Student Research Project / Master Thesis

Impact of Grid Fins on the Launch of Air Launch Systems

When launching reusable air launch systems, various aerodynamic effects can be utilized that cannot be used with vertical-launch rockets due to the launch direction and design. One of these effects is the lift of deployed grid fins. Depending on the angle of attack and deflection of the grid fins, the ascent of the launcher can be positively supported and thus contribute to additional payload capacity of the launch vehicle. This can also be accompanied by a targeted adjustment of the target trajectory and flight maneuvers in order to make the best possible use of the positive effect.

However, since grid fins are primarily used to stabilize the launcher during re-entry, they have a destabilizing effect when deployed due to their positioning in front of the centre of gravity during ascent. Accordingly, the flight control of the grid fins and thrust vector control must be designed in such a way that a potentially unstable flight system is actively stabilized while ensuring the most efficient ascent possible. Against this background, the deflection of the grid fins must be continuously adjusted during the ascent. For this reason, the effects of a consistently ideal grid fin deflection on the flight path and the maximum payload capacity during ascent are to be investigated in more detail in this thesis.

The work is divided into the following steps:

1. Literature research on the aerodynamics of rockets and grid fins, flight control and thrust vector control of rockets, particle filters as well as flight simulations
2. Definition of a reference launcher and its grid fins as well as a method for generating target trajectories
3. Definition of a flight control concept based on the grid fins and thrust vector control
4. Implementation and testing of the flight controller concept in a predefined flight simulation environment in Matlab/Simulink
5. Execution of a trajectory optimization by a particle filter to maximize the payload capacity
6. Critical analysis of the aerodynamic effects of the grid fins, the optimized trajectory and payload capacity as well as presentation of the optimization potential of the grid fin control

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Execution only after consultation of supervising university institute