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Abstract #XXX *(to be filled by the organizers)*
Preferred Topic: REUSYS *(several papers for ReFEx are submitted – a dedicated session is sought)*
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Title

ReFEx: Reusability Flight Experiment – Trajectory Design

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Abstract

The German Aerospace Center (DLR) project ReFEx aims at flying a trajectory representative for winged reusable first stages, while demonstrating maneuverability capabilities and ensuring safety. In November 2021 the ReFEx project passed the Critical Design Review (CDR) and is undergoing final integration and testing at the Institute of Space Systems in Bremen. The dimensions of ReFEx are a length of 2.7 m and a wingspan of 1.1 m. The mass of the vehicle is around 400 kg, [1].

A central goal of the Reusability Flight Experiment is the demonstration of controlled hypersonic flight along a reentry trajectory similar to those of full-scale, winged reusable launch vehicles (RLV). Therefore, the ReFEx trajectory is oriented towards flight paths of operational and conceptual winged reentry vehicles represented in a Mach-Altitude map. Additional maneuverability requirements are imposed on the ReFEx vehicle and its GNC subsystem. The first being a demonstration of a turn resulting in a heading change of approximately 180°. Furthermore, a predefined target in terms of position and Mach number is to be reached at the end of the experiment. In order to respect all requirements and experiment constraints, reentry trajectories are designed based on iterative solution of 3 DoF equations of motion with defined profiles of angle of attack (AoA) and bank angle. An extensive aerodynamic database is used for the determination of areas within the Mach-AoA domain that allow a trimmed flight. The profile of AoA is defined respecting these trimmability areas. The results of the 3 DoF analysis represent nominal ReFEx trajectories.

In a next step they are integrated in a 6 DoF closed-loop simulation environment, to analyze the mission performance under perturbed conditions. Due to the state uncertainty at payload separation, arising from the use of an unguided rocket during the ascent phase, it is not feasible to reach the nominal target from all the separation envelope and an alternative target needs to be defined. This can also be seen as a benefit as the flight experiment is capable of an autonomous emergency divert to a secondary landing site – a feature highly desirable for future RLVs aiming for maximum safety and versatility.

After End of Experiment (EoE) the ReFEx vehicle will continue with a controlled flight down to an altitude of several hundreds of meters. Prior to touchdown, a reduction of impact energy through a flare maneuver is currently planned. Thus, an analysis of the flare maneuver and its potential to reduce vertical velocity is included in this work.

References

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