Small Satellite Research Laboratory

Franklin College of Arts and Sciences

UNIVERSITY OF GEORGIA

The Spectral Ocean Color Satellite: A Pre-Integration, Post Critical Design Review Overview

Nicholas "Hollis" Neel, David Cotten

2018 Symposium on Space Innovations

Overview

- Small Satellite Research Laboratory founded in 2016
- Two funded missions
- Spectral Ocean Color (SPOC) Satellite
  - Undergraduate Student Instrument Project

- Research oriented
- Over 100 applicants each semester

SPOC

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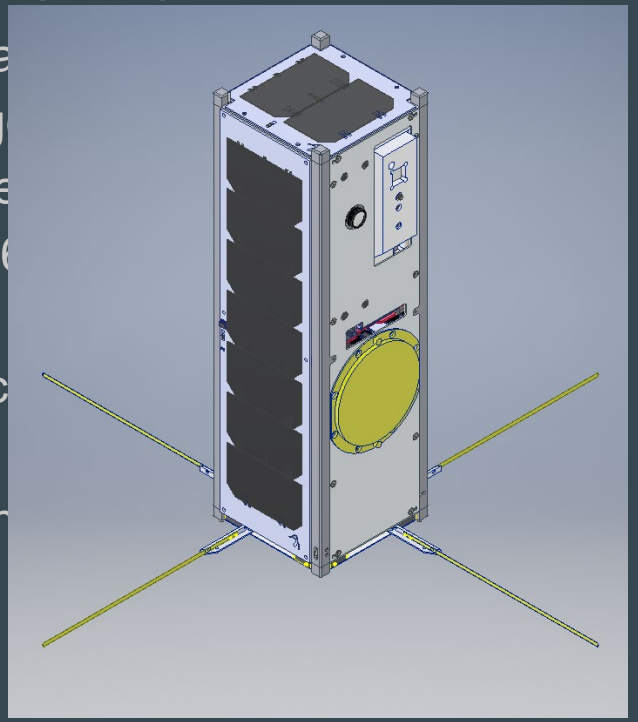
Spectral Ocean Color (SPOC) Satellite

The SPectral and Ocean Color (SPOC) Satellite sha
acquire moderate resolution imagery across a wide rang
of spectral bands to monitor coastal ecosystems and oce
color. SPOC will acquire image data between 433 and 8
nm to monitor 1) coastal wetlands status, 2) estuarine
water quality including wetland biophysical characteristic
and phytoplankton dynamics, and 3) near coastal ocean
productivity. SPOC shall use multispectral remote sensin
techniques to quantify vegetation health, primary
productivity, ocean productivity, suspended sediments,
and organic matter in coastal regions.



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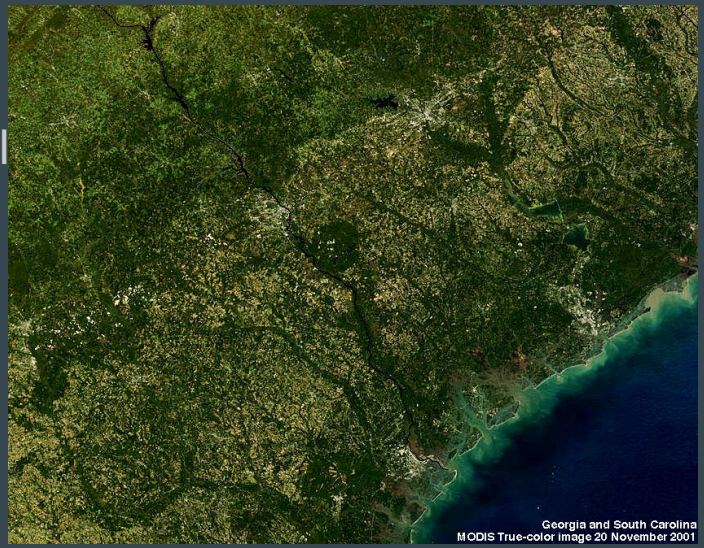
Mission Objectives

- Acquire moderate resolution imagery of coastal ecosystems, ocean color
- Acquire image data between 433 and 866 nm
- Use multispectral image products to monitor status of coastal wetlands, including estuarine water quality and ocean productivity
- Train STEM students
  - Data transmission techniques
  - Georeference mapping
  - Photogrammetric processing
  - Community outreach
  - Aerospace design, testing, and manufacturing



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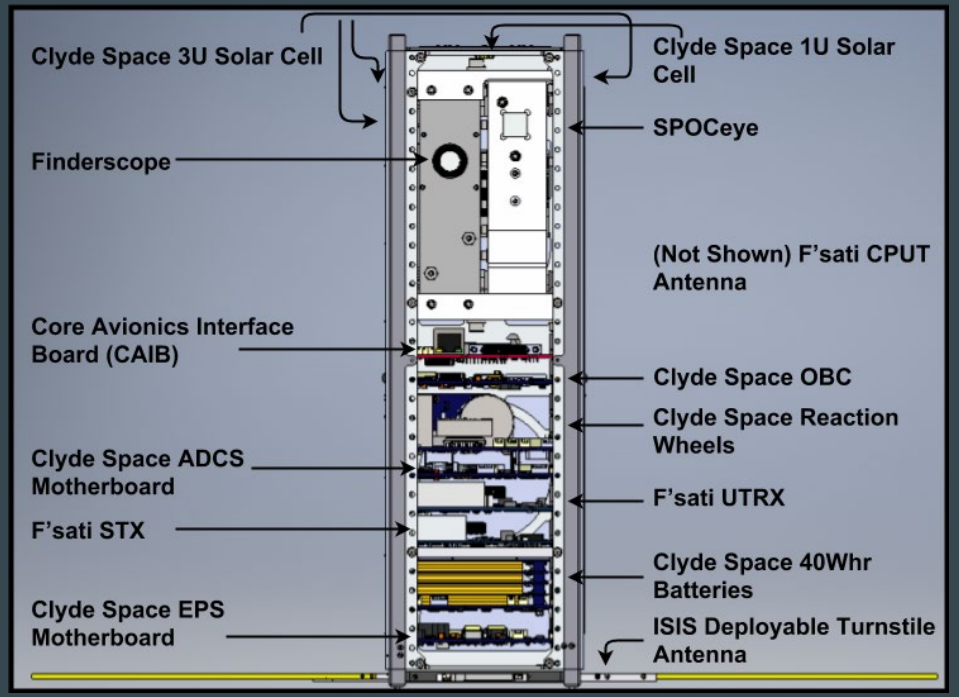
Success Criteria

Minimum	Full
Image one coastal target with spatial resolution 240m	Image the same coastal target 5 times with spatial resolution 150m
Acquire images with band spectral resolution of 50nm	Acquire images with band spectral resolution of 10nm
30 students involved for at least 2 semesters each over project lifetime	75 students involved for at least 2 semesters each over project lifetime
Give 5 community outreach presentations, mentor 2 local high school students, produce 5 space news/educational podcasts	Give 20 community outreach presentations, mentor 5 local high school students, produce 20 space news/educational podcasts, plus 1(instructional YouTube videos

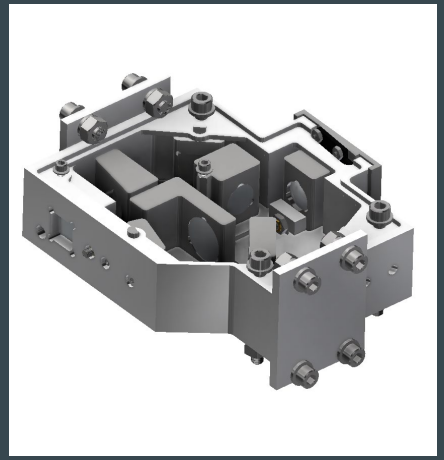
SPOC Avionics

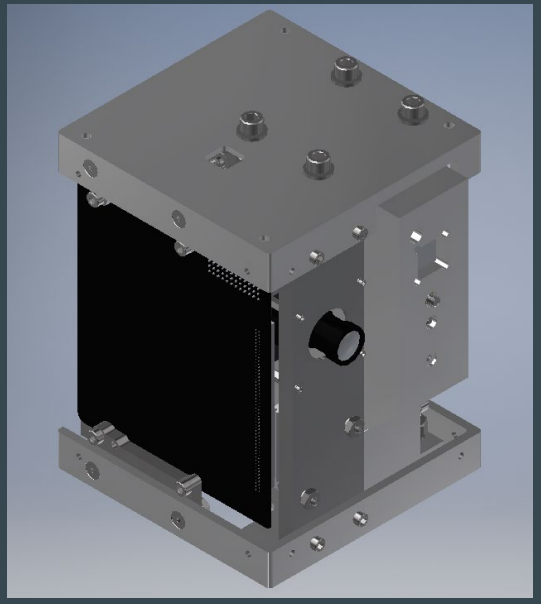
- Clyde Space Bus
  - F'Sati Communications board and Patch antenna
- ISIS Antenna
- Cloudland Instruments Payload
- 4D-Systems Finderscope



SPOC Payload

Structure is based on Cloudland designed HawkEye sensor, onboard SeaHawk mission (UNC Wilmington)





SPOCeye

- Pushbroom multispectral primary payload
- 16 adjustable bands
- 130 m GSD

Finderscope

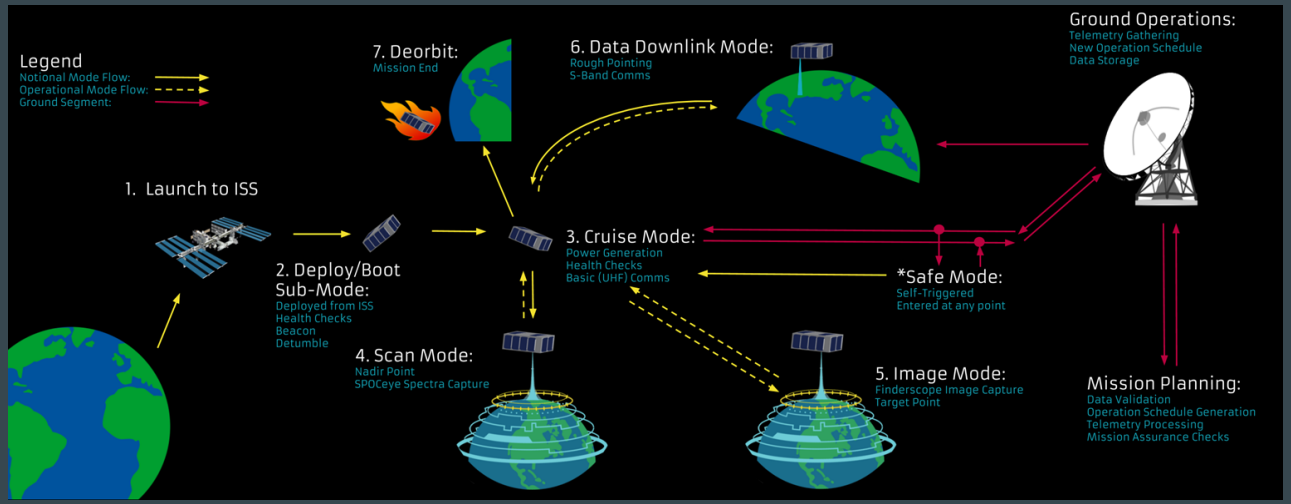
- Small 500m GSD imager
- Aid post data processing and acquire oblique satellite imagery

Concept of Operations

2 core principles:

1. Safe satellite operation

2. Acquisition of telemetry, payload, and end-product data to meet mission requirements

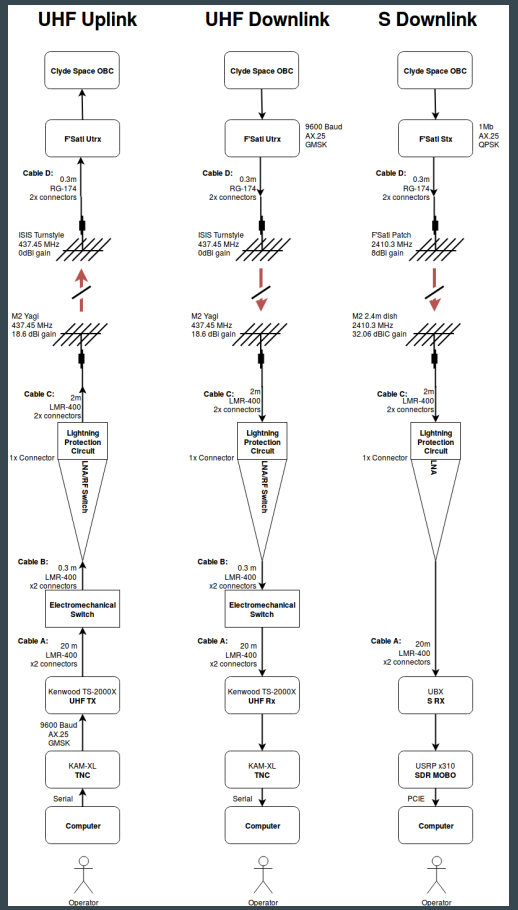


Target List

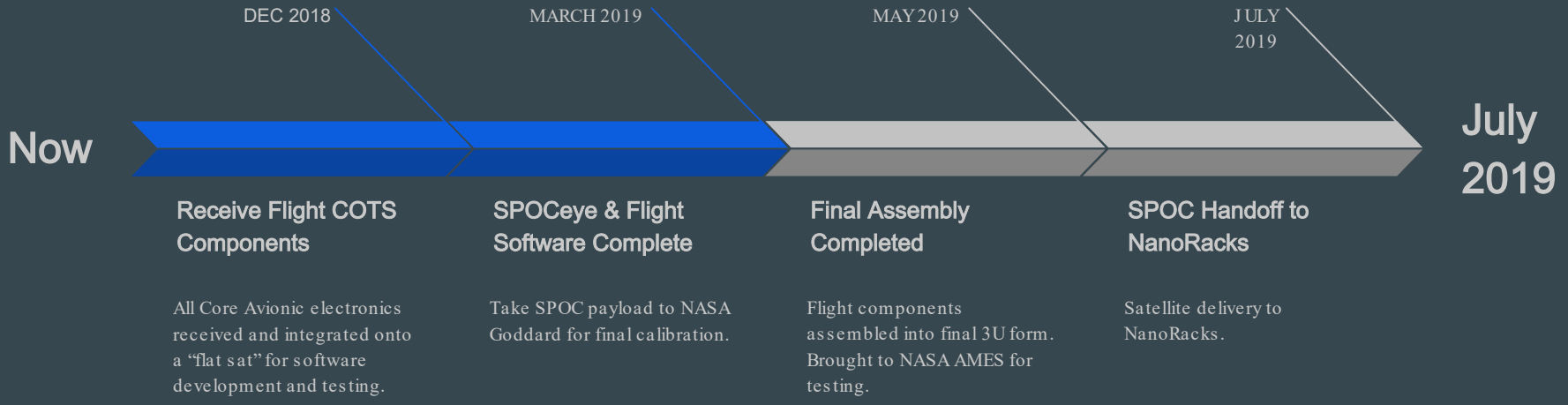
- Primary Targets:
  - Total Area ~606.7 km^2
  - Sites that have been preselected in order to fulfil the success criteria of the mission
- Secondary Targets:
  - Total Area ~1,004,494.782 km^2
  - Extended targets to image/scan should SPOC complete all success criteria for each primary target
- Tertiary Targets:
  - Experimental images/scans gathered for educational purposes, but does not have scientific merit
- Total Scan Area: ~5,253,788.03 km^2
- Will have margin to take multiple scans of primary targets to add temporal resolution

System Characteristics

- Communications:
  - +10dB link margin between ground and satellite
  - Transmitter at highest power
- Power
  - ~25W max power draw
  - ~1.3W min power draw
  - ~6W average power generation
- Mass
  - 3.74 kg total mass

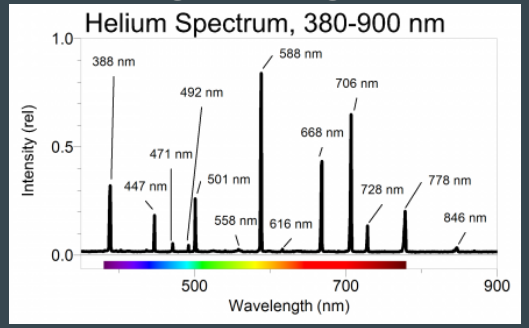


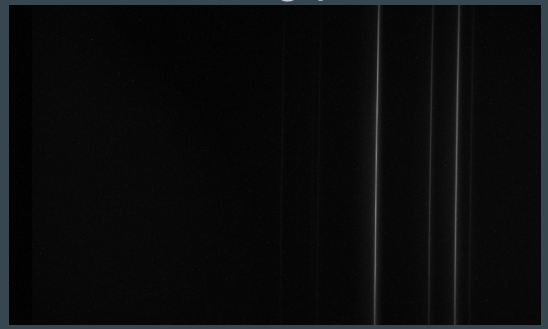
Timeline

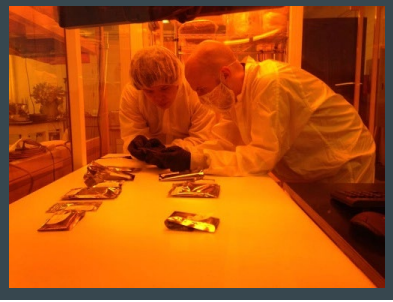

Now
DEC 2018
MARCH 2019
MAY 2019
JULY 2019
July 2019
Receive Flight COTS Components
All Core Avionic electronics received and integrated onto a "flat sat" for software development and testing.
SPOCeye & Flight Software Complete
Take SPOC payload to NASA Goddard for final calibration.
Final Assembly Completed
Flight components assembled into final 3U form. Brought to NASA AMES for testing.
SPOC Handoff to NanoRacks
Satellite delivery to NanoRacks.

SPOCNow

- Creating interface models
- Running final thermal and structural simulations
- Building ground station
- Software development
- Finalizing testing, assembly, and handling procedures





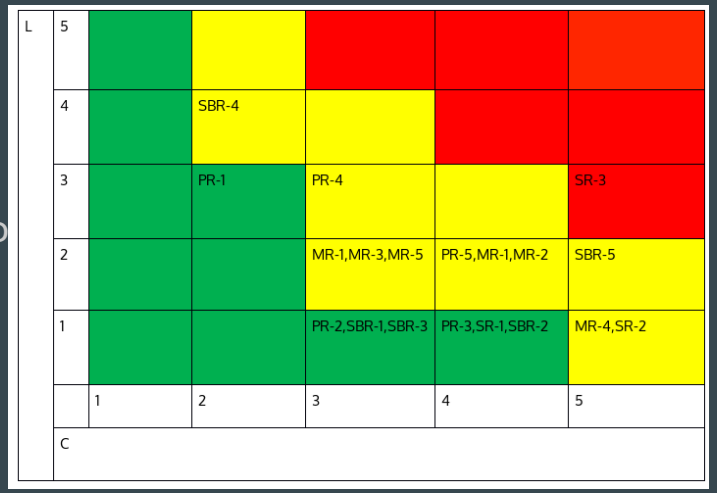


Licensing

- IARU Coordination letter required
  - Using UHF and S Band amateur bands
- NOAA Commercial Remote Sensing Regulatory Affairs License
  - Submitted draft and received feedback
  - Waiting on ODAR provided from NASA to complete
- FCC Experimental License
  - Not started
  - Do not qualify as amateurs for FCC

Major Risks

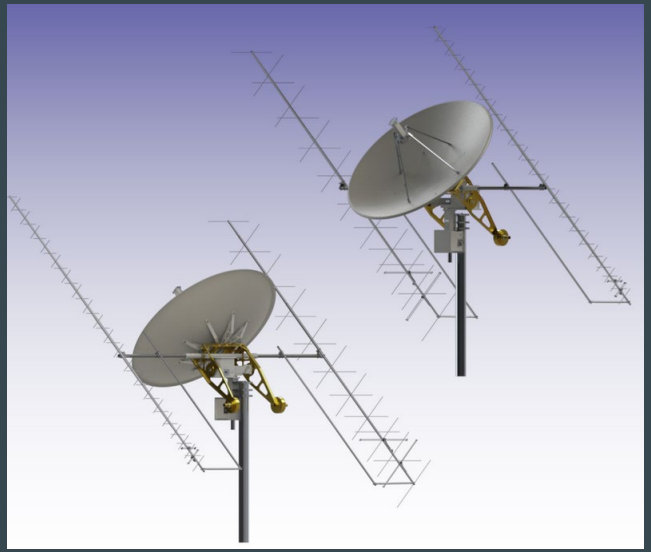
- SPOCeye flight unit machining
  - Currently caused a 3 month schedule slip
- Developing on flight hardware
  - Only funded for one set of components for the missio
  - Any component failures could cause major delay
- Lab turnover



Ground Segment Overview

UGA Ground Segment named The Center for Orbiting Satellite Mission Operations (COSMO)

- Two radio schemes:
  - Hardware Defined Radio (HDR)
  - Software Defined Radio (SDR)
- Location:
  - Roof of the UGA Geography Building



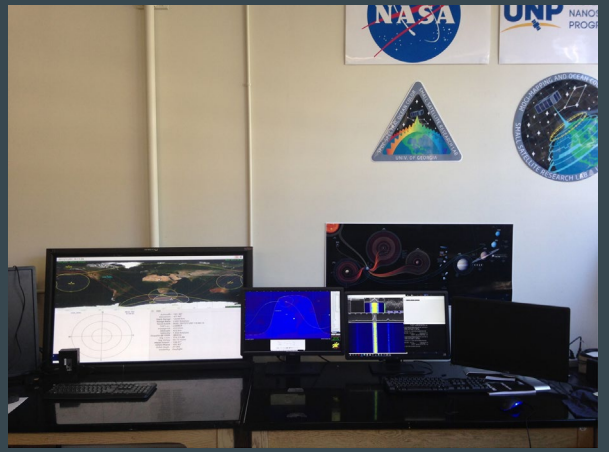
Hardware

HDR

- Kenwood TS-2000X transceiver
  - 138 MHz, 440 MHz, 1.2 GHz
- Kantronics KAM-XL Terminal Node Controller
  - AX.25 Packets, GMSK Modulation

SDR

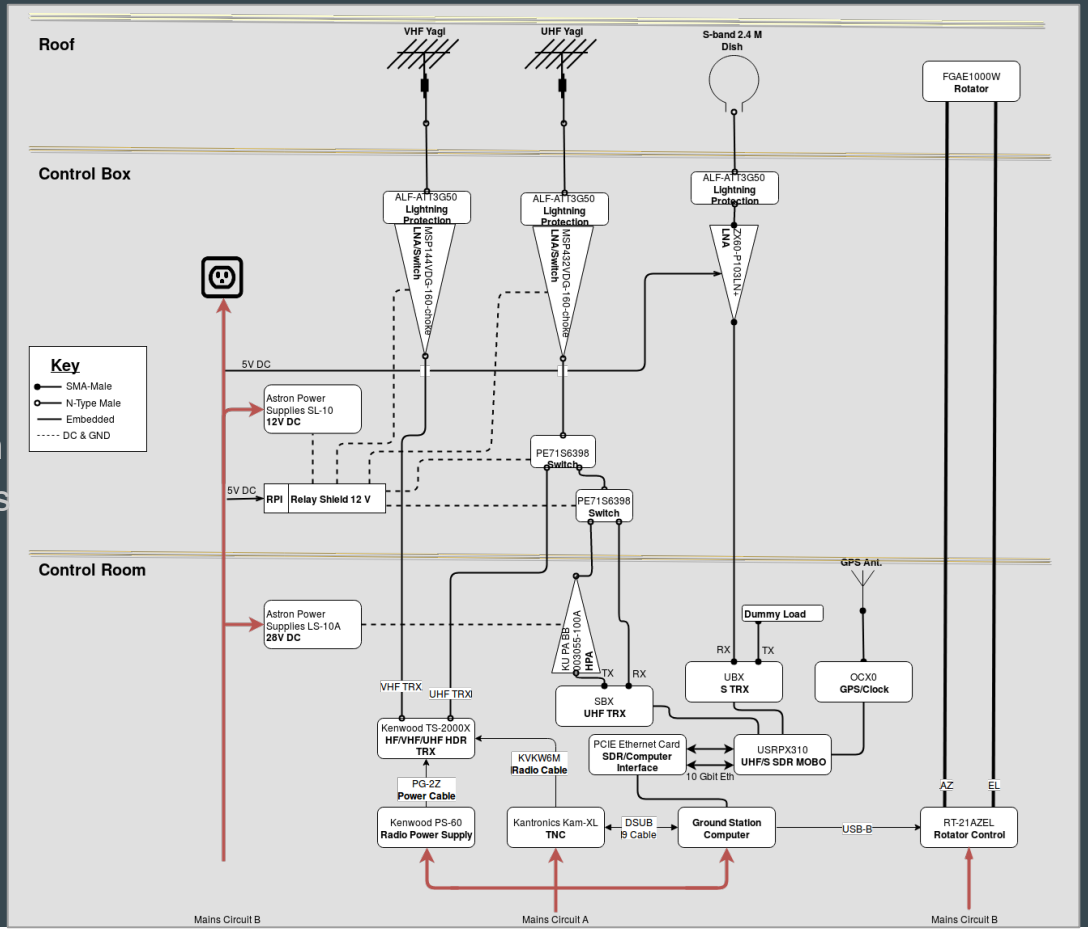
- Ettus research USRP X310
  - SBX, UBX daughterboards
  - Oven Controlled Oscillator and GPS module
- Khune 100W Power Amplifier (100-500 MHz)



Hardware Diagram

Other

- Broadband Mini Circuits LNA
- Advanced Receiver RF LNA/Switch
- Astron 28V and 12V Power Supplies
- Alpha Delta Surge Protectors
- M^2 Inc. Antenna System
- Green Heron RT-21AZEL
- Ground station computer
- Mission control computer



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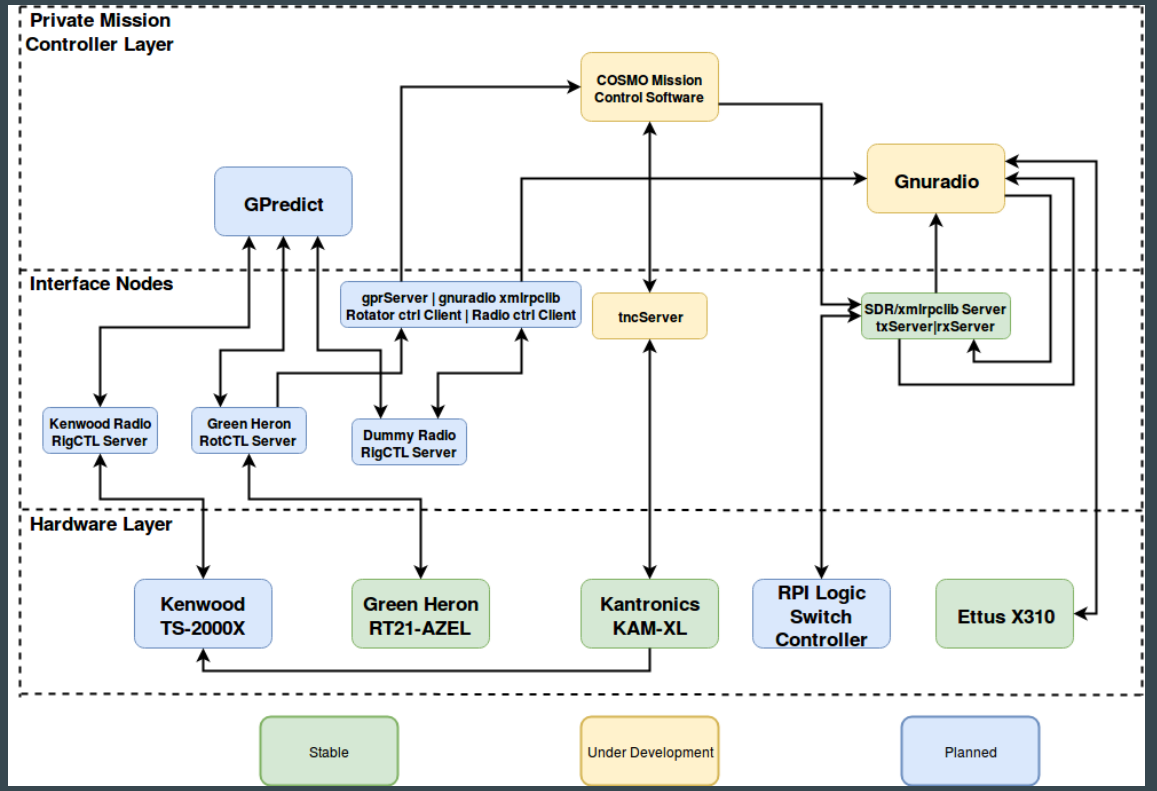
Software

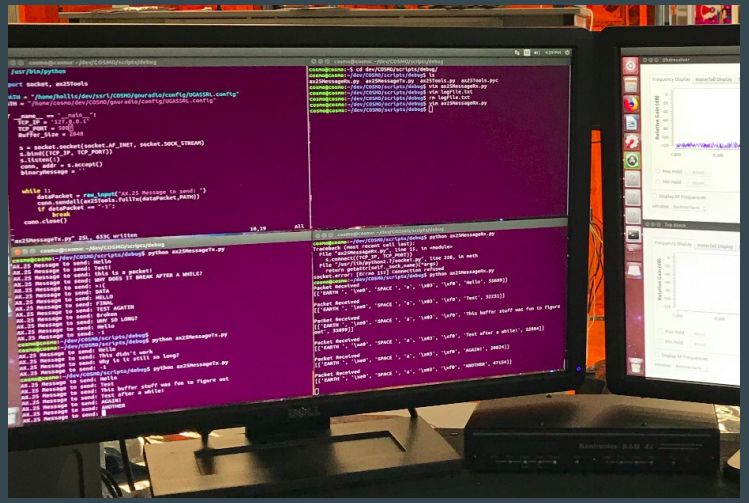
- GNURadio
  - SDR controller
- Gpredict
  - Positioning controller
  - Info source for Hamlib
- Hamlib
  - HDR controller
- Ball Aerospace COSMOS
  - Mission control software

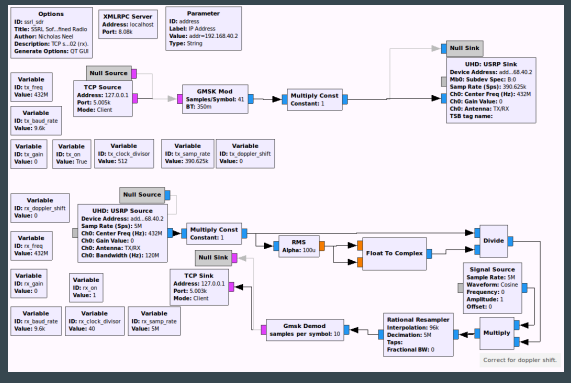


Software Defined Radio

- GNURadio used to modulate and demodulate packets
  - Custom GMSK modulation and demodulation blocks
  - Uses polyphase arbitrary resampler(s)
  - Transmits through UHD sink or receives through USRP source

- Received packets are sent to mission control hub (COSMOS)

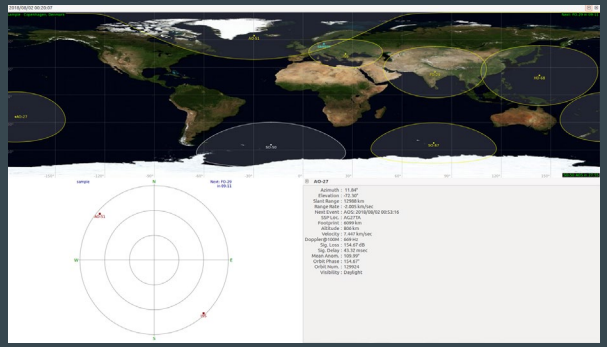




Satellite Tracking

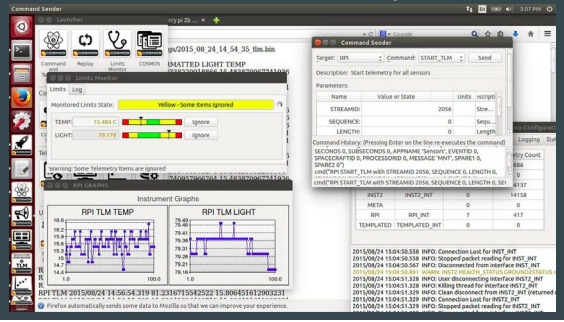
- Gpredict interfaces with transceiver and rotator controller
  - Uses Hamlib's rigctld library to control radio
  - Uses rotctld library to control RT-21AZEL

- Allows updated TLE for orbital propagation modeling with the SGP4/SDP4 tracking algorithms
  - ~1km error, grows ~3km per day
  - Create TLEs and utilize NORAD tracking



Mission Control

- Ball Aerospace COSMOS provides 15 highly customizable applications
  - Command and Telemetry Server
  - Command Sender
  - Packet Receiver
- TCP/IP connections created to connect COSMOS to other applications (Gpredict, GNURadio), consolidating modules into one command center



Ball Aerospace
COSMOS

NASA UNP

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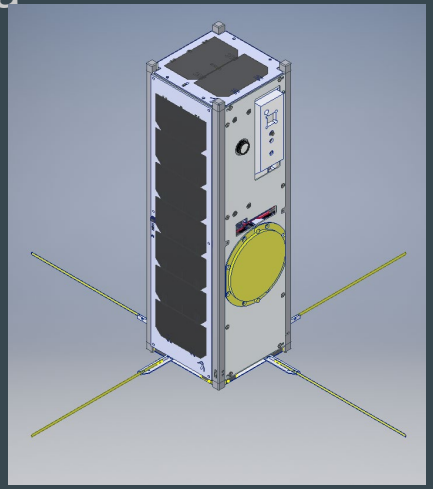
COSMO Comms

- Option 1: UHF Transceiver (Kenwood TS-2000x)
  - 440 MHz, 50 W
- Option 2: UHF Transceiver (USRP X310)
  - 440 MHz, 100W
- S-Band Receiver (USRP X310)
  - 2.4103 MHz
- Yagi Antenna 440 MHz
  - 18.6 dBic
- 2.4 M S Band Dish 2.4103
  - 32 dBic

SPOC Comms

- F'Sati UTRX transceiver (UHF uplink and downlink)
  - 430-440 MHz,
- Innovative Solutions in Space deployable turnstile antenna
- F'Sati STX
  - Transmit-only module for Sband downlink
- 8dBi patch antenna
- RG174 cables



Questions?

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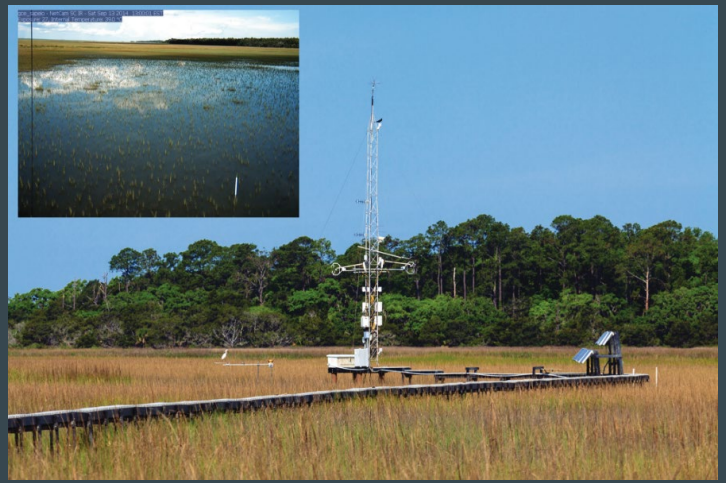
Extra Slides

Experiments

- Obtain radiance values of all surface targets
- Calculate Remote Sensing Reflectance (Rrs)
  - over targets with in-situ downwelling radiation measurements
  - Estimated over other targets
- Near Coastal Ocean Productivity
  - Total Suspended Sediment (TSS)
  - Chlorophyll
  - Particulate Organic Carbon (POC)
- Wetland Biophysical Characteristics
  - Normalized Difference Vegetation Index (NDVI)
  - Enhanced Vegetation Index (EVI)
- Other
  - Phycocyanin
  - Leaf Area Index (LAI)



Subsystems

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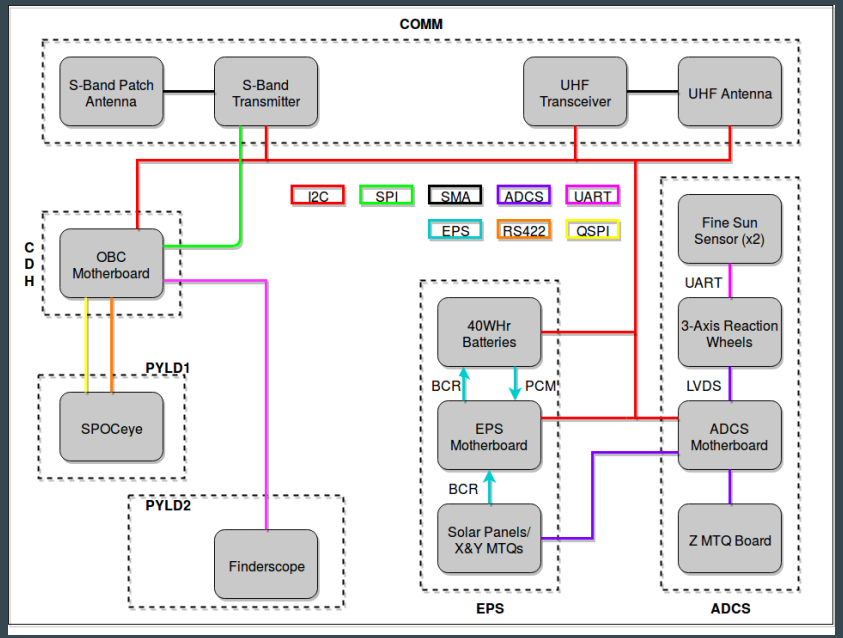
Command and Data Handling (CD&H)

The Command and Data Handling subsystem is a programmable system which actively carries out the CONOPS

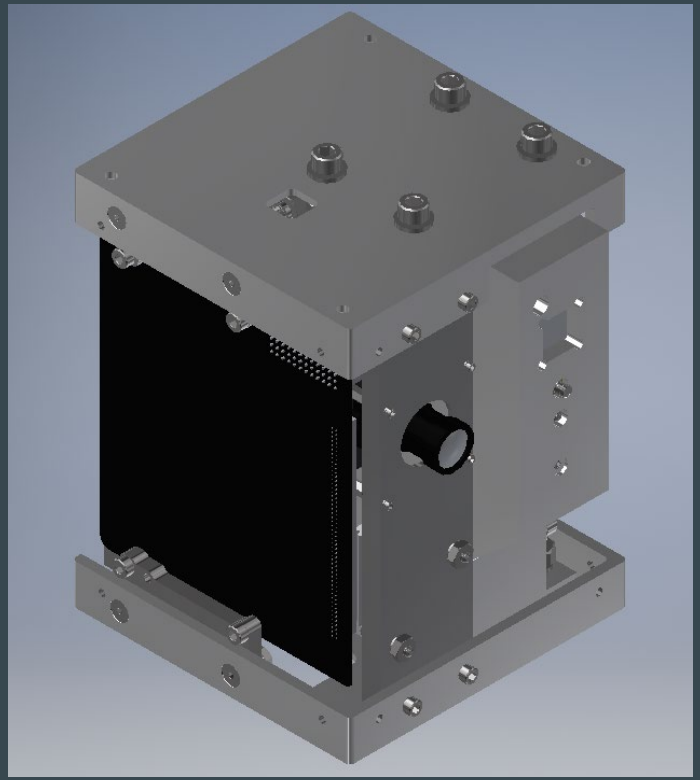
- Consists of the Clyde Space On Board Computer
- Handles all communications and stores all telemetry/science data
- Holds the custom Bright Ascension code



Payload (PYLD)

The Payload carries out the science aspect of the mission

- SPOCeye
- UCam-III finderscope

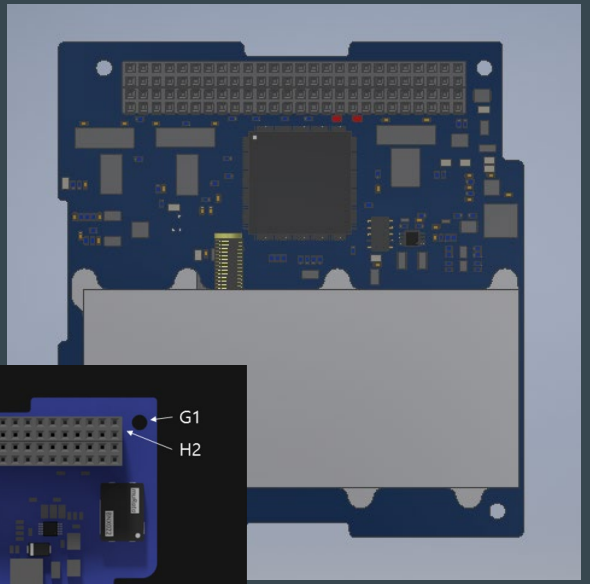


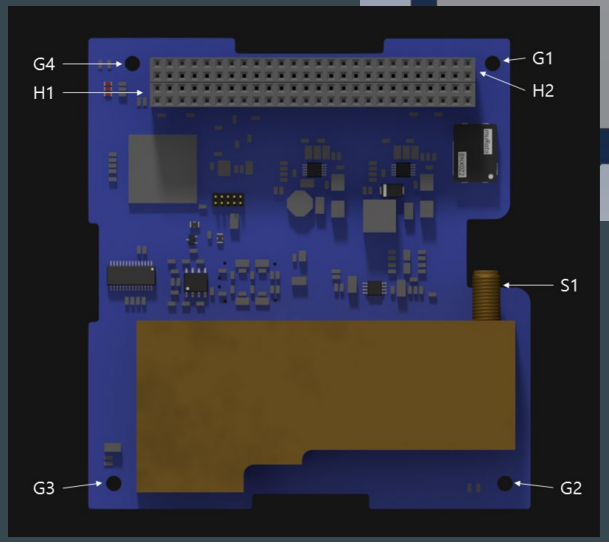
Communications (COMMS)

The Communications subsystem handles all RF communications to and from the Ground Segment.

- F'Sati UHF Transceiver
  - 430-440 MHz
- ISIS Turnstile Antenna
  - Tuned to 437.45 MHz

- F'Sati S Band Transmitter
  - 2.40-2.45 GHz
- F'Sati CPUT Patch Antenna
  - 2.40-2.45 GHz





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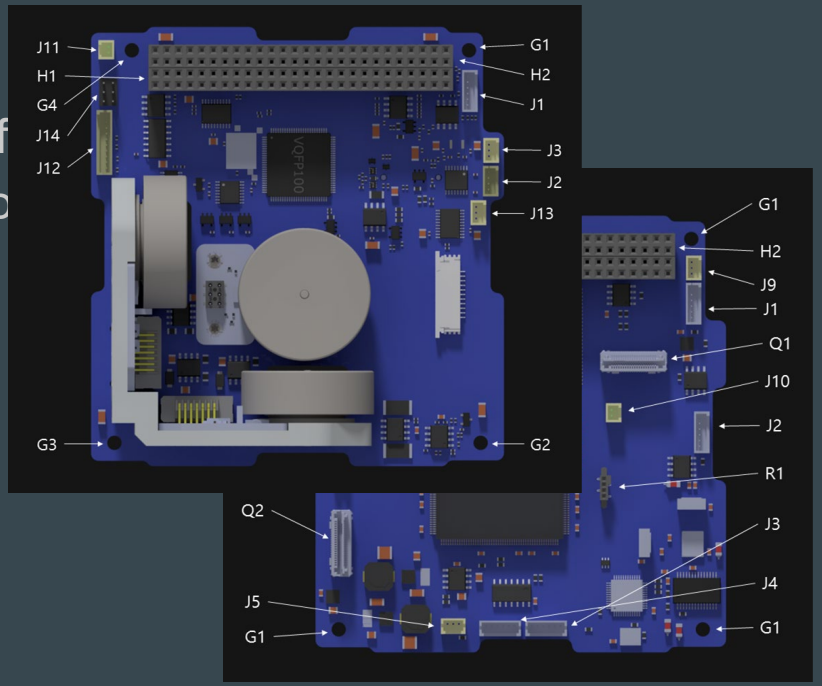
Attitude Determination and Control System (ADCS)

The Attitude Determination and Control Subsystem both characterizes the orientation of the satellite as well as can change the orientatio of the satellite.

- Clyde Space Reaction Wheels
- Clyde Space Motherboard (Gyroscope, Accelerometer, magnetometer, etc.)
- Solar Panels (Magnetorquers, GPS Antenna, Sun Sensors)



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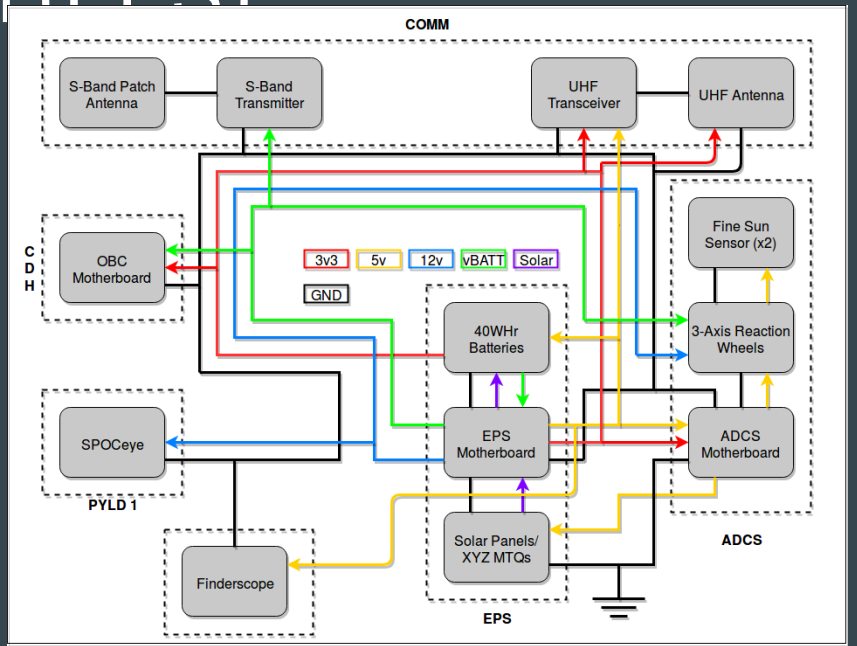
Electrical Power Subsystem (EPS)

The Electrical Power Subsystem generates and provides electricity to the bus.

- Clyde Space EPS Motherboard
- Clyde Space 40Whr Batteries
- Clyde Space Solar panels (23 cells)



Mission Assurance

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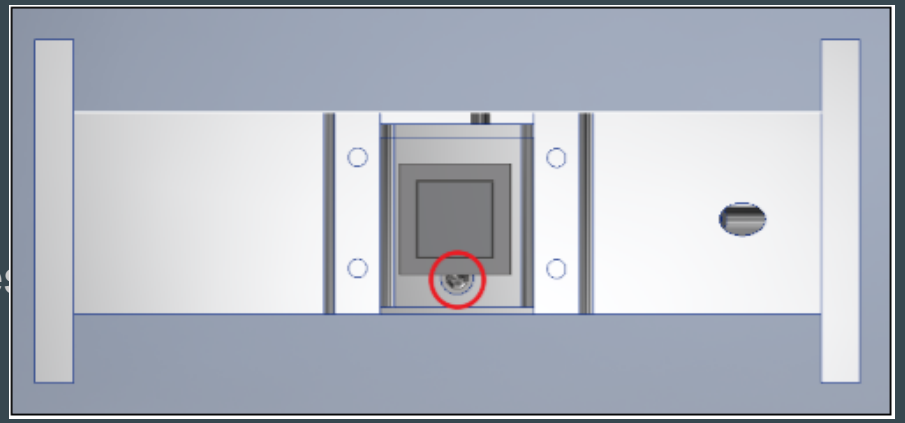
EMC/EMI Mitigation

- Potential EMI-shielding enclosure for SPOCeye
- Dunmore Aerospace for our Thermal Radiation Mitigation
- Aluminized Kapton film
- Voltage from current-carrying wires is negligible

Pressure Profile



- Vent holes required on enclosed spaces
- Rule of thumb: ¼”hole for 1 m^3 of air
- No concerns for frame
- SPOCeye camera includes vent area
  - Enclosed volume: 2.204 m^3
  - Hole dia: 5mm (about 40% obstructed)
  - Safety factor on hole: > 2000
- Satellite properly vented

Data Management Plan/ Protection Plan

- Encrypted data downlink
- Internal Server Storage
- Encrypted TCP communication within the UGA intranet
- VPN needed to access UGA services from outside