



OUT OF THIS WORLD SCIENCE

DOWN TO EARTH PRICES!

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Science Possibilities

Of the roughly 200 important questions identified by the current planetary decadal survey report, nearly 1/4 of them could be addressed by balloon borne telescopes. Observable targets range from the inner planets all the way to Pluto and beyond. Balloon borne observations offer unique science that is not possible from other current assets. For example, continuous observations of Venus for weeks at a time in the near UV to mid IR could offer new insight into atmospheric dynamics and super rotation. Balloon altitudes also offer an opportunity to look for CO₂ and spectral signatures of some organics which are not possible from ground.

SUMMARY OF A BALLOON BASED ASSET TO ADDRESS DECADAL SURVEY "IMPORTANT QUESTIONS."

| Category | Total # of DS "Important Questions" | # Answered or significantly addressed | % Addressed |
|------------------|-------------------------------------|---------------------------------------|-------------|
| Primitive Bodies | 33 | 10 | 30% |
| Inner Planets | 34 | 10 | 29% |
| Giant Planets | 39 | 7 | 18% |
| Satellites | 75 | 13 | 17% |
| Mars | 18 | 4 | 22% |
| Total | 199 | 44 | 22% |



Low Cost Approach to Planetary Science

Cost competitiveness is one of the significant advantages of balloon missions. A balloon based observatory is expected to cost between one and two orders of magnitude less than a space based mission with similar telescope and instruments. Numerous balloon missions have been developed and successfully flown for a few million or at most a few tens of millions of dollars. The smallest mission class in NASA planetary science division is the Discovery missions which currently are capped at \$450M plus launch vehicle costs and Phase E costs. The recent BOPPS mission was implemented at under \$6M, including the post mission science analysis.

An estimate was generated for the expected cost for a light weight, modular, and robust balloon borne observatory with a 1m telescope and precision pointing capability suitable for planetary science. The expected cost is under \$25M, and would be designed for at least five flights during its life-cycle; bringing the development cost/flight below \$5M.

The BOPPS Mission Demonstration

The Balloon Observation Platform for Planetary Science (BOPPS) mission flew from Fort Sumner, NM, USA in September 2014 and demonstrated some of the capability of balloon based telescopes. BOPPS re-flew an existing .8m optical telescope and 2 instruments, a UV-Vis and a near-to mid IR imager. The UV-Vis imager incorporated a Fast Steering Mirror (FSM) to improve the system's visible imaging performance. In the short mission a number of goals and science measurements were realized:

- First measurements for water and CO₂ of an Oort cloud comet
- Measured water production of Comet Siding Spring before its encounter with Mars
- First observation of 2.7 µ flux from Ceres to characterize water / hydroxyl infrared absorption
- Achieved goals of better than 1 arcsec pointing for the telescope and better than .1 arcsec pointing in visible wavelengths with the FSM system

