National Aeronautics and Space Administration

NASAfacts

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

Stage-based electrospray propulsion system for CubeSats

The objective of HiSPEED is to develop an efficient propulsion system to enable deep-space exploration with small satellites. The ion Electrospray Propulsion System developed at MIT's 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.

Concept image of HiSPEED

Micro-fabricated electrospray thrusters are extraordinarily small compared to the rest of propulsion system and the spacecraft. Therefore, multiple thrusters can be added without significantly increasing the overall propulsion system's mass or volume. The baseline design for the staging mechanism ejects spent thruster heads and tanks with an electrically-actuated mechanism.

The staging mechanism metrics include their ability to release spent tanks and thrusters reliably, while preserving thruster efficiency, thrust density, and lifetime of individual thruster heads. 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 this system for attitude control of the spacecraft. Using electrospray thrusters for both primary propulsion and attitude control will eliminate additional systems, such as reaction wheels and therefore increase the available mass and volume for scientific payloads.

Attitude control algorithms will be developed at NASA's Jet Propulsion Laboratory. The Small Satellite Dynamics Testbed at the Jet Propulsion Laboratory has spherical and planar air bearings that enable hardware-in-the-loop testing of sensors, algorithms, and the integrated control systems for 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.

The HiSPEED project is managed and funded by the Small Spacecraft Technology program 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 space- craft with goals to expand their reach to new destinations, and challenging new environments.

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

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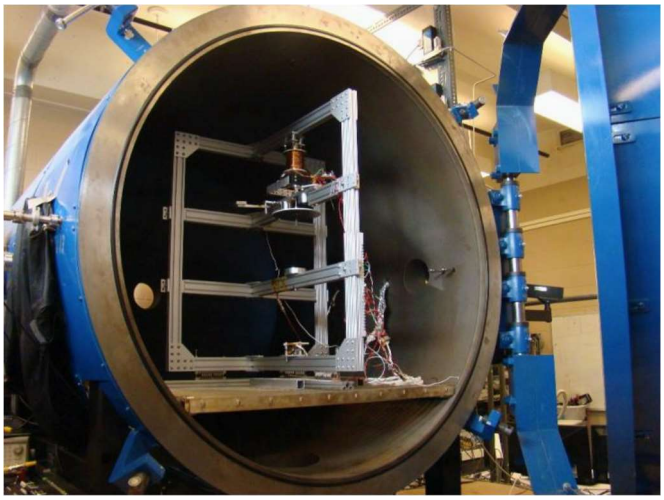

Vacuum chamber at MIT's Space Propulsion Laboratory with magnetically levitating balance

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

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