Phase 1 STTR Project Summary

Firm: Orbital Technologies Corporation
Contract Number: NNX09CF59P
Project Title: Advanced Microwave Electrothermal Thruster (AMET)

Purpose of the Research. The overall goal of this effort was to establish the technical feasibility of using the Advanced Microwave Electrothermal Thruster (AMET) for in-space propulsion with water propellant. The AMET uses an electrodeless discharge to transfer energy from microwaves to a steam plasma, with the discharge located immediately upstream of a nozzle. After it is heated, the propellant plasma is discharged through the nozzle to produce thrust. The AMET uses 915 MHz microwaves, and operates at a power level of approximately 75 kW. Because of its rare ability to use water propellant in an electric propulsion system, the AMET is well-suited for missions involving stops at the Moon or Mars, where water is known to be available in significant quantities. The overall objectives of the Phase 1 effort were to experimentally demonstrate the operation of the AMET, and to analytically describe the plasma chemistry in the nozzle flow through numerical modeling.

Brief Description of the Research Carried Out. The work consisted of (1) defining the system requirements for the Phase 1 AMET, (2) identifying a suitable microwave source for supporting the Phase 1 test operations, (3) refurbishing ORBITEC's existing Microwave Electrothermal Thruster (MET) hardware, (4) designing and fabricating hardware to support the Phase 1 testing, (5) conducting hot-fire tests and analyzing the resulting data, (6) numerically modeling the AMET plume characteristics, and (7) producing a preliminary design of a flight-like AMET. ORBITEC was responsible for project management and all elements of design, fabrication, and testing; the University of Alabama in Huntsville led the numerical analysis work.

Research Findings or Results. ORBITEC successfully demonstrated the operation of the AMET in a series of hot-firing tests, achieving steady plasma discharges and thruster operation. Plasma chemistry analysis of the AMET propellant produced estimates of specific impulse for three varying assumptions, ranging from a frozen flow scenario to an equilibrium scenario.

Justification for Phase 2 Continuation. The work conducted during the Phase 1 AMET project has established a strong foundation to enable a productive and successful Phase 2 AMET program. All of the Phase 1 technical objectives were met and the technical questions were positively answered. The successful demonstration of the AMET thruster in Phase 1 has clearly demonstrated the feasibility of the concept, and the supporting analysis work has confirmed that the goal of 800 seconds of specific impulse should be achievable with the AMET in a vacuum environment. The AMET is expected to mature into a highly reliable, simple, low-cost electric propulsion device which would be well-suited to a variety of in-space propulsion missions.

Potential Applications in Phase 3. The AMET will be an excellent choice for a number of in-space propulsion missions. In particular, as the only electric thruster capable of delivering high I_{sp} with water propellant, it is ideally suited for missions involving stops at either the Moon or Mars, both of which are known to hold large reserves of water ice at different surface locations.