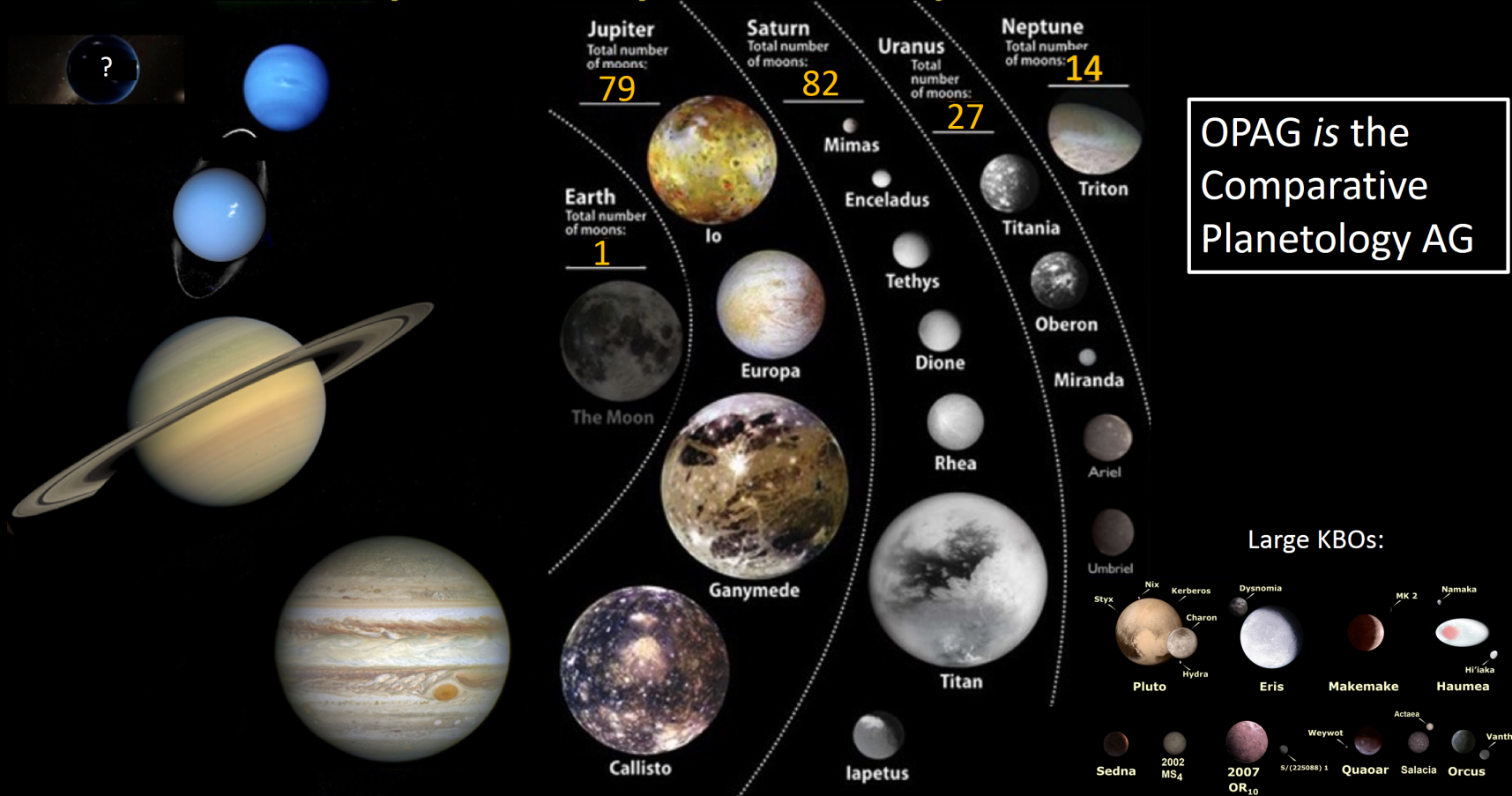


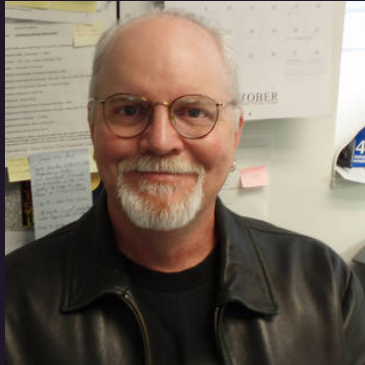
OPAG Update to the Planetary Science Advisory Committee (PAC)

Jeff Moore, OPAG Co-Chair, NASA ARC, PAC Meeting, 18 August 2020

Outer Solar System: Many Worlds to Explore



OPAG Steering Committee



Jeff Moore
OPAG Co-Chair
Ames Research Center



Linda Spilker
OPAG Co-Chair
Jet Propulsion Lab



Alfred McEwen
University of Arizona



Lynnae Quick
NASA Goddard



Kathleen Mandt
Applied Physics Laboratory

OPAG Steering Committee



Morgan Cable
Jet Propulsion Lab



Britney Schmidt*
Georgia Institute of Technology



Kunio Sayanagi
Hampton University



Tom Spilker
Consultant



Abigail Rymer
Applied Physics Lab

* =Rolling off

OPAG Steering Committee



Scott Edgington
Jet Propulsion Lab



Amanda Hendrix
Planetary Science Institute



Mark Hofstadter*
Jet Propulsion Lab



Jeff Bowman*
Scripps Oceanography Inst.



Terry Hurford
Goddard Space Flight Center



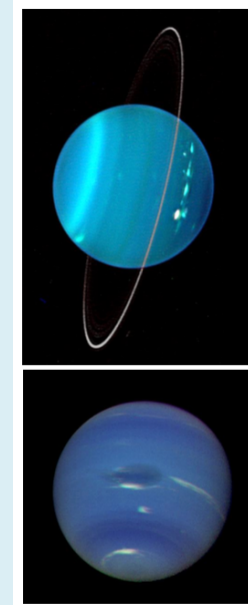
Carol Paty
University of Oregon

* =Rolling off

Outer Planets Assessment Group (OPAG) Charter

<https://www.lpi.usra.edu/opag/>

- NASA's community-based forum to provide science input for planning and prioritizing outer planet exploration activities for the next several decades
- Evaluates outer solar system exploration goals, objectives, investigations and required measurements on the basis of the widest possible community outreach
- Meets twice per year, summer and winter
 - Next meeting (virtual): 1-3 September 2020
- OPAG documents are inputs to the Decadal Surveys
- OPAG and Small Bodies Assessment Group (SBAG) have Joint custody of Pluto system and other planets among Kuiper Belt Objects



KBO planets

Recent and Upcoming OPAG-related Meetings

- **OPAG Meeting** (3-4 February 2020) Lunar and Planetary Institute, Universities Space Research Association (USRA) 3600 Bay Area Blvd, Houston, TX
- ***Joint VEXAG/OPAG/ExoPAG meeting*** (4-7 February 2020), Lunar and Planetary Institute, Houston, TX (*This was really useful and we would like to see more like this in the future*)

Upcoming Meetings:

- **OPAG Meeting** (1-3 September 2020) (Virtual)
 - Focus on upcoming Planetary Science and Astrobiology Decadal Survey
 - 6 Findings from February meeting that will be addressed in NASA HQ briefing (see backup slides for details of each finding)
- **Possible Town Hall at AGU** (7-11 December 2020)

Our Upcoming Meeting agenda

9/1/2020 (Tuesday)

9:00 a.m. – 11:00 a.m. PDT (12:00 p.m. – 2:00 p.m. EDT)

Welcome, Agenda Overview, Meeting Goals -Jeff Moore (NASA ARC) & Linda Spilker (JPL),
OPAG Chairs **10/9:00**

NASA Planetary Science Division (PSD) Update -Curt Niebur (NASA HQ) **50 / 9:10**

Decadal Survey Update -Phil Christensen (ASU) and Robin Canup (SwRI) **60/ 10:00**

BREAK 11:00 - 11:30 a.m. PDT (2:00 - 2:30 p.m. EDT)

11:30 a.m. – 2:00 p.m. PDT (2:30 p.m. – 5:00 p.m. EDT)

OPAG White Paper Discussion

Town Hall Discussion 90 / 12:30- 2:00

Our Upcoming Meeting agenda

9/2/2020 (Wednesday)

9:00 a.m. – 11:00 a.m. PDT (12:00 p.m. – 2:00 p.m. EDT)

Planetary Mission Concept Studies

Enceladus Flagship Mission Study -Shannon MacKenzie (JHU) **20/ 9:00**

Neptune-Triton Strategic Mission Study -Abigail Rymmer (JHU) **20/ 9:20**

Ice Giant Pre-Decadal Study -Mark Hofstadter (JPL) **10 min / 9:40 am**

Pluto Orbiter and Kuiper Belt Exploration Mission Study -Carly Howett (SwRI) **20/ 9:50**

Europa Lander Mission Study -Kevin Hand (JPL) & Cynthia Phillips (JPL) **20/ 10:10**

Town Hall Discussion and questions for earlier talks 10:30 - 11:00

BREAK 11:00 - 11:30 a.m. PDT (2:00 - 2:30 p.m. EDT)

11:30 a.m. – 2:00 p.m. PDT (2:30 p.m. – 5:00 p.m. EDT)

Approved Outer Planet Mission Updates

New Horizons -Alan Stern (SwRI) **15/ 11:30**

Europa Clipper -Robert Pappalardo & Jan Chodas (JPL) **20/ 11:45**

Dragonfly – Elizabeth "Zibi" Turtle (APL) **15/ 12:05**

Juno - Scott Bolton (SwRI) **15/ 12:20**

Town Hall Discussion 12:35 - 2:00

Our Upcoming Meeting agenda

9/3/2020 (Thursday)

9:00 a.m. – 11:00 a.m. PDT (12:00 p.m. – 2:00 p.m. EDT)

Discovery Candidates (Trident and IVO)

IVO – Alfred McEwen (UArizona, Tucson) **15/ 9:00**

Trident – Louise Prockter (JHU) **15/ 9:15**

CAPS Recommended Mission Concepts

Saturn System Mission Concepts -Tom Spilker **15/ 9:30**

Solar System Telescope Concepts Study -Kunio Sayanagi (HU) **15/ 9:45**

Town Hall Discussions: 10:00 - 11:00

BREAK 11:00 - 11:30 a.m. PDT (2:00 - 2:30 p.m. EDT)

11:30 a.m. – 2:00 p.m. PDT (2:30 p.m. – 5:00 p.m. EDT)

Additional Topics

PPIRB briefing – Alan Stern (SwRI) **15 /11:30**

CDAP, NFDAP, and SSW Status Reports –Henry Throop (NASA HQ) **15/ 11:45**

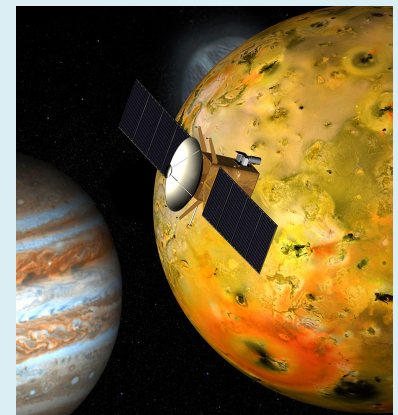
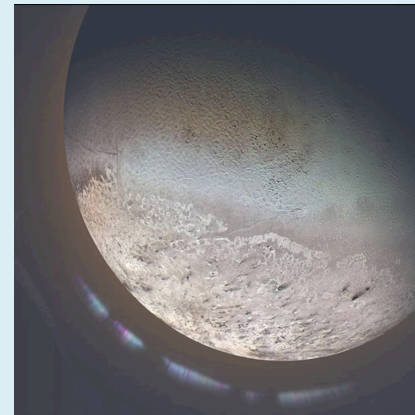
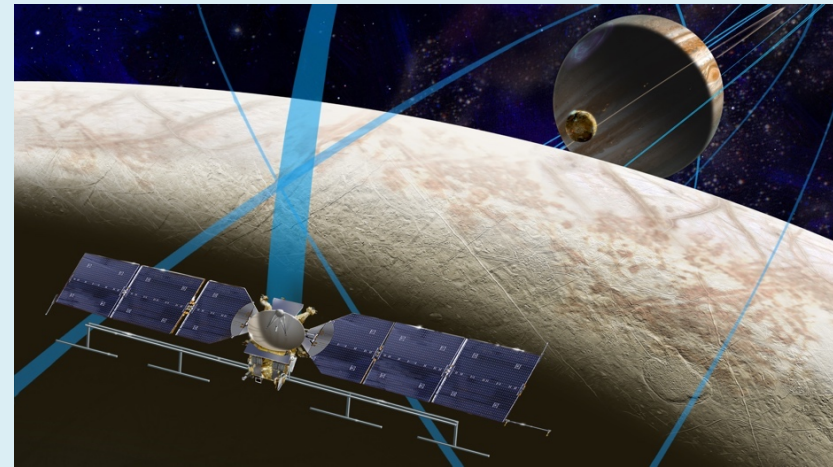
EDI WG update -Christina Richey (JPL) & Moses Milazzo (Other Orb LLC) **15 /12:00**

OPAG Steering Committee Membership Discussion **15 /12:15**

Town Hall Discussion & any new findings 60 /12:30-2:00

Some Recent Key Activities

- Io Volcano Observer (IVO) selected for further Discovery Mission study. Alfred McEwen (PI)
- TRIDENT selected for further Discovery Mission study. Louise Prockter (PI)
- Juno Probe Completed 28th Orbit of Jupiter
- Europa Clipper completed PDR progressing towards launch NLT 2025
- JUICE progressing towards 2022 launch
- 3 Outer Planet mission studies for the Decadal Survey: final reports submitted
- **OPAG Committee White Paper posted**



New Frontiers has been good for exploration of Outer Planets

- Missions from the 1st Decadal survey:
 - New Horizons
 - Juno
- Approved candidate missions in 2nd Decadal (V&V) to outer solar system:
 - Saturn Probe
 - Ocean Worlds: Enceladus and Titan
 - Dragonfly to Titan selected for NF-4
- OPAG supports keeping Io Observer and Ocean Worlds in NF-5, along with Saturn Probe
- If IVO is selected for Discovery, then there might be no Io Observer proposals submitted to NF-5, similar to what happened with the Trojan mission after Lucy was selected.
- **Though Dragonfly was selected for NF-4, OPAG supports CAPS recommendation for keeping Enceladus as an NF-5 option**



Dragonfly



OPAG Committee White Paper

- **Organized around Big Questions**
 - What is the distribution and history of life in the solar system?
 - What is the origin, evolution, and structure of planetary systems?
 - What present-day processes shape planetary systems, and how do these processes create diverse outcomes within and across different worlds?

With a fourth Cross-Divisional theme: How can solar system bodies inform our understanding of bodies in exoplanetary systems?
- **Strategic Approach**
 - Research and Analysis (R&A), International Partnership
- **Technology and Supporting Strategic Investment** (including)
 - Orbital vs. *In situ* in Exploration, Aerocapture, Earth-based Astronomy, Laboratory Measurements
- **Diversity Statement**
 - Foster an interdisciplinary, diverse, equitable, inclusive, and accessible community with improved representation of underrepresented people

OPAG Committee White Paper Conclusions

Large Directed Missions

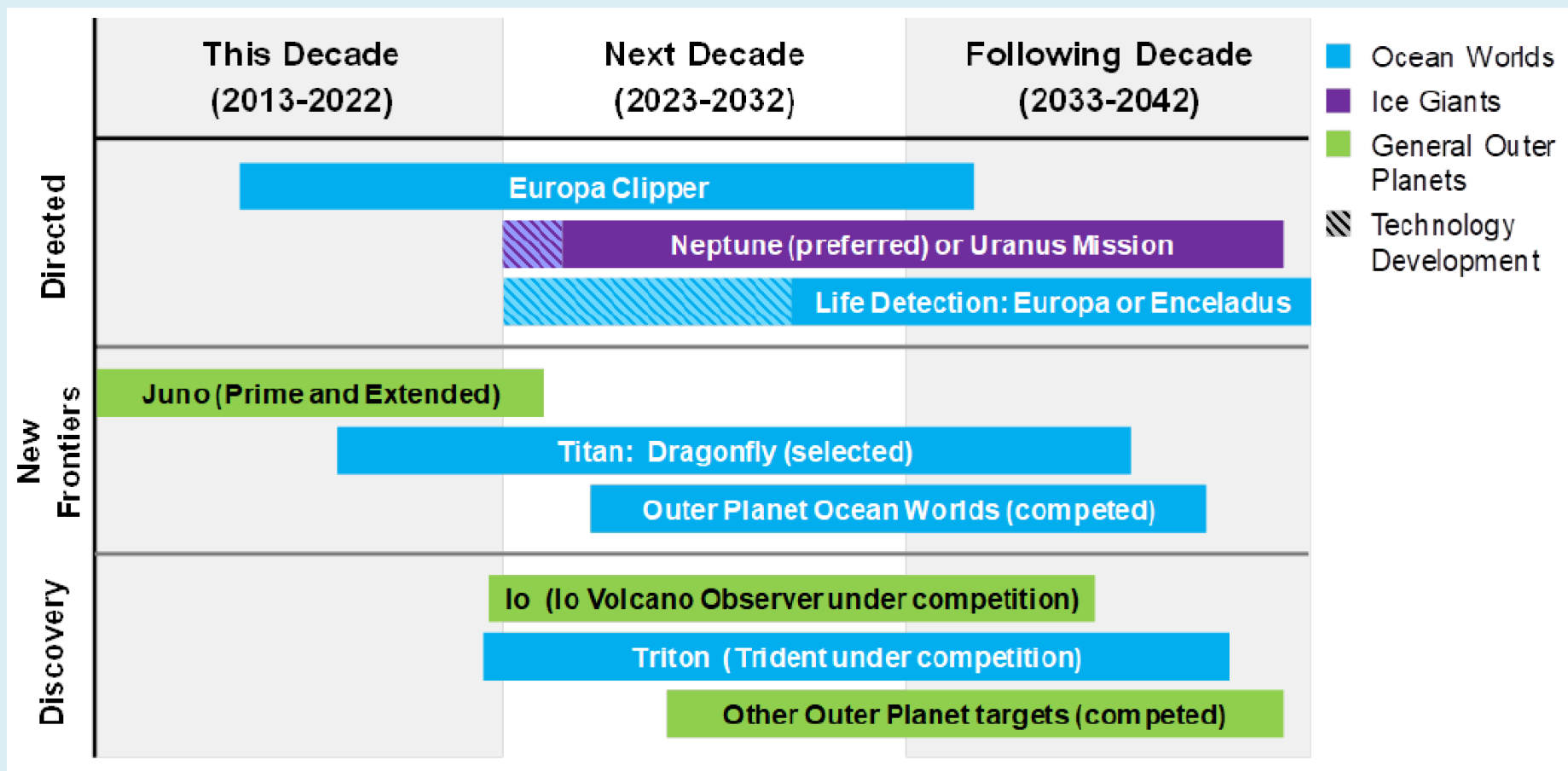
- **Complete Europa Clipper**
- **New start for an Ice Giant Systems mission**
 - Neptune is preferred since Triton is a higher-priority Ocean Worlds target
 - Re-affirms importance given to such a mission in previous Decadal Survey
 - No new technology efforts needed for this mission to proceed
- **New start for Ocean Worlds mission** in second half of decade
 - Search for life or biosignatures on an ocean world, most likely Europa or Enceladus
 - Life detection technology development could prove essential to either mission
 - Strongly support continuing ongoing technology development efforts
 - Recommend that current Decadal Survey include a Priority Question about life or biosignature detection rather than just the study of habitability

OPAG Committee White Paper Conclusions

New Frontiers Missions

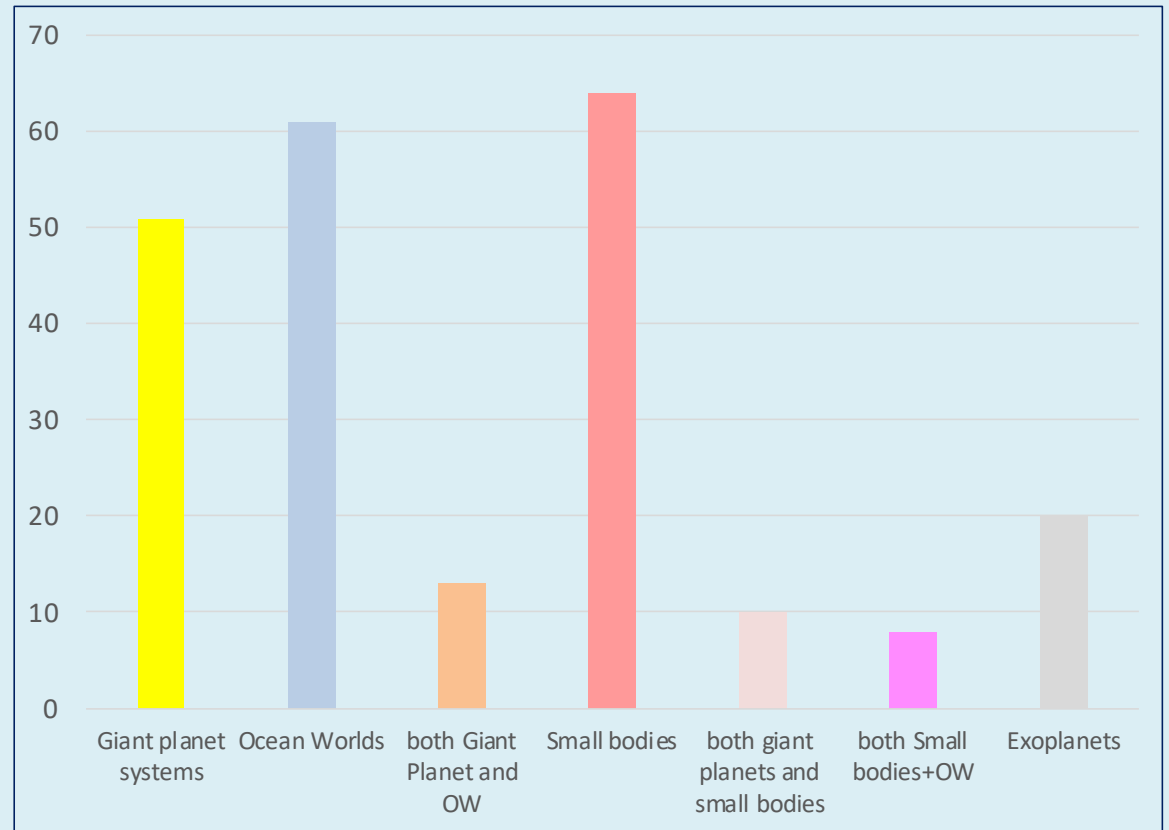
- OPAG supports opening competition to all solar system destinations, as recommended by the National Academies in 2008
 - Outer solar system has a great abundance of interesting worlds to explore,
 - Mission restrictions are a particularly onerous for future exploration
- Support inclusion of:
 - Enceladus and Titan ocean worlds missions
 - Io Observer (if IVO not selected for Discovery mission)
 - Saturn probes

Timeline for a robust Outer Planets Program spanning three decades



Preliminary OPAG-Relevant White Paper Statistics

Number of White Papers (of 381 submitting as of 13 August 2020)	
Giant planet systems	51
Ocean Worlds	61
both Giant Planet and OW	13
Small bodies	64
both giant planets and small bodies	10
both Small bodies+OW	8
Exoplanets	20



Back up slides

OPAG Findings February 3-4, 2020 Meeting

1. Europa Clipper. OPAG applauds the progress the Europa Clipper team is making toward its Critical Design Review (CDR) this coming August, and the transparency shown by the team that mission development's cost reserves are running very low. The reserve, quantified as Unallocated Future Expenses, reached 12% in November 2019 even though it met the JPL-required 25% as of June 2019. The project team has been able to reconstitute some of the reserve amount required ahead of its CDR, but there is danger that this savings effort will fall short, threatening the mission's science. NASA should recognize the scientific importance of the entire Europa Clipper payload, and strive to fly the full science instrument suite to best achieve the mission objectives.

Finding 1.

OPAG is concerned about the fast drain on the cost reserves. OPAG recognizes the scientific importance of flying the entire Europa Clipper science payloads, and urges NASA to minimize the impact of the low cost reserves on the science investigations.

OPAG Findings February 3-4, 2020 Meeting

2. Icy Satellite Technology support. OPAG strongly supports technology development programs that invest in future Ocean Worlds in situ exploration (similar in scope to the ICEE program). OPAG understands that the FY2020 congressional budget includes funding for Icy Satellite technology development. OPAG would like to know the operating plan for this budget line item.

Finding 2.

OPAG supports investment in future Ocean Worlds in situ technology development. OPAG would like a report on the operating plan for the Icy Satellite technology development line item listed in the FY2020 congressional budget.

OPAG Findings February 3-4, 2020 Meeting

3. Expanding RCN to other areas of planetary science. OPAG commends NASA for the outstanding impact that programs like the NASA Astrobiology Institute and the new Research Coordination Networks (RCN) have for building up a strong astrobiology community that is actively advancing the search for life in the solar system and beyond. These efforts have led to the development of groundbreaking mission concepts and have benefitted a diverse community of researchers eager to answer the question of whether we are alone in the universe. OPAG encourages NASA to build on this success by expanding RCN opportunities to other planetary science communities. In particular, a Giant Planet System Science RCN would provide opportunities for interdisciplinary coordination among members of the OPAG community who have explored the Jupiter and Saturn systems on missions like Galileo, Cassini, and Juno, and who are eager to conduct research (Voyager data analysis, theoretical research, and laboratory studies) relevant to future exploration of the Ice Giant systems.

Finding 3.

OPAG commends the outstanding success of NASA Astrobiology programs for building a strong interdisciplinary community advancing the search for life in the universe. OPAG encourages NASA to expand on this model by creating a new RCN for Giant Planet System Science.

OPAG Findings February 3-4, 2020 Meeting

4. Dual-anonymous review. OPAG applauds NASA's exploration of the dual-anonymous review process to address diversity/bias issues. OPAG notes that technology programs, particularly instrument development opportunities, are a particular challenge for Principal Investigators from diverse and intersectional backgrounds. For example, all of the PI's selected for the ICEE-2 instrument development program were male with limited representation along other axes of diversity, which gives an appearance of bias. OPAG encourages NASA to test the dual-anonymous review process on an instrument program as the next test program to provide a stronger dataset to evaluate the effectiveness of this review strategy. As examples of programs that receive a large number of proposals and represent good testing grounds of dual-anonymous review process, we point to the PICASSO and Applied Information Systems Research programs.

Finding 4.

OPAG commends NASA's efforts to test dual-anonymous review for R&A programs. OPAG encourages NASA to test dual-anonymous review on an instrument development program in the near future because this is a class of programs that can be perceived as lacking in diversity of selected PIs.

OPAG Findings February 3-4, 2020 Meeting

5. EDI Demographic and Climate Surveys. OPAG applauds the volunteer work being done by the Equity, Diversity and Inclusion (EDI) Working Group with participation from all planetary AGs. We fully support the letter sent by the EDI Working Group to NASA HQ on 28 January 2020 which is also available on the OPAG website.

Finding 5.

We encourage implementation of the two recommendations in the letter in time to inform the Decadal Survey, namely: 1) The community has a need for a survey across all of SMD that will enable analysis of multi-dimensional demographics data to understand the diversity aspects of our population, including data that goes beyond gender ratios and includes disciplines; and 2) NASA should commission regular (yearly), professionally-designed climate surveys so that we can fully identify the equity and inclusion issues within our community, and ensure those climate surveys consider relevant axes of power and career structures.

OPAG Findings February 3-4, 2020 Meeting

6. Advanced Radioisotope Power Systems (RPS) Program Availability Schedule. OPAG thanks June Zakrajsek of the NASA RPS Program for her briefing. We understand that the development of the eMMRTG has been suspended, and that the NextGen RTG is scheduled to be flight qualified in 2028, with flight unit production starting only after qualification is completed. Previous studies of outer solar system missions that baselined the eMMRTG, such as the recent ice giant missions studies [1], are now obsolete. Since the MMRTG is not a viable option for most long-duration missions [2], the NextGen RTG is the only remaining RPS option currently under development. A lengthy schedule for the NextGen RTG's flight availability could have significant negative impacts on the schedules for some Discovery, New Frontiers, and ice giant flagship mission concepts already studied by NASA and other institutions.

Finding 6.

OPAG requests a further presentation by NASA regarding the schedule for the NextGen RTG development, qualification, flight unit fabrication, testing and delivery for launch, to enable a more detailed discussion at the next OPAG public meeting.

1. Hofstadter, M.D., Simon, A., Ice Giants Pre-Decadal Survey Mission Study Report, JPL D-100520, p. 2-2, 2017 June; available at https://www.lpi.usra.edu/icegiants/mission_study/Full-Report.pdf
2. *ibid*, p 1-8, 2-8.