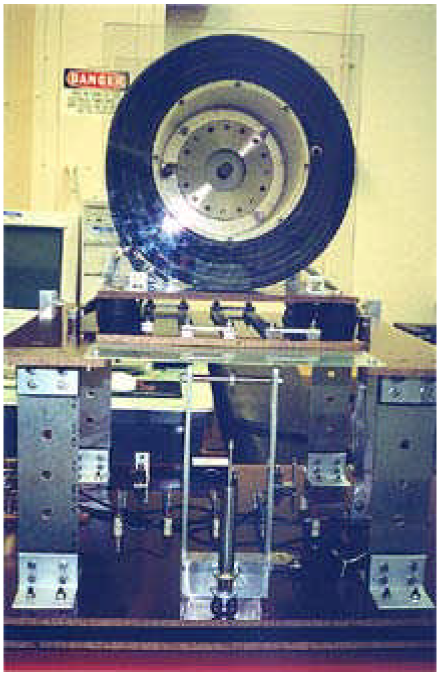
High-Power Magnetoplasmadynamic Thruster Being Developed

Self-field MPD thruster.

High-power electromagnetic thrusters have been proposed as primary in-space propulsion options for several of the bold new interplanetary and deep space missions envisioned by the Human Exploration and Development of Space (HEDS) Strategic Enterprise. As the lead center for electric propulsion, the NASA Glenn Research Center is actively involved in the design, development, and testing of high-power electromagnetic technologies to meet these demanding mission requirements.

One concept of particular interest is the magnetoplasmadynamic (MPD) thruster, shown schematically in the preceding figure. In its basic form, the MPD thruster consists of a central cathode surrounded by a concentric cylindrical anode. A high-current arc is struck between the anode and cathode, which ionizes and accelerates a gas (plasma) propellant. In the self-field version of the thruster, an azimuthal magnetic field generated by the current returning through the cathode interacts with the radial discharge current flowing through the plasma to produce an axial electromagnetic body force, providing thrust. In applied field-versions of the thruster, a magnetic field coil surrounding the anode is used to provide additional radial and axial magnetic fields that can help stabilize and accelerate the plasma propellant.

The following figure shows an experimental megawatt-class MPD thruster developed at Glenn. The MPD thruster is fitted inside a magnetic field coil, which in turn is mounted on a thrust stand supported by thin metal flexures. A calibrated position transducer is used to determine the force provided by the thruster as a function of thrust stand displacement. Power to the thruster is supplied by a 250-kJ capacitor bank, which provides up to 30-MW to the thruster for a period of 2 msec. This short period of time is sufficient to establish thruster performance similar to steady-state operation, and it allows a number of thruster designs to be quickly and economically evaluated. In concert with this experimental research, Glenn is also developing and using advanced numerical simulations to predict the performance of self-field and applied-field MPD thrusters. The pulsed high-power test facility serves as a testbed to validate the numerical thruster simulations, and the numerical simulations are, in turn, used to provide more efficient thruster designs. In addition, Glenn is currently refurbishing a megawatt-class steady-state thruster facility that will be used for extensive life testing of the optimized thruster designs developed from the numerical simulations and high-power pulsed MPD thruster experiments.



Experimental megawatt-class MPD thruster.

The ultimate goal of the high-power MPD thruster program is to provide an efficient, megawatt-class electromagnetic thruster capable of several thousand hours of continuous operation. Because of the high exhaust velocity inherent in electric propulsion thrusters, these devices can meet the most demanding mission applications with significantly less propellant than chemical rockets. For a given spacecraft launch mass, the reduction in propellant mass will allow more payload to be carried into orbit, requiring fewer launches and less cost for a total mission mass. Alternatively, the lower propellant mass requirements can be used to reduce the total spacecraft mass at launch, with a corresponding reduction in launch vehicle class and associated launch costs. Providing robust and economical in-space transportation, Glenn is leading the way to develop these high-power plasma thrusters of the future.

Ohio Aerospace Institute contact: Dr. Michael R. LaPointe, 216-433-6192, Michael.R.Lapointe@grc.nasa.gov
Author: Dr. Michael R. LaPointe
Headquarters program office: OAT
Programs/Projects: ASTP