



## **2021 Astrophysics Explorers**

# **GUIDELINES AND CRITERIA FOR THE PHASE A CONCEPT STUDY**

~~Amended November 8, 2022~~  
**Amended November 23, 2022**

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## Change Log

### January 7, 2021

Initial release

### September 19, 2022

This release has numerous updates. In particular, note new Requirement CS-82 and Requirement CS-83 on cyber-security, and new requirements on conjunction analysis in Phase B (Part III).

### October 20, 2022

The page limit in “CSR Structures and Page Limits” table for Executive Summary raised to 6 pages to be consistent with Requirement CS-10

The due date in Requirement CS-5 amended to be seven days after the CSR submission date.

Requirement CS-12 amended to show the correct number of allowable pages in the Science Investigation section.

Requirement CS-21 amended to be optional for missions that remain within Earth orbit at or below Geosynchronous Orbit. When providing trajectory data, option is added for submission of a trajectory file(s) electronically.

Requirement CS-23 amended to include an additional bullet.

Requirement CS-31 for providing an electronic version of the schedule in a Microsoft Project format is applicable to the MOs as well and the MIDEXs.

Requirement CS-31 amended to de-conflict the required level of schedule detail in the Microsoft Project electronic file and the schedule foldouts page limitation in the *CSR Structure and Page Limits* table; and to clarify the language for providing critical path.

Amended the language in Appendix L.18 about additional Cyber Security costs. Requirements in NIST SP 800-53 were applicable per NPR 7120.5E.

Added a Point of Contact in Appendix L.18 for Cyber Security support.

**November 8, 2022**

Amended Requirement CS-3 to inform the CSR Teams of availability of the MS-Excel cost table templates in the Program Library.

Amended Requirement CS-20 for MIDEEXs to clarify required compatibility with Launch Services Program Information Summary document.

Amended Requirement CS-24 to include plans for interfaces to collision-avoidance teams.

Amended Requirement CS-75 to include provisions for EAR controlled material.

**November 23, 2022**

Typographical errors corrected in multiple locations, none affecting content.

Final version, approved by Astrophysics Division and SMD Deputy AA for Research

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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 2021 Astrophysics Explorers Announcement of Opportunity (NNH21ZDA018O, and NNH17ZDA004O, Program Element Appendix Q, hereafter, the “AO”) Step-1 competition, NASA has selected a number of 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*.

Documents available through the 2021 Astrophysics Explorers Program Library at <https://explorers.larc.nasa.gov/2021APMIDEX/MIDEX/programlibrary.html> and <https://explorers.larc.nasa.gov/2021APMIDEX/MO/programlibrary.html> for 2021 Astrophysics MIDEX and MO respectively are intended to provide guidance for selected investigations. This website is hereafter referred to as the Program Library. Note that new documents have been added to the Program Library for this Step-2 acquisition.

Concept studies are intended to provide NASA with more definitive information regarding the cost, risk, and feasibility of the investigations, as well as small business subcontracting plans, optional Student Collaborations (SCs), Science 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 Step-1 selection (see below). This document provides guidelines and requirements for preparing a CSR. All program constraints, guidelines, definitions, and requirements specified in the AO are applicable to the CSR, except as noted herein. Note that except for the Student Collaboration incentive, the Adjusted 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 AO Cost Cap or Adjusted AO Cost Cap.

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

<b>TOPIC</b>	<b>MIDEX Section Reference(s)</b>	<b>MO Section Reference(s)</b>	<b>Reference(s) for Phase A CSR</b>
Detailed disposal plan	5.2.7 MIDEX AO	5.3.13 SALMON-3	Section L.9
Science Enhancement Option or its cost	5.1.5 MIDEX AO	5.2.5 SALMON-3, 5.2.4 PEA-Q	Section K
Verification and Validation of Software	4.6.1 MIDEX AO	4.5.1 SALMON-3	Requirement CS-22, Requirement CS-29; Independent Validation and Verification is not required
Costing of Conjunction Assessment Risk Analysis	4.6.4 MIDEX AO	4.5.4 SALMON-3	Requirement CS-24 [Amended November 8, 2022]
Requirements for real year dollar costs	Requirements B-13, B-50, B-51 MIDEX AO	Requirement B-13, B-58, B-59, B-60 SALMON-3	Requirement CS-9, Requirement CS-51
Student Collaborations	5.5.3 MIDEX AO	5.6.2 SALMON-3, 5.5.2 PEA-Q	Section H
Description of the Space Systems Protection implementation	5.2.11 MIDEX AO	5.3.9 PEA-Q	Section L.17
Ground Systems and facilities	Requirements B-27, B-29, B-35, B-40, B-47, B-66 MIDEX AO	Requirements B-29, B-34, B-36, B-38, B-44, B-49, B-55 B-80 SALMON-3 AO	See Part I, Evaluation criteria for TMC feasibility

CSRs and all required files are due by 4 p.m. Eastern time on June 1, 2023, by the method specified in Requirement CS-6.

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

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 five months of Phase B. A modification will be negotiated during the Bridge Phase 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 the 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 Bridge Phase.

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

The CSR evaluation process will include visits by the evaluation team to each investigation team's chosen site, to hear oral briefings and, if needed, to receive updates and clarification of material in the CSRs. These briefings will be conducted no earlier than three months following submission of the CSRs. NASA may identify significant weaknesses, questions, and requests for information, and ask that the investigation team respond to these either prior to, during, or after the Site Visit. Any additional information provided to NASA by the investigation team will be considered during the evaluation and treated as updates and clarifications to the CSR.

Investigation teams are responsible for the content and quality of their CSRs, Site Visit presentations, and responses to weaknesses and questions, including parts that may be prepared by partner organizations or by any other individual. All assumptions and calculations should be carefully documented in the CSR and agreed to by the PI and 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.

As the outcome of Step 2, it is anticipated that the Selection Official, the Associate Administrator of the Science Mission Directorate (SMD) at NASA Headquarters or their designee, plans to continue one MIDEX and one or two MO investigations into the subsequent phases of mission development for flight and operation. The target date for this continuation decision (*i.e.*, "down-selection") is as stated in the AO: the first quarter of calendar 2024.

For those investigations that are not continued, the contracts will be allowed to terminate without further expense to NASA. Every investigation team will be offered a debriefing of the evaluation of its CSR.

## **PART I – EVALUATION CRITERIA**

The evaluation of CSRs is very similar to the evaluation of Step-1 proposals, as described in Section 7.1 of the MIDEX AO and SALMON-3 AO. The evaluation criteria and their factors, specified in Sections 7.2.1 through 7.2.4 of the AO and SALMON-3 AO plus 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 Student Collaborations and small business subcontracting, will also be evaluated. In case of conflict between the AO and the CSR Guidelines, the CSR Guidelines take precedence.

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

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

The evaluation criteria for the Step 2 evaluation are:

- 1) Scientific Merit of the Proposed Investigation;
- 2) Scientific Implementation Merit and Feasibility of the Proposed Investigation;
- 3) TMC Feasibility of the Proposed Mission Implementation;
- 4) Merit of the Student Collaboration and Small Business Subcontracting Plans.

### **Scientific Merit of the Proposed Investigation**

The 2021 Astrophysics Explorers Program Scientist will determine whether any issues that may have emerged in the course of the concept study have resulted in significant changes to the science objectives or other aspects of the proposed Baseline and Threshold Science Missions (see Requirement CS-13 in PART II of this document) in such a manner as to have impacted the basis for the evaluation of the scientific merit of the investigation as determined by the peer review panel for the Step-1 proposal. If there are no significant changes to the proposed investigation that undermine the basis of this rating, the peer review panel rating for scientific merit of the Step-1 proposal will be the rating for scientific merit of the CSR. If there are significant changes, the Program Scientist will convene a peer review panel to re-evaluate the scientific merit of the objectives in light of these changes. The factors for re-evaluating this criterion will be the same as those used for the Step-1 proposal review (Section 7.2.2 of the MIDEX AO or Section 7.1 of the PEA-Q to the SALMON-3 AO).

### **Scientific Implementation Merit and Feasibility of the Proposed Investigation**

All of the factors defined in Section 7.2.3 of the MIDEX AO, and in Section 7.2.3 of the SALMON-3 AO modified as in Section 7.1 of the PEA Q also apply to the evaluation of the CSR. Note that details have been added to one of the subfactors of Factor B-1, Merit of the instruments and mission design. An additional subfactor has also been added to Factor B-2, Probability of technical success. *New factors and details added to Step-1 AO factor definitions are highlighted using blue italicized text for the evaluation of the CSR.*

- 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; 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.*
- 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 evaluation. *For the MO investigations only: the scientific expertise of the PI will be evaluated but not his/her experience with space missions. Comments about the managerial experience of the PI, and whether appropriate mentoring and support tools are in place, will be made to the Selecting Official but these comments shall not impact the investigation's Scientific Implementation Merit rating.*
- Factor B-6. Scientific Implementation Merit and Feasibility of any Science Enhancement Options (SEOs), if proposed. This factor includes assessing the appropriateness of the selected activities to enlarge the science impact of the mission and the costing of the selected activities. Although evaluated by the same panel as the balance of Scientific Implementation Merit and Feasibility factors, this factor will not be considered in the overall criterion rating.

- Factor B-7. *Maturity of proposed Level 1 science requirements and Level 2 project requirements. This factor includes assessment of whether the Level 1 science requirements are mature enough to guide the achievement of the objectives of the Baseline Mission and the Threshold Mission, and whether the Level 2 requirements are consistent with the Level 1 requirements. The Levels 1 and 2 requirements will be evaluated for whether they are stated in unambiguous, objective, quantifiable, and verifiable terms that do not conflict and for whether they are traceable to the science objectives. They will be evaluated for the adequacy, sufficiency, and completeness, including their utility for evaluating the capability of the instruments and other systems to achieve the mission objectives. The stability of the Level 1 science requirements and Level 2 project requirements will be assessed including whether the requirements are ready, upon initiation of Phase B, to be placed under configuration control with little or no expected modifications for the lifecycle of the mission.*

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 selection.

### **TMC Feasibility of the Proposed Mission Implementation**

All of the factors defined in Section 7.2.4 of the MIDEX AO, or the SALMON-3 AO modified by 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. *New factors and details added to Step-1 AO factor definitions are highlighted using blue italicized text for the evaluation of the CSR.*

Note that the risk management aspects of the Step-1 Factor C-4, Adequacy and robustness of the management approach and schedule, including the capability of the management team, have been removed from Factor C-4 and included in a new evaluation Factor C-6, Adequacy of the risk management plan. The text that is deleted from Step-1 AO Factor C-4 is indicated by the strike-through and is the basis for Factor C-6.

- Factor C-1. Adequacy and robustness of the instrument implementation plan. The maturity and technical readiness of the instrument complement will be assessed, as will the ability of the instruments to meet mission requirements. This factor includes an assessment of the instrument design, accommodation, interface, heritage, and technology readiness. This factor includes an assessment of the instrument hardware and software designs, heritage, and margins. This factor includes an assessment of the proposer’s understanding of the processes, products, and activities required to accomplish development and integration of the instrument complement. This factor also includes adequacy of the plans for instrument systems engineering and for dealing with environmental concerns. This factor includes an assessment of plans for the development and use of new instrument technology, plans for advanced engineering developments, and the adequacy of backup plans to mature systems within the proposed cost and schedule when systems having a TRL less than 6 are proposed.
- 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 and navigation/tracking/trajectory analysis), and the plans for launch services. This factor includes mission resiliency – the flexibility to recover from problems during both development and operations – including the technical resource reserves and margins, system and subsystem redundancy, and reductions and other changes that can be implemented without impact to the Baseline Science Mission.

- Factor C-3. Adequacy and robustness of the flight systems. This factor includes an assessment of the flight hardware and software designs, heritage, and margins. This factor includes an assessment of the proposer’s understanding of the processes, products, and activities required to accomplish development and integration of all elements (flight systems, ground and data systems, etc.). This factor includes an assessment of the adequacy of the plans for spacecraft systems engineering, qualification, verification, mission assurance, launch operations, and entry/descent/landing. This factor includes the plans for the development and use of new technology, plans for advanced engineering developments, and the adequacy of backup plans to ensure success of the mission when systems having a TRL less than 6 are proposed. The maturity and technical readiness of the spacecraft, subsystems, and operations systems will be assessed. The adequacy of the plan to mature systems within the proposed cost and schedule, the robustness of those plans, including recognition of risks and mitigation plans for retiring those risks, and the likelihood of success in developing any new technologies will be assessed.
- Factor C-4. Adequacy and robustness of the management approach and schedule, including the capability of the management team. This factor includes: the adequacy of the proposed organizational structure and WBS; the management approach including project level systems engineering; the roles, qualifications, and experience of the PI, PM, PSE, other named Key Management Team members, and implementing organization, mission management team, and known partners; the commitment, spaceflight experience, and relevant performance of the PI, PM, PSE, other named Key Management Team members, and implementing organization, mission management team, and known partners against the needs of the investigation; the prior working relationship of the implementing organization and known partners; the commitments of partners and contributors; and the team’s understanding of the scope of work covering all elements of the mission, including contributions. ~~Also evaluated under this factor is the adequacy of the proposed risk management approach, including any risk mitigation plans for new technologies, any long lead items, and the adequacy and availability of any required manufacturing, test, or other facilities. The approach to any proposed descoping of mission capabilities will be assessed against the potential science impact to the proposed Baseline Science Mission. The plans for managing the risk of contributed critical goods and services will be assessed, including the plans for any international participation, the commitment of partners and contributors, as documented in Letters of Commitment, and the technical adequacy of contingency plans, where they exist, for coping with the failure of a proposed cooperative arrangement or contribution.~~ This factor also includes assessment of elements such as the relationship of the work to the project schedule, the project element interdependencies, the associated schedule margins, and an assessment of the likelihood of meeting the proposed launch readiness date. Also evaluated under this factor are the proposed project and schedule management tools to be used on the

project, *along with the effect of the small business subcontracting plan including small, disadvantaged businesses.*

For the MO investigations, which are Class D, the capability of the management team will be evaluated as a whole, as opposed to assessing the capabilities of each of the Key Management Team members independently. The panel evaluating the “Technical, Management, and Cost Feasibility” will provide comments to the Selection Official about the mission experience of the PI and whether appropriate mentoring and support tools are in place.

- Factor C-5. Adequacy and robustness of the cost plan, including cost feasibility and cost risk. This factor includes elements such as cost, cost risk, cost realism, and cost completeness including assessment of the basis of estimate, the adequacy of the approach, the methods and rationale used to develop the estimated cost, *the methods and rationale used to develop the estimated cost*, the discussion of cost risks, the allocation of cost reserves by phase, and the team’s understanding of the scope of work (covering all elements of the mission, including contributions). The adequacy of the cost reserves 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. *Also evaluated under this factor are the proposed cost management tools to be used on the project.*
- 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 approach to any proposed descoping of mission capabilities will be assessed against the potential science impact to the proposed Baseline Science Mission. The plans for managing the risk of contributed critical goods and services will be assessed, including the plans for any international participation, the commitment of partners and contributors, as documented in Letters of Commitment, and the technical adequacy of contingency plans, where they exist, for coping with the failure of a proposed cooperative arrangement or contribution; *when no mitigation is possible, this should be explicitly acknowledged. The stability and reliability of proposed partners, and the appropriateness of any proposed contribution, is not assessed as a management risk but will be assessed by SMD as a programmatic risk element of the investigation.*
- Factor C-7. *Ground systems. This factor includes an assessment, including heritage and planned new development, of the proposed operations facilities, hardware, and software (i.e., those for mission operations and science operations), and a telecommunications analysis, ground network capability and utilization plan, and navigation plans.*
- Factor C-8. *Approach and feasibility for completing Phase B. The completeness of Phase B plans and the adequacy of the Phase B approach will be assessed. This assessment will include evaluation of the activities/products, the organizations responsible for those activities/products, and the schedule to accomplish the activities/products.*

Requirement 56 of the MIDEX AO and Requirement 71 of the SALMON-3 specify that the Concept Study Report shall demonstrate that the proposed SC is clearly separable from the proposed Baseline and Threshold Science Missions; will not increase the mission development risk; and will not impact the science investigation in the event that the SC is not funded, fails during flight operations, or encounters technical, schedule, or cost problems during development. Details of the SEO(s) and SCs evaluations are given in Section E.7 and H respectively.

### **Merit of the Student Collaboration and Small Business Subcontracting Plans**

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

There is no minimum and no maximum allowable cost for a SC. NASA is providing a SC option that is defined to be 1% of the PIMMC. The proposed cost of the SC, up to the SC incentive, is considered outside of the PIMMC. If the SC costs NASA more than the SC incentive, then the balance of the NASA cost of the SC must be within the PIMMC. SC incentive, as an addition to the mission's implementation, is not available to solve mission cost overrun issues. The SC provides no cost savings to a NASA investigation.

Merit of the Student Collaboration, if proposed. This factor will include an assessment of whether the scope of the SC follows the guidelines in Section 5.5.3 of the MIDEX AO or Section 5.6.2 of the SALMON-3 AO. The criteria to be used to evaluate the SC component and a discussion of those criteria are found in those AO sections and follow Science Policy Document SPD-31 available in the Program Library.

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 relative significance of each evaluation criterion in the Selection Official's consideration:

- Scientific merit of the proposed investigation: approximately 20%;
- Scientific implementation merit and feasibility of the proposed investigation: approximately 40%;
- TMC feasibility of the proposed mission implementation: approximately 40%.

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

### **Additional Selection Factors**

At the continuation decision (*i.e.*, the final down-selection), it may be necessary for the Selection Official to consider NASA budget changes and/or other programmatic factors, including but not

limited to changes in scientific mandates, national priorities, and budgetary forecasts that were not evident when the AO was issued. The PIMMC, as well as other programmatic factors, may be additional selection factors.

## **PART II – CSR OUTLINE AND REQUIREMENTS**

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. *New requirements and details added to Step-1 requirements are highlighted using blue italicized text for the evaluation of the CSR.*

The following replaces Requirement B-1 of the MIDEX AO or B-1 of the SALMON-3 AO. Requirement CS-1. *The CSR shall be written in English and shall employ metric (SI) and/or standard astronomical units, as applicable. It shall contain all data and other information that will be necessary for scientific and technical evaluations; provision by reference to external sources, such as Internet websites, of additional material that is required for evaluation of the CSR is prohibited.*

The following replaces Requirement B-4 of the MIDEX AO or B-4 of SALMON-3 AO. Requirement CS-2. *CSRs shall conform to the page limits specified in the CSR Structure and Page Limits table. A page quota higher than that in the Step-1 proposal has been allotted to accommodate an expected greater maturity of detail. Two extra pages each are allotted for each additional separate, non-identical science instrument in the Science Section (Section E); two extra pages are allotted for each additional separate, non-identical flight element (e.g., additional spacecraft are allotted two extra pages, but only non-identical spacecraft) in the Mission Implementation and Management Sections (Sections F and G); no extra pages are allotted where only a single instrument and a single flight element is proposed, or where all instruments and all flight elements are identical. Different instruments on otherwise identical spacecraft will be allotted extra pages only for additional non-identical science instruments; no extra pages will be allotted for the resulting additional non-identical flight elements. The total number of such extra pages in Sections E through I shall not exceed a maximum of 10 extra pages regardless of the number of science instruments and flight elements. Six extra pages are allotted for all science enhancement options (SEOs), in the Science Implementation Section (Section E.7); and six extra pages are allotted for the SC if one is proposed (Section H). Pages allocated for the proposed SC or SEOs shall not be used for any other purpose; otherwise, where extra pages are allotted in a given section, all pages may be used within that section as the Study Team chooses. Every page upon which printing appears will count against the page limits and, unless specifically exempted (e.g., Requirement CS-30 and Requirement CS-51), each foldout page will count as two pages against the page limits as appropriate for its area (e.g., a fold-out with the total area of two standard pages count as two pages, etc.).*

<b>CSR Structure and Page Limits</b>	
<b>Section</b>	<b>Page Limits</b>
A. Cover Page and Summary Information	No page limit, but be brief
B. Fact Sheet and Executive Summary	2 pages for Fact Sheet and 6 <b>[Amended October 20, 2022]</b> 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 proposed) F. Mission Implementation G. Management H. Other Factors to be Evaluated, including SC and SBC I. Preliminary Design and Technology Completion (Phase B) Plan	110 pages for full missions <b>or</b> 84 pages for missions of opportunity; plus 2 pages for each additional, separate, nonidentical instrument or flight element *; plus 6 pages to cover all SEO activities if proposed **; plus 6 pages for SC if proposed **. (3 Schedule Foldouts do not count against limit)
J. Cost Proposal K. Justification and Cost Proposal for optional SEO, if applicable	No page limit, but data must be presented in formats described; be brief
L. Appendices (no other appendices permitted) L.1 Letters of Commitment L.2 Relevant Experience and Past Performance L.3 Resumes L.4 Phase B Contract Implementation Data L.5 Data Management and Archiving Plan L.6 Any Incentive Plan(s) L.7 Technical Content of Any International Agreements L.8 International Participation Plans L.9 End of Mission Plan L.10 Compliance with Procurement Regulations by NASA PI Proposals L.11 Master Equipment List L.12 Heritage L.13 Classified Materials*** L.14 Additional Cost Data to Assist Validation L.15 Science Change Matrix L.16 Communications Design Data L.17 Space Systems Protection L.18 Cyber Security L.19 Draft Mission Definition Requirements Agreement L.20 Draft MAIP and MAR Compliance Matrix	No page limit, but brevity is encouraged.

L.21 Rideshare Accommodations Worksheet or ISS Technical Interface and Resources Feasibility L.22 Justification for the use of non-AMMOS MOS/GDS L.23 Trajectory Data L.24 Acronyms and Abbreviations L.25 References and Management Standards List	
<p>* Total extra pages is limited to 10 as described in Requirement CS-2 regardless of the number of science instruments and flight elements; extra pages may be distributed between Sections E through I as desired.</p> <p>** Pages allocated for the proposed SCs or SEOs shall not be used for any other purpose.</p> <p>*** Submitted separately</p>	

The following replaces Requirement B-5 of the MIDEX AO or B-5 of SALMON-3 AO. Requirement CS-3. Electronic *CSRs* shall be unlocked, bookmarked, searchable Adobe Portable Document Format (PDF) files, composed of the main *CSR*, all tables, and all applicable *CSR* appendices (see *Section L*). *A CSR shall consist of no more than two volumes divided into readily identifiable sections. Each file should be no larger than 60MB for ease of display and navigation. If two volumes are submitted, the first should correspond and conform to Sections A through L of PART II of this document; and a second volume should contain the cost proposal (Section J) and any cost appendices (e.g. L.4, L.14).* Images (e.g., figures and scans) shall be converted into machine-encoded text using optical character recognition). Audio, video, *or embedded animations* shall not be included. Links to other parts of the *CSR* are permitted, but links to materials outside of the *CSR* are not. *Materials identified as subject to U.S. export laws and regulations, marked in accordance with Section 5.8.3 of the MIDEX AO or Section 5.9.3 of the SALMON-3 AO, shall be redacted into separate versions of files that are collected in a Redacted folder. In addition to the PDF submission, the electronic files listed below shall be provided as part of the electronic submission.*

- *Final list of CSR participants in MS-Excel format (Requirement CS-4)*
- *Table of all CSR requirements in PDF format Requirement CS-5)*
- *Schedule in MS-Project format (Requirement CS-30)*
- *MEL in MS-Excel format (Section L.11)*
- *Program and Project Management Standards (Requirement CS-88)*
- *All cost Tables in MS-Excel format (See Section J of this document); **MS-Excel table templates file is available in the Program Library. [Amended November 8, 2022]***
- *Additional cost data to assist validation (See Section L.14 of this document)*

Requirement CS-4. *Provide a list of the individuals who have participated in the concept study (e.g., individuals who worked on the CSR, any CSR contributor, Red Team member, reviewer, etc.) and/or whom you are proposing to provide work should the mission be down-selected. Additionally, provide a list of all organizations named in the CSR, or providing developmental or research services, including the lead organization, subcontractors, vendors and contributing organizations who have an interest in the mission. Provide a draft list of the participants as a Microsoft Excel spreadsheet document to the Point of Contact (POC, AO*

*Section 6.1.5 or PEA Section 9) three months prior to the due date of the CSR. Use the Microsoft Excel spreadsheet template that has been posted to the Program Library. This list is to be updated and a final revision shall be included in a separate electronic file with the CSR submission.*

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

Requirement CS-5. *Create a separate document that contains a table with all of the requirements (Requirement CS-1 through Requirement CS-88) and the page, section, or table number that is the main place in the CSR where the requirement is addressed. This document shall be submitted no later than seven calendar days after the CSRs are due. ~~Provide this table as a PDF document along with the CSR submission.~~ [Amended October 20, 2022]*

Requirement CS-6. *The CSR and all required files shall be submitted electronically by the deadline specified in the Introduction section, via the NASA Box service, which is Federal Information Processing Standards (FIPS) 140-2 certified for Data-in-Transit (DIT) and Data-at-Rest (DAR). To submit CSRs through Box, investigation teams must provide an email list of no more than three (3) individuals requiring access to Box to submit files. This email list must be provided to the POC no less than seven calendar days before the CSRs are due. Individuals on the list will then receive an emailed invitation with a secure link to Box from NASA. Investigation teams are encouraged to submit a test file using the secure link to Box to ensure functionality prior to CSR submittal.*

CSRs written in their entirety by non-government institutions are not mandated to follow CUI marking instructions. However, CSRs that are written fully or partially by government institutions are required to include CUI markings. For those CSRs, it is mandatory to include a banner marking at the top of each page that contains CUI, to alert the reader. For example, pages with export-controlled information would get a “CUI//SP-EXPT” banner. Though not required except for NASA Export Controlled information, portion marking is a highly encouraged and can be accomplished by including a red bordered box, as shown in the document\_CUI\_Portion\_Marking\_Sample.pdf in the Program Library. Portion marking can also be done according to NASA CUI Handbook, page 11 ([https://cset.nasa.gov/wp-content/uploads/2021/05/ITS-HBK-CUI\\_v1.0.0.pdf](https://cset.nasa.gov/wp-content/uploads/2021/05/ITS-HBK-CUI_v1.0.0.pdf)).

The required uniform format and contents are summarized below. Failure to follow this outline may impede the evaluation process.

## **A. COVER PAGE AND SUMMARY INFORMATION**

The following replaces Requirement B-7 of the MIDEX AO or B-7 of SALMON-3 AO.

Requirement CS-7. 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.

The following replaces Requirement B-12 of the MIDEX AO or B-8 of SALMON-3 AO. Requirement CS-8. The Graphic Cover Page shall contain, at a minimum, the following information and elements displayed on the cover page of the *CSR*:

- The investigation title;
- The name of the proposing organization;
- The name of the PI;
- The name and title of an official who is authorized to commit the proposing organization through the submission of the *CSR*.

The following Summary Information shall be included in this Section:

- *Names and institutions of all participants in the investigation;*
- *The Enhanced PI-Managed Mission Cost of the investigation (\$FY22);*
- *The proposed contributions and contributing organizations, and*
- *A summary of the investigation, not to exceed 300 words.*

Per Requirement 86 in Section 5.8.3 of the MIDEX AO and Requirement 99 in Section 5.9.3 of 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 Proposal Summary Information):

“The information (data) contained in [insert page numbers or other identification] of this *CSR* 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.”

Proposers should be aware that the evaluators of Scientific Implementation Merit and Feasibility (Criterion B) will review a version of the *CSR* in which any export-controlled material has been redacted.

## **B. FACT SHEET AND EXECUTIVE SUMMARY**

This following replaces Requirement B-13 of the MIDEX AO or B-13 of SALMON-3 AO. Requirement CS-9. 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 PIMMC *in Real Year dollars (RYS) 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 RYS and in FY22\$ from Cost Table Template 2.*

Requirement CS-10. *The Executive Summary shall summarize the contents of the CSR and shall include an overview of the proposed baseline investigation, including its scientific objectives, technical approach, management plan, cost estimate, and SC, and small business subcontracting plans. The Executive Summary shall not exceed 6 pages in length.*

### **C. CSR TABLE OF CONTENTS**

The following replaces Requirement B-14 of the MIDEX AO or B-14 of the SALMON-3 AO. Requirement CS-11. Every CSR shall contain a table of contents that conforms to the outlines provided in Sections D through L, below. *A separate index of figures and tables shall also be included.*

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

### **D. SCIENCE INVESTIGATION**

Requirement CS-12. *The Science Investigation 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 of SALMON-3 AO. 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.15 of the CSR. The Science Investigation section shall not exceed 34 [Amended October 20, 2022] pages in length.*

Requirement CS-13. *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.15 of this document). Corrections (e.g., typos and errors) and nominal updates (e.g., revised references, clarified sentences) to this section, that do not constitute a change to the proposed science mission (i.e., no change to science mission objectives, requirements, implementation details, measurements, and data, etc.) are not required to be individually identified and tracked; however, a summary of such changes shall be provided.*

### **E. SCIENCE IMPLEMENTATION (including SEOs if any)**

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

The Level 1 science requirements define the science that must be completed to achieve the mission’s Science Objectives. The Level 1 requirements lead to the mission, science, and programmatic requirements as well as constraints imposed on the project. Consistent with NPR

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

The Level 1 requirements (referred to as program level requirements in NPR 7120.5E) and Level 2 project requirements specify requirements and constraints on science data collection, mission and spacecraft performance, prime mission lifetime, budget, schedule, launch vehicle, and any other requirements or constraints that need to be controlled. The Level 2 requirements flow down from the Level 1 requirements: for example, Level 2 requirements must describe the data products that would be needed to complete the Level 1 science requirements. 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 key element of risk management is the definition of mission success criteria. Mission success criteria are based on the threshold science mission; they should be the first level of flow-down of requirements from the overall mission science objectives. The mission science objectives are the “need” for the mission and the mission success criteria represent how you know you have met that “need”. Level 1 requirements then would flow down from the mission success criteria. Level 1 requirements would be robust enough (*i.e.*, have sufficient margin) to ensure the system’s detail design could be manufactured, built, and tested to achieve the mission success. In a perfect world, mission success criteria would be written before Level 1 requirements. However, this is not a requirement for the CSR, as mission success criteria are negotiated with NASA. To the extent that they are known at the end of Phase A, identify the draft mission success criteria in the CSR.

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

Requirement CS-14. *CSRs shall provide a set of proposed Level 1 science requirements that will achieve the science objectives of the Mission. Both Baseline Science Requirements and Threshold Science Requirements shall be identified. The Level 1 science requirements shall be clearly traceable to the science objectives. To the extent that they are known, identify the draft mission success criteria based on the threshold science requirements. CSRs shall provide Level 2 project requirements to guide the design and development of the mission. Lower-level requirements shall be provided to the extent that they are known and necessary to explain and justify the design concept including instrument capability, instrument performance, and other aspects of the system architecture that enable the accomplishment of the mission science objectives. State each requirement in unambiguous, objective, quantifiable, and verifiable terms. Requirements shall not conflict with each other. The Level 2 requirements shall be listed in Appendix L.19, Draft Mission Definition Requirements Agreement (MDRA).*

## E.2 Science Mission Profile

The following replaces Requirement B-22 of the MIDEX AO or B-22 of SALMON-3 AO. Requirement CS-15. This section shall discuss the science observing profile, including all mission-relevant parameters, such as orbit, navigation accuracy, operational timelines (including observing periods, data transmission periods and techniques, and time-critical events), etc. *The science observation strategy shall also be described in sufficient detail to understand the complexity of science operations, i.e., are the operations regular re-iteration of data collection sequences, thereby establishing a routine flow, or are there numerous, uniquely planned events thereby requiring repeated planning, testing, and upload cycles. The observation planning and decision-making processes shall be outlined including any priorities assigned to specific observations or measurements and any plans to update the observing strategy based on early observations. The schedule and workforce associated with science planning shall also be described. If science operations involve an ebb and flow of personnel to reduce costs during cruise or “quiet” phases, describe plans for maintaining sufficient trained personnel and for how they will be moved off and then back on the project.* The manner in which the proposed investigation objectives, selected instruments, and measurement requirements drive the proposed mission design and operations plan shall be included in this discussion.

## E.3 Instrumentation

Note the requirements in the Appendix B, Section E.1 of the MIDEX AO or SALMON-3 AO.

## E.4 Data Sufficiency

The following replaces Requirement B-21 of the MIDEX AO or B-21 of the SALMON-3 AO. Requirement CS-16. 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.nasa.gov>, and SBU Conversion Factors may be found at <https://hec.nasa.gov/user/policies/sbus.html>. Costs associated with HEC utilization will not count against the PIMMC.*

## E.5 Data Plan

As a Federal agency, NASA requires prompt public disclosure of the results of its sponsored research to generate knowledge that benefits the Nation. Thus, it is NASA’s intent that all knowledge developed under awards resulting from this solicitation be shared broadly.

The following replaces Requirements B-23 and B-24 of the MIDEX AO or Requirements Q-1 and Q-2 of the PEA.

Requirement CS-17. A *schedule-based end-to-end* Data Management and Archiving Plan, including approaches for the release of peer-reviewed publications, the release of the science data that underlie the results and findings in peer-reviewed publications, and the archiving of all

science products shall be described. *The schedule-based plan itself shall be provided in Appendix L.5 (see Requirement CS-72). The plan shall:*

- Include approaches for data retrieval, validation, preliminary analysis, image processing, calibration, correction, and archiving;
- Identify science products (e.g., flight data, ancillary or calibration data, theoretical calculations, higher order analytical or data products, laboratory data, etc.), including a list of the specific data products, and the individual team members responsible for the data products;
- Identify the appropriate NASA data archive and the formats and standards to be used. *Mission data must be made available through one of the following: 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 – including* the data latency by product – for submission of raw and reduced data, to the data archive, in physical units accessible to the science community, *as well as required calibration information;*
- *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

The following replaces Requirement B-25 of the MIDEX AO or B-24 of the SALMON-3 AO. Requirement CS-18. This section shall identify each member of the science team 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 science team member* shall be explicitly defined, the necessity of that role shall be justified, and the funding source (NASA or contributed) *for each science team member* shall be noted. *A summary table shall be included, with columns for 1) science team member name; 2) their roles and responsibilities on the mission; and 3) their time commitment, in FTEs or WYEs, for each mission Phase, A through F (as specified in Requirement CS-59 to Requirement CS-62).*

#### E.7 Plan for SEO

Note the requirements in Section 5.1.5 of the MIDEX AO or the requirements in Section 5.2.4 of the PEA.

### F. MISSION IMPLEMENTATION

#### F.1 General Requirements and Mission Traceability

Note the Requirement(s) in the Appendix B, Section F.1 of the MIDEX AO or SALMON-3 AO.

#### F.2 Mission Concept Descriptions

The following replaces Requirement B-30 of the MIDEX AO or B-39 of the SALMON-3 AO.

Requirement CS-19. Mission Design: This section shall address the following elements of the mission design to the extent that they are applicable to the proposed mission and that they are known. Any additional elements that are applicable to explaining the mission and demonstrating its feasibility shall also be addressed.

- Launch readiness 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), and/or trajectory design *and trajectory parameters for ballistic and low-thrust trajectories to permit independent validation*, as applicable to the proposed investigation;
- Critical events, *which includes LV separation real-time telemetry*;
- *Telecomm link summary for all communication modes (based on requirements identified in Appendix L.16, Communications Design Data)*;
- Ground station(s) usage (e.g., location(s), and transmitting and receiving communication parameters); and
- *Space system's fault management approach and design.*

The following replaces Requirement B-31 of the MIDEX AO or B-40 of SALMON-3 AO.

Requirement CS-20. Launch Services and Launch Vehicle Compatibility:

- *For MIDEX missions*, compatibility with the proposed launch vehicle shall be demonstrated by providing in the appropriate *CSR* section the launch site; fairing size; spacecraft mass; *launch mass margin*; and mission orbit characteristics such as altitude (km – circular or apogee/perigee), inclination, C3, heliocentric and/or declination (DLA). Any known non-standard requirements such as additional fairing doors, cleanliness and purge requirements, planetary protection, etc., shall be described. ***For the packaged flight system, the CSR shall include compliance to a selected MIDEX scenario in the Launch Services Information Summary (LSIS). The CSR shall describe the constraining fairing dimensions, critical clearance to the fairing dimensions, compatibility with the enveloping design launch loads and structural margins. [Amended November 8, 2022] Phase A concept study teams are to use the Launch Vehicle performance classes described in Section 5.9.2 of the AO and in the Program Library, and should work with Mr. Shaun Daly, 321-867-8400, shaun.daly@nasa.gov, for Launch Services Program support.***
- *For proposals proposing to use PEA-provided rideshare launch services, this section shall demonstrate compatibility with the Astro MO ESPA Rideshare Users Guide dated October 1, 2021 in the Program Library. A Phase A Rideshare Accommodation Worksheet template for Secondary Payloads is provided in the Program Library. The Rideshare Accommodation Worksheet shall be delivered as Appendix L.21 on the CSR due date. As stated in the PEA, a proposed rideshare investigation with a high probability of being compatible with several platforms is more likely to be selected than one with less flexible accommodation and orbit requirements. Phase A concept study teams should work with Mr. Shaun Daly, 321-867-8400, shaun.daly@nasa.gov, for rideshare support.*
- For missions of opportunity proposed as payloads to the International Space Station (ISS), Phase A study teams shall provide, in Appendix L.21, an updated Letter of ISS Technical Interface and Resource Accommodation Feasibility Assessment from the ISS Research

Integration Office, as specified in Requirement Q-14 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.21 on the CSR due date. Phase A concept study teams should work with Mr. Steven Hunning, 832-248-1034, steven.w.huning@nasa.gov, for ISS Program accommodation support.

Requirement CS-21. *Trajectory: For any mission that will perform Phase E operations beyond Geosynchronous Orbit, the following information shall be provided in Appendix L.23 of the CSR. This information is optional for missions that remain within Earth orbit at or below Geosynchronous Orbit. [Amended October 20, 2022]*

- *Checkout Duration: The minimum duration allocated after launch before the primary propulsion system will be commanded to provide required delta-v.*
  - *Initial Mass Assumptions: Provide the initial mass used for generation of the trajectories including propellant loading assumptions.*
  - *Event Basics: Provide the date/time of each trajectory event with a brief event description (e.g., Launch, Gravity Assist, Mid-Course Burn) and the appropriate data for the event (e.g., delta-v magnitude). These data should be included for three different scenarios corresponding to the Open, Middle, and Closing of the proposed launch window.*
- Any other trajectory-specific information not called out above that would be relevant to reviewers attempting to validate the trajectory should also be included. While the information listed in this requirement must be included in the PDF document, optionally, a trajectory file(s) may be submitted along with the electronic files listed in Requirement CS-3. [Amended October 20, 2022]*

The following replaces Requirement B-32 of the MIDEX AO and B-41 of the SALMON-3 AO.

Requirement CS-22. *Flight System Capabilities: This section shall address the following flight system capabilities to the extent that they are applicable to the proposed mission and that they are known. Any additional elements that are applicable to explaining the mission and demonstrating its feasibility shall also be addressed. Note that the heritage of the components and subsystems are to be discussed in Appendix L.12.*

- *Spacecraft parameters:*
  - (a) *Figure of the complete spacecraft/instrument system, on the launch vehicle and in-flight, with major components labeled and approximate overall dimensions.*
  - (b) *Block diagram of the spacecraft subsystems and their components.*
- *Subsystem descriptions including structure, telecommunications, thermal, power, propulsion (if required), attitude determination and control, command and data handling, in-flight fault management, flight software, and ground software. (Note that the discussion of the telecommunications subsystem should be limited to specifications, design, and proposed component hardware – discussion of the link performance is addressed as part of Appendix L.16, Communication Design Data). Subsystem detail shall include to the extent possible the following information:*
  - (a) *Propulsion, including: (i) a list of all specific events of the proposed delta-v budget (including statical analysis for stochastic maneuvers); (ii) for each propulsion mode type(s) (monoprop, biprop, dual-mode, solar electric, etc.), engines thrust levels, and*

- specific impulse, *and propellant allocation (e.g., impulse vs. attitude control system)*; and (iii) propellant margins.
- (b) Command and data handling, including: (i) spacecraft housekeeping data rates for nominal and safing strategy; (ii) data storage unit size (Mbits); (iii) maximum storage record and playback rate.
- (c) Power.
- Solar-powered mission:
- (i) power requirements *and margins* for each mission phase, (ii) type of array structure (rigid, flexible, body mounted); (iii) solar array axes of rotation (vector projected in spacecraft coordinates); (iv) array size; (v) solar cell type and efficiency; (vi) expected power generation at Beginning of Life and End of Life; (vii) worst case Sun incidence angle to solar panels *for each mission phase*; (viii) battery type and storage capacity; (ix) phased and worst case battery Depth Of Discharge (DOD); (x) spacecraft bus voltage.
- (d) Attitude Determination and Control, including system pointing requirements and capabilities. Describe or define the following: (i) each spacecraft operational mode, including the sensors and actuators used, control method, and safing and/or contingency modes; (ii) attitude determination methodology and estimate of accuracy including identifying whether ground post-processing is required to meet science needs; (iii) agility requirements for slews or scanning; (iv) appendage pointing requirements including articulation control methods and deployment accommodations; (v) sensor selection and performance including identifying mounting location and field-of-view (FOV); (vi) actuator selection and sizing including identifying mounting location(s); (vii) translational maneuver (delta-v) control and accuracy; (viii) momentum management approach and mitigation of impacts on navigation accuracy, if applicable; (ix) on-orbit calibrations, if required, including expected accuracy; and (x) attitude control requirements for the spacecraft pointing control, pointing knowledge (at the instrument interface), pointing stability or jitter.
- (e) Thermal control, including (i) temperature requirements including *allowable temperature ranges*; (ii) temperature control approach (i.e., passive vs. active); (iii) cooling loads; and (iv) special thermal design considerations (e.g., cryogenic instrument requirements).
- (f) Structures, including: (i) requirements; (ii) governing load cases and margins; (iii) chosen materials; and (iv) their qualification testing.*
- (g) Flight software: including (i) 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) the logical lines of code by Computer Software Configuration Item (CSCI) and the basis for these estimates; (iii) a description of the functionality for each CSCI; (iv) code counts categorized as either New, Modified, Full Reuse, or Autogenerated; (v) a description of the development method (spiral, waterfall, agile, etc.); (vi) the development approach for any major new algorithms to be incorporated in the flight software; (vii) the approach for interface management and plans for software verification and validation.*

The following replaces Requirement B-34 of the MIDEX AO or B-43 of the SALMON-3 AO. Requirement CS-23. Flight System Contingencies and Margins: 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
- *Any other driving mission element requirements derived from the Mission Functional Requirements [Amended October 20, 2022].*

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

See the table following Requirement B-35 in 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.

The following replaces Requirement B-35 of the MIDEX AO or B-44 of SALMON-3 AO.

Requirement CS-24. Mission Operations: This section shall address the following elements of mission operations *and communication* to the extent they are applicable to the proposed mission and that they are known. Any additional elements that are applicable to explaining the mission operations and demonstrating their feasibility shall also be addressed. This section shall provide, at a minimum, the following items:

- Description of ground systems and facilities, including supporting ground software *at the Mission Operations Center (MOC) and the Science Operations Center (SOC)* required for development and testing and operations;
- Telecommunications, Tracking, and Navigation (Deep-Space/Lunar and Earth Orbital missions, as well as missions that utilize telecom relay orbiters) including 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 parameters (frequencies, periods, capacities, margins, etc.), and retransmission capability. *For missions proposing the use of NASA network facilities, a Letter of Commitment from the NASA network provider describing the network's ability to deliver the required capabilities and capacities and the cost for doing so must be included in Appendix L.1. 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, early discussions should be initiated with the POC named in that document;*
- Description of approach for acquiring and returning critical event data, including clear identification of procurement, and costing for supplemental resources (e.g., mobile ground stations) if such are needed;

- Operations plan, including *a quantitative discussion of nominal sequence planning and commanding showing the ability of the Mission Operations and Ground Data System to analyze the spacecraft and payload data and to generate the necessary sequences to enable the spacecraft to meet the planned mission timelines*, team training, availability of spacecraft experts for operations, operations center development; and
- *Operational concept that includes the following. 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 S/C, 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 interface between the Flight Operations Team and the CARA or MADCAP team. [Amended November 8, 2022] 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.*

### F.3 Development Approach

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

The following replaces Requirement B-36 of the MIDEX AO or B-30 of SALMON-3 AO. Requirement CS-25. This section shall describe the systems engineering development approach. 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;*
- Roles and responsibilities for the interface management process—as specified in NPR 7123.1C and product development responsibilities;
- A description of how the interface management process will be developed and maintained;
- Mission assurance approach, including (i) fault tolerance and fault management, (ii) product assurance, and (iii) reliability;
- Essential trade studies to be conducted in *Phase B [Amended October 20, 2022]* including the considered options and driving requirements;
- Identification of the key Technical Performance Measures (TPMs)—as specified in NPR 7123.1C **[Amended October 20, 2022]**—and descriptions of how these margins and reserves are to be allocated, tracked, and monitored, with what tools and by whom, and who will have the authority to release the associated reserves and margins;

- Descriptions of when contracts are required, the acquisition strategy, including any incentive strategy.
- *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-26. *This section shall describe the plan for mission assurance. Plans for using reliability tools, such as fault tree analysis, probabilistic risk assessments, and failure modes and effects analyses, shall be described. Other mission assurance activities such as fault tolerance, reliability (e.g., use or non-use of redundancy, requirements for burn-in of parts, and requirements for total operating time without failure prior to flight) shall be described. Processes for identifying and tracking the correction of failures, both hardware and software, from the component level to the system level shall be described.*

The following replaces Requirement 33 of the MIDEX AO. This requirement is not part of SALMON-3 AO or PEA-Q but is applicable to all CSRs.

Requirement CS-27. *CSRs shall indicate any expected deviations from the recommended safety and mission assurance requirements in [Appendix D](#) of NPR 8705.4A for the proposed payload indicated in the AO (Class C for MIDEX or Class D for MO).*

Requirement CS-28. *CSRs for the Missions of Opportunity shall indicate any expected deviations from the recommended mission assurance requirements in the SMD Standard Mission Assurance Requirements for Payload Classification D, SMD Policy Document SPD-39. Tailoring below SPD-39 shall not be proposed. CSRs for the Medium Explorers shall indicate any expected deviation from the recommended mission assurance requirements in Explorers & Heliophysics Projects Division Mission Assurance Requirements (MAR), Class C, EHPD-RQMT-0001, Revision [A].*

#### F.4 New Technologies/Advanced Engineering Developments

Note the requirement(s) in the Appendix B, Section F.4 of the MIDEX AO or SALMON-3 AO.

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

The following replaces Requirement B-39 of the MIDEX AO or B-48 of the SALMON-3 AO.

Requirement CS-29. 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 are required to be developed and how they will be validated, critical path items, etc.) shall be included. The I&T description shall demonstrate the credibility of the overall I&T 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

The following replaces Requirement B-40 of the MIDEX AO or B-49 of the SALMON-3 AO. Requirement CS-30. A project schedule foldout(s) covering all phases of the investigation shall be provided to at least WBS 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 first 3 *schedule* foldouts will not count 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(s) and accompanying narrative (included in the page count for this section) shall address proposed major milestones, including, at a minimum, the following items:

- Spacecraft development, *integration and test*, and major review dates;
- Instrument development and major review dates including instrument-to-spacecraft/host integration and test;
- Ground systems development and major review dates (e.g., mission operations and data analysis development schedule);
- Major deliverables (e.g., Interface Control Documents (ICDs), simulators, engineering modules, flight modules, etc.);
- *Spacecraft-to-Launch Vehicle* integration and launch readiness;
- *Compliance with National Environmental Policy Act (NEPA) and Nuclear Launch Safety Approval processes, if appropriate; See Requirement CS-25.*
- Long-lead item specifications, development paths, and their impacts to schedule;
- Development schedule for *Student Collaborations (SCs)*; 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.*

The following replaces Requirement B-41 of the MIDEX AO and *is applicable to the MOs as well [Amended October 20, 2022].*

Requirement CS-31. The *electronic submission* shall also contain an electronic version of the schedule in a Microsoft Project format. Although the project schedule foldout(s) in *Requirement CS-30* does not need to have been generated in Microsoft Project, the project schedule provided *in the electronic submission* shall address the items specified in *Requirement CS-30* ~~at a level of detail commensurate with that of the graphical foldout~~ **[Amended October 20, 2022]**. The Microsoft Project schedule is not intended to be a fully Integrated Master Schedule for the project, but rather, it is to be a representation of the summarized schedule foldout that provides a quantified data set that will facilitate understanding of the proposed flow of development activities, timelines, milestones, schedule reserves, and risk. ~~Although tasks in this high-level summary schedule are not expected to be fully linked to their predecessor and successor tasks, the level of linkage detail should support the assignment of the critical path in the graphical foldout.~~ *The level of linkage detail must be complete enough to substantiate the assignment of the*

*primary critical path and any significant secondary critical path(s) in the graphical foldout(s) [Amended October 20, 2022]. Task links are also needed to identify points of assembly, integration, and testing in the schedule and links to major milestones. The detail on the schedule is required 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.*

## **G. MANAGEMENT**

The following replaces Requirement B-42 of the MIDEX AO or B-50 of the SALMON-3 AO. Requirement CS-32. This section shall describe the investigator's proposed management approach, *including essential management functions and the overall integration of these functions:*

- *The organization structure, including*
  - a) *The organization chart that clearly indicates how the investigation team is structured*
  - b) *The internal operations and lines of authority with delegation, together with internal interfaces;*
  - c) *Relationships with NASA, major team members, major subcontractors, their organization, and their reporting relationship in the program; and*
  - d) *The names of primary team members, their organization, and their reporting relationship within the project;*
- *The commitment and the roles and responsibilities of all institutional team members, including team members responsible for SC (as applicable).*

Requirement CS-33. *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, DPI if one is proposed, PM, PSE, and the balance of the Key Management Team in those processes. In particular, the management processes as they apply to the relationships among organizations and key personnel shall be described, including systems engineering and integration; requirements development; configuration management; schedule management; team member coordination and communication; progress reporting (both internal and to NASA); performance measurement; and resource management. This discussion shall include all phases of the mission, including preliminary analysis, technical definition, design and development, and operations phases, as well as products and results expected from each phase. Include a clear description of the methods and frequency of planned communication within the project team.*

Requirement CS-34. *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-35. *Each key position, including its roles and responsibilities, how each key position fits into the organization, and the basic qualifications required for each key position, shall be described. A discussion of the unique or proprietary capabilities that each partner organization brings to the team, along with a description of the availability of personnel at each partner organization to meet staffing needs, shall be included. The contractual and financial relationships between team partners shall be described.*

Requirement CS-36. *This section shall name all the team members who will occupy the key project management positions identified in Requirement CS-35. 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; and*
- (ii) Address the role(s), responsibilities, commitments by phase, and percentage of time devoted to the mission for the PI, DPI if one is proposed, 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-37. *This section shall describe plans for risk management, both in the overall mission design and in the individual systems and subsystems. NASA's required risk management procedures are provided in **NPR 8000.4B, Agency Risk Management Procedural Requirements**, available in the Program Library. The relevant Mission Assurance Requirement (MAR) document, available in the Program Library, will also apply. Note that the MAR requires a draft Mission Assurance Implementation Plan (MAIP) and Compliance Matrix to be submitted with the CSR (see Section L.20 of this document). Plans for using standard risk management tools, including probability and impact charts, risk lists, mitigation plans and triggers shall be described. The role(s) in the risk management process of each of the key management personnel shall be discussed. Provide quantitative risk assessments, where the probability and impact of occurrence are independently and numerically specified prior to mitigation; specification of probability and impact after mitigation is encouraged but not required. Where appropriate, an impact may be specified in terms of any resource that is quantified in the CSR. Furthermore, individual quantitative risk assessments may address multiple resources, as well as temporal increments (e.g., mitigation followed by post-mitigation). To determine the cumulative effect of risks on resources, each impact must be paired with a probability. The cumulative effect of the products of probabilities and impacts must not reduce the resource below that necessary to achieve baseline science. In the case of cost, the products of pre-mitigation probabilities and impacts shall be included as encumbered cost reserves or explicitly identified in the basis of estimate, including cost validations.*

Requirement CS-38. *A summary of reserves in cost and schedule shall be identified by mission phase, project element, and year, and the rationale for each shall be discussed. The specific means by which integrated costs, schedule, and technical performance will be tracked and managed must be defined. Specific reserves and the timing of their application must be described. Management of the reserves and margins, including who in the management organization manages the reserves and when and how the reserves are released, must be*

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

Requirement CS-39. *This section shall clearly delineate the Government-furnished property, services, facilities, etc. required to accomplish all phases of the mission.*

The following replaces Requirement 34 of the MIDEX AO or Requirement Q-11 of the PEA.

Requirement CS-40. *CSRs shall identify any tailorable NASA requirements described in NPR7120.5E that are proposed to be adjusted, include the rationale for the adjustment, and describe the cost, schedule, and/or other benefits that would be realized should one or more of the adjustments be accepted by NASA. For MO investigations, the CSRs shall provide the above information for proposed adjustments to requirements not specifically identified as being waived in the NASA Science Mission Directorate (SMD) Class-D Tailoring/Streamlining Decision Memorandum (e.g., Earned Value Management for missions with a cost under \$150M).*

Requirement CS-41. *This section shall clearly describe the approach to reporting progress to the Government, and indicate the progress reviews the Government is invited to attend to provide independent oversight. The process, including the individual or organization responsible, for reporting integrated cost, schedule, and technical performance must be discussed. A description of the information to be presented must be included.*

Requirement CS-42. *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-66 and Requirement CS-67);*
- 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, descopeing the contributed items and holding reserves to develop the contribution directly. Note that reserves held for this purpose should be weighted by likelihood and are considered encumbered. When no mitigation is possible, this must be explicitly acknowledged, and the stability and reliability of proposed partners, as well as the appropriateness of any proposed contribution, should be addressed; and*
- Acknowledgement of the complexities and risks involved with contributions and plans to handle those complexities or risks. This includes the schedule risk for implementing technical assistance agreements and international agreements. An adequate and realistic schedule must be allocated for having international agreements executed. NASA will not begin working on any international agreements until after the continuation decision is made.*

## **H. OTHER FACTORS, INCLUDING STUDENT COLLABORATIONS AND SMALL BUSINESS SUBCONTRACTING**

Requirement CS-43. *If a Student Collaboration is proposed, this section shall describe a detailed plan. This plan shall include:*

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

Requirement CS-44. *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 MIDEX AO or Section 4.2.6 of the SALMON-3 AO, shall be provided, with the exception of separately identifying and being evaluated on participation targets of Small Disadvantage Businesses (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.*

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

Once entering Phase B, Explorers projects will be subject to the same requirements as all other NASA missions. Note that the CSR only satisfies some of the KDP-B deliverable requirements, and that the balance will have to be developed early in Phase B (consistent with Section 2.2.7.1 in NPR 7120.5E: “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-45. *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-46. *The Phase B Plan shall include a detailed schedule and shall define the products to be delivered and the schedule for their delivery. The schedule shall include the PDR and delivery dates of the following required products:*

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

Requirement CS-47. *If more than one contractual arrangement is needed, a separate Statement of Work (SOW) and budget breakout shall be provided for each organization. Subsequent phases will be added to the contract after each phase has been approved through the confirmation review process.*

## **J. COST PROPOSAL**

Requirement CS-48. *A WBS as defined in NPR 7120.5E and NASA/SP-2016-3404/Rev1, NASA Work Breakdown Structure (WBS) Handbook, available in the Program Library, shall be provided and used to describe how all project costs are accounted in the cost proposal.*

Requirement CS-49. *This section shall include a discussion of sources of estimate error and uncertainty in the proposed cost.*

The following replaces Requirement B-49 of the MIDEX AO or B-57 of the SALMON-3 AO.

Requirement CS-50. *This section shall discuss cost risks and mitigation strategies.*

The following replaces Requirement B-50 of the MIDEX AO or B-58 of the SALMON-3 AO.

Requirement CS-51. *This section shall provide foldout cost tables, using the template of Cost Table Templates 3a and 3b. Tables 3a and 3b shall identify the proposed cost required in each mission phase and in each Fiscal Year; the costs shall be in Real Year dollars (RY\$) in Table 3a and FY 2022 dollars (FY22\$) in Table 3b. The top portion of Tables 3a and 3b 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 tables 3a and 3b 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 coordinating science ground stations, or nonstandard facilities, which shall be explicitly shown. The columns in Table 3a and 3b shall be grouped and subtotaled by mission phase and shall be labeled with the appropriate Fiscal Years. Years that span more than one mission phase shall be split into two columns by mission phase. The final columns in each of Tables 3a and 3b are totals in real year dollars (RY\$) and totals in Fiscal Year 2022 dollars (FY22\$) respectively. 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 available in the Program Library to translate between real year dollars (RY\$) and Fiscal Year 2022 dollars (FY22\$).*

Requirement CS-52. *The CSR cost proposal shall provide information on the anticipated costs for all mission phases. A detailed cost proposal is required for Phase B. Cost estimates are also required for the follow-on phases (i.e., Phases C/D, and E/F), including a description of the estimating techniques used to develop the cost estimates. See Section K for requirements for any SEO costs. A discussion of the basis of estimate shall be provided, with a discussion of heritage and commonality with other programs. Quantify and explain any cost savings that result from heritage. All costs, including all contributions made to the investigation, shall be included. Specific information that would better enable NASA to validate costs (e.g., WBS Level 3 data) may be provided as an appendix (see Section L.14 of this document). This will include cost by NASA fiscal year to the lowest level of detail the project is working with, in Microsoft Excel format.*

Requirement CS-53. *Provide a table with the new obligation authority (NOA) required in RYS 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-54. *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-55. *The CSR shall identify each reserve amount to the lowest level consistent with the proposed reserve management strategy. For example, if each subsystem manager will have spending authority over a reserve for the subsystem, each such amount shall be identified separately. If more convenient, the reserve details may be shown in a separate table, with totals reported using each of Cost Table Templates 3a and 3b. Show costs (NASA SMD and contributed) associated with each Co-I and collaborator using Cost Table Templates 4a and 4b respectively, on one page each; all Co-Is and collaborators shall be identified in the applicable table.*

Requirement CS-56. *All contributions and direct/indirect costs associated with the work performed at NASA Centers shall be fully costed and accounted for in the CSR and summarized in one page using the template provided in Cost Table Template 5. NASA Center costs shall include Civil Servant services, as well as the cost for the use of Government facilities and equipment on a full-cost accounting basis. The purpose of this data is twofold: 1) to determine those costs that are included in the NASA SMD cost but are not funded out of the Explorers program, and 2) to determine Civil Servant contributions that are not included in the NASA SMD cost. Teams should work with their respective NASA Centers to develop estimates for these costs. Contributions by NASA Centers should be documented by a Letter of Commitment, provided as an appendix (see Section L.1, Requirement CS-66 and Requirement CS-67).*

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

Requirement CS-57. *The inflation index provided in Table B4 of the AO and in NASA FY 2022 inflation table in the Program Library shall be used to calculate all real-year dollar amounts if an industry forward pricing rate is not available. If something other than the provided inflation index is used, the rates used must be documented.*

Requirement CS-58. *All costs shall include all burdens and profit/fee in real-year dollars by fiscal year, assuming the inflation rates used by NASA in Table B4 of the AO and in NASA FY 2022 inflation table in the Program Library, or specifically documented industry forward pricing rates.*

Requirement CS-59. *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-70).*
- Work Breakdown Structure. *A WBS shall be provided for Phase B. The structure of the WBS should be consistent with the plans set forth in the Science Implementation, Mission Implementation, and Management sections of the concept study and the Statement of Work (SOW) 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, DPI if one is proposed, 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-54 (Cost Table Template 2) shall be provided. The cost summary for Phase B shall be developed consistent with the WBS and include all costs to NASA SMD along with all contributed costs. The cost summary for Phase B shall be phased by month.
- Elements of Cost Breakdown. Cost or pricing data as defined in FAR 15.401 and supporting evidence stating the basis for the estimated costs by the WBS levels used in the table created for Requirement CS-54 (Cost Table Template 2) shall be provided. This information is in addition to that provided in Requirement CS-51 through Requirement CS-55 (Cost Table Templates 1 through 5). The cost proposal shall include, but is not limited to, the following cost elements:
  - (a) Direct Labor. (i) The basis of labor-hour estimates for each of the labor classifications; (ii) the number of productive work-hours per month; (iii) a schedule of the direct labor rates used in the proposal, with a discussion of the basis for developing the proposed direct labor rates for the team member organizations involved; the forward-pricing method (including midpoint, escalation factors, anticipated impact of future union contracts, etc.); and elements included in the rates, such as overtime, shift differential, incentives, and allowances; (iv) if available, evidence of Government approval of direct labor rates for proposal purposes for each labor classification for the proposed performance period; and (v) if Civil Servant labor is to be used in support of the Phase B study, but is not to be charged directly to the investigation, this labor shall be considered as a contribution by a domestic partner, subject to the same restrictions as other contributions by domestic or foreign partners, and a discussion of the source of funding for the Civil Servant contributions shall be provided.
  - (b) Direct Material. A summary of material and parts costs for each element of the WBS shall be provided.
  - (c) Subcontracts. Each effort (task, item, etc., by WBS element) to be subcontracted, and list the selected or potential subcontractors, locations, amount budgeted/proposed, and types of contracts shall be identified. Explain the adjustments, if any, and the indirect rates (or burdens) applied to the subcontractors’ proposed or anticipated amounts. Describe fully the cost analysis or price analysis and the negotiations conducted regarding the proposed subcontracts.
  - (d) Other Direct Costs. (i) A summary of travel and relocation costs, including the number of trips, their durations, and their purposes; (ii) a summary of all unique computer related costs; (iii) specific task areas of problems that require consultant services, including the quoted daily rate, the estimated number of days, associated costs (e.g., travel) if any, and a statement of whether the consultant has been compensated at the quoted rate for similar services performed with Government contracts; and (iv) any other direct costs included in the proposal for Phase B, provided in a manner similar to that described above.
  - (e) Indirect Costs. (i) all indirect expense rates for the team member organizations (in the context of the AO, indirect expense rates include labor overhead, material overhead,

*general and administrative [G&A] expenses, and any other cost proposed as an allocation to the proposed direct costs); (ii) a schedule of off-site burden rates, including a copy of the company policy regarding off-site vs. on-site effort, if applicable; (iii) evidence of Government approval of any/all projected indirect rates for the proposed period of performance, including the status of rate negotiations with the cognizant Government agency, and a comparative listing of approved bidding rates and negotiated actual rates for the past five fiscal years; and (iv) fee arrangements for the major team partners.*

**Requirement CS-60.** *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, DPI if one is proposed, PM, PSE, Co-Is, 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-54 (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-61.** *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.
- Cost Estimating Technique. Describe the process and techniques used to develop the Phase E cost estimate. For portions of the cost proposal developed using a grass-roots methodology, provide the bases from which the estimates were derived and details on how the estimates were extrapolated from the bases. For portions of the cost proposal derived from vendor quotes/historical actuals/catalogue prices/etc. include sufficient information to understand the fidelity of the values. For portions of cost in the CSR derived from analogies, describe the value of and the methodology for extrapolating the analogy. For portions of the cost proposal derived parametrically, provide a description of the cost-estimating model(s) and techniques used in the Phase E cost estimate. Discuss the heritage of the models applied to this estimate including any differences between missions contained in the model's database and key attributes of the proposed mission. Include the assumptions used as the basis for the Phase E cost and identify those which are critical to cost sensitivity in the investigation. If any "discounts" were assumed in the cost estimates for business practice initiatives or streamlined technical approaches, describe how these have been incorporated in the cost estimate and will be managed by the investigation team.
- Workforce Staffing Plan. Provide a workforce staffing plan (including Civil Servants) which is consistent with the WBS. This workforce staffing plan must include all team member organizations and must cover all management, manufacturing, technical (scientific and engineering), and support staff. The workforce staffing plan must be phased by fiscal year. Time commitments for the PI, DPI if one is proposed, 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-54 (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-62. This section shall provide a cost estimate for performing the Closeout Phase (Phase F) of the mission. The Phase F cost estimates should correlate with the plans set forth in the Science Investigation, Science Implementation, Mission Implementation, and Management sections. In completing this section, the following guidelines will apply:

- Work Breakdown Structure. A WBS must be included for the Closeout of the mission. The WBS should be consistent with the plans set forth in the Science Implementation, Mission Implementation, and Management sections.
- Cost Estimating Technique. Describe the process and techniques used to develop the Phase F cost estimate. For portions of the cost proposal developed using a grass-roots methodology, provide the bases from which the estimates were derived and details on how the estimates were extrapolated from the bases. For portions of the cost proposal derived from vendor quotes/historical actuals/catalogue prices/etc. include sufficient information to understand the fidelity of the values. For portions of cost the proposal derived from analogies, describe the value of and the methodology for extrapolating the analogy. For portions of the cost proposal derived parametrically, provide a description of the cost-estimating model(s) and techniques used in the Phase F cost estimate. Discuss the heritage of the models applied to

*this estimate including any differences between missions contained in the model's database and key attributes of the proposed mission. Include the assumptions used as the basis for the Phase F cost and identify those which are critical to cost sensitivity in the investigation. If any "discounts" were assumed in the cost estimates for business practice initiatives or streamlined technical approaches, describe how these have been incorporated in the cost estimate and will be managed by the investigation team.*

- *Workforce Staffing Plan. Provide a workforce staffing plan (including Civil Servants) which is consistent with the Work Breakdown Structure. This workforce staffing plan must include all team member organizations and must cover all management, manufacturing, technical (scientific and engineering), and support staff. The workforce staffing plan must be phased by fiscal year. Time commitments for the PI, DPI if one is proposed, PM, PSE, Co-Is, 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-54 (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-63.** *This section shall summarize the estimated costs to be incurred in Phases A through F, including: Concept and Technology Development (Phase A), Preliminary Design and Technology Completion (Phase B); Final Design and Fabrication (Phase C); System Assembly, Integration and Test, and Launch, extending through in-orbit checkout, usually launch plus 30 days (Phase D); Operations and Sustainment (Phase E); Closeout (Phase F); LV, upper stages, or launch services; ground system costs beyond what is provided by the AO; rideshare services beyond those provided by the AO; and cost of activities associated with social or educational benefits (if not incorporated in any of Phases A through F). The Cost Table Template 1 shall be used to summarize these costs. The total mission cost estimate shall be consistent with the Work Breakdown Structure. Detailed plans for any aspects of the mission not discussed elsewhere in the CSR shall be discussed here. The funding profile shall be optimized for the mission. Contributions not included in the NASA SMD cost shall be clearly identified as separate line items.*

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

**Requirement CS-64.** *The cost elements proposed in the formal proposal for contract award shall be traceable to the cost proposal provided in the CSR. Any changes in cost from the CSR shall be described in detail.*

## **K. JUSTIFICATION AND COST PROPOSAL FOR ANY SCIENCE ENHANCEMENT OPTION**

SEO activities, discussed in AO Section 5.1.5, include extended missions, guest investigator programs, general observer programs, and archival data analysis programs. The selections from

the Step-1 proposals were made primarily on the merit of the baseline proposed science; no prejudice or commitment to any attendant proposed SEO activity was made at selection. It is incumbent upon investigation teams, therefore, to fully discuss these project additions in the CSR.

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

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

Requirement CS-65. *If applicable, this section shall provide sufficient data and justifications to enable analysis of not only the science value of the SEO concept, but also its viability and cost. This section shall also provide a cost estimate for performing any SEO activities. In completing the Cost section, the guidelines for Phases B through D apply. Complete a one-page summary of costs using the format shown using the format of Cost Table Template 7. Also, include the total amount in the SEO line item at the bottom of the table in Requirement CS-55 (Cost Table Template 3). Include a discussion of the estimating techniques used to develop the cost estimates.*

## **L. CSR APPENDICES**

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

### **L.1 Letters of Commitment**

The following replaces Requirement B-56 of the MIDEX AO or B-66 of the SALMON-3 AO. Requirement CS-66. Letters of commitment *signed by officials authorized to commit the resources of the respective institutions or organizations* ~~signed by an institutional official~~ shall be provided from (i) all organizations offering contributions of goods and/or services (*including Co-I and collaborator 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 mission regardless of source of funding. *Personal letters of commitment signed by the individual shall be provided from (iii) every Proposal Team member as defined in Section 5.8.2 of the MIDEX AO or Section 5.9.2 of the SALMON-3 AO. Critical participants are those participants (organizations and individuals) who are assigned tasks considered by the PI to be critical to the success of the mission, including those who provide unique required services. All other participants are non-critical. See AO Section 5.8.1 for detailed definitions of (i), (ii), and (iii). Note that participants may fall under multiple headings, in which case, provide a letter of commitment for each applicable heading. A complete letter of commitment from a vendor will include the specifics of the quote.*) If the use of NASA-

*provided communication or navigation services is proposed, this appendix shall include an associated letter of commitment.*

**Requirement CS-67.** *This appendix shall include letters of commitment from non-U.S. institutions that are contributors to Explorers 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 requirements referenced in Section 5.8.1 of MIDEX AO, or Section 5.9.1 of the SALMON-3 AO apply to institutional letters of commitment. Letters of commitment provided for the Step-1 proposal can be reused if the description of the commitment is unchanged and if the letter of commitment meets the requirements for letters of commitment for the Concept Study Report.

## L.2 Relevant Experience and Past Performance

In evaluating the CSR, NASA will consider the past performance of the major partner organizations. The evaluation of past performance will not be arithmetic; instead, the information deemed to be most relevant and significant will receive the greatest consideration. Relevant experience will be viewed as the demonstrated accomplishment of work, which is comparable or related to the objectives of the CSR. This includes space-based instrument development and investigations and associated development processes including engineering processes, management processes, operations, data analysis and delivery of data to the 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-68.** *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

The following replaces Requirement B-57 of the MIDEX AO or B-67 of SALMON-3 AO. Requirement CS-69. This section shall include resumes or curriculum vitae for the PI, PM, PSE, any other named Key Management Team members *identified in the Management section*, and all Co-Is *identified in the Science section*. Specifically, each resume shall cite the individual's experience that is pertinent to the role and responsibilities that she/he will assume in the proposed investigation. Project management experience shall be included in the resumes of the PI, PM, and PSE. Resumes or curriculum vitae shall be no longer than three pages for the PI and one page for each additional participant. Resumes shall be organized alphabetically after that of the PI, by surname. Photographs shall not be included in any of the resumes.

### L.4 Phase B Contract Implementation Data

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

Requirement CS-70. *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-71. *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 and Archiving Plan

Requirement CS-72. *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-73. *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-74. *Draft language for the technical content of any International Agreement(s) is required for all non-U.S. partners in the investigation. Sample agreements are available in the Program Library. The draft language must include: (i) a brief summary of the mission and the foreign partner's role in it; (ii) a list of NASA's responsibilities within the partnership; and (iii) a list of the non-U.S. partner's responsibilities within the partnership. Note that NASA prefers to establish agreements with foreign Government funding agencies, and not with the institution that will be funded to perform the work.*

## L.8 International Participation Plans (Update from Proposal)

The following replaces Requirement B-60 of the MIDEX AO or B-70 of the SALMON-3 AO. Requirement CS-75. If the *investigation* includes international participation, either through involvement of non-U.S. nationals and/or involvement of non-U.S. entities, this section shall *describe any updates to plans for* compliance with U.S. export laws and regulations; e.g., 22 CFR 120-130, et seq. and 15 CFR 730-774, et seq., *that were provided in the Step-1 proposal (see Appendix B, Section J.5 in the MIDEX 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 [http://www.pmdtc.state.gov/ddtc\\_public](http://www.pmdtc.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, 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.; **or otherwise controlled under the Export Administration Regulations (EAR), 15 CFR parts 730–774, issued by the United States Department of Commerce, Bureau of Industry and Security (BIS) under laws relating to the control of certain exports, reexports, and activities. [Amended November 8, 2022]**

## L.9 Limiting the Generation of Orbital Debris and End-of-Mission

This appendix is required only for missions to Low Earth Orbit (LEO) (< 2000 km perigee), near Geosynchronous Orbit (GEO) (GEO ± 300 km), or the Moon (orbiters and landers).

Per NPR 8715.6B, *NASA Procedural Requirements for Limiting Orbital Debris and Evaluating the Meteoroid and Orbital Debris Environments*, orbital debris is defined as any object placed in space by humans that remains in orbit, and no longer serves any useful function. Objects range

from spacecraft to spent launch vehicle stages to components, and also include materials, fragments, or other objects which are intentionally or inadvertently cast off or generated.

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

For missions traveling beyond Earth orbit, plans for conducting these assessments are required at the end of Phase A only for missions where the mission approach (either during nominal operations, in the event of an anomaly, or at the end of mission) indicates that the likelihood of generating orbital debris in the locations described above is high during nominal operations.

Requirement CS-76. *This section shall discuss briefly how the mission meets the NPR 8715.6B and NASA-STD-8719.14C orbit debris requirements applicable to its proposed orbit. For LEO missions, this section shall briefly discuss the lifetime of the mission and whether it meets the 25-year post-mission (or 30-year from launch—whichever comes first) requirement. An orbital lifetime analysis addressing all assumptions and inputs contributing to the analysis shall be provided and describe, at a minimum:*

- *Vehicle Mass*
- *Drag Area or Cross-sectional Area*
- *Initial orbit used for the analysis*
- *Solar and atmospheric conditions assumptions (i.e., models or parameters)*
- *Methodology: analytical tool, table lookup, reference plot.*

#### L.10 Compliance with Procurement Regulations by NASA PI Proposals

Note the requirement in the Appendix B, Section J.10 in of the MIDEX AO or in the Appendix B, Section J.6 of the SALMON-3 AO.

Note that the SALMON-3 AO erroneously references NFS 1872.308 in Section 5.4.5 and in Appendix B, Section J.6. The Correct NFS reference is 1872.306.

#### L.11 Master Equipment List

Note the requirement(s) in the Appendix B, Section J.11 of the MIDEX AO or Section J.8 of SALMON-3 AO.

#### L.12 Heritage

Note the requirement(s) in the Appendix B, Section J.12 of the MIDEX AO or Section J.9 of SALMON-3 AO.

#### L.13 Classified Materials

Note the requirement(s) in Section 5.8.4 of the MIDEX AO or Section 5.9.4 of SALMON-3 AO.

#### L.14 Additional Cost Data to Assist Validation (Optional)

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

#### L.15 Science Change Matrix

Requirement CS-77. *If the Phase A effort results in changes from any science objective proposed in Step 1, this appendix shall provide a table with the following columns: the original objective, the new or revised objective, rationale for the change, and the section/paragraph in the CSR where the change occurs.*

#### L.16 Communications Design Data

Requirement CS-78. *Provide data and detailed link analyses for all communication modes, adequate to assess the design of the communications concept. This shall include a communications block diagram (showing all components) and link budget design control tables for all radio communications links (data and carrier) showing relevant spacecraft and earth station parameters and assumptions for the highest data rate and the emergency link at the maximum distance and throughput at which each particular link could be used. In particular the following parameters shall be provided: transmitter power, transmitter Antenna Gain, Transmitter Off-Boresight Pointing Loss, Transmitter Circuit Loss, Carrier Frequency, Transmitter-Receiver Range, Receiver Antenna Gain, Receiver Off-Boresight Pointing Loss, Receiver Circuit Loss, Receiver Bandwidth, Receiver System Temperature, Hot Body Noise Temperature, Data Modulation Index, Ranging Modulation Index, Data Rate, Forward Error Correcting Code including code rate, block size (if applicable), constraint length (if applicable), Carrier Modulation Index, Carrier Link Margin, and Data Link Margin. For more information on these requirements, including table format, see **NASA's Mission Operations and Communication Services**, available in the Program Library.*

#### L.17 Space Systems Protection

On 15 July 2022, NASA approved the revision A update to NASA-STD1006, *Space System Protection Standard* (originally published on 29 Oct 2019).

The following three requirement replace Requirement 36, 37, and 38 of the MIDEX AO or Requirements Q-26, Q-27, Q-28 of the PEA Q respectively.

Requirement CS-79. *CSRs shall provide plans to protect uplink commands using approaches compliant with FIPS 140-2 Level 1.*

Requirement CS-80. *CSRs shall provide plans to ensure that the command uplink, position, navigation, and timing subsystems can recognize and survive interference.*

Requirement CS-81. CSRs shall *provide plans* to protect command uplink information, including command dictionaries, at no less than the *CUI* level.

#### L.18 Cyber Security

With the rise in cyberattacks on all computer systems, NASA needs to be proactive in protecting all flight and ground assets. To protect mission IT assets, NASA requires projects to develop a System Security Plan (SSP) using the NIST 800-53 controls as a basis. The requirement to follow NIST 800-53 flows from NPR 2810.1. The SSP begins with a description of the mission, including all end-to-end data flows, and uses NIST 800-series documents to develop the content of the SSP.

Requirement CS-82. *The CSR shall provide a ground system data flow diagram showing end-to-end flows of all mission data, including any flows to facilities outside the control of the mission itself (such as tracking stations).*

Requirement CS-83. *The CSR shall describe plans to develop a System Security Plan using the NIST 800-53 controls as a basis.*

~~To the extent that these~~ The requirement for an SSP does not go beyond what is required in NPR 7120.5E, so the ~~additional~~ costs associated with the SSP will be within ~~outside~~ the AO Cost Cap. **[Amended October 20, 2022]**

*Questions concerning Cyber Security may be addressed to: Mr. Reynaldo Anzaldua, SMD Information Security Executive, E-mail: reynaldo.anzaldua@nasa.gov. [Amended October 20, 2022]*

#### L.19 Draft Mission Definition Requirements Agreement

Requirement CS-84. *A draft Mission Definition Requirements Agreement (MDRA) shall be provided. MDRAs define Level 2 requirements for the baseline mission, encompassing the programmatic, science and instrument, mission implementation and spacecraft, and ground data requirements. An example MDRA is provided in the Program Library.*

#### L.20 Draft MAIP and MAR Compliance Matrix

Requirement CS-85. *This section shall provide a draft Mission Assurance Implementation Plan (MAIP) and appropriate Compliance Matrix: for the MIDEX, **the Explorers & Heliophysics Projects Division (EHPD) Mission Assurance Requirements (MAR), Class C,** and for the MO, the **SMD Standard Mission Assurance Requirements for Payload Classification D, SMD Policy Document SPD-39** in the Program Library.*

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

See Requirement CS-20 for instructions on the Rideshare Accommodation Worksheet or ISS

## Technical Interface and Resource Accommodation Feasibility.

### L.22 Justification for the use of non-AMMOS MOS/GDS Tools

Requirement CS-86. *This section shall describe the justification for using Mission Operations Services (MOS)/Ground Data System (GDS) tools other than those available from NASA's Advanced Multi-Mission Operation System (AMMOS). For each non-AMMOS tool, this section shall contain:*

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

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

### L.23 Trajectory Data

See Requirement CS-21 for providing trajectory data.

### L.24 Acronyms and Abbreviations List

Requirement CS-87. This section shall provide a list of abbreviations and acronyms.

### L.25 Program and Project Management Standards

Requirement CS-88. *This section shall provide a list of any internal program and project management standards to be used in the proposed development (e.g., GEVS, "GOLD Rules"). To the extent practicable, the referenced documents shall be included with the electronic submission.*

CSRs may additionally provide, in this appendix, a list of other reference documents and materials used in the concept study. The documents and materials themselves cannot be submitted unless they are within the CSR's page limit. Investigation teams are encouraged to include an active URL for those documents available through the Internet. If the URL is password protected, provide the password in the CSR.

## **PART III – OTHER FACTORS REQUIRED AFTER DOWN-SELECTION**

### **Education Program Plan, and Communications and Outreach**

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 to as Public Outreach) must be developed during Phase B of the mission. The plan must include topline messaging, target audiences, and media processes linked to reaching target audiences. Mission-related communications will be negotiated and funded directly through a NASA Center and are not within the PIMMC.

### **Conjunction Assessment Risk Analysis**

NASA has established conjunction assessment risk analysis requirements in NID 7120.132 for Earth-orbiting missions up through GEO and NPR 8715.6B, Chapter 3 for missions in other orbits, which will apply to investigations selected through this AO. Two organizations—the Conjunction Assessment Risk Analysis (CARA) team at NASA Goddard Space Flight Center for Earth-orbiting missions and the MARS (and Moon) DeepSpace Collision Avoidance Process (MADCAP) team at the Jet Propulsion Laboratory for Moon and Mars missions—are funded directly by NASA HQ and the Multi-Mission Ground Systems and Services (MGSS) program, respectively, to perform the actual analysis and risk assessment; the costs for these services need not be included in the mission PIMMC. However, an investigation to which these requirements are applicable will have to establish a working interface between the Flight Operations Team and the CARA or MADCAP team. This interface will be used to routinely share orbital ephemerides data and covariance data, any maneuvering plans, and to perform any maneuver planning activities required for collision avoidance once on orbit. See “Appendix D. Best Practices for NASA Missions” in OCE-51, NASA Spacecraft Conjunction Assessment and Collision Avoidance Best Practices Handbook in the Program Library for more detail. Estimates of how many maneuver planning events may be required in a particular orbit regime may be requested from the CARA program.

While provision of a draft will be deferred to early Phase B, an Orbital Collision Avoidance Plan (OCAP) must be completed by PDR following the guidance in NID 7120.132 as part of final mission design and orbit selection. The conjunction assessment operations process and associated interface between the mission and CARA or MADCAP team must be agreed-to and documented in a Conjunction Assessment Operations Interface Agreement (CAOIA) by ORR.

For additional information regarding CARA, including potential input on orbit and trajectory trade studies, proposers may contact Ms. Lauri Newman (Telephone: 301-286-3155; email:

lauri.k.newman@nasa.gov). For information regarding MADCAP, please contact Dr. Try Lam (Telephone: 818 354 6901; email: try.lam@jpl.nasa.gov).

To the extent that these requirements go beyond what is required in NPR 7120.5E, the additional costs associated with them will be outside the AO Cost Cap.