2022 HELIOPHYSICS EXPLORERS

DRAFT GUIDELINES AND CRITERIA FOR THE PHASE A CONCEPT STUDY

~~**DRAFT July 1, 2022**~~

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Table of Contents

DRAFT
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INTRODUCTION

As the outcome of the 2022 Heliophysics Explorers Program Announcements of Opportunity (AOs) (Small Explorer (SMEX) AO - NNH22ZDA012J and Explorer Missions of Opportunity (MO) AO - NNH22ZDA013J, hereafter, the "SMEX AO" and the "MO AO", respectively) Step-1 competition, NASA has selected SMEX and MO investigations that the Agency will fund to perform concept studies. The concept study for each selected investigation will constitute the investigation's Concept and Technology Development Phase (Phase A) of the Formulation process as outlined in NPR 7120.5F, *NASA Space Flight Program and Project Requirements*.

Documents available through the respective 2022 Heliophysics SMEX and MO Program Libraries at https://explorers.larc.nasa.gov/HPSMEX22/SMEX/programlibrary.html and https://explorers.larc.nasa.gov/HPSMEX22/MO/programlibrary.html are intended to provide guidance for selected investigations. Note that new documents have been added to the Program Libraries for this Step-2 acquisition.

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), optional Citizen Science (CS), Science Enhancement Options (SEOs), if proposed, and PI-Team-developed Enhancing Technology Demonstration Opportunities (Enhancing TDOs), if proposed, before final down-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) for SMEX investigations, and approximately six months after the Concept Study Kick-Off Meeting for MO investigations. This *Guidelines and Criteria for the Phase A Concept Study* (hereafter the CSR Guidelines) document provides guidelines and requirements for preparing a CSR. All program constraints, guidelines, definitions, and requirements specified in the AOs are applicable to the CSR, except as noted herein; examples of these include:

- Principal Investigators (PIs) will propose Level 1 requirements in their CSRs, including the criteria for full mission success that satisfy the Baseline Science Mission, and for minimum mission success that satisfy the Threshold Science Mission. (See Sections 5.1.4 5 and 7.4.4 in the AOs)

- 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 AOs. (See Sections 4.3.1 and 7.4.4 in the AOs)
- NASA intends down-selected investigations to be implemented as Category 3 projects (per NPR 7120.5F) with Class D payloads (per NPR 8705.4A, *Risk Classification for NASA Payloads*). NPR 7120.5F and NPR 8705.4A are available in the Program Libraries. (See Section 4.1.4 in the AOs)
- Heliophysics Explorer missions are required to meet the requirements for safety, reliability, and mission assurance as specified in the Science Mission Directorate (SMD) Policy Document (SPD)-39: *SMD Standard Mission Assurance Requirements for Payload Classification D* document in the Program Libraries. (See SMEX AO Sections 4.1.2 and 5.2.8 and MO AO Sections 4.1.2 and 5.2.10)
- The Enhancing TDO incentive will be provided at the beginning of Step 2 and is expected to be approximately $3M FY22$ for the SMEX investigations and $1M FY22$ for the MO investigations. (See Section 5.2.3.2 in the AOs)
- Small business subcontracting plans are required, covering Phases B/C/D/E/F

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

- Detailed disposal plan (see SMEX AO Section 5.2.7 or MO AO Section 5.2.9, and Section L.9 of this document)
- Science Enhancement Option or its cost, if proposed (see SMEX AO Section 5.1.8 or MO AO Section 5.1.7)
- Independent Verification and Validation of Software (see Section 4.6.1 in the AOs)
- Costing of coordination with Conjunction Analysis Risk Analysis (see Section 4.6.4 in the AOs)
- Schedule-based end-to-end Data Management and Archive Plans (see Requirement B-24 in the AOs, and Section L.5 of this document)
- Demonstration of maximum channel bandwidth (see SMEX AO Section 5.2.5 or MO AO Section 5.2.7)
- Discussion of critical event coverage capabilities (see SMEX AO Section 5.2.6 or MO AO Section 5.2.8)
- Non-AMMOS system use and description (see SMEX AO Section 5.2.9 or MO AO Section 5.2.11)
- Descriptions of the Space Systems Protection implementation (see SMEX AO Section 5.2.10 or MO AO Section 5.2.12)
- Ground system data flow diagram (see SMEX AO Section 5.2.11 or MO AO Section 5.2.13)
- Naming of Project Manager (PM) and Project Systems Engineer (PSE) (see Section 5.3 in the AOs)
- Detailed discussion of the descope approach (see Section 5.3.6 in the AOs)
- Discussion of cost estimate error and uncertainty (see Section 5.6.3 in the AOs)
- Requirements for real year dollar costs (see SMEX AO Section 5.6.3, Requirement B-13, Requirement B-51, and Requirement B-52; or MO AO Section 5.6.3, Requirement B-50, and Requirement B-51)

- Updated Planetary Protection Plans (see SMEX AO Section 5.1.7). Note that the baseline Planetary Protection Plan is due at PDR.
- Enhancing Technology Demonstration Options (see Section 5.2.3 in the AOs)
- Student Collaborations, if proposed (see Section 5.5.2 in the AOs)
- Citizen Science, if proposed (see Section 5.4.4 in the AOs)

Electronic versions of CSRs and all required files, along with images of the original signatures of the Principal Investigator 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 2022 Heliophysics Explorers Program Program Scientist, via the NASA *Box* service by 4 p.m. Eastern time on TBD 2024 for SMEX CSRs and TBD 2023 for MO CSRs.

Electronic submission requires the utilization of the NASA Box 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 *Box*, investigation teams must provide an email list of no more than three (3) individuals requiring access to *Box* to submit proposals. This email list must be provided to the Program Scientist no less than seven calendar days before the CSRs are due. Individuals on the list will then receive an emailed invitation with a secure link to *Box* from NASA. Investigation teams are encouraged to submit a test file using the secure link to *Box* 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, but will need to be provided by the project shortly after a down-selection decision.

For each investigation selected in Step 1, the Explorers Program Office at the NASA Goddard Space Flight Center (GSFC) will negotiate a priced option for a four-month Bridge Phase into the Phase A contracts. After they are notified of the Phase A selection, organizations to be awarded a Phase A contract will receive a Request for Proposal (RFP) for a detailed cost proposal that includes the effort to complete Phase A and as a separately priced option, the first four months of Phase B (*i.e.,* the Bridge Phase). The Bridge Phase option will be exercised for the down-selected investigation.

The focus of the Bridge Phase will be: 1) participation in the project kick-off meeting with the Explorers Program Office; 2) work with the Explorers Program Office to negotiate and award the balance of Phase B; 3) other interactions with the Explorers Program Office as necessary, and 4) other project work planned for the first four months of Phase B. A modification will be negotiated during the first four months of Phase B to cover the remainder of that phase through KDP-C.

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, the Step-1 proposals, each CSR must be a self-contained document.

The CSR evaluation process will include visits (either in person, virtual, or hybrid) 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 three months following submission of the CSRs; scheduling and expectations for the Site Visits will be addressed at the Concept Study Kick-Off Meeting. NASA may identify significant weaknesses, questions, and requests for information, and ask that the investigation team respond to these either prior to, during, 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 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 their team, to 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 one SMEX investigation, one Standard-class MO investigation, and one SmallSat-class MO investigation into the subsequent phases of mission development, flight, and operations (*i.e.*, Phases B-F). The target dates for these continuation decisions (*i.e.*, "down-selections") is Fall 2024 for the SMEX investigation and Summer 2024 for the MO investigations.

Upon a continuation decision, NASA will execute the Bridge Phase option and begin to provide Phase B funding for the project(s) that are continued beyond the Phase A concept study. During the Bridge Phase, NASA and the continued project(s) will negotiate and sign contract modification necessary for the remaining portion of Phase B, on the basis of information provided in the CSR (*e.g.* Sections I, J, and L.4). The Bridge Phase is intended to cover Phase B and to provide continuity while negotiations are completed to modify the contract to include Phases C/D and E/F.

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 evaluation of CSRs is very similar to the evaluation of Step-1 proposals, as described in Section 7.1 of the AOs. The evaluation criteria and their factors, specified in Sections 7.2.1 through 7.2.4 of the AOs, 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 Collaborations and small business subcontracting, will also be evaluated. In case of conflict between the AOs and the CSR Guidelines, the CSR Guidelines take precedence.

All information relevant to the evaluation will be considered during the evaluation of Step-2 concept studies, 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 the Scientific Merit of the Proposed Investigation is required (as described below), the Step-1 proposals will not be used in the Step-2 evaluation.

The evaluation criteria for the Step-2 evaluation are the Scientific Merit of the Proposed Investigation; the Scientific Implementation Merit and Feasibility of the Proposed Investigation; and the Technical, Management, and Cost (TMC) Feasibility of the Proposed Mission Implementation. Additional factors to be evaluated are the Quality and Merit of the Student Collaboration and Small Business Subcontracting Plans.

Scientific Merit of the Proposed Investigation

The Heliophysics Explorers Program Scientist will determine whether any issues that may have emerged in the course of the concept study have resulted in significant changes to the science objectives or other aspects of the proposed Baseline and Threshold Science Missions (see Requirement CS-18 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 also 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 those changes. The factors for re-evaluating this criterion will be the same as those used for the Step-1 proposal review (Section 7.2.2 of the AOs).

Scientific Implementation Merit and Feasibility of the Proposed Investigation

All of the factors defined in Section 7.2.3 of the AOs also apply to the evaluation of the CSR. Note that details have been added to a subfactor 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. *New factors and details added to Step-1 AO factor definitions for the evaluation of the CSR are highlighted using italicized text.*

- 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, and data archiving plan. This factor includes the merit of plans for data analysis 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 and analysis 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; 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 *scientific* expertise of the PI will be evaluated but not their experience with NASA missions. 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 of science leaders will also be evaluated. This evaluation factor also includes an evaluation of the Diversity and Inclusion Plan (see SMEX AO Requirement B-71 or MO AO Requirement B-69). The Science Panel will evaluate the Diversity and Inclusion Plan focusing on how executable and effective the Plan is expected to be. Additional reviewers with expertise in diversity and inclusion initiatives may also provide comments to NASA on the Diversity and Inclusion Plans.

Comments about the managerial experience of the PI, and whether appropriate mentoring and support tools are in place, will be made to the Selecting Official but these comments shall not impact the investigation's Scientific Implementation Merit rating.

Factor A-3 of the AOs will also be re-evaluated as a factor for Scientific Implementation Merit and Feasibility; it has been renumbered as Factor B-6 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 B-7, B-8, and B-9 are not described in the AOs, and therefore were not evaluated for Step-1 proposals. These new factors will be evaluated for the CSRs in addition to the factors specified in Section 7.2.3 of the AO (repeated or updated above as Factors B-1 through B-6).

- Factor B-7. *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.*

- Factor B-8. *Scientific Implementation Merit and Feasibility of any Science Enhancement Options (SEOs), if proposed. This factor includes assessing the potential and 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-9. *Scientific Implementation Merit and Feasibility of any PI-Team-Developed Enhancing Technology Demonstration Opportunities (TDOs), if proposed. This factor includes assessing the potential and 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.*

Any impact to the Baseline Science Mission due to the inclusion of TDO(s) and/or SEO(s) will also be included in the evaluation factors above. Details of the TDO(s) and SEO(s) evaluations are given in Section H.

TMC Feasibility of the Proposed Mission Implementation

All of the factors defined in Section 7.2.4 of the AOs 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. *New factors and details added to Step-1 AO factor definitions for the evaluation of the CSR are highlighted using italicized text.*

Note that the risk management aspects of the Step-1 AO 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 C-6, Adequacy of the risk management plan. The text that is deleted from Step-1 AO Factor C-4 is indicated by the strike-through and is the basis for Factor C-6.

- 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 TRL less than 6 are proposed, as applicable.

- 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, delta-V, and propellant), the concept for mission operations (including ~~communication~~ *operational scenarios and timelimes for each mission phase, operations team roles and responsibilities, and navigation/tracking/trajectory analysis*), and the plans for launch services (including the approach the PI will utilize to make the flight worthiness determination if proposing PI-provided launch services, ensuring the adequacy of the technical work performed by the launch provider). 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 plans, *processes*, products, and activities required to

accomplish maturation, development, integration and verification of all elements of the flight system. This factor includes an assessment of the adequacy of all elements of flight system resiliency, including flight software/hardware fault management, system and subsystem redundancy, and hardware reliability. *This factor includes an assessment of the adequacy of the plans for spacecraft systems engineering, qualification, verification, mission assurance, and launch operations*. 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.*

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 or delivery readiness date. Also evaluated under this factor are the proposed project and schedule management tools to be used on the project.

- 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, commitment, qualifications, and experience of *the PI, PM, PSE, other* named Key Management Team members, the implementing organization and known partners; the spaceflight experience of *the PM, PSE, and all other* named Key Management Team members (PI excepted); *relevant performance of* the implementing organization and known partners against the needs of the investigation; the prior working relationship 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. ~~Also evaluated under this factor is the adequacy of the proposed risk management approach, 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 management of 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.~~ 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 or delivery date. Also evaluated under this factor are the proposed project and schedule management tools to be used on the project.

The capability of the management team will be evaluated as a whole, as opposed to assessing the capabilities of each of the Key Team Members independently. The panel evaluating the "Technical, Management, and Cost Feasibility" will provide comments to the Selection Official

about the mission experience of the PI and whether appropriate mentoring and support tools are in place.

- 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 used to develop the estimated cost, *the methods and rationale used to develop the estimated cost,* the discussion of cost risks, the adequacy and allocation of cost reserves by phase, and *the team's understanding of* the scope of work (covering all elements of the mission, including contributions and all elements associated with a PI-provided access to space [if applicable], such as launch site payload processing and mission unique services). The adequacy of the cost reserves and understanding of the cost risks—including those associated with PI-provided access to space associated delay and/or opportunity uncertainty—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.*

The application and proposed used of any NASA-Developed Enabling TDO will be evaluated for appropriateness and conformance to the guidelines in Section 5.2.3 of the AOs. The infusion of the proposed TDO will be evaluated against the factors in this section, as applicable; the feasibility of the TDO will not be evaluated. As the use of a NASA-Developed Enabling TDO is part of the Baseline Science Mission, the evaluation of the TDO will be included in the risk rating. All proposers will receive feedback on any proposed use of a NASA-Developed Enabling TDO.

The application and proposed use of any PI-Team-Developed Enhancing TDO will be evaluated for appropriateness and conformance to the guidelines in Section 5.2.3 of the AOs. The feasibility of the technology implementation will be evaluated against the factors in this section. The TMC evaluation will be independent of the Baseline Science Mission and will not impact the TMC risk rating for the Baseline Science Mission, unless the TDO is assessed to not be separable from the Baseline Science Investigation, whereupon the impact to the Baseline Mission will be evaluated and considered in the risk rating.

- 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 non-NASA launch delay, cancellation, and the risk of mission failure attributed to the launch service;* 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 management of 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 C-7 and C-8 are not described in the AOs and therefore were not evaluated for Step-1 proposals. These new factors will be evaluated for the CSRs in addition to the factors given in Section 7.2.4 of the AOs (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.*

Any impact to the Baseline Science Mission due to the inclusion of SC(s) and/or SEO(s) and/or enhancing TDO(s) will also be included in the factors above. Details of the SC(s) and SEO(s), as well as enhancing TDO(s) evaluations, are given in Section H.

The panel evaluating the "TMC Feasibility of the Proposed Mission Implementation" will also provide comments to NASA regarding the extent to which the proposed investigation provides career development opportunities to train the next generation of engineering and management leaders. While these comments will not be considered in the evaluation, they may be considered during down-selection.

Quality and 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 Student Collaboration (SC). NASA is providing a SC incentive that is defined to be 1% of the PIMMC. The proposed cost of the SC, up to the SC incentive, is considered outside of the PIMMC. If the SC costs more than the SC 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 implementations, nor to solve cost overrun issues. The SC provides no cost savings to a NASA investigation.

Quality and Merit of the Student Collaboration, if proposed. This factor will include an assessment of whether the scope of the SC follows the guidelines in Section 5.5.2 of the AOs. The criteria to be used to evaluate the SC component and a discussion of those criteria are described in SPD-31 available thorugh the Program Library.

To address the merit evaluation, SC proposals are required to include appropriate plans and budgets for evaluation, participant recruitment and retention, mentoring and oversight of students to maximize their learning and describe Research & Development (R&D) conduct, particularly design and development of flight systems; assembly, integration and test; and mission operations and data analysis that enhances, without interference, the mission's success.

Quality and 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 40%;
- TMC feasibility of the proposed mission implementation: approximately 40%.

Quality of plans for Small Business Subcontracting, and for an optional Student Collaboration and optional Citizen Science, if proposed, will be evaluated as separate factors and considered during the selection process.

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, career development opportunities to train the next generation of science, engineering and management leaders; 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 OUTLINE AND REQUIREMENTS

Successful implementation of a 2022 Heliophysics 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 PART II of this document; and a second volume containing the cost proposal (Section J) and any cost appendices (*e.g.*, L.4, L.15). It shall be written 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 shall not exceed 5.5 lines per vertical inch (6.5 lines per 3 vertical centimeters) and page numbers shall be specified. Margins at the top, both sides, and bottom of each page shall be no less than 1 inch if formatted for 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 formatted for A4 paper. Single-column or double-column formats are acceptable for text pages. Fonts for text and figure captions shall be no smaller than 12-point (i.e., no more than 15 characters per horizontal inch; six characters per horizontal centimeter). There is no minimum requirement for fonts used within figures and table, but 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. 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; two extra pages are allotted for each additional separate, non-identical flight element (*e.g.*, spacecraft), and three extra pages are allocated to proposals utilizing PI-provided access to space; in the Mission Implementation and Management Sections (Sections F and G); ten extra pages are allotted for all science enhancement options (SEOs) combined, in the Science Implementation Section (Section E); ten extra pages are allotted for Enhancing TDOs (TDOs) combined, if proposed. Different instruments on identical spacecraft will only be allotted extra pages for additional non-identical science instruments; no extra pages will be allotted for the resulting additional non-identical flight elements. Five extra pages are allotted for the 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.*, schedule foldouts; cost tables required in Sections I and J).

CSR Structure and Page Limits	
Section	**Page Limits**
A. Cover Pages	No page limit, but be brief
B. Fact Sheet and Executive Summary	2 pages for Fact Sheet, and 5 pages for Executive Summary
C. Table of Contents	No page limit
D. Science Investigation (changes from Step 1 highlighted)	34
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	110 pages for SMEX investigations **or** 84 pages for MO investigations; plus 2 pages for each additional, separate, nonidentical instrument; plus 2 pages for each additional flight element; plus 3 pages for PI-provided access to space; plus 5 pages for SC if one is proposed; plus 5 for Citizen Science if proposed; plus 10 pages for SEO ; plus 10 pages for Enhancing TDOs if 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 Any Incentive Plan(s)* L.7 Technical Content of Any International Agreements* L.8 International Participation Plans* L.9 End of Mission Plan L.10 Compliance with Procurement Regulations by NASA PI Proposals* L.11 Master Equipment List L.12 Heritage L.13 Classified Materials*** L.14 Small Business Subcontracting Plan* L.15 Additional Cost Data to Assist Validation** L.16 Science Change Matrix L.17 Communications Design Data* L.18 Space Systems Protection* L.19 Draft Mission Definition Requirements Agreement L.20 Draft MAIP and MAR Compliance Matrix* L.21 Rideshare Accommodations Worksheet or ISS Technical Interface and Resources Feasiblity L.22 NASA-Developed Technology Infusion Plan L.23 Justification for the use of non-AMMOS MOS/GDS L.24 Acronyms and Abbreviations L.25 References and Management Standards List*	No page limit, but small size encouraged. ~~* Electronic only. Include appendix in the PDF of the CSR but do not include it in the hardcopy CSR.~~ ~~** Hardcopy and electronic for text and high-level summary tables. Electronic only for detailed cost tables. Include text and high-level summary tables in both the hardcopy and PDF of the CSR, but include detailed cost tables only in the PDF of the CSR.~~ *** Submitted separately.

Requirement CS-5. The CSR and all required files shall be submitted electronically via NASA's Box service. The CSR submittal deadline is specified in the Introduction section. All files must be compatible with both Microsoft Windows and Apple macOS.

Requirement CS-6. 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-7. Electronic CSRs shall be unlocked, bookmarked, searchable Adobe Portable Document Format (PDF) file(s) composed of the main CSR, all tables, and all applicable CSR appendices (see Section L of this document). Images (*e.g.*, figures and scans) shall be converted into machine-encoded text using optical character recognition. Audio, video, or embedded animations shall not be included. Additionally, materials identified as subject to U.S. export laws and regulations, in accordance with Section 5.8.3 of the AOs, shall be redacted into separate versions of files that are collected in a Redacted folder. File size limitations from Step 1 are removed. There is no total CSR size limit but the PDF portion should not contain information beyond what would have been in a printed version. The PDF files 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. All electronic files listed below shall also be provided as part of the electronic submission.

- Cost Tables in MS-Excel format (Requirement CS-5)
- Schedule in MS-Project format (Requirement CS-8)
- Final list of CSR participants in MS-Excel format (Requirement CS-9)
- Fact Sheet in PDF format (Requirement CS-14)
- Trajectory file(s) (Requirement CS-33 and Requirement CS-34)
- MEL in MS-Excel format (Requirement CS-100)
- Program and Project Management Standard References (Requirement CS-117)
- All cost files in electronic format (See Section L.15 of this document)

Requirement CS-8. 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 7120.5F. 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) except where greater detail is necessary to identify the critical paths, except where greater detail is necessary to identify critical paths, as well as significant TRL or engineering development activities and events. The file is to provide a quantified data set that will facilitate understanding of the proposed flow of development activities, timelines, milestones, schedule reserves, and risk as represented on the graphical foldout(s). The level of linkage detail must be complete enough to substantiate the assignment of the primary critical path and any significant secondary critical path(s) in the graphical foldout(s). A Phase B schedule consistent wih the plans detailed in Section I shall be included in the file.

Requirement CS-9. 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 a draft list of the participants as a Microsoft Excel spreadsheet document to the point-of-contact (Section 6.1.5 in the AOs) 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-10. Create a separate document that contains a table with all of the requirements (Requirement CS-1 through Requirement CS-117 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 point-of-contact for the AOs by email no later than seven days after the CSRs are due**.**

Requirement CS-11. 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 of the CSR are detailed below. Failure to follow this outline may result in reduced ratings during the evaluation process.

A. COVER PAGES

Requirement CS-12. A Graphic Cover Page and Summary Information, prepared as directed below, shall preface every CSR. These pages will not be counted against the page limits.

Requirement CS-13. The Graphic Cover Page shall contain, at a minimum, 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;
- The images of signatures of the PI and the authorizing official (unless these signatures appear on the CSR Summary Information), per Requirement CS-6;
- 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 89 in Section 5.8.3 of the SMEX AO and Requirement 105 in Section 5.8.3 of MO AO, 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-14. Every CSR shall include a Fact Sheet that provides a brief summary of the investigation. The Fact Sheet 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 teaming arrangements and all named key personnel);
- Schedule summary;
- The proposed PIMMC in Fiscal Year 2022 dollars (FY22$) and in Real Year dollars (RY$) from Table B3b and Table B3a, respectively; and
- The proposed Total Cost, including a breakdown of any contributed costs by contributing organization, in FY22$ and in RY$ from Table B3b and Table B3a, respectively.

Requirement CS-15. 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 if proposed, and small business subcontracting plans. The Executive Summary shall not exceed 5 pages in length.

C. CSR TABLE OF CONTENTS

Requirement CS-16. 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.

D. SCIENCE INVESTIGATION

Requirement CS-17. The Science Investigation section shall describe the science investigation as specified by Requirements B-15 through B-18 in Appendix B of the AOs. 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.16 of the CSR. The Science Investigation section shall not exceed 30 pages in length.

Requirement CS-18. 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.16 of this document). 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 any)

E.1 Level 1 and Level 2 Requirements

The Level 1 requirements identify the mission, science, and programmatic requirements as well as constraints imposed on the project. Consistent with NPR 7120.5F, 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.

The Level 1 requirements (referred to as program requirements in NPR 7120.5F) and Level 2 project requirements specify requirements and constraints on science data collection, mission and spacecraft performance, prime mission lifetime, budget, schedule, launch vehicle, 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 requirements must describe the data products that would be needed to complete the Level 1 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.

A key element of risk management is the definition of mission success criteria. Mission success criteria should be the first level of flow-down of requirements from the overall mission science objectives. The mission science objectives are the “need” for the mission and the mission success criteria represent how you know you have met that “need”. Mission success criteria are based on the threshold science requirements. Level 1 requirements then would flow down from the mission success criteria. Level 1 requirements would be robust enough (i.e., have sufficient

margin) to ensure the system's detail design could be manufactured, built and tested to achieve the mission success. Ideally, mission success criteria would be written before Level 1 requirements. However, this is not a requirement for the CSR, as mission success criteria are negotiated with NASA. To the extent that they are known at the end of Phase A, identify the draft mission success criteria in the CSR.

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

Requirement CS-19. CSRs shall provide a set of proposed Level 1 requirements that will achieve the objectives of the Baseline Science Mission. Both Baseline Science Requirements and Threshold Science Requirements shall be identified. To the extent that they are known, identify the draft mission success criteria based on the threshold science requirements. The Level 1 requirements of the investigation, as agreed to by the PI, PM, PSE and other key personnel shall be unambiguous, quantifiable, objective, verifiable, and treaceable to the mission objectives. Examples of Level 1 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 given at previous PI Masters Forums. CSRs shall provide Level 2 project requirements to guide the design and development of the mission. 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.19, Draft Mission Definition Requirements Agreement (MDRA).

E.2 Science Mission Profile

Requirement CS-20. 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), etc. 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 shall be included in this discussion.

E.3 Instrumentation

Requirement CS-21. 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, and sample collection and preservation system as applicable, 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 technology readiness level (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-22. 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;
- Instrument thermal control capability;
- Applicable instrument diagrams (*e.g.*, optical path); and
- Characteristics of relevant instrument components (*e.g.*, listing of size of optics) in the MEL.

E.4 Data Sufficiency

Requirement CS-23. 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; 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.

Requirement CS-24. In accordance with the NASA Plan: Increasing Access to the Results of Scientific Research and with SMD Policy Document SPD-41, Scientific Information policy for the Science Mission Directorate, 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, laboratory data, etc.), including a list of the specific data products, and the individual team members responsible for the data products;
- Identify the appropriate NASA 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;
- 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-25. This section shall identify each key member of the science team and their roles and responsibilities. Resumes or curricula vitae of science team members shall be included as appendices to the CSR. The role of PI and each Co-investigator (Co-I) shall be explicitly defined, the necessity of that role shall be justified, and the funding source (NASA or contributed) shall be noted. ~~The role of each collaborator shall be described~~. 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 FTEs or WYEs, for each mission Phase, A through F (as specified in Requirement CS-79 to Requirement CS-82). Collaborator roles may be defined and justified as done for Co-Is.

E.7 Plan for SEO and/or Enhancing TDO

Requirement CS-26. If an SEO is proposed, this section shall define and describe plans the proposed activities (see SMEX AO Section 5.1.8 or MO AO Section 5.1.7). The SEO shall be directly related to the mission (i.e., analyze mission data, not enhance theory). The SEO shall be clearly separable from the Baseline Science Mission and Threshold Science Mission investigations. Additionally, a justification and a cost plan for SEO activities are required in Section L of this document.

Requirement CS-27. If Citizen Science is proposed, this section shall define and describe plans for the proposed activities (see Section 5.4.4 of the AOs). Additionally, a justification and a cost plan for CS acticities are required in Section L of this document.

Requirement CS-28. If applicable, this section shall define and describe plans for Enhancing Technology Demonstration Opportunity (TDO) activities (see Section 5.2.3.2 of the AOs), including a TDO development plan. The TDO shall be clearly separable from the Baseline Science Mission and Threshold Science Mission investigations. Additionally, a justification and a cost plan for the TDO's development and integration activities are required in Section L of this document, along with the TDO's MEL and Microsoft Project schedule files (See Requirements CS-6 and CS-7). The cost of any Enhancing TDO accommodation that directly affects the resources available to the Baseline or Threshold Mission (*e.g.*, increased launch mass, increased power) shall be included in the PIMMC.

F. MISSION IMPLEMENTATION

F.1 General Requirements and Mission Traceability

Requirement CS-29. 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-30. The mission functional requirements that the science goals and objectives impose on the mission design elements, including mission design, instrument accommodation, spacecraft design, required launch vehicle 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 Appendix B of the AOs, 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-31. 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. At minimum, the following mission elements shall be addressed: mission design, flight system capability, mission operations, and any additional elements.

Requirement CS-32. Mission Design: This section shall address the following elements of the mission design to the extent that they are applicable to the proposed mission. Any additional elements that are applicable to explaining the mission and demonstrating its feasibility shall also be addressed.

- Launch or delivery readiness date;
- Launch window, and launch or delivery 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), and/or trajectory design and trajectory parameters for ballistic and low-thrust trajectories to permit independent validation, as applicable to the proposed investigation;
- Critical events, which includes LV separation telemetry;
- Telecomm link summary for all communication modes (based on requirements identified in Appendix L.17, Communications Design Data);
- 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-33. Trajectory: For any mission traveling beyond Geostationary Earth Orbit (GEO) to achieve its science orbit, the following information shall be provided in the electronic submission as part of a Trajectory Supplement.

- Checkout Duration: The minimum duration allocated after launch before the primary propulsion system will be commanded to provide required delta-V.
- 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, delta-V magnitude). These data should be included for three different scenarios corresponding to the Open, Middle, and Closing 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.

This information is optional for missions that remain within Earth orbit at or below GEO. There is no requirement that this data also be included in the electronic CSR (PDF file). Any graphical

references, tables, figures, etc. shall be presented in a minimum of 150 dots per inch (dpi). 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-34. Electric Propulsion (EP): For investigations using solar-electric propulsion, the following information shall be included in the electronic submission as part of a Trajectory Supplement:

- 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 EP aspects of the trajectory and orbit, should also be included.

Requirement CS-35. Launch Services and Launch Vehicle Compatibility: Any PI-provided launch services shall be described. For both AO-provided and PI-provided launch services, compatability with the proposed launch vehicle shall be demonstrated by providing in the appropriate CSR section the launch site; fairing size; spacecraft mass; *launch mass margin;* and mission orbit characteristics such as altitude (km – circular or apogee/perigee), inclination, C3, heliocentric and/or declination (DLA). Any known non-standard requirements such as additional fairing doors, cleanliness and purge requirements, planetary protection, 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.

2022 Heliophysics Explorers Program Phase A concept study teams are to continue to use the LV performance classes described in the SMEX AO Section 5.9.2 or the MO AO Section 5.2.4 and in the Program Libraries. Costs for launch services shown in the AOs are to be considered as adjustments in the Adjusted AO Cost Cap rather than a charge to the PIMMC. 2022 Heliophysics Explorers Program Phase A concept study teams should work with Mr. Norman Phelps, 321-867-5147, norman.l.phelps@nasa.gov, for Launch Services Program support.

For CSRs utilizing AO-provided rideshare launch services, this section shall demonstrate compatibility with the *Secondary Payload Adapter* (*SPA) Rideshare Users Guide (RUG) (hereafter the Helio SPA RUG)* dated May 1, 2022 in the Program Libraries. A Phase A Rideshare Accommodation Worksheet template for Secondary Payloads is provided in the Program Libraries. The Rideshare Accommodation Worksheet shall be delivered as Appendix L.21 on the CSR due date. As stated in the AOs, a proposed rideshare investigation with a high probability of being compatible with several primary missions is more likely to be selected than one with less flexible accommodation and orbit requirements. For the Phase A study, this statement is extended to cover compatibility with access to space provided through the CubeSat

Launch Initiative, and with the Small Launchers listed in the LSP Small Payload Access to Space Catalog. NASA may consider those additional possibilities if no suitable timely primary launch is available to accommodate the rideshare payload. Mission of opportunity concept study teams should work with Mr. Norman Phelps, 321-867-5147, norman.l.phelps@nasa.gov, for rideshare support.

For payloads to the International Space Station (ISS), Phase A study teams shall provide, in Appendix L.1, an updated Letter of ISS Technical Interface and Resource Accommodation Feasibility Assessment from the ISS Research Integration Office, as specified in SMEX AO Requirement 102 or MO AO Requirement 33. An updated *Proposer Requested ISS Resource Table* (March 2019) is posted to the Program Libraries. This table shall be delivered as L.21 on the CSR due date. Explorer Phase A study teams should work with Mr. Steven Huning, (281) 244-8043, steven.w.huning@nasa.gov, for ISS Program accommodation support.

Requirement CS-36. Flight System Capabilities: This section shall address the following flight system capabilities to the extent that they are applicable to the proposed 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.12.

- Spacecraft parameters:
  (a) Figure of the complete spacecraft/instrument system, on the launch vehicle 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 (if required), attitude determination and control, command and data handling, in-flight fault management, flight software, and ground software. (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.17). Subsystem detail shall include the following information:
  (a) Propulsion, including: (i) a list of all specific events of the proposed delta-V budget (including 3-sigma values for stochastic maneuvers); (ii) for each propulsion mode type (monoprop, biprop, dual-mode, solar electric, etc.), engines and thrust levels, specific impulse, (iii) propellant allocation (*e.g.*, impulse vs. attitude control system); and (iv) propellant margins, including nominal (to meet delta-V requirement) and additional (to meet mass growth).
  (b) Command and data handling, including: (i) spacecraft housekeeping data rates for nominal and safing strategy; (ii) data storage unit size (Mbits); (iii) maximum storage record and playback rate.
  (c) Power.
  Solar-powered mission:
  (i) expected power requirement and margins for each mission phase, (ii) type of array structure (rigid, flexible, body mounted); (iii) solar array axes of rotation (vector projected in spacecraft coordinates); (iv) array size; (v) solar cell type and efficiency; (vi) expected power generation at beginning of life and end of life; (vii) worst case Sun incidence angle to solar panels for each mission phase ~~during~~

~~science mission~~; (viii) battery type and storage capacity; (ix) phased and worst case battery Depth of Discharge (DOD); (x) spacecraft bus voltage.

(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 (delta-V) 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), pointing stability or jitter.

(e) Thermal control, including: (i) temperature requirements including deltas; (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; (iii) description of the functionality for each CSCI; (iv) code counts categorized as either New, Modified, Full Reuse, or Autogenerated; (v) development method (spiral, waterfall, agile, etc.); (vi) 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-37. Additional Mission Elements: This section shall address any other major mission elements (*e.g.*, lander, upper stage, etc.) to the extent that they are applicable to the proposed mission ~~and to the extent that they are known at the time of proposal submission~~. Any additional elements that are applicable to explaining the mission and demonstrating its feasibility shall also be discussed.

- Provide a block diagram and description of relevant subsystems; and
- Demonstrate that the proposed design can accomplish the mission within the allocated resources.

Requirement CS-38. Flight System Contingencies and Margins: This section shall summarize contingencies and margins of all key flight systems resources. It shall provide estimates of implementation performance and design margins with respect to the required performance. At a minimum, it shall include the following:

- Dry mass;
- Launch mass actually available to the proposed mission;
- Propellants;

- Power;
- CPU utilization;
- Data storage;
- Attitude control; and
- Any other driving mission element requirements derived from the Mission Functional Requirements.

~~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 SMEX AO Requirement B-36 or the table following MO AO Requirement B-35 for definitions of contingency and margin).

Requirement CS-39. Mission Operations: This section shall address, at a minimum, the following elements of mission operations and communication to the extent they are applicable to the proposed mission. Any additional elements that are applicable to explaining the mission operations and demonstrating their feasibility shall also be addressed. This section shall provide, at a minimum, the following items:

- 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 (i) downlink information and data volume; (ii) uplink information; (iii) for all transmit and receive modes, provide mode timeline, data rate(s), durations, and compliance with maximum channel bandwidth; and (iv) ground network utilization plan including ground stations, downlink parameters (frequencies, periods, capacities, margins, etc.), and retransmission capability;
- Description of approach 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, availability of spacecraft experts for operations, operations center development; and
- Operational concept that includes the following. (i) 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. (ii) Timelines for each key mission phase; containing S/C, Payload, and ground events and processing and identifying margin for each phase if available. (iii) Data Flow Diagrams which clearly show the major operational facilities and key software components utilized for both the uplink and downlink processes. (iv) A Phase E Organization diagram and Team Responsibilities clearly indicating the key manager for each of the project facilities in the data flow diagram. (v) 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. (vi) A plan for required maintenance and refresh of vendor supplied ground systems (hardware and software) during extended cruise operations. (vii) 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 Appendix 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.

F.3 Development Approach

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

Requirement CS-40. 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-41. 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-42. This section shall describe any proposed new technologies and/or advanced engineering developments 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 7123.1C, *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*);
- 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:
  - Demonstration (testing) in a relevant environment can be accomplished at the system level or at lower level(s);
  - 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; and
  - Include discussion of simulations, prototyping, demonstration in a relevant environment, life testing, etc., as appropriate;
- An estimate of the resources (staffing, cost, and schedule) required to complete the technology and/or advanced engineering development; and
- Approaches to 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-43. An illustration and discussion of the time-phased flow of the Integration and Test (I&T) Plan shall be presented. It shall include the key facilities, testbeds, and team members involved in the I&T Plan.

Requirement CS-44. The project's assembly, integration, test, and verification (AIT&V) 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, multiple-build units, special facilities that may be required for testing, large scale simulation tools that are required to be developed and how they will be validated, critical path items, etc.) shall be included. The AIT&V description shall demonstrate the credibility of the overall AIT&V approach, as reflected by consistency between the described 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-45. A project schedule foldout(s) covering all phases of the investigation shall be provided to at least WBS level 3 for the spacecraft (subsystem-level) and Level 4 for instruments (instrument subsystems), except where greater detail is necessary to identify critical path, as well as significant TRL or engineering development activities and events. Schedule foldout(s) 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 7120.5F. The schedule foldout(s) and accompanying narrative shall address proposed major milestones, including, at a minimum, 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 (ICDs), simulators, engineering modules, flight modules, etc.);
- Launch vehicle integration and launch or delivery readiness;
- Compliance with National Environmental Policy Act (NEPA) and Nuclear Launch Safety Approval processes, if appropriate;
- Long-lead item specifications, development paths, and their impacts to schedule;
- Development schedule for Student Collaborations (SCs); Science Enhancement Options (SEOs), if any; or PI-Team-Developed Enhancing Technology Demonstration Options (TDOs), if any;
- Schedule critical paths 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.

The schedule narrative and foldout(s) must be consistent with the Microsoft Project schedule delivered with the CSR per Requirement CS-8.

G. MANAGEMENT

Requirement CS-46. This section shall present the investigation's proposed 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) *Discussion of* the decision-making authority, teaming arrangement, responsibilities, including internal operations and lines of authority with delegations, together with internal interfaces;
  (c) The primary team members reporting relationship within the project;

(d) Relationships with NASA, major subcontractors, and associated investigators;
(e) The mission unique roles and responsibilities, as specifically applicable to the proposed investigation, of the PI, PM, Project Systems Engineer (PSE), and other Key Management Team members;

- The commitments and the roles and responsibilities of all institutional team members, including team members responsible for SC (as applicable).
  (a) The names of the primary team members, their organizations, and their reporting relationships in the program; and
  (b) The time commitment of each named Key Management Team member, in a table in months per year by mission phase.

Requirement CS-47. 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-48. 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-49. 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-50. This section shall name all of the team members who will occupy the key project management positions identified in Requirement CS-49. It shall, in addition:
(i) 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;
(ii) Provide any program/project management certifications held by or planned to be obtained by the PM; and

(iii) 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-51. 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 8000.4C, Agency Risk Management Procedural Requirements, available in the Program Library. SPD-39, *SMD Standard Mission Assurance Requirements For Payload Classification D* 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.20 of this document). 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.

For missions proposing PI-provided launch or rideshare services (purchased or contributed) the concept study must demonstrate clear understanding of the specific risks inherent in this type of launch service arrangement and must discuss their approach for mitigating these risks. Examples of such risks are schedule control over launch date, demanifesting risk if spacecraft is unable to meet integration schedule and/or requirements (rideshare), launch delay penalties, reduced analytical products, limited LV insight, limited approval rights of payload/mission integration with the LV, etc.

Requirement CS-52. This section shall include a discussion of the management approaches for controlling cost growth.

Requirement CS-53. 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-54. This section shall clearly delineate the Government-furnished property, services, facilities, etc. required to accomplish all phases of the mission.

Requirement CS-55. This section shall list the major project reviews expected to be conducted during the project's life cycle consistent with NPR 7120.5F and the approximate time frame in the Project Schedule for each review.

NASA NPR 7120.5F 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 7120.5F 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. NASA's Science Mission Directorate has defined a new approach to managing Class-D science investigations. The *NASA Science Mission Directorate (SMD) Class-D Tailoring/Streamlining Decision Memorandum* describes the approach that has been approved by SMD leadership to guide the implementation of Class D investigations. This Memorandum, along with other Class-D policy and guideline documents, are in the Program Libraries. All Class-D investigations solicited by these AOs must use the principles, guidelines, and approaches described in the documents. Investigations in other risk classes may also propose tailoring to NASA requirements. 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-56. 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. For the missions of opportunity, the CSRs shall provide the above information for proposed adjustments to requirements not specifically identified in the Streamlined Class-D Memo as already being tailored.

Requirement CS-57. 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-58. 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 Section L.1, Requirement CS-87 and Requirement CS-88);
- 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, or proposing backup access to space opportunities using PI-provided launch or rideshare services. 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

Requirement CS-59. If a Student Collaboration (SC) 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, including a description of recruitment and retention policies likely to reach individuals from groups under-represented in STEM;
- 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-60. If a proposal contains a SC, the proposal shall demonstrate that the proposed SC is clearly separable from the proposed Baseline and Threshold Science Missions; will not increase the mission development risk; and will not impact the science investigation in

the event that the SC is not funded, fails during flight operations, or encounters technical, schedule, or cost problems during development.

Requirement CS-61. If a proposal contains a SC, the proposal shall identify the funding set aside for the SC, and any contributions to the SC. This funding may be outside the PI-Managed Mission Cost up to the Student Collaboration incentive, and any SC costs beyond the Student Collaboration incentive, unless contributed, shall be within the PI-Managed Mission Cost.

Requirement CS-62. A Small Business Subcontracting Plan, covering Phases B through F, shall be provided as an appendix; see Section L.14, Requirement CS-103.

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

Once entering Phase B, Heliophysics Explorers 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 7120.5F: "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-63. 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-64. 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-65. 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-66. A WBS as defined in NPR 7120.5F and NASA/SP-20210023927, NASA Work Breakdown Structure (WBS) Handbook, available in the Program Libraries, shall be provided and used to describe how all project costs are accounted in the cost proposal.

Requirement CS-67. This section shall include 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 (*e.g.*, load isolation systems, unique mechanical/electrical interfaces, payload processing facilities, commodities, post-encapsulation access requirements, supplemental propulstion systems, deployable telemetry tracking assets, and GN2 purge), 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 Sections 4 and 5 of the AOs.

Requirement CS-68. This section shall provide a Basis of Estimate (BoE), including a description of the methodologies and assumptions used to develop the proposed cost estimate. The cost estimating methodology discussion in this section shall provide an overview of the cost estimate development process. Additional cost estimates or other validation efforts shall be described, the results presented, and any significant discrepancies discussed. A description of cost reserves that provides insight into the adequacy and robustness of the proposed unencumbered cost reserve level(s) shall be provided. The rationale for the proposed cost reserve levels shall be presented. Proposers shall include additional Basis of Estimate data to assist the validation of their costs estimates. Examples of useful Basis of Estimate (BoE) data for different cost estimating methodologies include:

- Example for system and subsystem estimates based on analogy. Include the original heritage cost and rationale for any adjustments used to obtain the current proposed element costs.
- Example for system and subsystem estimates based on a parametric model. Provide the name and version of the model, general heritage assumptions and other key inputs used that can help explain the cost estimate.
- Example for bottom-up system and subsystem estimates, provide information on what portion of the WBS element is labor vs material. For the labor, provide a FTEs and/or WYEs breakout by year with average labor rates. For material provide a summary list of the significant hardware quotes used in the estimate, the date of the quote, and the importance of the quoted hardware to mission success.

Requirement CS-69. This section shall include a discussion of sources of estimate error and uncertainty in the proposed cost.

Requirement CS-70. This section shall include a discussion of cost risks *and mitigation strategies.*

Requirement CS-71. This section shall provide two foldout cost tables, using the template tables B3a and B3b in the Program Libraries. The tables shall identify the proposed cost required in each mission phase and in each NASA fiscal year; the costs shall be respectively in Fiscal Year 2022 dollars (FY22$) and in Real Year dollars (RY$). 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 enhanced mission costs. The rows in the table shall be the NASA standard WBS elements as defined in NPR 7120.5F and NASA/SP-20210023927. The costs for most elements shall be provided at least to WBS Level 3. It is requested that instruments be

shown to WBS Level 4 where the data is available. The costs of individual instruments and any unique flight system elements such as coordinating science ground stations, or nonstandard facilities, 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. Years that span more than one mission phase shall be split into two columns by mission phase. The tables includes totals by WBS and by phase and life cycle in both FY22$ and RY$. Investigation teams shall use their own forward pricing rates to translate between FY22$ and RY$. For organizations that are without approved forward pricing rates, investigation teams may use the NASA inflation/deflation indices available in the Program Library to translate between FY22$ and RY$.

Requirement CS-72. 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, and E/F), including a description of the estimating techniques used to develop the cost estimates. See Section K for requirements for any SEO and/or Enhancing TDO 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 as an appendix (see Section L.15 of this document). 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-73. Provide a table with the new obligation authority (NOA) required in RY$ by fiscal year using the format of Cost Table Template 5. If the mission is selected for flight, SMD will use this information to prepare its budget request.

Requirement CS-74. 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-75. The cost of the entire project shall be summarized on two pages, presented using each of the template tables B3a and B3b in the Program Libraries. 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 Tables B3a and B3b. Show costs (NASA SMD and contributed) associated with each Co-I and collaborator using Cost Table Templates 3a and 3b respectively**,** on one page each; all Co-Is and collaborators shall be identified in the applicable table.

Requirement CS-76. All contributions and direct/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 4. NASA Center costs shall

include Civil Servant services, as well as the cost for the use of Government facilities and equipment on a full-cost accounting basis. 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 Heliophysics Explorers 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 Section L.1, Requirement CS-87 and Requirement CS-88).

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

Requirement CS-77. The inflation index provided in the tables found in the NASA FY2022 inflation table, posted 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-78. All costs shall include all burdens and profit/fee in real-year dollars by fiscal year, assuming the inflation rates used by NASA in NASA FY2022 inflation table posted in the Program Libraries, or specifically documented industry forward pricing rates.

Requirement CS-79. 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 Section L.4 and Requirement CS-91).
- 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 database 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-74 (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-74 (Cost Table Template 2) shall be provided. This information is in addition to that provided in Requirement CS-71 through Requirement CS-75 (Cost Table Templates 1 through 6). 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 AOs, 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-80. 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-74 (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-81. 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-74 (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-82. 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-74 (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-83. 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; Near Space Network, Deep Space Network and other ground system costs beyond what is provided by the AOs; access to space services beyond those provided by the AOs and cost of activities associated with social or educational benefits (if not incorporated in any of Phases A through F). The 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-84. 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 OPTIONAL SEO AND ENHANCING TDO ACTIVITIES

SEO activities, discussed in SMEX AO Section 5.1.8 or MO AO Section 5.1.7, include extended missions, guest investigator programs, general observer programs, and archival data analysis programs. Enhancing TDO activities, discussed in Section 5.2.3.2 of the AOs, may be an instrument, investigation, new technology, hardware, or software that may be demonstrated on either the flight system or ground system. 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 and Enhancing TDO activity was made at selection. It is incumbent upon investigation teams, therefore, to fully discuss these project additions in the CSR.

Funding for SEO and Enhancing TDO 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 and Enhancing TDO activities.

All definitions, guidelines and constraints outlined in the AOs and applicable to SEOs and Enhancing TDOs 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-85. For any and each SEO activity proposed, this section shall provide sufficient data and justifications to enable analysis of not only the science value of the concept, but also its TRL at CSR submittal where applicable, and viability. This section shall also provide a cost estimate for performing the SEO activity. In completing the cost section, the guidelines for Phases B through D apply. For each SEO proposed, complete a one-page summary of costs using the formation shown in the Cost Table Template 6. Also, include the total amount in the SEO line item, expanded by WBS as applicable, at the bottom of the tables in Requirement CS-71 (Tables B3a and B3b). Include a discussion of the estimating techniques used to develop the cost estimates.

Requirement CS-86. For any and each enhancing TDO activity proposed, this section shall provide sufficient data and justifications to enable analysis of not only the science and technology value of the concept, but also its TRL at CSR submittal where applicable, and viability. This section shall also provide a cost estimate for performing the TDO activity. In completing the cost section, the guidelines for Phases B through D apply. For each TDO proposed, complete a one-page summary of costs using the formation shown in the Cost Table Template 6. Also, include the total amount in the TDO line item, expanded by WBS as applicable, at the bottom of the tables in Requirement CS-71 (Tables B3a and B3b). Include a discussion of the estimating techniques used to develop the cost estimates. For any contributed TDO element, a letter of commitment from the contributiong organization shall be submitted in Section L.1. The letter shall commit the contributor to both maturing the technology and supporting its integration with the mission. The letter must include the cost estimates of these contributions.

L. CSR 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-87. Letters of commitment shall be provided 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 critical 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-88. This appendix shall include letters of commitment from non-U.S. individuals and/or institutions that are team members or contributors to 2022 Heliophysics Explorers Program 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-89. 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-90. This section shall include resumes (or curricula vitae) for the PI, PM, PSE, any other named Key Management Team members identified in the Management section, and all Co-Is identified in the Science section. Specifically, each resume shall cite the individual's experience that is pertinent to the role and responsibilities that she/he will assume in the proposed investigation. Project management experience shall be included in the resumes of the PI, PM, and PSE. Resumes shall be no longer than three pages for the PI and one page for each additional participant. Photographs shall not be included in any of the resumes.

L.4 Phase B Contract Implementation Data

This appendix provides data necessary for the Heliophysics 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-91. 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 1-8 for evaluation purposes, and 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-92. 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-93. 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-94. 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-95. 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 (Update from Proposal)

Requirement CS-96. If the investigation includes international participation, either through involvement of non-U.S. nationals and/or involvement of non-U.S. entities, this section 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 AOs). 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/ddtc_public 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 AOs, are generally either 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.; or otherwise controlled under the Export Administration Regulations (EAR), 15 CFR parts 730–774, issued by the United States Department of Commerce, Bureau of Industry and Security (BIS) under laws relating to the control of certain exports, reexports, and activities.

L.9 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) (GEO ± 300 km), or at the Moon (lunar orbiters, impactors, or landers) or near Lagrange points.

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 launch vehicle 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 8719.14C, *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 8719.14C are available in the Program Library.

NASA-STD 8719.14C 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, an Initial ODAR may be submitted in response to 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 8719.14C. While Initial ODAR Section 2 (Orbital Debris Limitation Summary) indicates that "Further analyses are not needed at this time", questions that require analysis or raise concerns regarding the design of the mission (*e.g.*, objects significantly greater than the 1 kg threshold in question (i) for Full Spacecraft Development, or constellations of spacecraft), 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 traveling beyond 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-97. When required, this section shall include a discussion of how end-of-mission requirements will be met.

L.10 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 1872.306).

Requirement CS-98. For NASA Center CSRs, this section shall include any descriptions, justifications, representations, indications, statements, and/or explanations that are required by the regulations.

L.11 Master Equipment List

Requirement CS-99. This section shall include a Master Equipment List (MEL) in a spreadsheet and a Microsoft Excel format file with no document formatting summarizing all flight element subsystem components and individual instrument element components to support validation of proposed mass estimates, power estimates, continencies, design heritage, and cost. Fully contributed instruments should include enough subsystem detail to support validation of instrument design. A template for this MEL is included as Table B5 of the AOs and in the Program Library.

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 (CBE) 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-100. The MEL shall be ~~additionally~~ provided in Microsoft Excel format with the electronic submission.

L.12 Heritage

Requirement CS-101. 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;
- A description of changes required to accommodate project-unique applications and needs;
- 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.

The evaluation team will use a scale with three levels (full, partial, or none) as illustrated in the table below.

	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

Requirement CS-102. 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.13 Classified Materials

See Section 5.8.4 of the AOs for options and associated requirements.

L.14 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 Section 5.5.1 of the AOs, shall be provided, with the exception of separately identifying and being evaluated on participation targets of SDBs in North American Industry Classification System (NAICS) codes determined by the Department of Commerce to be underrepresented industry sectors. 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.15 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.

The information provided may include cost by NASA fiscal year to the lowest level of detail the project is working with, in Microsoft Excel format.

L.16 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 a table with the following columns: the original objective, the new or revised objective, rationale for the change, and the section/paragraph in the CSR where the change occurs.

L.17 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 RF Output 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.18 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. 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.

Space Systems Protection Requirement 1 (SSPR 1) in NASA-STD-1006 states, "Programs/projects shall protect the command stack with encryption that meets or exceeds the Federal Information Processing Standard (FIPS) 140, Security Requirements for Cryptographic Modules." This requirement may be tailored to accommodate the nature of the mission and the following tailoring is suggested for use by applicable missions:
(1) Hosted instruments only require protection of the instrument command stack.
(2) Hosted instruments are only responsible for protection of the command stack until the host spacecraft operations center receives commands.
(3) Deep space missions (operations more than two million kilometers from Earth) may choose to limit controls applied to the space link if certain controls (*e.g.* encryption and authentication) pose significant burden to operability or mission success, and if the threat to the space link is low.
(4) Category 3/Class C or Class D missions may authenticate without encryption if they have no propulsion.
Proposers are encouraged to offer appropriate tailoring to SSPR 1, but an assessment of the additional impact of the tailoring not being accepted by NASA must be provided.

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 Controlled Unclassified Information (CUI).

Requirement CS-106. Provide the detailed plans 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 CUI level.

Requirement CS-109. Demonstrate that adequate resources (including, but not limited to, cost, schedule, technical accommodation, *etc.*) have been allocated to comply with NASA-STD-1006 *including* generating of a PPP by PDR and addressing associated Candidate Protection Strategies.

Requirement CS-110. Provide a ground system data flow diagram showing end-to-end flows of all mission data, including any flows to facilities outside the control of the mission itself.

Requirement CS-111. Demonstrate that adequate resources (including, but not limited to, cost, schedule, technical accommodation, *etc.*) have been allocated to develop *and implement* an System Security Plan consistent with NIST 800-53.

L.19 Draft Mission Definition Requirements Agreement

Requirement CS-112. 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 MDRA is provided in the Program Library.

L.20 Draft MAIP and MAR Compliance Matrix

Requirement CS-113. This section shall provide a draft Mission Assurance Implementation Plan (MAIP) and Compliance Matrix for the SPD-39, SMD Standard Mission Assurance Requirements For Payload Classification D document in the Program Libraries. See the document for details.

L.21 Rideshare Accommodation Worksheet or ISS Technical Resource and Accommodation Feasibility

See Requirement CS-35 for instructions on the Rideshare Accommodation Worksheet or ISS Technical Interface and Resource Accommodation Feasibility

L.22 Infusion Plan for NASA-Developed Technology

Requirement CS-114. This section~~, which shall not exceed five pages in length,~~ shall describe any proposed utilization of NASA-Developed technology as Enabling TDO(s). At a minimum, this description shall address the following topics to the extent that they are not addressed in the body of the CSR:

1) Demonstration of the proposer's understanding of the chosen NASA-developed technology, as well as their understanding of inherent risks associated with its use.
2) Description of technology infusion implementation plan with respect to utilization of the chosen NASA-developed technology. At a minimum, this shall include:
    a. Description of any required flight hardware development and integration plans for producing flight-qualified hardware/software.
    b. 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.
3) Description of the application, appropriate use, and benefits of the NASA-developed technology in the proposed investigation, including description of how this technology would enhance the proposed investigation's science return.
4) Description of how the proposer would engage with the relevant NASA program office's intention to have insight into the flight hardware development, IV&V testing and results, flight development lessons learned, and performance data obtained during flight for the chosen NASA-developed technology.

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

L.23 Justification for the use of non-AMMOS MOS/GDS Tools

Requirement CS-115. This section shall describe the justification for using MOS/GDS tools other than those available from the AMMOS. For each non-AMMOS tool, this section shall contain:

1) A list of requirements that the equivalent AMMOS tool does not meet for the proposed flight project; and,
2) the proposed non-AMMOS tool that satisfies the listed requirements.

If an AMMOS tool will meet the flight project requirements, this section must outline the reasons for not using that tool (*e.g.*, cost of mission-specific adaptations to the AMMOS tool, extensive heritage of use of the non-AMMOS tool by the mission operator).

L.24 Acronyms and Abbreviations List

Requirement CS-116. This section shall provide a list of abbreviations and acronyms.

L.25 References and Management Standards List

CSRs may additionally provide, in this appendix, a list of other reference documents and materials used in the concept study. The documents and materials themselves cannot be submitted, unless they are within the CSR's page limit. 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. This may not include references to audio or video materials. However, CSRs must be self-contained: any data or other information intended as part of a proposal must be included within the proposal itself.

In addition, if the CSR proposes to use internal program and project management standards, then this section must provide those standards.

Requirement CS-117. 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.

COST TABLE TEMPLATE 1
TOTAL MISSION COST FUNDING PROFILE TEMPLATE
(FY costs* in Real Year Dollars, Totals in Real Year and FY 2022 Dollars)

TIME-PHASED COST BREAKDOWN BY ORGANIZATION									
Item	FY1	FY2	FY3	FY4	FY5	...	Fyn	Total (RY$)	Total (FY22$)
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 FY 2022 Dollars)

TIME-PHASED COST BREAKDOWN BY WBS AND MAJOR COST CATEGORY					
WBS/Cost Category Description	FY1	…	Fyn	Total (RY$)	Total (FY22$)
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
CO-I COMMITMENT AND COST
FUNDING PROFILE TEMPLATE
(FY costs in Real Year Dollars, Totals in Real Year and FY 2022 Dollars)

	Phase B	Phases C and D	Phase E	Phase F	Total (RY$)	Total (FY22$)
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 3a as appropriate.

COST TABLE TEMPLATE 3b
COLLABORATOR COMMITMENT AND COST
FUNDING PROFILE TEMPLATE
(FY costs in Real Year Dollars, Totals in Real Year and FY 2022 Dollars)

	Phase B	Phases C and D	Phase E	Total (RY$)	Total (FY22$)
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 3b as appropriate.

COST TABLE TEMPLATE 4
NASA CIVIL SERVICE COSTS
FUNDING PROFILE TEMPLATE

(FY costs in Real Year Dollars, Totals in Real Year and FY 2022 Dollars)

Item	FY1	FY2	FY3	FY4	FY5	...	Fyn	Total (RY$)	Total (FY22$)
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, and/or PI-Team-Developed Enhcancing TDO include any Civil Service costs, include them in Table 4 as appropriate.

COST TABLE TEMPLATE 5
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)	$	$	$	$	$	$	$	$
Enhancing TDO (optional)	$	$	$	$	$	$	$	$
ESI (as required)	$	$	$	$	$	$	$	$
Total	$	$	$	$	$	$	$	$

Total NOA (RY$) in Cost Table Template 5 must match Total Costs (RY$) provided in Cost Table Template 1 and other cost tables.

COST TABLE TEMPLATE 6
FUNDING PROFILE TEMPLATE FOR SEO ACTIVITIES
(FY costs in Real Year Dollars, Totals in Real Year and FY 2022 Dollars)
Follow a similar template for any PI-Developed Enhancing TDO

Item	FY1	…	Fyn	Total (RY$)	Total (FY22$)
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-SELECT

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 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.