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Corresponding author: Bykerk, Tamas  
e-mail of corresponding author: [tamas.bykerk@dlr.de](mailto:tamas.bykerk@dlr.de)  
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### Title

## Preparatory CFD Studies for Subsonic Analyses of a Reusable First Stage Launcher during Landing within the RETPRO Project

### Authors

Tamas BYKERK <sup>1\*</sup>, Sebastian KARL<sup>1</sup>

*\* Corresponding author*

<sup>1</sup> DLR Göttingen, Institute for Aerodynamics and Flow Technology, Department of Spacecraft, Bunsenstr. 10, Göttingen, 37073, Germany, [tamas.bykerk@dlr.de](mailto:tamas.bykerk@dlr.de)

### Abstract

The RETPRO project (Validation of Wind Tunnel Test and CFD Techniques for Retropropulsion), as part of ESA's Future Launchers Preparatory Programme, aims at preparing the tools necessary for a reliable design and simulation of future launchers or spacecraft. A particular focus is assigned to vertical take-off and landing configurations using retro propulsion as part of their control concept for entry, descent, and landing manoeuvres. Wind tunnel tests and computational fluid dynamics are used to generate a comprehensive aerodynamic database, which is required for flight dynamics simulations, enabling mission and performance analyses of possible future launcher designs. Two successful campaigns analyzing the hypersonic re-entry burn phase of flight as well as the supersonic glide phase have been completed in the H2K and TMK facilities at DLR Cologne [1-3].

The final phase of the RETPRO project looks to perform aerothermal tests by combusting H<sub>2</sub>/O<sub>2</sub> during a retro burn in the subsonic VMK test section, simulating the landing environment. As was completed for the previous test campaigns, CFD reconstructions of selected tests are performed to evaluate the ability of RANS simulations to match the plume structure and flowfield, as well as surface pressure and heat flux measurements taken during the campaign. This paper will be primarily concerned with the CFD sensitivity studies conducted to determine the dependence of plume structure and surface measurements on factors such as grid density, combustion chamber conditions, wall temperature and turbulence model. Where possible, results from wind tunnel tests will be used to evaluate the combination of settings which best represent the experiments.

### References

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