



## Scientific Priorities for the Outer Solar System

July 2006

scientific objectives



required measurements



mission concepts

### Scientific Goals and Pathways for Exploration of the Outer Solar System

A report of the Outer Planets Assessment Group (OPAG)  
July 2006



## Why the Outer Solar System?

**Finding 1: Compelling Science** – Important scientific discoveries continue to be made in the outer solar system through NASA missions and research programs. OPAG affirms the findings of the NRC Decadal Survey and NASA's 2006 Roadmap that the outer solar system provides critical clues to unraveling the mysteries of **how solar systems form and evolve, how planetary systems become habitable, and how life has evolved in our solar system.**

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## How? Generally

**Finding 2: Steady, Balanced Strategy** – Addressing these scientific questions requires a **balanced strategy** of outer solar system exploration that includes steady support for vigorous programs of basic research, data analysis, and technology development. Fundamental new discoveries are best made with a mixture of mission sizes that includes large flagship missions, along with small and medium-sized missions. A **stable budget** is crucial for continuity of scientific and technical capability. Such a strategy is most efficiently implemented as a coherent **Outer Planets Exploration Program.**

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## How? Specifically

### Findings on:

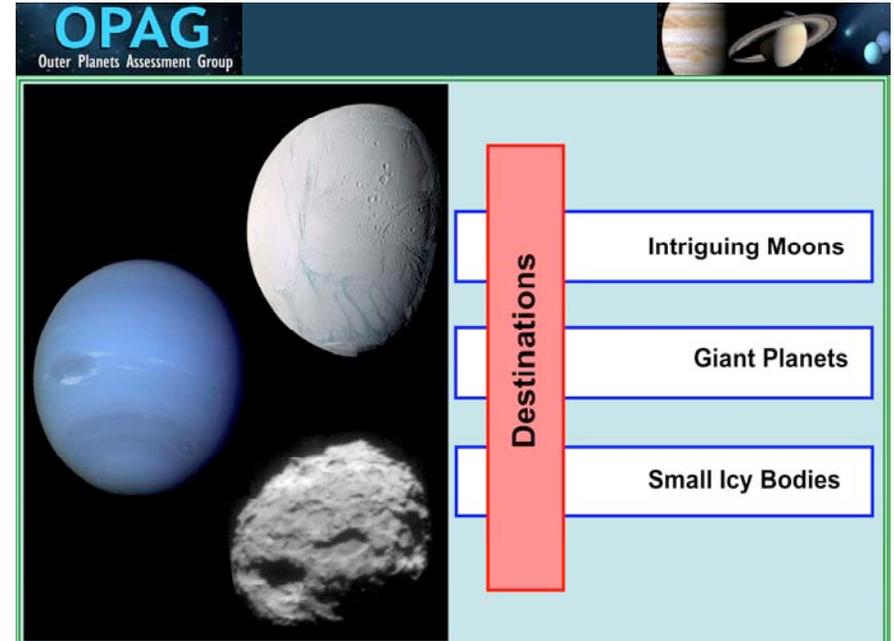
- R&A
- Mission Concept Studies
- Technology
- New Frontiers program
- Discovery program

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## How? Specifically

**Finding 3: Mission Studies** – OPAG encourages NASA to begin comprehensive mission studies toward destinations in the outer solar system in order to assess the technical feasibility, realistic cost and time frame of viable missions. **OPAG affirms the findings of the Decadal Survey, COMPLEX, and SSES, that Europa is the top-priority science destination in the outer solar system.** Titan and Enceladus are also important science destinations and OPAG urges NASA to evaluate potential missions to these targets.

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## Flagships

- Several scientifically important destinations in the outer solar system require a flagship mission.
- Support Cassini extended mission & Cassini Data Analysis Program.

• Recognizing the recent trends of escalating costs of large missions within NASA's SMD, OPAG advocates that all studies of missions involve scientists working closely with mission engineers and that these studies must be subject to a review of technical, management and cost by an independent body. OPAG is concerned that any delays and/or cost over-runs of the next flagship mission might jeopardize the long-term goals for scientific exploration of the outer solar system.

## PSS July letter

Flagship missions will be required to address many of the most fundamental scientific objectives of solar system exploration and must be accommodated within any long-range strategy for the Planetary Science Division. The New Frontiers Program, too, is critical to the accomplishment of solar system exploration objectives. The New Frontiers Program should therefore not be expanded in an attempt to accommodate the goals and objectives of flagship-class missions.

**Do BOTH flagships AND New Frontiers**

## PSS September Report

NASA's Science Plan calls out Europa, Titan, and Enceladus as key targets for exploration of the outer solar system. To make progress on those elements of the Science Plan

***The PSS recommends that in-depth studies to evaluate mission concepts and technologies for potential outer solar system missions should be completed as soon as feasible.***

The scientific goals for these missions have been defined in the NASA Science Plan and developed by the NRC, OPAG, and a variety of "focus groups." On the basis of current understanding of the highest-priority scientific goals, these missions would involve a Europa orbiter, a Titan aerial vehicle, and an Enceladus lander. The mission definition studies should involve broad scientific community involvement and multiple institutions. **We envision mission concept studies for each of the three bodies to be funded at approximately \$1M per study to address specific science goals within the scope of the NASA Science Plan, namely a flagship-class (~\$2-3B) mission to be accomplished within a ~15-year time frame.** The study results should be reviewed independently for their potential scientific return, technical feasibility, and cost. Moreover, NASA should work with OPAG and the science focus groups to develop an ongoing program of advanced mission concepts and technologies that will permit the full implementation of Science Plan objectives.

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## Mission Concept Studies

- OPAG strongly encourages NASA to complete mission concept studies of missions to Europa, Titan and/or Enceladus, giant planets (particularly their deep atmospheres) and small bodies as important scientific targets in the outer solar system as soon as possible and with sufficient fidelity to inform a decision about the next flagship mission.
- **To inform decisions about a future flagship mission, concept studies of outer planet flagship missions must be with sufficient fidelity to ascertain whether missions realistically fit into a "flagship box" of a set timeframe (e.g. 15 years) and a set total mission cost (e.g. \$2.5B).**

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## Europa

- Europa remains the consensus priority target of the OPAG community, as it is in the NRC Decadal Survey, in reports to NASA from both COMPLEX and SSES.

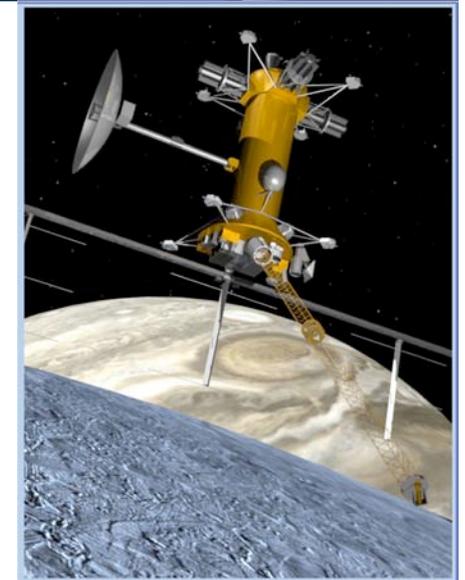
...and Roadmap

...and Science Plan



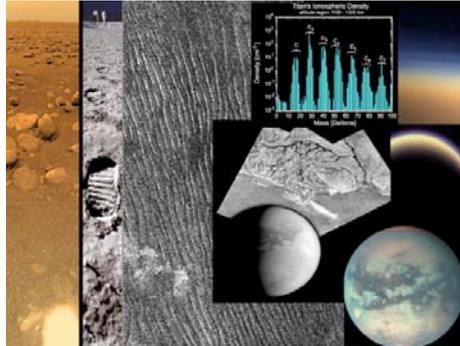
## Europa

- OPAG encourages NASA to undertake a comprehensive Phase A mission study to assess the feasibility of a Europa mission that can achieve the priority science within an accurate and realistic cost-cap and complete the primary mission by a timeframe of 2020-2022.



- Results from the Cassini-Huygens mission have demonstrated that Titan is a compelling destination. Titan is unique in its own right, but intriguing commonalities with Earth make it also valuable for comparison with Earth.
- The OPAG Working Group concludes: 1) exploration of Titan requires a flagship mission and 2) a flagship Titan mission should include an orbiter as well as a balloon/aerobot/probe.
- OPAG urges NASA to support studies of potential missions to Titan to evaluate the best approach to exploring this intriguing moon.

## Titan



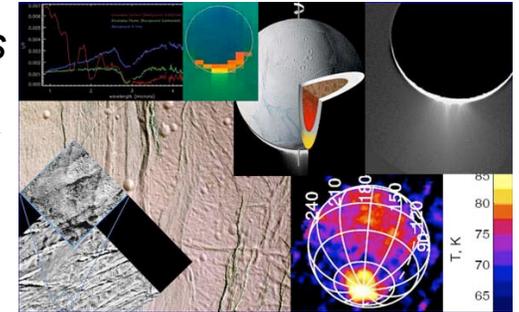
## New Frontiers

OPAG supports an AO for the 3rd New Frontiers mission in the 2008 timeframe and encourages NASA to make the scope of the AO broad. OPAG notes there are possible outer solar system targets for New Frontiers missions. OPAG encourages NASA to allow such missions within the next AO for New Frontiers missions.

## Enceladus *Enceladus Focus Group*

*Carolyn Porco & Chris McKay*

Workshop Sunday  
before DPS



OPAG has begun discussions of Enceladus as a potential mission target and will expand these discussions as it continues to be studied by Cassini.

## Discovery

- OPAG notes the value of Discovery missions in the exploration of the outer solar system.
- Given that radioisotope power systems (RPS) expand the opportunities for outer solar system exploration, OPAG recommends NASA explore ways to include the use of such power systems in the Discovery program.

## R&A

- OPAG notes the findings and recommendations of the NRC's Space Studies Report on Research and Analysis supporting a balanced program for NASA's scientific research (<http://www7.nationalacademies.org/ssb/>)
- OPAG endorses the recommendations of the Planetary Science Subcommittee of the NAC (<http://science.hq.nasa.gov/strategy/subcomm.html>)
- OPAG is encouraged to see Cassini Data Analysis Program (CDAP) started. The initial budget of \$2.5M is expected to double in subsequent years. However, the funding profile for the program is inadequate considering the expected science return of the Cassini mission.
- A Cassini Extended Mission is a fantastic opportunity to further science return. Cassini science teams as well as CDAP will both need to be funded to maximize scientific return.

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## November Meeting report

OPAG enthusiastically received Jim Green's announcement that NASA HQ plans to implement Science and Technology Definition Teams (STDTs) to study flagship missions to icy moons, specifically Europa, Titan, Enceladus and Ganymede.

*It must be recognized that the scientific goals and potential mission concepts for these additional objects are not as mature as those for Europa. We note that the addition of Ganymede to the list accommodates interests of scientists in Europe and that a mission to Ganymede may address broader goals of the jovian system.*

## November Meeting report

To provide the necessary information for NASA to decide on the next flagship to the outer solar system such STDTs should:

- (i) Comprise a team of scientists working close with mission engineers
- (ii) Be funded adequately to complete studies to sufficient depth to allow NASA to accurately evaluate the viability of each mission
- (iii) Report scientific goals, technical feasibility, management structure and mission costs which will be reviewed by an independent body
- (iv) Complete all reports by a set deadline (e.g. 9 months)
- (v) Take full advantage of national engineering and scientific resources by NASA assigning leadership of the studies to different institutions (with the expectation that organizations will pool/share their unique expertise as required).

### Small Bodies

Currently or recent missions to small bodies – Deep Impact, Stardust, Dawn, New Horizons, Rosetta

Time for an evaluation of small-body science in light of these missions

To this end, the OPAG primitive body working group is tasked to evaluate what (a) current/planned missions and (b) ground-based studies, are likely to have told us 5-10 years hence.

OPAG notes that COMPLEX is chartered to conduct rigorous studies of scientific issues. We urge COMPLEX to consider a study such as described above and to evaluate the outstanding scientific issues. Such a study is vital for assessing the next steps in exploration of primitive bodies of the outer solar system.

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## Technology

- ‡ OPAG welcomes Jim Green's announcement that Alan Harmon will be joining NASA HQ to lead PSS' technology development.
- ‡ OPAG appreciates the collaboration with Idaho National Labs and welcomes a report on their spring workshop
- ‡ OPAG notes that Stirling Generators offer potential for improved efficiency of power generation and requests a briefing on the progress of their development at the next OPAG meeting.
- ‡ Aerocapture is a key technology for some future missions (e.g. Titan orbiter, giant planet orbiters). NASA's Planetary Science Division is urged to inform NASA's technology division that testing of aerocapture technologies with the next New Millennium mission is a high priority for outer solar system exploration.
- ‡ OPAG reiterates that planetary science missions require reliable communication systems and is highly dependent on maintenance of the Deep Space Network.

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**Next Meetings:  
May 1-2nd, 2007  
Boston Area**

**November, 2007  
Near APL**

*<http://www.lpi.usra.edu/opag>*

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