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THRUST VECTOR CONTROL FOR CONTROLLED DEORBITATION – DEVELOPMENT AND TESTING

Abstract

This paper details an overview of the development and testing of the Thrust Vector Control (TVC)

system, being a part of the deorbitation propulsion system based on a Solid Rocket Motor (SRM), developed at the Lukasiewicz Research Network – Institute of Aviation in Warsaw, Poland (L-Ilot). The main purpose of the TVC mechanism is to increase the controllability of the deorbitation system. The TVC design incorporates outside flaps working as deflectors, moved in and out of the exhaust stream of a nozzle, at the exit plane. The presence of the flap in the motor's exhaust plume produces a lateral force relative to the nozzle axis, resulting in thrust deflection. The paper presents the design process, simulations, test preparations, results with lessons learned and conclusions. The chosen concept is a variation of a Fowler mechanism, commonly used in aviation in a wing design. It benefits from the kinematics: the flap slides backward before hanging inwards. This setup allows to save the volume of the mechanism, as the geometry of the design can be circumscribed to the maximum diameter of the SRM. Moreover, in a stowed position it does not elongate the axial dimension of the motor. Also, in terms of control, the design should benefit: the variable–ratio design could be adjusted according to specific needs. The system is relatively lightweight (unlike the gimbal where the entire motor needs to be moved). Additionally, the method requires only minor changes in the SRM design – adding additional mounting features on the nozzle part (unlike movable nozzle where motor design is highly affected by incorporated TVC). The main disadvantage is the axial force (thrust of SRM) reduction (in consequence specific impulse also) required to achieve the desired vectored thrust. The thrust reduction is proportional to the deflection angle. The topic of testing: preparation and results are the most challenging parts of the project, and those are identified in the herein article. Firstly, the functional tests of the mechanism are described, and the results are compared with the simulation. Secondly, the preparation of tests in the vacuum chamber (characterized by a volume of 265m3) is described and interpreted. In conclusion, it appears that the proposed TVC system, developed by L-Ilot and its partners, can become a reliable and crucial element in the end-of-life strategy for a wide range of spacecrafts, helping the further utilization of Earth's orbit.