2021 ASTROPHYSICS EXPLORERS

DRAFT GUIDELINES AND CRITERIA FOR THE PHASE A CONCEPT STUDY

DRAFT January 8, 2021

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Change Log as of January 8, 2021

January 8, 2021
Initial release, based on the Concept Study Guidelines and Criteria for the 2019 Astrophysics Explorers. An updated release is expected by January 31, 2021.

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2021 ASTROPHYSICS EXPLORERS

GUIDELINES AND CRITERIA FOR THE PHASE A CONCEPT STUDY

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INTRODUCTION

As the outcome of the Small Explorers (MIDEX) MIDEX Announcement of Opportunity (~~NNH19ZDA011O~~ hereafter "the AO") and the MIDEX Astrophysics Explorers Missions of Opportunity (MO) Program Element Appendix (PEA-tbd) for the Third Stand Alone Missions of Opportunity Notice (SALMON-3) Announcement of Opportunity (NNH17ZDA004O-APEXMO2 PEA-tbd, hereafter "the PEA") Step 1 competition, NASA has selected MIDEX 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 7120.5E, *NASA Space Flight Program and Project Requirements*.

NASA recognizes and supports the benefits of having diverse and inclusive scientific, engineering, and technology communities, and fully expects that such values will be reflected in the composition of all mission and instrument teams.

Documents available through MIDEX Astrophysics MIDEX Program Library at https://explorers.larc.nasa.gov/2021APMIDEX/MIDEX/programlibrary.html are intended to provide guidance for investigations selected, and MIDEX Astrophysics MO Program Library is available through https://explorers.larc.nasa.gov/2021APMIDEX/MO/programlibrary.html for the same purpose. These websites are hereafter are referred to as the Program Library. Templates, spreadsheets, and forms that must be submitted can be found in the Program Library. The versions of NASA documents, also posted in the program library, must be used for consistency regardless of any later versions that may be issued after this guidelines and criteria document is released.

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), and Science or science/technology Enhancement Options (SEOs), if proposed, before final selection for implementation.

The product of a concept study is a Concept Study Report (CSR), to be delivered to NASA approximately nine months after the Concept Study Kick-Off Meeting (see below). This document provides guidelines and requirements for preparing a CSR; samples of these include:

- Principal Investigators (PIs) will propose Level 1 Science requirements in their CSRs, including draft criteria for mission success satisfying the Threshold Science Mission.
- The PI-Managed Mission Cost may not increase by more than 20% from that in the Step 1 proposal to that in the CSR, with adjustments as applicable, and it may not exceed the Cost Cap specified in the AO or the PEA.
- NASA intends full mission investigations to be implemented as Category 3 projects (per NPR 7120.5E) and with Class D payloads (per NPR 8705.4, *Risk Classification for NASA Payloads*). Missions of opportunity are to be implemented as Category 3 projects with Streamlined Class D payloads except for Partner Missions of Opportunity (PMOs), which depend on the host mission's risk classification requirements. Class D and Streamlined Class D documents, NPR 7120.5E, and NPR 8705.4 are available in the Program Libraries.
- For the full mission investigations and the Missions of Opportunity, the *Explorers and Heliophysics Projects Division (EHPD) Program Mission Assurance Requirements (MAR) – Mission Risk Classification for Class D* document, available in the Program Library, will apply to investigations that are selected for concept studies.
- Missions of opportunity are subject to all concept study requirements and must demonstrate compliance with Explorers Mission Assurance Requirements, except where tailoring of the requirements is justifiable, either because they are not relevant to the mission, or the requirements are tailorable (*e.g.,* the requirement may be decreased in the level of detail, formality, or risk posture based on the mission described) within the scope of the mission, while meeting the requirement. In all cases, tailoring of any concept study requirement must be justified in the appropriate section.
- Small business subcontracting plans are required, covering Phases B/C/D/E/F
- All program constraints, guidelines, definitions, and requirements specified in the AO or the PEA are applicable to the CSR, except as noted herein. Several items that were deferred from Step 1 that must be provided in the CSR include:
    - Detailed disposal plan (see MIDEX AO Section 5.2.7 or SALMON-3 AO Section 5.3.13 and Appendix B J-7)
    - Science Enhancement Option or its cost (see MIDEX AO Section 5.1.5 or Section E-6 of the SALMON-3 AO)
    - Independent Verification and Validation of Software (see MIDEX AO Section 4.6.1 or Section 4.5.1 of the SALMON-3 AO)
    - Costing of Conjunction Assessment Risk Analysis (see MIDEX AO Section 4.6.4 or Section 4.5.4 of the SALMON-3 AO)
    - Schedule-based end-to-end data management plan (see MIDEX AO Requirement B-24, or Section E.4 of the SALMON-3 AO, and Section E.5 in this document)
    - Requirements for real year dollar costs (see MIDEX AO Section 5.6.2, Requirement B-13, Requirement B-51, and Requirement B-52, or Requirements B-58 to B-60 in the SALMON-3 AO)
    - Space Systems Protection (see MIDEX AO Section 5.2.5.1 or Section 5.3.7 in the PEA)

CDs/DVDs containing the CSRs and all required files, along with 2 signed, original hardcopies, are due by 4pm Eastern time on TBD 2023 at:

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MIDEX Astrophysics Explorers CSR
Science Mission Directorate
NASA Research and Education Support Services (NRESS)
Suite 500
2345 Crystal Drive
Arlington, VA 22202

Phone for commercial delivery: 202-479-9030

Evaluation of CSRs is a major part of Step 2 in the acquisition process. 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 his/her 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.

Phase A contracts for all selected investigations will include a five-month priced option for a Bridge Phase, that will be exercised for the down-selected investigation. The focus of the Bridge Phase will be: 1) participation in the Explorers Program Office project kick-off meeting; 2) work with the Explorers Program Office to negotiate and award the balance of Phase B; 3) other interactions with the Explorers Program Office as necessary, and 4) other project work planned for the first three months of Phase B. A modification will be negotiated during the first three months of Phase B, to cover the remainder of the Phase through KDP-C. 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 five-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 3 months of Phase B (Bridge Phase).

Upon a continuation decision, NASA will execute the Bridge Phase option, and begin to provide Phase B funding for projects that are continued beyond the Phase A concept study. During the Bridge Phase, NASA and the continued projects will negotiate and sign contract modifications necessary for the remaining portion of Phase B on the basis of information provided in the CSR (*e.g.,* Sections J, K, and L.4), and a detailed cost proposal in response to an RFP issued by GSFC for the remainder of Phase B.

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 consider each CSR carefully. Because members of this evaluation team may not have reviewed, nor be provided access to, Step 1 proposals, each CSR must be a self-contained document.

The CSR evaluation process will include visits by the evaluation team to each investigation team's chosen site, to hear oral briefings and, if needed, to receive updates and clarification of

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material in the CSRs. These briefings will be conducted no earlier than three months following submission of the CSRs; scheduling for these visits will be addressed at the Concept Study Kick-Off Meeting. NASA may identify weaknesses and questions and ask that the investigation team respond to these either prior to or at the site visit.

Any additional information provided to NASA by the investigation team at the site visit, in response to the NASA-identified weaknesses and questions, or in response to NASA requests for additional information, will be treated as updates and clarifications to the CSR.

As the outcome of Step 2, it is anticipated that the Selecting Official, the Associate Administrator of the Science Mission Directorate (SMD) or designee, plans to continue at least one of the full mission investigations and at least one mission of opportunity investigation into the subsequent phases of mission development for flight and operation. The target date for this continuation decision (*i.e.,* "down-selection") is fall 2021.

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 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. Part III describes other factors that are not required and will not be evaluated in the CSR, but will need to be provided by the project shortly after a down-select.

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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 MIDEX AO or the SALMON-3 AO. The evaluation criteria and their factors, specified in Sections 7.2.2 through 7.2.4 in both the MIDEX AO and the SALMON-3 AO or Section 7.1 of the PEA, 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 small business subcontracting, will also be evaluated. In case of conflict between the MIDEX AO, the SALMON-3 AO, or the PEA and the CSR Guidelines, the CSR Guidelines take precedence.

All information relevant to the evaluation, including information presented during the site visit, information provided in response to weaknesses and questions, and information contained in the CSR will be considered during the evaluation.

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 PI-Managed Mission Cost has not grown by more than 20%) and for determining if reevaluation of Scientific Merit of the Proposed Investigation is required (as described below), the Step 1 proposals will not be used in the Step 2 evaluation.

The PI-Managed Mission Cost will not increase by more than 20% from that in the Step 1 proposal to that in the Phase A Concept Study Report, and, in any case, will not exceed the cost cap specified in the AO or the PEA.

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

Definition of Heritage

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

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

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	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

Scientific Merit of the Proposed Investigation

The Astrophysics Explorers Program Acquisition Scientist will determine whether any issues that may have emerged in the course of the concept study have effected significant changes to the science objectives or other aspects of the proposed Baseline and Threshold Science Missions (see Requirement CS-17 in Section II of this document) in such a manner as to have impacted the basis for the evaluation of the scientific merit of the investigation as determined by the peer review panel for the Step 1 proposal. If there are no significant changes to the proposed investigation that undermine the basis of this rating, the peer review panel rating for scientific merit of the Step 1 proposal will be the rating for scientific merit of the CSR. If there are significant changes, the Program Scientist will convene a peer review panel to reevaluate the scientific merit of the objectives in light of these changes. The factors for reevaluating this criterion will be the same as those used for the Step 1 proposal review (Section 7.2.2 of both the MIDEX AO and the SALMON-3 AO, or Section 7.1 of the PEA).

Scientific Implementation Merit and Feasibility of the Proposed Investigation

All of the factors defined in Section 7.2.3 of the MIDEX AO and the SALMON-3 AO or Section 7.1 of the PEA apply to the evaluation of the CSR. For missions of opportunity, "mission" should be replaced with "investigation," as applicable. Note that details have been added to one of the subfactors of Factor B-1, Merit of the instruments and mission design. Also, an additional subfactor has been added to Factor B-2, Probability of technical success.

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- Factor B-1. Merit of the proposed mission architecture, instruments, and measurement techniques for addressing the goals and meeting the science objectives. This factor includes how well the anticipated measurements support the goals and objectives, *including details on data collection strategy and plans* (*n.b.*, items in italics added for the evaluation of the CSR);; the appropriateness of the selected instruments and mission architecture for addressing the goals and objectives; and the appropriateness of the mission requirements for guiding development and ensuring scientific success.

- 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* (*n.b.*, subfactor in italics added for the evaluation of the CSR).

- Factor B-3. Data adequacy, analysis, and archiving. This factor includes the degree to which the proposed mission and instruments can provide the quality and quantity of data necessary to complete the investigation and meet the proposed science objectives. Additionally, it includes the merit of data analysis plans, including the fidelity of physical models required to connect the measurements to the science objectives; and plans for archiving, to preserve data and analysis of value to the science community. Considerations include planning and budget adequacy, with plans for well-documented, high-level data products and software usable to the entire science community; adequate resources for physical interpretation of data; reporting scientific results in the professional literature (e.g., refereed journals); and timely release of the data to the public domain.

- Factor B-4. Science resiliency. This factor includes both developmental and operational resiliency. Developmental resiliency includes the approach to descoping the Baseline Science Mission to the Threshold Science Mission in the event that development problems force reductions in scope. Operational resiliency includes the ability to withstand adverse circumstances, the capability to degrade gracefully, and the potential to recover from anomalies in flight.

- Factor B-5. Probability of science team success. This factor will be evaluated by assessing the experience, expertise, and organizational structure of the science team and the mission design in light of any proposed instruments. The role of each Co-Investigator (Co-I) will be evaluated for necessary contributions to the proposed investigation; the inclusion of Co-Is who do not have a well-defined and appropriate role may be cause for downgrading during the CSR evaluation. For missions of opportunity other than Partner Missions of Opportunity (PMOs), the *scientific* expertise of the PI will be evaluated but not his/her experience with NASA missions. Comments about the managerial experience of the PI, and whether

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appropriate mentoring and support tools are in place, will be made to the Selecting Official but these comments shall not impact the "Investigation Implementation Merit" rating.

- Factor B-6. Merit of any Science Enhancement Options (SEOs), if proposed. This factor includes assessing the potential of the selected activities to enlarge the science impact of the mission, and the appropriate 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. *The panel will provide comments to NASA on their findings for this factor.*

A new evaluation factor that is not described in the AO or the PEA and was not evaluated for Step 1 proposals will also be included. This Factor B-8 below will be evaluated for the CSRs in addition to the factors specified in Section 7.2.3 of the both the MIDEX AO and the SALMON-3 AO, or Section 7.1 of the PEA, and repeated or updated above as Factors B-1 through B-7.

- Factor B-8. Maturity of proposed Level 1 science requirements and Level 2 project requirements. This factor includes assessment of whether the Level 1 requirements are mature enough to guide the achievement of the objectives of the Baseline Science Mission and the Threshold Science Mission, and whether the Level 2 requirements are consistent with the Level 1 requirements. The CSR will be evaluated for whether the requirements are stated in unambiguous, objective, quantifiable, and verifiable terms that do not conflict. The CSR will be evaluated for the adequacy, sufficiency, and completeness of the Level 1 and Level 2 requirements, 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.

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

TMC Feasibility of the Mission or Investigation Implementation, Including Cost Risk

All of the factors defined in Section 7.2.4 of both the MIDEX AO and the SALMON-3 AO or Section 7.1 of the PEA apply to the evaluation of the CSR. All of these factors are interpreted as including an assessment as to whether technical, management, and cost feasibility are at least at a Phase A level of maturity.

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

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- Factor C-1. Adequacy and robustness of the instrument implementation plan. The maturity and technical readiness of the instrument complement will be assessed, as will the ability of the instruments to meet mission requirements. This factor includes an assessment of the instrument design, accommodation, interface, heritage, and technology readiness. This factor includes an assessment of the instrument hardware and software designs, heritage, and margins. This factor includes an assessment of the proposer's understanding of the processes, products, and activities required to accomplish development and integration of the instrument complement. This factor also includes adequacy of the plans for instrument systems engineering and for dealing with environmental concerns. This factor includes an assessment of plans for the development and use of new instrument technology, plans for advanced engineering developments, and the adequacy of backup plans to mature systems within the proposed cost and schedule when systems having a Technology Readiness Level (TRL) less than 6 are proposed.

- Factor C-2. Adequacy and robustness of the mission design and plan for mission operations. This factor includes an assessment of the overall mission design and mission architecture, the spacecraft design and design margins (including margins for launch mass, delta-V, and propellant), the concept for mission operations (including communication, navigation/tracking/trajectory analysis, and ground systems and facilities), and the plans for launch services (including the approach the PI will utilize to make the flight worthiness determination if proposing non-NASA 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. (*n.b.*, This factor will be applied only to the extent that it is appropriate for the MO proposals solicited by the PEA).

- Factor C-3. Adequacy and robustness of the flight systems. This factor includes an assessment of the flight hardware and software designs, heritage, and margins. This factor includes an assessment of the proposer's understanding of the processes, products, and activities required to accomplish development and integration of all elements (flight systems, ground and data systems, etc.). This factor includes an assessment of the adequacy of the plans for spacecraft systems engineering, qualification, verification, mission assurance, launch operations, and entry/descent/landing. This factor includes the plans for the development and use of new technology, plans for advanced engineering developments, and the adequacy of backup plans to ensure success of the mission when systems having a TRL less than 6 are proposed. The maturity and technical readiness of the spacecraft, subsystems, and operations systems will be assessed. The adequacy of the plan to mature systems within the proposed cost and schedule, the robustness of those plans, including recognition of risks and mitigation plans for retiring those risks, and the likelihood of success in developing any new technologies will be assessed. (*n.b.*, This factor will be applied only to the extent that it is appropriate for the MO proposals solicited by the PEA).

- 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

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organizational structure and Work Breakdown Structure (WBS); the management approach including project level systems engineering; the roles, qualifications, and experience of the PI, Project Manager (PM), Project Systems Engineer (PSE), other named Key Management Team members, and implementing organization, mission management team, and known partners; the commitment, spaceflight experience, and relevant performance of the PI, PM, other named Key Management Team members, and implementing organization, mission management team, and known partners against the needs of the investigation; the prior working relationships of the implementing organization and known partners; the commitments of partners and contributors; and the team's understanding of the scope of work covering all elements of the mission, including contributions. For the Missions of Opportunity (other than Partner Missions of Opportunity), 1) 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; and 2) 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 "Technical, Management, and Cost Feasibility" rating. This factor also includes assessment of CSR elements such as the relationship of the work to the project schedule, the project element interdependencies, the associated schedule margins, and an assessment of the likelihood of meeting the proposed launch readiness date. Also evaluated under this factor are the proposed project and schedule management tools to be used on the project *along with the effect of the small business subcontracting plan including small disadvantaged businesses on the management approach and schedule* (*n.b.*, subcontracting plan subfactor, in italics, added for the evaluation of the CSR).

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

The following evaluation factor has been removed as a subset of Factor C-4 described in the AO or the PEA and has been revised for the evaluation of the CSR.

- Factor C-6. Adequacy of the risk management plan. The adequacy of the proposed risk management approach will be assessed, including any risk mitigation plans for new technologies, any long-lead items, and the adequacy and availability of any required manufacturing, test, or other facilities. The approach to any proposed descoping of mission capabilities will be assessed against the potential science impact to the proposed Baseline Science Mission. The plans for managing the risk of contributed critical goods and services will be assessed, including the plans for any international participation, the commitment of

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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.

The following are new evaluation factors that are not described in the AO or the PEA and were therefore not evaluated for Step 1 proposals. These will be evaluated for the CSRs in addition to the factors given in Section 7.2.4 of both the MIDEX AO and the SALMON-3 AO, or Section 7.1 of the PEA and repeated or updated above as Factors C-1 through C-6.

- Factor C-7. Ground Systems. This factor includes an assessment of the proposed mission operations plans, facilities, hardware and software, processes, and procedures.

- 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.

For the purpose of the CSR, investigation teams are not required to hold reserves against Government Furnished Equipment (GFE) such as an AO-provided Launch service. They should assume the Government will deliver as promised on factors such as Launch Vehicle (LV) performance and schedule. The Government is holding separate reserves on its promises.

The panel evaluating the "Technical, Management, and Cost Feasibility" will 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.

Merit of the Student Collaboration, and Small Business Subcontracting Plans

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

Merit of Student Collaboration (SC), if proposed. This factor will include an assessment of whether the scope of the SC follows the guidelines in Section 5.5.3 of the AO or Section 5.6.2 of the SALMON-3 AO.

CSRs may define a Student Collaboration (SC) that is a separate part of the proposed investigation. Principal Investigators shall have wide latitude to create SC opportunities that offer authentic, hands-on experiences within the mission life-cycle. A SC can take the form of an instrument development, an investigation of scientific questions, development of supporting hardware or software, or other aspects of the investigation. SC elements that involve only analysis of data may not be proposed. Mentoring shall be an essential component of an SC, and a

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flexible approach is appropriate. The mentoring approach must be documented and a mentoring agreement shall be signed by the student(s), mentor and PI. Mentors may include experiences undergraduates, graduate students, postdocs, experienced technicians, etc.

The SC must be incorporated into the mission on a nonimpact basis. That is, the SC may not increase the mission development risk or impact the development or performance of the baseline or threshold science investigation in any way that would cause the baseline or threshold mission to be compromised in the event that the SC component is not funded; encounters technical, schedule, or cost problems; or fails in flight. A SC must be dependent upon the proposed mission being implemented, e.g., require the provision of flight elements and/or access to science/engineering data generated by the mission. A SC may, but is not required to, have the potential to add value to the science or engineering of the mission.

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

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

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 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.

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 Selecting 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, including cost risk: approximately 40%.

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Student Collaboration and Small Business Subcontracting Plans will be evaluated as separate factors and considered during the selection process.

Additional Selection Factors

At the continuation decision (i.e. final down-selection), the Selecting Official may 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 or the PEA were issued. The PI-Managed Mission Cost, as well as other programmatic factors, may be additional selection factors.

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PART II - REQUIRED QUANTITIES, MEDIA, FORMAT, AND CONTENT

Successful implementation of an Explorers 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 one volume divided into readily identifiable sections that correspond and conform to Sections A through L of the following guidelines. It shall be typewritten in English and shall employ metric (SI) and/or standard astronomical units, as applicable. It shall contain all data and other information that will be necessary for scientific and technical evaluations; provision by reference to external sources, such as Internet websites, of additional material that is required for evaluation of the CSR is prohibited. Exception: The cost proposal (Section J) and any cost appendices (*e.g.,* L.4, L.16) may be submitted as a separate volume.

Requirement CS-2. All printed parts of a CSR, including photographs and/or colored graphics, shall be printed on recyclable white paper. 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. Three-ring binders are acceptable.

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 11inch paper; 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 tables, 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, below. A page quota higher than that in the Step 1 proposal has been allotted to accommodate an expected greater maturity of detail in Sections D through G, plus a Phase B plan. As specified in the Table, two extra pages are allotted for each additional, separate, non-identical science instrument and two extra pages are allotted for each additional, separate, non-identical flight element (*e.g.,* additional non-identical spacecraft are allotted two extra pages). Five extra pages are allotted for a Student Collaboration (SC) if one is proposed. Pages allocated for any proposed SC shall not be used for any other purpose. Every side of a page upon which printing would appear will count against the page limits unless specifically exempted. Each foldout page will count as two pages against the page limits unless specifically exempted (*e.g.,* cost tables required in Sections J and K).

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CSR Structure and Page Limits:

Section	Page Limits
A. Cover Page and Investigation Summary (not to exceed 300 words)	No page limit on cover page, 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, if any) 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 full missions **or** 84 pages for missions of opportunity; plus 2 pages for each additional, separate, non-identical instrument or flight element; plus 5 pages for SC if one is proposed, not including schedule foldouts
J. Cost Proposal K. Justification and Cost Proposal for optional SEO Activities, if applicable	No page limit, but data must be presented in formats described; be brief
L. Appendices (No other appendices permitted) 1. Letters of Commitment* 2. Relevant Experience and Past Performance 3. Resumes* 4. Phase B Contract Implementation Data* 5. Data Management Plan 6. Any Incentive Plan(s)* 7. Technical Content of Any International Agreements* 8. International Participation Plans* 9. Draft Mission Assurance Implementation Plan (MAIP) and Mission Assurance Requirements (MAR) Compliance Matrix 10. Draft Mission Definition Requirements Agreement 11. End of Mission Plan 12. Compliance with Procurement Regulations by NASA PI Proposals* 13. Master Equipment List 14. Heritage 14a. Classified Materials*** 15. Small Business Subcontracting Plan* 16. Additional Cost Data to Assist Validation** 17. Science Change Matrix 18. Communications Design Data* 19. Space Systems Protection* 20. Rideshare Accommodations Worksheet or ISS Technical Interface and Resources Feasibility* 21. Acronyms and Abbreviations 22. References*	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. Applies to Appendices L.1, L.3, L.4, L.6, L.7, L.8, L.12, L.15, L.18, L.19, L.20, and L.21. ** 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. Applies to Appendix L.16. *** Submitted separately.

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Requirement CS-5. Two hardcopies of the CSR shall bear on their cover sheets the original signatures of the Principal Investigator and an official of the PI's institution who is authorized to commit its resources (see Section A, below). These "original" copies shall be printed on a single side of each page, and shall be bound in a manner (*e.g.*, with a binder clip, with a rubber band, in an accordion folder, etc.) that allows each copy to be disassembled easily for reproduction in the event that NASA needs additional copies

Requirement CS-6. Five CD-ROMs (CDs) or single-layer DVD-ROMs (DVDs) containing unlocked, bookmarked, searchable PDF file(s) of the CSR - limited to the main body of the CSR, all tables, all appendices, and the MEL - as well as a separate PDF of the Fact Sheet and Microsoft Excel files of cost tables and the MEL, shall be provided. There is no total size limit except the capacity of the media (CD or DVD), but the PDF portion should not contain information beyond what would have been in a printed version (i.e., no embedded animations, movies, etc; and graphics should not have a resolution higher than a normal printer could handle). The PDF files should be no larger than 60MB for ease of display. If necessary, a PDF file 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 table on directly preceding CS-5 of the CSR Guidelines and Criteria document, regardless of file size.

Requirement CS-7. The CDs or DVDs shall also contain an electronic version of the schedule in a Microsoft Project format. The tasks in the schedule must follow the standard WBS defined in NPR 7120.5E. The detail on the schedule is requested to go to at least Level 3 for the spacecraft elements (one level below the spacecraft level) and Level 4 for the payload developments (one level below each instrument) where the data are available. The CDs/DVDs may contain cost files associated with Appendix L.16.

Requirement CS-8. Provide a list of the individuals who have participated in the concept study (*e.g.*, individuals who worked on the CSR, any CSR contributor, Red Team member, reviewer, *etc.*) and/or whom you are proposing to provide work should the mission be down-selected. Additionally, provide a list of all organizations named in the CSR, or providing developmental or research services, including the lead organization, subcontractors, vendors and contributing organizations who have an interest in the mission. Provide an estimate of the total cost or budget for the organizations listed, over the life of proposal for baseline mission. Provide a draft list of the participants as a Microsoft Excel spreadsheet document to the point-of-contact listed below, 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 on the CD or DVD 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.

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Point of Contact for CSR information:
Dr. Patricia M. Knezek
Astrophysics Division
Science Mission Directorate
National Aeronautics and Space Administration
Washington, DC 20546-0001
Telephone: 202-358-0327
E-mail: patricia.m.knezek@nasa.gov

Requirement CS-9. Create a separate document that contains a table with all of the requirements (Requirement CS-1 through Requirement CS-100) 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 listed above by email no later than seven days after the CSRs are due.

Each CD or DVD must include the required files. These CDs or DVDs and the files in them must be compatible with both Microsoft Windows and Apple MacOS.

The CDs or DVDs must not have paper labels because, if they become unglued, slot-loading drives cannot read them. Other methods, including water-based markers, may be used to label the CDs or DVDs.

Requirement CS-10. If science objectives provided with the Step 1 proposal have changed as a result of the concept study, these changes from the original proposal's science investigation section shall be clearly identified in the CSR.

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

A. COVER PAGE AND INVESTIGATION SUMMARY

Requirement CS-11. 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-12. The Graphic Cover Page shall contain the following information and elements displayed on the cover page of the CSR:

- The investigation title;
- The name of the proposing organization;
- The name of the PI;
- The name and title of an official who is authorized to commit the proposing organization through the submission of the CSR;
- The signature of the PI and the authorizing official (unless these signatures appear on the CSR Summary Information) only on the original copies, per Requirement CS-5;
- Names and institutions of all participants in the investigation;
- The total NASA – SMD cost of the investigation;

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- The proposed contributions and contributing organizations, and
- A summary of the investigation, not to exceed 300 words.

Per Requirement 83 in Section 5.8.3 of the MIDEX AO and Requirement 99 in Section 5.8.4 of the SALMON-3 AO, if the CSR contains export controlled material, the following Export Controlled Material Statement shall be prominently displayed in Section A of the CSR (following the CSR Summary Information):

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

B. FACT SHEET AND EXECUTIVE SUMMARY

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

- Science objectives (including the importance of the science to the program science goals);
- Mission overview;
- Instrument complement;
- Key spacecraft characteristics;
- Mission management and participating organizations (including all named key teaming arrangements);
- Schedule summary;
- The proposed PI-Managed Mission Cost in Real Year dollars (RY$) and in Fiscal Year 2022 dollars (FY22$) from Cost Table Template 1; and
- The proposed Total Cost, including a breakdown of any contributed costs by contributing organization, in RY$ and in FY22$.

Requirement CS-14. The Executive Summary shall summarize the contents of the CSR and shall include an overview of the proposed baseline investigation, including its scientific objectives, technical approach, management plan, cost estimate, and SC, and small business subcontracting plans.

C. TABLE OF CONTENTS

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

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

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D. SCIENCE INVESTIGATION

Requirement CS-16. This section shall describe the science investigation as specified by Requirements B-15 through B-18 in Appendix B of the AO or Requirements B-15 through B-18 in Section D in Appendix B of the SALMON-3 AO plus Section 5.2 of the PEA. 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.17.

Requirement CS-17. Any changes to the Baseline and Threshold Science Missions defined in the Step 1 proposal shall be identified and the rationale for the change(s) provided. Such changes to the science mission shall be highlighted in bold or a color with column marking for easy identification. In addition, a change matrix showing the original (proposed) science objective(s), any new or revised science objective(s), rationale for the change(s), and location(s) within the CSR is required as an appendix (see Section L.17). 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 Science Requirements and Level 2 Project Requirements

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

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

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

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If the mission success criteria are not included in the CSR, they will need to be identified at the System Requirements Review (SRR) after down-select, when the project falls under NPR 7120.5E.

Requirement CS-18. A set of proposed Level 1 science requirements that will achieve the objectives of the Baseline Science Mission shall be provided. State both baseline science requirements and threshold science requirements. To the extent that they are known, identify the draft mission success criteria based on the threshold science requirements. The Level 1 science requirements of the investigation, as agreed to by the PI, PM, PSE and other key personnel, must be clearly identified in this section; they must be quantified, verifiable, and clearly tied to the science objectives. Examples of Level 1 science requirements can be found within the Program Level Requirements Appendix (PLRA) documents in the Program Library, along with presentation slides on Level 1 and Level 2 requirements given at PI Masters Forum 8. A set of Level 2 requirements that flow down from the Level 1 requirements to guide the design and development of the mission shall be provided. Lower level requirements shall be provided to the extent that they are known and necessary to explain and justify the design concept including instrument capability, instrument performance, and other aspects of the system architecture that enable the accomplishment of the mission science objectives. State each requirement in unambiguous, objective, quantifiable, and verifiable terms. Requirements shall not conflict with each other. The Level 2 requirements shall be listed in Appendix L.10, Draft Mission Definition Requirements Agreement.

E.2 Science Mission Profile

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

E.3 Instrumentation

Requirement CS-20. This section shall describe the instrumentation and the rationale for its selection. It shall identify instrument systems (*i.e.*, individual instruments), instrument subsystems, and instrument components, including their characteristics and requirements, and indicate items that are proposed for development, as well as any existing instrumentation or

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

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

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

E.4 Data Sufficiency

Requirement CS-22. This section shall discuss the quality and quantity of data to be generated by each instrument, as they relate to the proposed science investigation goals and objectives. The flow-down from science investigation goals to measurement objectives and instrument performance shall be stated clearly and supported by quantitative analysis. If your mission requires NASA High-End Computing HEC resources, in your CSR, state your: 1) requirements, by year, for computing in the "standard billing units" (SBUs); 2) data storage need in Terabytes, by year; 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 PI-Managed Mission Costs.

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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-23. In accordance with the *NASA Plan: Increasing Access to the Results of Scientific Research*, a schedule-based end-to-end data management plan, including approaches for data retrieval, validation, preliminary analysis, image processing, calibration, correction, and archiving shall be described. The plan shall:

- Identify science products (*e.g.,* flight data, ancillary or calibration data, theoretical calculations, higher order analytical or data products, and laboratory data), including a list of the specific data products, and the individual team members responsible for the data products;
- Identify the appropriate data archive and the formats and standards to be used. The approved NASA Astrophysics data archives are the High Energy Astrophysics Science Archive Research Center (HEASARC), the Mikulski Archive for Space Telescopes (MAST), and the Infrared Science Archive (IRSA);
- 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-24. This section shall identify each key member of the Science Team (*i.e.,* one whose participation is essential to the success of the investigation) and his/her roles and responsibilities. Resumes or curricula vitae of Science Team members shall be included as appendices to the CSR. The role of each Co-I shall be explicitly defined, the necessity of that role shall be justified, and the funding source (NASA or contributed) for the PI and each Co-I shall be noted. A summary table shall be included, with columns for 1) PI or Co-I name; 2) their roles and responsibilities on the mission; and 3) their time commitment, in FTEs/WYEs, for each phase of each mission Phase, A through F (as specified in Requirement CS-69 to Requirement CS-72). Non-funded members of the Science Team shall be identified in the CSR as collaborators; the role of collaborators may be defined and justified.

E.7 Plan for SEO

Requirement CS-25. If applicable, this section shall describe plans for Science Enhancement Option (SEO) activities (see Section 5.1.5 of the AO, or 5.2.5 of the SALMON-3 AO and Section 5.2.4 of the PEA). Additionally, a justification and a cost plan for SEO activities are required in Section K of this document.

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F. MISSION IMPLEMENTATION

F.1 General Requirements and Mission Traceability.

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

Requirement CS-27. The mission functional requirements that the science goals and objectives impose on the mission design elements, including mission design, instrument accommodation, spacecraft design, required 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 Appendix B of the MIDEX AO and the SALMON-3 AO, or in the Program Library, provide examples of a tabular Mission Traceability Matrix, with examples of matrix elements. Specific information that describes how the science investigation imposes unique requirements on these mission design elements shall be included.

F.2 Mission Concept Descriptions.

Requirement CS-28. Designs for all elements of the mission shall be described in sufficient detail to demonstrate that the mission concept meets all of the basic requirements for a space flight mission, including mission design, spacecraft design, and supporting ground systems. Discussion of how the various mission elements meet the Mission Functional Requirements shall be included.

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

- Proposed launch date, launch window, and launch date flexibility;
- Mission duration;
- Orbit type (Earth orbit, heliocentric, *etc.*) and orbit parameters (semi-major axis, eccentricity, inclination, node time of day, argument of perigee, altitude, allowable dispersions) for all orbits, and trajectory design and trajectory parameters for ballistic and low-thrust trajectories to permit independent validation, as applicable to the proposed investigation;
- All critical events, which includes launch vehicle separation real-time telemetry;
- Telecomm link summary for all communication modes (based on requirements identified in Appendix L.18, Communications Design Data);
- All ground station(s) usage (*e.g.,* location(s), and transmitting and receiving communication parameters); and
- Space system's fault management approach and design.

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Requirement CS-30. This section shall demonstrate compatibility with the proposed launch vehicle performance level as defined in the AO, the PEA, and the Program Library.

- Explorer Phase A study teams for full mission proposals are to continue to use the launch vehicle performance classes described in Section 5.9.2 of the AO and in the Program Library. Explorer Phase A study teams should work with TBD, for Launch Services Program support not involving rideshare.
- Proposals utilizing PEA-provided rideshare to LEO or GTO should continue to follow the instructions in Section 5.3.6.1 of the PEA-tbd.
- Proposals utilizing PEA-provided access to cislunar space should continue to follow the instructions in Section 5.3.6.2 of the PEA-tbd.
- For missions of opportunity proposed as payloads to the International Space Station (ISS), Phase A study teams shall provide, in Section L.1, an updated Letter of ISS Technical Interface and Resource Accommodation Feasibility Assessment from the ISS Research Integration Office, as specified in Requirement O-7 of the PEA. An updated *Proposer Requested ISS Resource Table* (March 2019) is posted to the Program Library. This table shall be delivered as Appendix L.20 on the CSR due date. Explorer Phase A study teams should work with the POC named in Section 5.3.6.3 of the PEA-tbd.
- For missions of opportunity using Alternative Access to Space, Phase A study teams should continue to follow the instructions in Section 5.3.7 of the PEA-tbd.

Requirement CS-31. This section shall address all aspects of the flight system including the following flight system capabilities to the extent that they are applicable to the mission. Any additional elements that are applicable to explaining the mission and demonstrating its feasibility shall also be addressed. Note that the heritage of the components and subsystems are to be discussed in Appendix L.14.

- Spacecraft parameters:
  (a) Figure of the complete spacecraft/instrument system, on the 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, attitude determination and control, command and data handling, and flight software, to include their interface and interaction with the fault management design. (Note that the discussion of the telecommunications subsystem should be limited to specifications, design, and proposed component hardware – discussion of the link performance is addressed as part of Appendix L.18). 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(s) (*e.g.*, monoprop, bi-prop, dual-mode, solar electric, *etc.*), identify engines and thrust levels, specific impulse, and propellant allocation (impulse vs. attitude control system); (iii) propellant margins.
  (b) Command and Data Handling including (i) spacecraft housekeeping data rates for nominal and safing strategy; (ii) data storage unit size (Mbits); (iii) maximum storage record and playback rate.
  (c) Power: As appropriate, identify (i) type of array structure (rigid, flexible, body mounted); (ii) solar array axes of rotation (vector projected in spacecraft coordinates); (iii) array size; (iv) solar cell type and efficiency; (v) expected power generation at Beginning of

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Life (BOL) and End of Life (EOL); (vi) worst case Sun incidence angle to solar panels during science mission; (vii) battery type and storage capacity; (viii) worst case battery Depth of Discharge (DOD); (ix) spacecraft bus voltage; and (x) power profiles and margins for all power modes.

(d) Attitude Determination and Control, including system pointing requirements and capabilities. Describe or define the following: (i) each spacecraft operational mode including the sensors and actuators used, control method, and safing and/or contingency modes; (ii) attitude determination methodology and estimate of accuracy including identifying whether ground post-processing is required to meet science needs; (iii) agility requirements for slews or scanning; (iv) appendage pointing requirements including articulation control methods and deployment accommodations; (v) sensor selection and performance including identifying mounting location and field-of-view (FOV); (vi) actuator selection and sizing including identifying mounting location(s); (vii) translational maneuver (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; (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); and (iii) cooling loads; and (iv) special thermal design considerations (*e.g.,* cryogenic instrument requirements).

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

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

<u>Requirement CS-32.</u> This section shall summarize contingencies and margins of all key flight systems resources. For the driving mission element requirements derived from the Mission Functional Requirements, it shall provide estimates of implementation performance and design margins with respect to the required performance. It shall include the following:

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

For any other driving mission element requirements derived from the Mission Functional Requirements, provide estimates of implementation performance and design margins with

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respect to the required performance (see the table following Requirement B-35 in Appendix B of the AO or the table following Requirement B-28 in Appendix B of the SALMON-3 AO for definitions of contingency and margin).

Requirement CS-33. This section shall address the following elements of mission operations and communication to the extent they are applicable to the mission. Any additional elements that are applicable to explaining the mission operations and demonstrating their feasibility shall also be addressed. This section shall provide

- Description of ground systems and facilities including supporting ground software at the Mission Operations Center (MOC) and the Science Operations Center (SOC) required for development and testing and operations;
- Telecommunications, Tracking, and Navigation (Deep-Space/Lunar and Earth Orbital missions, as well as missions that utilize telecom relay orbiters) including downlink information and data volume, uplink information, and for all transmit and receive modes, provide mode timeline, data rate(s), and durations, and the ground network utilization plan including ground stations; downlink frequencies, periods, capacities, margins, etc.; and retransmission capability. Where the use of NASA's network services may not be within the capabilities and capacities described in the NASA's *Mission Operations and Communications Services* document, discussions should be initiated with the POC named in that document. A Letter of Commitment to be included in Section L.1 is required from the NASA network provider describing the network's ability to deliver the required capabilities and capacities and the cost for doing so;
- Plan for acquiring and returning critical event data, including clear identification of procurement and costing for supplemental resources (*e.g.,* mobile ground stations) if such are needed;
- Operations plan, including a quantitative discussion of nominal sequence planning and commanding showing the ability of the Mission Operations and Ground Data System to analyze the spacecraft and payload data and to generate the necessary sequences to enable the spacecraft to meet the planned mission timelines, team training, and availability of spacecraft experts for operations, operations center development; and
- Operational concept that includes the following. Operational Scenarios with a description of each mission phase from launch through end of mission and an integrated description of the ground events and spacecraft/payload events for key mission phases. Timelines for each key mission phase; containing spacecraft, Payload, and ground events and processing and identifying margin for each phase if available. Data Flow Diagrams which clearly show the major operational facilities and key software components utilized for both the uplink and downlink processes. A Phase E Organization diagram and Team Responsibilities clearly indicating the key manager for each of the project facilities in the data flow diagram. An identification of the heritage of each project facility including: the software and hardware within that facility and the identification of the percentage of new, modified or no changes for each major software element. A plan for required maintenance and refresh of vendor supplied ground systems (hardware and software) during extended cruise operations. A plan for retention of adequate development and test resources, spacecraft and Ground Support Equipment (GSE) test beds, *etc.* during Phase E that addresses the impact of operations development and testing on routine and contingency mission operations.

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G.3 Development Approach.

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

Requirement CS-34. 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-35. 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). 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-36. 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 7123.1B, Appendix E, in the Program Library);
- Rationale for combining the TRL values of components and subsystems to derive each full system TRL as proposed, appropriately considering TRL states of integration (see NASA/SP-2016-6105 Rev 2, *NASA Systems Engineering Handbook,* in the Program Library);
- Rationale for the stated TRL value of an element that is an adaptation of an existing element of known TRL;
- The approach for maturing each of the proposed systems to a minimum of TRL 6 by PDR:

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- 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;
- Include discussion of simulations, prototyping, demonstration in a relevant environment, life testing, etc., as appropriate;

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

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

F.5 Assembly, Integration, Test, and Verification.

Requirement CS-37. An illustration and discussion of the time-phased flow of the Integration and Test (I&T) Plan shall be presented. Additionally, the key facilities, testbeds, and team members involved in the I&T Plan shall be summarized.

Requirement CS-38. The project's verification approach shall be described in this section. Flow diagrams, narrative text, and/or other relevant data may be used to convey this information. Elements of the approach that pose special challenges for the project (*e.g.,* mission critical performance or functional requirements that cannot be tested on the ground, special facilities that may be required for testing, large scale simulation tools that must be developed and how they will be validated, critical path items, *etc.*) shall be highlighted. The description of testing and verification shall demonstrate the credibility of the overall approach as reflected by consistency between the described test plans and the schedule, cost, and other resources needed to carry them out. The testing and verification of the space system's fault management approach and implementation shall be discussed.

F.6 Schedule.

Requirement CS-39. A project schedule foldout (or foldouts) covering all phases of the investigation shall be provided. This foldout will not be counted against the page limits. The schedule format shall indicate the month and year of each milestone, have a corresponding table of dates, and follow standard NASA WBS elements for task descriptions as prescribed in NPR 7120.5E. The schedule foldout and accompanying narrative shall address major milestones, including the following items:

- Spacecraft development, integration and test, and major review dates;
- Instrument development and major review dates including instrument-to-spacecraft/host integration and test;

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- Ground systems development and major review dates (*e.g.*, mission operations and data analysis development schedule);
- Major deliverables (*e.g.*, Interface Control Documents, simulators, engineering modules, flight modules, *etc.*);
- Spacecraft-to-launch vehicle integration and launch readiness;
- Long-lead item specifications, development paths, and their impacts to schedule;
- Development schedule for Student Collaborations (SCs), or Science Enhancement Options (SEOs) if any;
- Schedule critical path identification, including any significant secondary critical paths; and
- Funded schedule reserve, with indications of appropriate reserves associated with major milestones and deliverables, including allocated critical path reserves.

G. MANAGEMENT

NASA NPR 7120.5E establishes the requirements by which NASA formulates and implements space flight programs and projects. This document emphasizes program and project management based on life cycles, Key Decision Points (KDPs), and evolving products during each life-cycle phase. These requirements have been modified in the *NASA Science Mission Directorate (SMD) Class-D Tailoring/Streamlining Decision Memorandum* for Class-D investigations less than $150M, not including launch services costs. Missions of opportunity (except for PMOs) are considered to be Streamlined Class-D investigations. Full MIDEX missions are not eligible for Class D streamlining.

Streamlined Class-D investigations must identify those requirements not specifically identified as already being tailored in the *NASA Science Directorate (SMD) Class-D Tailoring/Streamlining Decision Memorandum* and described in NPR 7120.5E that are proposed for adjustment, provide a rationale for each adjustment, and describe any cost, schedule, and/or other benefits that would be realized should one or more of the adjustments be accepted by NASA. Note that these adjustments reflect potential modifications to the baseline investigation, to be addressed after down-selection.

Investigations in other risk classes (i.e., A, B, or C) may also contain proposed adjustments to NASA requirements. Proposers must identify the tailorable requirements described in NPR 7120.5E that are being adjusted, provide a rationale for each adjustment, and describe any cost, schedule, and/or other benefits that would be realized should one or more of the adjustments be accepted by NASA. Note that these adjustments reflect potential modification to the baseline investigation, to be addressed after down-selection.

The panel evaluating the third evaluation criterion, "Technical, Management, and Cost" (TMC) Feasibility of the Proposed Investigation Implementation, will provide comments to the Selection Official on the proposed adjustments 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.

<u>Requirement CS-40.</u> CSRs shall identify any requirements that are proposed for adjustment, include the rationale for the adjustment, and describe the cost, schedule, and/or other benefits

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that would be realized should one or more of the adjustments be accepted by NASA. For the missions of opportunity except PMOs, the CSRs shall provide the above information for proposed adjustments to requirements not specifically identified in the *NASA Science Directorate (SMD) Class-D Tailoring/Streamlining Decision Memorandum* as already being tailored.

Requirement CS-41. This section shall describe the management approach, including essential management functions and the overall integration of these functions:

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

Requirement CS-42. 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 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-43. 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-44. 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 member 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.

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Requirement CS-45. This section shall name all of the team members who will occupy the key project management positions identified in Requirement CS-44. 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-46. This section shall describe plans for risk management, both in the overall mission design and in the individual systems and subsystems. NASA's required risk management procedures are provided in NPR 8000.4B, *Risk Management Procedural Requirements*, which is available in the Program Library. The *Explorers Program Mission Assurance Requirements (MAR) Mission Risk Classification - NPR 7120.5 Class D,* document, available in the Program Library, will also apply to Class D missions. A draft Mission Assurance Implementation Plan (MAIP) and MAR Compliance Matrix must submitted with the CSR (See Section L.9). 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 a proposed future 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/technology. In the case of cost, the products of pre-mitigation probabilities and impacts shall be included as encumbered cost reserves or explicitly identified in the basis of estimate, including cost validations.

Requirement CS-47. 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

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investigation as a total system including instrument(s), spacecraft, ground system, launch services, and operations.

Requirement CS-48. This section shall clearly delineate the Government-furnished property, services, facilities, *etc.*, required to accomplish all phases of the mission.

Requirement CS-49. This section shall list the major project reviews expected to be conducted during the project's life cycle and the approximate time frame in the Project Schedule when each review will occur.

Requirement CS-50. This section shall clearly describe the approach to reporting progress to the Government and indicate the progress reviews that 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-51. 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-76 and Requirement CS-77);
- 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/or holding reserves to develop the contribution directly. Note that reserves held for this purpose should be weighted by likelihood and are considered encumbered. When no mitigation is possible, this must be explicitly acknowledged, and the stability and reliability of proposed partners, as well as the appropriateness of any proposed contribution, should be addressed; and
- Acknowledgement of the complexities and risks involved with contributions, and plans to handle those complexities or risks. This includes the schedule risk for implementing technical assistance agreements and international agreements. An adequate and realistic schedule must be allocated for having international agreements executed. NASA will not begin working on any international agreements until after the continuation decision is made.

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

Requirement CS-52. If a Student Collaboration is proposed, this section shall describe a detailed plan. This plan shall include:

- A summary description of the planned SC;
- A development schedule for the SC, including decision points for determining readiness for flight;
- A demonstration of how the SC will be incorporated into the mission investigation on a non-impact basis;

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- 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 include signed mentoring agreements, to maximize the opportunity for teaching, learning, and success in contributing to the mission;
- An appropriate plan for evaluation of student development; and
- Identification of the cost of the SC separately from the investigation.

Requirement CS-53. A Small Business subcontracting plan, covering Phases B through F, shall be provided as an appendix; see Section L.15, Requirement CS-95.

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

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

Requirement CS-54. 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-55. 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, if any;
- A complete set of Baseline Level 1 requirements including mission success criteria; and
- The baseline project plan.

Requirement CS-56. 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.

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J. COST PROPOSAL

Requirement CS-57. A WBS as defined in NPR 7120.5E shall be provided and used to describe how all project costs are accounted in the cost proposal.

Requirement CS-58. This section shall detail the estimated cost of the proposed investigation. The estimated cost shall encompass all proposed activities, including all applicable mission phases, mission unique or special launch services, flight systems, ground systems, ground network fees, contributions, any other AO-specific activities (*e.g.,* SC), and all cost reserves. Cost for ground network fees, data archive, and other mission-unique elements shall be clearly described. These costs shall be consistent with the policies and requirements in Sections 4 and 5 of the AO or the PEA.

Requirement CS-59. This section shall describe the methodologies used to develop the cost estimate and provide an overview of the cost estimate development process. Any additional cost estimates or other validation efforts shall be described, the results presented, and any significant discrepancies discussed. The rationale for the proposed cost reserve levels shall be presented. Additional basis of estimate data shall be provided to assist the validation of the costs estimates. Examples of useful basis of estimate data include cost comparisons to analogous items/missions, vendor quotes, and parametric model results.

Requirement CS-60. This section shall discuss cost risks and mitigation strategies.

Requirement CS-61. This section shall provide a foldout cost table, using the template of Cost Table Templates 3a and 3b, which will not be counted against the page limit. The table shall identify the proposed cost required in each mission phase and in each fiscal year; the costs shall be in Real Year dollars (RY$). The top portion of the table shall contain cost data relevant to the PI-Managed Mission Cost. The lower portion shall contain cost data for contributions and enhanced mission costs. The rows in the table shall be the NASA standard WBS elements as defined in NPR 7120.5E. The costs for most elements shall be provided to WBS level 3. It is requested that instruments be shown to WBS level 4 where the data is available. Exceptions are the costs of individual instruments and any unique flight system elements such as landers or sample return capsules, which shall be explicitly shown. The columns in the table shall be grouped and subtotaled by mission phase and shall be labeled with the appropriate fiscal years. Fiscal years that span more than one mission phase shall be split into two columns by mission phase. The table includes totals by phase and life cycle in both RY$ and Fiscal Year 2022 dollars (FY22$). Investigation teams shall use their own forward pricing rates to translate between RY$ and FY22$. For organizations that are without approved forward pricing rates, investigation teams may use the NASA inflation/deflation indices from the 2019 NASA New Start for FY22 Inflation Tables, which can be found in the Program Library, to translate between real year dollars (RY$) and fiscal year 2022 dollars (FY22$) (*n.b.*, these are updated inflation tables and are different from those in the MIDEX AO and SALMON-3 AO).

Requirement CS-62. The CSR cost proposal shall provide information on the anticipated costs for all mission phases. A detailed cost proposal is required for Phase B. Cost estimates are also required for the follow-on phases (*i.e.*, Phases C/D, E, and F) including a description of the

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estimating techniques used to develop the cost estimates. See Section K for requirements for any SEO costs. A discussion of the basis of estimate shall be provided, with a discussion of heritage and commonality with other programs. Quantify and explain any cost savings that result from heritage. All costs, including all contributions made to the investigation, shall be included. Specific information that would better enable NASA to validate costs (*e.g.,* WBS level 3 data) may be provided as an appendix (see Appendix L.16). This will include cost by fiscal year to the lowest level of detail the project is working with, in Microsoft Excel format.

Requirement CS-63. Provide a table with the new obligation authority (NOA) required in RY$ by fiscal year using the format of Cost Table Template 6. If the mission is selected for flight, SMD will use this information to prepare its budget request.

Requirement CS-64. 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-65. The cost of the entire project shall be summarized on one page, and presented using each of Cost Table Templates 3a and 3b. The purpose of the table is to (1) provide detailed insight into project costs by cost element and (2) provide a basis for comparison of the project proposed cost with the evaluation team's independent cost analysis. Identify each reserve amount to the lowest level consistent with the proposed reserve management strategy. For example, if each subsystem manager will have spending authority over a reserve for the subsystem, each such amount shall be identified separately. If more convenient, the reserve details may be shown in a separate table, with totals reported using each of Cost Table Templates 3a and 3b. Show costs (NASA SMD and contributed) associated with each Co-I using the template of Cost Table Template 4 in one page; all Co-Is shall be identified in this table.

Requirement CS-66. All contributions provided by NASA Centers, including Civil Servant services, as well as the cost for the use of Government facilities and equipment on a full-cost accounting basis, shall be included. All direct and indirect costs associated with the work performed at NASA Centers shall be fully costed and accounted for in the CSR and summarized in one page using the template provided in Cost Table Template 5. The purpose of this data is twofold: 1) to determine those costs that are included in the NASA SMD cost but are not funded out of the Explorer program, and 2) to determine Civil Servant contributions that are not included in the NASA SMD cost. Teams should work with their respective NASA Centers to develop estimates for these costs. Contributions by NASA Centers should be documented by a Letter of Commitment, provided as an appendix (see Section L.1, Requirement CS-76 and Requirement CS-77).

Definitions for cost element terms shown in the cost tables are provided in Appendix C.2 of the MIDEX AO and the SALMON-3 AO.

Requirement CS-67. The inflation index provided in the NASA FY22 Inflation Tables, posted in the Program Library shall be used to calculate all real-year dollar amounts, if an industry

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forward pricing rate is not available. If something other than the provided inflation index is used, the rates used must be documented.

Requirement CS-68. All costs shall include all burdens and profit/fee in real-year dollars by fiscal year, assuming the inflation rates used by NASA (NASA FY22 Inflation Tables, posted in the Program Library) or specifically documented industry forward pricing rates.

Requirement CS-69. 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-80).
- 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 concept study and the Statement of Work provided as an Appendix to the concept study. The WBS shall be described to the subsystem level (*e.g.,* Attitude Control System, Propulsion, Structure and Mechanisms) for the spacecraft, to at least the instrument level for simple instruments, and to the major component level for more complicated instruments. All other WBS elements shall be at least to the major task level (*e.g.,* Project Management, Systems Engineering, GSE).
- Workforce Staffing Plan. A workforce staffing plan that is consistent with the WBS shall be provided. This plan shall include all team member organizations and must cover all management, technical (scientific and engineering), and support staff. The workforce staffing plan shall be phased by month. Time commitments for the PI, PM, PSE, Co-Is, and other key personnel must be clearly shown.
- Proposal Pricing Technique. The process and techniques used to develop the cost proposal for Phase B shall be described. For portions of the cost proposal developed with a grass-roots methodology, the bases from which the estimates were derived and details on how the estimates were extrapolated from the bases shall be provided. For portions of the cost proposal derived from vendor quotes/historical actuals/catalogue prices/*etc*., information sufficient to understand the fidelity of the values shall be provided. For portions of cost the proposal derived from analogies, the value of and the methodology for extrapolating the analogy shall be described. For portions of the cost proposal derived parametrically, the cost-estimating model(s) and techniques used in the cost estimate for Phase B shall be described. The heritage of the models and/or techniques applied to this estimate, including any differences between missions contained in the model's data base and key attributes of the proposed mission shall be described. Assumptions used as the basis for the cost for Phase B shall be included, and those that are critical to cost sensitivity in the investigation shall be identified. If any "discounts" were assumed in the cost estimates for business practice initiatives or streamlined technical approaches, a description of how these have been incorporated in the cost estimate and will be managed by the investigation team shall be provided.
- Phase B Time-Phased Cost Summary. A summary of the total costs for Phase B consistent with the table created for Requirement CS-64 (Cost Table Template 2) shall be provided. The cost summary for Phase B shall be developed consistent with the WBS and must include all costs to NASA SMD along with all contributed costs. The cost summary for Phase B shall be phased by month.

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- 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-64 (Cost Table Template 2) shall be provided. This information is in addition to that provided in Requirement CS-61 through Requirement CS-65 (Cost Table Templates 1 through 5). The cost proposal shall include, but is not limited to, the following cost elements:
  (a) Direct Labor. (i) The basis of labor-hour estimates for each of the labor classifications; (ii) the number of productive work-hours per month; (iii) a schedule of the direct labor rates used in the proposal, with a discussion of the basis for developing the proposed direct labor rates for the team member organizations involved; the forward-pricing method (including midpoint, escalation factors, anticipated impact of future union contracts, *etc.*); and elements included in the rates, such as overtime, shift differential, incentives, and allowances; (iv) if available, evidence of Government approval of direct labor rates for proposal purposes for each labor classification for the proposed performance period; and (v) if Civil Servant labor is to be used in support of the Phase B study, but is not to be charged directly to the investigation, this labor shall be considered as a contribution by a domestic partner, subject to the same restrictions as other contributions by domestic or foreign partners, and a discussion of the source of funding for the Civil Servant contributions shall be provided.
  (b) Direct Material. A summary of material and parts costs for each element of the WBS shall be provided.
  (c) Subcontracts. Each effort (task, item, *etc.*, by WBS element) to be subcontracted, and list the selected or potential subcontractors, locations, amount budgeted/proposed, and types of contracts shall be identified. Explain the adjustments, if any, and the indirect rates (or burdens) applied to the subcontractors' proposed or anticipated amounts. Describe fully the cost analysis or price analysis and the negotiations conducted regarding the proposed subcontracts.
  (d) Other Direct Costs. (i) A summary of travel and relocation costs, including the number of trips, their durations, and their purposes; (ii) a summary of all unique computer related costs; (iii) specific task areas of problems that require consultant services, including the quoted daily rate, the estimated number of days, associated costs (*e.g.* travel) if any, and a statement of whether the consultant has been compensated at the quoted rate for similar services performed with Government contracts; and (iv) any other direct costs included in the proposal for Phase B, provided in a manner similar to that described above.
  (e) Indirect Costs. (i) all indirect expense rates for the team member organizations (in the context of the AO or the PEA, 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.

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Requirement CS-70. 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-64 (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-71. 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

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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-64 (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-72. 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 concept study. 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 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 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

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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-64 (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-73. 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); launch vehicle, upper stages, and launch services beyond what is provided by the AO or the PEA; rideshare services beyond those provided by the PEA; ground system costs; and cost of activities associated with social or educational benefits (if not incorporated in any of Phases A through F). 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-74. 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.

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COST TABLE TEMPLATE 1
TOTAL MISSION COST 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$)	Total (FY22$)
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.

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COST TABLE TEMPLATE 2

(Phased costs in Real Year Dollars, Totals in Real Year and FY2020 Dollars)

TIME PHASED COST BREAKDOWN BY WBS AND MAJOR COST CATEGORY					
WBS/Cost Category Description	FY1	FY2	• • •	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	$	$	$	$	$

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

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

WBS#	WBS Element	Phase A			Phase B			Phase C/D				Phase E				Phase F			RY$
		FY2020	FY2021	Total	FY2021	FY2022	Total	FY2022	FY2023	FY2024	Total	FY2024	FY2025	FY2026	Total	FY2026	FY2027	Total	Total
01	Project Management																		
02	Systems Engineering																		
03	Safety & Mission Assurance																		
04	Science / Technology																		
	Breakout pre-launch science from technology development activities																		
05	Payload(s)																		
	List each instrument separately																		
06	Spacecraft																		
	List each major flight system element separately																		
07	Mission Operations																		
	Breakout separable services, e.g., DSN, etc.																		
08	Launch Vehicle / Services																		
09	Ground System(s)																		
	Breakout non-standard cost, e.g., coordinating ground stations																		
10	Systems Integration & Testing																		
11	Student Collaboration in Excess of Incentive																		
	Reserves																		
	PI-Managed Mission Cost																		
	Student Collaboration Incentive (if applicable)																		
	Contributions																		
	List by organization and WBS element																		
	Total Mission Cost																		
	Student Collaboration Incentive (if applicable)																		
	Other AO-specific Activities																		
	List by activity and WBS element																		
	Enhanced PI-Managed Mission Cost																		
	Phase B Bridge Phase Funding (*included above*)																		

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

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

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COST TABLE TEMPLATE 3b
FISCAL YEAR COSTS IN FISCAL YEAR 2022 DOLLARS (to nearest thousand)

(Totals in Fiscal Year 2022 Dollars)

Total Mission Cost Profile Template

FY Costs and Totals in Fiscal Year 2020 Dollars (FY 2020$)

WBS#	WBS Element	Phase A			Phase B			Phase C/D				Phase E				Phase F			FY 2020$
		FY2020	FY2021	Total	FY2021	FY2022	Total	FY2022	FY2023	FY2024	Total	FY2024	FY2025	FY2026	Total	FY2026	FY2027	Total	Total
01	Project Management																		
02	Systems Engineering																		
03	Safety & Mission Assurance																		
04	Science / Technology																		
	Breakout pre-launch science from technology development activities																		
05	Payload(s)																		
	List each instrument separately																		
06	Spacecraft																		
	List each major flight system element separately																		
07	Mission Operations																		
	Breakout separable services, e.g., DSN, etc.																		
08	Launch Vehicle / Services																		
09	Ground System(s)																		
	Breakout non-standard cost, e.g., coordinating ground stations																		
10	Systems Integration & Testing																		
11	Student Collaboration in Excess of Incentive																		
	Reserves																		
	PI-Managed Mission Cost																		
	Student Collaboration Incentive (if applicable)																		
	Contributions																		
	List by organization and WBS element																		
	Total Mission Cost																		
	Student Collaboration Incentive (if applicable)																		
	Other AO-specific Activities																		
	List by activity and WBS element																		
	Enhanced PI-Managed Mission Cost																		
	Phase B Bridge Phase Funding (*included above*)																		

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

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

COST TABLE TEMPLATE 4
CO-I COMMITMENT AND COST
FUNDING PROFILE TEMPLATE
(FY costs in Real Year Dollars, Totals in Real Year and FY2020 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 4a as appropriate.

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COST TABLE TEMPLATE 5
NASA CIVIL SERVICE COSTS
FUNDING PROFILE TEMPLATE
(FY costs in Real Year Dollars, Totals in Real Year and FY2020 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 include any Civil Service costs, include them in Table 5 as appropriate.

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

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

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

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K. JUSTIFICATION AND COST PROPOSAL FOR ANY SEO ACTIVITIES

SEO activities, discussed in Section 5.1.5 of the AO or 5.2.5 of the SALMON-3 AO and 5.2.4 of the PEA, include extended missions, guest investigator programs, general observer programs, and archival data analysis programs. The selections from the Step 1 proposals were made primarily on the merit of the baseline proposed science; no commitment to any attendant proposed SEO activity was made at selection. It is incumbent upon investigation teams, therefore, to fully discuss these project additions in the CSR.

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

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

<u>Requirement CS-75.</u> If applicable, this section shall provide sufficient data and justifications to enable analysis of not only the science value of the concept, but also its viability and cost. This section shall also provide a cost estimate for performing any SEO activities. In completing the Cost section, the guidelines for Phases B through D apply. Complete a one page summary of costs using the format shown in Cost Table Template 7. Also, include the total amount in the SEO line item at the bottom of the table in Requirement CS-65 (Cost Table Template 3). Include a discussion of the estimating techniques used to develop the cost estimates.

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COST TABLE TEMPLATE 7
FUNDING PROFILE TEMPLATE FOR ANY SEO ACTIVITIES
(FY costs in Real Year Dollars, Totals in Real Year and FY 2022 Dollars)

Item	FY1	FY2	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	$	$	$	$	$

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L. APPENDICES

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

L.1 Letters of Commitment.

Requirement CS-76. This appendix shall include letters of commitment from (i) all organizations offering contributions of goods and/or services (including Co-I services, both U.S. and non-U.S.) 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 CSR regardless of source of funding, signed by officials authorized to commit the resources of the respective institutions or organizations. Critical participants are those participants 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. Personal letters of commitment signed by the individual shall be provided from (iii) every U.S. or non-U.S. Co-I. See AO Section 5.8.1 for detailed definitions of (i), (ii), and (iii). Note that participants may be members of multiple classes, in which case, provide letters of commitment covering all applicable classes. If the use of NASA-provided communication or navigation services is proposed, this appendix will include a letter of commitment.

Requirement CS-77. This appendix shall include letters of commitment from non-U.S. individuals and/or institutions that are team members or contributors to Explorer investigations. These letters of commitment shall provide evidence that the non-U.S. institution and/or government will commit the appropriate technical, personnel, and funding resources to the proposed investigation if selected by NASA. Such commitments shall be submitted no later than the site visit.

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

Letters of commitment provided for 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

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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 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-78. 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-79. This appendix shall include resumes or curriculum vitae for the PI and all Co-Is identified in the Science section, and for any Key Management Team Members identified in the Management section. The resumes shall clearly indicate experience related to the job the individual will perform on the proposed investigation. Any project management experience that the PI or PM have shall be described in their resumes. Resumes or curriculum vitae shall be no longer than three pages for the PI and one page for each additional participant. Photographs shall not be included in any of the resumes.

L.4 Phase B Contract Implementation Data.

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

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Requirement CS-80. 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 1-7 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-81. 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-82. 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-83. 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-84. Draft language for the technical content of any International Agreement(s) is required for all non-U.S. partners in the investigation. Sample agreements are available in the Program Library. The draft language must include (i) a brief summary of the mission and the foreign partner's role in it; (ii) a list of NASA's responsibilities within the partnership; and (iii) a list of the non-U.S. partner's responsibilities within the partnership. Note that NASA prefers to establish agreements with foreign Government funding agencies, and not with the institution that will be funded to perform the work.

L.8 International Participation Plans - Discussion of Compliance with U.S. Export Laws and

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Regulations (Update from Proposal).

Requirement CS-85. If the investigation includes international participation, either through involvement of non-U.S. nationals and/or involvement of non-U.S. entities, this appendix shall describe any updates to plans for compliance with U.S. export laws and regulations, *e.g.,* 22 CFR 120-130, *et seq*. and 15 CFR 730-774, *et seq*., provided in the Step 1 proposal (see Section J.5 of Appendix B in the AO or the SALMON-3 AO). The discussion shall describe in detail the proposed international participation and shall include, but not be limited to, whether or not the international participation may require the proposer to obtain the prior approval of the Department of State or the Department of Commerce *via* a technical assistance agreement or an export license or whether a license exemption/exception may apply. If prior approvals via licenses are necessary, discuss whether the license has been applied for or, if not, the projected timing of the application and any implications for the schedule. Information regarding U.S. export regulations is available at https://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 AO or the PEA, are generally considered "Defense Articles" on the United States Munitions List and subject to the provisions of the International Traffic in Arms Regulations (ITAR), 22 CFR 120-130, *et seq*.

L.9 Draft Mission Assurance Implementation Plan (MAIP) and Mission Assurance Requirements (MAR) Compliance Matrix

Requirement CS-86. A draft Mission Assurance Implementation Plan (MAIP) and Mission Assurance Requirements (MAR) Compliance Matrix shall be provided. See section 1.1 of the MAR provided in the Program Library.

L.10 Draft Mission Definition Requirements Agreement.

Requirement CS-87. A draft Mission Definition Requirements Agreement (MDRA) shall be provided. MDRAs define mission Level 2 requirements for the baseline mission, encompassing the programmatic, science and instrument, mission implementation and spacecraft, and ground data requirements. MDRA examples are provided in the Program Library.

L.11 End-of-Mission Plan.

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

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

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

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

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

Requirement CS-88. When required, this section shall include a discussion of how end-of-mission requirements will be met.

L.12 Compliance with Procurement Regulations by NASA PI Proposals.

This appendix is required only for CSRs submitted by NASA PIs or NASA Centers (excluding JPL). CSRs submitted by NASA Centers must comply with regulations governing proposals submitted by NASA PIs (NFS 1872.306).

Requirement CS-89. For NASA Center CSRs, this section shall include any descriptions, justifications, representations, indications, statements, and/or explanations that are required by the regulations.

L.13 Master Equipment List.

Requirement CS-90. This appendix shall include a Master Equipment List (MEL) summarizing all flight element subsystem components and individual instrument element components to support validation of proposed mass and power estimates – including contingencies, design heritage, and cost. A template for this MEL is included as Table B5 of the MIDEX AO, Table B4 of the SALMON-3 AO, 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

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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-91. The MEL shall be additionally provided in Microsoft Excel format on the CDs or DVDs.

L.14 Heritage.

Requirement CS-92. This section shall discuss each element of any heritage from which the proposed investigation derives substantial benefit, including heritage from spacecraft subsystems, instruments, ground systems, flight and ground software, test set ups, simulations, analyses, etc. This discussion shall be at an appropriate level of granularity (*e.g.,* component, assembly, subsystem) to clearly separate the heritage element from other elements of the design. The discussion of each element shall include:

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

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

Requirement CS-93. 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.14a Classified Materials.

Requirement CS-94. CSRs submitted in response to the AO or the PEA, as well as the proposed investigations and all proposed technologies, shall be unclassified. The CSR shall be

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complete including an unclassified appendix regarding heritage (see the previous section for further details).

In order to increase the capabilities of investigations proposed in response to the AO or the PEA while minimizing the development and operations risks within the PI-Managed Mission Cost, proposers may choose to leverage technology that was developed by other institutions and agencies as well as technology developed by NASA and NASA-funded partners. It is recognized that some technology relevant to proposed missions may have classified heritage.

CSRs that propose the use of hardware with classified heritage may provide a classified CSR appendix to NASA to allow validation of classified heritage claims. The classified appendix regarding heritage may include Letters of Validation for classified heritage claims from technology development sponsors. The proposer is responsible for determining what information is classified and what information is unclassified; any classified information provided to NASA must be handled appropriately.

When a proposer submits a classified appendix regarding heritage in addition to a complete CSR, the requirements on content, format, and length are the same as, but independent from, those for the unclassified appendix regarding heritage included in the CSR (see the previous section for further details) with the exceptions that Letters of Validation and cost bases of estimate may be included in the classified appendix regarding heritage.

The entire CSR including the unclassified appendix regarding heritage will be read and evaluated by the entire evaluation review panel. The evaluation review panel will not have access to the classified appendix regarding heritage. Proposers are strongly encouraged to provide as much information and detail as possible on their technology heritage in the unclassified appendix regarding heritage.

The evaluation processes for a submitted classified appendix will be supplemented. At least one reviewer with appropriate clearance and relevant expertise will review the classified appendix regarding heritage; this reviewer may be a member of the review panel or this reviewer may be a specialist reviewer. All findings generated during the review of the classified appendix regarding heritage will be unclassified, and these findings will be provided to the technical/management/cost review panel as input for assessing the technical, management, and cost (TMC) feasibility of the proposed approach for mission implementation. No clarifications or site visit presentations will be requested concerning findings from evaluation of the classified appendix regarding heritage.

NASA allows three options for proposers to support heritage claims from classified programs: 1) delivery to NASA of a classified appendix regarding heritage, 2) “delivery in place” of a classified appendix regarding heritage, and subject to possible restriction 3) sponsor verification of the heritage claims derived from classified programs. Each option is explained in Sections 5.8.4.1 through 5.8.4.3 of the AO and 5.8.2.1 through 5.8.2.3 of the PEA.

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L.15 Small Business Subcontracting Plan.

Requirement CS-95. 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 AO or Appendix A, Section XII of the SALMON-3 AO 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.16 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 on each submitted CD/DVD, if accompanied by discussion in this appendix.

L.17 Science Change Matrix.

Requirement CS-96. If the Phase A effort results in changes from any science objective proposed in Step 1, this appendix shall provide the original objective, the new or revised objective, rationale for the change, and the section/paragraph in the CSR where the change occurs.

L.18 Communications Design Data.

Requirement CS-97. Provide data and detailed link analyses for all communication modes, adequate to assess the design of the communications concept. This shall include a communications block diagram (showing all components) and link budget design control tables for all radio communications links (data and carrier) showing relevant spacecraft and earth station parameters and assumptions for the highest data rate and the emergency link at the maximum distance and throughput at which each particular link could be used. In particular the following parameters shall be provided: transmitter power, transmitter Antenna Gain, Transmitter Off-Boresight Pointing Loss, Transmitter Circuit Loss, Carrier Frequency, Transmitter-Receiver Range, Receiver Antenna Gain, Receiver Off-Boresight Pointing Loss, Receiver Circuit Loss, Receiver Bandwidth, Receiver System Temperature, Hot Body Noise Temperature, Data Modulation Index, Ranging Modulation Index, Data Rate, Forward Error Correcting Code including code rate, block size (if applicable), constraint length (if applicable), Carrier Modulation Index, Carrier Link Margin, and Data Link Margin. For more information on these requirements, including table format, see *NASA's Mission Operations and Communication Services,* in the Program Library.

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L.19 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.

NASA has issued a standards document, "*Space System Protection Standard*," NASA-STD-1006, establishing protection requirements to ensure NASA missions are resilient to purposeful threats, which can be found in the Program Library. This standard applies to all NASA projects, although some requirements can be tailored. Preliminary plans to comply with these requirements should be included in the CSR. Down-selected projects must develop a final plan early in Phase B. The evaluation panel will provide comments to the Selection Official on plans in the CSR to comply with the requirements of NASA-STD-1006.

CSR teams proposing to tailor any of the requirements in NASA-STD-1006 may contact the Enterprise Protection & Cybersecurity Lead for SMD, Ms. Betsy Edwards, (202) 358-2690, betsy.edwards@nasa.gov, to discuss the proposed adjustments.

Because these are new requirements, the additional costs associated with them are outside the AO and PEA Cost Cap.

Requirement CS-98. Describe plans, as applicable, to address the space system protection requirements specified in NASA-STD-1006, including any proposed tailoring.

L.20 Rideshare Accommodation Worksheet or ISS Technical Resource and Accommodation Feasibility

See Requirement CS-30 for instructions on the Rideshare Accommodation Worksheet or ISS Technical Interface and Resource Accommodation Feasibility.

L.21 Acronyms and Abbreviations List.

Requirement CS-99. This section shall provide a list of abbreviations and acronyms.

L.22 References List.

Requirement CS-100. 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 documents shall be included on the CD/DVD.

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

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password protected, provide the password in the CSR.

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 and Outreach Program (previously referred as Public Outreach) is required. Mission-related communications are funded directly through a NASA Center and are not within the PI-Managed Mission Cost. 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.

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