National Aeronautics and
Space Administration

Headquarters
Washington, DC 20546-0001

Reply to
Attn of: SMD/DAAR

May 4, 2018

Dr. Fiona Harrison
Space Studies Board
National Academy of Sciences
500 5th Street, NW
Washington, DC 20001

Dear Dr. Harrison,

I would like to express my appreciation for the delivery of the report "Powering Science: NASA's Large, Strategic Science Missions". The panel members are to be thanked and congratulated. NASA appreciates the excellent job of the Committee and applauds it for the clarity, conciseness, and thoroughness of the Report. I would also like to express our gratitude to Drs. Ralph McNutt and Kathryn Thornton, the committee co-chairs, the volunteer members and National Academies staff, who worked extremely hard in support of this effort and in its dissemination to various stakeholders.

I have reviewed the findings and recommendations of the report, and I am pleased to convey NASA's responses to them. In general, NASA concurs with the study's recommendations although in several instances, as shown below, there are portions of recommendations with which NASA must demur. Please do not hesitate to contact Dr. Michael New, who can be reached at 202-358-1766 or michael.h.new@nasa.gov, with any questions about NASA's response.

Sincerely,

Thomas Zurbuchen
Associate Administrator,
Science Mission Directorate

cc: CalTech/F. Harrison
SMD/T. Zurbuchen
•M. New
•P. Luce
•P. Hertz
•J. Green
•M. Freilich
SSB/Richard Rowberg
•D. Day
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UVA/K. Thornton

NASA Response to "Powering Science: NASA's Large Strategic Science Missions"

On the balance of mission sizes

Recommendation: NASA should continue to plan for large strategic missions as a primary component for all science disciplines as part of a balanced program that also includes smaller missions.

Response: NASA concurs with this recommendation. NASA uses the National Academies' Decadal Surveys as a principal input for developing and prioritizing NASA's programs in the four science disciplines. The Statement of Task for each Decadal Survey includes "recommending a balanced program of large, medium, and small activities" for the next decade. NASA will continue to plan for the large strategic missions that are recommended as priorities by the Decadal Surveys.

On balance between missions in development and missions in operation

Recommendation: When faced with the requirement to trade-off between development and operation of large strategic missions and the smaller missions within their portfolios, NASA's Science Mission Directorate divisions should look first to their relevant decadal surveys and their midterm reviews for guidance. If these are insufficient, the SMD divisions should seek the advice of their relevant advisory groups.

Response: NASA partially concurs with this recommendation. In addition to the decadal surveys, midterm assessments, and advisory groups, NASA also uses the Senior Reviews to develop trade-offs between larger and smaller operating missions. In addition, due to potential disqualifying conflicts of interest, not all trade-offs can be effectively handled by all advisory groups.

On improvements in, and preparation for, decadal surveys

Recommendation: In preparation for the decadal surveys, large strategic mission proposal teams should consider describing ranges of scientific scope for their recommended large strategic missions, such as minimum science goals and maximum budgets, as well as identifying what science goals are most desirable at different budget levels. This approach may allow the scientific community and NASA to develop less expensive implementation strategies for mission concepts that do not exceed current budget limitations.

Response: NASA concurs with this recommendation. The ongoing mission concept studies in astrophysics are all developing multiple architectures, each with a different science capability and cost. The recently completed mission concept studies for outer planet missions in planetary science also developed a range of possible architectures, each with different science capability and cost. NASA will continue studying notional mission architectures to enable NASA and the scientific community to make trades between science capabilities and cost.

Recommendation: Budget constraints should be included in the development of a decadal scientific program. Flexibility in the "decision rules" that decadal surveys produce should allow for both the de-scoping of large strategic missions in the face of cost overruns or insurmountable technical barriers as well as the "up-scoping" of missions as new technological or other opportunities arise.

Response: NASA concurs with this recommendation. NASA always provides guidance to Decadal Survey committees on the most likely planning budgets, and program commitments, for the next decade. The decadal survey statement of task includes tasking the committee with providing guidance to NASA to use in response to changing budgetary constraints over the decadal timescale.

Recommendation: The decadal surveys should formulate mission concept variants or other means to assess the boundaries of cost and technical risk and recommend the application of decision rules to provide flexibility to the NASA science divisions and most importantly the scientific community. This will enable further refinement of mission concepts when pursuing the scientific priorities identified by the decadal surveys.

Response: NASA partially concurs with this recommendation. The Decadal Survey committees generally do not have the technical capabilities nor the time to formulate mission concept variants. Rather the Decadal Surveys should recommend to NASA the desired science capabilities and cost range, and NASA can lead the pre-formulation mission concept studies following the decadal survey report.

Recommendation: Decadal surveys should be informed by, but not narrowly restricted to, future projections of available budgets. Such flexibility may enable new and potentially revolutionary large strategic missions.

Response: NASA concurs with this recommendation. Future budgets are always unknown. The NAS report "The Space Science Decadal Surveys: Lessons Learned and Best" provides a number of lessons-learned and recommended best practices for future decadal survey committees for handling budget uncertainty.

Finding: Cost control of large strategic missions remains vital in order to preserve overall programmatic balance.

Response: NASA concurs with this recommendation. NASA has increased its cost control requirements, now requiring that cost and schedule commitments be at a joint confidence level (JCL) of at least 70%. Since NASA implemented this rule, NASA has had success in managing the SMD portfolio as whole within cost commitments made at Key Decision Point C (Confirmation). The 11 Science missions launched after completing a 70% JCL estimate at KDP-C have underrun their Phase C/D budget commitments by a net 7%.

Recommendation: NASA should ensure that robust mission studies that allow for trade-offs (including science, risk, cost, performance, and schedule) on potential large strategic missions

are conducted prior to the start of a decadal survey. These trade-offs should inform, but not limit, what the decadal surveys can address.

Response: NASA concurs with this recommendation. The ongoing mission concept studies in astrophysics are all developing multiple architectures, each with a different science capability and cost. The recently completed mission concept studies for outer planet missions in planetary science also developed a range of possible architectures, each with different science capability and cost. The Planetary Science Division (PSD) has also been conducting a number of potential large strategic mission studies such as the Ice Giants and the Europa lander studies to feed into the next decadal study. In each case, variants and trade-offs have also been conducted to explore the science per dollar investment for each concept. NASA will continue studying notional mission architectures to enable NASA and the scientific community to make trades between science capabilities and cost.

On cost estimation of large strategic missions

Recommendation: NASA should continue to use its various cost estimation and cost management tools to assess and control the costs and risks of large strategic missions to ensure that they remain a viable option. As new technologies and new missions arise, new cost estimation tools will be required to enable NASA to determine their likely costs. NASA should support the development of new tools to perform robust cost estimates and risk assessment. These new cost estimation tools will also be helpful in support of the National Academies' decadal surveys.

Response: NASA concurs with this recommendation. NASA is currently developing the Project Cost Estimating Capability (PCEC) for improved cost estimates of large, strategic missions beyond what the legacy NAFCOM system is capable of and is actively participating in other efforts to improve cost estimation (such as the NASA Cost Symposium). Cost modeling, however, is based on past missions and as NASA develops novel and innovative missions, cost modeling can never be entirely accurate.

NASA has also modified its processes to improve cost control by

- Getting multiple internal and independent estimates for each project;
- Using probabilistic estimates and ranges instead of point estimates, particularly early in a project;
- Establishing multiple decision gates with estimates at each gate;
- Not committing to a project or its cost until the start of implementation at KDP-C; and,
- Establishing more conservative cost commitments at the Agency level.

On providing data about missions to the public

Recommendation: In order to demonstrate the role and scientific productivity of large strategic missions in advancing science, technology, and the long-term health of the field, NASA's Science Mission Directorate should develop a publicly accessible database, updated at least annually, that tracks basic data related to all confirmed missions in development as well as

operational and past missions from each of the SMD divisions. These data should include development costs; publication numbers and other bibliographic data; outreach data (number of press releases and so on should be tracked); science, engineering, and other full-time equivalents (FTEs); and other routine data typically sought in senior review proposal submittals once prime missions have been completed. These data should be of sufficient detail and quality to enable basic analyses related to scientific productivity and contributions to the health of the respective fields.

Response: NASA partially concurs with this recommendation. NASA agrees that there is value in better communicating about its missions, but the level of specificity recommended by the committee may not be appropriate for a lay audience, especially as it could lead to false comparisons of the scientific productivity and contributions to the health of the respective fields based on numbers only. In addition, it is not clear that publication numbers alone reflect scientific productivity any more for missions than for individuals. SMD is in the process of redesigning its website and will use the committee's suggested database content to inform this process. In particular, the committee's recommendation provides an outline to help standardize the key facts and figures that SMD will highlight going forward for all missions on the website.

There is also NASA-internal value in collecting some of the information recommended by the committee as a way to assess the overall health of the respective fields, especially in light of SMD's on-going commitment to developing the next generation of scientists and engineers. We are therefore in the process of developing mechanisms to assess career pathways through our suite of missions to inform future work.