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Satellite Water Propulsion: 3D Printed Ceramic Thruster & Space Debris Mitigation Concept

Authors

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Abstract

The Institute of Space Systems (IRS) at the University of Stuttgart is developing an ultimate green electrolysis-based water propulsion system for satellites. One major goal is to replace the commonly used but highly toxic hydrazine. Using water instead, which is decomposed in orbit, allows a higher fuel efficiency and dramatically decreases the handling complexity and costs, enabling collision avoidance on power limited satellites of smaller institutions. The water propulsion system in development is one of the technology demonstrations on the institute's ROMEO mission, a small satellite with a planned launch date in 2025 [1]. A prototype of this propulsion system has previously been successfully built and tested at IRS [2, 3].

The main subject of this paper is the proof of concept of the newly designed 3D-printed ceramic GOX/GH2 thruster, which was previously presented during its development [4]. The vulnerability to thermal shock precluded ceramics until now as main thruster material. However, this ceramic can handle the applied thermal loads and allows higher operating temperatures than non-oxygen-sensitive metals. This enables a higher gas intermixture and therefore an increased thruster efficiency. Characterisation test results such as performance data and CT scans are presented and discussed. Since the chemical thruster needs to be fired multiple thousand times during the ROMEO mission, the catalytic ignition concept is addressed, which includes degradation and respective test results. Different operation strategies and alternative concepts are examined. Based on the discussed results of this first ceramic thruster prototype, further development steps are identified, and a possible next generation is presented.

The second subject of the paper are different orbit-raising strategies and systems design aspects exclusive for impulsive water electrolysis propulsion systems, which are assessed with respect to ROMEO's special space debris mitigation concept using the institute's WESPAT tool [5]. Since the water propulsion system technology demonstrator is going to raise the satellite to an elliptical medium earth orbit, where it would stay for decades before burning in earth's atmosphere in case of a system failure, these strategies target to minimize natural orbital lifetime at all times.

References

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