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SHAPING THE FUTURE OF AEROSPACE

A year of firsts for electric propulsion

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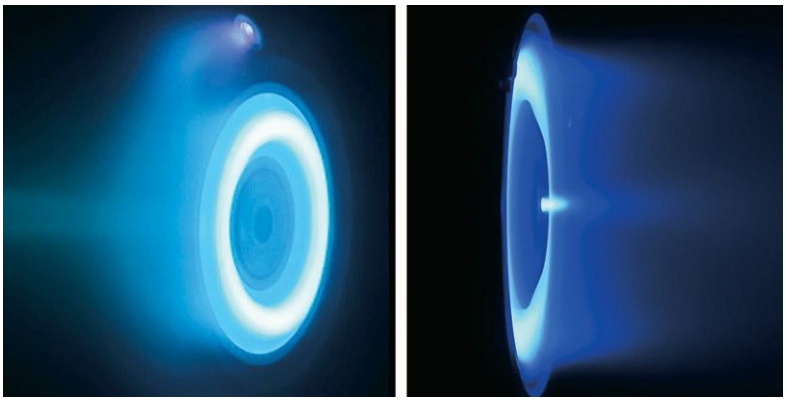
The **Electric Propulsion Technical Committee** works to advance research, development and application of electric propulsion for satellites and spacecraft.



▲ On the left is a Hall thruster identical to those installed on NASA's Psyche asteroid probe. On the right is a SpaceX argon Hall thruster operating at the company's vacuum facility in Redmond, Washington. This design is installed on the company's Starlink v2 Minis, the first of which were launched in February.

NASA/JPL-Caltech and SpaceX

In November, operators at **NASA's Jet Propulsion Laboratory** fired the **Hall Effect thrusters, or HETs**, on the **Psyche** spacecraft, the first time HETs have been used in interplanetary space. Built at JPL, Psyche was launched in October from NASA's Kennedy Space Center in Florida.

In February, **SpaceX** launched the first of its **Starlink V2 Mini satellites**. These next-generation spacecraft are equipped with HETs that operate on argon, instead of the krypton propellant on previous Starlinks. Shortly after launch, the satellites turned on their 4.2-kilowatt thrusters, the first time **argon HETs** have been operated in space.

In May, the 100th **BHT-350 HET** built by Massachusetts-based **Busek** was sent to orbit during a launch of 16 **OneWeb** satellites. Over 100 units are now operating in space aboard spacecraft in OneWeb's Gen1 broadband constellation.

In other satellite news, the **Gravity Space-1** satellite in August maneuvered to geostationary orbit via thrust vectoring with Austria-based Enpulsion's **NANO AR3** electric thruster. In June, **ExoTerra** of Colorado demonstrated its Halo micro-HET in orbit. In March, the water resistojet system built by **Pale Blue Inc.** of Japan was operated for the first time on the **EYE nano satellite** as part of the **STAR SPHERE project** by Sony Corp. In June, **Neumann Space** of South Australia launched the first center-triggered pulsed cathodic arc thruster.

In ground-based research, researchers from **Imperial College London, URA Thrusters** of the U.K. and **Aliena Pte Ltd.** of Singapore for the first time operated a HET with water electrolyzed into hydrogen for the cathode and oxygen for the main thruster. **University of Michigan researchers** demonstrated a tenfold increase in power density for a HET operating at 45 kW on xenon and alternative propellants. Under **NASA's Evolutionary Xenon Thruster project**, thrust levels of a gridded-ion thruster were doubled by incorporating modifications to increase beam uniformity in the thruster.

At the **Jet Propulsion Lab**, researchers developed a heaterless hollow cathode made of lanthanum hexaboride (LaB6) that radiatively heats the thermionic insert with a high-voltage discharge to an internal refractory metal tube. This technology eliminates arcing and has been used to reliably start LaB6 cathodes capable of discharge currents up to 50-300 amperes. In March, an **air-breathing microwave plasma cathode** was tested at the **University of Surrey** with a low-power xenon cylindrical HET. Researchers observed stable thruster operation on both xenon and air at thruster discharge powers of 100-300 watts.

In Massachusetts in January and May, students from **Olin College, Wellesley College** and **Brandeis University** fired a Hall thruster at 200-600 W, the first fully undergraduate team to design and operate a steady-state electric propulsion thruster.

Looking to future flights, **Northrop Grumman** in June secured orders for the last of three planned **Mission Extension Pods**. These all-electric "jet packs" would attach to satellites in geostationary orbit and maneuver them via **NGHT-1X** thrusters to extend their lifetimes. At Safran, the **PPS 5000** 5-kW HET saw a sharp increase in orders and production rates. Busek delivered the first two **BET-MAX** electrospray systems for launch.

In October, the **Japan Aerospace Exploration Agency, JAXA,** completed testing of its 6-kW-class HET. A unit is scheduled to launch in 2025 aboard Engineering Test Satellite-9.

Qualification and production of flight hardware began for the first element of NASA's planned **Lunar Gateway** space station, the **Power and Propulsion Element**. Provided by **Maxar**, the PPE will have 48 kW of electric propulsion distributed among HETs provided by **Aerojet Rocketdyne** and **Busek**. In June, the second 13-kW integrated string test was completed at **NASA's Glenn Research Center** in Ohio, and Aerojet Rocketdyne and NASA in July completed acceptance testing of the first 12-kW Hall thruster.

Overall, the future looks bright with electric propulsion continuing to expand across the solar system. ★