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Year in review

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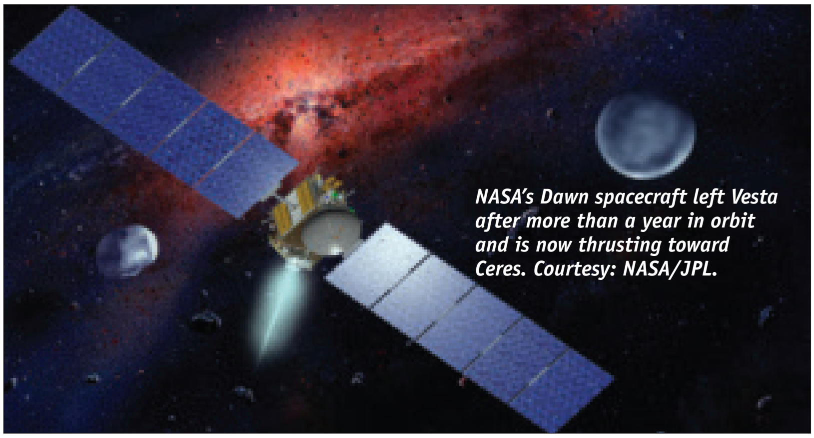
Electric propulsion


NASA's Dawn spacecraft left Vesta after more than a year in orbit and is now thrusting toward Ceres. Courtesy: NASA/JPL.

Electric propulsion (EP) continues to make enabling contributions to Earth and solar system science. NASA's Dawn spacecraft, powered by its ion propulsion system (IPS), has left the protoplanet Vesta and is now cruising toward a 2015 arrival at the dwarf planet Ceres. Through September of this year, IPS has operated over 25,000 hr, provided a delta-V of over 7 km/sec, and consumed 262 kg of xenon propellant. ESA's GOCE (gravity field and steady-state ocean circulation explorer) mission is mapping the Earth's gravitational field in conjunction with a QinetiQ T5 ion thruster system. The system, commissioned in March 2009, has accumulated 24,000 hr of operation.

A study by the Keck Institute for Space Studies at Caltech demonstrated that 40-kW-class EP can enable a mission to capture and return a small near-Earth asteroid to cislunar space. The retrieval of a 7-m-diam., 500-metric-ton asteroid could be completed by the mid-2020s. ESA's BepiColombo mission will deliver two spacecraft to Mercury orbit in 2021. The craft will rely on a QinetiQ T6 ion thruster system that is now undergoing qualification.

The use of EP on commercial spacecraft continues to expand rapidly worldwide, led by the announcement of the first 'all-electric' communications spacecraft, Boeing's 702SP. L-3 Communications now has 76 xenon ion propulsion system thrusters in orbit on 18 Boeing satellites. Space Systems/Loral has launched 12 spacecraft with Hall thrusters that have logged over 20,000 hr on orbit, with two single thrusters having fired for more than 2,500 hr each. The second Air Force AEHF spacecraft reached GEO on August 27. On board the satellite are four Aerojet/Lockheed Martin BPT-4000 Hall thrusters, bringing the total in orbit to eight. The launch of Yahsat 1B in April has raised the number of Snecma's Hall thruster systems in space to 14. By the end of this year, they will have accumulated 18,770 hr of operation.

Research activities continue worldwide in industry, academia, and government laboratories. Busek is investigating condensable propellants for Hall thrusters. Performance meeting or exceeding that on xenon was measured with iodine-fueled Hall thrusters at power levels up to 9 kW. At the Australian National University, work on the helicon double-layer thruster is proceeding. Construction will begin soon on a large Space Simulation Facility to be used for thermal/vacuum testing.

NASA's evolutionary xenon thruster, or NEXT, a 7-kW ion thruster developed by NASA Glenn and Aerojet, has processed 750 kg of propellant in life testing. An engineering model high-voltage Hall accelerator thruster, built by Glenn and Aerojet, has undergone characterization testing as part of a sequence that precedes a life test. Performance testing of 20- and 50-kW Hall thrusters has also been conducted.

Inductive pulsed plasma thrusters are under development at NASA Marshall. Several conical theta-pinch thrusters with different cone angles, and a flat-plate thruster with pulsed gas injection and solid-state switching, were tested on a sensitive hanging-pendulum thrust balance.

Researchers at JPL have demonstrated magnetic shielding in Hall thrusters, a technique that protects the channel walls from ion sputtering. The first principles of magnetic shielding were derived through numerical simulations with the code Hall2De. Experiments with a magnetically shielded H6 Hall thruster showed that erosion rates were at least two orders of magnitude lower than those of unshielded thrusters, effectively eliminating channel erosion as a life-limiting mechanism. JPL also demonstrated a graphite-walled version of the H6 operating at high efficiency (over 60%) by exploiting the reduction in plasma-wall interactions provided by magnetic shielding, which is anticipated to yield significant reductions in the mass and cost of Hall thrusters. Finally, JPL installed a 12-kW solar array for direct-drive system development and successfully demonstrated single and dual Hall thruster configurations at over 10 kW.

by **Richard Hofer**