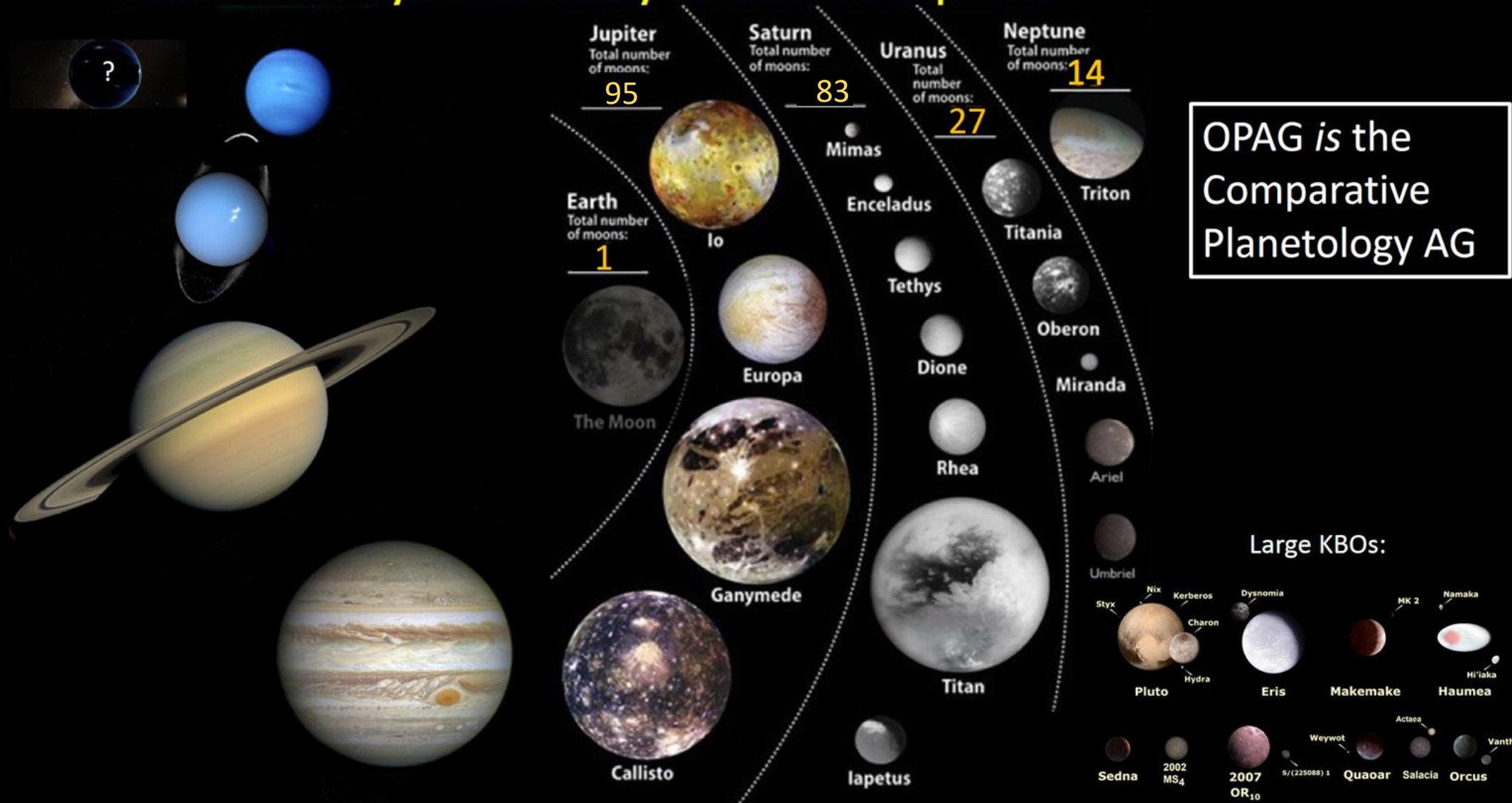


OPAG Update to the Planetary Science Advisory Committee (PAC)

Amanda Hendrix, OPAG Chair, PAC Meeting, 10 July 2024

Outer Solar System: Many Worlds to Explore



Findings from June 2024 OPAG community meeting (1)

New Frontiers-5 (NF5). NF is the primary funding path for competed outer planets missions. As such, the NF5 delay has been very difficult for the OPAG community.

Finding #1.

a. OPAG strongly supports NASA's current plan to provide a community announcement describing NF5 Announcement of Opportunity (AO) parameters (including but not limited to expected cost cap, proposed launch readiness dates, RPS availability, launch vehicle options with performance curves, updated target list) in the Oct-Dec of 2024 timeframe, which is 18 months ahead of the planned AO release in Q3 FY2026 (Apr-June 2026). Proposal teams require expected AO parameters in order to conduct trade studies and design their mission concepts, and it is critical, in the interest of the community, for NASA to stick to the announced schedule without further delays.

b. OPAG strongly supports the decision to have CAPS revisit the NF5 target list due to the multiple delays in the AO and due to new developments since the Decadal Survey. The outer planets targets Io, Saturn Probe, Enceladus and Triton are all exceedingly compelling targets. We note here that OPAG urges consideration of (NF7 target) Triton for the NF5 list in light of the developments since the last Decadal Survey (see OPAG finding #3 November 2023*; May 20, 2024 OPAG presentation to CAPS*; and OPAG Spring 2024 meeting presentation by K. Mitchell*) that demonstrate multiple feasible launch opportunities over the expected (delayed) NF5 launch window. This new development, combined with the unavoidable timing lag in NF6 and NF7 (which makes those opportunities less viable for a mission to arrive before Triton's southern hemisphere slips into darkness for 70 years) makes NF5 an important opportunity for this mission target. A Triton mission concept was placed on the NF7 list in OWL solely based on the assumption that a trajectory would only be achievable in the then-presumed NF7 timeframe, but the schedule delays (and new trajectory work) have invalidated this assumption. **We urge NASA to include Triton, along with the other outer planets targets, on the NF5 list, in line with the Decadal Survey intentions.**

Findings from June 2024 OPAG community meeting (2)

Uranus Orbiter and Probe (UOP). The President's Budget request for FY25 includes UOP, starting with \$2.6M in FY27 (year 1, for formulation studies), then ~\$25M in year 2, then ~\$60M in year 3. OPAG has pointed out (November 2023 OPAG finding) that, while science goals for a UOP mission have been laid out in several mission studies and OWL, the prioritization of these goals needs to be accomplished in order to move forward with decisions on instrument payloads, mission timing and to drive formulation studies.

Finding #2. OPAG appreciates that the FY25 President's Budget Request includes funding to begin formulation studies for the UOP mission in FY27. OPAG strongly encourages NASA to commit to starting these activities in FY27 as planned to be consistent with Decadal Survey recommendations, and given that science return can be maximized by arriving at Uranus as close to the equinox (2049) as possible. Formation and support of a core science team (with clear, long-term roles; see November 2023 OPAG finding) no later than FY27 would support the timely refinement and prioritization of UOP science objectives that would drive any required focused formulation studies for this already well-studied mission.

Findings from June 2024 OPAG community meeting (3)

NGRTGs. OPAG thanks Mr. Carl Sandifer II, the RPS Program Manager, for presenting about the status of Radioisotope Power Systems (RPS) development. OPAG is pleased to hear that the construction and preparation of the MMRTG unit for Dragonfly is progressing. OPAG also welcomes the progress on the Constant-Rate Production (CRP) toward the planned goal of 1.5 kg/year production rate, and is pleased to hear that the production rates could be increased to meet future demand. OPAG also appreciates the development progress on the Next Generation Radioisotope Thermoelectric Generator (NGRTG) units in which a Mod 0 unit will be ready for testing in Summer 2024, and a production line for Mod 1 will be ready by 2030. OPAG looks forward to these units being ready for flight as the availability of these NGRTGs is critical to future missions of OPAG importance, such as the Uranus Orbiter and Probe (UOP) and New Frontiers missions to the outer solar system.

While appreciative of these efforts, OPAG is concerned that the RPS planning mission set does not yet include plans to infuse NGRTGs in upcoming missions. NGRTGs are critical enabling technology for UOP and perhaps for the New Frontiers 5 (NF5) mission, both to be launched in the mid-2030s. A prerequisite to designing these future missions is a valid assumption about the type and performance of power sources that will be available. In particular, as the community awaits an NF5 announcement in the October-December 2024 timeframe, we are concerned that the availability and performance of NGRTGs for NF5 missions remain unclear, and will not be included in the NF5 assumptions.

Finding #3. OPAG thanks NASA and the RPS Program for their continuing efforts to prepare RPSs that are critical for high priority future missions without alternatives, especially for outer planets missions, including UOP. OPAG requests NASA to assess the readiness and performance metrics of NGRTGs, and potentially make this capability available for technology infusion on missions launching after 2030 [e.g., NF5, UOP, perhaps Discovery].

Findings from June 2024 OPAG community meeting (4)

Uranus Stellar Occultations. Several upcoming stellar occultation events represent critical Earth-based opportunities to measure the upper atmospheric vertical structure of Uranus. Our knowledge today of the Uranian upper atmospheric structure is largely based on Voyager 2 measurements in 1986. Given sufficiently large telescope apertures and favorable observing conditions, Earth-based measurements during the upcoming stellar occultations have the strong potential to improve characterization of the micro-bar region over the Voyager 2 measurements. Uranus occults stars more frequently when it traverses the crowded background starfield of the galactic plane twice per its 84-year orbit. Thus, Uranus' next galactic plane crossing in the early 2030s is a valuable opportunity to characterize its atmosphere and rings. In particular, the events on April 8, 2025, February 15, 2031, October 9, 2031, and February 6, 2032 occult exceptionally bright stars. The occultation on February 15th, 2031 involves a 4th magnitude star, which happens less than once per Uranian orbit, and represents a once-in-a-century opportunity to characterize the upper atmosphere of Uranus from Earth. The other three events, in which 6th-8th magnitude stars are occulted, are the eighth to tenth times stars of similar brightnesses have been occulted during the current Uranian orbit after the seven events observed during the last galactic plane crossing in the 1980s. These four events together represent the brightest stars being occulted by Uranus at least until 2050. Aerocapture maneuvers are sensitive to the atmospheric density in the micro-bar region, and reducing uncertainties in that region would reduce risks during aerocapture maneuvers. Reducing upper atmospheric uncertainties will also improve future probe designs and enhance their science return.

Finding #4. OPAG requests that NASA prioritize resources (e.g., ROSES programs such as the Solar System Observations (SSO), NASA Keck time, IRTF) to observe the upcoming stellar occultations by Uranus on April 8, 2025, February 15, 2031, October 9, 2031, and February 6, 2032. In particular, an exceptionally bright star is occulted on February 15, 2031, enabling a once-in-a-century opportunity to measure the Uranian upper atmosphere from Earth. Stellar occultation measurements sense altitudes that are important to future aerocapture vehicles and atmospheric entry probes, and thus these measurements could reduce risks to future missions, in addition to delivering valuable scientific knowledge about the upper atmosphere of Uranus and its rings.

Findings from June 2024 OPAG community meeting (5)

Hubble Space Telescope for Solar System Observations.

The Hubble Space Telescope (HST) continues to provide critical observations of solar system targets that are unattainable from ground-based facilities, other space telescopes or deep space probes. Unfortunately, extreme declines in HST Guest Observer (GO) Program funding began in 2023, will worsen significantly this year, and are expected to become even more severe by next year, according to reports to the Space Telescope Users Committee . Furthermore, the future of grants that use archival (AR) data (and thus request funding only, no observing time) is uncertain.

Finding #5. OPAG emphasizes the importance of HST as an asset for critical solar system science observations. OPAG is concerned about the severe cuts in funding for HST users in recent observing cycles. OPAG requests that PSD look into the appropriate solution to adequately support HST data analysis, perhaps by allowing ROSES proposals to more liberally allow use of HST data than currently, including allowing the use of archival (AR) data.

Findings from June 2024 OPAG community meeting (6)

Super Heavy Lift Launch Vehicles.

Super heavy lift launch vehicles (SHLLV) (e.g., SLS, New Glenn, Starship) are now being developed and represent potential crucial enabling capabilities for planetary missions, as discussed in the most recent Decadal Survey. In particular for outer planet missions, the use of SHLLV would eliminate the need for a Jupiter Gravity Assist, shortening cruise time, as well as deliver more mass to the target thus increasing science return. For all planetary missions, SHLLV capabilities would increase the deliverable mass.

Finding #6. Given current plans to produce super heavy lift launch vehicles at a cadence likely faster than they will be used, OPAG encourages NASA to study use of these potentially very enabling capabilities for planetary purposes including UOP. OPAG requests that NASA work to make available its assessment of super heavy launch vehicle offerings by NASA and industry and anticipated costs to SMD on a timeline that would allow them to be considered for future PSD missions, and report the findings to OPAG at a 2025 meeting.

Statements of Support & Concern from June 2024 OPAG community meeting (1)

- **Strong Support for Existing Outer Solar System Missions.** OPAG continues to strongly endorse Europa Clipper as it prepares to launch in October 2024. We also congratulate the Dragonfly team on their mission confirmation and are particularly grateful for the supportive coordination between the Dragonfly mission team and NASA for moving the mission forward in this challenging budget environment. OPAG additionally supports ongoing missions in (and beyond!) the outer solar system and recognizes the outstanding science return of missions such as JUICE, Europa Clipper, Juno, New Horizons, and Voyager 1 & 2, in the past, present, and future. OPAG is concerned, however, that two US-contributed instruments on JUICE still have unfunded co-investigators.
- **Support for Jupiter System Science to Europa Clipper.** OPAG recognizes the scientific benefits of exploring the broader Jovian system with Europa Clipper and taking advantage of cruise opportunities. We additionally support the JUICE-Clipper Steering Committee investigation of joint activities that is identifying opportunistic science measurements and assessing their potential impacts and feasibility. OPAG encourages NASA to implement a mechanism to allow for such observations and to add science team members (via e.g., a Participating Scientist, or Guest Investigator program) to plan and conduct investigations during Clipper's approach to the Jupiter System.

Statements of Support & Concern from June 2024 OPAG community meeting (2)

OPAG supports the development of a joint Code of Conduct for the AGs, by the XAG-EDIA Group with collaboration from OPAG (and other AGs). We applaud NASA's steps to improve inclusion in funded work through the ROSES Inclusion Plan Pilot Program. These steps are essential to attracting and retaining the best talent, and for ensuring safe and productive work environments. In defining team member roles of proposed inclusion efforts, many groups draft team Codes of Conduct.

Similarly, such Codes have proliferated among conference organizations and mission teams, in efforts to prevent and respond to personal and research misconduct. Having a uniform code of conduct for the AGs would clarify expected behaviors, making it easier to respond appropriately to misconduct when it occurs. Furthermore, OPAG supports a NASA effort toward a unified Code of Conduct or Guidelines for Ethical Conduct for NASA sponsored activities, with the aim of streamlining the implementation and enforcement of inclusion plans.

Statements of Support & Concern from June 2024 OPAG community meeting (3)

- **Discovery missions.** Discovery missions could enable focused science investigations at Outer Planets targets, as indicated by past Discovery proposal submissions. For some of these concepts, RPS technology could be enabling. During the NASA PSD Update, Deputy Director Eric Ianson stated that there will not be a Discovery AO in the next two years. OPAG eagerly awaits finer details on the upcoming Discovery AO plans and guidelines, and requests that NASA consider making RPS technology available for Discovery mission concepts, which in turn would factor into NASA's RPS development plans over the next decade.
- **Support for a cohesive Ocean Worlds Strategy.** The Origins, Worlds, and Life Decadal Survey recommended that NASA develop scientific exploration strategies for areas of broad scientific importance – including ocean worlds explicitly – that have an increasing number of U.S. missions and international collaboration activities. Scientific exploration strategies examples to be considered included 1) coordination within NASA to support key research topics encompassing remote sensing, laboratory, theoretical, and ground-based telescopic investigations focused on upcoming missions; 2) a technology development plan to enable future missions; and 3) collaboration of possible future activities between U.S. and international and commercial partners to maximize NASA's investments, aid in the selection of an optimal suite of missions, and enhance the exchange of scientific knowledge and data. In the absence of an Ocean Worlds Exploration Program, OPAG and SBAG have jointly established an Ocean Worlds Working Group (OWWG) to develop the scientific and technological priorities for ocean world exploration with broad community participation. OPAG supports the OWWG and recognizes the importance of their activities as inputs to the Mid-Decadal Review and NASA's strategies for the second half of the decade. *OPAG requests that NASA clarify how the results of OWWG's work may be most constructively relayed to the Agency.*

Statements of Support & Concern from June 2024 OPAG community meeting (4)

EDIA Topics.

OPAG applauds the efforts of the Cross-AG EDIA Working Group!

a. The importance of an appointed EDIA position within NASA SMD

OPAG supports NASA's ongoing efforts promoting inclusivity, equity, diversity, and accessibility of the science community. In coordination with the Cross-AG EDIA WG, OPAG supports the recruitment of a senior scientist as an outward-facing point of contact for improving the work culture of a broader workforce associated with SMD. Focusing on those funded externally to NASA, a coordinated effort is needed to ensure consistency across divisions to maximize existing efforts to reach NASA goals. OPAG is working with the Cross-AG EDIA WG on drafting the details for this potential position and invites inputs from NASA and community members.

b. EDIA Training and Workshops

OPAG supports NASA's investment in training and workshops to further equity, diversity, inclusion, and accessibility (EDIA) in NASA activities and among its workforce (e.g., Harassment Bystander Training by OtherOrb, and the recently funded TWSC trainings "Bringing EDIA to the Planetary Sciences Community: A Two-Day AG- style meeting of the cross-AG EDIA Working Group"). OPAG supports the concept of individual proposers being allowed to propose for funding to attend such workshops, as part of their proposal inclusion plans. Such federal funding can be particularly important to proposers working at institutions with limited resources and/or other restrictions for EDIA trainings. Future AG contracts should include funding to support DEIA training, such as bystander intervention training, for the AG steering committees.

Statements of Support & Concern from June 2024 OPAG community meeting (5)

University of Arizona Space Science Series books.

OPAG was disappointed to learn that the end of NASA support for LPI Publication Services threatens the University of Arizona Space Science Series books. This would adversely impact the planetary science community, both in helping to provide resources for early career researchers as well as those joining planetary science from other fields regardless of career stage. NASA's subsidization of this book series has kept them relatively inexpensive and accessible to the community for many years. Given that support for this book series is such a small cost (approx. 1.0 FTE), OPAG expresses its support for finding resources within NASA to continue this important publication line and to making the publications open access.

Nuclear Power and Propulsion. Nuclear fission-based power and propulsion technologies could introduce capabilities currently not available for space exploration. Fission power at the multi-kW level could be highly beneficial for Ocean Worlds melt probes, while nuclear thermal propulsion could significantly reduce flight times to outer planets targets, as well as increase the deliverable mass. Based on the long technology maturation timeline and significant investments needed, with an early investment and continuing support, fission based nuclear systems could be infused into Outer Planets missions targeting the next decadal time frame. OPAG is excited about the capabilities that could be enabled by these emerging space nuclear fission power technologies. OPAG supports efforts to leverage ongoing industry efforts on terrestrial systems, and technology developments at other government agencies.

Statements of Support & Concern from June 2024 OPAG community meeting (6)

International Cooperation on Missions. OPAG endorses the value of international cooperation in planetary exploration. International cooperation brings benefits that outweigh any added cost and complexity in planning and executing the cooperation. International collaboration also enables further exchange of ideas to broaden participation in planetary exploration. OPAG will strive to facilitate discussions between international outer planets communities by welcoming presentations by potential international partners in future NASA outer planet missions.