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Iodine Satellite

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Sponsoring Program(s)

Marshall Space Flight Center/Center Management and Operations
Center Strategic Development Steering Group

Project Description

This project is a collaborative effort to mature an iodine propulsion system while reducing risk and increasing fidelity of a technology demonstration mission concept.[1] The FY 2014 tasks include investments leveraged throughout NASA, from multiple mission directorates, as a partnership with NASA Glenn Research Center (GRC), a NASA Marshall Space Flight Center (MSFC) Technology Investment Project, and an Air Force partnership.

Propulsion technology is often a critical enabling technology for space missions. NASA is investing in technologies to enable high value missions with very small and low-cost spacecraft, even CubeSats. However, these small spacecraft currently lack any appreciable propulsion capability. CubeSats are typically deployed and drift without any ability to transfer to higher value orbits, perform orbit maintenance, or deorbit. However, the iodine Hall system can allow the spacecraft to transfer into a higher value science orbit. The iodine satellite (iSAT) will be able to achieve a ΔV of >500 m/s with <1 kg of solid iodine propellant, which can be stored in an unpressurized benign state prior to launch.

The iSAT propulsion system consists of the 200 W Hall thruster, solid iodine propellant tank, a power processing unit, and the necessary valves and tubing to route the iodine vapor. The propulsion system is led by GRC, with critical hardware provided by the Busek Co.

The propellant tank begins with solid iodine unpressurized on the ground and in-flight before operations, which is then heated via tank heaters to a temperature at which solid iodine sublimates to iodine vapor. The vapor is then routed through tubing and custom valves to control mass flow to the thruster and cathode assembly.[2] The thruster then ionizes the vapor and accelerates it via magnetic and electrostatic fields, resulting in thrust with a specific impulse >1,300 s.

The iSAT spacecraft, illustrated in figure 1, is currently a 12U CubeSat. The spacecraft chassis will be constructed from aluminum with a finish to prevent iodine-driven corrosion. The iSAT spacecraft includes full three-axis control using wheels, magnetic torque rods, inertial management unit, and a suite of sensors and optics. The spacecraft will leverage heat generated by spacecraft components and radiators for a passive thermal control system.

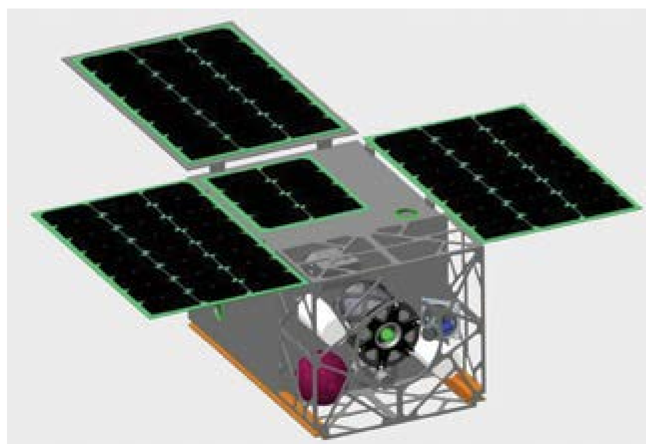

Figure 1: Preliminary FY 2014 12U concept design.

Anticipated Benefits

The benefits of the iodine Hall technology and iSAT demonstration include enabling significant small spacecraft maneuverability with a propulsion system viable with secondary payload launch opportunities.[3] Most of the technology benefits are derived from the unpressurized storage, low pressure operation, and high density. The storage and operating pressures allow for additive manufacturing of the propellant tank and shapes to maximum volume. Also, the iodine density components with the Hall thrusters results in more than an order of

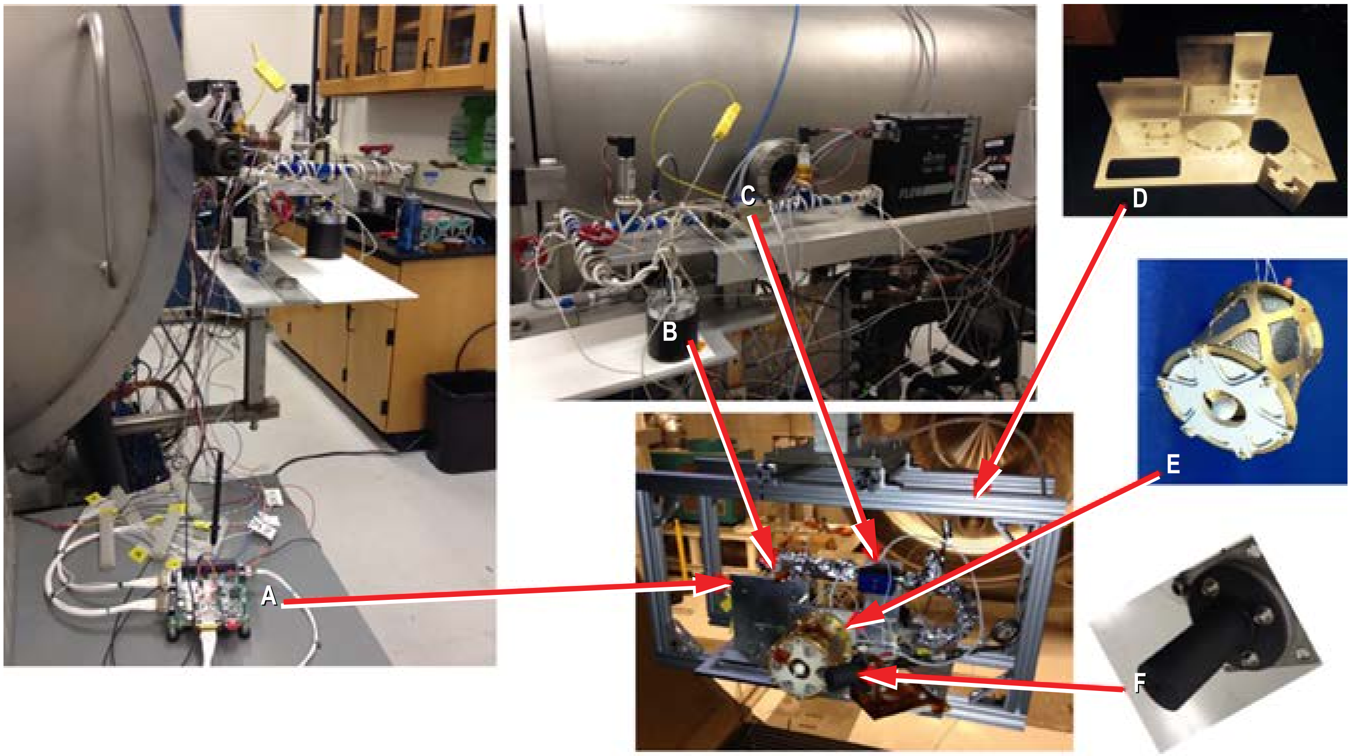

Figure 2: Custom control electronics (A), propellant reservoir (B), VACCO iodine valve (C), integrated test plate (D), Busek BHT-200-I thrusters (E), and Colorado State University electride cathode (F) on the MSFC pendulum thrust stand B4205 R101.

magnitude improvement in ΔV per unit volume of small sat state of the art.

Potential Applications

The primary applications are geocentric maneuverability and interplanetary transit for small spacecraft. The technology enables cost-effective geocentric constellation deployment, orbit maintenance, and deorbit. The technology can also enable EELV Secondary Payload Adapter class small sats to depart from geosynchronous transfer orbit and go to the Moon, asteroids, Mars, and Venus, saving potentially upwards of $100M in launch costs to interplanetary destinations. Higher power systems can also be used for orbit transfer vehicles and eventually have potential for human exploration activities with ground test and propellant packaging advantages.

Notable Accomplishments

This project was approved under the Small Spacecraft Technology Program for a technology demonstration mission in early FY 2017.

References

1. Dankanich, J.W.; Polzin, K.A.; Calvert, D.; and Kamhawi, H.: "The iodine Satellite (iSAT) Hall Thruster Demonstration Mission Concept and Development," 50th Joint Propulsion Conference, Cleveland, OH, July 28–30, 2014.

2. Dankanich, J.W.; Szabo, J.; Pote, B.; et al.: "Mission and System Advantages of Iodine Hall Thrusters," 50th Joint Propulsion Conference, Cleveland, OH, July 28–30, 2014.

3. Polzin, K.A.; and Peeples, S.: "Iodine Hall Thruster Propellant Feed System for a CubeSat," 50th Joint Propulsion Conference, Cleveland, OH, July 28–30, 2014.