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The SUPREME plasma thruster and the testing of its cryogenic infrastructure

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The EU EIC project Superconductor-Based Readiness Enhanced Magnetoplasmadynamic Electric Propulsion (SUPREME) aims to increase the technological readiness of applied-field magnetoplasmadynamic thrusters (AF MPDT) by demonstrating the integration of a high-temperature superconductor coil (HTSC) together with multiple other advanced technologies for a thruster in the 5 kW power range. Next to the integral HTS technology, SUPREME implements enabling sub-technologies such as an advanced power processing unit (PPU), radiatively cooled electrodes, an advanced thermal management system (TMS) and a heaterless multi-channel hollow cathode. In addition, investigations of the propellant supply unit (PSU) prepare the total propulsion system for flight under the consideration of the propellant flexibility that AF-MPDTs possess.
As part of the project, a breadboard model of the SUPREME thruster is assembled and experimental campaigns to provide a comprehensive investigation of the thruster performance will be conducted at the Institute of Space Systems (IRS) at the University of Stuttgart. We showcase the design of the test setup and highlights the integration of the HTSC in combination with its cryogenic cooling system.
In our talk we will present the overall design and focus on the cryogenic infrastructure and expected heat loads. Since the thruster uses mass, this results effectively in a mass leak for the vacuum system, which is to be dealt with by the vacuum pumps. During operation, we find that the elevated vacuum levels will reduce the insulation capabilities of the MLI radiation shielding. The tests at University of Twente are to ensure that a sufficient cooling performance of the coil is available for long-term thruster operation, as at an elevated temperature the coil can suffer thermal runaway and quench. It should be noted that the coil will run at DC during operations and thus the loads are expected to be minimal. Our test show that the (dummy) coil remains under 50K at 15 W, showing good performance under simulated excessive heat loads, both in the lab experiments as well as the numerical validation. The experimental campaign of the cryogenic cooling system paves the way for a successful integration phase at IRS Stuttgart and serves as a steppingstone towards a next-generation plasma thruster.

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