January 10–11, 2013 Meeting
Atlanta, Georgia

The Outer Planets Assessment Group is a NASA-supported forum for scientists, engineers, and other interested parties. At OPAG meetings, the group strategizes about current and future exploration of the Outer Solar System and works to enhance communication between the Outer Planets community and NASA. OPAG met this winter for two days, with an emphasis on hearing the final report from the Europa Science Definition Team, which was charged with responding to the recommendations of the Planetary Science Decadal Survey. Other Decadal Survey recommendations were also extensively discussed. Below, we (the OPAG Steering Committee) assess the state of the field. We then describe the January 2013 OPAG meeting, and conclude with our major findings based on discussion at the January meeting and amongst the Steering Committee.

Exploration of the Outer Planets — Where Are We Today?

As of early 2013, NASA’s program of Outer Planets exploration appears at first blush to be in good shape. A major, flagship-class mission – Cassini – is operating all but flawlessly in orbit around Saturn. Plans to continue the Cassini mission in an extended phase into FY15 received the highest ranking of all the missions considered in the recent Planetary Mission Senior Review. The first New Frontiers mission, New Horizons, is closing in on its prime target, the Pluto-Charon system. The second New Frontiers mission, Juno, is en route to Jupiter and in excellent health. Research and Analysis programs devoted to Outer Planets science, OPR (Outer Planets Research) and CDAPS (Cassini Data Analysis and Participating Scientists), while greatly oversubscribed, are funded. Earth-based discoveries supported by NASA continue apace.

But there is a dark cloud on this seemingly rosy horizon. NASA’s preeminence in Outer Solar System exploration is the result of decades of planning and investment, and the Outer Solar System in particular requires foresight because of the distances and time scales involved: 1) The Voyager missions were started while the Pioneers were in development and then launched; 2) The Galileo mission was started while the Voyagers were still cruising to Jupiter; and 3) Cassini-Huygens was started while Galileo was still en route to Jupiter. Yet there is still no plan (as embodied in the President’s proposed FY14 budget) to follow up on the discoveries at Jupiter or Saturn and their moons (by Galileo and Cassini-Huygens, respectively) with a
flagship-class mission, much less any formal consideration of a mission to the ice giants, Uranus and Neptune. The 2003-2012 and the 2013-2022 Planetary Science Decadal Surveys recommended such missions, and both recommended as their highest-priority, non-Mars, major mission, one to explore Europa and its potential habitability.

By the close of 2017, only a few years hence, both the Cassini and Juno missions will have met their spectacular ends, and the New Horizons prime mission to fly by Pluto will be history. The Outer Solar System will then go “radio quiet,” with only the 1970s-era Voyager spacecraft still sending back feeble signals, and the New Horizons mission joining their rank if its extended Kuiper Belt mission is approved. Unless something changes soon, NASA and America will cede its leadership role in this arena of Solar System exploration, because the only new Outer Solar System spacecraft presently in development is the European Space Agency’s JUICE mission to Jupiter and Ganymede. NASA is a minor partner in JUICE, but even that ESA mission does not reach Jupiter until 2030.

One reason that NASA finds itself in this situation is our country’s fiscal situation. How this will play out is unclear, but if austerity becomes policy over the next few years, it will be difficult to resume Outer Planet exploration once the current level of vigor fades. The Outer Planets community is well aware of all these facts, and has taken steps to rigorously reexamine its Decadal-recommended mission to Europa. The Europa mission concept that has emerged, the Europa Clipper, provides flagship-class science at a price point ($2B) that is widely recognized as responsible, especially when the total costs are amortized over an ~20-yr lifetime.

The Outer Planets community recognizes that a restoration of Planetary Science Division’s budget to something approaching 2012 levels is necessary to move such a mission forward. The recently passed and signed into law NASA budget for FY13 provides an important and substantial fraction of this restoration, at least for the current fiscal year. NASA must recognize that a tremendous opportunity now presents itself. A major Outer Planets spacecraft mission is now ready to start, a mission that may revolutionize our understanding of life in the Universe, and a mission that is affordable. NASA has an opportunity, and an obligation to acknowledge the importance of exploring and understanding the Outer Solar system, and to act upon it. If NASA does not seize this opportunity, American preeminence in Solar System exploration will be forfeit. The important discoveries to be made in the Outer Solar System will either lie dormant or undiscovered or will be made by other nations decades hence.
I. Meeting description
Presentations were heard as follows:

Thursday 10 January

**Planetary Science Division Update**
Jim Green, NASA Headquarters

**Outer Planets Status**
Curt Niebur, NASA Headquarters

**Outer Planets Research Program**
Terry Hurford, Goddard Space Flight Center

**Cassini Data Analysis and Participating Scientist Program Update**
Henry Throop, NASA Headquarters

**Demographics of Planetary Sciences**
Fran Bagenal, University of Colorado

ASRGs, Pu-238, and MMRTG Development
Len Dudzinisk, NASA Headquarters

**Europa Mission Studies Overview**
David Senske, Jet Propulsion Laboratory
Louise Prockter, Applied Physics Laboratory
Brian Cooke, Jet Propulsion Laboratory

**In-Space Propulsion Technologies**
Eric Pencil and David Anderson, NASA Glenn Research Center

**Thermal Protection System Options for Planetary Probes**
Don Ellerby, NASA Ames Research Center

**Game Changing Technologies Infusion**
Steve Gaddis, NASA Langley Research Center

Friday 11 January

**Ice Giant Working Group Report**
Mark Hofstadter, Jet Propulsion Laboratory

**Future Outer Planet Exploration Meeting, London**
Leigh Fletcher, University of Oxford

**The Discovery AO Experience**
Michael New, NASA Headquarters

**Lessons Learned in Decadal Planning**
Steve Mackwell, Lunar and Planetary Institute
Amy Simon-Miller, NASA Goddard Space Flight Center

**Io Workshop Report**
David Williams, Arizona State University

**The Case for Discovery at Callisto**
Bruce Bills, Jet Propulsion Laboratory

**JWST for Solar System Observations**
Stephanie Milam, NASA Goddard Space Flight Center

**NRO Telescopes for Planetary Observations**
Amanda Hendrix, Planetary Science Institute

**Stratospheric Balloon Update**
Tibor Kremic, NASA Glenn Research Center

**Status of PSD Technology for Outer Planets**
Pat Beauchamp, Jet Propulsion Laboratory

**Cassini-Planetary Data System Usability**
Kathryn Weid, Jet Propulsion Laboratory

**CCPP/AMDA Tool for Cassini and JUICE**
Baptiste Ceccconi, Observatoire de Paris, Meudon

**Ganymede Lander Workshop, Moscow**
Kevin Hand, Jet Propulsion Laboratory

**Pluto System on the Eve of New Horizons**
Bill McKinnon, Washington University in St. Louis
II. OPAG Findings

1. **Europa Clipper.** OPAG offers its unequivocal and strongest support for the *Europa Clipper* mission. The ultimate result of more than a decade of ever more detailed study and down-selects, this mission offers paradigm-shifting, flagship-level science at Jupiter’s ocean moon. *Europa Clipper* is very highly responsive to the Decadal Survey recommendation that the cost of the then-proposed Jupiter Europa Orbiter (JEO), which was ranked scientifically on par with a Mars sample-caching mission, be substantially reduced. *Europa Clipper* retains most of the scientific return of JEO, while the costs have been more than halved. The breakthrough concept of a multiple flyby mission derives in part from the highly successful multiple-Titan-flyby experience of Cassini, and for many of the Europa remote sensing instruments the multiple-flyby architecture actually offers a superior platform for operations and radiation reduction. *Europa Clipper* could enter phase-A today, and should be started as soon as funds allow. Beneficial near-term uses of the Europa mission “pre-formulation and/or formulation activity” funds, to use the FY13 budget law language, would include instrument maturation and accelerated attention to high-priority technical trades.

*OPAG strongly encourages NASA to recognize this opportunity and begin work on the Europa Clipper. OPAG wishes to be informed at the earliest opportunity of NASA’s plans for the monies appropriated by Congress for Europa mission formulation and/or pre-formulation activities. Further, OPAG wishes to be informed at the earliest opportunity of NASA’s long-range plan for formulating (starting) the Europa mission described in the FY13 budget law.*

2. **Cassini Extended Mission.** OPAG is extremely pleased that the science of the Cassini extended mission for FY 2013-2015 was so highly ranked in the recent Planetary Mission Senior Review. Cassini remains the Outer Planets community’s premier existing mission, flagship or otherwise, and one whose rate of scientific discovery continues undiminished. OPAG especially looks forward to Cassini’s end-of-mission proximal orbits, in 2016-2017, and the scientific synergy with Juno’s close-in investigation at Jupiter.

*OPAG continues to strongly urge that NASA fund Cassini at the level required to safely operate the spacecraft and to obtain and analyze the data necessary to accomplish the science objectives of the entire Cassini Solstice Mission.*

3. **NASA Participation in JUICE.** OPAG is also extremely pleased that NASA has enabled U.S. participation in ESA’s Jupiter Icy Moons Explorer (JUICE), through
provision of instruments, instrument components, and support for U.S. co-investigators. OPAG especially commends NASA for putting together the $100M lifecycle commitment on very short notice and in a difficult budgetary environment. With the initial selections having been announced by ESA, OPAG naturally strongly urges that NASA follow through on its proposed support, even in the face of present budgetary difficulties. JUICE is the only mission now in development that will return to any of the giant planets after the nominal ends of both the Cassini and Juno missions in 2017. While a US-led mission to Jupiter and Europa remains to be started, it is fitting and proper that NASA play a supporting and beneficial role in JUICE.

OPAG strongly endorses NASA’s stated support of $100M for ESA’s JUICE mission. Given the long-term nature of this (and other) Outer Planets missions, OPAG urges NASA to consider measures in the years ahead that will allow for greater participation in JUICE by younger U.S. scientists — some of whom may only be in grade school at the present time! Given the lifetime of the JUICE mission, the budgetary strictures of today may not be applicable years from now.

4. New Frontiers Program Opportunities. OPAG is deeply concerned with the future of Outer Solar System exploration. As stated earlier, after 2017 the Outer Solar System will go “radio quiet,” limited to the modest transmissions from the Voyager Interstellar mission, possible New Horizons post-Pluto Kuiper belt explorations, and the arrival of ESA’s JUICE mission at the Jupiter system in the 2030s. At the January OPAG meeting, there was much discussion of the possibility (and wisdom) of unifying the Decadal Survey’s New Frontiers 4 and 5 lists. Driving this discussion was the apprehension that there may only be one New Frontiers opportunity in the decade covered by the Survey (2013-2022), and not the two mission opportunities recommended. On the other hand, the Decadal Survey is a carefully crafted, consensus document, and one that should not be revised in an ad hoc manner. We suggest that one avenue to address the general issue of when or if the Decadal Survey as written might be revised in order to better address drastically changed budgetary or scientific priorities would be through the midterm review process (akin to the NOSSE review of the previous Planetary Decadal Survey).

Given continuing uncertainties in the planetary budget, and the possibility that budgets will be reduced in the future by ongoing sequestration, OPAG suggests that NASA ask the NRC Committee on Astrobiology and Planetary Science (CAPS) to advance a midterm reconsideration of New Frontiers targets.

5. Discovery in the Outer Solar System. OPAG strongly supports the potential for Outer Solar System Discovery missions, and urges NASA to consider ways to level the
playing field for these missions within the Discovery Program. Such missions have been proposed in the past, notably in the most recent call with specific incentives, but none have been selected. These missions are at a major disadvantage because of several factors. For example, longer Phase Es are generally required for missions to the Outer Solar System, and data downlinks are generally longer and more costly in terms of DSN time.

OPAG heard a “lessons learned” presentation by Discovery Program Director Michael New, and discussed numerous suggestions for exploring the Outer Solar System under Discovery. This issue is important, especially as a tightly cost-constrained planetary exploration program puts greater emphasis on PI-led missions. OPAG therefore decided to convene a working group to further address the matter of “leveling the playing field.” This Discovery in the Outer Solar System working group will assess lessons learned from the recent past AO experiences, and suggest adjustments that, if accepted, would allow the Outer Solar System missions to be competitive in the Discovery line.

*OPAG suggests NASA work to assess lessons learned from the recent past AO experiences and consider appropriate adjustments to the next Discovery AO. OPAG for its part has convened a working group to submit recommendations to NASA along these lines.*

**6. Pu-238 Restart.** OPAG reiterates the central importance of radioisotope power systems for deep space exploration. OPAG heard a detailed report from Len Dudzinski (NASA Headquarters) on ASRG development, and commends ongoing NASA and Science Mission Directorate efforts to have Pu-238 production restarted in the U.S. OPAG is heartened by the recently passed NASA budget for FY13, which provides funds to NASA to support DOE production of Pu-238, and by continuance of this effort in the President’s proposed budget for FY14. We strongly support NASA’s ongoing efforts to make sufficient amounts of plutonium available for Outer Solar System (and other) missions. OPAG also strongly supports making ASRG technology available for PI-led missions. The framework for their inclusion requires careful consideration, however, as their use in New Frontiers or Discovery should not be viewed as a technical or cost risk during mission competition.

*OPAG strongly supports PSD efforts to have DOE restart Pu-238 production with funds appropriated by Congress. OPAG further supports making ASRGs available in the next Discovery and New Frontiers calls, provided that this technology has reached a sufficiently high TRL level.*

**7. Thermal Protection Systems.** OPAG highlighted concerns regarding thermal protection systems (TPS) for Outer Planet probes in its findings from the March 2012
meeting, which we elaborate on here (and in parallel with our colleagues at VEXAG). Continued development of entry technologies is critical to ensuring availability for New Frontiers-4 Saturn Probe mission proposals. OPAG encourages NASA’s Planetary Science Division to monitor progress on entry technologies sponsored by the Space Technology Mission Directorate (STMD) and entry technologies available from industry, and then to coordinate the release of the most current technical information prior to issuance of the Announcements of Opportunity for Discovery and New Frontiers.

*OPAG particularly encourages NASA to incentivize the adoption of entry-probe technologies needed for Outer Planet missions (including instrumentation to monitor the performance of the thermal protection systems) in the forthcoming Discovery and New Frontiers calls.*

**8. Technology Development for Outer Planets.** On the broader technology front, OPAG is concerned that Planetary Science Division (PSD) technology development is not meeting the Decadal Survey or the Planetary Science Technology Review (PSTR) panel recommendations, and is being disproportionately cut, thus jeopardizing future missions to the Outer Solar System and other destinations. OPAG proposes that funds for technology development be restored to the extent possible. OPAG also urges that PSD implement the plan devised in response to the PSTR panel. Particularly, OPAG urges that PSD appoint a Technology Program Director as soon as possible to lead the strategic planning.

OPAG suggests that now is the time to do strategic technology planning for PSD in general, and for Outer Planet technologies specifically. Mission studies should be performed to define the technologies required when necessary. OPAG itself commits to updating the technology plan required for Outer Planet Missions. This long range planning effort should be followed by implementing a well-balanced, considered technology development program that looks to the next decade as well as this one. For Outer Planet exploration, a well thought-out plan to address power, propulsion, communication, probe technologies and instrument needs, as well as in situ Titan and giant planet technologies, is critical.

*OPAG encourages PSD to work vigorously with the STMD and with Space Communications and Navigation to advocate for Outer Planet technology developments under their auspices.*

**III.** The location and format of the next OPAG meeting will be decided when the budget and travel policies for such meetings are determined by NASA.