Fine attitude and orbit optimal control system - WP 1.2.4

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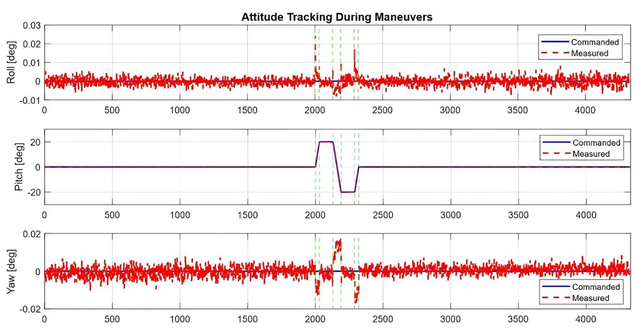
INTRODUCTION – WP OBJECTIVES

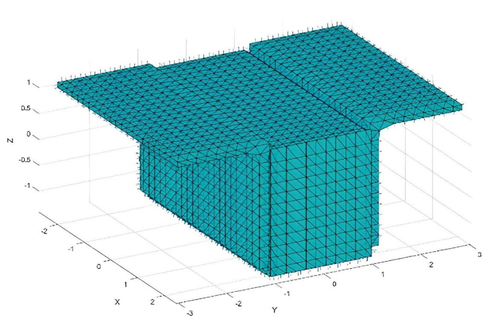
Current activities address the development of advanced models and algorithms for orbital and attitude control of LEO and VLEO satellites. A high-fidelity 6-DOF MATLAB/Simulink simulation framework has been implemented to model coupled orbital and attitude dynamics in the ECI frame, including major environmental disturbances. The simulator integrates orbital guidance and attitude control modules and supports feasibility analyses and control strategy design for VLEO missions and constellations.

Enabling technologies under development include a payload motion compensation system based on image-in-the-loop control of the focal plane using piezoelectric actuators, advanced attitude control algorithms such as adaptive Sliding Mode control, aerodynamic characterization for attitude stabilization, and the development of fine and coarse sun sensors based on COTS components with onboard data acquisition.

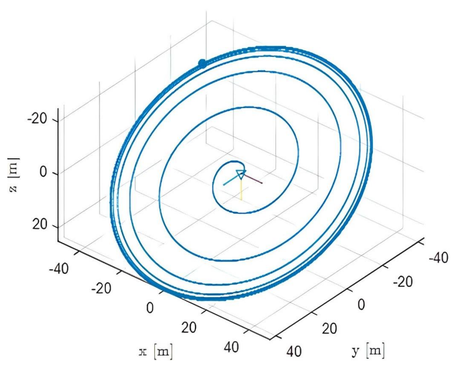
ADVANCED GUIDANCE AND CONTROL STRATEGIES

A 16U CubeSat platform is used to validate advanced Guidance and Control strategies under realistic inertia and disturbance conditions, with a focus on robust attitude and relative motion control. An adaptive geometric SMC (AGSMC) is developed for three-axis attitude tracking, demonstrating accurate performance during manoeuvring phases while aiming to robustness against modelling uncertainties.



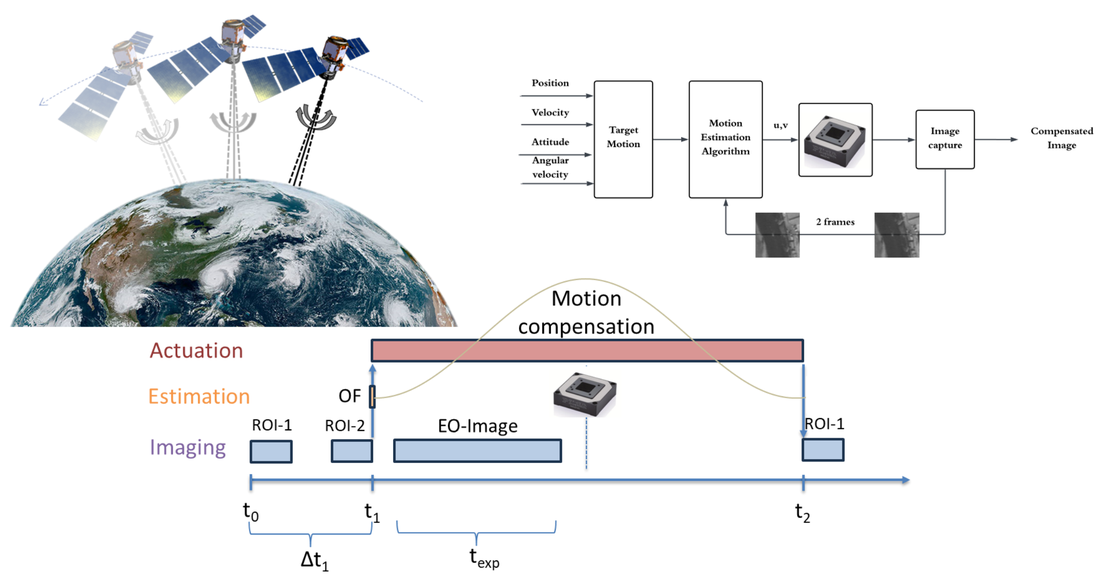


Formation flying capabilities are investigated through circular relative motion tracking and control within, enabling repeatable and bounded relative trajectories relevant to distributed space missions.



FORWARD-MOTION COMPENSATION FOR VLEO

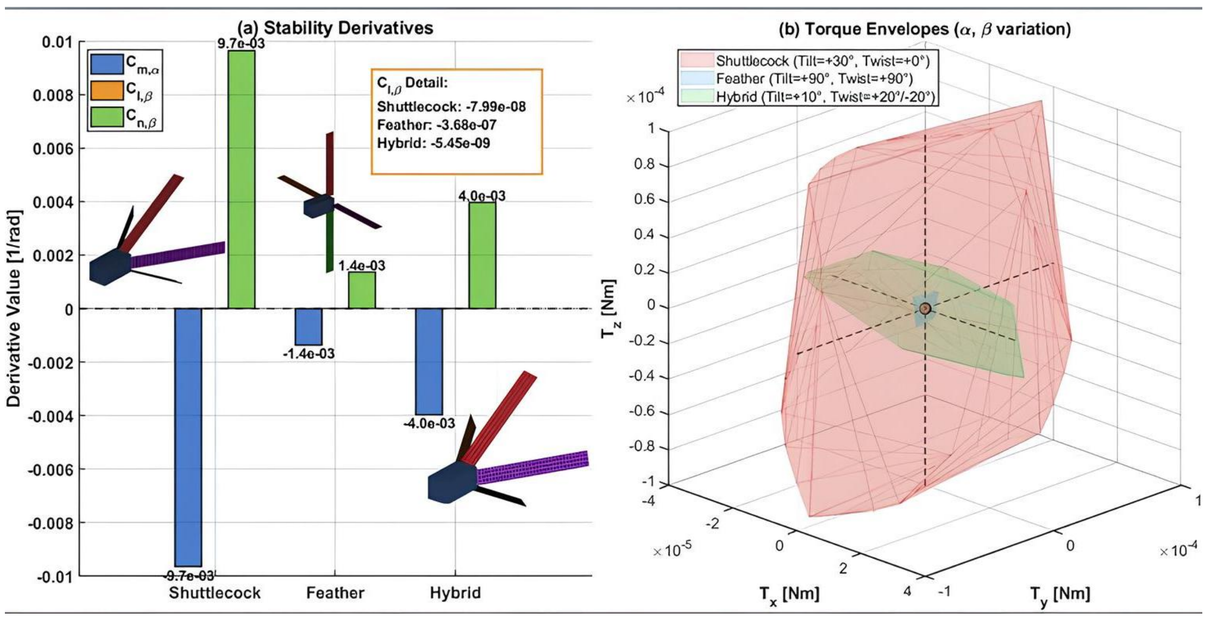
A forward-motion compensation system for VLEO EO payloads is under investigation, using image-in-the-loop control of the imaging sensor position via piezoelectric actuators. A MATLAB/Simulink simulation environment was developed to estimate the maximum blur-free exposure time enabled by the concept. Simulations use synthetic imagery for image-in-the-loop motion estimation, with optical flow computed from ROI image pairs; performance is measured by the integration interval during which residual scene motion stays within one pixel. Results show an average >10× increase in exposure time compared to the uncompensated baseline for nadir-pointing s/c travelling on a 250km altitude VLEO.



HYBRID AERODYNAMIC FIN CONFIGURATION FOR VLEO

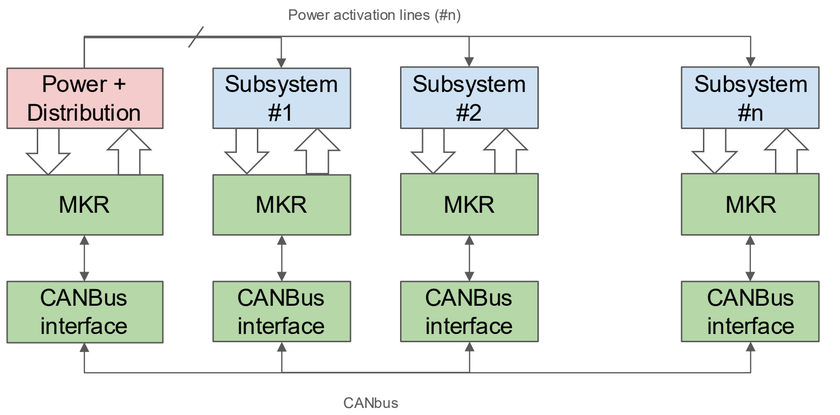
The work proposes an hybrid tilt–twist fin configuration for CubeSats in VLEO, combining passive aerodynamic stability with enhanced control authority. A parametric free-molecular aerodynamic analysis is conducted to evaluate forces, torques, and stability characteristics.

Results show a favourable compromise between low drag and effective attitude control compared to classical fin architectures.



DISTRIBUTED CAN-BASED AND SUN SENSORS SUB-SYSTEM

Modular system with distributed architecture, based on small reconfigurable microprocessor modules, connected on a CANBus serial bus, for acquisition processes, "housekeeping", control and power distribution.



Twelve photoresistor sensors (six couples) are used to measure the angle orientation of a space platform with respect to the sun.

They operate in pairs arranged along radial axes on a circular support (the cylindrical support is for demonstration purposes only). The data is processed by a processor (based on MKR) that provides a measurement of the sun's azimuthal position (over 360 degrees) relative to a fixed reference system with the probe. The data is shared via a CAN Bus.

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