Student Research Project / Master Thesis

Design of a Fail-Safe Flight Control for Reaction Control Systems of Reusable Nanolauncher First Stages

GAIA Aerospace is currently investigating the reusability of nanolauncher first stages. Various maneuvers on the part of an integrated reaction control system are required to ensure reusability. On the one hand, a flip maneuver of the first stage is to be performed after stage separation so that the engines are aligned for re-entry in the direction of flight. Furthermore, the alignment of the first stage must be stabilized both during stage separation and for re-entry.

In order to meet these requirements, the reaction control system of the nanolauncher must have fail-safe control around all three rotational degrees of freedom. In the event of a thruster valve failure, it must guarantee an alternate law similar to civil aviation, which enables precise guidance and stable alignment of the first stage despite lower performance. However, couplings between the individual axes of rotation and differences in performance in opposite directions of rotation present a major challenge.

For this reason, a reaction control system with a corresponding flight control logic is to be designed and tested in a flight simulation as part of this work.

The work is divided into the following steps:

1. Literature research on reusable rockets, reaction control systems, flight control, quaternions, pulse width modulation and reliability of aircraft and spacecraft
2. Identification and definition of requirements for the flight control and control logic of the reaction control system in the event of a failure and definition of failure scenarios
3. Design of the flight control and control logic of the reaction control system to meet the requirements for corresponding failures
4. Implementation of the flight controller concept in a Matlab/Simulink environment
5. Testing and optimization of the flight control system in a flight simulation based on the previously defined failure scenarios
6. Critical analysis of the controller concept and presentation of further optimization potential

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Execution only after consultation of supervising university institute