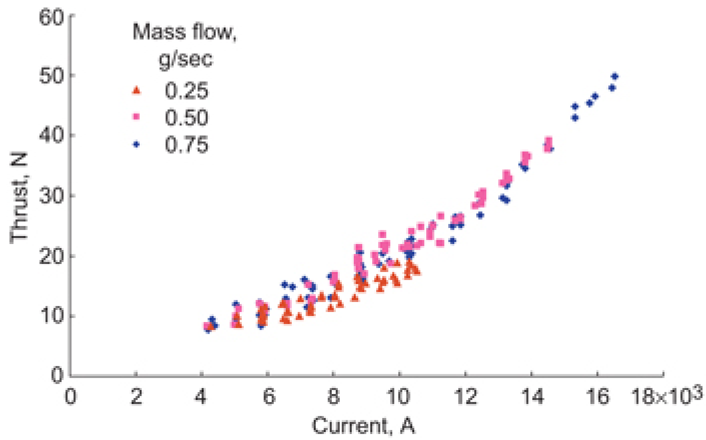
Testing Done for Lorentz Force Accelerators and Electrodeless Propulsion Technology Development

The NASA Glenn Research Center is developing Lorentz force accelerators and electrodeless plasma propulsion for a wide variety of space applications. These applications range from precision control of formation-flying spacecraft to primary propulsion for very high power interplanetary spacecraft. The specific thruster technologies being addressed are pulsed plasma thrusters, magnetoplasmadynamic thrusters, and helicon-electron cyclotron resonance acceleration thrusters.

The pulsed plasma thruster mounted on the Earth Observing-1 spacecraft was operated successfully in orbit in 2002. The two-axis thruster system is fully incorporated in the attitude determination and control system and is being used to automatically counteract disturbances in the pitch axis of the spacecraft. Recent on-orbit operations have focused on extended operations to add flight operation time to the total accumulated thruster life. The results of the experiments pave the way for electric propulsion applications on future Earth-imaging satellites.

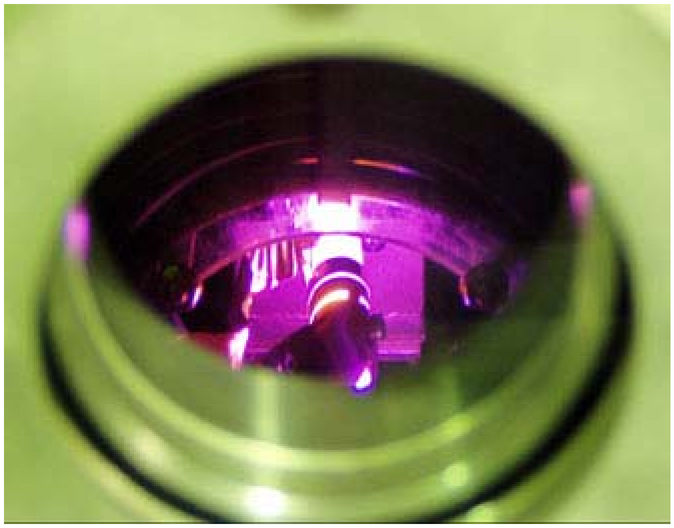
Future pulsed plasma thrusters will include longer-life, higher-precision, multiaxis thruster configurations for applications such as three-axis attitude control systems or high-precision, formation-flying systems. Advanced components, such as a mica-foil capacitor, a wear-resistant spark plug, and a multichannel power-processing unit were developed under NASA contract with Unison Industries, General Dynamics, and C.U. Aerospace. A life test has demonstrated over 39 million pulses on these components, which approaches the near-term life requirements for deep-space interferometry demonstrator missions. The spark plug life is less than expected. Excessive spark plug electrode wear is being addressed by incorporating novel wear-resistant metals. The improved design is currently under evaluation. In addition, a three-axis pulsed-plasma thruster demonstration module, which examines thruster packaging issues, was fabricated and was operated successfully in a functionality test.

High-power steady-state Lorentz force accelerators are being considered as primary propulsion options for robotic and piloted interplanetary and deep-space missions. The Lorenz force accelerator team is developing megawatt-class magnetoplasmadynamic thrusters to meet these demanding future mission requirements. The self-field baseline magnetoplasmadynamic thruster has been tested with argon propellant at power levels up to approximately 5 MW. Thruster performance was accurately measured using a thrust stand and calibrated mass flow and power measurements. The thrust reached values up to 50 N at 16,000 A, for mass flow rates ranging from 0.25 to 0.75 g/sec, with thruster operation at higher currents limited by the onset of voltage oscillations. The thrust values display the expected quadratic increase in thrust with discharge current characteristic of these devices. The use of an additional applied magnetic field and the use of hydrogen propellant are the next steps in improving thruster performance.



Magnetoplasmadynamic thruster performance mapped over a range of currents and flow rates.

Electric propulsion thrusters either currently in use or near realization share the need for electrodes in direct contact with the plasma they generate. The elimination of the electrode-plasma interaction could either increase lifetime with high-performance propellants or allow the use of in situ propellants such as lunar oxygen. In recognition of the potential advantages offered by electrodeless propulsion, Glenn has begun to investigate helicon wave sources both as possible replacements to existing thruster components and as the basis for future advanced in-space propulsion systems. The initial research effort has been to determine the feasibility of a short, narrow helicon source and to find the proper magnetic field strengths, radiofrequency power levels, and flow rates for effective plasma ionization. The first operation of the helicon source to generate plasma was achieved as shown in the photograph.



Helicon source operating in inductive mode inside the vacuum chamber.

Find out more about this research:
Earth Observing-1 PPT experiment at http://space-power.grc.nasa.gov/ppo/projects/eo1/
Earth Observing-1 at http://eo1.gsfc.nasa.gov/
Lorentz Force Accelerator research at Glenn at http://www.grc.nasa.gov/WWW/lfa/

Glenn contact: Eric J. Pencil, 216-977-7463, Eric.J.Pencil@nasa.gov
Ohio Aerospace Institute (OAI) contact: James H. Gilland, 216-433-6192, James.H.Gilland@grc.nasa.gov
Authors: Eric J. Pencil, James H. Gilland, Lynn A. Arrington, and Dr. Hani Kamhawi
Headquarters program offices: Science, Exploration Systems, Earth Science, Space Science, Space Flight, Aerospace Technology
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