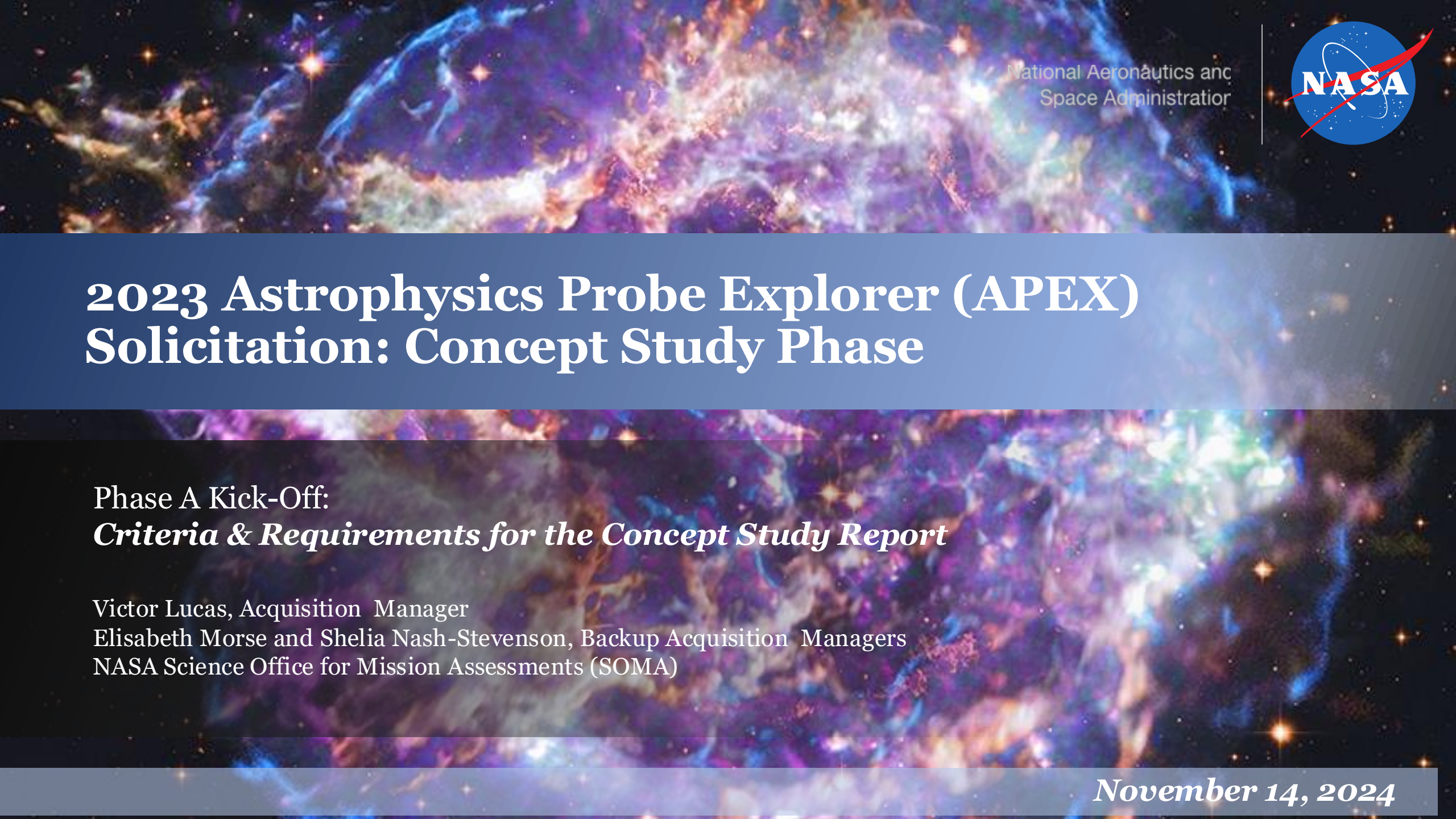

2023 Astrophysics Probe Explorer (APEX) Solicitation: Concept Study Phase

Phase A Kick-Off:
Criteria & Requirements for the Concept Study Report

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NASA Science Office for Mission Assessments (SOMA)

November 14, 2024

Outline

Criteria & Requirements Document: Overview

The *Criteria & Requirements for the Phase A Concept Study Report* (C&R) document contains instructions for preparation of the Concept Study Report (CSR).

- An updated draft version of the C&R has been posted to the Program Library of the 2023 Astrophysics Probe Acquisition Homepage: https://explorers.larc.nasa.gov/2023APPROBE. After the ongoing SMD review is completed, a final version will be posted.
- Requirements are designated as CS-1 to CS-153.
- Note the following language from the document:
  - ➢ All program constraints, guidelines, definitions, and requirements specified in the AO are applicable to the CSR.
  - ➢ Only new requirements and modified requirements appear in the C&R for the Phase A Concept Study document.
  - ➢ In case of conflict between the 2023 Astrophysics Probe AO and the C&R document, the C&R document takes precedence.
  - ➢ Each CSR must be a self-contained document and must not refer to information contained in the Step 1 proposal.

    The only permitted exception is Appendix L.18. Science Change Matrix

Criteria & Requirements Document: CSR Outline per Req. CS-5

- The format of the CSR is specified in Sections A through L
- The CSR Structure and Page Limits are specified in Table 2
  - 2 pages for Fact Sheet and 6 pages for Executive Summary
  - 45 pages for Section D, Science Investigation including GO/GI with changes from Step 1 identified
  - Base of 130 pages for Sections E through I:
    - + 3 pages for each additional separate, non-identical instrument
    - + 2 pages for each additional separate, non-identical flight element
    - + 6 pages for all SEOs combined, if proposed
      - *Reserved for SEOs and must be Section E –Science Implementation Section*
    - + 15 pages for Student Collaboration (SC), if proposed
    - +6 pages for Citizen Science (CS), if proposed
    - +Schedule foldouts
  - No page limits for Section J, *Cost Proposal*, and Section K, *Justification & Cost Proposal for optional Science Enhancement Options (SEOs)*
  - No page limit for Section L Appendices
- Appendices shall not be renumbered

Criteria & Requirements Document: CSR Submission per Req. CS-6, CS-7, CS-8, CS-9, CS-10, CS-11

- The CSR with all Appendices is due 4 p.m. ET, November 14, 2025
  - Accompanied by final version of CSR participants file (Req. CS-9) and Fact Sheet (Req. CS-16)
- The augmented submission is due 4 p.m. ET, November 21, 2025
  - Trajectory supplement, if applicable (Req. CS-40 and CS-41)
  - Schedule in MS-Project format (Req. CS-57)
  - MEL in MS-Excel format (Req. CS-134)
  - Program and Project Management Standard References (Req. CS-152)
  - All Cost Tables in MS-Excel format (Req. CS-100, CS-101 and CS-107)
  - Excel spreadsheets or model files to accompany the additional cost data to assist in validation, if applicable (Section L.17)
- All files shall be submitted via NASA Box.
- Electronic CSRs shall be unlocked, bookmarked, and searchable PDF file(s) –limited to the main body of the CSR, all tables and appendices, with no embedded audio, video or animations and no external links.
- Materials identified as subject to U.S. export laws and regulations, in accordance with AO Section 5.8.3, must be marked and redacted versions put into a “Redacted” folder in the submission.

Criteria & Requirements Document: Updated Criterion C Factors (1 of 5)

- All of the Technical, Management, and Cost (TMC) Feasibility factors defined in AO Section 7.2.4 apply to the evaluation of the CSR
- All of the AO factors, updated C&R factors, and new C&R factors are evaluated to ensure the CSR's technical, management, and cost feasibility are at least at a Phase A level of maturity.
- In the C&R document, changes in Evaluation Factors from the AO are noted in *blue italicized text*. Some bullets on the major changes are noted below. More detail on each is provided in the C&R document, PART I.
  - Factor C-1. Adequacy and robustness of the instrument implementation plan
    - Includes assessment of *the approach to multiple builds, where applicable*
    - Includes assessment of *the adequacy of backup plans, where applicable*
  - Factor C-2. Adequacy and robustness of the mission design and plan for mission operations
    - Includes more details for *ground systems, navigation/tracking/trajectory analysis, operational scenarios and timelines for each mission phase, operations team roles and responsibilities, and GI/GO interfaces and operational coordination*

Updated Criterion C Factors (2 of 5)

- Factor C-3. Adequacy and robustness of the flight systems
  - Includes assessment of *the approach to multiple builds if applicable*
  - Includes *an assessment of the adequacy of the plans for spacecraft systems engineering, qualification, verification, mission assurance, and launch operations*
  - Maturity and technical readiness assessment includes that of *the operations system*
  - Includes *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*
- Factor C-4. Adequacy and robustness of the management approach and schedule including the capability of the management team
  - Includes assessment of the *WBS; project level systems engineering*
  - The named Key Management Team includes at least the PI, the PM, and the PSE
  - Includes *the ability to build, test, and integrate the required number of flight units with repeatable quality and performance standards on the required schedule, the system design's impact on the repeat manufacturability, the proposer's management of any subcontracted manufacturer, and the ability to capture and apply lessons learned for the effective production of subsequent units.*

Updated Criterion C Factors (3 of 5)

- Factor C-4 (cont'd). Adequacy and robustness of the management approach and schedule including the capability of the management team
  - Includes assessment of *the resiliency of the production and test schedule to problems appearing in multiple-unit builds*
  - Includes assessment of *the proposed project and schedule management tools to be used on the project*
  - Risk management aspects of AO Factor C-4 are used as basis for new Factor C-6 in Step 2
- Factor C-5. Adequacy and robustness of the cost plan, including cost feasibility and cost risk
  - Includes *how multiple unit builds are costed*
  - Includes *the methods and rationale used to develop the estimated cost*
  - Includes *the proposed cost management tools to be used on the project.*

Updated Criterion C Factors (4 of 5)

- Factor C-6. Adequacy of the risk management plan
  - Derived from Factor C-4 of the AO
  - Also includes *the approach to any proposed descoping of mission capabilities*
  - Where there are proposed cooperative arrangement or contribution, *when no mitigation to risk is possible, this should be explicitly acknowledged.*

Updated Criterion C Factors (5 of 5)

Two new factors are added in Step 2:

- *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 including GO/GI), and a telecommunications analysis, ground network capability and utilization plan, and navigation plans.

- *Factor C-8. Approach and feasibility for completing Phase B*

  This factor includes the completeness of Phase B plans and the adequacy of the Phase B approach. This assessment will include evaluation of the activities/products, the organizations responsible for those activities/products, and the schedule to accomplish the activities/products.

Deferred Step 1 items Required for Step 2 (C&R Table 1)

- The C&R document requirements take precedence.

	AO Requirement Description	AO Section	AO Requirement(s)	Reference(s) for Phase A CSR
1	Independent Verification and Validation of Software	4.6.1	n/a	Requirement CS-54
2	Costing of coordination with Conjunction Assessment Risk Analysis	4.6.4	n/a	Requirement CS-45
3	Science Enhancement Option and its cost, if proposed	5.1.6	18 and 19	Requirement CS-34
4	Demonstration of maximum channel bandwidth	5.2.7.2	44	Requirement CS-45
5	Discussion of critical event coverage capabilities	5.2.8	48	Requirement CS-45
6	Detailed plan for orbital debris and disposal	5.2.9	49	Appendix L.10
7	Non-AMMOS system use and description	5.2.10	50	Appendix L.24 Requirement CS-150
8	Descriptions of the Space Systems Protection implementation	5.2.11	51	Appendix L.20 Requirement CS-142-145
9	Ground system data flow diagram	5.2.12	52	Requirement CS-45
10	Naming of the Project Manager (PM)	5.3.2	54	Requirement CS-62
11	Naming of the Project Systems Engineer (PSE)	5.3.3	55	Requirement CS-62
12	Citizen Science and its cost, if proposed	5.1.7	n/a	Requirement CS-79-81
13	Student Collaborations and their cost, if proposed	5.4.6	68, 69	Requirement CS-76-78
14	Discussion of cost estimate error and uncertainty	5.5.3	77	Requirement CS-91
15	Schedule-based end-to-end Data Management and Archive Plans	4.4.2, 4.4.3	B-30 and B-31	Appendix L.5
16	Requirements for real year dollar costs	5.5.1	70, B-15, B-59, and B-60	Requirement CS-94 Cost templates

List of Participants and Table of CS Requirements

- Requirement CS-9 The Concept Study Team shall 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 they are proposing to provide work should the mission be down-selected. Additionally, the Study Team shall 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. The Concept Study Team shall provide the draft list of the participants as a Microsoft Excel spreadsheet document to the point-of-contact [Dr. Patricia Knezek] (AO Section 6.1.5) three months prior [August 14, 2025] to the due date of the CSR [November 14, 2025], using the Microsoft Excel spreadsheet template in the Program Library. This list is to be updated and a final revision shall be included in a separate electronic file at the time of CSR submission.
- Requirement CS-10 The Concept Study Team shall create a separate document that contains a table with all of the requirements (Requirement CS-1 through Requirement CS-153) and the page, section, or table number that is the main place in the CSR where the requirement is addressed. Concept Study Teams shall provide this table as a PDF document to the point-of-contact for the AO by email no later than seven calendar days after the CSRs are due. [Augmented submission: November 21, 2025]

Trajectory Supplement

Requirement CS-40 Trajectory for non-Electric Propulsion: For any mission that will perform Phase E operations beyond Geostationary Earth Orbit (GEO) to achieve its science orbit, the following information shall be provided in a file or files along with the CSR submission as part of a trajectory supplement. This information is optional for missions that remain within Earth orbit at or below GEO. Any graphical references, tables, figures, etc. shall be presented in a minimum of 150 dots per inch (dpi).

1. Checkout Duration: The minimum duration allocated after launch before the primary propulsion system will be commanded to provide required delta-v.
2. Initial Mass Assumptions: Provide the initial mass used for generation of the trajectories including propellant loading assumptions.
3. Event Basics: Provide the date/time of each trajectory event with a brief event description (e.g., Launch, Gravity Assist, Fly-by, Rendezvous, Mid-Course Burn) and the appropriate data for the event (e.g., flyby altitude, flyby angle, flyby/intercept velocity, delta-v magnitude). These data should be included for three different scenarios corresponding to the Open, Middle, and Closing of the proposed launch window.
4. Event Body Ephemeris: Provide ephemeris data for all event bodies (fly-by planet, asteroid fly-by, comet rendezvous, etc.). Include the source of the ephemeris data and the epoch for the actual ephemeris point used for a particular event.
5. Any other trajectory specific information not called out above that would be relevant to reviewers attempting to validate the trajectory

Trajectory Supplement

Requirement CS-41 Trajectory for Electric Propulsion: For any investigation using Electric propulsion, the following information shall be provided in a file or files along with the CSR submission as part of a Trajectory Supplement. Any graphical references, tables, figures, etc. shall be presented in a minimum of 150 dots per inch (dpi):

1. Checkout Duration: The minimum duration allocated after launch before the primary propulsion system will be commanded to provide required delta-v.
2. Initial Mass Assumptions Power model for performance based on solar distance: Provide the functional relationship showing the performance of the solar arrays as a function of the trajectories including propellant loading assumptions.
3. Event Basics: Provide the date/time of each trajectory event with a brief event description (e.g., Launch, Gravity Assist, Fly-by, Rendezvous, Mid-Course Burn) and spacecraft's distance from the Sun.
4. EP Throttling Model: Provide the throttling model used to generate EP engine performance at any point during the trajectory and a brief explanation of the approach.
5. Assumed Engine Duty Cycle: Provide the overall Duty Cycle for the EP engines and if applicable provide the duty cycle over each trajectory segment.
6. Number of Engines: Provide the maximum number of engines on the spacecraft that could be operating simultaneously. In addition, provide the number of engines operating throughout each phase of the trajectory.
7. Any other trajectory specific information not called out above that would be relevant to reviewers attempting to validate the EP aspects of the trajectory and orbit.

Orbital Debris, Collision Avoidance, End-of-Mission

Orbital Debris (Section L.10)

Requirement CS-127 This appendix shall discuss briefly how the mission meets the NPR 8715.6 and NASA-STD-8719.14 orbit debris requirements applicable to its proposed orbit.

Requirement CS-128 For LEO missions, this appendix shall discuss the lifetime of the mission and whether it meets the 25-year post mission requirement [...]

Requirement CS-129 **This appendix shall provide a brief description, including any cost deltas, of the impact on the investigation if the 25-year post-mission orbital lifetime requirement is changed to 5 years.** This description shall assume that the requirement change is implemented at PDR. The evaluators may submit comments to the Selection Official on appendix material that addresses this requirement.

Requirement CS-130 For non-LEO missions, this appendix shall include a discussion of how end-of-mission requirements will be met.

Requirement CS-131 If the plan is to dispose of the satellite at the end of mission, this appendix shall provide the parameters of the disposal orbit, the delta-v allocation for disposal, and any other relevant assumptions.

Conjunction Assessment Risk Analysis (CARA)

- The Program Library includes NPR 8079.1 and the Office of the Chief Engineer (OCE)'s document OCE-51, *NASA Spacecraft Conjunction Assessment and Collision Avoidance Best Practices Handbook*

Cost Related Items

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

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

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

TMC Cost Process

The backup section explains the TMC Cost Analysis process (already discussed in APEX Pre-Proposal Conference)

Site Visits

- Site visits with oral briefings will be used to clarify implementation details and commitments.
- Site visits are anticipated ~3 months after the CSR due date at location sites to be coordinated between each PI/Concept Study Team and NASA HQ/SOMA.
- The site visit durations will be up to 7 hours plus up to 1 hour for an optional tour / demonstration.
- All site visit presentations / briefings shall be in a plenary session with all Evaluation Team members attending - no splinter sessions.
- Written significant weaknesses, questions, and/or requests for information will be provided to the PI/Proposal Team several (TBD) days before the site visit. All teams will have the same lead time.
- Some questions will require an early response, 2-4 (TBD) days before the site visit.
- Any additional information provided to NASA by the Concept Study team at the site visit, in response to the NASA-identified weaknesses and questions, or in response to NASA requests for additional information, will be treated as updates and clarifications to the CSR.

Phase B Plan

- Immediately following the continuation decision (i.e., down-selection), the successful team 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 team will be required to provide cost and pricing data for Phase B that are necessary and required to implement the contract for Phase B. Complete cost and pricing data will be required for each organization participating in Phase B. These data should allocate project costs per the cost categories defined in Table 15-2 of the FAR.
- Once entering Phase B, APEX projects are subject to the same requirements as all other NASA projects. 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 7120.5: “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.”).

Additional Documents in the Program Library

https://explorers.larc.nasa.gov/2023APPROBE/programlibrary.html

- Space Systems Protection documents FIPS PUB 140-2 Change Notices (12-3-2002)
- Samples of International Agreement examples (Juno with Belgium, MSL with France)
- Program Level Requirements Appendix (PLRA) examples (TESS, ICON)
- Mission Definition Requirements Agreement (MDRA) example (ICON)
- Level 1/Level 2 Requirements Presentation from PI Forum
- CSR Conflicted Party List Template
- Microsoft Excel versions of the Step 2 *Cost Template Tables* in the C&R document
- Science Change Matrix Example

Points of Contact

- Launch Services Program (LSP):
  John Calvert, Mission Manager
  john.h.calvert@nasa.gov

- Space Communications and Navigation:
  Jeff Hayes, NASA HQ SCaN Program Office
  jeffrey.hayes-1@nasa.gov

- Spectrum Office:
  bryan.a.rhodes@nasa.gov

- Project Protection Plan and Cybersecurity:
  Jerry Esper, SMD Program Executive for Systems Security
  jerry.s.esper@nasa.gov

- Conjunction Analysis Risk Assessment (CARA):
  Alinda Mashiku
  alinda.k.mashiku@nasa.gov

- Multimission Automated Deepspace Conjunction Assessment Process (MADCAP):
  David Berry
  david.s.berry@jpl.nasa.gov

All further questions pertaining to the APEX AO and C&R

MUST be addressed by email to:

Dr. Patricia Knezek
APEX Program Scientist
Science Mission Directorate
NASA Headquarters
Washington, DC 20546
patricia.m.knezek@nasa.gov

Victor Lucas
APEX Acquisition Manager
Science Office for Mission Assessments
victor.f.lucas@nasa.gov

(subject line to read “APEX AO")

Questions?

Please review the Criteria & Requirements document as soon as possible, so questions can be addressed in a timely manner.

Initial deadline for questions on the C&R: January 17, 2025

Backup: References

APEX AO Reference Material

APEX Acquisition Home Page

The APEX acquisition home page is available at

https://explorers.larc.nasa.gov/2023APPROBE/

The contents of the web site include the following:

- Community announcements and APEX AO news
- Links to the APEX AO and to SAM.gov
- Program Library
- Evaluation Plan
- APEX AO Q&As
- Teaming interest
- Preproposal conference materials

APEX AO Reference Material

APEX Program Library

- The Library provides additional regulations, policies, and background information. The Library is accessible at https://explorers.larc.nasa.gov/2023APPROBE/programlibrary.html
- It is incumbent upon the proposer to ensure that the documents used in proposal preparation are of the date and/or revision available in the Program Library.

Questions and Answers

- Questions sent to the PS and AM are answered on the Acquisition Homepage at https://explorers.larc.nasa.gov/2023APPROBE/
- Questions are welcome up to 14 days before CSR due date (*i.e.*, by October 31, 2025).
- Questions are anonymized before publication on the web page.
  - The Evaluation Panels are not made aware of what proposers originated which questions.
- Publication ensures that all proposers have equal access to the same information.

Back-Up: TMC Cost Analysis

Cost Analysis Overview

- Cost is one important element of Technical, Management and Cost (TMC), but only one.
- Initial cost analyses are performed on the basis of information provided in the proposals

  (*e.g.*, technical baseline, schedule, WBS, cost consistency and completeness, basis of estimate, contributions, use of full cost accounting)
- Cost models for TMC Base Independent Cost Estimates ("base ICE")
  - Two or more cost models are used to validate the proposed cost for Phases B-D. One or more for Phase E.
  - Cost Models are chosen to be complementary to each other when possible, *i.e.,* different modeling approaches.
  - For Step 2 evaluations, more cost models may be used.
  - Cost model inputs are obtained from the information in the Proposal in order to develop the TMC ICE for the project "as proposed".
- The TMC identifies implementation threats (weaknesses) and assigns Cost Threats where applicable.
  - Cost Threats are estimates of the cost to mitigate the identified threat and the likelihood that the mitigation will be needed. The total of all Cost Threats above a selected threshold are compared to the proposed unencumbered reserves.
  - Benefit of the doubt is applied in the assignment of cost threats. Cost threats are additional considerations related to a Major Weakness, not a full characterization of the MW.
- The entire panel participates in Cost deliberations. All information from the entire evaluation process is considered in the final cost assessment. The cost assessment is one consideration in the risk rating.

Decoding Cost Validation MW

- A cost validation Major Weakness can take the following form:

A sum of cost elements over which the selected cost model(s) are validated against actuals.
Typically can be:
- WBS 1+2+3
- WBS 5
- WBS 6+10
- Total Phases B-D
- Total Phase E

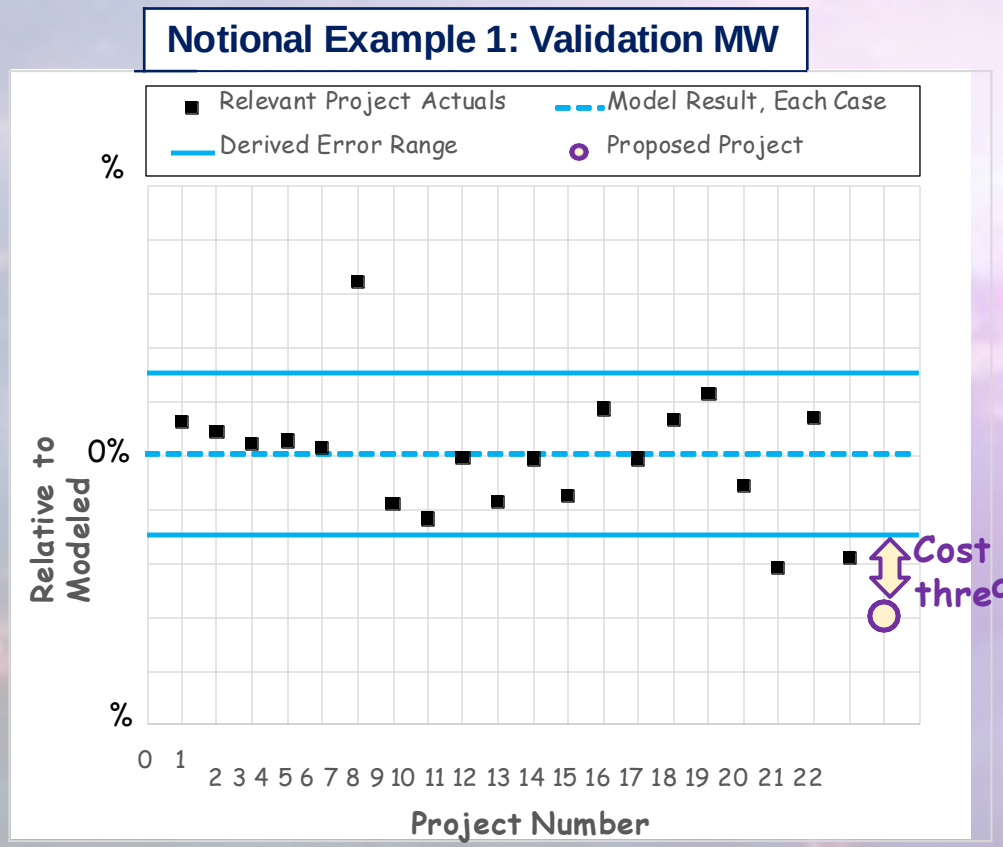
The proposed costs for WBS X.XX cannot be validated, as the TMC Base Independent Cost Estimate exceeds the proposed cost by more than the error range.

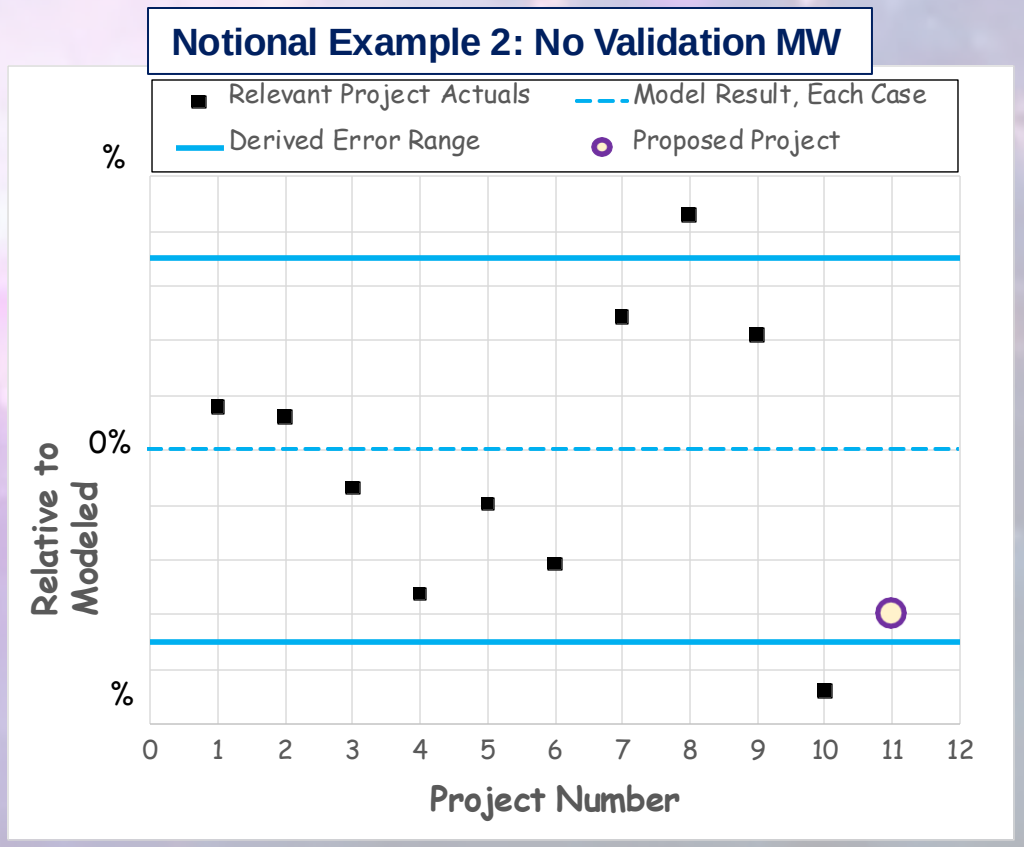
The TMC Base ICE:
- combines the results of the models used (no reserves)
- is performed with the best performing models selected after testing several models against past actuals relevant to this acquisition
- follows the same process, for all proposals in this acquisition
- uses inputs that are based exactly on information in the proposal (*incl.* MEL, schedule, heritage, TRL, cost BOE, *etc.*)

A specific error range is:
- defined prior to the start of proposal evaluations
- derived for this acquisition and each WBS group
- applied to the TMC Base ICE
- based on the combined performance of the selected models on past actuals relevant to this acquisition

Notional Validation Error Bar Example

- How large a difference from the cost model is needed to trigger a validation finding?
- It depends on how well the chosen cost model combination validates against actuals of relevance, statistically.

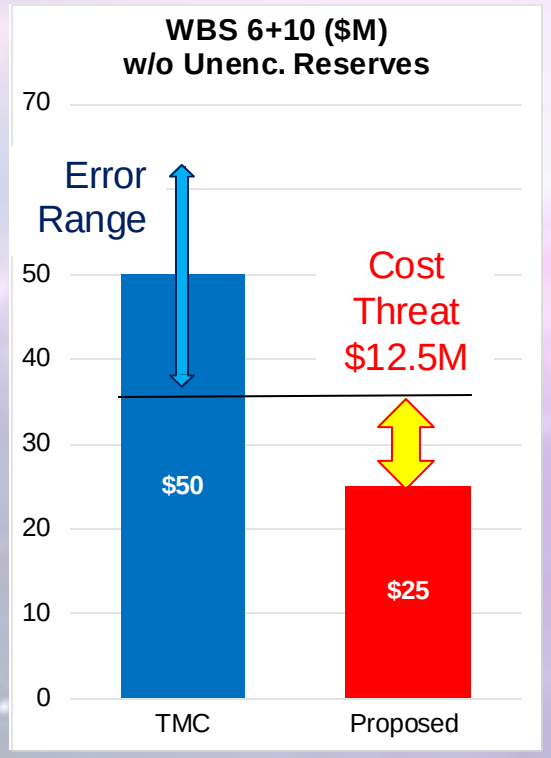




Decoding Cost Validation MW: Example

Notional Proposal A: validates

Notional Proposal B: does not validate



- The situation shown in notional example A would not result in a validation finding.
- The situation shown in notional example B would result in the following finding:

"The proposed costs for the sum of WBS 6 and 10 cannot be validated, as the TMC Base Independent Cost Estimate exceeds the proposed cost by more than the error range. "

…followed by a cost threat statement.

Cost Threat Matrix

- The likelihood and cost impact, if any, of each weakness is estimated then stated in terms of Likelihood and Impact categories
  - The **likelihood** is the probability range that the cost impact will materialize.
  - The **cost impact** is the current best estimate of the range of costs to mitigate the threat.
- The cost threat matrix defines the adjectives that describe the likelihood and cost impact.
- The minimum cost threat is $1M for Phases B/C/D *and $250K for Phase E*.

Normal black text shows the Phases B/C/D version of the CTM
Italics blue text shows the Phase E version of the CTM

			Cost Impact (CI) % of PI-Managed Mission Cost to complete Phases B/C/D or *% of Phase E* not including unencumbered cost reserves or contributions					
	Likelihood of Occurrence	**Weakness**	**Very Minimal** 0.5% < CI ≤ 2.5% ($xM < CI ≤ $xM) *1% < CI ≤ 2.5%* *($xM < CI ≤ $xM)*	**Minimal** 2.5% < CI ≤ 5% ($xM < CI ≤ $xM) *2.5% < CI ≤ 5%* *($xM < CI ≤ $xM)*	**Limited** 5% < CI ≤ 10% ($xM < CI ≤ $xM) *5% < CI ≤ 10%* *($xM < CI ≤ $xM)*	**Moderate** 10% < CI ≤ 15% ($xM < CI ≤ $xM) *10% < CI ≤ 15%* *($xM < CI ≤ $xM)*	**Significant** 15% < CI ≤ 20% ($xM < CI ≤ $xM) *15% < CI ≤ 20%* *($xM < CI ≤ $xM)*	**Very Significant** CI > 20% (CI > $xM) *CI > 20%* *(CI > $xM)*
Likelihood (L, %)	Almost Certain (L > 80%)							
	Very Likely (60% < L ≤ 80%)							
	Likely (40% < L ≤ 60%)							
	Possible (20% < L ≤ 40%)							
	Unlikely (L ≤ 20%)							

Note: Each "$xM" is converted to dollars according to the associated percentage depending on the proposed PIMMC.

Decoding Cost Threat Statement

- When a Cost Threat is associated with a Major Weakness, the cost threat statement takes the following form:

Estimated likelihood of the cost threat being realized:
- Unlikely: < 20% (weight 10%)
- Possible: 20% - 40% (weight 30%)
- Likely: 40% - 60% (weight 50%)
- Very Likely: 60% - 80% (weight 70%)
- Almost Certain: > 80% (weight 90%)

This finding represents a cost threat assessed to have a [LIKELIHOOD] likelihood of a [IMPACT] cost impact being realized during development and/or operations, which results in a reduction from the proposed unencumbered cost reserves.

Estimated magnitude of the cost threat relative to the proposed cost (PIMMC in that phase):
- Very minimal: 0.5% – 2.5% (subject to lower $ threshold)
- Minimal: 2.5% - 5%
- Limited: 5% - 10%
- Moderate: 10% - 15%
- Significant: 15% - 20%
- Very Significant: > 20%

(Can be a specific estimate or middle of the range)

Phase affected by cost threat
- Cost threat impact ranges established separately for Phases B-D and Phase E
- Cost threats evaluated separately against Phases B-D and Phase E
- Impact of cost threats on reserves applied separately to Phases B-D reserves and to Phase E reserves

If realized, cost threats would consume unencumbered cost reserves
- By definition, TMC-identified cost threats are above and beyond the proposed cost basis and the proposed encumbered cost reserves

Decoding Cost Threat Statement: Examples

Example of cost threat statement 1: cost validation Major Weakness

- The cost validation process results in a cost threat of $12.5M for WBS 6+10. The notional example PIMMC for Phases B-D is $100M.
- The TMC ponders the case made in the proposal for cost-reducing paradigm and gives further benefit of the doubt to the proposer. The likelihood of this cost threat is estimated in the range 20%-40%.
- The TMC appends the following statement to the cost validation MW:

> *This finding represents a cost threat assessed to have a **Possible** likelihood of a **Moderate** cost impact being realized during **development**, which results in a reduction from the proposed unencumbered cost reserves.*

Example of cost threat statement 2: technical Major Weakness

- The TMC considers that the Technology Readiness Level (TRL) is overstated and that it is likely that a TRL development plan will be required before KDP-C. The notional example PIMMC for Phases B-D is $100M.
- The TMC estimates that the cost for an adequate TRL development plan would be in the range of $2.5M to $5M
- The TMC writes the technical MW and appends the following statement:

> *This finding represents a cost threat assessed to have a **Likely** likelihood of a **Minimal** cost impact being realized during **development**, which results in a reduction from the proposed unencumbered cost reserves.*

Decoding Summary Statement

Cumulative impact of cost threats

- The Form C "Overall Evaluation/Rationale" Summary could include a statement of the following form.
- When present, this statement informs the risk rating, together with all of the Major Findings. This statement alone does not automatically result in any specific rating.

Example (could also be Phase E)

Subtract total from the total proposed unencumbered cost reserves in that p hase

Applies to unencumbered only. (Encumbered reserves are already assigned to other, specific risks.)

The TMC-identified cost threats reduce the Phases B–D unencumbered cost reserves below the 25% required by the AO.

Total of all identified threats
- weigh impact by likelihood
- add %unencumbered reserves required by the AO (25% for Phases B-D, 15% for Phase E)

TMC compares remaining to AO-required %
- An informational statement
- TMC also assesses the appropriateness of the proposed %unencumbered cost reserves for the specific proposed scope, as justified by the proposal

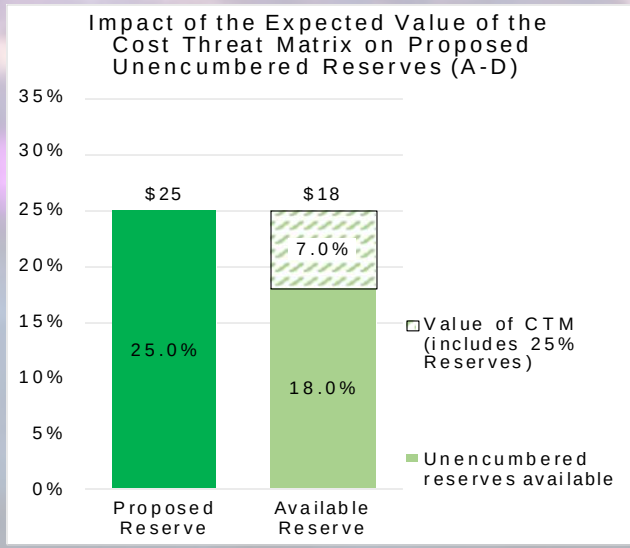
Decoding Summary Statement: Example

Example of cumulative impact (notional)

- The cumulative impact of the cost threats for this notional example brings the unencumbered cost reserves level from the proposed level of 25% down to 18%.

Example for Phases B/D	
PIMMC without unenc. reserves	$100.0
Proposed unenc. reserves %	25%
Proposed unenc. reserves	$25.0
Total expected cost threat impact	$5.6
Reserves % on cost threats	25%
Total impact of cost threats	$7.0
Proposed unenc. reserves minus expected cost threats	$18.0
Proposed unenc. reserves minus expected cost threats %	18.0%

		Cost Impact (CI) % of Baseline Mission Cost to complete Phases B-D not including unencumbered cost reserves or contributions					
Likelihood of Occurrence	Weakness	Very Minimal $1.0M<CI≤2.5% ($1M<CI≤$2.5M)	Minimal 2.5%<CI≤5% ($2.5M<CI≤$5M)	Limited 5%<CI≤10% ($5M<CI≤$10M)	Moderate 10%<CI≤15% ($10M<CI≤$15M)	Significant 15%<CI≤20% ($15M<CI≤$20M)	Very Significant CI>20% (CI>$20M)
AlmostCertain (L>80%)							
VeryLikely (60%<L≤80%)							
Likely (40%<L≤60%)	TRL Maturation		$1.9 $3.75M x 50% = $1.9M				
Possible (20%<L≤40%)	Cost Validation				$3.7		
Unlikely (L≤20%)							



Clarification of Cost PMWs

The Clarification (Step 1) or SQRL and Site Visit (Step 2) process offers a chance for updating cost information

Information from proposers provided in Clarifications (Step 1) or in SQRL responses and during the Site Visit (Step 2) may be relevant to cost threat statements associated with PMWs.

For example, the following types of information may be folded into the cost analysis even after the initial proposal (Step 1) or CSR (Step 2) submission.

- Past actuals for efforts justified as being similar or otherwise relevant.
- References to past efforts justified as being similar, for which past actuals in CADRe exist.
- Further basis of estimate details, for the specific area(s) identified in the PMW.
- Resolution of inconsistencies or clarification of any misunderstanding affecting cost model inputs.

Benefit of the Doubt in Cost Validation

The TMC Cost Validation process has been geared in several ways towards providing proposers the benefit of the doubt.

1. The inputs to the cost models are derived directly from the descriptions in the proposal (Step 1) or CSR (Step 2), “as proposed”
   - This includes all heritage and TRL level claims.
   - TMC’s independent assessment of technical parameters, if it differs from that of the proposal, is not factored into the Base ICE. It would be reflected in separate findings, with associated cost threats if applicable.
2. Validation error bars are derived specifically for each solicitation. They reflect how well the selected cost model combination performs against actuals of relevance to the solicitation.
   - A cost validation finding major weakness is written only if the proposed cost is outside that error bar.
3. The validation cost threat impact only reflects excursions outside of the error bar (not the full delta between modeled and proposed).
4. The validation cost threat impact is weighted by the cost threat likelihood.
5. Proposal and clarification content can affect the likelihood of the validation cost threat.

Evaluation of the Cost Basis of Estimate

- AO Req. B-53 (Step 1) and Req. CS-78, CS-79 (Step 2) describe requirement for the Basis of Estimate (BOE):
  - Traceable to the WBS of Table B3 (Step 1) or B3a and B3b (Step 2),
  - Description of the methodologies and assumptions used to develop the proposed cost estimate,
  - Description of cost reserves that provides insight into their adequacy and robustness,
  - If applicable, document the multiple-build costing methodology,
  - Any additional BOE data to assist the validation of the cost estimates.
- The type of data useful to support a BOE depends on the method used for the cost estimate
  - Example if based on analogy: list heritage cost and rationale for adjustments
  - Example if using parametric model: model name and version, key inputs used with rationale
  - Example if using bottom-up estimates: breakout of labor vs material, FTEs and/or WYEs and average labor rates, list of significant hardware with date and importance to investigation.
- TMC's evaluation of the quality of the proposer's basis of estimate is separate from TMC's ICE analysis.
- Different findings can result from the BOE and from the ICE. If the findings are Major (or Significant Minor in Step 2), they are both considered during polling for the final risk rating.

Cost Validation Lessons Learned

Proposal teams who do the following tend to better support their proposed cost

- Estimate both schedule and cost iteratively, starting early in proposal development; let that inform the proposed scope.
- Estimate both schedule and cost conservatively by accounting for remaining unknowns and for expected cost growth during proposal development and during Phase A.
- Identify cost-driving parameters clearly and consistently (including TRL, modifications from heritage, engineering models & spares, *etc.*)
- Use NASA Standard WBS definitions and terminology.

Cost Threats Lessons Learned

Proposal teams who do the following tend to better support their proposed reserves posture

- Apply risk management process early; plan mitigations appropriate for the proposed project class.
- Encumber appropriate amounts of cost reserves against those risks that could impact schedule and/or cost.
- Determine the levels of funded schedule reserve and of unencumbered cost reserves that would be adequate and robust for the proposed project –as well as their phasing.
  - Unencumbered cost reserves higher than the minimum AO requirement, and funded schedule reserves higher than typical practices, may be necessary for some elements of some projects, such as those requiring specific technology maturation.
  - Remember to also carry unencumbered cost reserves against the encumbered cost reserves; encumbered cost reserves are part of the base PIMMC.
- Remember that appropriate cost reserves could be either the minimum required by the AO, or higher as assessed by the TMC evaluation panel based on the justification provided by the proposal.

Additional Information on Cost Estimation

- NASA WBS Handbook in the Program Library https://explorers.larc.nasa.gov/2023APPROBE/pdf_files/NASA03.%20NASA%20SP-3404%20WBS%20Handbook.pdf
- NASA Cost Estimating Handbook: https://www.nasa.gov/ocfo/nasa-cost-estimating-handbook-ceh/
- Note that several NASA cost models that may be relevant to some projects are free to proposers and do not require cost expert training (spreadsheet-based and compatible with Mac and PC). These include:
  - Project Cost Estimating Capability (PCEC)
  - NASA Instrument Cost Model (NICM)
  - Mission Operations Cost Model (MOCET)

  Access can be requested at https://software.nasa.gov/software/category/all/aw/1/cost

  Use of these models is not a requirement nor an expectation.