VECTOR: A 3U CubeSat for Educational and Algorithmic Development in Space-Based Optical Imaging

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Abstract

VECTOR is a 3U CubeSat designed as an educational platform and on-orbit search and control laboratory for multi-messenger astronomy developed primarily by undergraduate students. Its design invites broad participation, allowing students and the public to engage with and contribute to the mission through algorithm development and testing, building on the success of the ESA's OPS-SAT. VECTOR combines optical astronomy with a modular in-house developed bus architecture, serving as an accessible in-space testbed and transient event observer.

Mission Objectives

Primary Mission: Algorithm Testbed
- Real-time testing of pointing/navigation and imaging algorithms in space.
- Simulates observatory configurations for algorithm development and optimization (e.g., imaging while slewing).

Secondary Mission: Transient Detection
- Detects optical counterparts of transient events (e.g., GRBs, FRBs) using NASA's GCN/IPN notifications.
- High control authority enables rapid response imaging for multi-messenger astronomy.

Tertiary Mission: Modular Bus Design
- Demonstrates a new configurable, high-performance (low SWaP) 3U bus
- Enables future modular astronomy and geospatial CubeSat missions.

Educational Imapct

This mission includes STEM outreach through a guest investigator program for interested public algorithm submissions, along with a possible integration into the ESE curriculum as a platform for senior design and ESE 488: Signals and Imaging Lab projects.
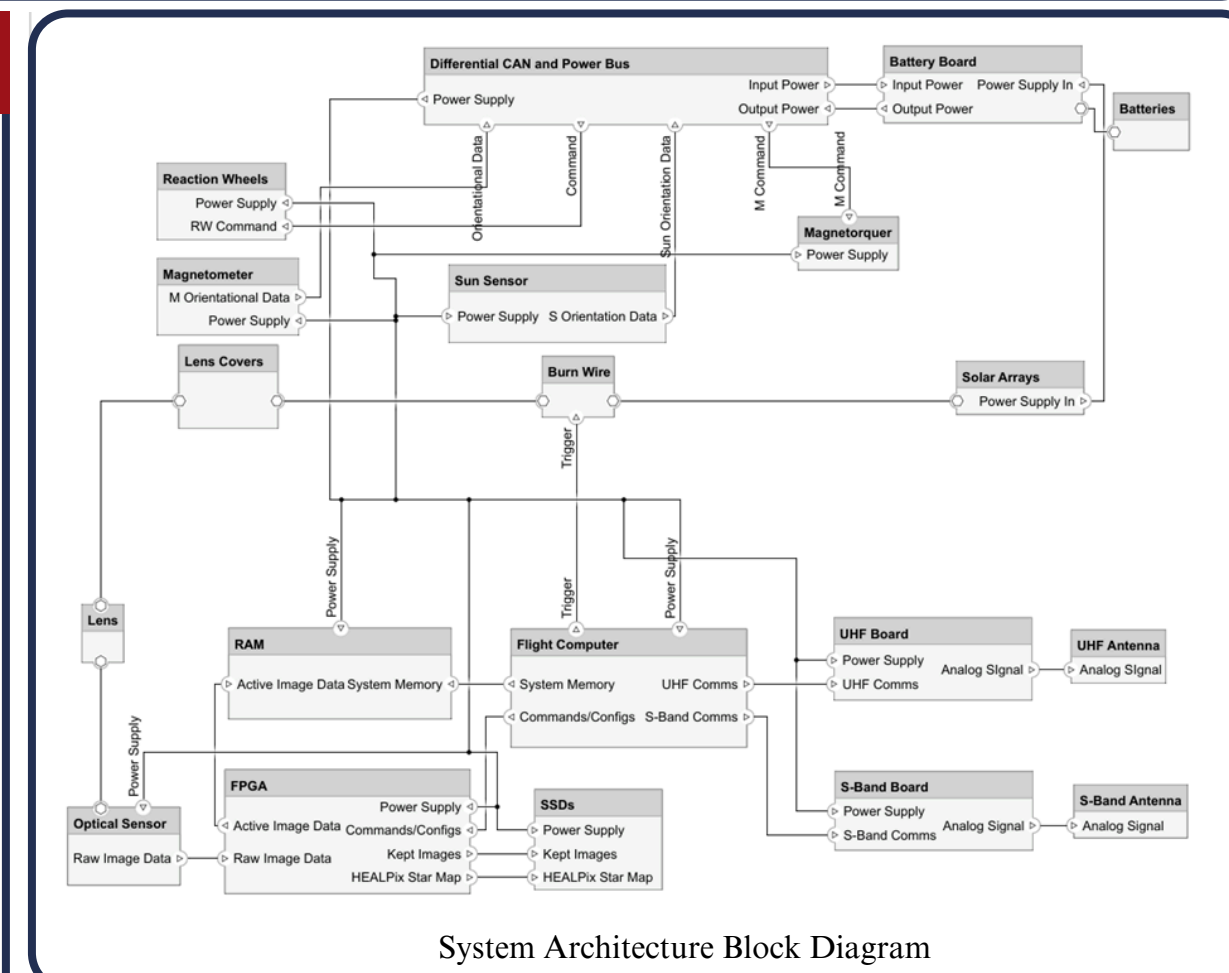
Payload Systems
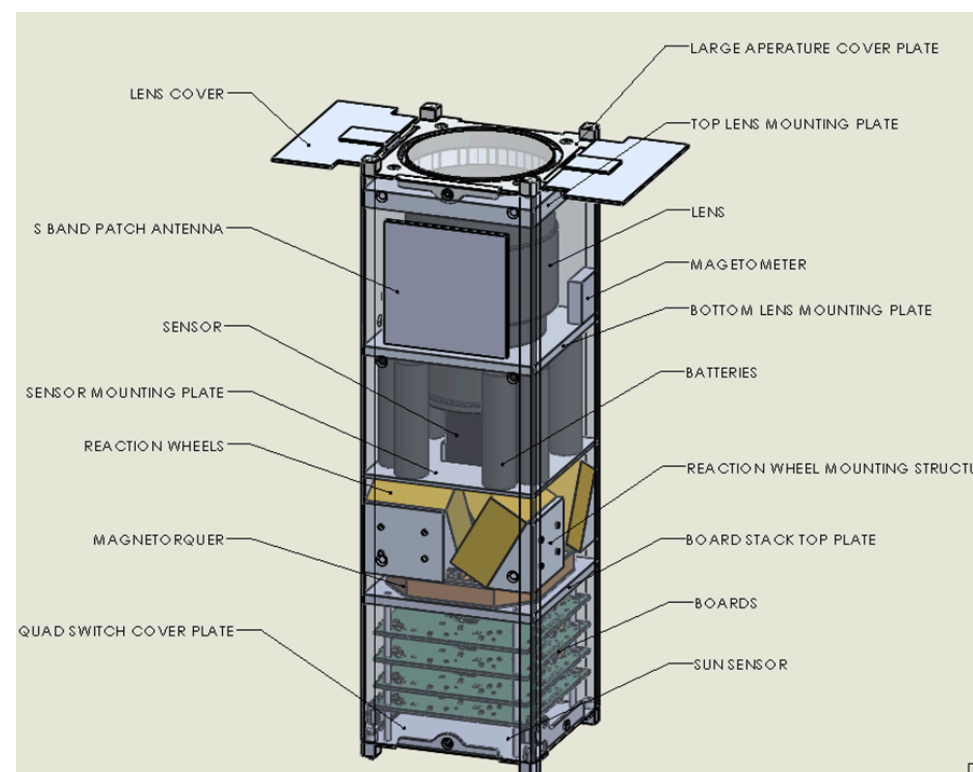
The payload consists of the (1) Imaging System with a Canon lens, CMOS optical sensor, and FPGA for processing; (2) Control and Navigation system with reaction wheels and magnetorquer; and (3) Communications system with S band patch antennas.
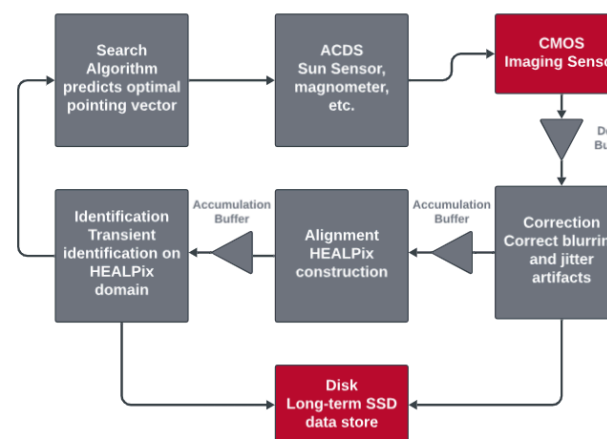
Preliminary Diagram of the Imaging Software Pipeline

System Architecture Block Diagram

Expected Outcomes

We recently submitted a CSLI proposal for VECTOR to NASA. Pending the proposal outcome, we expect VECTOR to demonstrate rapid optical follow-up of transients. We hope to validate our modular bus design for scalable CubeSat missions. And we hope to make significant contributions to multi-messenger astronomy and STEM education.

Acknowledgments