Master Thesis

Impact of Grid Fin Failures on the Re-Entry of Reusable Launchers

GAIA Aerospace is currently investigating the re-entry of a reusable air launch system. During re-entry of the first stage, the grid fin actuators may fail or individual grid fins may fail to deploy. Depending on the time of the failure and the positioning of the respective grid fin on the first stage, the flight control must be adjusted. The changed lift and drag conditions of a misaligned grid fin also require an immediate adjustment of the target trajectory.

The first stage should be able to fly precisely to a recovery point in order to ensure the shortest possible recovery by helicopter or recovery vessel. However, due to the reduced control characteristics in the event of a grid fin failure, the operational radius of the first stage on re-entry is also reduced in addition to the stabilization characteristics. Thus, both a loss of control and an operating radius that is too small can jeopardize the reusability of the system. For this reason, this thesis aims to develop a control concept for an optimal trajectory and stable flight characteristics, taking into account various failure scenarios of the grid fin actuators.

For this purpose, the work is divided into the following steps:

1. Literature research on reusable launchers, grid fins, electromechanical actuators, artificial neural networks, particle filters and flight control of rockets
2. Definition of failure scenarios, an approach for the automated generation of target trajectories during the flight and an adaptive flight control concept for the grid fins of the degraded system
3. Implementation of the failure scenarios, the target trajectory generator and the flight control in a predefined flight simulation in a Matlab/Simulink environment
4. Implementation of a particle filter to identify the ideal flight path and subsequent training of an artificial neural network for failure correction
5. Critical analysis of the correction measure and the effects of failure on the trajectory and flight stability
6. Summary of the results and presentation of further optimization potential

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Execution only after consultation of supervising university institute