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Title

Aerodynamic and aerothermal comparison between the CAL1C and CAL1D geometries for the CALLISTO vehicle

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Abstract

The current European long term strategy aims at moving towards reusable launch vehicles (RLV) for the first stages of launchers. To further the research into RLV relevant technologies, three partners, the German Aerospace Center (DLR), the Japan Aerospace Exploration Agency (JAXA) and the French Space Agency (CNES) are cooperating in the development of a launch vehicle demonstrator. It is a vertical take-off and vertical landing (VTVL) reusable subscale launcher first stage demonstrator - the "Cooperative Action Leading to Launcher Innovation in Stage Toss back Operations" (CALLISTO). The mission of the CALLISTO vehicle is to return to the launch pad using retro propulsion and an Approach and Landing System (ALS) [5] with extendable landing legs. This development leads to additional aerothermal design questions compared to traditional launchers. In the case of CALLISTO the highest heat fluxes are cause by heating from hot exhaust gases of the aft bay section. This especially affects the unfolded ALS during the final phase of the landing approach. The arising heat fluxes influence the structural design and the thermal protection system (TPS) of the ALS. Computational fluid dynamics (CFD) simulations are supporting the development by predicting loads. The development process of the databases for aerodynamic [4] and aerothermal [1] loads for the development geometry CAL1C have been presented, as well as different analyses to investigate the influence of angle of attack, angle of roll, atmospheric conditions, flight speed, thrust level, nozzle gimbaling and ground distance [2, 3].
Since the previous publications the design process of the Callisto vehicle has matured and a new geometric shape of the vehicle called CAL1D has been designed. In this work we analyse the differences in aerodynamic and aerothermal loads between the geometries for the configuration with deployed landing legs. The simulations are done using Reynolds averaged Navier Stokes (RANS) methods with a Spalat-Almaras turbulence model and frozen chemistry. We analyse the flow field as well as the surface distributions of pressure and heat fluxes.

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