Satellite for Optimal Control and Imaging

- 2U CubeSat developed at University of Washington to be the first in-space demonstration of real-time optimization-based attitude control
- Our mission is to provide educational opportunities at UW and a testbed for A&A-developed control algorithms
- Selected for launch by 11th CubeSat Launch Initiative call

Cutaway of SOC-i showing internal components in flight configuration

IV. Risk Mitigation with COTS Subsystems

SOC-i is AACT’s first CubeSat. We have intentionally limited the scope of custom-built hardware to minimize the risk of first-mission failure that is a common pitfall for university CubeSat teams.

Guidance, Navigation, and Control (GNC)

- Active 3-axis control is required to demonstrate the SOAR technology
- 4 NanoAvionics reaction wheels, magnetorquers integrated in the ±X, ±Y, and ±Z solar arrays
- 3 magnetometers, 3 gyros, and a SolarMEMS digital sun sensor for reliable fine attitude knowledge

Communications

- SOC-i uses amateur UHF band to downlink to UW-based receiver
- Pacific Crest XDL Micro radio has flight heritage aboard EQUiSat
- EnduroSat UHF antenna is sole deployable on SOC-i with triple-redundant release mechanism

Electrical Power System

- Primarily sourced from Clyde Space with four 2U body-mount solar arrays, power distribution board, and 20 W-hr battery pack

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V. Custom Chassis and On-Board Computer

AACT has plans for future missions that will be entirely custom CubeSats carrying UW science payloads. On SOC-i, we are custom building just a few initial subsystems. This avoids over-scoping while laying the foundation for more custom subsystems in future flights.

2U Chassis

- Goals: (1) provide easy access to SOC-i internals and (2) be easily adaptable to 1U or 3U sizes
- Consists of 2 identical rail walls, 2 distinct endplates, and stiffness ribs
- Initial design by senior capstone student
- Manufactured entirely by students, machining is underway pending COVID-19 shop closures

The chassis is comprised of modular rail walls and endplates (rib omitted)

On-board Computer

- Custom student design adapted from NXP i.MRT1050 dev board
- Microprocessor based on ARM Cortex-M7 platform
- Utilizes I2C, UART, and SPI for peripheral interfacing
- Firmware/software uses FreeRTOS for task execution

The OBC houses the microprocessor, GNC sensors, data interfaces, and real-time clock

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VI. Imaging Payload (IMG)

SOC-i has accurate pointing capability, making it an ideal platform for space-based imaging. A basic CMOS camera is being flown as a secondary payload to provide images from space for outreach purposes.

- Mounted to -Z face of SOC-i to keep sun out of field of view
- Board is designed to house IMG hardware and magnetorquer control circuitry, currently being fabricated

SOC-1 takes problem data and automatically generated initial solution guess as inputs. It iteratively computes a convex approximation of the original problem and solves the resulting subproblem (second-order cone program). The discrete-time optimal solution is interpolated to give continuous commands to the feedback controllers.

SOC builds on previous work done at UW. The pointing inclusion and exclusion constraints are formulated with an equivalent convex quadratic representation, and the solution process uses elements of successive convexification.

Reorientation maneuvers are executed such that:
1. The sun vector remains in the sun sensor field-of-view
2. Sun vector simultaneously remains out of the camera field-of-view
3. Actuator and slew rate limits are not violated
4. Given a target attitude, SOC computes maneuvers on-board with no pre-loaded solution or ground intervention

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