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AERODYNAMIC VEHICLE DESIGN, FLYING QUALITIES, AND MISSION ANALYSIS FOR A REUSABLE VTOL MICRO-LAUNCHER FIRST STAGE

Abstract

Safely landing launch vehicles back on Earth for stage reusability is a major economic and technological challenge. The European Commission's Horizon 2020 RRTB research and innovation project (Recovery and Return-To-Base European Reusable Micro-Launcher) explores radical new concepts for the Earth re-entry and landing of a Vertical Take-Off and Landing (VTOL) micro-launcher first stage, with an entry mass around 3 tons. In collaboration with Pangea Aerospace, DEIMOS Space has designed a novel aerodynamic drag device for the hypersonic and supersonic re-entry phase. It provides aerodynamic deceleration and stability, and fits within a broader Concept of Operations (CONOPS). Computational Fluid Dynamics (CFD) was used to design and characterize the drag device, and to develop an aerodynamic database (AEDB) that covers the hypersonic, supersonic, and subsonic regimes. The unique vehicle shape leads to some interesting design challenges and flow characteristics.

This paper describes the aerodynamic design, the Flying Qualities Analysis (FQA), and the Mission Analysis (MA) for the RRTB project, performed by DEIMOS Space, who are also responsible for the end-to-end GNC in the return flight. The return mission CONOPS is driven by the landing phase. The Electric-Ducted Fan (EDF) landing system, developed primarily by Pangea Aerospace, performs a controlled hover landing at a horizontal vehicle attitude within a 10x10 m area. This puts constraints on the re-entry phase, which is performed without the use of retro-propulsion. The drag device employs petals with stabilizing fins to dramatically increase the aerodynamic drag and static stability during reentry. Using the aerodynamic database DEIMOS Space has done mission simulations, including a suborbital boostback maneuver and a passive re-entry assisted by the drag device, to explore the capabilities of the current design. The results give an outlook on the opportunities and challenges for reusable micro-launchers.

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