The National Academies of
SCIENCES • ENGINEERING • MEDICINE

DIVISION ON ENGINEERING AND PHYSICAL SCIENCES
SPACE STUDIES BOARD

Decadal Survey on Planetary Science and Astrobiology: Panel on Small Solar System Bodies

Eighth Meeting

FINAL AGENDA

Wednesday, 10 March 2021

(All times are EST—UTC -5 hours)

OPEN SESSION[1]

10:45 a.m.	*The audio and video connection will go live*	
11:00 a.m.	Welcome	Nancy Chabot and Carol Raymond
11:05 a.m.	Dynamical Modeling of Early Solar System Formation: Current Understanding and Open Questions I[2]	Alessandro Morbidelli Observatoire de la Côte d'Azur
11:25 a.m.	Dynamical Modeling of Early Solar System Formation: Current Understanding and Open Questions II[3]	David Nesvorný Southwest Research Institute
11:45 a.m.	General Discussion	Members and Speakers
12:00 p.m.	Interior Structure of Asteroids: Current Understanding and Open Questions I	Masatoshi Hirabayashi Auburn University
12:20 p.m.	Interior Structure of Asteroids: Current Understanding and Open Questions II	Ron Ballouz University of Arizona
12:40 p.m.	General Discussion	Members and Speakers
1:00 p.m.	*Break*	

[1] https://nasem.zoom.us/j/93944958857?pwd=V3pjem5Od1U3Z3B5OTdNNyttbU1GZz09
Meeting ID: 939-4495-8857 Password: 833797

[2] Timing of planetesimal formation (two generations), the dichotomy, the evidence for spatial separation of NC and CC bodies, the evidence for the existence of planetesimals not sampled in meteorite collections.

[3] Streaming instability, binaries, implantation of outer-disk planetesimals in the asteroid belt, and asteroid belt evolution after the gas disk dispersal.

CLOSED SESSION

2:00 p.m.	News and Updates	Nancy Chabot and Carol Raymond
2:30 p.m.	Status Report from Mission Studies	Science Champions
4:00 p.m.	Future Meetings and Review of Action Items	Nancy Chabot
5:00 p.m.	*Adjourn*	

NOTES

Note to Observers: This meeting is being held to gather information to help the committee conduct its study. This committee will examine the information and material obtained during this, and other public meetings, in an effort to inform its work. Although opinions may be stated and lively discussion may ensue, no conclusions are being drawn at this time and no recommendations will be made. In fact, the committee will deliberate thoroughly before writing its draft report. Moreover, once the draft report is written, it must go through a rigorous review by experts who are anonymous to the committee, and the committee then must respond to this review with appropriate revisions that adequately satisfy the Academy's Report Review committee and the chair of the NRC before it is considered an NRC report. Therefore, observers who draw conclusions about the committee's work based on today's discussions will be doing so prematurely.

Furthermore, individual committee members often engage in discussion and questioning for the specific purpose of probing an issue and sharpening an argument. The comments of any given committee member may not necessarily reflect the position he or she may actually hold on the subject under discussion, to say nothing of that person's future position as it may evolve in the course of the project. Any inference about an individual's position regarding findings or recommendations in the final report are therefore also premature.

Note to Presenters: If your presentation contains unpublished data, ITAR controlled and/or other sensitive information, please be aware that the open sessions at the meeting are being webcast and presentation materials given to the committee may be posted on a publicly accessible website. Please edit your presentations accordingly.

Question and Answers: Given the size of the steering group and the limited amount of time available for questions and answers, comments and questions from non-members cannot be accommodated during this meeting.

STATEMENT OF TASK AND RELATED DOCUMENTS

The guiding document for the decadal survey is the Statement of Task. The Scope, Considerations, Approach, and Products outlined below are additional counsel for the committee and its staff while they carry out their work.

STATEMENT OF TASK

The Space Studies Board shall establish a survey committee (the "committee") to develop a comprehensive science and mission strategy for planetary science that updates and extends the Board's current solar system exploration decadal survey, Vision and Voyages for Planetary Science in the Decade 2013-2022 (2011).

The new decadal survey shall broadly canvas the field of space- and ground-based planetary science to determine the current state of knowledge and to identify the most important scientific questions to be addressed during the interval 2023-2032.

For the first time, this decadal survey will also study aspects of planetary defense, now that this activity is fully incorporated as an element of NASA's planetary science endeavors. The survey will also take into account planned human space exploration activities.

In addition, the survey and report shall address relevant programmatic and implementation issues of interest to NASA and the National Science Foundation (NSF). Since the content and structure of the program portfolios of the two agencies are distinct from one another, implementation and investment recommendations specific to each agency should be elaborated in separate sections of the final report. This will ensure that the report's investment guidance will be clearly addressed to the appropriate agency.

It is critically important that the recommendations of the Committee be achievable within the boundaries of anticipated funding. NASA and NSF will provide an up-to-date understanding of these limitations to the committee at the time of survey initiation.

The report should provide a clear exposition of the following:

1. An overview of planetary science, astrobiology, and planetary defense—what they are, why they are compelling undertakings, and the relationship between space- and ground-based research;
2. A broad survey of the current state of knowledge of the solar system;
3. The most compelling science questions, goals and challenges which should motivate future strategy in planetary science, astrobiology, and planetary defense;
4. A coherent and consistent traceability of recommended research and missions to objectives and goals;
5. A comprehensive research strategy to advance the frontiers of planetary science, astrobiology and planetary defense during the period 2023-2032 that will include identifying, recommending, and ranking the highest priority research activities (research activities include any project, facility, experiment, mission, or research program of sufficient scope to be identified separately in the final report). For each activity, consideration should be given to the scientific case, international and private landscape, timing, cost category and cost risk, as well as technical

readiness, technical risk, lifetime, and opportunities for partnerships. The strategy should be balanced, by considering large, medium, and small research activities for both ground and space;

6. Recommendations for decision rules, where appropriate, for the comprehensive research strategy that can accommodate significant but reasonable deviations in the projected budget or changes in urgency precipitated by new discoveries or technological developments;

7. An awareness of the science and space mission plans and priorities of NASA human space exploration programs and potential foreign and U.S. agency partners reflected in the comprehensive research strategy and identification of opportunities for cooperation, as appropriate;

8. The opportunities for collaborative research that are relevant to science priorities between SMD's four science divisions (for example, comparative planetology approaches to exoplanet or astrobiology research); between NASA SMD and the other NASA mission directorates; between NASA and the NSF; between NASA and other US government entities; between NASA and private sector organizations; between NASA and its international partners; and

9. The state of the profession including issues of diversity, inclusion, equity, and accessibility, the creation of safe workspaces, and recommended policies and practices to improve the state of the profession. Where possible, provide specific, actionable and practical recommendations to the agencies and community to address these areas.

SCOPE

In order to ensure the committee provides actionable advice and to ensure consistency with other advice developed by the National Academies, guidelines for the scientific scope of the survey are as follows:

1. The report should address and be organized according to the significant, overarching questions in planetary science, astrobiology, and planetary defense.

2. Basic or supporting ground- and space-based, laboratory, field, and theoretical research in astrobiology is within scope. Any findings and recommendations in the area of astrobiology should take into consideration the National Academies' report *An Astrobiology Strategy for the Search for Life in the Universe* (2018);

3. Interactions between solar and heliospheric phenomena and the atmospheres, magnetospheres, and surfaces of solar system bodies are within scope. Reassessment of recommendations treated in the National Academies' *Solar and Space Physics: A Science for a Technological Society* (2012) is out of scope;

4. Excluding analog studies, focused study of the Earth system, including its atmosphere, magnetosphere, surface, and interior, is out of scope (these topics are treated in the National Academies' *Thriving on our Changing Planet: A Decadal Strategy for Earth Observation from Space* (2017);

5. Studies of meteorites and other extraterrestrial materials in terrestrial laboratories that further planetary science goals are in scope but findings and recommendations in this area should take into consideration the National Academies' report *Strategic Investments in Instruments and Facilities for Extraterrestrial Sample Curation and Analysis* (2018).

6. Recommendations for ground- and space-based investigations to detect exoplanets are out of scope (these topics are being addressed by "ASTRO2020: Decadal Survey on Astronomy and Astrophysics" currently in progress). However, the identification of scientific issues and questions related to the study of exoplanets, including the comparative planetology and potential habitability of solar and extrasolar planets, is in scope.

7. Scientific investigations of near-Earth objects, both for the impact hazard presented to Earth and the future exploration and resource opportunities, are within scope. Findings and recommendations in this area should take into consideration the National Academies' report *Defending Planet Earth: Near-Earth-Object Surveys and Hazard Mitigation Strategies* (2010) as well as more recent National Academies' and community studies related to this area such as the *Near-Earth Object Observations in the Infrared and Visible Wavelengths* (2018)

8. Findings and recommendations concerning planetary protection policies are out of scope. But, the identification of planetary protection considerations for recommended missions– as recommended in the National Academies' *Review and Assessment of the Planetary Protection Policy Development Processes* (2018)–and research or technology development to mitigate concerns about biological contamination are in scope.

9. Recommendations regarding new construction of major new ground-based observatories are out of scope (these are addressed within the scope of the ASTRO2020 decadal survey currently in progress). The role that current and contemplated new ground-based facilities can play in advancing planetary science is in scope. How the facilities under consideration in the ASTRO2020 survey (when available) could benefit planetary science is within scope.

10. The scientific identification and initial validation of technosignatures is in scope but the application of such signatures in survey studies is out of scope. Recommendations in this area should take into account the summary of the Technosignatures Workshop found in the meeting report *NASA and the Search for Technosignatures* (2018) as well as the National Academies' reports *An Astrobiology Strategy for the Search for Life in the Universe (2018) and Exoplanet Science Strategy* (2018).

CONSIDERATIONS

National Science Foundation Recommendations

For NSF, the survey will be most effective if it is aspirational, inspirational, and transformative. The decadal survey should assess how the current NSF portfolio of facilities and individual investigator grants address these priorities, as well as how currently planned and new facilities under consideration in the ASTRO2020 survey could benefit the planetary science priorities. The study may recommend changes to NSF's portfolio of facilities, including initiating divestment actions, as it deems necessary to advance the science and to optimize the value of current and future facilities.

The decadal survey steering committee is encouraged to comment on NSF opportunities for expanding partnerships, whether private, interagency, or international.

National Aeronautics and Space Administration Recommendations

The report should reflect NASA's statutory responsibility for flight mission investigations. The committee is strongly encouraged to adhere to the following guidelines as they draft the principal components of the NASA implementation portion of the report:

1. Recommendations for individual flight investigations for initiation between 2023 and 2032 as follows (note that dollar values given below do not include launch vehicle or Phase E costs; full Life Cycle Costs for PI-led missions may be as much as double these values):

a. Flight investigations believed executable for less than approximately $500 million (candidates for the Discovery or SIMPLEx programs) should not be identified or prioritized. They will be proposed by community investigators to address the science goals and challenges called for in the statement of task;

b. The report should consider whether specific flight investigations with costs in the approximate range $500-900 million (New Frontiers class) should continue to be specified or whether this mission class should be open in a manner similar to the Discovery program; If specific flight investigations are recommended, the report should provide a candidate list of objectives for each mission;

c. The report should identify specific destinations and science goals for "large strategic missions" with costs projected to exceed $900 million;

d. The prioritization of flight investigations for Mars and the Moon should be integrated with flight investigation priorities for other solar system objects into a single prioritized list of all recommended missions;

e. The findings and recommendations contained in *Visions into Voyages for Planetary Science in the Decade 2013-2022*, together with other recent National Academies' reports on topics relevant to planetary science, astrobiology and planetary defense should be used as input to the decadal efforts. Missions identified in these reports that have not yet been confirmed for implementation must be reprioritized;

f. The study will assess whether NASA's plans for Mars Sample Return (MSR) play an appropriate role in the research strategy for the next decade. The study may include findings and recommendations regarding those plans, as appropriate, including substantive changes in NASA's plans. Recommendations may include, but are not limited to, actions ranging from increased investments (upscopes) to reduced investments (descopes) and termination. It is not necessary to rank MSR, among other recommended activities for space; and

g. It is understood that initiation of missions on these lists will depend on actual resource availability.

2. Recommendations for NASA-funded supporting research required to maximize the science return from the flight mission investigations and to provide the context and impetus for future flight mission investigations;

3. A discussion of strategic technology development needs and opportunities relevant to NASA planetary science programs; and,

4. A discussion of (a) how planned and potential human space flight activities will provide new opportunities for planetary science and (b) what areas of planetary science will provide information needed to support human space flight activities.

PLANETARY DEFENSE CONSIDERATIONS

1. Although science can also benefit from Planetary Defense flight missions, the flight missions in this line are focused on NEO search and/or characterization, or in-space mitigation technology development. Currently, these are strategic, directed investigations as opposed to competed. As such, the report could identify specific prioritized planetary defense goals for "strategic missions", even if the anticipated costs are below the current $500M competed mission threshold.

2. The panel should look for opportunities with Planetary Science flight missions where Planetary Defense objectives could be achieved with augmentation by Planetary Defense funding to add capability or enhance operations of otherwise purely Planetary Science missions.

3. Planetary Defense flight investigations believed executable for less than approximately $500 million should be identified and prioritized. They could be either directed to a specific purpose or, if for a more broadly identified objective (e.g. Apophis encounter), proposed by community investigators through an AO process to address the Planetary Defense goals and challenges identified.

4. It is not foreseen the projected budget for Planetary Defense would allow flight projects in excess of $500M development costs. However, if the panel finds specific flight investigations are needed with Life Cycle Costs (LCC) in the approximate range $500 million to $1 billion, the report should provide the candidate objectives to be achieved for each mission and they should be prioritized.

APPROACH

The organization of the study is sized based upon prior planetary decadal surveys. The committee will consist of a steering group–approximately 15-20 members, responsible for the overall organization and execution of the study, and the production of a final consensus report that will undergo the usual National Academies review processes–and five or six supporting panels–approximately 10-12 members each–responsible for providing the scientific and technical breadth to span the diverse suite of scientific topics and potential solar system destinations.

The scheme used to allocate the domain of study among the panels should support delivery of a report organized according to the significant, overarching questions in planetary science, astrobiology, and planetary defense. Individual panels may span multiple solar system target bodies, with specific panel structure determined by the National Academies and the committee's chair(s). An important role of the panels will be to evaluate input from the research community about issues of scientific and programmatic priorities in the field. In keeping with prior planetary science decadal surveys, the work of the study panels will be integrated and incorporated as chapters in the final survey report.

One representative from each of the panels shall serve on the steering group. The composition of the steering group and panels will take full advantage of the diversity of the

planetary science, astrobiology, and planetary defense communities in factors such as gender, race, ethnicity, career stage, types and sizes of institutions, geographic distribution, etc. It is imperative that some early career researchers be invited to serve on panels.

In assembling the committee and panels, calls for nominations will be sent to the planetary science, astrobiology, and planetary defense communities and sponsors. National Academies' staff will nominate a candidate for chair after consultation with the Space Studies Board, the Committee on Astrobiology and Planetary Science and other relevant stakeholders. The chair will work with committee staff and others to develop the structure for the study and a slate of nominees for the balance of the committee's membership.

In assembling the slate of nominees for the steering group and panels, committee staff will follow National Academies' procedures for reducing and balancing biases, and for ensuring that the steering group and panels have the needed expertise across disciplines and diversity among their members, including gender, career stage, underrepresented groups, types and sizes of institutions, and geographic distribution.

In designing and pricing the study, the Academies should include resources for independent and expert cost analysis support to ensure that all flight mission cost estimates can be meaningfully intercompared and are as accurate as possible given the varying maturity of project concepts and other recognized uncertainties. The prioritized list of science missions should be developed with the anticipated resources in mind.

The final report must represent a comprehensive and authoritative analysis of the subject domain and represent the community stakeholders. The study activity will include town hall meetings, sessions at geographically dispersed professional meetings, and aggressive use of electronic communications for soliciting and aggregating inputs from across the community and country. It is anticipated that a call for white papers will be issued prior to the commencement of the study itself. The committee may also convene focused workshops on special topics of interest. Other input-gathering methods will be explored and used, including a pre-study event to inform early-career researchers about the scope of, and their potential role in, the decadal survey.

PRODUCTS

It is suggested that the committee produce three products: a complete, integrative report of the findings and recommendations of the study, incorporating the reports of the supporting panels; an abbreviated high-level presentation of the main findings and recommendations suitable for distribution to the general public; and a web-based archive of report-relevant documents, including all community white papers and mission studies.

DRAFT SCHEDULE FOR THE SURVEY

Sep-Oct 2020	Steering group and panel meetings commence;
Oct-Dec 2020	Steering group identifies science themes and priority science questions
Nov-Dec 2020	Identify additional mission studies needed and pass on to NASA
Jan-Feb 2021	Panels draft "Current State of Understanding" text and elaborate on how key science questions might be addressed in the coming decade
Feb-March 2021	Form cross-panel writing groups to draft the chapters on the 12 key science questions
Mar-Apr 2021	Additional mission studies are completed by design centers and their assessment by steering group and panels begins
Oct 2021	Draft report sent to external reviewers
Dec 2021	Revision of report completed
Jan-Feb 2022	Report approved for release. Report formatted and copyedited
Feb-Mar 2022	Deliver report to NASA and NSF in prepublication format
Mar 2022	Public release of report in prepublication format
Mar-Dec 2022	Dissemination activities and formal publication of survey report by NAP
Mar 2023	End of NASA contract for PSDS2020.