Planetary Mission Capability of Small Low-Power Solar Electric Propulsion Systems[1]

Carl G. Sauer, Jr, Chen-wan L. Yen
Members of the Technical Staff
Jet Propulsion Laboratory
California Institute of Technology
Pasadena, California

ABSTRACT

"There is currently a vigorous investigation underway of low-cost planetary missions using small, inexpensive spacecraft. In order to keep the total mission costs down either a medium class launch vehicle such as a Delta II or an intermediate class launch vehicle such as an Atlas IIA or Atlas IIAS would be required for these planetary missions. Although most planetary missions can be performed using conventional chemical propulsion, many of these missions will require long flight times and possibly complex, multiple planetary gravity assists to deliver even a minimal science payload.

Many advanced propulsion mission studies have shown the potential benefits of using a spacecraft powered by Solar Electric Propulsion (SEP) for many planetary missions, in particular for rendezvous missions to asteroids and comets. "The current interest in performing small, low-cost planetary missions has spurred the examination of the use of relatively small, low- power SEP systems for these missions. These SEP spacecraft would have solar array power levels in the range of 5- 10 kW and would use launch vehicles similar to those proposed for the small chemical propulsion missions.

There are several advantages in using SEP powered spacecraft for these small planetary missions. Small body rendezvous missions, for instance, can be performed without the use of time consuming gravity assist trajectories. 'The consequence of a basically simpler trajectory is that shorter mission times can be realized. As an example a mainbelt asteroid rendezvous mission can be performed in 1.5 to 2.5 years as compared to the 3-6 years required for a comparable ballistic mission. Because of the much higher specific impulse of an ion engine as compared with a chemical propulsion thruster, greater payloads may be realized for a SEP system using an equivalent launch vehicle.

This paper presents the result of an examination of the use of small SEP systems for planetary missions including asteroid and comet rendezvous missions, outer planet orbiter missions, solar probe missions and a Pluto flyby mission. A comparison is made of the performance of both ballistic and SEP propulsion systems for these missions.

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consuming gravity assist trajectories. The consequence of a basically simpler trajectory mode is that shorter mission times can be realized. As an example, many main belt asteroid rendezvous missions can be performed in 1.5 to 2.5 years as compared to the 5-6 years required for comparable ballistic missions. in addition, primarily because of the much higher specific impulse associated with ion engines as compared with chemical propulsion systems, much higher payloads are possible for SEP systems for comparable small body missions using equivalent launch vehicles.

SEP powered spacecraft can also be used for other planetary missions such as outer planet orbiter missions, a Pluto flyby mission, or a Mercury orbiter mission although the performance advantages of SEP as compared with conventional chemical propulsion is not as great as for the small body rendezvous missions. Outer planet orbiter missions would still require some form of chemical propulsion since the SEP solar array could not provide the necessary power at the large heliocentric distances characteristic of the outer planets. For planetary missions much beyond approximately 3-4 AU the SEP system would probably be used more like a high energy upper stage augmenting the launch vehicle. There are also possibly performance advantages in using a SE]' powered spacecraft for near Earth asteroid rendezvous missions although it is likely that the small payloads provided by chemical propulsion systems are more than adequate. Although a SEP system can provide an attractive payload for a Mercury orbiter mission in as short a transfer time as 1.5'-2 years, there may be difficulties in designing a SEP spacecraft to handle the thermal environment at the distance. of Mercury from the sun.

This proposed paper presents the result of a examination of the performance of small SE]' systems for the above mentioned planetary missions including both asteroid and comet rendezvous missions, outer planet orbiter missions, a Pluto flyby mission and a Mercury orbiter mission, The emphasis is on delivery capability for these missions using reasonable assumptions for launch capability and performance for the solar array and ion propulsion system. Actual science payload capability is not addressed in this paper and would be dependent upon more detailed spacecraft and system design for each of the missions.

References:

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