OPAG Summer Meeting
14-15 June 2022

Preamble

The OPAG community acknowledges the incredible efforts of the Decadal Steering Committee, Panelists, and the co-chairs Robin Canup and Phil Christensen. The enormous effort put into fairly balancing the community needs and organizing the highest priority science objectives is clearly reflected in the *Origins, Worlds, and Life: Decadal Strategy for Planetary Science and Astrobiology* (hereafter referred to as OWL). The priority questions identified in OWL are strongly consistent with those identified previously by the OPAG community (Moore et al., 2021[1]). Furthermore, prioritization of the Uranus Orbiter and Probe and the Enceladus Orbilander Flagship missions, as well as the mission themes identified for New Frontiers 6 and 7, are strongly and enthusiastically supported by OPAG, and reflects the diversity of interests and targets in our broad community. We look forward to supporting the Decadal recommendations through findings and actions that help ensure the successful execution of this exciting portfolio of exploration.

Our first action is to form a working group sourced from OPAG, SBAG, and the broader Ocean Worlds community to develop a coherent Ocean Worlds strategy, as recommended by OWL, for consideration by NASA. This proposed strategy would consolidate R&A, technology development, interagency collaboration, and workforce maturation in support of OWL-recommended missions to Ocean World targets. This action is consistent with a recent SBAG finding to do the same.

OPAG strongly endorses the community-led actionable recommendations to advance Inclusion, Diversity, Equity, and Accessibility (IDEA or DEIA) within the planetary science and astrobiology community, such as those identified in OWL's State of the Profession chapter[2], the NASEM report "Advancing DEIA in the Leadership of Competed Space Missions"[3], and "A Consensus Report on Recommendations from the 2022 Advancing IDEA in Planetary Science Conference"[4], among others. A common theme across the documents (and identified as a priority topic in the June 2022 OPAG meeting) is that multiple mechanisms are necessary for early career scientists to gain experience during mission development and mission operational phases, as well as

[1] https://baas.aas.org/pub/2021n4i371/release/1
[2] https://nap.nationalacademies.org/read/26522/chapter/18
[3] https://nap.nationalacademies.org/catalog/26385/advancing-diversity-equity-inclusion-and-accessibility -in-the-leadership-of-competed-missions
[4] https://zenodo.org/record/6656887#.YqyNRy-B2X0

opportunities to progress in mission roles over time. In addition to sufficient funding for these programs, effective mentorship is recognized as being critically important to the goal of achieving a planetary science and astrobiology workforce that reflects the demographics of the U.S. as a whole. Mentorship training, including sensitivity training for mentors who work with mentees that have under-represented identities, is therefore critical. In addition to mission on-ramps, graceful off-ramp mechanisms should also receive explicit considerations for long-duration missions to the outer solar system.

OPAG also looks forward to the NASA response to our OWL-related findings from the Fall 2021 meeting, in addition to those listed below, at our November 2022 meeting.

Lastly, the OPAG steering committee and community members have invested a significant effort towards studying launch window availability for a range of launch vehicles and payload sizes in order to better define the potential opportunities for reaching outer solar system targets. The results of this analysis were presented during the June 2022 OPAG meeting in a dedicated session (see presentation[5] by Dr. Candy Hansen). It is evident that missions to the ice giants are incredibly sensitive to launch windows, and the timing of AOs for New Frontiers calls should reflect these restrictions. This sensitivity is explicit in the Recommended Program chapter of OWL, which states "The recommendation that Triton Ocean World Surveyor be delayed until NF-7 took into consideration launch trajectories, which benefit from a Jupiter gravity assist likely available in the NF-7 timeframe." OPAG urges NASA to automatically reassess the target list for New Frontiers 6 in the event that the timing of the AO and planned launch window is delayed compared to that assumed by OWL. A change to that timing, which is possible given the budgetary decision rules outlined in OWL and the history of New Frontiers mission opportunities, would impact whether a mission to Neptune/Triton (e.g., Triton Ocean World Surveyor) is achievable in New Frontiers 6, as opposed to New Frontiers 7. Attention to launch window availability is paramount to the success of exploration of the outer solar system, especially the ice giants and their moons.

Finding 1. Start Uranus Orbiter and Probe in FY24

The OWL Decadal Survey recommended Uranus Orbiter and Probe (UOP) as the highest priority new large mission to be started in this decade. In the Recommended Program, the recommendation is for the mission to be funded with a New Start to be approved for FY24. In the Level Program, the recommendation is to delay the New Start to FY28 without a Jupiter gravity assist and a reduced spacecraft capability, reducing the mass and descoping the payload -- and therefore significantly reducing science of the Flagship.

[5] https://www.lpi.usra.edu/opag/meetings/jun2022/slides/Hansen.pdf

To quote the OWL Decadal Survey, the Recommended Program “enables robust development of diverse science and engineering communities, drives technology development, and maintains U.S. leadership in solar system exploration. It begins the UOP Flagship in FY 2024 to support a launch in the early 2030s that minimizes cruise length and complexity and initiates the Orbilander Flagship late in the decade to reveal the astrobiological conditions of an ocean world.”

In terms of science in the Uranus system, the ideal arrival at Uranus would be in or before 2049. The sun will be crossing the equator in 2049 (equinox) so Uranus' atmosphere will be active, unique ring science can be captured, and the entire surfaces of the moons will be sunlit during daytime (i.e., controlled only by the day-night cycle, with no areas shaded by polar night). This is in contrast to the Voyager flyby when the sun was shining on Uranus' south pole, the atmosphere was quiescent, and the northern hemispheres of the moons were hidden in polar night. For an arrival date later than 2049, the subsolar point moves to the south and the northern hemisphere is increasingly again in polar night; since this is a cosine function, the lighting degrades relatively rapidly. One Uranian year is 84 Earth years (!), making it critical to leverage this unique observing geometry during this opportunity.

In order to arrive at Uranus by 2049, the optimal approach is to use a Jupiter gravity assist (JGA) trajectory. Such JGA launch opportunities to Uranus fall between 2029 and 2032. Using a JGA trajectory saves propellant and thus enables more mass for the spacecraft at a given launch mass and also leads to a shorter duration interplanetary flight. If UOP has a new start in 2024 it is eminently feasible to make the 2031 launch with JGA (even with a one year margin for potential launch delays until 2032). However, if the new start is delayed to 2028 then it is no longer feasible to meet the JGA launch window. Without JGA, the trajectory will use inner planets gravity assists, e.g., an EEVE GA. Although the spacecraft-available launch mass does not suffer significantly, the spacecraft will require thermal and power design modifications to fly to a Venus-distance from the Sun, and thus may reduce the science payload mass fraction and with it the science return; the arrival date would slip out to 2052, which is still useful science-wise, but would lead to losing desirable science observation opportunities of the north polar caps of the moons and missing the unique equinox science.

In summary, with the 2024 new start, a mission could launch in 2031, and could arrive in 2044. This would enable a Jupiter gravity assist, shortening cruise. It would also enable access to the Uranian system leading up to the ideal 2049 time period where the mission would have equatorial lighting, allowing observing access to both poles. Also, the atmosphere of Uranus will likely exhibit more activity. However, with a delayed 2028 new start, equinox science will be missed.

Furthermore, OWL recommends an Enceladus mission later in the decade, and if UOP isn't given a new start until FY2028, it is less likely that NASA will be able to meet this OWL recommendation.

Finally, it is critical that UOP have a FY2024 new start to maintain the workforce. To quote OWL, "Indeed, delay of UOP until the end of the decade would focus interim new developments on smaller programmatic elements and maintaining the vitality of the whole program and the community in these circumstances may be **very challenging**."

Finding: OPAG urges NASA to seek a New Start for Uranus Orbiter and Probe in the FY24 budget, with launch no later than 2032. Starting the mission in FY24 will ensure full science return by maximizing access to the fully illuminated north polar regions of the Uranian system as recommended by OWL for UOP. It will also ensure engineering workforce continuity and maintain the opportunity for a New Start of Enceladus Orbilander within this decade as recommended by OWL.

Finding 2. Release the New Frontiers 6 AO as soon as possible

OPAG welcomes the earlier release of the NF-5 AO. OPAG remains concerned that NF-5, which is a hold-over from the previous decadal, may be the only New Frontiers (NF) selection in the coming decade. NF-6, while included in the OWL Recommended Program, is the first NF call to reflect the recommendations of OWL but would be “late, or not included” in the Level Program. NF-7 is not included in either the Recommended or Level Program. The number of Discovery AOs, on the other hand, remains the same in both the Recommended and Level Programs.

The New Frontiers (NF) program, initiated in 2003, has been the most effective gateway for PI-led missions to the outer solar system. Of the 16 Discovery missions selected to date, all but one (Lucy) have targeted the inner Solar System. The OWL recommendation to put Phases E & F back into the Discovery Principal Investigator-managed mission-cost (PIMMC) will only reinforce this dichotomy. As such, New Frontiers remains the primary competed mission vehicle for outer planets science in the next decade.

Finding: Given that the NF-5 AO will be released earlier than assumed by OWL and the importance of NF for outer planets science, OPAG encourages NASA to release the NF-6 AO as early as possible, consistent with the OWL recommendations, to ensure the OWL-recommended NF-6/7 lists have selection opportunities in the next decade.

Finding 3. Ensure adequate RPS availability for upcoming missions (Update of Finding #1 from the OPAG Fall 2021 meeting)

OPAG thanks Candy Hansen for presenting at the June 2022 meeting on the required trajectories and lighting geometries for OWL-recommended targets, and the need for Radioisotope Power Systems (RPS) to enable outer planet missions. We also thank Concha Reid, acting manager of the RPS Program, for her informative presentation on the current status of NASA's RPS development activities.

At present, only one NextGen RTG unit has been identified for New Frontiers 5 or for a Flagship mission to be launched in the 2030's. In addition, one additional NextGen RTG ("Mod1") unit may be fabricated by the 2030's, but there is no commitment to fuel it. The RPS Program's effort to develop a higher-power version of NextGen unit ("Mod2") continues; however, no clear timeline for its availability was presented. The OPAG community notes that the one NextGen RTG unit currently assumed for the NF-5/Flagship in 2030 underestimates the power needs of such missions; in comparison, the UOP Flagship mission requires three NextGen RTG units. This shows a significant mismatch between Pu^{238} and clad availability and production rates, and RTG needs for OWL-recommended missions.

Finding: OPAG urges NASA to develop a plan to fuel RTG units for UOP, the next Flagship mission recommended by OWL, and for potential NF and/or Discovery missions, so that those units are available for launch(es) in the early 2030's. OPAG further urges NASA to commit to a timely development of the NextGen Mod2 RTG, which could replace the Mod1 configuration while enhancing power availability, and with it, science return.