



Software Infrastructure for ADCS on CubeSats

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Abstract

This report summarizes the design of Attitude Determination and Control Systems (ADCS) software for a CubeSat. This ADCS software model is split into three modules: (1) a library that handles calculations and data interpretation, (2) a manager daemon that handles how ADCS data is sent and received, and (3) an interface with 42, a spacecraft visualization software.

Background

The Oregon Small Satellite Project's objective is to build and launch Oregon's first satellite, dubbed **OreSat**. The project is managed and hosted by the Portland State Aerospace Society (PSAS) at Portland State University.

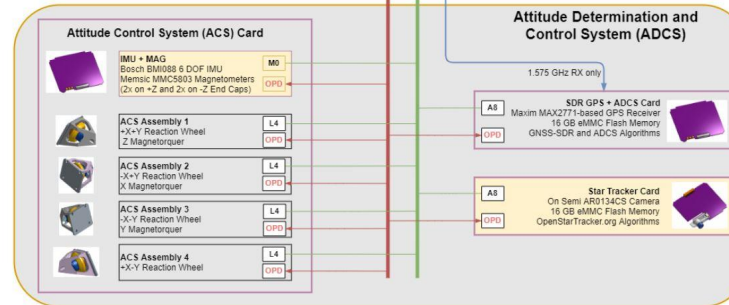
OreSat will carry two payloads: OreSat Live, which will provide a live stream of Oregon from orbit, and a cirrus flux camera. Both of these payloads require adjustments in OreSat's attitude, which are handled by an Attitude Determination and Control System (ADCS). The objective of OreSat's ADCS software, the focus of this report, is to handle data flow between ADCS instruments.

Materials

This software was developed on Linux Ubuntu 20.04 running on Oracle VirtualBox 6.1. Visual Studio Code and occasionally Vim were used for writing source code. Version control was managed by both Git bash and GitHub. All source code was written in Python.

Design and Implementation

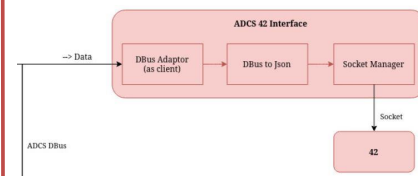
The ADCS software package's job is to move data to and from satellite instruments on the ACS card and processes on the ADCS card, as seen here:



ADCS's software is split into three components: the ADCS library, ADCS manager, and ADCS-42 interface.

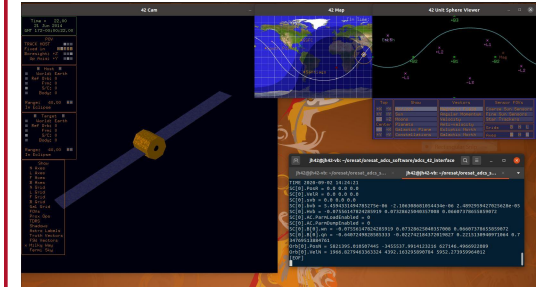
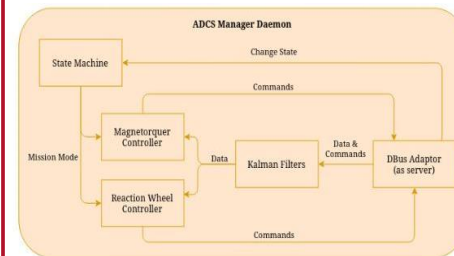
ADCS Library – Contains modules that calculate satellite properties that are used elsewhere on the ADCS board. The library converts mission data, sensor data, and OreSat's current state into commands that are passed to the magnetorquers and reaction wheels. The library also has a simulator that propagates these commands and outputs several vectors that describe the satellite's state afterward.

ADCS-42 Interface – 42 is an open-source spacecraft attitude simulator and visualization software. This interface receives state data from the ADCS D-Bus, formats it, and sends it to a daemon running 42 via a socket:



ADCS Manager – Handles data flow on the ADCS board via a daemon. The manager hosts a D-Bus server that fetches local board data and asynchronously fires data signals that can be retrieved by other processes on the ADCS board.

Below is a block diagram of the ADCS library and manager. The state machine, controllers, and Kalman filters all constitute the library. Ultimately, all output from the manager daemon comes from its D-Bus.



An example of 42. The terminal shows the state vectors used in the visualization on the left.

Results and Possible Future Work

This software package is currently being tested as a Debian package on the ADCS-dev board. The Python source code runs as intended, but the packaging itself is still being debugged.

Furthermore, the ADCS library is still being finalized, so the manager and 42 interface may need to be updated to accommodate these changes.

Acknowledgements

The following people were critical to the success of this project:

- Cory Gillette** – Designed and wrote the ADCS library.
- Ryan Medick** – Helped write the ADCS manager.
- Dr. Haim Baruh** – Funded this research and guided me in searching for research opportunities.
- Andrew Greenberg** – Served as my research advisor and introduced me to PSAS and OreSat.

Relevant Repositories

Oregon Small Satellite Project: <https://github.com/oresat>
OreSat ADCS Software: <https://github.com/oresat/oresat-adcs-software>
42: <https://github.com/ericstoneking/42>



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