IAF SPACE TRANSPORTATION SOLUTIONS AND INNOVATIONS SYMPOSIUM (D2)
Technologies for Future Space Transportation Systems (5)

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A FULL-SCALE SIMULATION AND ANALYSIS OF FORMATION FLIGHT DURING IN-AIR-CAPTURING

Abstract

Over the past two decades, the commercial success of SpaceX has brought a renewed interest to Reusable Launch Vehicles (RLVs). The currently employed methods like down-range landing and return to launch site require additional fuel for deceleration and landing, hence causing a penalty on the payload capacity. An innovative idea patented by German Aerospace Center (DLR) eliminates the need of additional propulsion system by using a winged-stage which is captured mid-air, and towed back to the launch site by an aircraft. This concept named 'In-Air-Capturing (IAC)' is currently being researched under the Horizon 2020 project - Formation flight for in-Air Launcher 1st stage Capturing demonstration (FALCon). The project is aimed at further development of IAC technology, not only through analysis and simulations at full-scale level, but also through sub-scale demonstrations and testing. In this paper, a part of the study associated with the full-scale simulation of IAC will be presented.

The complete test scenario for the full-scale simulation includes a 3-Stage-To-Orbit launch vehicle (called RLVC4), which is launched vertically. At Main Engine Cut-Off, the winged first stage separates from the launch vehicle and re-enters the atmosphere. During this ballistic descent, the velocity is reduced from supersonic to a subsonic glide. In the meantime, a towing aircraft (selected to be an Airbus A340-600) loiters at about 10 km altitude until the RLV arrives. Once the RLV is in vicinity, between 8 km and 2 km altitude, the IAC process begins. The aircraft approaches the RLV to achieve a parallel glide formation. During this manoeuvre, a capturing device is released from the aircraft, which autonomously ensures mating of the two bodies. Finally, the RLV is towed back to an airstrip where it lands horizontally.

The paper would include the simulation and analysis of the formation flight required for the IAC in six degrees of freedom. This would require the participating aircraft to have similar flight characteristics, like velocity and flight path angle, separated by a safe distance. The sensitivity to initial conditions, signal transfer delays and external disturbances will be studied. Additionally, bounds in duration and range of formation flight due to aerodynamic and control surface limitations will also be presented. The end goal would be to determine the optimal conditions for IAC manoeuvre, and ensure longer formation time to allow for multiple capture attempts.