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Title

Research and test activities on sustainable space propulsion systems at TU Darmstadt

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Abstract

CubeSats, and other micro-satellites have been launched in growing numbers into orbit over the last decade. However, their growing number leads to an increased collision risk and the generation of space debris, which can threaten operational satellites and future space missions in the respective orbit. The aim to preserve the cleanliness of space has created a demand for compact propulsion systems for those satellites. These propulsion systems can ensure manoeuvrability of a satellite during the mission, but also allow to de-orbit the satellite either at the end of useful lifetime or in the case of an unexpected failure. Several alternative propulsion concepts are being developed in the space community and some of the challenges are the use of alternative, green propellants and the miniaturization of the thrusters and subsystems.

The institute of "Gas Turbines and Aerospace Propulsion" (GLR) at the Technical University of Darmstadt has started developing solutions for those challenges. Three research focus areas were defined: (1) Clean Water electrolysis propulsion system for CubeSats, using water as propellant and developing a small thruster system as a de-orbiting solution; (2) Small-scale Rotating Detonation Engine (RDE), as a compact propulsion system, theoretically offering high thrust and efficiency, thus having a significantly higher specific impulse for in-orbit propulsion; (3) Development of novel miniaturized ignition concepts, such as resonance ignition, catalytic ignition and a non-thermal plasma ignition concepts. These focus areas are inter-linked, research on miniaturized ignition systems has potential application in both CubeSat propulsion systems and small-scale RDEs. The aim of our research strategy is the development of new compact propulsion systems to address the identified challenges.

The GLR has built test infrastructure for the development and performance assessment of the above-mentioned research projects. Two main test benches offer a test platform covering a large range of propulsion systems. The PICO (Propulsion Infrastructure for CubeSat Operations) test bench operates on gaseous oxygen (O2) and hydrogen (H2) with a total mass flow of up to 0,2 g/s, allowing testing of thruster up to 1 N. The LOTUS (Liquid Oxygen Test Unit for Space) testbench has the ability to run thrusters up to 35 N, with a total mass flows up to 30 g/s. In addition to gaseous oxygen, LOTUS has a cryogenic cooling unit to run with liquid oxygen (LOX) and besides gaseous hydrogen, gaseous methane (CH4) can be used as fuel. Besides the test benches, a vacuum chamber (EVA), with a chamber volume of 0,4 m^2 and a vacuum level down to < 10 mbar is available. With the EVA chamber, the developed thruster systems and ignition concepts can be tested under vacuum conditions.

The aim of this paper is to present the research strategy and test infrastructure of the institute of "Gas Turbines and Aerospace Propulsion" at Technical University Darmstadt. First concepts and preliminary feasibility studies from our research areas will be presented.