NASAfacts

High Specific-impulse Electrospray Explorer for Deep-space (HiSPEED)

Stage-based Electrospray Propulsion System for CubeSats

The objective of the High Specific-impulse Electrospray Explorer for Deep-space (HiSPEED) project is to develop an efficient propulsion system to enable deep-space exploration with small satellites. The ion electrospray propulsion system developed at Massachusetts Institute of Technology's (MIT) Space Propulsion Laboratory is one of the first systems to offer compact and efficient propulsion that is compatible with the CubeSat form factor. However, existing thruster heads have lifetimes less than the required firing time for a deep-space mission. Therefore, a stage-based approach is considered where burnt out thruster heads are ejected and replaced, thereby extending the overall lifetime of the propulsion system.

Electrospray thruster heads account for less than 3% of the mass and 0.05% of the volume of the entire propulsion system. Therefore, multiple thruster heads can be stacked without significantly increasing the overall propulsion system's mass or volume. The baseline design for the staging mechanism ejects the used thruster heads with an electrically-actuated compression mechanism.

Electrospray thruster metrics include their efficiency, thrust density, and lifetime of an individual thruster head and the entire system as a whole. The MIT Space Propulsion Laboratory has several vacuum chamber facilities to characterize the performance of these devices. One such facility is a magnetically levitating balance that allows the electrospray thrusters to be fired in a frictionless environment.

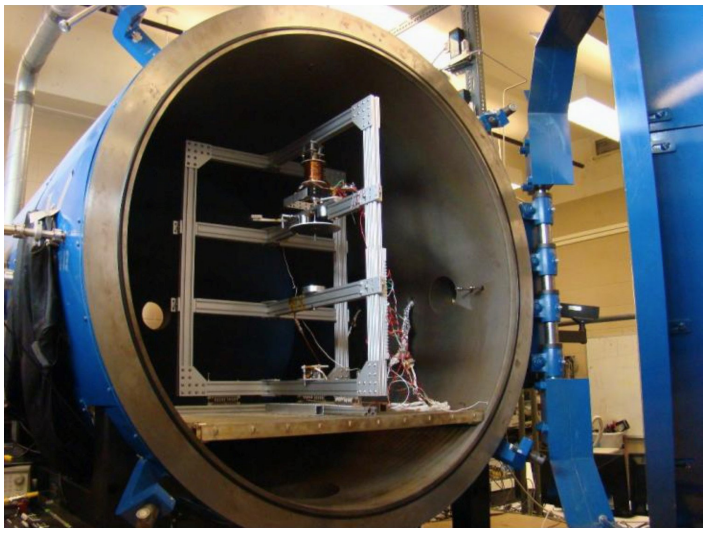
Also, being considered is the use of the same system for attitude control of the spacecraft. Using electrospray thrusters for both primary propulsion and attitude control will eliminate the need for additional systems, such as reaction wheels, therefore increasing the available mass and volume for scientific payloads.

Concept image of HiSPEED

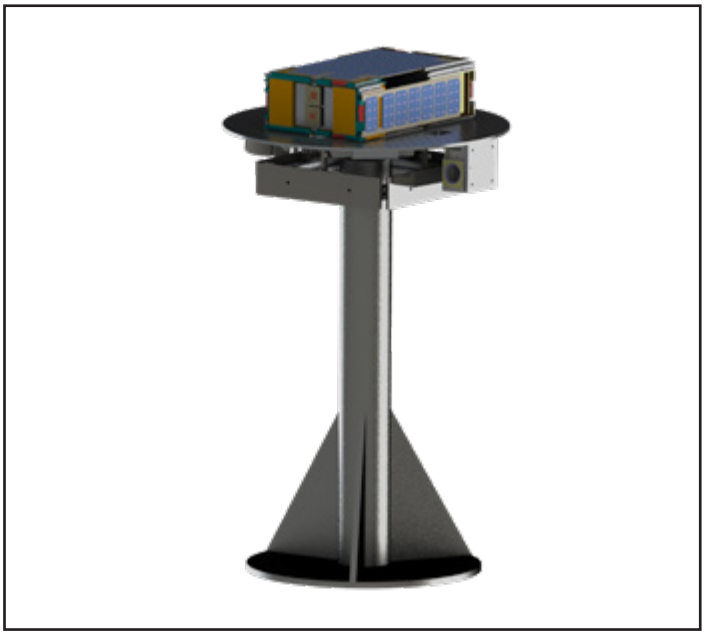
Development of this system will open up frequent and sustainable deep-space exploration using small spacecraft, while improving the affordability of challenging missions. In addition, electrospray propulsion has potential applications in precise attitude control for the next generation of space telescopes or as a compact de-orbiting system to help mitigate the buildup of space debris.

This work is being performed at MIT's Space Propulsion Laboratory in collaboration with NASA's Jet Propulsion Laboratory (JPL). Attitude control algorithms will be developed at JPL. The Small Satellite Dynamics Testbed at JPL has spherical and planar air bearings that enable hardware-in-the-loop testing of sensors, algorithms, and the integrated control systems for HiSPEED.

The HiSPEED project is managed and funded by the Small Spacecraft Technology Program (SSTP) within the Space Technology Mission Directorate. The SSTP expands U.S. capability to execute unique missions through rapid development and in space demonstration of capabilities for small spacecraft applicable to exploration, science, and the commercial space sector. The SSTP will enable new mission architectures through the use of small spacecraft with goals to expand their reach to new destinations, and challenging new environments.



Vacuum chamber with magnetically levitating balance at MIT's Space Propulsion Laboratory.



Air bearing with mock satellite at JPL's Small Satellite Dynamics Testbed

For more information about the SSTP, visit:
www.nasa.gov/directorates/spacetech/small_spacecraft

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FS #2018-03-09-ARC