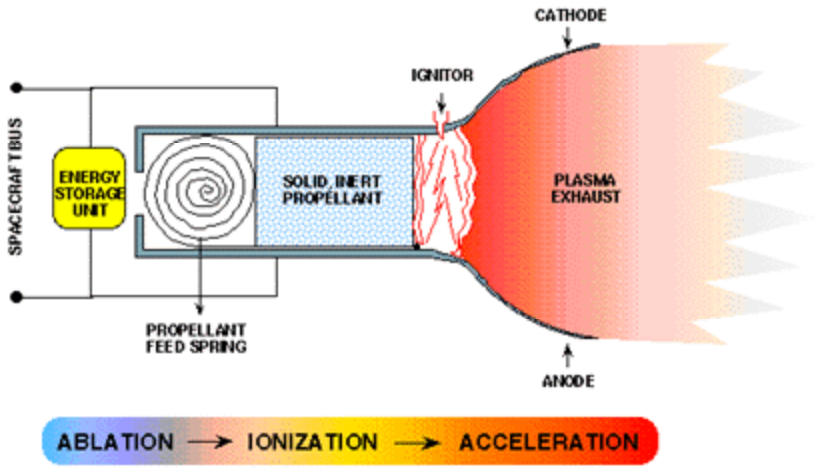
Pulsed Plasma Thruster Technology Development and Flight Demonstration Program

Because of anticipated near- and far-term mission needs for innovative new electric propulsion technologies, the NASA On-Board Propulsion program is sponsoring NASA Lewis Research Centers' Pulsed Plasma Thruster (PPT) technology development program to rapidly advance PPT technology. This is a joint effort of Lewis' On-Board Propulsion Branch and Space Flight Project Branch. Building on state-of-the-art technology developed and flown in the 1970's and 1980's for Department of Defense missions, newly developed PPT program designs are realizing significant gains in system mass reduction, thrust to mass ratio, total impulse to mass ratio, and variability of impulse bit.

At the beginning of the PPT development program, and well before the inception of any flight programs, the effort was truly characterized by the term "technology push." After the fundamental feasibility, initial technology evaluations, multiple mission applications, and potential benefits of a new generation of PPT's were established in-house at Lewis, a contracted effort with the PRiMEX Aerospace Company was initiated, and more exhaustive market and technology assessments were conducted. From these combined efforts, a baseline system for near-term technology development was established. At the same time, a PPT technology development roadmap was developed to focus PPT efforts on both near- and far-term mission performance requirements.

PPT CHARACTERISTICS AND CANDIDATE MISSIONS

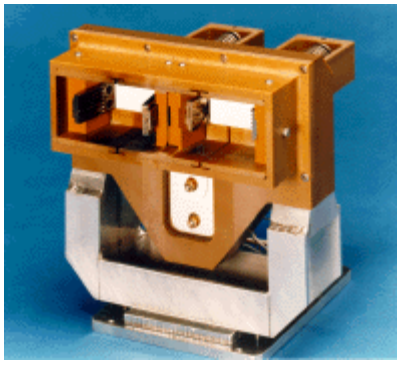
Characteristics
Variable operating range, W . . . 1 to 200
Specific impulse, I_{sp}, sec . . <300, >2000
Propellant . . . . . Solid, inert
Candidate missions
Insertion and deorbit
Propulsive attitude control system
Precision station keeping
Drag makeup



PPT operating principle.

The PPT system is composed of power and control electronics, a high-energy capacitor, electrodes, and chlorofluorocarbon-based fuel bars. The use of solid, nontoxic propellant bars eliminates fluid propellant systems (valves, piping, fuel tanks, and heaters) and the complex ground handling systems used in traditional propulsion systems. The fuel is ablated, ionized, and accelerated electromagnetically from the PPT during a high-voltage capacitor discharge across the face of the fuel bar (see the figure).

The PPT system offers a simple, lightweight, microthrust propulsion capability with minimal spacecraft interface requirements (power, control and data, and mechanical requirements only) for spacecraft attitude control, orbit-raising and translation, and precision positioning. To assess various component and system technologies, PRiMEX designed and assembled a breadboard PPT unit early in the contracted effort (see the photo). This device allows easy assembly and disassembly to facilitate rapid hardware modification and testing. The breadboard PPT has undergone extensive testing at PRiMEX and is currently being tested at Lewis to assess system-level performance and environmental characteristics. Results from these breadboard PPT system and ongoing component tests are being applied to near-term flight demonstration PPT designs. In addition, fundamental supporting research is being performed by the Ohio State University, Worchester Polytechnic Institute, the University of Illinois (Urbana), and Auburn University.



NASA Lewis/PRiMEX breadboard PPT.

The first PPT flight is planned to use a single PPT system to demonstrate propulsive attitude control (pitch-axis only) for NASA's Earth Observer-1 spacecraft (EO-1). EO-1, which is scheduled to fly in mid-1999, will be the first Earth-orbiting mission under NASA's New Millennium Program. The NASA Goddard Space Flight Center has responsibility for EO-1, and Lewis engineers are working closely with Goddard personnel to assure that the E0-1 PPT system meets performance, life, and spacecraft integration requirements.

Beyond EO-1, the program is targeting technology for precision formation flying for applications such as long baseline interferometry using distributed spacecraft (such as the New Millennium Program's Deep Space 3 mission). Multiple PPT units with three-axis fuel bars are currently envisioned for this application to provide translation and precision positioning of two to three formation-flying spacecraft.

Find out more about the PPT program.

Bibliography

Curran, F.M.; et al.: Pulsed Plasma Thruster Technology Direction. AIAA Paper 97-2926, 1997.

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