Chair of Spacecraft Systems
TUM School of Engineering and Design
Technical University of Munich

Bachelor Thesis

Simulation Model and Hardware-in-the-Loop Verification of the EventSat ADCS

Start date: October 2026

Duration: 6 months

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Supervisor: Alessandro Golkar

Topic — Simulation Model and Hardware-in-the-Loop Verification of the EventSat ADCS

EventSat is a 6U CubeSat under development at the Chair of Spacecraft Systems, targeting a Sun-synchronous orbit at 450 km altitude and operating in five defined attitude modes Detumbling, Safe, Idle, Observation and Communication. Attitude determination and control is provided by CubeSpace. This implements a baseline EventSat model in D2S2, the simulation framework used at the chair, capturing the spacecraft's physical properties, communication capabilities, power modes and ADCS modes, so that the model can serve as the common starting point that subsequent EventSat simulation studies inherit rather than re-create. The baseline is then exercised against the CubeADCS hardware in a hardware-in-the-loop (HIL) configuration and used to answer two open ADCS design questions: how reaction-wheel momentum accumulates and when saturation is reached, and how much energy storage detumbling requires.

Research Objectives

Overall Objective: The overall objective is to implement a baseline simulation model of EventSat in D2S2, verify it against the CubeADCS flight hardware in a hardware-in-the-loop setup, and use the validated baseline to quantify reaction-wheel momentum build-up and desaturation strategy, and the energy storage required for detumbling.

On the engineering side, the objective is a reusable and parameterised EventSat baseline (mass properties, orbit, communication capabilities, power modes and the five ADCS modes) that is validated against hardware rather than assumed. On the analysis side, the objective is a momentum model of the reaction wheels under the EventSat mode profile, yielding the time to saturation per mode, a magnetorquer-based desaturation law with its duty cycle and power cost, an assessment of whether magnetorquers and wheels should be operated continuously in combination to delay saturation, and a worst-case detumbling energy budget derived from the deployer tip-off rate.

Goal type: implementation and validation, followed by an analysis component built on the validated baseline.

Success Criteria: Success is measured by four outcomes: (i) a running D2S2 EventSat baseline that reproduces all five ADCS modes and the associated power modes, with every input parameter documented in a released parameter spreadsheet; (ii) a HIL run in which the CubeADCS responds to OBC commands under simulated dynamics, together with a documented answer on whether the CubeComputer remains reachable through the OBC while the HIL loop is running; (iii) a predicted time-to-saturation and desaturation duty cycle consistent with the magnetic moment and the momentum storage capacity; and (iv) a detumbling energy figure with stated margin, traceable to the EventSat power budget.

Project Tasks and Timeline

Month 1: Literature Review, Parameter Baseline & Environment Setup

- Review literature on ADCS simulation, including dynamics modelling and control: PID, B-dot, and magnetic momentum desaturation; review the D2S2 framework, the CubeSpace documentation suite (ICD, Product Description, User Manual) and the internal EventSat ADCS documentation.
- Consolidate the EventSat baseline parameters: mass and inertia properties, orbit, communication capabilities, power modes and ADCS modes, recording the source of each value.
- Set up the D2S2 development environment and the CubeADCS ground support setup (CubeSupport application and CubeSupport PCB).

Deliverables: literature summary; an Excel workbook summarizing all parameters used in the baseline, with source and confidence level for each; a working development and ground-support environment.

Month 1-2: Model Implementation in D2S2

Deliverables: baseline EventSat model implemented in D2S2 — physical properties, communication capabilities, power modes and the five ADCS modes (Detumbling, Safe, Idle, Observation, Communication) — cross-checked against the parameter workbook, structured for reuse by other EventSat simulations, and documented in GitLab. Implementation of the TT&C and Power capabilities for the downlink and uplink capabilities and power budget variation.

Month 3 : Hardware-in-the-Loop Integration & Testing

- Define the HIL architecture and the interface path between D2S2 and the CubeADCS through the OBC (CAN, UART, I²C or RS485), including timing and data-rate constraints.
- Execute HIL test cases per ADCS mode and compare the results against the software-only baseline.

- Determine whether the CubeComputer can be commanded and interrogated through the OBC while the HIL simulation is running, and document the resulting operational constraints.

Deliverables: HIL test plan and executed test report; documented answer on OBC-to-CubeComputer interaction during HIL operation; a discrepancy list between simulated and hardware behaviour, with proposed model corrections.

Month 4: Momentum, Desaturation & Detumbling Analysis

- Model reaction-wheel momentum accumulation over the mission mode profile and estimate the time to saturation for each mode.
- Define and evaluate the desaturation strategy: magnetorquer-only unloading triggered at a momentum threshold versus continuous combined wheel and magnetorquer operation, including duty cycle and power cost.
- Derive the energy storage required to detumble from the expected deployer tip-off rate, with margin, and compare it against the EventSat power budget.

Deliverables: momentum and saturation analysis with plots; a recommended desaturation control mode and duty cycle; a detumbling energy budget; final thesis and results presentation.

Month 5: Sensitivity analysis of the results + Thesis writing

- Vary the most uncertain inputs to verify how the performance change
- Extract Engineering insight on the next steps and suggest potential improvements in the location on the position of actuators and sensors.
- Thesis Writing

Month 6: Finalize results and thesis writing

- Finalize Thesis writing

Expectations

• Conduct independent and systematic engineering work as part of the EventSat ADCS team
• Critically analyse implementation methodology and results, and document all assumptions together with their sources
• Maintain regular communication with the supervisory team and the ADCS team, and regular presence at the chair. Participate to EventSat Group meeting.
• Version and document all code, models and parameter data in GitLab

Advisor

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