

Senior Review Subcommittee Report on Proposals for Mission Extensions for 2019

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**Meeting of the Planetary Science Advisory
Committee (PAC)
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**Room 3D42
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Approach I

- The NASA Planetary Mission Senior Review (PMSR) for 2019 was carried out in a series of face-to-face meetings from 6 to 10 May 2019.
- To comply with the provisions of the Federal Advisory Committee Act (FACA), the applicable six missions were evaluated by members of individual Subject Matter Expert (SME) panels assembled by Arctic Slope Research Services (ASRS), contracted by NASA for this purpose
- Prior to these meetings individual SME panelists reviewed the mission project Senior Review / Extended Mission proposals

Approach II

- The subsequent face-to-face meetings allowed for members of each mission to respond to questions posed by the corresponding SME panel
- Each SME panel produced a NASA Planetary Science Division (Consolidated) Senior Review Findings 2019 report and provided two votes on each mission: one for Scientific Merit and one for Technical Merit
- At the individual initiative of two of the panels, two votes were taken for two of the missions for both in-guide and over-guide variants, as documented in the extended mission proposals

Approach III

- These reports and votes were provided to the Senior Review Subcommittee (SRS) made up of seven Special Government Employees (SGEs) selected by personnel of the NASA Planetary Science Division (PSD) for this purpose
- The SRS observed each SME panel and its deliberations and asked questions of the SMEs, but these queries were limited to procedural and programmatic questions
- Each SME panel and each Senior Review proposal team were otherwise explicitly isolated from each other

Approach IV

- The SRS observed *all* proceedings and discussions of all panels and parties
- This activity was undertaken in accord with all applicable documented requirements to ensure that the final evaluations and recommendations were consistent and without prejudice across all six missions reviewed
- The SRS produced a descriptive summary for each mission, including findings of fact and recommendations to the Planetary Science Advisory Committee (PAC) for disposition of each Senior Review proposal

Approach V

- A high-level, bulletized summary of each SME (*Consolidated Senior Review Findings*) report was produced, the Scientific Merit and Technical Merit scores and their averages were reviewed and discussed
- This publicly releasable report documents these materials and constitutes the formal and final report of the SRS to the PAC.
- Subject to all of these considerations, the numerical and adjectival rankings are shown in Table 1
- Section 6 provides details on the SME scorings; section 7 provides details on the translation of these scorings to the SRS rankings.

Table 1. SRS Summary of Mission Rankings for 2019 (Ordered by Mission Ranking)

Mission	Recommended Budget	Mean of Scientific + Technical Merit	Adjectival Rating
Lunar Reconnaissance Orbiter (LRO)	Inguide	4.90	Excellent (Science = E)
Mars Reconnaissance Orbiter (MRO)	Inguide	4.88	Excellent (Science = E)
Mars Science Laboratory (MSL)	Inguide	4.75	Excellent (Science = E)
Mars Science Laboratory (MSL)	Overguide	4.75	Excellent (Science = E)
Mars Odyssey (MODY)	Overguide	4.75	Excellent
Mars Atmosphere and Volatile Evolution (MAVEN)	Inguide	4.50	Very Good / Excellent
Mars Express (MEX)	Descope	3.30	Good / Very Good
Mars Odyssey (MODY)	Inguide	2.75	Good
Mars Express (MEX)	Inguide	2.40	Fair / Good

Background and Senior Review Subcommittee

- The Senior Review Subcommittee (SRS) and individual review panels met in Pittsburgh, Pennsylvania, from 6 to 10 May 2019.
- Each review panel of subject matter experts (SME), selected by Arctic Slope Research Services (ASRS), were briefed by the lead NASA Designated Federal Officer (DFO) and the ASRS lead for one hour on the Charge to the Panel
- Each mission project team was then provided with 90 minutes to present a salient summary of their mission and response to panel questions
- The mission project team, limited to five participants, was then excused and the review panel deliberated for 30 minutes on the presentation and responses
- The project team was called back for followup for 30 minutes and then excused a second time.

Schedule I

- The actual presentation order was determined by the availability of personnel (project, panel, SRS, and HQ)

	Monday 5/6/2019	Tuesday 5/7/2019	Wednesday 5/8/2019	Thursday 5/9/2019	Friday 5/10/2019
8:00 AM	Breakfast	Breakfast	Breakfast	Breakfast	Breakfast
8:30 AM	Charge to Panel 1	Panel 2 deliberation/write-up	Charge to Panel 4	Panel 5 deliberation/write-up	SRS deliberation/write-up
9:00 AM					
9:30 AM	Project 1 presentation		Project 4 presentation		
10:00 AM	MRO	SRS deliberation	LRO	SRS deliberation	
10:30 AM		Charge to Panel 3		Charge to Panel 6	
11:00 AM	Panel 1 deliberation		Panel 4 deliberation		
11:30 AM	Project 1 callback	Lunch	Project 4 callback	Lunch	
12:00 PM	Lunch		Lunch		Lunch
12:30 PM		Project 3 presentation		Project 6 presentation	SRS deliberation/write-up
1:00 PM	Panel 1 deliberation/write-up	MAVEN	Panel 4 deliberation/write-up	Mars Odyssey	
1:30 PM					
2:00 PM		Panel 3 deliberation		Panel 6 deliberation	
2:30 PM	SRS deliberation	Project 3 callback	SRS deliberation	Project 6 callback	
3:00 PM	Charge to Panel 2	Panel 3 deliberation/write-up	Charge to Panel 5	Panel 6 deliberation/write-up	End of Day 5
3:30 PM					
4:00 PM	Project 2 presentation		Project 5 presentation		
4:30 PM	MSL	SRS deliberation	Mars Express	SRS deliberation	
5:00 PM		End of Day 2		End of Day 4	
5:30 PM	Panel 2 deliberation		Panel 5 deliberation		
6:00 PM	Project 2 callback		Project 5 callback		
6:30 PM	End of Day 1		End of Day 3		

Schedule II

- The SME Panel then deliberated (with only SRS members, DFO and Civil Servant backups to the DFO also in attendance), leading to a vote on the Scientific and Technical Merit for 90 minutes and subsequently were excused for the Panel chair to write up the (Consolidated) Senior Review Findings which were forwarded to the SRS as input to this report
- The entire SRS membership, the NASA DFO, the ASRS lead, and the Lead Scientist, Mars Exploration Program were invited to, and generally present for, all of these sessions; detailed notes for all sessions were taken by the NASA-support Secretary
- The SRS then wrote this report, as guided by the Senior Review Subcommittee of the Planetary Advisory Committee Guidelines for Conducting the 2019 Senior Review
 - The SRS consisted of seven individuals, including the Chair and Deputy Chair
 - The Deputy Chair and the other five members (one of whom is also a member of the PAC), were each responsible for leading and coordinating the discussion within the SRS for one of the SME panels
- The Chair, as assisted by the Deputy Chair and the other SRS members, is responsible for this report

Applicable Documents

- The transition of the Planetary Science Advisory Committee (PAC) to a formal Federal Advisory Committee Act (FACA) body—and associated concerns regarding potential conflicts of interest expressed by NASA Legal Counsel and the NASA Ethics Office—led to substantive changes in previous protocols as described in governing documents dating from October 2018
- In response, the SRS and NASA Program Executive drafted and adopted the Senior Review Subcommittee of the Planetary Advisory Committee Guidelines for Conducting the 2019 Senior Review prior to the first SRS deliberation to ensure the SRS members were all acting under the same assumptions
- That document incorporates the required modifications to the Memorandum for the Record (MoR): Plan for the 2019 Planetary Mission Senior Review and the Planetary Senior Review Terms of Reference (ToR)
- This unofficial document was used for internal guidance and documentation on the last day (10 May 2019) of the review, all of which consisted exclusively of SRS and NASA personnel and the ASRS lead.

Leveling of Missions

- The SRS observed consistent and equal treatment during mission project presentations and SME panel deliberations
 - The SMEs covered the science topics with uniform thoroughness and fairness
 - This consistency was aided by the presence of some SME panelists on multiple panels and by some SMEs chairing multiple panels
 - Conflicts of interest were avoided throughout
- Some members of the SRS identified a potential lack of appropriate science expertise (in organic geochemistry) for MSL
 - However, after in-depth discussion among the SRS membership, it was concluded that this did not substantively affect the overall evaluation of the SRS for MSL
- Another concern identified by ASRS personnel and the SME panels, which affected several projects, was the lack of appropriate expertise to address in-depth the Technical Merit of several missions
 - The issue occurred due to the difficulty encountered by the ASRS lead in identifying appropriate, non-conflicted candidates for Panel membership
 - The problem was mitigated somewhat by the expertise of two of the members of the SRS and the presence of the current Lead Scientist for the Mars Exploration Program at NASA Headquarters

SRS Summaries, Findings, and Recommendations by Mission I

- Each of the SME panel chairs completed a NASA Planetary Science Division (Consolidated) Senior Review Findings 2019 document
 - Near-final drafts of each SME Finding Document were forwarded to all members of the SRS
 - The SRS discussion lead for each mission used the relevant mission report and related SRS discussions to draft the SRS report, which was then discussed, modified, and agreed to by the entire SRS
 - The results of this agreement formed the basis for this report.
- Based upon a review of the materials, the SRS extracted a short summary, based heavily on a combination of the SME panel's proposal summary and its rationale for the Science Merit and Technical Merit evaluations
 - The SRS worked to provide consistency of language, ranking, and analysis among the different SME Panel reports
 - The goal was to distill down the relevant findings and recommendations to emphasize highlights for public dissemination and delivery to the PAC

SRS Summaries, Findings, and Recommendations by Mission II

- In addition, the SRS extracted the numerical and adjectival scores for Science and Technical Merit along with a précis of the strengths and weaknesses identified by the SME panels for each mission.
- The SRS produced a separate summary considered to be its more important product
 - The goal was to produce summaries that are concise and actionable and to capture discussions of both the SME panels and the SRS
 - To this end, the majority of the final meeting day (Friday 10 May) was used to reach consensus language for each of the SRS “paragraph assessments.”
 - These reports are provided in the following sub-sections of this section (Section 4)
 - Details of the adjectival and numerical evaluations, summarized at the top level in Table 1, are given in Section 5 and were used to rank the missions explicitly, as provided for in the ToR
 - The top level strengths and weakness of the proposed extended missions, as clarified in the oral presentations of the mission project teams during the week are provided in Section 6

Lunar Reconnaissance Orbiter (LRO)

- ***Finding.*** The SRS found that the new NASA policies regarding lunar exploration emerged after the LRO proposal was submitted; therefore, the Project was unable to discern implications of this new budget policy on LRO requirements. LRO already collects a significant volume of landing site data for mission; however, the new policies of returning humans to the Moon by 2024 could escalate data and data product demands that could rapidly impact their budgets as commercial and NASA missions accelerate to fulfill the new policies and objectives
- Therefore, the SRS found that LRO's requested inguide funding is appropriate at this time; however, consideration should be given to the fact that product and budget demands may increase, given new NASA exploration policies, e.g. flowing from CLPS.

Mars Atmosphere and Volatile Evolution (MAVEN)

- ***Finding:*** Maven requests no over-guide funding. MAVEN is carrying no reserve, and, in the past, they have been able to solve their issues within their allocated funding. The SRS agrees with the numerous strengths identified by the Maven Mission SME Panel and their recommendation for guideline funding.
- ***Recommendation:*** The SRS recommends that this scientifically productive mission receive the identified guideline funding.

Mars Express (MEX) I

- ***Finding.*** The proposed mission extension is primarily a continuation of existing observations. The SRS agreed with the SME panel that insufficient justification was provided for the science proposed. The notable exceptions were the proposed MARSIS ionospheric and subsurface soundings and HRSC observations of the anti-Mars hemisphere of Phobos. This situation led to two separate votes by the SME panel: one for the science proposed as written and a second for the proposed science restricted to what the SME panel considered the highest priority. This second vote supported the narrower science objectives of (1) upper atmosphere and ionosphere, (2) subsurface sounding, and (3) anti-Mars Phobos/Deimos observations. The second vote did not support the proposal's remaining science objectives of (1) study of lower atmosphere and the convective boundary layer, (2) surface feature observations, and (3) surface composition analysis.
- ***Recommendation.*** The SRS agrees with this finding of the SME panel.

Mars Express (MEX) II

- ***Finding.*** The SME panel noted among the key potential contributions that the synergy with MAVEN could allow improved understanding of Mars-solar wind interaction and responses of the magnetosphere and ionosphere to different drivers. Additional potential value includes further high-resolution observations of apparent liquid water sequestered at the poles in combination with MRO SHARAD radar probing. The proposal did not make a strong overall case that groundbreaking science would result from this mission extension. Productivity (as quantified through publication numbers) was low. The team did not demonstrate that the data in the PDS are widely used by the scientific community.
- ***Recommendation.*** The SRS agrees with this finding of the SME panel.

Mars Express (MEX) III

- **Finding.** The overguide includes three requests: (1) restore ASPERA science funding, (2) produce new HRSC maps, and (3) produce new HRSC metadata. The SME panel did not support any of these overguide requests.
- **Recommendation.** The SRS agrees with this finding of the SME panel.
- **Recommendation.** Given the present findings and analogous comments from the 2016 Senior Review, the SRS encourages serious consideration about the appropriateness of continued NASA science support for this mission
 - If support is continued, it should be directed at the descoped version of the science themes listed above
 - Further, the SRS believes this mission is categorized incorrectly as a NASA science mission and encourages rethinking of both the mission's management structure and review process, which could reduce overhead significantly

Mars Odyssey (MODY)

- ***Finding.*** The SRS recognizes the demonstrated high science productivity of the MODY team and the value of the proposed science objectives and is concerned that increases in cost of contracted operations has severely impacted MODY science research, team productivity, and opportunities for adding new scientists.
- ***Recommendation.*** The SRS is in full support of funding the requested overguide for science operations.
- ***Finding.*** The SRS finds that residual risk to operations exists until STL [System Test Lab] upgrades can be implemented.
- ***Recommendation.*** The SRS recommends that the Mars Program conduct a cost/risk analysis to determine if a STL upgrade is warranted during EM8 [Extended Mission 8].

Mars Reconnaissance Orbiter (MRO)

- **Finding.** The proposal included an Overguide request for three elements:
 - (1) upgrading the SHARAD pipeline to produce 3-D volumetric data,
 - (2) recalibrating HIRISE due to higher operating temperatures, and
 - (3) FY21 and 22 budget increases due to inflation.
- **Recommendation.** The SRS recommends funding items (1) and (2), in agreement with the SME panel.
- **Finding.** The SRS finds that, considering that this is the fifth mission extension, the proposed UFE [Unallocated Future Expense] is inappropriately high and could be applied to funding a portion of the Overguide.

Mars Science Laboratory (MSL) I

- ***Finding.*** The SRS finds both the project and the SME panel did not adequately acknowledge that EM 3 might be the last opportunity to complete significant scientific investigations, given the progressive reduction in RTG power output and battery storage capacity, and problems with the drill, the wheels, and memory.
- ***Finding.*** New protocols for the analysis of SAM samples may expand the range of detectable organic molecules, advancing the decadal objective of determining whether there has been life on Mars. Recent efforts have revealed better organic preservation than reported earlier in the mission. Mars 2020 does not have a mass spectrometer. These three items increase the importance of sample analysis.

Mars Science Laboratory (MSL) II

- ***Recommendation.*** The SRS recommends funding an Overguide to add command cycles as per the Overguide option. The search for organics by SAM has the potential for producing groundbreaking science results; therefore, SAM should be provided with additional resources from the proposed Overguide science budget.
- ***Recommendation.*** The SRS recommends that the MSL team should concentrate more on sampling/analysis and less on extending drive distance.
- ***Finding.*** The SRS finds that, considering this is the third mission extension, the proposed UFE is inappropriately high and could be applied to funding a portion of the Overguide.

Ranking of Missions I

- The SME Panels were instructed not to compare missions but to vote on them on their inherent weaknesses and strengths
- All panels were guided by the NASA Planetary Science Division (Consolidated) Senior Review Findings 2019 form
 - **Criterion 1:** Science Merit was based upon seven factors and **Criterion 2:** Technical Merit was based upon five factors
 - Following final deliberation, each panel voted simultaneously in separate votes for each criterion
 - The numerical votes were based upon the key 5 = Excellent, 4 = Very Good, 3 = Good, 2 = Fair, and 1 = Poor
 - Average scores were then computed for each criterion as well as an average score given by the average of the two criteria

Ranking of Missions II

- Details of the scoring methodology used along with the NASA criteria for the adjectival scores are given in Section 11 Appendix: NASA Ranking Definitions
 - The next section (Section 6) provides a précis of each SME report
 - This distillation, made by the SRS includes the SME votes on both scientific and technical merit along with summarized major strengths and weaknesses from the SME reports
 - This material was discussed by the SRS for consistency across all of the missions reviewed and was used as input to Section 4 above
 - The SRS did not “revote” on any mission

Lunar Reconnaissance Orbiter (LRO)

Science 4.80

Excellent	Very Good	Good	Fair	Poor
4	1	0	0	0

Science Weaknesses

None

Technical 5.00

Excellent	Very Good	Good	Fair	Poor
5	0	0	0	0

Technical Weaknesses

None

Mars Atmosphere and Volatile Evolution (MAVEN)

Science 4.57

Excellent	Very Good	Good	Fair	Poor
4	3	0	0	0

Science Weaknesses
None

Technical 4.43

Excellent	Very Good	Good	Fair	Poor
3	4	0	0	0

Technical Weaknesses
None

Mars Express (MEX)

Science 1.50

Excellent	Very Good	Good	Fair	Poor
0	0	0	4	1

Limited Science (Descope) 3.60

Excellent	Very Good	Good	Fair	Poor
0	3	2	0	0

Technical Weaknesses

- The cost is not supported by the limited science value of the proposed measurements and operational activities.
- Although over-guide funding would restore ASPERA participation, allow production of HRSC maps of volcanoes, and production of HRSC metadata for Phobos and Deimos images, none of these tasks is demonstrated to be scientifically compelling (with the exception of imaging at high-resolution the anti-Mars hemisphere of Phobos).

Science Weaknesses

- The science objectives proposed are a continuation of existing measurements. There are inadequate explanations of how this continuation of research would significantly expand our understanding of the Martian atmosphere or surface over the current level.
- US investigators' funding for HRSC was previously cut by half, and the focus in the proposal will be on radiometric and geometric calibrations, updated point spread models, and imaging water-related features and volcanoes. The potential science enabled by these new tasks do not seem to be compelling or unique.
- The proposal did not explicitly state how much each of the 16 US Co-I's would receive. At proposed funding levels the depth of research possible is at best shallow.
- Much of the science proposed is iterative. For instance, uniqueness and importance of OMEGA/CRISM observations was not demonstrated.
- The limited funds available for science translates to limited opportunities for developing leadership skills and roles of existing team members.
- Data use by the scientific community appears limited and declining over time.

Technical 3.00

Excellent	Very Good	Good	Fair	Poor
0	1	3	1	0

Mars Odyssey (MODY)

Science

Guideline Funding: 2.75

Excellent	Very Good	Good	Fair	Poor
0	0	3	1	0

Overguide Funding: 4.75

Excellent	Very Good	Good	Fair	Poor
3	1	0	0	0

Technical Weaknesses

- The increased costs associated with mission operations have greatly reduced science funding under the guideline funding level from a current 24% of project budget to 17%. Science constitutes a small proportion of the overall mission budget so that the high science productivity for the mission is a major strength, but only if science funding is increased to the overguide level to maintain the number of supported Co-Is at about the current level of 16.
- Gyro failure and antenna rotation failures, if they occurred, could reduce the operational lifetime of the mission to as short as one year. The likelihood of these events was judged to be very small.

Science Weaknesses

- No major weaknesses noted.
- Opportunities would be greatly diminished under guideline funding because of the reduction in funded Co-I's. This would be somewhat meliorated with overguide funding although the long-term trend in reduction of science funding during mission renewals reduces the opportunities for developing leadership skills.

Technical

Guideline Funding: 2.75

Excellent	Very Good	Good	Fair	Poor
0	0	3	1	0

Overguide Funding: 4.75

Excellent	Very Good	Good	Fair	Poor
3	1	0	0	0

Mars Reconnaissance Orbiter (MRO)

Science 4.75

(One panelist abstained, stating that they were not qualified to vote on **Scientific Merit**)

Excellent	Very Good	Good	Fair	Poor
3	1	0	0	0

Science Weaknesses

NONE

Technical 5.0

(All members voted on **Technical merit**.)

Excellent	Very Good	Good	Fair	Poor
5	0	0	0	0

Technical Weaknesses

None

Mars Science Laboratory (MSL)

Science 5.00

Excellent	Very Good	Good	Fair	Poor
6	0	0	0	0

Science Weaknesses

None

Technical 4.50

Excellent	Very Good	Good	Fair	Poor
3	3	0	0	0

Technical Weaknesses

None

Findings on Implementation Strategy I

- Table 1 reproduces the summary table from this report given in the Executive Summary of Section 1
- Table 2 summarizes the SME scores of the SME reports of Section 6 and shows how the SRS used these data to provide the SRS summary
- The SRS notes that the adjectival bins provide the finest credible resolution in ranking, considering the subjectivity introduced at each stage of the process, a feature never avoidable in such evaluations

Table 1. SRS Summary of Mission Rankings for 2019 (Ordered by Mission Ranking)

Mission	Recommended Budget	Mean of Scientific + Technical Merit	Adjectival Rating
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Mars Express (MEX)	Descope	3.30	Good / Very Good
Mars Odyssey (MODY)	Inguide	2.75	Good
Mars Express (MEX)	Inguide	2.40	Fair / Good

Table 2. Summary of SME Evaluations

Mission	Science Merit					Sci Score	Technical Merit					Tech Score	Mean S + T	Cost		Note
	E	VG	G	F	P		E	VG	G	F	P			IG	OG	
LRO	4	1	0	0	0	4.80	5	0	0	0	0	5.00	4.90	5		-
MRO	3	1	0	0	0	4.75	5	0	0	0	0	5.00	4.88	5		1
MSL	6	0	0	0	0	5.00	3	3	0	0	0	4.50	4.75	4	2	2
MODY	3	1	0	0	0	4.75	3	1	0	0	0	4.75	4.75		4	3
MAVEN	4	3	0	0	0	4.57	3	4	0	0	0	4.43	4.50	C/NV	NP	
MEX	0	3	2	0	0	3.60	0	1	3	1	0	3.00	3.30	D		4
MODY	0	0	3	1	0	2.75	0	0	3	1	0	2.75	2.75	4		
MEX	0	0	0	4	1	1.80	0	1	3	1	0	3.00	2.40			5

Notes:

C/NV = Consensus, but no vote

D = Limited science

IN = Inguide, i.e. guide line from NASA for cost proposal

NP = Not proposed

OG = Overguide

1 = One panelist abstained, stating that they were not qualified to vote on Scientific Merit; "Strong support for OG" but no vote

2 = 4 votes for proposal for inguide funding and 2 votes for proposal for overguide funding (6 votes were cast regarding funding level) in a separate vote (not carried out by other SME panels)

3 = OG on science; no vote on OG for STL testbed

4 = Science merit if descoped to keep MARSIS + HRSC-Phobos only, per SME panel

5 = Science merit as proposed by mission project team

Findings on Implementation Strategy I

- With respect to the SRS evaluation of rank, based upon the work of the SME panels, that LRO, MRO, and MSL all were ranked as “Excellent” with MAVEN as “Very Good/Excellent” as proposed
 - Clearly, there should be no debate on scientific or technical grounds that all four of these missions should be extended in keeping within the guidelines and certainly the spirit of the recent (2016) National Academies report Extending Science: NASA's Space Science Mission Extensions and the Senior Review Process.
- While there was no debate about the Science and Technical scores for MSL, there was discussion among the SRS with respect to the inguide and overguide
 - This discussion came from the SME panel vote wherein there were 4 votes for the proposal for Inguide funding and 2 votes for the proposal for overguide funding
 - This issue does not affect the ranking of MSL; it only affects how MSL might be implemented
 - The issue of exactly how Inguide versus overguide proposal options should be handled by reviewers is not a new one, and it does suggest a process improvement issue discussed in Section 9.3 below.
- The situations with respect to Mars Express and Mars Odyssey extensions is not so clear
 - As noted, the SME panel for Mars Odyssey found issues with respect to the possible mission results under the Inguide budget, but also felt that with appropriate overguide funding, this would be an excellent mission worth continuing
 - The SRS concurred

Findings on Implementation Strategy II

- Both the SME panel and the SRS found the case of Mars Express, as expressed in the extended mission proposal, to be more problematic
 - The question revolved about what new, compelling science the mission could yield
 - It was the sense of the SRS that as proposed, the mission fell short but that with appropriate descopes in activity – and funding – continuance of the mission might make sense.
- On science and technical grounds alone, the SRS agreed that the ranking, which could be derived from averaging the science and technical scores from the SME votes on those matters, is a fair, equitable, level, and reasonable metric for the ranking of the missions, with the caveat that the numbers themselves should not be given the weight of the adjectival ratings.
- The SRS notes that, this said, the scientific and technical rankings of a given mission with the portfolio provide only one input, albeit a very important one, into the decision-making process
 - That process must balance (1) programmatic issues, such as NASA's plans for a near-term human return to the Moon, (2) the need for sufficient relay bandwidth from Mars, considering all of the assets there, and (3) international agreements and missions, such as NASA's contributions to Mars Express, against budgetary limitations
 - The latter typically, i.e., historically, must balance current assets against future needs, e.g. commercial developments in cis-lunar space such as CLPS and a future Mars Sample Return (MSR) mission, in a constrained financial environment.
- The Senior Review for extended missions continues to play an essential role in the corresponding deliberations.

Minority Opinions

- All initial differing opinions among the SRS membership were resolved during the SRS discussions
- This report is a **consensus statement** amongst the SRS membership

Suggested Process Improvement: Structure of This Review and Rationale

- This Senior Review differs from all previous ones in two aspects:
- In accord with the NASA Transition Authorization Act of 2017 (P.L. 115-10) this is the first review based upon a three-year rather than two-year cadence (cf. the ToR [Glaze, 2018]).
- The application of FACA to the PAC necessitated a new structure due to the potential for unresolvable conflicts of interest amongst appropriate SMEs with especial focus on Mars mission extensions [Glaze and Knopf, 2019]; see Figure 2.

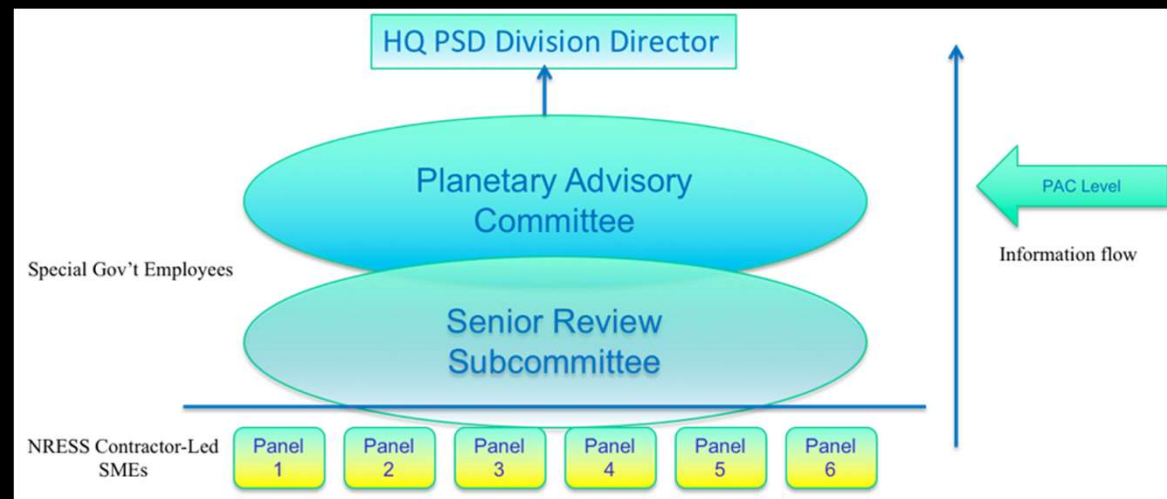


Fig. 2. Schematic of the structure of the process used for the 2019 Senior Review. This report is the product of the Senior Review Subcommittee (SRS).

Suggested Process Improvement I:

What Did Work and Did Not Work: Lessons to Learn

- 1) Everyone would likely agree that Terms of Reference (ToR) are required for the review. However, the details and their implementation are crucial. They must:
 - Clearly define what the Division/Directorate wants to achieve with the Senior Review,
 - Be aligned with directions to proposers,
 - Be signed 4-6 months prior to the Review, enabling selection of review panels and creation of memorandums for conduct of the reviews,
 - Define exactly what will be public, from meeting proceedings to post-review documentation,
 - Define the products and analyses/evaluations to be conducted and provided to the Planetary Advisory Committee

Suggested Process Improvement II:

What Did Work and Did Not Work: Lessons to Learn

- 2) Mission panels must contain both engineering/programmatic SMEs, as well as discipline-appropriate scientists for proper evaluation of submitted proposals. This is usually difficult to do and requires planning ahead and allowing sufficient (significant) time to populate the panels
- 3) Mission panels need to have overlap of at least 1 to 2 (unconflicted) members to ensure continuity and enhance leveling during deliberations
- 4) The Senior Review Subcommittee needs to have more than a single day, or significant time between panels, to discuss the review and develop a position
 - Without some restructuring of procedures, this makes holding the review(s) within a single week problematic
 - For example, the SRS does not need to hear the charge to the (SME) panel more than once and could work in parallel to some of those sessions

Suggested Process Improvement III:

What Did Work and Did Not Work: Lessons to Learn

- 5) Even though the main proposal is page limited, the total packages are overly extensive and not commensurate with the budget commitments under consideration (<2% of the PSD annual budget)
 - In fact, this process could likely be conducted with merely a well-defined presentation package lasting 2-4 hours, which would significantly reduce burden on the proposing missions, reduce cost and complexity, and be more efficient for the review panel(s)
- 6) If the current proposal/presentation structure continues, the presentation content should be clearly defined otherwise they tend to become “marketing” presentations of minimal value to the PMSR decision processes

Suggested Process Improvement III:

What Did Work and Did Not Work: Lessons to Learn

- 7) Metrics such as science team and non-science team paper counts and PDS data set usages should be well defined, e.g. with a panel input via NSPIRES, so that there is a common basis for assessment
- 8) This new process constitutes a significant workload and commitment, so panelists whose salaries are not covered by their home institution should be reimbursed at their current salary/rate (some honoraria were <30% of 40-hour-week pay)

Assessing Mission Options I

- For this review, as well as previous ones, extended mission proposers were given explicit information on budget guidance and mission options (Section II. of Guideline Narrative for Planetary Mission Senior Review Science Evaluation, 11 October 2018 - DRAFT)
 - Noting that “Each mission will be provided funding targets for FY19 and a budget guideline for FY20 through FY22” the proposers were provided with three options:
 - (1) Within Guideline (referred to herein as “inguide”)
 - (2) Science De-Scope, and
 - (3) Overguide
 - Depending upon the proposal and its context, these categories can be handled quite differently amongst the missions
 - As a result, the different SMEs handled the options differently: the MSL panel held a vote on overguide versus inguide, although the science and technical votes were the same for each
 - MAVEN did not propose an overguide option, separate science and technical votes were taken (with different results) for the overguide and Inguide options for Mars Odyssey, and the SME panel for Mars Express invented a de-scope option and then took separate votes on the science merit alone of these two options

Assessing Mission Options II

- While the SME panels can have no direct effect on how the proposals are written, they should be given explicit guidance to hold separate science and technical votes on all options presented in the extended mission proposals

Auxiliary Information and Documents

- Appendix: SRS Guidelines Used in Conducting the 2019 Senior Review
 - Senior Review Subcommittee of the Planetary Advisory Committee, Guidelines for Conducting the 2019 Senior Review, 10 May 2019
- Appendix: NASA Ranking Definitions
- Appendix: Acronyms
- References
 - NASA (2018), Planetary Science Division (PSD) Planetary Mission Senior Review (PMSR) – 2019, Guideline Narrative for Planetary Mission Senior Review Science Evaluation, 11 October 2018, DRAFT.
 - NASA Planetary Science Division (no date), Terms of Reference Planetary Mission Senior Review.
 - National Academies of Sciences, Engineering, and Medicine 2016. Extending Science: NASA's Space Science Mission Extensions and the Senior Review Process. Washington, DC: The National Academies Press. <https://doi.org/10.17226/23624>.
 - Glaze, L. and Knopf, W. (2019) Planetary Mission Senior Review 2019, Update on Process, Viewgraph package 2 April 2019.
 - Throop (2019) NASA HQ Planetary Science Division, Planetary Mission Senior Review (PMSR), Charge to the Panel, May 6-10, 2019, Viewgraph package 6 May 2019.