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AERODYNAMIC STUDIES IN PREPARATION FOR CALLISTO - REUSABLE VTOL LAUNCHER FIRST STAGE DEMONSTRATOR

Abstract

Reusability applied to launchers is expected to reduce costs of access to space and an increase of the operational flexibility. With the goal to improve knowledge in this field, DLR and CNES are jointly developing a vertical take-off and landing (VTVL) reusable and subscale launcher first stage demonstrator. With this vehicle, called Callisto (Cooperative Action Leading to Launcher Innovation in Stage Toss back Operations), DLR and CNES want to acquire and demonstrate the capability to launch, land and relaunch a vehicle under conditions representative for an operational launcher first stage. Furthermore, during Callisto demonstration flights, data will be gathered to improve knowledge on the operation of reusable vehicle and therefore help optimizing reusability capabilities of future launch systems. In order to demonstrate the feasibility of the Callisto project during the system requirement review (SRR) and in preparation of the Preliminary design review (PDR), extensive aerodynamic analyses have been performed. The entire CALLISTO reference mission is complex and includes both standard and new flight phases: ascent, tilt-over manoeuvre, descent and landing. During the flight, the vehicle aerodynamic configuration, the weight and balance characteristics change significantly. The flight envelope is characterised by a large range of Mach numbers and dynamic pressure, the angle of attack changes from close to 0 during ascent to close to 180 during descent and landing. One of the most important flight phases is the controlled descent in the dense layers of the atmosphere with aerodynamic control surfaces. Therefore aerodynamic design of the vehicle and especially guarantying stability and controllability are of key importance. The use of classic engineering aero prediction methods cannot provide the necessary precision and reliability for the estimation of the aerodynamic coefficients even in very early design phase. Therefore CFD methods have to be used much earlier over design processes when compared to legacy vehicles. For instance, the simulation of the retro-propulsion plume is of particular importance, as it has a major impact onto base pressure distribution and aerothermal loads. The paper will summarize the main findings of the aerodynamic analysis and show the progress made during the Callisto project.