIFICATION AND COST PROPOSAL FOR ANY SEO ACTIVITIES

SEO activities, discussed in AO Section 5.1.6, include extended missions, guest investigator programs, general observer programs, and archival data analysis programs. The selections from the Step-1 proposals were made primarily on the merit of the baseline proposed science; no prejudice or commitment to any attendant proposed SEO activity was made at selection. It is incumbent upon investigation teams, therefore, to fully discuss these project additions in the CSR.

Funding for SEO activities are outside the AO Cost Cap, and will therefore result in a separate decision by NASA as to whether to accept or reject these proposed expansions to the Baseline Science Mission. Therefore, the CSR must provide sufficient clarity to allow contractual execution if NASA elects to fund any SEO activities.

All definitions, guidelines and constraints outlined in the AO and applicable to SEOs are still valid for the concept study. There are no page count limits for narrative descriptions, rationale, and data for these enhancements, but conciseness and brevity are encouraged.

Requirement CS-78. If applicable, this section shall provide sufficient data and justifications to enable analysis of not only the science value of the concept, but also its viability and cost. This section shall also provide a cost estimate for performing any SEO activities. In completing the Cost section, the guidelines for Phases B through D apply. Complete a one-page summary of costs using the format shown using the format of Cost Table Template 7. Also include the total amount in the SEO line item at the bottom of the table in Requirement CS-68 (Cost Table Template 3). Include a discussion of the estimating techniques used to develop the cost estimates.

L. APPENDICES

The following additional information is required to be supplied with the CSR. This information is to be provided in the form of appendices to the CSR, and, as such, will not be counted within the specified page limit.

L.1 Letters of Commitment

Requirement CS-79. This appendix shall include letters of commitment from: (i) all organizations offering contributions of goods and/or services (including Co-I services, both U.S. and non-U.S.; collaborators excepted) on a no-exchange-of-funds basis, including all non-U.S. organizations providing hardware or software to the investigation; and (ii) all major or critical participants in the mission regardless of source of funding, signed by officials authorized to commit the resources of the respective institutions or organizations. Personal letters of commitment signed by the individual shall be provided from: (iii) every Proposal Team member. Critical participants are those participants (organizations and individuals) who are assigned tasks considered by the PI to be critical to the success of the mission, including those who provide unique required services. All other participants are non-critical. See AO Section 5.8.1 for detailed definitions of (i), (ii), and (iii). If the use of NASA-provided communication or navigation services is proposed, this appendix shall include an associated letter of commitment. Note that participants may be members of multiple classes, in which case, provide a letter of commitment for each applicable class.

Requirement CS-80. This appendix shall include letters of commitment from non-U.S. individuals and/or institutions that are team members or contributors to Explorer investigations. These letters of commitment shall provide evidence that the non-U.S. institution and/or government will commit the appropriate technical, personnel, and funding resources to the proposed investigation if selected by NASA. Such commitments shall be submitted no later than the Site Visit.

The required elements in a letter of commitment are: (i) a precise description of what is being contributed by the partner and what assumptions are being made about NASA's role; and (ii) the strongest possible statement of whether the contribution will be funded, or what further decisions must be made before the funding is committed by the partner. An authorized officer or representative of the partner institution or government must sign the respective letter of commitment.

Letters of commitment provided for the Step-1 proposal can be reused if the description of the commitment is unchanged and if the letter of commitment meets the requirements for letters of commitment for the Concept Study Report.

L.2 Relevant Experience and Past Performance

In evaluating the CSR, NASA will consider the past performance of the major partner organizations. The evaluation of past performance will not be arithmetic; instead, the information deemed to be most relevant and significant will receive the greatest consideration. Relevant experience will be viewed as the demonstrated accomplishment of work, which is comparable or related to the objectives of the CSR. This includes space-based instrument development and investigations and associated development processes including engineering processes, management processes, operations, data analysis and delivery of data to the Solar Data Analysis Center, Space Physics Data Facility, or other appropriate data archives. NASA will review the past performance information provided by the proposer. In addition, NASA may review the major team partners' past performance on other NASA and/or non-NASA projects or contracts that provide insight into those institutions' past performance on airborne or space-based instrument development and investigations and associated development processes including engineering processes, management process, operations, data analysis and delivery of data to the appropriate data archive. In conducting the evaluation, NASA reserves the right to use all information available.

Requirement CS-81. This appendix shall describe relevant experience and past performance by the major team partners (organizations) in meeting the requirements of projects similar to the subject of the CSR. This may include space-based instrument development and investigations. The discussion of relevant experience and past performance shall include: (i) a description of each project; (ii) its relevance to the subject of the CSR; (iii) the proposed performance and the actual performance; (iv) the planned delivery schedule of data to the appropriate data archive and the actual delivery schedule of data to the appropriate data archive; (v) the proposed cost and actual cost; (vi) the proposed schedule and actual schedule; (vii) an explanation of any differences between proposed performance, cost and schedule and what was actually achieved; and (viii) points of contact for the past project's customer. If the customer for the past project was the United States Government, then the contract number must be included along with current technical point(s) of contact and phone number(s). For projects that are not yet complete, the current projected performance, cost, and schedule must be used in place of actual values. Projects that ended more than 5 years ago need not be included.

Investigation teams are cautioned that omissions or an inaccurate or inadequate response to this evaluation item will have a negative effect on the overall evaluation, and while NASA may

consider data from other sources, the burden of providing relevant references that NASA can readily contact rests with the investigation team.

L.3 Resumes

Requirement CS-82. This appendix shall include resumes or curriculum vitae for the PI and all Co-Is identified in the Science section, and for any Key Management Team members identified in the Management section. The resumes shall clearly indicate experience related to the job the individual will perform on the proposed investigation. Any project management experience that the PI or PM have shall be described in their resumes. Resumes or curriculum vitae shall be no longer than three pages for the PI and one page for each additional participant.

L.4 Phase B Contract Implementation Data

This appendix provides data necessary for the Explorers Program Office to modify the contract during the first Bridge Phase in order to add the balance of Phase B activities to the contract. Provision of Phase B contract implementation data may be deferred to the date of each concept study team's Site Visit.

Requirement CS-83. This appendix shall provide cost and pricing data for Phase B that meet the requirements of the FAR Part 15 Table 15-2. These cost and pricing data are necessary and required to implement the contract. Complete cost or pricing data shall be included with the CSR for each organization participating in Phase B, and must be signed by each organization's authorized representative. This requirement may be satisfied with one form, provided that all institutions involved in Phase B are included and have provided the appropriate signatures. These data are *in addition* to the data provided in Cost Tables Templates 1 to 7 for evaluation purposes, allocate project costs per the cost categories defined in Table 15-2, but still align at the highest levels with the evaluation data. Also see Section J of PART II above for additional guidance.

Requirement CS-84. This appendix shall provide draft SOWs for all potential contracts with NASA. SOWs shall be provided for each contract phase (*i.e.*, Phases B through F) and shall clearly define all proposed deliverables (including science data) for each option, potential requirements for Government facilities and/or Government services, and a proposed schedule for the entire mission.

L.5 Data Management Plan

Requirement CS-85. This appendix shall provide a discussion of all plans (schedules, costs, and deliverables) and their approach and commitment to delivering project data to the appropriate NASA data archives, and indicate such in the plans and schedules for Phase B. This discussion shall also provide assurance that all activities ("womb to tomb") have been considered and included with separate allocation and budgeting of appropriate resources.

L.6 Incentive Plan(s)

Requirement CS-86. If applicable, this appendix shall provide draft incentive plans. Incentive plans must outline contractual incentive features for all major team members. Incentive plans must include both performance and cost incentives, as appropriate.

L.7 Technical Content of any International Agreement(s)

Requirement CS-87. Draft language for the technical content of any International Agreement(s) is required for all non-U.S. partners in the investigation. Sample agreements are available in the Program Library. The draft language must include: (i) a brief summary of the mission and the foreign partner's role in it; (ii) a list of NASA's responsibilities within the partnership; and (iii) a list of the non-U.S. partner's responsibilities within the partnership. Note that NASA prefers to establish agreements with foreign Government funding agencies, and not with the institution that will be funded to perform the work.

L.8 International Participation Plans - Discussion of Compliance with U.S. Export Laws and Regulations (Update from Proposal)

Requirement CS-88. If the investigation includes international participation, either through involvement of non-U.S. nationals and/or involvement of non-U.S. entities, this appendix shall describe any updates to plans for compliance with U.S. export laws and regulations, *e.g.,* 22 CFR 120-130, *et seq*. and 15 CFR 730-774, *et seq*., provided in the Step-1 proposal (see Appendix B, Section J.5 in the AO). The discussion shall describe in detail the proposed international participation and shall include, but not be limited to, whether or not the international participation may require the proposer to obtain the prior approval of the Department of State or the Department of Commerce *via* a technical assistance agreement or an export license or whether a license exemption/exception may apply. If prior approvals *via* licenses are necessary, discuss whether the license has been applied for or, if not, the projected timing of the application and any implications for the schedule. Information regarding U.S. export regulations is available at http://www.pmddtc.state.gov/ and http://www.bis.doc.gov/. Investigation teams are advised that under U.S. law and regulation, spacecraft and their specifically designed, modified, or configured systems, components, parts, *etc*., such as instrumentation responsive to the AO, are generally considered "Defense Articles" on the United States Munitions List and subject to the provisions of the International Traffic in Arms Regulations (ITAR), 22 CFR 120-130, *et seq*.

L.9 Planetary Protection Plan

Requirement CS-89. If applicable, this section shall describe the plan for compliance with the planetary protection requirements described in AO Section 5.1.5. It shall address: (i) the anticipated planetary protection Category of the mission under NASA directives; (ii) the proposed mission operational accommodations to comply with the anticipated requirements, including organizational responsibilities; and (iii) the proposed steps to be taken for the preparation of orbital and/or landed portions of the spacecraft to comply with any requirements for overall microbiological cleanliness and recontamination prevention prior to launch. If describing a sample return mission, this appendix shall additionally address (iv) the nature of the

proposed implementation of back-contamination control and subsequent containment and testing of returned samples or the proposed rationale for the mission to be relieved from a containment requirement. This appendix shall address steps intended to be taken for planetary protection compliance and the implementing organization(s) responsible for implementing those steps.

L.10 Curation Plans.

Requirement CS-90. As applicable, this section shall describe the plan for compliance with the curation requirements described in AO Sections 4.4.4, 4.4.5, and/or 4.4.6.

L.11 End-of-Mission Plan

This appendix is required only for missions conducting significant operations or ending their mission life in low Earth orbit (LEO) (< 2000 km perigee), near geosynchronous orbit (GEO) ± 300 km, or at the Moon (*e.g.*, lunar orbiters, impactors, or landers).

Per NPR 8715.6B, *NASA Procedural Requirements for Limiting Orbital Debris and Evaluating the Meteoroid and Orbital Debris Environments*, orbital debris is defined as any object placed in space by humans that remains in orbit, and no longer serves any useful function. Objects range from spacecraft to spent LV stages to components, and also include materials, fragments, or other objects which are intentionally or inadvertently cast off or generated.

NPR 8715.6B and NASA-STD 8719.14A, *NASA Process for Limiting Orbital Debris*, require all missions to develop an Orbital Debris Assessment Report (ODAR) and assess whether an End-of-Mission Plan (EOMP) is required. Both NPR 8715.6B and NASA-STD 8719.14A are available in the Program Library.

NASA-STD 8719.14A indicates "an 'Initial ODAR' is required for each project to assist NASA management in considering potential orbital debris issues during concept development (Phase A) and development of preliminary requirements, specifications, and designs (Phase B) to estimate and minimize potential cost impacts." As such, provision of an Initial ODAR will be considered sufficient for this section. However, given that the Office of Safety and Mission Assurance (OSMA) will not interface with projects until Phase B, the Step-2 Evaluation Panel will perform the reviews referenced in NASA-STD 8719.14A. While Sections 2 of both Initial ODARs (for Full Spacecraft Development and for Spacecraft Instrument or Component Development) indicates that "[f]urther analysis is not needed at this time", questions that require an analytical basis (*e.g.*, 5 for Full Spacecraft Development), or raise concerns regarding the design of the mission (*e.g.*, objects significantly greater than the 1 kg threshold in 8 for Full Spacecraft Development and 4 for Spacecraft Instrument or Component Development), may elicit follow-ups from the Step-2 Evaluation Panel.

Every selected investigation team must conduct a formal assessment during Phase A of the orbital debris the spacecraft or instrument will create upon mission termination.

For missions not in Earth orbit, plans for conducting these assessments are required at the end of Phase A only for missions where the mission approach (either during nominal operations, in the

event of an anomaly, or at the end of mission) indicates that the likelihood of generating orbital debris in the locations described above is high during nominal operations.

Requirement CS-91. When required, this section shall include a discussion of how end-of-mission requirements will be met.

L.12 Compliance with Procurement Regulations by NASA PI Proposals

This appendix is required only for CSRs submitted by NASA PIs or NASA Centers (excluding JPL). CSRs submitted by NASA Centers must comply with regulations governing proposals submitted by NASA PIs (NFS 1872.308).

Requirement CS-92. For CSRs submitted by NASA Centers, this section shall include any descriptions, justifications, representations, indications, statements, and/or explanations that are required by the regulations.

L.13 Master Equipment List

Requirement CS-93. This appendix shall include a Master Equipment List (MEL) summarizing all flight element subsystem components and individual instrument element components to support validation of proposed mass and power estimates—including continencies, design heritage, and cost. A template for this MEL is included as AO Table B5.

The breakouts should be traceable to block diagrams and heritage claims provided in other parts of the proposal. For each major component, current best estimates (CBEs) and contingency for mass and power, number of flight units required, and some description of the heritage basis must be provided. Power values should represent nominal steady state operational power requirements. Information to be provided includes identification of planned spares, identification of engineering models and prototypes with their fidelities, required deliveries for simulators and testing, contingency allocations for individual components, and other component description/characteristics. Certain items should include additional details sufficient to assess functionality and/or cost, to identify and separate individual elements.

List each electronic board separately, identify the functionality of each board (either in the MEL or in the Mission Implementation section), and provide the speed the board will be running at. If proposing Field Programmable Gate Arrays (FPGAs) or Application Specific Integrated Circuits (ASICs), or Radio Frequency Integrated Circuits (RFICs), list the design size (in the appropriate sizing parameter such as logic cells, logic elements), the board the chip(s) will be integrated onto, and how much heritage will be used in the design.

Requirement CS-94. The MEL shall be provided in Microsoft Excel format.

L.14 Heritage

Requirement CS-95. This section shall discuss each element of any heritage from which the proposed investigation derives substantial benefit, including heritage from spacecraft subsystems, instruments, ground systems, flight and ground software, test set ups, simulations,

analyses, *etc*. This discussion shall be at an appropriate level of granularity (*e.g.,* component, assembly, subsystem) to clearly separate the heritage element from other elements of the design. The discussion of each element shall include:

- A concise description of the design heritage claimed;
- Anticipated benefits to the proposed investigation;
- A brief rationale supporting the claim that the benefits of heritage will be achieved; and
- For any proposed elements with substantial design heritage, a comparison of the cost of the heritage items to the proposed cost.

CSRs shall substantiate all heritage claims, including descriptions of changes required to accommodate project-unique applications and needs. Where enhancements to heritage elements are proposed or heritage is from a different application, sufficient descriptions must be provided to independently assess the current level of maturity.

Requirement CS-96. If a CSR claims any heritage from which the proposed investigation derives substantial benefit, this appendix shall discuss each element to an appropriate level of granularity (*e.g.*, component, assembly, subsystem) to clearly separate the heritage element from other elements of the design.

L.15 Classified Materials

In order to increase the capabilities of investigations proposed in response to the AO while minimizing the development and operations risks within the PIMMC, proposers may choose to leverage technology with classified heritage that was developed by other institutions and agencies, as well as by NASA and NASA-funded partners.

If a proposer chooses to submit a classified appendix regarding heritage, the requirements on content and format are the same as, but independent from, those for the unclassified appendix regarding heritage included in the CSR (see M.14 above for further details), with the exceptions that Letters of Validation and cost bases of estimate may be included in the classified appendix regarding heritage.

The full evaluation panel will not have access to the classified appendix regarding heritage. Proposers are strongly encouraged to provide as much information and detail as possible on their technology heritage in the unclassified appendix regarding heritage.

NASA allows three options for proposers to support heritage claims from classified programs: 1) delivery to NASA of a classified appendix regarding heritage, 2) “delivery in place” of a classified appendix regarding heritage, and subject to possible restriction 3) sponsor verification of the heritage claims derived from classified programs. Each option is explained in a subsection below.

Delivery to NASA

Proposers may provide NASA access to a classified CSR appendix for validation of classified heritage claims. The classified appendix regarding heritage may include Letters of Validation for classified heritage claims from technology development sponsors and a classified cost bases of

estimate. The proposer is responsible for determining which information is classified and which information is unclassified; any classified information provided to NASA must be handled appropriately, including appropriate marking must comply with the applicable Security Classification Guide (SCG) or similar document. The proposer is responsible for obtaining any "need to know" permission for at least one reviewer with appropriate clearance and relevant expertise to evaluate the classified appendix regarding heritage.

The delivery to NASA option of a classified appendix regarding heritage requires delivery to NASA Headquarters (HQ) separately from the CSR. A single copy of the classified appendix regarding heritage must be submitted along with a cover letter referencing the submitted CSR by name, PI, and proposing organization. The "need to know" permission for the reviewer should be discussed in a cover letter. The proposer assumes all responsibility for determining the appropriate security clearance and method of delivery to NASA HQ of the classified appendix regarding heritage. The classified appendix regarding heritage must be handled and delivered to NASA HQ in compliance with NPR 1600.1A, NASA Security Program Procedural Requirements.

Requirement CS-97. Proposers that choose to deliver to NASA a classified appendix regarding heritage shall submit the appendix and a cover letter to NASA HQ no later than the deadline for receipt for the electronic submission in the INTRODUCTION. The proposer shall determine the appropriate security classification for the classified appendix, the proposer shall obtain any permission required for a reviewer to read the classified appendix, and the proposer shall ensure that all appropriate security requirements are followed in delivering the classified appendix to NASA HQ.

Requirement CS-98. The point-of-contact (POC) for the AO (see Section 6.1.5) shall be notified of the intent to submit a classified appendix regarding heritage and its level of classification to ensure sufficient evaluator clearance. The POC notification shall include whether the sender is considering delivery to NASA via a classified email system in lieu of physical delivery. The unclassified appendix regarding heritage shall also indicate that a classified appendix is being submitted.

The address for delivery of the package containing the classified appendix regarding heritage is: Mr. Paul Raudenbush, Chief, NASA Headquarters Security Office, Suite 1M40, 300 E Street SW, Washington, DC 20546. The package containing the classified appendix regarding heritage should be sent to NASA HQ by an appropriate means (*e.g.*, courier, U.S. Registered Mail, *etc.*) with coordination in advance with the receiving facility.

Should a proposer choose to deliver a classified appendix regarding heritage to NASA in addition to a complete CSR, the evaluation process (see AO Section 7.1.1) will be supplemented. At least one NASA-selected evaluator with appropriate clearance and relevant expertise will review the classified appendix regarding heritage; this evaluator may be a member of the evaluation panel or this evaluator may be a specialist reviewer. All findings generated during the review of the classified appendix regarding heritage will be unclassified, and these findings will be provided as input for assessing the Technical, Management, and Cost (TMC) Feasibility of the Proposed Mission Implementation. Clarifications may be requested concerning findings from evaluation of the classified appendix regarding heritage.

"Delivery in Place"

Proposers may choose to utilize the option for "delivery in place" of the classified appendix regarding heritage, where the classified material is not delivered to NASA but is kept at the point of origin. The complete, unclassified CSR must state that a classified appendix regarding heritage has been delivered in place and provide the classification level of the material, the location of the material, and the POC to be contacted to access the material.

Should a proposer choose to submit a classified appendix regarding heritage to NASA in addition to a complete CSR using the "delivery in place" mechanism, the evaluation process (see AO Section 7.1.1) will be supplemented. At least one NASA-selected evaluator with appropriate clearance and relevant expertise will travel to the delivery location at Discovery Program cost to review the classified appendix regarding heritage; this evaluator may be a member of the evaluation panel or this evaluator may be a specialist reviewer. All findings generated during the review of the classified appendix regarding heritage will be unclassified, and these findings will be provided as input for assessing the Technical, Management, and Cost (TMC) Feasibility of the Proposed Mission Implementation. Clarifications may be requested concerning findings from evaluation of the classified appendix regarding heritage.

Requirement CS-99. Proposers that choose the option of "delivery in place" of a classified appendix regarding heritage shall develop—and deliver to a designated POC/custodian—the appendix by the deadline for electronic submission in the INTRODUCTION, with a cover page record of the last date that the document was edited. The POC/custodian of the classified appendix shall certify the date of receipt of the document and its unchanged status, each time the classified appendix is viewed by a reviewer. The proposer shall determine the appropriate security classification for the classified appendix, the proposer shall obtain any permission required for a reviewer to read the classified appendix at the proposer's designated facilities, and the proposer shall ensure that all appropriate security requirements are followed in the handling of the classified appendix.

Requirement CS-100. The POC for the AO (see AO Section 6.1.5) shall be notified of the intent to utilize the "delivery in place" option for a classified appendix regarding heritage, the level of classification to ensure sufficient evaluator clearance, and the POC/custodian contact information.

Sponsor Verification

CSRs that include technologies with classified heritage may utilize sponsor verification. This option is only available if the sponsor organization is not a proposed partner. Such CSRs would only reference classified materials, including associated cost bases of estimate; the materials would not be provided to NASA in any format. In lieu of a direct review of the classified materials, the evaluation panel will compile a list of questions regarding claims made in the CSR that need substantiation by the classified material. The list would be sent to the sponsor of the classified programs who must verify that the claims are supported

Requirement CS-101. Proposers that choose the option of sponsor verification of classified materials shall provide an enumeration of claims related to the classified materials in the body of the CSR.

Requirement CS-102. The POC for the AO (see AO Section 6.1.5) shall be notified of the intent to utilize the sponsor verification option and the POC to whom associated questions would be sent.

L.16 Small Business Subcontracting Plan

Requirement CS-103. A small business subcontracting plan covering Phases B through F, including the proposed goals and targets and the quality and level of work that will be performed by various categories of small business concerns, as described in AO Section 5.5.1, shall be provided. Its effect on the technical, management, and cost feasibility of the investigation shall be described. This plan will be negotiated prior to any Phase B contract award.

L.17 Additional Cost Data to Assist Validation (Optional)

In addition to the specific cost table data requested in the Cost Proposal (Section J), investigation teams may also provide any additional costing information/data that they feel will assist NASA to validate the project's proposed costs. Vendor quotes, cost estimates, rationale for design heritage cost savings, are all examples of data that can be included here. Input and output files for any publicly available cost model may be included with each electronic submission, if accompanied by discussion in this appendix.

L.18 Science Change Matrix

Requirement CS-104. If the Phase A effort results in changes from any science objective proposed in Step 1, this appendix shall provide the original objective, the new or revised objective, rationale for the change, and the section/paragraph in the CSR where the change occurs.

L.19 Communications Design Data

Requirement CS-105. Provide data and detailed link analyses for all communication modes, adequate to assess the design of the communications concept. This shall include a communications block diagram (showing all components) and link budget design control tables for all radio communications links (data and carrier) showing relevant spacecraft and earth station parameters and assumptions for the highest data rate and the emergency link at the maximum distance and throughput at which each particular link could be used. In particular the following parameters shall be provided: Transmitter Power, Transmitter Antenna Gain, Transmitter Off-Boresight Pointing Loss, Transmitter Circuit Loss, Carrier Frequency, Transmitter-Receiver Range, Receiver Antenna Gain, Receiver Off-Boresight Pointing Loss, Receiver Circuit Loss, Receiver Bandwidth, Receiver System Temperature, Hot Body Noise Temperature, Data Modulation Index, Ranging Modulation Index, Data Rate, Forward Error Correcting Code including code rate, block size (if applicable), constraint length (if applicable), Carrier Modulation Index, Carrier Link Margin, and Data Link Margin. For more information on

these requirements, including table format, see *NASA's Mission Operations and Communication Services*, available in the Program Library.

L.20 Space Systems Protection

Previously identified threats and vulnerabilities to space systems have indicated that the command uplink to robotic spacecraft needs to be better protected. On February 1, 2019, the NASA Associate Administrator issued a letter directing that all newly started or newly solicited robotic spacecraft protect their command uplink through the use of encryption that is compliant with Level 1 of the Federal Information Processing Standard (FIPS) 140-2. This requirement does not apply, however for (1) hosted instrument payloads; (2) Class C or D spacecraft lacking propulsion subsystems; and (3) spacecraft that will operate more than two million kilometers ("deep space") from the Earth. For more information regarding Space Systems Protection requirements that will be imposed after down-selection, see the NASA-STD-1006.pdf and associated FAQs for Protecting Spaceborne Assets 13-May-2020.pdf, available in the Program Library.

Additionally, the letter from the Associate Administrator required that the command uplink, position, navigation, and timing subsystems recognize and survive interference. Finally, information pertaining to the command uplink, including command dictionaries, must be protected—at least to the level of Sensitive But Unclassified (SBU).

The requirements associated with AO Section 5.2.11 were deferred until Step 2, but are now applicable. Because these are new requirements, the additional costs associated with them are outside the AO Cost Cap.

Requirement CS-106. Provide the detailed plans, as applicable, addressing the protection of uplink commands using approaches compliant with FIPS 140-2 Level 1.

Requirement CS-107. Provide the detailed plans addressing the ability of command uplink, position, navigation, and timing subsystems to recognize and survive interference.

Requirement CS-108. Provide the detailed plans addressing the protection of command uplink information at no less than the Sensitive But Unclassified level.

L.21 Description of Engineering Science Investigation (ESI)

Requirement CS-109. If applicable, this section shall describe proposed approach to achieving the goals and objectives of the Entry, Descent, and Landing (EDL) ESI. At a minimum, this description shall address the following topics to the extent that they are not addressed in the body of the CSR:

- Demonstration of the proposer's understanding of the goals and objectives of the ESI;
- Description of the method(s) to be applied to obtain diagnostic and technical data about vehicle performance and entry environments. At a minimum, this shall include:
  (a) Description of any required flight hardware development and integration plans for producing flight-qualified hardware/software.
  (b) Description of the data to be collected, planned calibrations, and downlink process.

(c) Demonstration that the proposed instruments and data are sufficient to achieve the goals and objectives of the ESI.
(d) If any fallbacks/alternatives exist and are planned, description of the cost, schedule, and performance liens they will impose on the baseline design, as well as the decision milestones for their implementation.

- A discussion of potential impacts of the ESI on the prime science mission;
- Estimated mass, power, telecommunications, cost, and schedule impacts associated with the implementation of the proposed ESI; and
- Description of data products, including any applicable mission engineering data, and their provision to NASA.

This section need not repeat information that may be found in the body of the CSR. However, for completeness, discussions of the ESI in the body of the CSR should be referenced from this section.

L.22 Draft Mission Definition Requirements Agreement

Requirement CS-110. A draft Mission Definition Requirements Agreement (MDRA) shall be provided. MDRAs define Level 2 requirements for the baseline mission, encompassing the programmatic, science and instrument, mission implementation and spacecraft, and ground data requirements. An example of an MDRA is provided in the Program Library.

L.23 Draft MAIP and MAR Compliance Matrix

Requirement CS-111. This section shall provide a draft Mission Assurance Implementation Plan (MAIP) and Compliance Matrix for the *Explorers & Heliophysics Projects Division (EHPD) Mission Assurance Requirements (MAR) Mission Risk Classification – NPR 7120.5 Class C* document, available in the Program Library. See the document for details.

L.24 Launch Readiness Date Slip

Requirement CS-112. This section shall include a detailed discussion of the science, engineering, risk, and cost impacts of delaying the Launch Readiness Date by two years. Include budget profiles assuming an extended Phase B.

L.25 LRD Preference

Requirement CS-113. This section shall describe the impact of both LRDs. The discussion is requested to inform programmatic considerations and will not be evaluated. Topics covered should include cost, schedule, LV, and any other significant benefits or detriments. Proposers are encouraged to make the assumptions needed to minimize the impact to the mission should the non-preferred launch date be chosen by NASA; such assumptions should be noted in the discussion.

L.26 Acronyms and Abbreviations List

Requirement CS-114. This section shall provide a list of abbreviations and acronyms.

L.27 References and Management Standards List

Requirement CS-115. This section shall provide a list of any internal program and project management standards to be used in the proposed development (*e.g.*, GEVS, "GOLD Rules"). To the extent practicable, the referenced documents shall be included with the electronic submission.

CSRs may additionally provide, in this appendix, a list of other reference documents and materials used in the concept study. Investigation teams are encouraged to include an active URL for those documents available through the Internet. If the URL is password protected, provide the password in the CSR.

COST TABLE TEMPLATE 1
TOTAL MISSION COST FUNDING PROFILE TEMPLATE
(FY costs* in Real Year Dollars, Totals in Real Year and FY19 Dollars)

Item	FY1	FY2	FY3	FY4	FY5	...	FYn	Total (RY$)	Total (FY19$)
Phase A	$	$	$	$	$	$	$	$	$
- Organization A									
- Organization B									
- *etc*.									
Phase B	$	$	$	$	$	$	$	$	$
- Organization A									
Phases C and D	$	$	$	$	$	$	$	$	$
- Organization A									
Phase E	$	$	$	$	$	$	$	$	$
- Organization A									
Phase F	$	$	$	$	$	$	$	$	$
- Organization A									
PI Mission Cost	$	$	$	$	$	$	$	$	$
Contributions by Organization (Non-U.S. or U.S.) to:									
Phase A	$	$	$	$	$	$	$	$	$
- Organization A									
Phase B	$	$	$	$	$	$	$	$	$
- Organization A									
Phases C and D	$	$	$	$	$	$	$	$	$
- Organization A									
Phase E	$	$	$	$	$	$	$	$	$
- Organization A									
Phase F	$	$	$	$	$	$	$	$	$
- Organization A									
Contributed Costs (Total)	$	$	$	$	$	$	$	$	$
						Total Mission Cost			$

* Costs must include all costs including fee. Include the optional SC costs, up to the SC incentive, in Table 1 as a contribution by SMD that is part of the Total Mission Cost.

COST TABLE TEMPLATE 2

(Phased costs in Real Year Dollars, Totals in Real Year and FY19 Dollars)

TIME-PHASED COST BREAKDOWN BY WBS AND MAJOR COST CATEGORY					
WBS/Cost Category Description	FY1	…	FYn	Total (RY$)	Total (FY19$)
Total Direct Labor Cost	$	$	$	$	$
WBS 1.0 Management					
WBS 2.0 Spacecraft					
WBS 2.1 Structures & Mechanisms					
WBS 2.2 Propulsion					
etc.					
Total Subcontract Costs	$	$	$	$	$
WBS # and Description					
:					
etc.					
Total Materials & Equipment Cost	$	$	$	$	$
WBS # and Description					
:					
etc.					
Total Reserves	$	$	$	$	$
WBS # and Description					
:					
etc.					
Total Other Costs	$	$	$	$	$
WBS # and Description					
:					
etc.					
Fee					
Other (Specify)					
Total Contract Cost	$	$	$	$	$
Total Other Costs to NASA SMD	$	$	$	$	$
Launch Services					
Ground Segment					
SC, up to incentive					
SEO					
Other (Specify)					
Total Contributions (Non-U.S. or U.S.)	$	$	$	$	$
Organization A:					
WBS # and Description					
etc.					
Organization B:					
WBS # and Description					
etc.					
TOTAL COST FOR PHASE	$	$	$	$	$

COST TABLE TEMPLATE 3a
FISCAL YEAR COSTS IN REAL YEAR DOLLARS (to nearest thousand)
(Totals in Real Year Dollars)

Total Mission Cost Profile Template
FY Costs and Totals in Real Year Dollars (RY$)

WBS#	WBS Element	Phase A			Phase B			Phase C/D				Phase E				Phase F			RY$
		FY2017	FY2018	Total	FY2018	FY2019	Total	FY2019	FY2020	FY2021	Total	FY2021	FY2022	FY2023	Total	FY2023	FY2024	Total	Total
01	Project Management																		
02	Systems Engineering																		
03	Safety & Mission Assurance																		
04	Science / Technology																		
	Breakout pre-launch science from technology development activities																		
05	Payload(s)																		
	List each instrument separately																		
06	Spacecraft																		
	List each major flight system element separately																		
07	Mission Operations																		
	Breakout separable services, e.g., DSN, etc.																		
08	Launch Vehicle / Services																		
09	Ground System(s)																		
	Breakout non-standard cost, e.g., coordinating ground stations																		
10	Systems Integration & Testing																		
11	Student Collaboration in Excess of Incentive																		
	Reserves																		
	PI-Managed Mission Cost																		
	Student Collaboration Incentive (if applicable)																		
	Contributions																		
	List by organization and WBS element																		
	Total Mission Cost																		
	Student Collaboration Incentive (if applicable)																		
	Other AO-specific Activities																		
	List by activity and WBS element																		
	Enhanced PI-Managed Mission Cost																		
	Phase B Bridge Phase Funding (*included above*)																		

Label columns with actual fiscal years. Add or remove FY columns as necessary.

Include the optional SC costs, up to the SC incentive, in Table 3a as a contribution by SMD that is part of the Total Mission Cost and the Enhanced PI-Managed Mission Cost. Include the optional SEO costs in Table 3a as Other AO-specific Activities that are part of the Enhanced PI-Managed Mission Cost.

COST TABLE TEMPLATE 3b
FISCAL YEAR COSTS IN FISCAL YEAR 2019 DOLLARS (to nearest thousand)

(Totals in Fiscal Year 2019 Dollars)

Total Mission Cost Profile Template

FY Costs and Totals in Fiscal Year 2017 Dollars (FY 2017$)

WBS#	WBS Element	Phase A			Phase B			Phase C/D			Phase E			Phase F			FY 2017$
		FY2017	FY2018	Total	FY2018	FY2019	Total	FY2019	FY2020	FY2021	Total	FY2021	FY2022	FY2023	Total	FY2023	FY2024	Total	Total
01	Project Management																		
02	Systems Engineering																		
03	Safety & Mission Assurance																		
04	Science / Technology																		
	Breakout pre-launch science from technology development activities																		
05	Payload(s)																		
	List each instrument separately																		
06	Spacecraft																		
	List each major flight system element separately																		
07	Mission Operations																		
	Breakout separable services, e.g., DSN, etc.																		
08	Launch Vehicle / Services																		
09	Ground System(s)																		
	Breakout non-standard cost, e.g., coordinating ground stations																		
10	Systems Integration & Testing																		
11	Student Collaboration in Excess of Incentive																		
	Reserves																		
	PI-Managed Mission Cost																		
	Student Collaboration Incentive (if applicable)																		
	Contributions																		
	List by organization and WBS element																		
	Total Mission Cost																		
	Student Collaboration Incentive (if applicable)																		
	Other AO-specific Activities																		
	List by activity and WBS element																		
	Enhanced PI-Managed Mission Cost																		
	Phase B Bridge Phase Funding (*included above*)																		

Label columns with actual fiscal years. Add or remove FY columns as necessary.

Include the optional SC costs, up to the SC incentive, in Table 3b as a contribution by SMD that is part of the Total Mission Cost and the Enhanced PI-Managed Mission Cost. Include the optional SEO costs in Table 3b as other AO-specific Activities that are part of the Enhanced PI-Managed Mission Cost.

COST TABLE TEMPLATE 4a
CO-I COMMITMENT AND COST
FUNDING PROFILE TEMPLATE
(FY costs in Real Year Dollars, Totals in Real Year and FY19 Dollars)

	Phase B	Phases C and D	Phase E	Phase F	Total (RY$)	Total (FY19$)
NASA SMD Cost						
Co-I #1 Name/Organization						
Percent Time						
Cost						
Co-I #2 Name/Organization						
Percent Time						
Cost						
Co-I #n Name/Organization						
Percent Time						
Cost						
Total NASA SMD Co-I Cost						
Contributions						
Co-I #1 Name/Organization						
Percent Time						
Cost						
Co-I #2 Name/Organization						
Percent Time						
Cost						
Co-I #n Name/Organization						
Percent Time						
Cost						
Total Contributed Co-I Cost						

If the optional SC and/or SEO include any Co-I costs, include them in Table 4a as appropriate.

COST TABLE TEMPLATE 4b
COLLABORATOR COMMITMENT AND COST
FUNDING PROFILE TEMPLATE
(FY costs in Real Year Dollars, Totals in Real Year and FY19 Dollars)

	Phase B	Phases C and D	Phase E	Total (RY$)	Total (FY19$)
Contributions					
Collaborator #1 Name/Organization					
Percent Time					
Cost					
Collaborator #2 Name/Organization					
Percent Time					
Cost					
Collaborator #n Name/Organization					
Percent Time					
Cost					
Total Contributed Collaborator Cost					

If the SC and/or optional SEO include any Collaborator costs, include them in Table 4b as appropriate.

COST TABLE TEMPLATE 5
NASA CIVIL SERVICE COSTS
FUNDING PROFILE TEMPLATE
(FY costs in Real Year Dollars, Totals in Real Year and FY19 Dollars)

Item	FY1	FY2	FY3	FY4	FY5	...	FYn	Total (RY$)	Total (FY19$)
Workforce	$	$	$	$	$	$	$	$	$
- NASA Center A									
- NASA Center B									
- *etc.*									
Facilities	$	$	$	$	$	$	$	$	$
- NASA Center A									
Other*	$	$	$	$	$	$	$	$	$
- NASA Center A									
NASA Civil Service Costs included in NASA SMD Cost	$	$	$	$	$	$	$	$	$
Contributions by NASA Centers									
Workforce	$	$	$	$	$	$	$	$	$
- NASA Center A									
- NASA Center B	$	$	$	$	$	$	$	$	$
- *etc.*	$	$	$	$	$	$	$	$	$
Facilities									
- NASA Center A									
Other*									
- NASA Center A									
Contributed NASA Civil Service Costs	$	$	$	$	$	$	$	$	$
						Mission Totals			$

*Specify each item on a separate line. If the optional SC and/or SEO include any Civil Service costs, include them in Table 5 as appropriate.

COST TABLE TEMPLATE 6
NEW OBLIGATION AUTHORITY BUDGET PROFILE TEMPLATE
(All budget numbers in Real Year Dollars)

	FY1	FY2	FY3	FY4	FY5	...	FYn	Total
PI Mission Cost	$	$	$	$	$	$	$	$
SC Incentive (optional)	$	$	$	$	$	$	$	$
SEO (optional)	$	$	$	$	$	$	$	$
TDO (optional)	$	$	$	$	$	$	$	$
ESI (if required)	$	$	$	$	$	$	$	$
Total	$	$	$	$	$	$	$	$

Total NOA (RY$) in Cost Table Template 6 must match Total Costs (RY$) provided in Cost Table Template 1 and other cost tables.

COST TABLE TEMPLATE 7
FUNDING PROFILE TEMPLATE FOR ANY SEO ACTIVITIES
(FY costs in Real Year Dollars, Totals in Real Year and FY19 Dollars)

Item	FY1	…	FYn	Total (RY$)	Total (FY19$)
Extended Mission	$	$	$	$	$
- Organization A					
- Organization B					
- *etc*.					
Guest Investigator Program	$	$	$	$	$
- Organization A					
General Observer Program					
- Organization A					
Archival Data Analysis Program	$	$	$	$	$
- Organization A					
Additions to NASA SMD Cost	$	$	$	$	$

PART III - OTHER FACTORS REQUIRED AFTER DOWN-SELECTION

Among NASA's strategic goals is to communicate the results of its efforts to the American public and to enhance the science and technical education of the next generation of Americans. However, Education Program plans are not needed at this time. NASA may impose Education Program requirements during or subsequent to the Phase A concept study phase and will negotiate any additional funding necessary to meet these requirements.

A Communications and Outreach Program (previously referred as Public Outreach) is required. Mission-related communications are funded directly through a NASA Center and are not within the PIMMC. The communications plan must be developed during Phase B of the mission. The plan must include top-line messaging, target audiences, and media processes linked to reaching target audiences and associated detailed budgets, milestones, metrics and timelines, and reporting requirements.