CySat - Satellite Mission Design

Team ID: SDMay20-49
Client: M:2:I

- Advisor: Dr. Phillip Jones
- Team Members: Bryan Friestad, Ryan Hansen, Chase Kirchner, Kyle Muehlenthaler, Talon Stromgren, Xiangzhu Yan

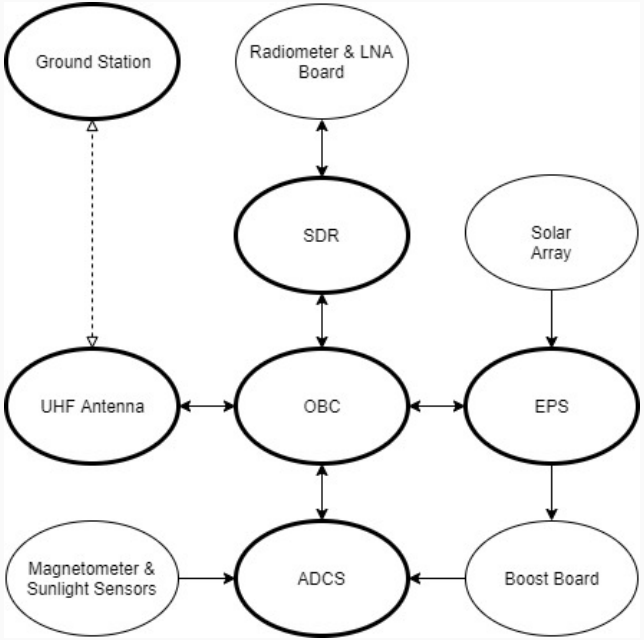
High Level

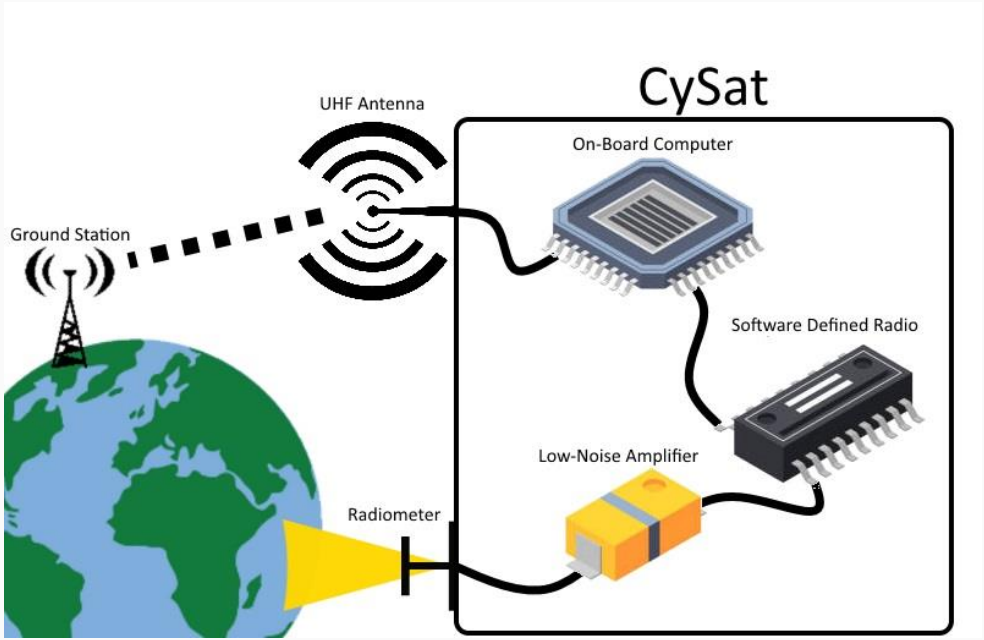
- Design the software for a satellite and ground station
- Satellite will be launched from ISS in Late 2020
- Payload will measure soil moisture content of Earth
- Software Defined Radio (SDR) will perform calculations on measurements to send back to Earth
- Ground Station will collect data from Satellite when it is overhead

Problem Statement

- CySat as a project has multiple purposes
- It is a learning experiment for students working on it
- It will pave the way for future launches
- The payload is centered around one of the project advisor’s thesis

Project Concept





Functional Requirements

- Autonomous behavior
- Collects and stores scientific data
- Communicates with ground station

Technical Constraints & Considerations

- The components are expensive and/or fragile
- There are some things we cannot test on the ground
- There are numerous other team members to coordinate with
- It may be difficult/impossible to update software during flight

Risks

- According to NASA 42% of satellites launched between 2000-2016 failed
  - Extensive testing on Earth
- Components shaking apart on launch
  - Vibration test
- Worry of boards being damaged or fried under improper care
  - Checking documentation
  - Anti-static measures

Resource/Cost Estimate

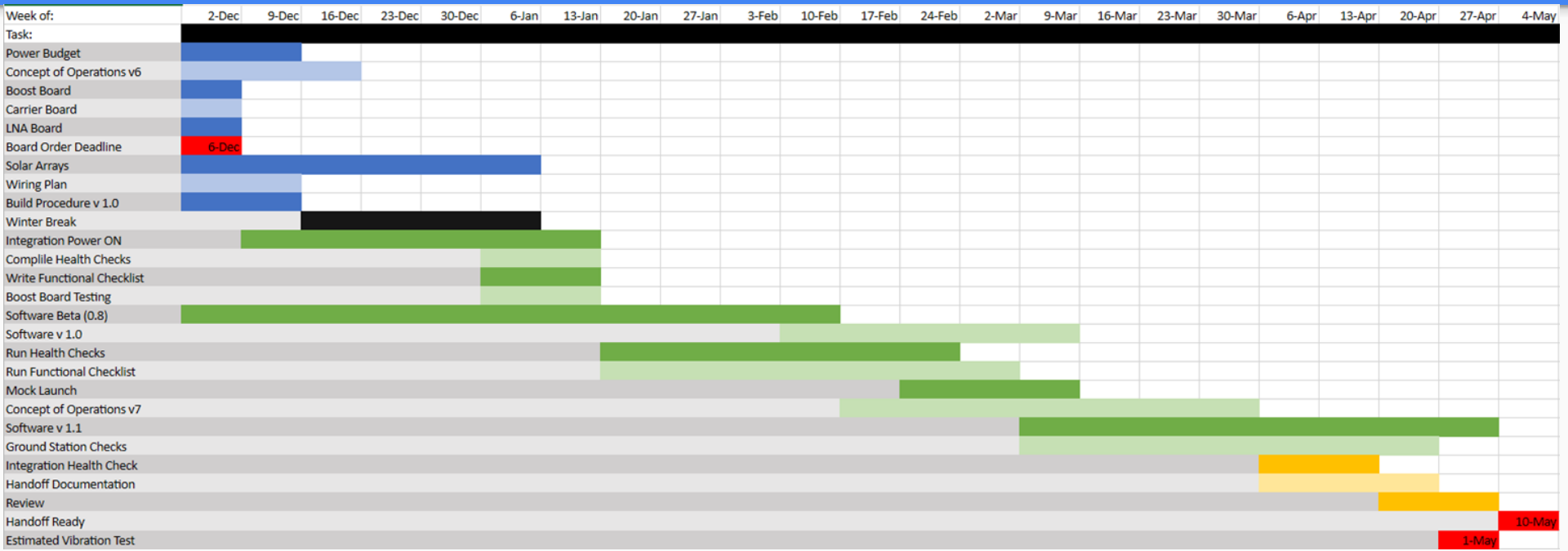
CySat has invested over $120,000 into CySat-1 from entities such as M2I, ISGC, NASA, and other donors.

M2I also provides all resource and lab equipment in M:2:I lab in Howe Hall.

Project Milestones

- Boost board redesigned and reordered
- SDR carrier board redesigned and ready to be ordered
- SDR software can process and save radiometer readings
- Ground Station Software Version 1.1
- OBC code can perform Mock Launch, simulating all events from the moment of satellite hand off to the beginning of the main operating phase
- Code is heavily documented and progress videos were made to assist in future project development
- Infrastructure for smooth handoff has been laid, including introductory videos and “next steps” documents to ease transition

Project Schedule



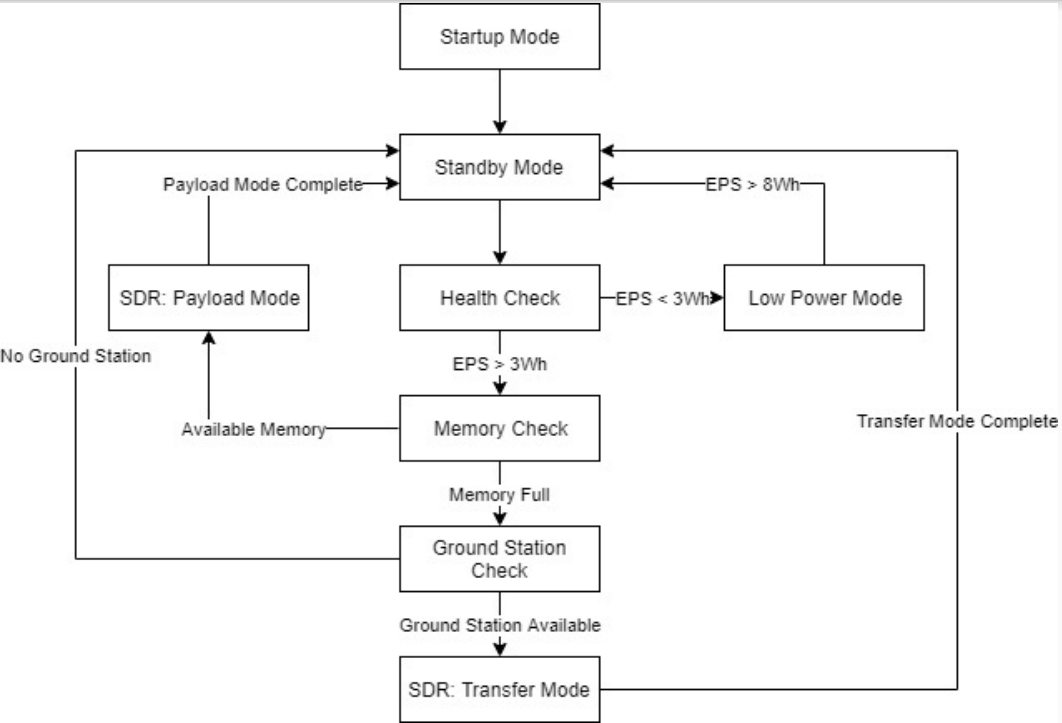
Functional Decomposition

- OBC (On-Board Computer) - Processing system overseeing and controlling all satellite functions.
- EPS (Electrical Power Subsystem) - Provides all components with power.
- ADCS (Attitude determination and control system) - Detumble and correct orbital motion of the CubeSat after launching from the ISS.
- SDR (Software Defined Radio) - Converts the analog payload system data into digital information that can be saved and sent back to Earth.

Functional Decomposition

- Ground Station - Communicates with Satellite for health checks and saves data via simple GUI
- UHF (Ultra High Frequency) Transceiver - Packets information to be sent and configures beacon messages as well as frequency and various other functions.
- UHF Antenna - Used to send and receive information from and to the ground station.

Detailed Design



- OBC contains a majority of the software code
- OBC software control flow will be the focus of second semester (concept shown left)
- Software requirements will need to meet M:2:I constraints

Technology Used

- PC-104 - compact stacking signal bus structure
- I2C - synchronous, multi-master, multi-slave, serial computer bus
- UART - universal, asynchronous receive/transmit
- FM - UHF frequencies via radio
- STM32F4 processor on the OBC

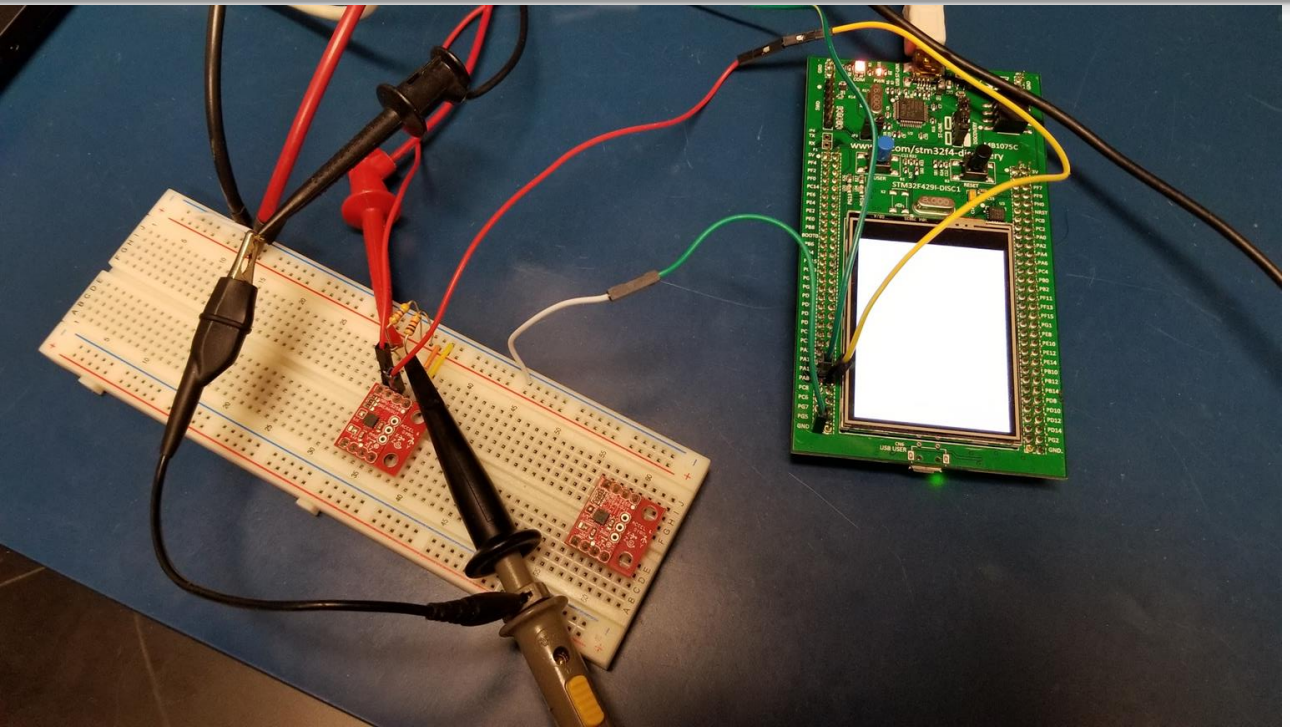
Testing Plan

- How is testing performed?
  - Our approach is considered hybrid
  - Software is emulated on development boards
  - Some actual platform testing is completed (UHF transceiver and ADCS for example)
- Component testing
  - All isolated health checks for each component
  - ADCS Health Check by CubeSupport

Testing Plan

- Integration testing:
    - Health checks collected by OBC and sent to ground station.
    - Ensure each component can be powered from the stack
    - All components of satellite can communicate with central control
- System level / Acceptance testing:
    - Mock Launch (up to main operating phase)
    - Mock Mission (main operation and end of life)

Prototype Implementations



- STMicro Discovery board hooked up to a SparkFun IMU breakout board to test I2C communications

Engineering Standards & Design Practices

- 12207-2017 - ISO/IEC/IEEE International Standard - Systems and software engineering -- Software life cycle processes
  - Used the common software lifecycle processes while working with developing the satellite subsystem integrations
- 29119-4-2015 - ISO/IEC/IEEE International Standard - Software and systems engineering-- Software testing--Part 4: Test techniques
  - Used for testing health checks on the satellite subsystems

Project Status

- Subsystems have been interfaced with separately.
- System integration with OBC, EPS, and UHF Transceiver has been successful.
- Preparing system integrations for mock launch requirements.
- COVID-19 delays are preventing integrations for mock mission requirements.

Team Member Roles & Contributions

- Bryan Friestad - Team Lead, OBC Lead, EPS Lead - 240 hr
- Ryan Hansen - SDR Lead - 196 hr
- Chase Kirchner - Ground Station Lead - 150 hr
- Kyle Muehlenthaler - UHF Radio Lead - 176 hr
- Talon Stromgren - Analog Components Lead - 156 hr
- Xiangzhu Yan - ADCS Lead - 164 hr

The future prospect of the project

- Detailed documentation is being worked on to provide the next team a clear starting point
- More commands will need to be written on the OBC to interface with the ground station and other subsystems
- Introductory videos for the next team, to give them a brief explanation of each of the main subsystems. This will assist in electing subsystem leads
- Clear and concise testing documents for PCBs and software components

Questions?