LOW-COST SPACE ACCESS FOR PLANETARY SCIENCE MISSIONS USING HIGH POWER SOLAR ELECTRIC PROPULSION

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Introduction:

As rideshare launches become more commonplace, secondary or small payloads continue to be challenged by the limited choice of orbits, upper stage restart capability and risk-averse nature of primary payloads to allow for flexibility in the deployment sequence. The result is that a secondary payload's final orbit is limited by its host and the propulsion capability of the individual spacecraft, particularly so for cubesat class passengers. For Planetary Science missions rideshare access to space is very difficult due to the often unique orbits and destinations. Many of these challenges can be met through the use of a propulsive rideshare adapter or Orbital Maneuvering Vehicle (OMV). An OMV that leverages High Power Solar Electric Propulsion (HP-SEP) extends the range that an OMV can be used beyond Earth orbit. The HP-SEP OMV leverages much of the development work of a chemical propulsion variant in addition to investments made by NASA into the various elements of the "SEP String" including high power deployable solar arrays, high power Hall Effect Thrusters, and their associated Power Processing Units (PPU).

The HP-SEP OMV can reduce costs for space access using rideshare and enable low cost missions beyond Earth orbit that previously could only be achieved through the expense of a large and costly dedicated rocket (see Figure 1). The HP-SEP OMV platform provides mission augmentation as well and can provide many of the services of a spacecraft bus reducing the cost and complexity of the payload.

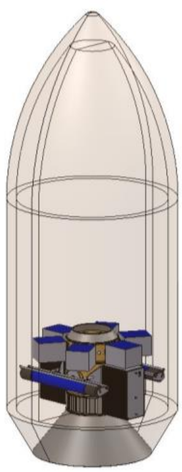

Figure 1: HP-SEP OMV Concept in F9 Fairing

Moog has analyzed, developed and supported numerous missions employing OMV functionality. In this paper a number of case studies are described to illustrate the utility, value and flexibility of the OMV as a mission enabling technology. Moog and NASA Glenn have analyzed a case using this system to spiral out from LEO to GEO and beyond to lunar orbit for a demonstration mission. This same system operationally can be used for deployment from a GTO rideshare to a variety of destinations beyond Earth orbit (BEO). A survey of potential mission applications that could be leveraged by the Planetary Science community is included (see Table 1).

Table 1: HP-SEP OMV Mission Examples

Mission Type	Mission Examples
Lunar Orbit	Lunar Cubesat Comm Relay[1], SLS EM-1 payloads[2], South Pole Aitken Basin sample return mission[2], Lunar Geophysical Network[2], Ecliptic Spinning Lunar Landers[4]
Earth Moon L2	Artemis Mission follow on, "Dark Side of the Moon" Communications coverage, Occulter that would formation fly with telescopes such as James Webb Space Telescope and WFIRST
Near Earth Asteroids	NEA Tour[5], Commercial Asteroid Mining[6], 2008 EV5 Precursor Mission (prior to ARRM)[6]
Mars Missions	Phobos and Deimos science missions[2], Mars Comm Relay[7], MARS$_{DROP}$ mission[9], Mars Discovery Class Missions[2]
Venus Missions	Venus In-Situ Explorer[2], Venus Climate Mission[2]
Distance Asteroids	Asteroid Interior Composition Mission[2], Jupiter Trojan Asteroid[2]

The performance of small satellite technology continues to improve at an exponential pace but, if small satellites and payloads continue to compromise optimal orbit for general space access or very difficult beyond Earth orbit, true potential cannot be fulfilled. In each of the scenarios identified, the particular use of an OMV gives rise to a number of shared launch opportunities that would not have previously been considered and improves the overall access to space for rideshare passengers. The OMV can provide services as a hosted payload platform further reducing the overall mission costs.

References:

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[9] Staehle (2015) *29th Annual AIAA/USU Conference On Small Satellites,* SSC15-XI-3