Electric propulsion

The Aerojet/Lockheed Martin Space Systems BPT-4000, a 4.5-kW Hall thruster system, was launched for the first time aboard the USAF Advanced Extremely High Frequency satellite. It also completed over 10,000 hr of ground testing, marking the most throughput ever demonstrated on a Hall thruster. Acceleration channel erosion was reduced significantly after about 5,600 hr. Numerical simulations at JPL revealed with potentially breakthrough implications that by properly shaping the magnetic field near the channel walls, their erosion can be practically eliminated.

In 2010, three science missions featured EP in flight. The Hayabusa spacecraft's ion engine system powered it back to Earth after a seven-year mission to asteroid Itokawa. The system logged 39,637 engine-on hours, including 14,830 hr on a single engine. Aerojet has entered into an agreement with NEC to market this system in Japan and the U.S.

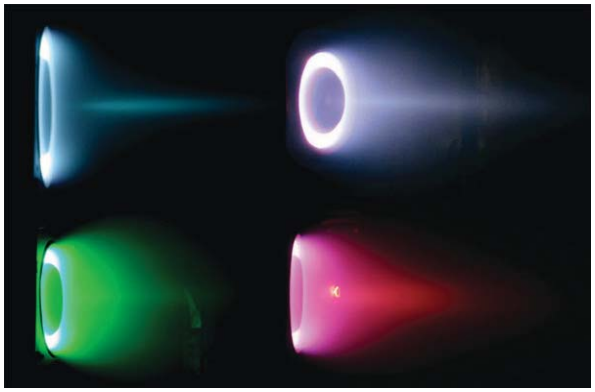
By the end of August, the three-engine ion propulsion system (IPS) on NASA's Dawn spacecraft had operated in flight for 16,500 hr and delivered a delta-V of 4.8 km/sec while consuming 183 kg of the original 425 kg of xenon propellant. Dawn is scheduled to rendezvous with Vesta in July 2011 and Ceres in 2015.

ESA'S GOCE satellite is providing unique data on Earth's gravity field and geoid using two T5 ion thrusters. The ion propulsion assembly from QinetiQ is operating well.

ESA's LISA Pathfinder, scheduled to launch in 2012, features a drag-free system using micronewton EP provided by ESA and NASA. BepiColombo, a Cornerstone mission to Mercury to launch in 2014, will rely on a 4.5-kW T6 IPS from QinetiQ.

Space Systems/Loral (SS/L) has launched six spacecraft with stationary plasma thrusters (SPTs). The SPT subsystems in flight have together logged over 11,000 hr of thruster operation. They incorporate four Fakel SPTs and two SS/L power processing units. The last three satellites feature new SPT modules with greater range of motion. SS/L has five SPT subsystems delivered to spacecraft scheduled to launch through 2011, and five more to be delivered to spacecraft under construction.

At Snecma, Safran Group, the last two of four PPS 1350-G thrusters for Alphasat were delivered. Production of thruster module assemblies has attained significant milestones: By the end of the year, flight model 16 will be delivered, with orders or options up to model 20. Twenty years in-orbit and 12,000 hr of thrusting time have been accumulated. For the small GEO EP thruster assembly, eight SPT-100 thrusters have been procured, and Snecma will begin integration activities. Developed under ESA, small GEO satellites will rely on Hall thrusters from Snecma, or on HEMPT units from Thales.



Testing of advanced metal propellants for EP took place at Michigan Technological University. From upper left and going clockwise the propellants are xenon, bismuth, zinc, and magnesium. Courtesy Michigan Technological University.

At over 31,500 hr of operation, NASA's evolutionary xenon thruster—a 7-kW ion engine developed by NASA Glenn and Aerojet—became the longest lifetime thruster of any type ever, with a total propellant throughput over 520 kg and total impulse over 19 MN-sec.

The high-voltage Hall accelerator, a high-specific-impulse engineering model thruster built by Aerojet and NASA Glenn, has undergone performance testing. The thruster incorporated a life-extending discharge channel replacement innovation. The testing of the NASA-300M Hall thruster was performed for power and voltage levels up to 20 kW and 600V with xenon and krypton propellants.

The French GDR research group (CNRS/CNES/Snecma/universities) continued Hall thruster physics investigations, with partnerships with the Charles University of Prague and the IPPLM institute of Warsaw. With Snecma, ONERA, and IPPLM, the GDR will design, manufacture, and test a 20-kW Hall-effect thruster within the HiPER European research program on high-power EP. Testing will begin in 2011.

Princeton Plasma Physics Laboratory, with Aerospace Corporation, examined performance improvements for cylindrical Hall thrusters (CHTs). The lab built low-power permanent magnet CHTs with improved magnetic design, which demonstrated superior performance over CHT with electromagnets during measurements at NASA Marshall. With a larger volume-to-surface ratio over conventional Hall thrusters, the CHT potentially offers less erosion and longer lifetime.

by **Olivier Duchemin**