Student Research Project / Master Thesis
Drag Control of Reentering First Stages using Thrust Vector Actuators

Thrust vector control systems are an essential component of any actively controllable launch vehicle system. In the case of liquid rocket engines, these usually consist of two linearly adjustable actuators and a gimbal on which the engine is mounted so that it can rotate about two axes. In the case of engine clusters, the challenge in the design of thrust vector control is not only the fast and precise deflection of the engines, but also the interaction of the engines.

During the reentry of reusable first stages, the engines usually point in the direction of flight. The direct inflow from the concave bell nozzles results in high aerodynamic drag, which contributes to the deceleration of the first stage. With the aid of thrust vector control, the bell nozzles can be additionally deflected, which means that the drag can be actively varied. This has a direct influence on the g-loads acting on the first stage during reentry. Targeted control of the engine cluster deflection can thus result in a reduction in the support structures required and thus in mass savings at the first stage. For this reason, the effect of thrust vector controls on the reentry of first stages and the potential mass savings will be investigated in more detail in this thesis.

The work is divided into the following steps:

1. Literature research on reusable launchers, launcher structures, thrust vector controls, engine clusters, flight simulations and CFD
2. Definition of a reentry scenario with the corresponding inflow conditions as well as a reference launch vehicle with the corresponding engine positions
3. CAD modeling of the reference launch vehicle and engine positions
4. Identification of the aerodynamic braking effect of the cluster settings by means of CFD
5. Implementation and testing of the aerodynamic braking effect in a predefined flight simulation environment in Matlab/Simulink
6. Critical analysis of the effects on the launch system and presentation of further potential for optimization

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Execution only after consultation of supervising university institute