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CFD ANALYSIS OF INTERACTION EFFECTS BETWEEN VEHICLES IN FORMATION FLIGHT FOR IN-AIR CAPTURING OF REUSABLE LAUNCHERS

Abstract

Reusing the complex, high performance, high-cost rocket stages and engines by returning them back to their launch site is becoming important not only from economical aspects but also from an ecological point of view. An innovative return mode, 'in-air capturing (IAC)', is chosen as it provides a better performance in terms of efficiency and fuel consumption compared to other technical approaches such as vertical landing. In this mode, a winged reusable launcher vehicle (RLV) which has slowed down to subsonic velocity through atmospheric braking is captured using an aircraft and towed back to launch site. First, the vehicles approach each other in a parallel formation with similar velocities by keeping a safe distance between them. During this formation, a capturing device autonomously captures the RLV. Once the capturing has been achieved, the captured configuration is pulled up from a gliding flight to cruise flight with a towing aircraft serving as an external propulsion system to the RLV. During these phases, the RLV is exposed to the wake of the towing aircraft and will face disturbances that will likely lead to a reduction in formation envelope. The impact of proximity between the ACCD and the RLV should also be evaluated to determine whether any modification or reinforcement of the structure of the towing aircraft airframe is required. Moreover, during the pull-up manoeuvre, the towing aircraft is at high incidence leading to a strong downwash velocity component that also requires further attention. In this work, a full-scale three-dimensional RANS simulation will be performed with the open source CFD code OpenFOAM 6.0 using the k-ω SST turbulence model and a compressible solver rhoSimpleFoam to investigate aforementioned issues. The wake of the towing aircraft obtained from a separate simulation is imposed at the inlet to recreate the resulting inflow velocity deficit and turbulence effects. The CFD results will be analysed to gain better insight in the flow field and interaction effects between the three vehicles and aerodynamic performance to be considered in the future work full-scale multibody simulations of the capturing phase. This paper is a part of H2020 FALCon project and continuation of the work by Singh, S. et al. (2021).

Singh, S.; Stappert, S.; Bussler, L.; Sippel, M.; Buckingham, S.; Kucukosman, C.: A Full-Scale Simulation and Analysis of Formation Flight during In-Air-Capturing, IAC-21-D2.5.2, 72nd International Astronautical Congress (IAC) Dubai, October 2021)