Student Research Project / Master Thesis

Impact of Quaternion-Based Flight Controllers on the Precision of Reusable Air Launch Systems

GAIA Aerospace is currently investigating the reusability of air launch systems. To ensure reusability, the precision and robustness of attitude control during the entire flight is of crucial importance. Simple measurement inaccuracies of the inertial measurement unit and the satellite navigation system in combination with a control system that is prone to deviations can result in deviations from the actual recovery point of several kilometers upon re-entry and thus stand in the way of reuse.

One way to improve the precision of flight control is to implement a quaternion controller. Quaternion controllers have the advantage over Euler angle controllers that they have no singularities at the poles of the earth and in vertical flight, which make precise flight control impossible. The closer the system is to a singularity, the more error-prone the flight attitude determination becomes.

For this reason, the effect of quaternion controllers compared to Euler angle controllers on the precision and performance of reusable air launch systems will be investigated in more detail in this thesis.

The work is divided into the following steps:

1. Literature research on reusable rockets, thrust vector control, control technology, quaternions, navigation systems and flight simulations
2. Identification and definition of flight control requirements
3. Design of two flight control systems based on quaternions and Euler angles for the entire flight path in line with requirements
4. Implementation of the flight controllers and a navigation system model in a Matlab/Simulink environment and execution of flight simulations
5. Testing and comparing of the two flight controls in terms of precision and robustness
6. Critical analysis of the controller concepts and presentation of further optimization potential

Contact: **Kai Höfner, M.Sc.**
Tel. +49 (0)162 / 656-8462, E-Mail: kai.hoefner@gaia-aerospace.com
Execution only after consultation of supervising university institute