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Bachelor / Master Thesis Announcement

Satellite design considerations for differential lift and drag control methods

Using several small, unconnected, co-orbiting satellites rather than a single monolithic satellite has many advantages. However, due to their tight volume and mass constrains other solutions than using chemical and/or electric thrusters to withstand given natural perturbations and/or to perform reconfiguration maneuvers are of highest interest. In VLEO, atmospheric forces are a possible solution for propellant-less relative motion control.

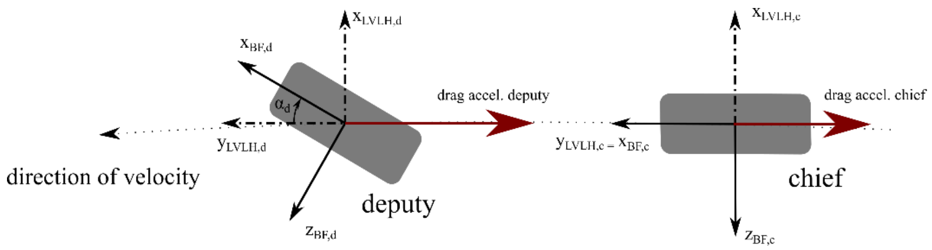

Figure 1: Exemplary visualization of a negative differential drag configuration.

At the Institute of Space Systems (IRS), this methodology is actively researched since 2018. A major goal is to design realistic and optimal maneuver trajectories for differential drag and lift controlled satellite formations. For an trajectory to be optimal, a defined cost functional J (e.g. the maneuver time, the respective oscillations (in case a smooth trajectory is desired) or the resulting orbital decay during the maneuver) has to be minimized.

Recent analysis revealed that the minimum decay during a differential drag controlled maneuver can be reduced by increasing the ballistic coefficients of the satellites (i.e. the satellite mass). However, whereas this is a simple but effective solution for differential drag controlled spacecraft, things change if additionally differential lift is considered. Thus, the research question to be answered within this thesis is how can satellites be designed especially for differential lift and drag applications? The goal is to derive satellite design recommendations with respect to their dedicated maneuver goal such as e.g. being time optimal, minimizing the orbital decay values or to achieve a best-possible trade-off between both extrema. To do so, analytic gas-surface interaction models as well as the particle code ‘PICLas’ can be used. A successful implementation of the task would represent a first step towards including the satellite design in the optimization process. This would allow to not only optimize the individual maneuver trajectory itself but the combination of the satellite design and maneuver trajectory and thus represent a more holistic approach.

Task description of the Bachelor / Master thesis work:

- Familiarization with the methodology of differential lift and drag;
- Familiarization with gas-surface interactions and satellite aerodynamics;
- Optimizing satellite shapes for dedicated maneuver goals;
- Critical assessment of the results and documentation.

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