Conceptual Design of a Combined Mercury Orbiter and Solar Physics Mission

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Abstract

A Mercury Orbiter mission has been assigned high priority in the Roadmaps of two of NASA's four space science themes: Solar System Exploration (SSE) and Sun Earth Connection (SEC). JPL worked with SSE and SEC Science teams to develop a mission concept capable of satisfying the principal goals of both themes.

Mercury has been visited by only one previous mission, Mariner 10 in 1974, and while very successful, that mission raised as many questions as it answered. The key objectives for the new mission are:

- The formation and evolution of Mercury: Determine the planets global geography, look for evidence of volcanism and tectonics, measure the mineralogical and elemental surface composition, study and characterize the polar ice cap and characterize the atmosphere/exosphere.

- Current internal structure of Mercury and its temporal evolution: Characterize the gravity and magnetic fields, compare with interior models of Venus, Earth, and Mars.

- Structure and dynamics of Mercury's magnetosphere and its interaction with the solar wind and the planet's surface and exosphere: Study the physical process taking place during magnetospheric substorms, and compare them to those at Earth, study convection and energy transport/storage within the magnetosphere and how it is affected by interplanetary conditions, determine the extent to which Mercury's surface and atmosphere has been modified by the solar and the magnetospheric charged particle populations.

- Use of the proximity of Mercury's orbit to the sun for serendipitous observations of the sun and solar wind.

Getting to Mercury and into orbit requires substantial propulsive energy. Both solar electrical propulsion (SEP) and solar sail were found to provide significant advantage over conventional chemical propulsion. The baseline case uses SEP with launch on a Delta 2 (7925), delivering a net mass of 600 kg to Mercury orbit, via a Venus gravity assist trajectory.

The baseline orbit is driven mainly by science and thermal considerations. Imaging science requires low passes for high resolution while the thermal control requires time at long range from Mercury (low view factor) to dump heat. This results in a highly elliptical orbit: 200 km by 10,000 km with periapse at the equator. If solar sail capability with precise controllability would be available, a more desirable sun synchronous elliptical orbit could be maintained.

The spacecraft is 3-axis stabilized to provide an appropriate platform for remote sensing and uses a turntable to satisfy the needs of some of the particles and field instruments for full angular coverage . Thermal cent rol is maintai ned by absorbing heat into storage media during periapse passes (when the view factor of the planet is high) and radiating in the high altitude portion of each orbit.

Orbital operations will follow a pattern of acquiring large quantities of remote sensing data near periapse once in every three orbits and using the remaining two and a half plus orbits to downlink the data interleaved with real time particles and field data. This pattern satisfies the principal science objectives of both the SSE and SEC participants.