Advanced Propulsion Benefits to New Millennium Class Missions

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ABSTRACT

With NASA's current emphasis on a smaller, better, faster approach to planetary exploration, a new class of mission has been proposed called New Millennium. This class of mission encompasses solar system science that can be done with scientific payloads ranging from 10kg to 50kg, and launched on Med-Lite or smaller expendable launch vehicles (ELVs). The Advanced Space Analysis Office and the Space Propulsion Technology Division at NASA Lewis Research Center performed a study to assess the ability of advanced space propulsion technologies to enable challenging New Millennium mission to the solar system that would not be possible with existing chemical propulsion technology. This paper briefly reviews the technologies and analysis techniques in the study, and presents system trade results for a broad range of missions.

The study examined the performance of several propulsion technologies: Solar Electric Propulsion (SEP) using Arcjets, Hall Thrusters, Pulsed Plasma Thrusters, and Ion Thrusters, advanced chemical bi-propellant Hot-Rockets, and state-of-the-art chemical propulsion. Each propulsion technology was studied for application to several challenging solar system missions: a Vesta rendezvous, a Nereus rendezvous and sample return, a Mars rendezvous, a Deimos sample return, and Mercury rendezvous. For each mission, each propulsion technology's performance was examined for launch off of several small ELVs: Pegasus XL, Taurus XL, Titan IIG, and Lockheed LLV. Conservative groundrules were assumed including a 30% contingency on spacecraft dry mass, and a 10% margin on launch vehicle performance. For Mars and Venus missions, planets with an atmosphere, aerobraking was assumed to lower the orbit after a monopropellant stage captured the spacecraft into a high energy, low periapsis orbit. A sample of the results are included in the chart below.

	Units	Arc Jet	Hall	Ion NSTAR	Ion XIPS	Adv. Chemical	S.O.A. Chemical
Nereus Rendezvous							
ELV		Taurus XL	Taurus XL	Taurus XL	Taurus XL	Taurus XL	Taurus XL
Science Mass	(kg)	49	37	60	11	59	57
Trip Time	(days)	605	369	340	475	642	642
Mars Rendezvous							
ELV		Titan IIG	Titan IIG	Titan IIG	Titan IIG	Titan IIG	Titan IIG
Science Mass	(kg)	14	53	209	135	212	206
Trip Time	(days)	163	184	317	738	204	204
Vesta Rendezvous							
ELV				Titan IIG		Titan IIG	Titan IIG
Science Mass	(kg)			71		-77	-83
Trip Time	(days)			713		1,180	1,180

In comparison to state-of-the-art chemical propulsion, the results show that NSTAR Ion propulsion and advanced chemical propulsion technologies can offer benefits in delivered science mass for the missions studied. In addition, NSTAR Ion technology enables a Vesta rendezvous mission in this launch vehicle class. In general, the results show that advanced propulsion has significant benefit for missions requiring a high on-board $\triangle V$.