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WIND TUNNEL INVESTIGATIONS IN CALLISTO - REUSABLE VTVL LAUNCHER FIRST STAGE DEMONSTRATOR

Abstract

In order to make access to space more affordable for both scientific and commercial activities the German Aerospace Center (DLR), the Japanese Aerospace Exploration Agency (JAXA), and the French National Centre for Space Studies (CNES) joined in a trilateral agreement to develop and demonstrate the technologies that will be needed for future reusable launch vehicles. In the joined project CALLISTO (Cooperative Action Leading to Launcher Innovation in Stage Toss back Operations) a demonstrator for a reusable vertical take-off, vertical landing rocket is being developed and built. As long-term objective this project aims at paving the way to develop a reusable launcher first stage, and the joint efforts of the three agencies will culminate with CALLISTO demonstration flights from the Kourou Space Center in French Guyana.

The aerodynamic and aerothermal characteristics of the CALLISTO vehicle are investigated by DLR, including its challenging variety of configurations and flight envelope with high angles of attack and subsonic, transonic and supersonic flight regimes. To cross-check the CFD data and for an enhanced understanding of the vehicle aerodynamics, experiments were performed in the Trisonic Wind Tunnel (TMK) at the DLR Department of Supersonic- and Hypersonic Flow Technologies in Cologne for Mach numbers between 0.5 and 2.5. The experiments considered the ascent as well as the backwards orientated descent configurations of the vehicle with folded and deployed control surfaces at several deflection angles. The angle of attack was continuously varied for all configurations.

The measurements of force and moment coefficients demonstrated the trimmability, stability and controllability of the vehicle for the planar fins deflection angles of up to 20° for all tested Mach numbers. Furthermore, the dependency of the aerodynamic coefficients on the Mach number was analysed. Roll moment measurements showed efficient controllability of the roll angle. Investigations with oil film technique gave insight in the boundary layer separation of the body and the fins. The influence of the support sting on the measured forces and moments was assessed by a numerical analysis.

This paper describes the tested configurations, the experimental methods and main results of the test campaign. Follow-up investigations in CALLISTO project will evaluate the influence of the exhaust

plume on the aerodynamics of the vehicle.