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

Interdisciplinary Project

Start date: As soon as possible

Topic: *Evaluating Mission Control Softwares*

The EventSat mission is a 6U CubeSat technology demonstration mission sponsored by the Chair of Spacecraft Systems to apply event cameras to detect stars and other space objects. Event cameras are a specialized type of camera that use changes in brightness on a pixel-by-pixel level to detect motion in view. Building upon existing work, which has demonstrated the effectiveness of these cameras on ground in conjunction with telescopes, our mission seeks to demonstrate the effectiveness of this class of camera for space-based observation.

In complement to the satellite's development, a mission control center for satellite operation is being developed. This mission control center serves as an interface to the ground station and will be used to monitor and command the satellite. One vital element of the mission control center is its associated software. Mission Control System (MCS) is a software stack that interfaces with the Ground Station, sends and receives data packages to a satellite (or multiple satellite) and allows further data analysis. This project will evaluate several Open Source MCS packages, e.g. YAMCS (Yet Another Mission Control Software) and adapt one of them for use in the Chairs mission control center.

Goals

- **Evaluation of Alternatives:** Assess which Open Source MCS frameworks exist and select the most appropriate framework for a prototype development
- **Demonstrator Development:** Develop a demonstration MCS for the EventSat Mission that can be extended into a full prototype.
- **Testing:** Test the most important functions of an MCS using dummy components and/or EventSat flight hardware.

Accompanying Modules

The Modules that accompany this IDP can be chosen by the student(s) within the following selection, based on the focus direction they want to take the project:

- Systems Engineering – Fundamentals: Focus on gathering stakeholder needs, requirements from those needs and applying various systems engineering methods to the system under design
- Introduction to Spaceflight: Broad overview of all knowledge related to the physics of spaceflight (Orbits and Attitude), space engineering (Power, Communications, systems engineering) and space as an area of human activity (e.g. Space economy and economic actors)
- Space Mission Design: In-Depth application of approaches learned during the student's studies so far on a design study of a space mission based on fixed input parameters.

All modules have 5 ECTS and 4 SWS teaching (Lecture + Exercise)

Tasks

- Compile a set of high-level requirements for an EventSat MCS
- Research which Open Source MCS frameworks exist and select a framework for development into an MCS demonstrator
- Develop the core modules of an MCS, including framing/deframing, package handling, connecting to a remote ground station and reading of Telemetry and preparation of Telecommands
- Test the functions of the MCS using dummy components (Software and Hardware) and/or real EventSat Flight Hardware
- Document all procedures and troubleshooting steps for future team members.

Documentation and Presentation:

- Prepare detailed user documentation (e.g., Wiki pages, GitLab repositories, LaTeX documents)
- Write an accompanying in LaTeX or Word that details the approach and
- Develop a presentation summarizing the results

Requirements

- Familiarity with deployment and configuration of server software in container environments (e.g., Docker, Docker Compose, Kubernetes)
- Familiarity in working with version control tools (Gitlab)
- Basic understanding of network protocols and distributed systems (e.g., client-server communication, REST APIs, WebSockets)
- Familiarity with scripting or programming for system integration (e.g., Python, Bash)
- Basic knowledge of telemetry and telecommand concepts in satellite or ground segment operations
- Basic knowledge of Java

Helpful and appreciated are also:

- Familiarity with ground segment and mission control concepts (e.g., data flows, operations monitoring, anomaly handling)
- Knowledge of database systems and their use in storing telemetry data
- Experience with GUI/dashboard development for data visualization (e.g., Grafana, Python frameworks)
- Understanding of information security principles (e.g., authentication, encryption, access control)
- Familiarity with CubeSat operations or space mission lifecycle is an asset
- Experience with hardware-in-the-loop setups or simulated data sources is beneficial
- Note: This project is subject to export control regulations

Expected results:

- A comprehensive and user-friendly functional test set-up for satellite hardware, including modular Python scripts and an optional GUI
- A comprehensive semester thesis in double-column paper format
- Well-documented code maintained on a GitLab repository
- A brief presentation outlining the project results

Supervisor

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