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The year in review

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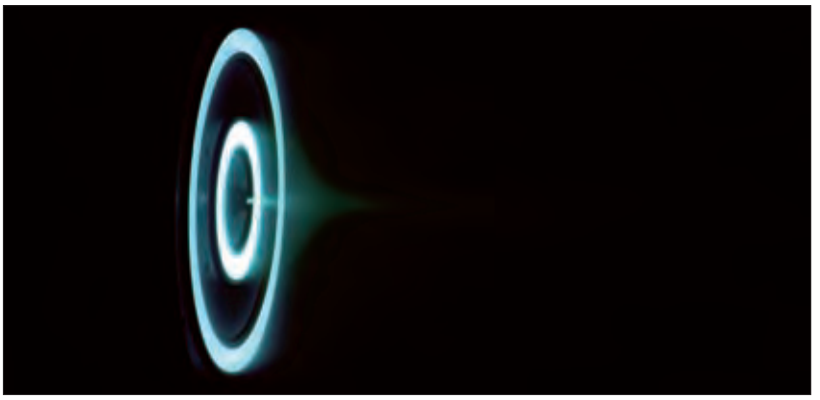
Electric propulsion



The University of Michigan and Air Force Research Laboratory developed and operated the first concentric Hall thruster, called the X2 for its two channels. (Courtesy of the University of Michigan.)

Snecma's products include this thruster module assembly. (Courtesy of Snecma, Vernon operations.)

by **Joshua L. Rovey**

This was an active year for electric propulsion in flight and R&D programs. The 30-cm NSTAR ion thrusters manufactured by L-3 Communications for NASA's Dawn spacecraft have been operated for a total of 8,000 hr and have provided a total impulse of 2.6 MN-sec. Dawn is scheduled to rendezvous with the asteroid Vesta in August 2011. Japan's Hayabusa asteroid explorer restarted its four microwave discharge ion engines for a delta-V maneuver in February. The engines have operated over 35,000 hr in deep space; the satellite is scheduled to return to Earth in 2010. ESA's Gravity Ocean Circulation Explorer satellite was launched in March with a pair of ion thrusters manufactured by QinetiQ.

ESA's LISA Pathfinder, scheduled for launch in 2011, will use both colloid and field emission EP for disturbance reduction and attitude control. Busek and JPL delivered colloid micro-Newton thruster flight units to ESA, while Alta will supply the cesium field emission system. Snecma completed acceptance testing of four PPS-1350 stationary plasma thrusters for ESA's Alphasat and was selected to supply eight EDB Fakel SPT-100 thrusters for the ESA Small GEO satellite. An Israeli Hall-effect thruster manufactured by Rafael was integrated onto the joint Israeli and French VENμS spacecraft.

L-3 Communications launched four 25-cm ion thrusters onboard a Boeing 702 satellite, with another four thrusters in satellite integration and 12 in production. Space Systems/Loral launched five spacecraft with stationary plasma thrusters, with another three subsystems delivered and six scheduled for delivery.

NASA's evolutionary xenon thruster (NEXT) long-duration test has accumulated over 24,300 hr of operation, processed over 434 kg of xenon, and demonstrated a total impulse in excess of 16 MN-sec. Plans call for extending the test to demonstrate first failure mode (accelerator grid wear-through), projected at 750 kg at full power. The Japan Aerospace Exploration Agency is developing a 20-mN ion engine for the super-low-altitude satellite. L-3 Communications is developing a throttleable 8-cm XIPS thruster that operates at 100-350 W, with 2-14 mN of thrust. Busek demonstrated three small RF gridded ion thrusters delivering 0.2-, 2-, and 11-mN thrust with specific impulse ranging from 1,300 to 3,800 sec.

Aerojet delivered the engineering model of NASA's high-voltage Hall accelerator. It will begin performance acceptance tests, environmental tests, and ultimately a long-duration test where it is anticipated to operate for more than 15,000 hr. Michigan Tech University demonstrated Hall-effect thrusters using light metallic elements for propellant. A nominally 2-kW thruster was operated on both magnesium and zinc. ElectroDynamic Applications designed a helicon Hall thruster that was then manufactured by Aerojet. It is a two-stage thruster with helicon ionization first stage coupled to a Hall accelerator stage to provide high thrust-to-power operation. The University of Michigan and Air Force Research Laboratory developed and operated the first concentric Hall thruster, named the X2 for its two channels. It is designed to reduce specific mass and maximize power during high thrust-to-power operation.

MSNW demonstrated the ELF (electrodeless Lorentz force) thruster, a new concept for pulsed electromagnetic propulsion that uses rotating magnetic fields to create a high-density, magnetized plasmoid called a field-reversed configuration. Operation on air and xenon from 1,000 sec to 5,000 sec specific impulse at energy levels suitable for 20-100-kW steady-state operation was demonstrated. Ad Astra Rocket operated the first stage, helicon section, of the VX-200 200-kW VASIMR engine at full power with maximum magnetic field. A record power of almost 150 kW was added to the plasma with the second-stage, RF booster. And the Ecole Polytechnique in France is currently developing the PEGASES (plasma propulsion with electronegative gases) thruster. It produces and accelerates both positively and negatively charged ions, which recombine and form a neutral beam. This technique is expected to reduce plasma-spacecraft interactions.