Outer Planets Assessment/Analysis Group
March 29–30, 2012 Meeting
Saint Louis, MO

The Outer Planets Assessment Group is a NASA-supported forum for scientists, engineers and other interested parties to strategize current and future exploration of the outer solar system and to enhance communication between the outer planets community and NASA. Major findings of OPAG as informed by the March 2012 meeting are outlined below, followed by a meeting description and additional details on the individual findings.

I. Summary of OPAG Findings

1. A single, descoped Europa “flagship-science-class” mission should move forward with a detailed design study for optimization and a possible new start (entry into phase A). Studies for a Europa Orbiter, Multiple-Europa-Flyby, and Europa Lander option have been completed, along with independent technical reviews and cost estimates. All 3 Europa mission options are highly scientifically meritorious, and the Orbiter and Multiple-Flyby options directly responsive to the Planetary Science Decadal Survey. Based on a thorough evaluation of their potential science return, technical and programmatic risk, and cost, either the Europa Orbiter or Multiple-Europa-Flyby option should move forward. The strong majority view of the OPAG community is that the Multiple-Flyby option (a jovian orbiter optimized for the study of Europa with a science payload specifically tailored to the task) offers the greatest science return per dollar, greatest public engagement, and greatest flow through to future Europa exploration.

2. The Cassini extended mission should be funded and supported through the planned 2017 end-of-mission. OPAG is gravely concerned about effects of proposed reductions for FY 2013-2014 in terms of loss of personnel and increased risk. OPAG continues to strongly urge that NASA fund the Cassini Solstice Mission at the level required to safely operate the spacecraft and to obtain and analyze the data required to accomplish the science objectives of the Cassini Solstice Mission.

3. OPAG lauds the selection of the Jupiter Icy Moons Explorer (JUICE) by ESA as the first L-class mission in ESA’s Cosmic Visions program. OPAG fully endorses the JUICE mission, which will place the first orbiter around an icy satellite – Ganymede – a satellite that hosts both a magnetosphere and (most likely) an internal water ocean. OPAG strongly urges NASA to enable meaningful U.S. participation in JUICE through provision of instruments, instrument
components, and support for U.S. co-investigators and participating scientists.

4. Within the context of the PSD budget, OPAG urges that NASA make every effort to restore the cadence of PI-led Discovery and New Frontiers missions as recommended by the Decadal Survey. This concern is not specific to the Outer Planets; it is a cross-cutting issue that affects the entire planetary program.

5. OPAG urges that the remainder of Outer Planets monies in FY 2012 be spent on Outer Planets (OP) priorities: 1) Detailed design study of a single Europa mission option; 2) Initiation of a study of a Uranus mission responsive to Decadal Survey science goals for the ice giants; 3) Technology development for future Outer Planets missions (e.g., TPS for Outer Planet probes); and 4) R&A in support of future missions.

6. OPAG lauds the selection of the first 12 Participating Scientists for the Cassini mission (8 US) as part of the Cassini Data Analysis and Participating Scientist Program, and supports additional selections in the coming years. OPAG is, however, dismayed by the most recent selection rates for the Outer Planets Research program (OPR), which is a core research program in NASA’s R&A portfolio. We urge NASA to bring these selection rates up to a level consistent with other core R&A programs, and selection rates up overall.

7. NASA should continue to do what is necessary to make sufficient amounts of plutonium (Pu-238) available for outer solar system (and other) missions. 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.

8. OPAG is deeply concerned about the notional out-year budget for Outer Planets technology development, especially in light of the recent recommendations of the Planetary Science Technology Review Panel. OP technology investments appear both inadequate and uncoordinated. OPAG finds in particular that Thermal Protection Systems (TPS) for Outer Planet Probes is a concern, and asks that PSD a) determine future mission needs for PSD and NASA as a whole and b) match those against the current materials and technologies available. OPAG notes in addition that investment in balloon-borne astronomy for OP could both be quite cost-effective and scientifically productive.

II. Meeting description and details of major priorities

OPAG met this spring for two days, with an emphasis on hearing new reports from the Europa Science Definition Team, which was charged with responding to the recommendations of the Planetary Science Decadal Survey. Extensive discussion and debate followed regarding the the best path forward for the scientific
exploration of Europa and the Jupiter system as a whole. The ongoing Cassini Solstice Mission was also well discussed, with an emphasis on the upcoming Senior review for extended missions.

Presentations were heard as follows:

**Thursday 29 March**
- **Planetary Science Division Update**
  - Jim Green, NASA Headquarters
- **Outer Planets Status Update**
  - Curt Niebur, NASA Headquarters
- **Outer Planets Research Program**
  - Terry Hurford, Goddard Space Flight Center
- **Cassini Data Analysis and Participating Scientist Program**
  - Henry Throop, NASA Headquarters
- **Cassini Status & Senior Review**
  - Linda Spilker, Jet Propulsion Laboratory
- **Decadal Technology Implementation**
  - Pat Beauchamp, Jet Propulsion Laboratory
- **Europa Mission Studies Overview**
  - Louise Prockter, Applied Physics Laboratory
- **Europa Lander Option – Science**
  - Dave Senske, Jet Propulsion Laboratory
- **Europa Lander Option – Technical**
  - Ray Crum, Jet Propulsion Laboratory
- **Europa Mission Studies Wrapup**
  - Bob Pappalardo and Greg Garner, Jet Propulsion Laboratory
- **Io Global Map Rollout**
  - David Williams, ASU

**Friday 30 March**
- **Titan Mare Explorer for Discovery**
  - Jonathan Lunine, Cornell University
- **Uranus Working Group Report**
  - Mark Hofstadter, Jet Propulsion Laboratory
- **Planetary Science from a Balloon-Based Observatory – Update**
  - Tibor Kresic, Glenn Research Center
- **Radiosonde Power Systems Program – ASRG Vibration Analysis**
  - Tom Sulli, Glenn Research Center & Doug Mehoke, Applied Physics Laboratory
- **Jupiter Icy Moon Explorer (JUICE)**
  - Michele Dougherty, Imperial College London & Olivier Grasset, Jet Propulsion Laboratory
- **Solar Power for Outer Planets Missions**
  - Kurt Klaus and Michael Elspasman, Boeing

Given the emphasis on the Europa mission studies at the meeting, and the overall threat to Outer Planets exploration in the present budget climate, our first finding concerns this critically important potential mission.

1) **Europa Descope Mission Options**

The Planetary Decadal Survey recommended a Europa mission as its second-highest priority flagship mission, and a mission *scientifically on par* with Mars Sample Return, but only if mission costs could be markedly reduced from that estimated for the Jupiter Europa Orbiter. Accordingly, a Science Definition Team was formed and at this OPAG meeting the SDT presented its results. The results of the completed studies of the Europa Orbiter and Multiple-Flyby options were summarized (these had been presented in full at the October 2011 OPAG meeting); at NASA's direction, a third option, a Europa Lander, was also studied, and these results were presented in full for the first time. Finally, independent risk and cost assessments were
presented for all 3 options.

The Planetary Science Decadal Survey (2013-2022) mandated that any future flagship-scale mission to Europa needed to be substantially descoped to reduce its overall cost. OPAG emphasizes that “flagship” in this case does not mean a mission carrying a great many instruments to address a very broad range of planetary science. The Europa missions under study address a more focused range of scientific objectives, but ones of the greatest merit and priority as defined in both the first and most recent Planetary Science Decadal Surveys. The difficulty and expense of getting to and operating at Europa lift these missions out of the PI-led cost categories (as presently defined); moreover, the scientific goals of these missions are nothing short of transformative and paradigm-shifting, and thus must be considered “flagship-science-class.”

The Europa SDT considered 3 mission options: 1) an Orbiter option to perform geophysical measurements (“Ocean” science) that can only be achieved from Europa orbit, 2) a Multiple-flyby option to perform remote measurements (“Chemistry” and “Energy” science) that can be achieved from jovian orbit via multiple Europa flybys, and 3) a Lander option to perform in situ science. Both the Orbiter and Multiple-Flyby mission options (http://www.lpi.usra.edu/opag/Oct2011/presentations) achieve key science objectives, and while scientifically complementary, each option has very high science value of its own. The Orbiter mission option readily accommodates instruments that are less massive, require lower power, and operate at lower data rates, whereas the Multiple-Flyby mission option readily accommodates instruments that are more massive, require higher power, and operate at higher data rates.

The Europa Lander option would enable unique in situ science opportunities, and is the most definitive way to probe Europa’s composition as relevant to habitability. This option would also provide extremely valuable geophysical and geological science. Landing on Europa obviously carries risk, and though limited information exists at present about the surface at lander spatial scales, promising target sites can be identified. The SDT found that while terrain uncertainty risk can be reduced through a robust deorbit, descent, and landing system, technology investment during development would be required.

At the March OPAG meeting cost estimates by JPL and risk assessments from a JPL-led review board were presented to the first time. These summary assessments are reproduced below:
The full Europa SDT report was delivered to NASA HQ on 1 May 2012, outlines a highly pragmatic path to Europa exploration. OPAG finds that 1) Either the Orbiter or Multiple-Flyby mission option would fulfill high-priority Europa science objectives; 2) Each option has very high science value on its own and is directly and highly responsive to the Decadal Survey; and 3) Scientific priorities drive both mission option architectures, permitting lower-cost Europa mission options. Moreover, the cost and risk assessments for the Orbiter and Multiple-Flyby options meet the criteria of the Decadal Survey. The cost and risk of the Lander option, however, were considered by OPAG to be too high to recommend pursuing the mission option further at the present time (essentially, the terrain uncertainty risk is an “unknown unknown” and can only be reduced by gaining new knowledge of Europa at the relevant spatial scales).

Based on an evaluation of their potential science return, technical and programmatic risk, and cost, OPAG finds that a pragmatic path forward to accomplish the highest priority “flagship-class” Outer Planets science in the Planetary Science Decadal Survey is choose either the Europa Orbiter or Multiple-Flagship mission option for a detailed design study. This would allow this single, descoped mission option to be scientifically optimized (the SDT mission options were designed to be more complementary) while maintaining strict controls on cost. The goal should be a timely new start for this Europa mission (entry into phase A).

OPAG is not chartered as, nor was March meeting convened as, a selection committee for future Europa missions. Vigorous debate nonetheless occurred regarding the Orbiter and Multiple-Flyby missions options. Both options were recognized as highly scientifically meritorious, but the strong majority of the OPAG members present and of the OPAG Steering Committee favored the Multiple-Flyby option (the ultimate choice is a programmatic one, of course, and would be NASA’s to make). The rationale for this assessment can be summarized as: 1) the Europa Multiple-Flyby mission (a jovian orbiter optimized for the study of Europa with a

<table>
<thead>
<tr>
<th>Option</th>
<th>Cost (FY15$M)</th>
<th>Risk</th>
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<tbody>
<tr>
<td>Orbiter*</td>
<td>$1.6B</td>
<td>Low</td>
</tr>
<tr>
<td>Multiple-Flyby*</td>
<td>$1.9B</td>
<td>Low</td>
</tr>
<tr>
<td>Lander</td>
<td>$2.8B-$3.5B</td>
<td>High</td>
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*Aerospace Corp. independent CATE review found that there are no significant technical risks or schedule threats for the Orbiter or Multiple-Flyby mission concepts.*
science payload specifically tailored to the task) will provide more data (nominally 30 or more flybys) and involve more of the scientific community than the Europa orbiter; 2) the Europa Multiple-Flyby mission addresses the habitability question much more directly than the Europa Orbiter; 3) the Multiple-Flyby’s strong emphasis on remote sensing (imaging and radar sounding) has strong and direct public appeal; and 4) the Multiple-Flyby mission does a remarkable job addressing a primary science goal: whether liquid water (plus any materials therein) reach the surface. The latter is a high priority with the public and the Decadal Survey, and the Multiple-Flyby mission would provide the data necessary to choose a scientifically compelling and safe landing site for any future landed mission.

OPAG finds the Europa SDT report to be highly responsive to the Decadal Survey, and either the Europa Orbiter or Multiple-Flyby option would make a scientifically compelling Outer Planets “flagship-science-class” mission. OPAG recommends going forward with a detailed design study of a single mission option, and strongly encourages a new start (when practical) for this mission.

2) Cassini Solstice Mission

Cassini will be the only Outer Planet Flagship mission flying this decade, and OPAG remains gravely concerned that further budget cuts will cause significantly more science loss in an already “descoped,” extended mission. OPAG is specifically concerned about proposed reductions for FY 2013-2014 in terms of loss of personnel and increased risk to the mission. The potential loss of personnel would result in:

1) Science loss and increased risk to science observations in FY13-14;
2) Fewer people to implement science observations, resulting in fewer and less complex science observations and a reduced ability to plan for FY15 and beyond; there is, in particular, concern about being able to fund engineering at a sufficient level to make sure the mission gets to the proximal orbits;
4) Slower response to instrument anomalies, which would then be addressed on a best effort basis;
5) Reduced calibration support, and less well-validated data to PDS;
6) Slower response time to new discoveries, and additional science opportunities might be missed; and
7) Loss of funds to educate and mentor the next generation of planetary scientists (team associates and postdocs).
OPAG strongly agrees with the Planetary Decadal Survey in its recommended support for funding of Cassini through the planned 2017 end-of-mission. Specifically, we strongly endorse the science of the Cassini Solstice Mission, particularly the Juno-like final orbits. As our previous letter report (Oct 2011 Meeting) emphasized, we strongly urge that NASA fund the Cassini Solstice Mission at the level the Cassini Team requires to safely operate the spacecraft and to obtain and analyze the data that are required to accomplish the science objectives of the Cassini Solstice Mission.

3) Jupiter Icy Moons Explorer

OPAG lauds the 2 March 2012 selection of the JUpiter ICy Moons Explorer (JUICE) by ESA as the first L-class mission in ESA’s Cosmic Visions program. OPAG fully endorses the JUICE mission, which will place the first orbiter around an icy satellite – Ganymede – a satellite that hosts both a magnetosphere and (most likely) an internal water ocean. OPAG support for JUICE was reflected in its 14 March 2012 letter to Dr. Fabio Favata (Head of Science Planning and Community Coordination Office at ESA).

Exploring the Outer Solar System is truly an international endeavor, stretching back to the Galileo mission and continuing to this day with the phenomenally productive and successful Cassini-Huygens mission. ESA’s selection of JUICE affirms the importance of Outer Planet exploration for humankind. OPAG notes, however, that the incorporation of 2 Europa flybys into the planned JUICE orbital tour, as a way to recover some of the lost science of the cancelled EJSM mission, by no means accomplishes the Europa science recommended by the Planetary Decadal Survey for a Europa mission (the Multiple-Europa flyby option in particular incorporates at least 30 flybys, and achieves global coverage with its remote sensing instruments).

OPAG strongly urges NASA to enable meaningful U.S. participation in JUICE through provision of instruments, instrument components, and support for U.S. co-investigators and participating scientists. OPAG further lauds the efforts to date of NASA, in partnership with other stakeholders (e.g., OMB, OSTP), in this regard (i.e., PSD’s announcement of a $100M life-cycle contribution to the JUICE mission).

4) President’s FY 2013 Budget and PI-led Missions
OPAG laments the 20% reduction to PSD, not the least of which because it eliminates the possibility, even within the notional outyear budget, of starting a descoped “flagship-science-class” mission to the Outer Planets.

Within the context of the PSD budget, OPAG urges that NASA make every effort to restore the cadence of PI-led Discovery and New Frontiers missions as recommended by the Planetary Decadal Survey. This concern is not specific to the Outer Planets, but is a cross-cutting issue that affects the entire planetary program.

5) Future Outer Planets Planning and Funding

OPAG has previously stated a need for activities to support future missions. These include focused technology development, focused mission studies, and planetary environment model definition. These “foci” should be aligned with the findings of the Planetary Science Decadal survey. Monies for funding for an “Outer Planets Flagship” were included in the FY12 NASA budget. The funding was used to support the Europa Science Definition Team in their Europa Option studies.

OPAG urges that the remainder of Outer Planets monies in FY 2012 be spent in a judicious manner on Outer Planets priorities (with exception of further Europa studies, these are not in priority order):

1) Detailed design study of a single Europa mission option;
2) Initiation of a study of a Uranus mission responsive to Decadal Survey science goals for the ice giants;
3) Technology development for future Outer Planets missions (e.g., thermal protection systems for Outer Planet probes);
4) R&A in support of future missions.

OPAG wishes to be kept informed as to the disposition of this funding.

6) Cassini Participating Scientists and Outer Planets Research Program

OPAG lauds the selection of the first 12 Participating Scientists for the Cassini mission (8 US) as part of the Cassini Data Analysis and Participating Scientist Program, and supports additional selections in the coming years.

OPAG is, however, dismayed by the most recent selection rates (<20%) for the Outer Planets Research program (OPR), which is a core research program in
NASA’s R&A portfolio. We urge NASA to bring OPR selection rates up to a level consistent with other core R&A programs, and to raise the selection rates for all core programs to a level that ensures that all the best science proposed is funded.

7) Plutonium-238 Shortage

As in all other recent OPAG reports, we reiterate the central importance of radioisotope power systems for deep space exploration. Both the New Horizons mission to Pluto and the Kuiper Belt and 2 of 3 Discovery missions now in competition have taken advantage of the availability of radioisotope power systems, and could not carry out their missions otherwise.

NASA should continue to do what is necessary to make sufficient amounts of plutonium (Pu-238) available for Outer Solar System (and other) missions. 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.

8) Technology Investment for Outer Planets

OPAG is deeply concerned about the President’s notional out-year budget for Outer Planets technology development, especially in light of the recent recommendations of the Planetary Science Technology Review Panel. Outer Planets technology investments appear both inadequate and uncoordinated.

OPAG finds in particular that Thermal Protection Systems (TPS) for Outer Planet Probes are a concern, and asks that PSD a) determine future mission needs for PSD and NASA as a whole and b) match those against the current materials and technologies available.

OPAG finds in addition that investment in balloon-borne astronomy for OP could both be cost-effective and scientifically productive. OPAG asks that the benefits and costs of such be evaluated by PSD for planetary in general.

III. The next OPAG meeting will be held September 18-19 in the DC area.