Applications of Secondary Propulsion Systems for Microspacecraft, Drag-Free, and Precision Formation Flying Missions

John K. Ziemer, Juergen Mueller,
Colleen M. Marrese-Reading, and Robert F. Shotwell
Jet Propulsion Laboratory, M/S 125-109
4800 Oak Grove Drive, Pasadena, CA 91109
(818) 393-4582, John.K.Ziemer@jpl.nasa.gov

ABSTRACT

We present a survey of secondary propulsion systems with applications to microspacecraft, drag-free, and precision formation flying missions. These systems are designated as "secondary" for traditional reasons and in some cases could actually be the single or primary propulsion system. This paper includes information gathered from a recent NASA MSFC sponsored Integrated In-Space Transportation Planning (IISTP) Phase II study of secondary propulsion systems.

In this paper we examine propulsion systems capable of providing thrust within the range of 1-1000 μN including chemical, electrothermal, electrostatic, and electromagnetic systems, both steady state and pulsed in nature. This includes hydrazine, cold or warm gas and vaporizing microthrusters, gas-fed and ablative pulsed plasma thrusters, field effect thrusters, and miniature ion and hall thrusters. Within each category there are many types of propulsion systems that have been developed by many different institutions. Where possible, the most recent published data will be used to compare and contrast each system.

For each system the thrust, specific impulse, power requirements, etc. are presented along with a discussion on the current state-of-the-art developments and technology readiness level. Each propulsion system is examined in terms of applications to upcoming NASA missions including LISA, ST7 DRS, TPF and others.

Thruster Type	Cold Gas	PPT	FEEP (Indium)	FEEP (Cesium)	Colloid	Miniature Ion
Thrust (mN)	4.5 - 4,500	0.002 - 0.7	0.001 - 1	0.001 - 1.4	0.001 - 1	0.5 - 3
Isp (sec)	60 (N_2)	500 - 1500	6,000 - 9,000	6,000 -9,000	500 - 1,500	3000 (typ.)
Ibit (Ns)	10^{-4}	10^{-4} - 10^{-6}	10^{-8} (est.)	10^{-8} (est.)	10^{-8} (est.)	TBD
Specific Power (W/mN)	N/A	70 - 100	60	60	1	30
Propellant	Typ. N_2	Teflon	Indium	Cesium	Glycerol, Ionic Liquids, Formamide	Typ. Xenon
Contamination Concerns	No	Yes	Yes	Yes	Yes	No
Comments	• Central Tank • Large req'd propellant volume	• Modular Fuel Bar, • Pulsed Operation Only	• Modular Tank Design, • Capillary Feed	• Modular Tank Design, • Capillary Feed	• Modular Tank Design, • Capillary Feed	• Central Tank • Scalable to significantly higher thrusts for larger engines • Supercritical (compact) propellant storage