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Title
Aerothermal analysis of the RETALT2 SSTO vehicle

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Abstract
The European space strategy aims at maintaining autonomous, reliable and cost-effective access to space. Reusability represents a possible approach for reducing costs and improving flexibility of European launch systems.
In this framework, the Retro Propulsion Assisted Landing Technologies (RETALT) project, funded by the European Union Horizon 2020 program (grant agreement No 821890) and concluded in the last trimester of 2022, had as objective to study critical technologies for Vertical Take-off Vertical Landing (VTVL) Reusable Launch Vehicles (RLVs) applying retro propulsion combined with Aerodynamic Control Surfaces (ACS) [1]. Two reference launch vehicle configurations, namely RETALT1 and RETALT2, were defined.

- RETALT1: A heavy lift Two Stage To Orbit (TSTO) RLV with a payload of up to 14 t into the Geo Transfer Orbit (GTO). The general layout of the RETALT1 configuration is similar to the SpaceX rocket "Falcon 9".
- RETALT2: A smaller Single Stage To Orbit (SSTO) configuration capable to deliver 500 kg into Low Earth Orbits (LEO). Despite the similarity to the McDonnell Douglas rocket "DC-X", RETALT2 is supposed to rely, as well as RETALT1, on European technologies only.

Since the RETALT2 concept is more novel, its applicability is to be seen more academically compared to RETALT1.
The return and the landing of the vehicle are performed by exploiting retro propulsion and the novel aerodynamic control surfaces together with aerodynamic breaking due to its capsule-like shape (e.g. like Soyuz, ExoMars, Hayabusa). The shaping results in a reduction of additional propellant for the descent phase and enables the use of the broad knowledge in atmospheric entry technologies existing in DLR.

Because of this specific re-entry mission profile, the Thermal Protection System (TPS) represents the most crucial design element for this configuration. The assessment of thermal loads exerting on the vehicle surface is of paramount importance for TPS sizing.
A fast-response surrogate model for the aero-thermodynamic heating, called Aero-Thermal DataBase (ATDB), has been developed and successfully applied in the framework of RETALT project for predicting the heat flux on each point of the RETALT1 launch vehicle surface as function of flight time and local surface temperature [2,3].

This paper describes the creation of Aero-Thermal DataBases for the RETALT2 launch vehicle configuration. An ATDB has been generated for the ascent trajectory and another one for the re-entry flight.
Furthermore, representative results, obtained from CFD simulations performed for the ATDBs creation, are shown with the aim of discussing typical flow field structures observed during the RETALT2 ascent and entry trajectories and

resulting heat pattern on the rocket surface. In fact, the aero-thermodynamic heating is affected by plume spreading, plume to plume interactions, hot exhausted gases which surrounds the vehicle during the propelled phases and aerodynamic forces.

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