# Command and Data Handling and Flight Software

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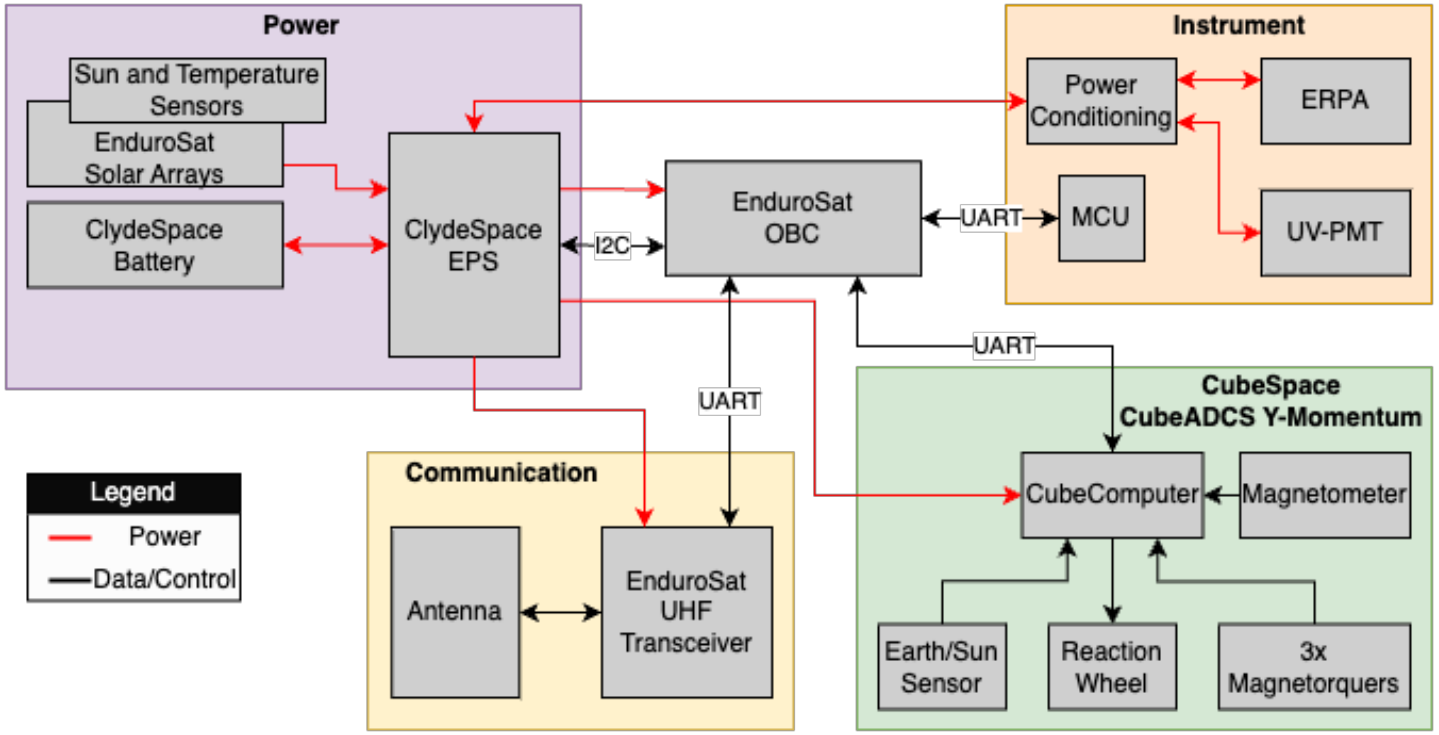
SSU NH 1867

# Introduction

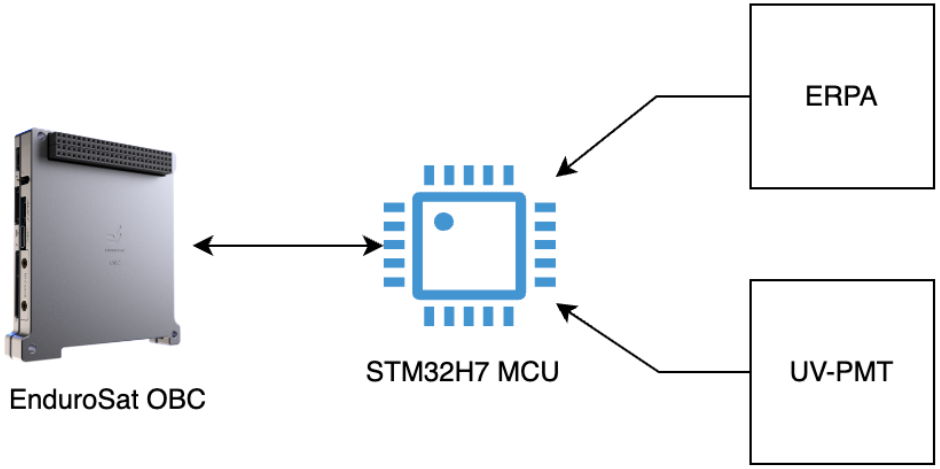
- The IMAP Student Collaboration goals are ***to augment IMAP science return, develop hands-on research experience for students, and contribute to diversifying space science***.
- **3UCubed**: 3 Universities; 3 CubeSats; Upwelling, Uplifting Undergraduates
- Three universities: Sonoma State University, Howard University, University of New Hampshire
  - **Each university builds their own EM (3 EMs)**.
  - Our measure of success is **to deliver to CSLI and launch one CubeSat (1 FM)**.
  - a strong recruitment and retention program, with a dedicated online community.
- Mission model
  - Two instruments being developed, combined size ≤ 1.5U
  - **Joint work on the design** between the three universities with specific work aligned with experience (UNH on instrument, SSU on ground station and FSW, HU on thermal).

# Subsystem Overview



# Instrument Design

- **Two Instruments:**
  - Ultraviolet-Photo-Multiplier-Tube (UV-PMT)
  - Electron Retarding Potential Analyzer (ERPA)
- **STM32 Microcontroller Unit:**
  - Collects analog data from instruments
  - Packetizes instrument data
  - Sends data to OBC



# Instrument Data Packets

- Instrument data split into packets
  - Each ERPA packet: 48 bits
    - Sent to OBC every 6.25ms
  - Each ERPA HK Packet: 48 bits
    - Sent to OBC every 6.25ms
  - Each UV-PMT packet: 48 bits
    - Sent to OBC every 125ms
  - Each Housekeeping packet: 228 bits
    - Sent to OBC every 5s
- During testing, instrument MCU sends data to a computer
  - Computer runs GUI program to interpret and display incoming data

**ERPA** Packet Structure

| SYNC | SEQ | ERPA |
|---|---|---|
| Fixed 2-byte hexadecimal | 2-byte packet counter | ERPA data reading |

**ERPA HK** Packet Structure

| SYNC | SEQ | SWPMON |
|---|---|---|
| Fixed 2-byte hexadecimal | 2-byte packet counter | ERPA SWP voltage reading |

**UV-PMT** Packet Structure

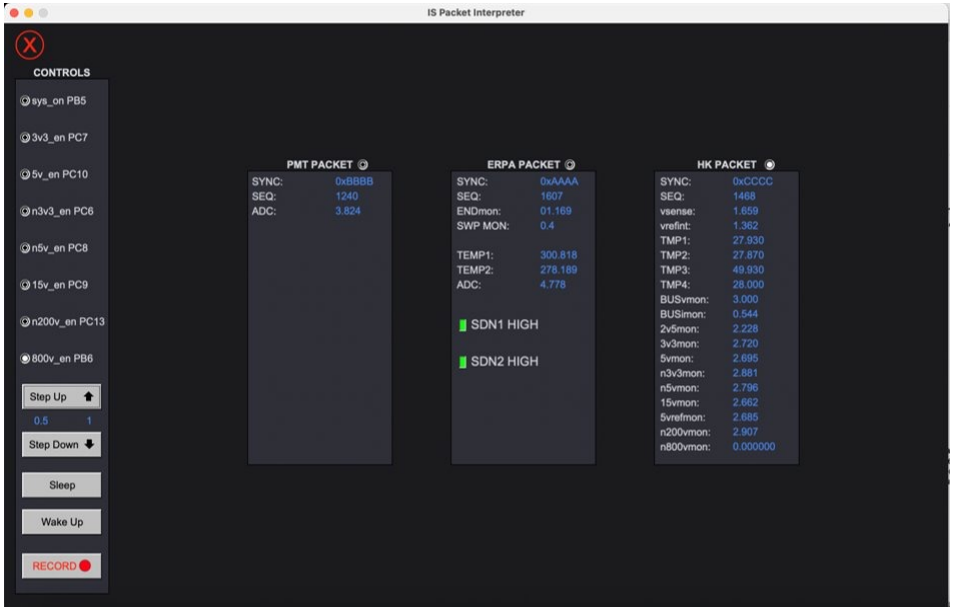
| SYNC | SEQ | PMT |
|---|---|---|
| Fixed 2-byte hexadecimal | 2-byte packet counter | PMT data reading |

**Housekeeping** Packet Structure

| SYNC | SEQ | MCUHK | TMP x4 | VMON x9 |
|---|---|---|---|---|
| Fixed 2-byte hexadecimal | 2-byte packet counter | MCU Housekeeping | I2C temp sensors | Voltage Monitor ADCs |

# Instrument Test with Computer

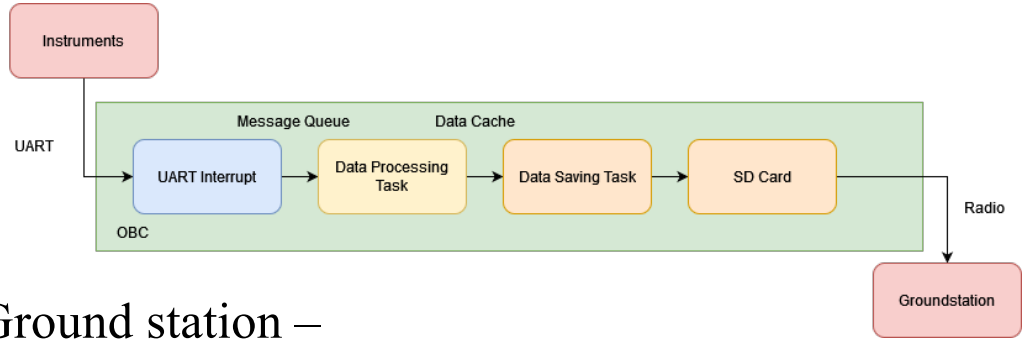
- Student created **graphical user interface** for reading instrument and instrument-MCU Data.
  - Ability to control behaviors of instrument MCU
    - Enable GPIOs
    - Increase SWP DAC output
    - Put MCU into Sleep Mode (Low-power)
    - Wake MCU up from sleep




Student-created instrument data graphical user interface

# On Board Computer

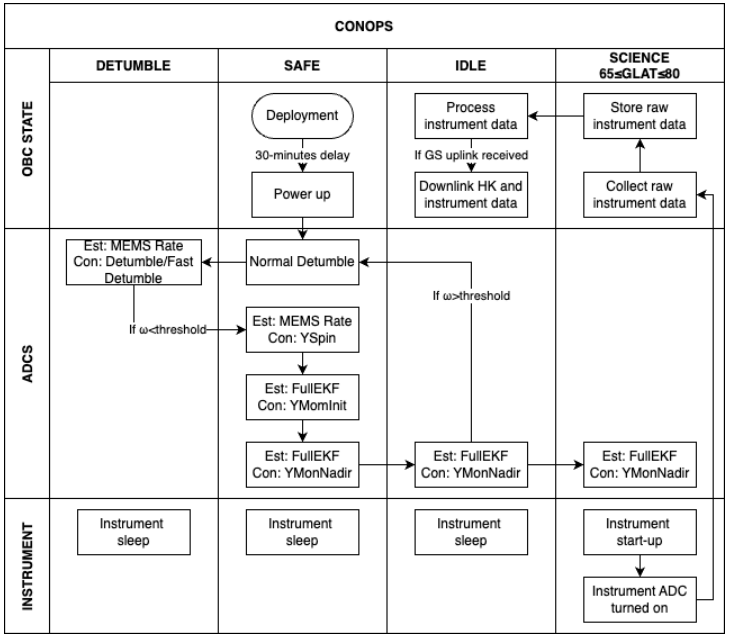
- Instrument data is sent to the OBC via UART
- Data goes through a series of steps before it can be sent down to Earth
- Note:
  - Interrupt limitations
  - Inter-thread communication
  - More steps between SD Card and Ground station – ConOps!



# ConOps

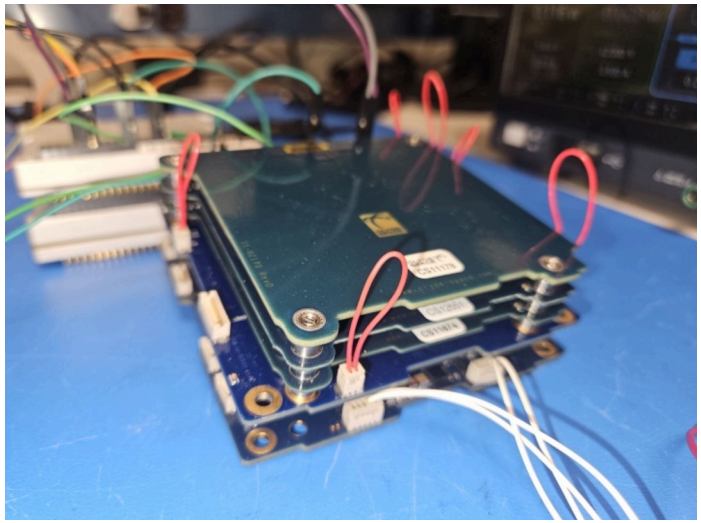
- The OBC goes into different states depending on the status of the satellite

- Safe
  - Power up/Error
- Detumbling
  - Too much spinning
- Communication
  - Ground station in range
- Science
  - Orbit in position for data collection
- Idle
  - Default state



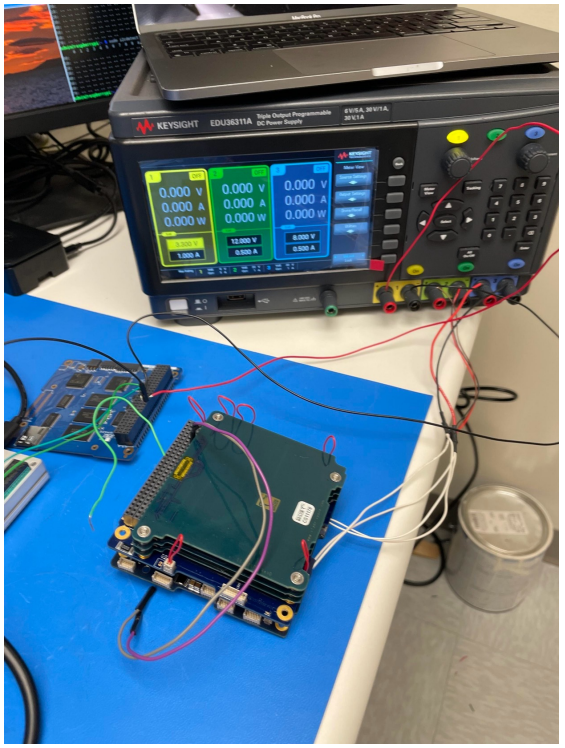
# Electrical Power System

- **I2C** based ClydeSpace model 25-02452 EPS, alongside ClydeSpace BAT(battery) model 01-02685
- **Telecommands** are the foundation of commanding the EPS
  - Write commands: establish events
  - Read commands: return resultant of a given event
- **Telemetry** data enables the OBC to monitor the continual operations of the EPS



# Pre-Integration Testing

- Fabricated basic user interface to force OBC commanding of **ClydeSpace** EPS using **Endurosat** SDK (software development kit) and customized FIDL file
  - Enabled for functionality testing of OBC and EPS communication
  - Ensured I2C network was functional
- Functionality testing included:
  - Obtaining the board status
  - Incrementing and reading the manual reset count
  - Powering the PDUs(Power Distribution Units) and checking their voltage/current



# Electrical Power System Integration

- Integration focused on **ClydeSpace** EPS with **Endurosat** SDK generic EPS driver
- ClydeSpace telecommands needed to be **mapped** to Endurosat telecommands
- All commands that were **unsupported/supported** by ClydeSpace were **removed/added** from EnduroSat generic driver
- ClydeSpace EPS does not have a PIU (Power Integrated Unit mainboard) therefore housekeeping data needed **manual collection** implemented
- Communication with BATT was introduced in housekeeping collection
  - EPS could not provide necessary telemetry for battery daughterboard data

# Thank you

Any Questions?



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