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A SURVEY OF WATER-BASED PROPULSION SYSTEMS FOR HYBRID MISSION ARCHITECTURES

Abstract

State-of-the-art satellite missions are often inflexible and lifetime limited by the predetermined fuel reserves on-board the spacecraft. The desire for in-space refueling motivates development of both novel technologies and novel systems architectures. The ability to use resources easily storable and readily available in space will enable paradigm-shifts in space exploration. For example, in-orbit refueling near locations of interest could enable capabilities from asteroid material retrieval to multi-purpose spacecraft with open-ended possibilities. While many propulsion architectures may be amenable to refueling in some capacity, there is a particular interest in water-based propellants for this application. Water is the third most abundant molecule in our solar system and can be found in or around every planet orbiting the sun in atmospheres, surface and subsurface oceans, and in vast frozen reservoirs. The inert nature of water has also made it attractive as a propellant to the small satellite market and has driven the development of various small-scale water propulsion systems. This research summarizes the state of the art of in-space propulsion architectures which operate on water as the propellant. An ideal systems architecture for mission flexibility invokes a mixture of high thrust and high specific impulse propulsion systems which share a common propellant. High thrust maneuvering, such as that provided by chemical or monopropellant thrusters, is needed for fast re-orienting of the spacecraft. High specific impulse propulsion is ideal for station-keeping or long duration legs of a mission. In the interest of a hybrid propulsion architecture that operates using water, a survey of the field of water-based space propulsion systems is presented. The state of art of the technology and the demonstrated performance parameters are presented for a vast collection of devices. Metrics of interest are: thrust, specific impulse, input power, propulsion system mass, volume, and operational range. This research effort will result in a valuable comparative assessment of various water-based propulsion system for various applications and potential pairs of high specific impulse and high thrust systems for hybrid architectures. The develop of such a system that can operate on in-situ resources is a critical component of NASA's lunar exploration strategy, which includes an emphasis on volatile extraction to reduce reliance on Earth resources.