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# IMPROVED PRESSURE-VOLUME-TEMPERATURE GAUGING METHOD FOR ELECTRIC PROPULSION SYSTEMS (PVT-GAMERS): FLIGHT-MODEL EXPERIMENT FOR ZERO-G VALIDATION.

**Abstract**

Current forecasts suggest that, by 2030, at least 50% of telecommunication satellites will use electric propulsion (EP) as the only propulsion system on board. In this EP new era, the use of high-pressurized xenon tanks at supercritical stage is becoming very popular, in particular for long duration missions. The ever-increasing operations time has led to a substantial increment of the amount of propellant stored on-board, from the initial 200-350 kg to present-day masses of the order of 800-1500 kg. Despite the need to know the available propellant mass during operations, the retrieval is still challenging, and inaccurate, as no technological alternatives have been proven to satisfy with the needed requirements for long duration missions.

Recently we have proposed a new gauging method that uses TLR-9 hardware components, i.e. able to be directly implemented on current spacecraft. The method, called improved-PVT method, is based on a better understanding of the thermal properties of the stored xenon. Laboratory experiments and theoretical work demonstrated an accuracy improved by a factor 8 with respect to classical Pressure-Volume-Temperature retrievals [A. Soria-Salinas, et al., 2017]. In fact it gives an error of mass gauging of 0.1% with respect to the initial mass, at a pressure of about 70 bar (just below the critical pressure of CO2).

This method has been implemented in the PVT-GAMERS experiment, selected to fly ESA Fly Your Thesis! 2018 parabolic plight campaign. As a technology demonstrator of the integral improved-PVT method, it consists of a suit of 6 small-scaled and pressurized propellant tanks, sensed with pressure and temperature sensors, with a heating duty cycle and real time data processing. The PVT-GAMERS experiment will fly on several Airbus A310 Zero-G flights, where micro/hyper g-loads will allow to demonstrate the robustness of the method against thermal gradients, thruster ignitions, external accelerations and propellant management operations scenarios. These flights will also increase the TRL of the full system from 4 to 6.

In this work, we shall present the development, testing and ground calibration of the PVT-GAMERS experiment, including: 1) heat transfer and mechanical modelling of the experiment assembly through computational fluid dynamic (CFD) and finite element method (FEM) techniques, at in-flight configuration, for comparison analysis with laboratory data; 2) flight and emergency tests, assembly validation,

expected results and operational procedures compilation; and 3) calibration of mass retrieval algorithm applied over six scaled xenon propellant tanks at End of Life (EOL) scenario on ground conditions.