

Magnesium Hall Thruster

For solar system exploration

This Phase II project is developing a magnesium (Mg) Hall effect thruster system that would open the door for *in situ* resource utilization (ISRU)-based solar system exploration. Magnesium is light and easy to ionize. For a Mars–Earth transfer, the propellant mass savings with respect to a xenon Hall effect thruster (HET) system are enormous. Magnesium also can be combusted in a rocket with carbon dioxide (CO₂) or water (H₂O), enabling a multimode propulsion system with propellant sharing and ISRU. In the near term, CO₂ and H₂O would be collected *in situ* on Mars or the moon. In the far term, Mg itself would be collected from Martian and lunar regolith.

In Phase I, an integrated, medium-power (1- to 3-kW) Mg HET system was developed and tested. Controlled, steady operation at constant voltage and power was demonstrated. Preliminary measurements indicate a specific impulse (Isp) greater than 4,000 s was achieved at a discharge potential of 400 V. The feasibility of delivering fluidized Mg powder to a medium- or high-power thruster also was demonstrated.

Phase II of the project evaluated the performance of an integrated, high-power Mg Hall thruster system in a relevant space environment. Researchers improved the medium power thruster system and characterized it in detail. Researchers also designed and built a high-power (8- to 20-kW) Mg HET. A fluidized powder feed system supporting the high-power thruster was built and delivered to Busek Company, Inc.

Applications

NASA

- ▶ NASA Flagship, Frontier, and Discovery class missions:
 - Extremely high Isp at voltages typical of low-cost, flight-qualified power processors
- ▶ Missions to asteroids, comets, and the outer planets
- ▶ Sample return missions
- ▶ Lunar and Martian missions
- ▶ Manned missions for transporting fuel and cargo
- ▶ *In situ* propellant use at the Moon and Mars

- ▶ Multimode Mg-based propulsion system:
 - Featuring a Mg rocket and a Hall thruster with full or partial propellant sharing

Commercial

- ▶ Satellite orbit maintenance, orbit raising, and repositioning
- ▶ One-half of a multimode propulsion system that also contains a Mg-based rocket

Phase II Objectives

- ▶ Evaluate the performance of an integrated, laboratory model Mg Hall thruster system in a relevant space environment
- ▶ Develop a Mg Hall thruster system
- ▶ Achieve Isp of 4,000 to 6,000 s from commercial orbital transportation services–derived 400- to 600-V power processing unit (PPU)

Benefits

- ▶ Higher Isp and less life-limiting erosion than a xenon HET:
 - Isp for a high-efficiency Mg Hall thruster driven by a 400-V PPU may exceed 5,000 s
- ▶ Low propellant cost and low-pressure propellant storage
- ▶ System efficiency in excess of 50 percent

Firm Contact

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