CYSAT SENIOR DESIGN

SDMAY21-25

CYSAT MISSION DESIGN

The Team

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THE CLIENT

MAKE:2:INNOVATE

class engineering:MakeToInnovate

Sponsored by:

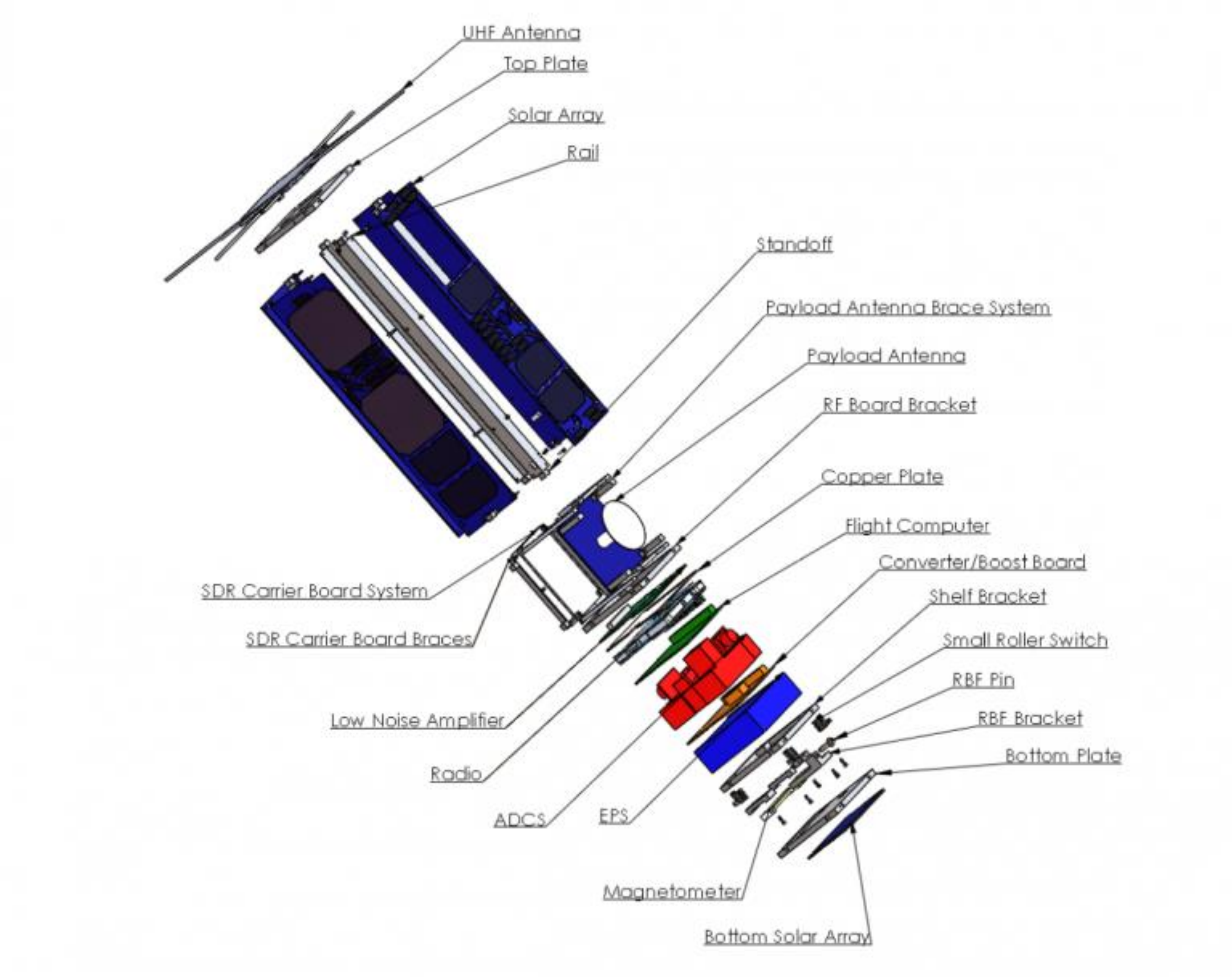
BOEING

Faculty Advisor

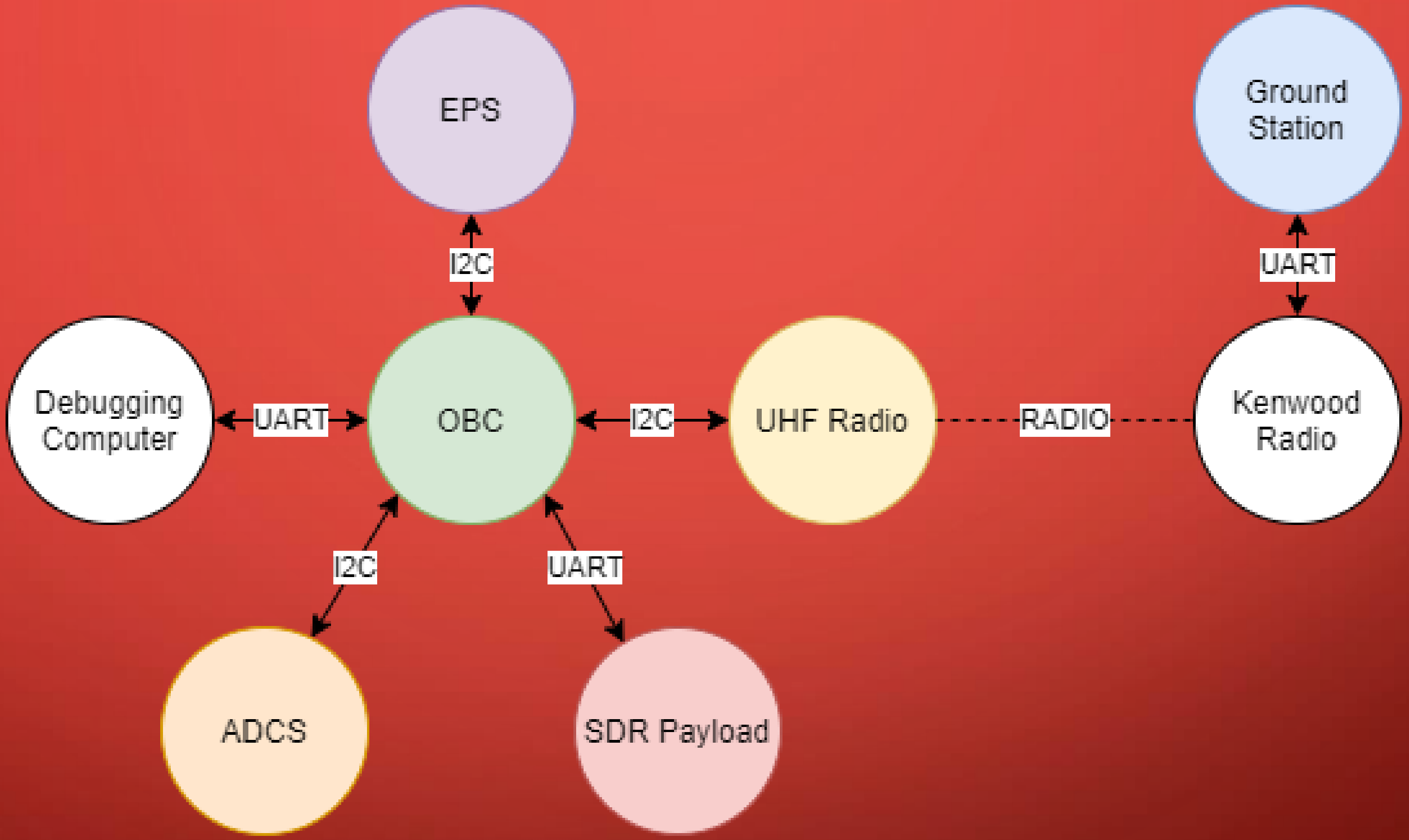
Dr. Phillip Jones

PROJECT VISION – WHAT IS CYSAT?

- 3U Cube Satellite built by ISU Students
- Orbit earth for 6 months
- Collect soil moisture data and relay the data back to earth



CONCEPTUAL/VISUAL SKETCH



FUNCTIONAL REQUIREMENTS

- Must power up no earlier than 30 minutes after deployment from the International Space Station
- Must stabilize and point itself towards earth for data collection
- Must take soil moisture readings from Earth via a microwave radiometer
- Must be capable of transmitting SDR data back to the ground station in Ames, IA at a rate of 400 kb per week while within 500km of the Ground Station
- Must operate battery heaters based on the current operating temperature so as to prevent battery charging at temperatures below 0° C
- Must disable 3.3 V and 5 V outputs if the operating temperature is greater than 55° C or if battery voltage falls below 3.5 V

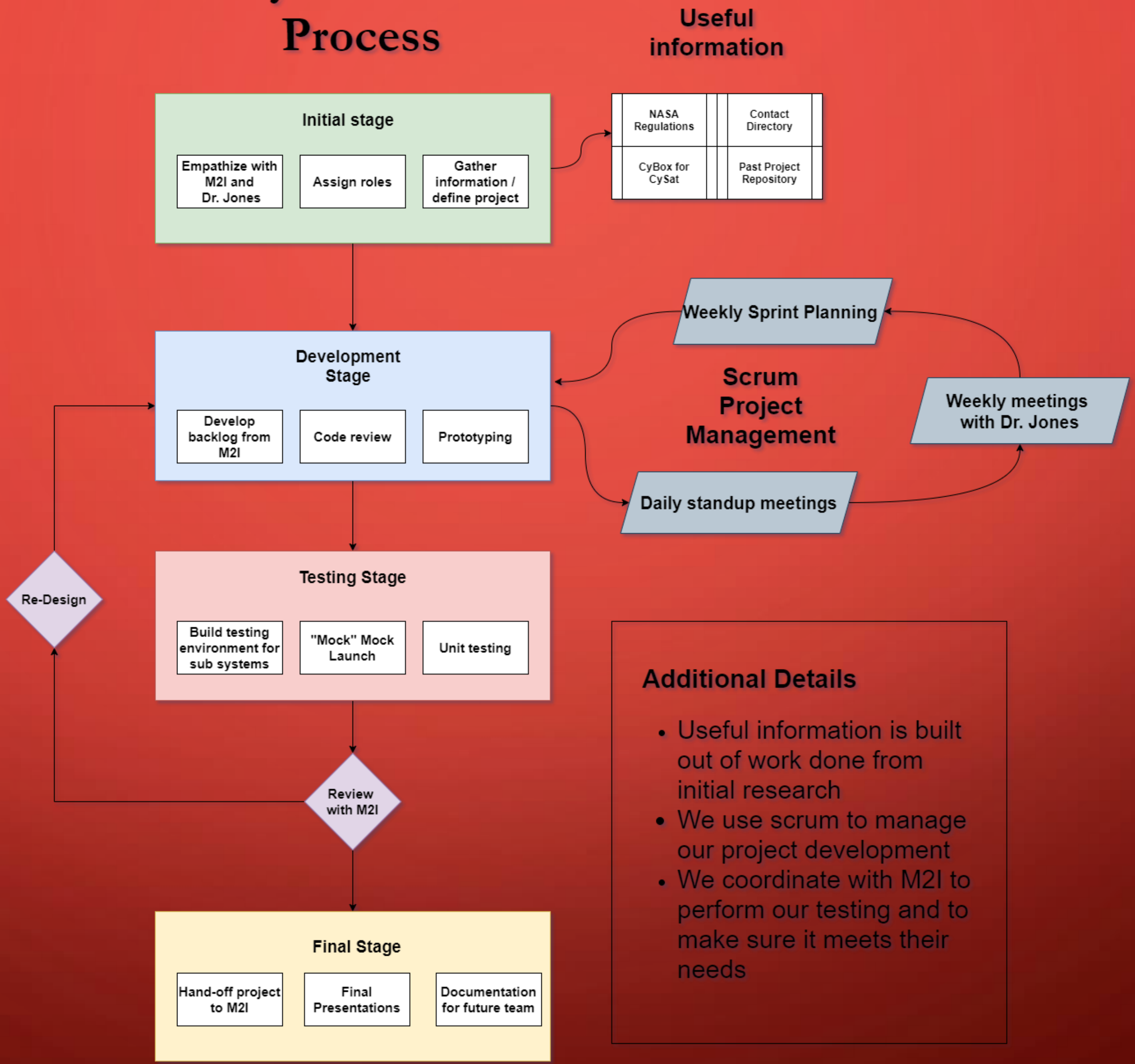
FUNCTIONAL REQUIREMENTS CONT'D

- Must collect data for its orbit life, a minimum of 2 months and a maximum of 6 months
- Must meet NASA's CubeSat standards and regulations
- Must receive and execute commands issued by the Ground Station while within beacon range (500 km)
- Ground Station must keep logs of sent/received commands and data, separated daily or weekly
- Must successfully deorbit at the end of its lifespan, estimated to be 221 days
- Must begin detumbling when total orbital spin exceeds 40 rads/second

NON-FUNCTIONAL REQUIREMENTS

- Ground Station UI must be performant and fault tolerant (minimal downtime, error recovery)

CySat Team Process



Additional Details

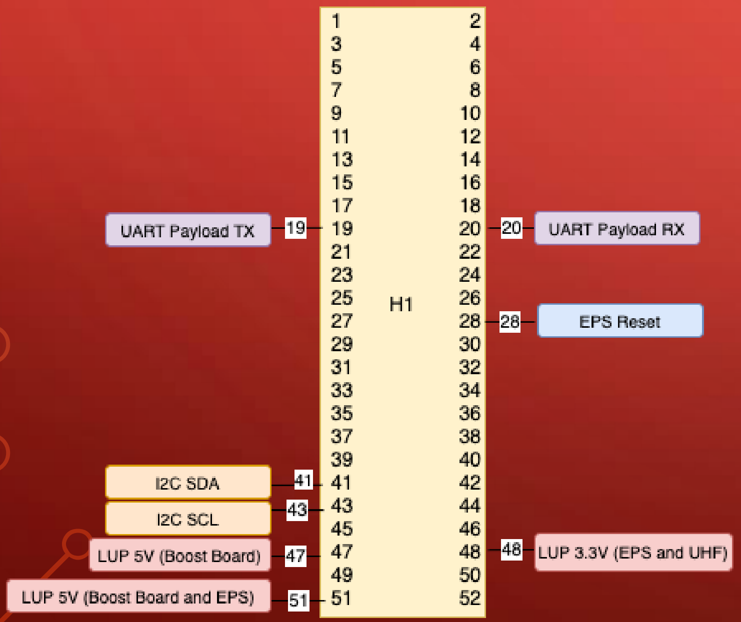
- Useful information is built out of work done from initial research
- We use scrum to manage our project development
- We coordinate with M2I to perform our testing and to make sure it meets their needs

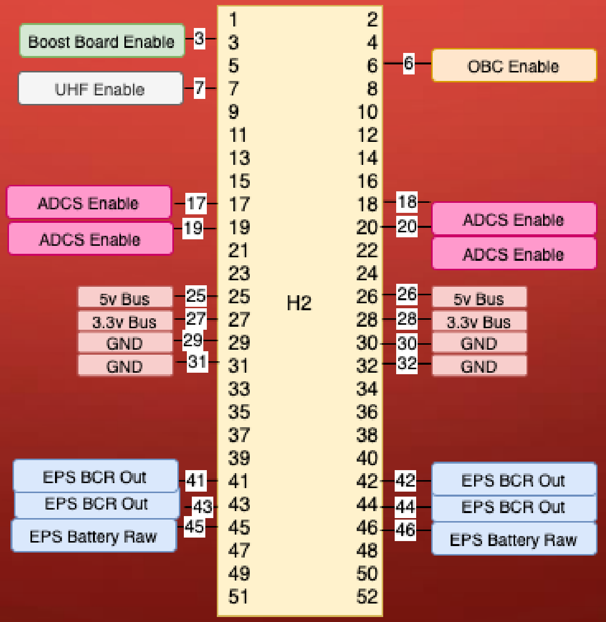
PROJECT PLAN

MILESTONES / DESIGN

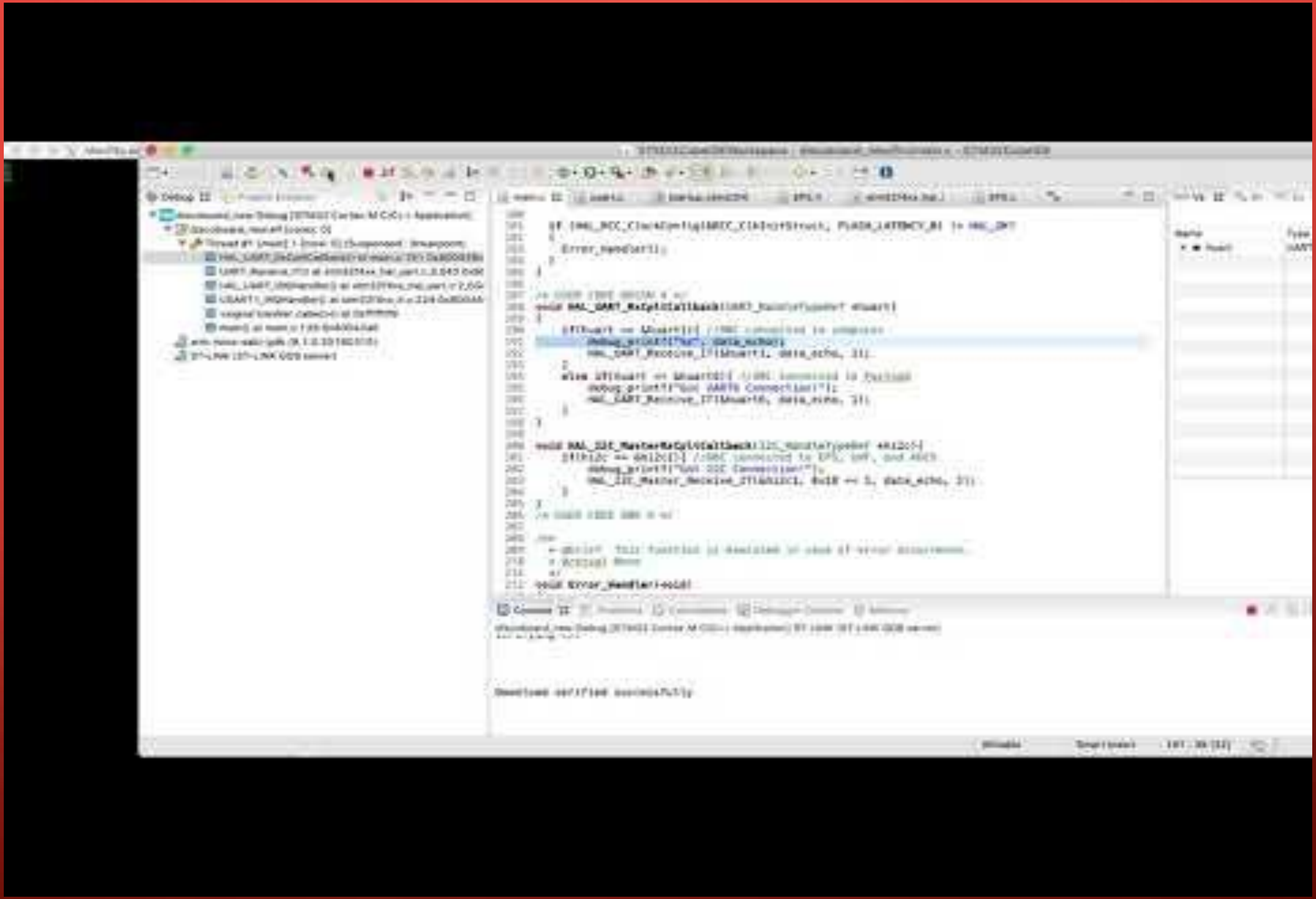
ON-BOARD COMPUTER(OBC)

- Why Endurosat OBC?
- Communication with Interrupts
- Bootloader for Live Patches





OBC DEMO



GROUND STATION

- Ground Station Communication
- Ground Station Command Protocol
- Data and Command Logging
- Subsystem Health Visualization
- User Testing (Ongoing)

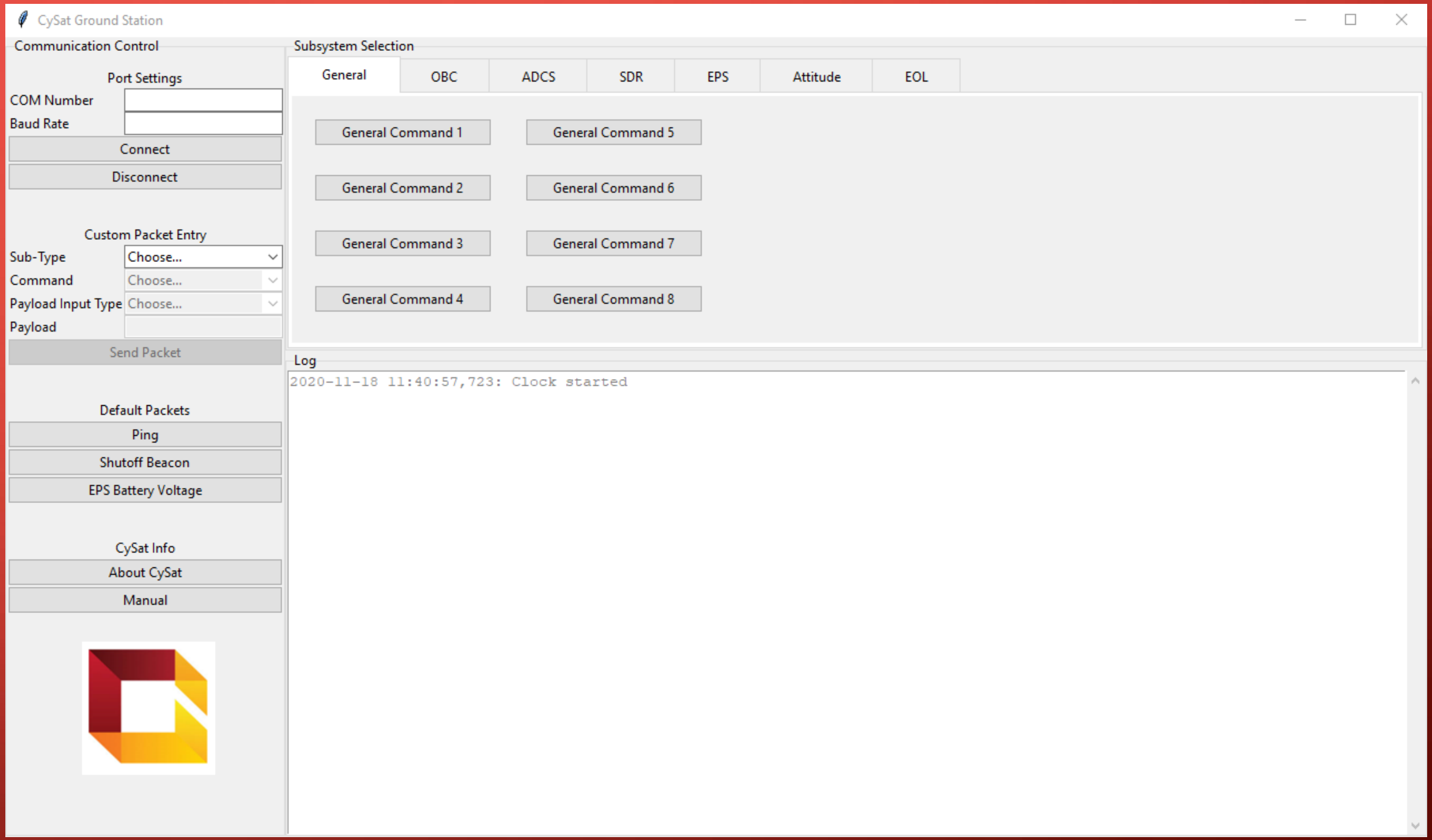
CySat Packet Protocol

- Ensures data consistency
- Longitudinal Parity or CRC Checksum

Start Character 0xff	Subsystem Type (1 byte)	Command (1 byte)	Data Length (1 byte)	Data (N bytes)	Checksum (1 byte)

GROUND STATION PROTOTYPE

- Ground Station UI Wireframed and Partially Implemented by Previous Team
- Serious rewrite necessary



ULTRA-HIGH FREQUENCY RADIO(UHF RADIO)

- Communication from computer into radio for debugging
- Establish connection between Kenwood and UHF
- Communication with Ground Station
- Receive and Send commands to OBC
- Receive and send packets from Ground Station and OBC

```
=~=~=~=~=~=~=~=~=~=~=~= PuTTY log 2012.11.13 13:47:12 =~=~=~=~=~=~=~=~=~=~=~=
ES+R2201 CA8FBE89
OK+0076620F41
```

ELECTRICAL POWER SYSTEM (EPS)

- EPS Communication with OBC via I2C
- Health Checks
- Charge and Discharge
- Battery Protection

- 3.3V and 5V outputs
- Solar panels fabricated by M:2:I

EPS COMMUNICATION FORMAT

Figure 2a: Typical I2C READ Command Communication (e.g. "Battery Voltage", Command 1)

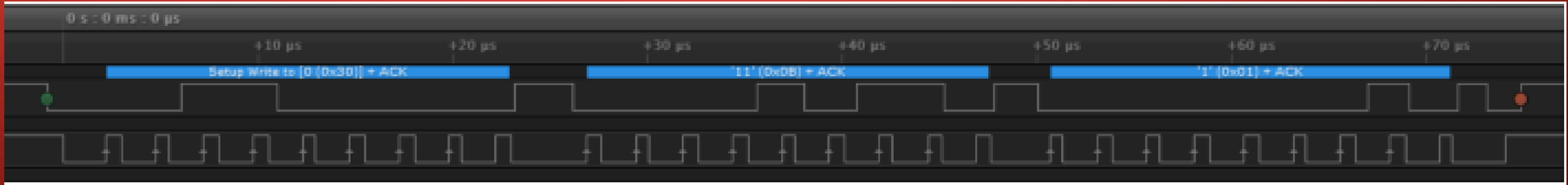
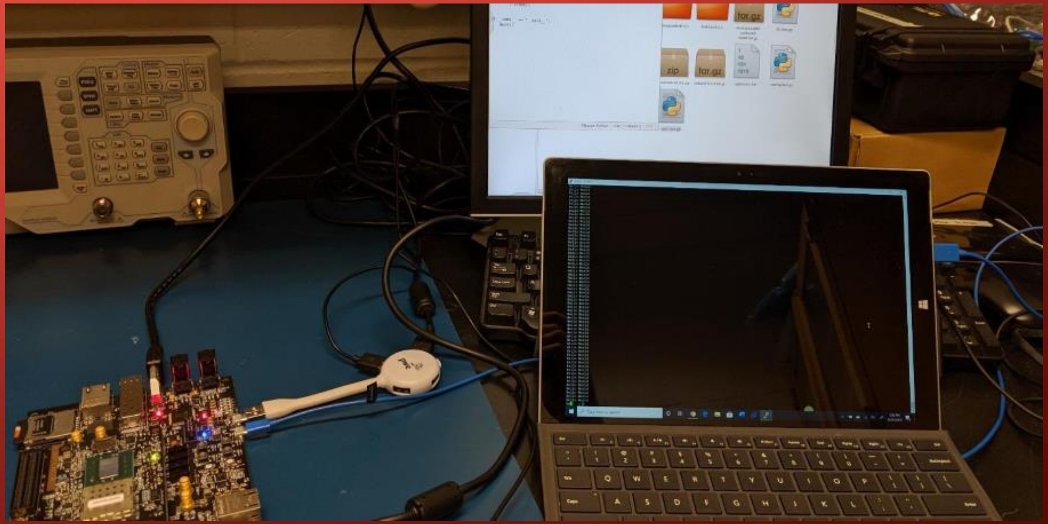


Figure 2b: Typical I2C WRITE Command Communication (e.g. turning ON the "Out 1")

SOFTWARE DEFINED RADIO PAYLOAD(SDR PAYLOAD)

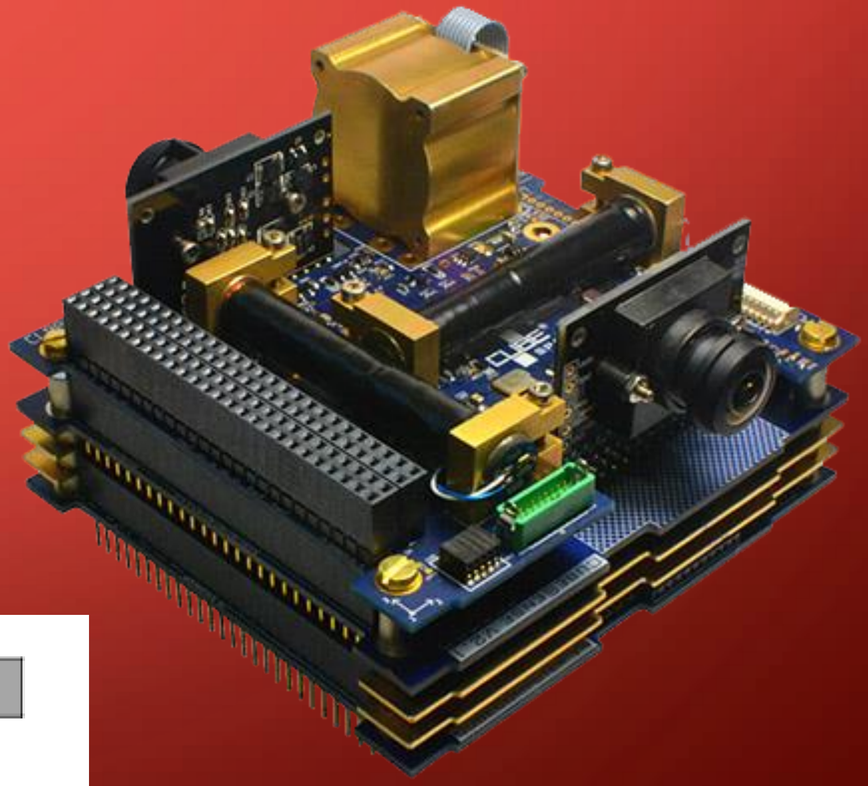
- Communication with OBC
- Data Collection Testing
- Payload Functionality Integration with OBC



ATTITUDE DETERMINATION AND CONTROL SYSTEM (ADCS)

- Orientation of the Satellite
- Storage of Telemetry Data

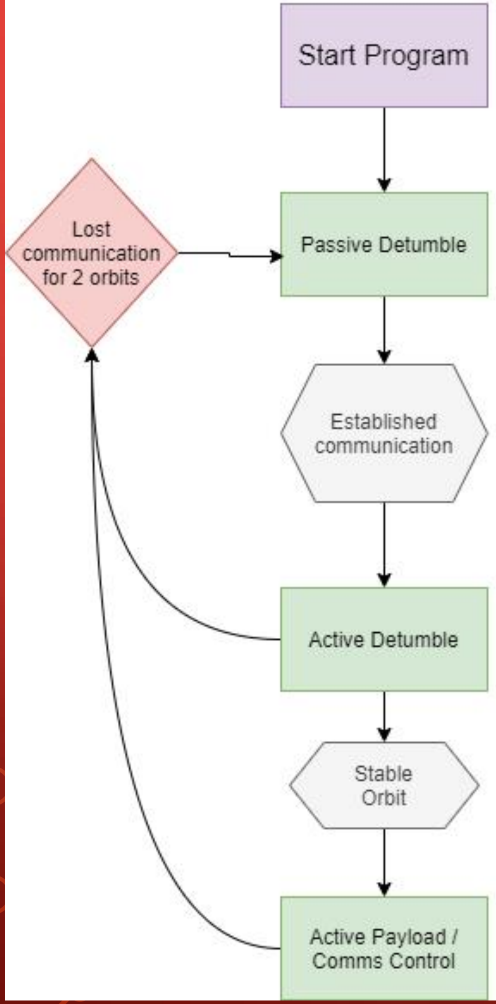
- Mode Activation Control
- I2C Communication



S	0xAE	TC ID	TC data 0	...	P
	Master writes node address (write operation)	Master writes telecommand ID	Master writes data bytes		

ADCS MODE CONTROL

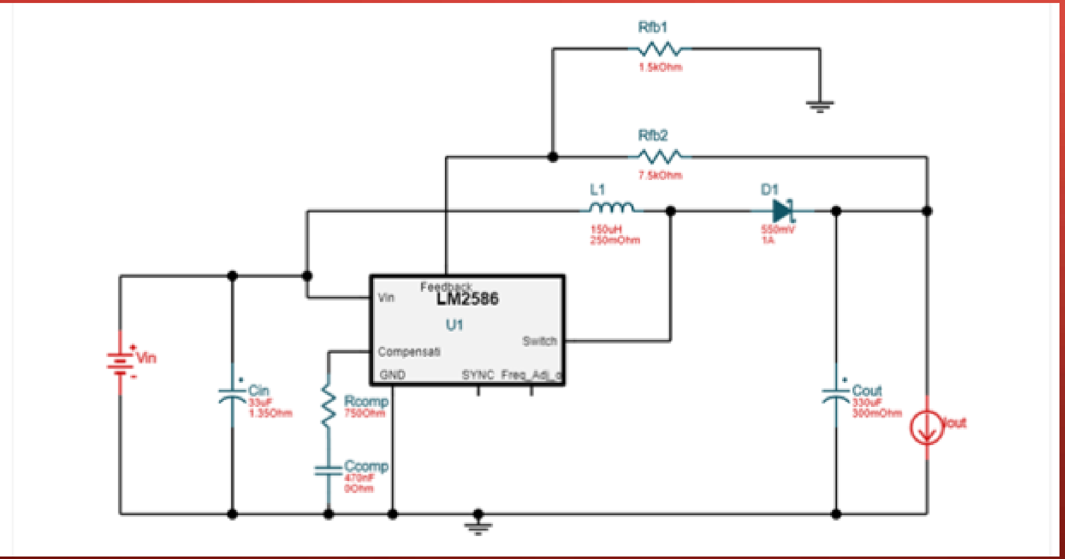
High level mode workflow

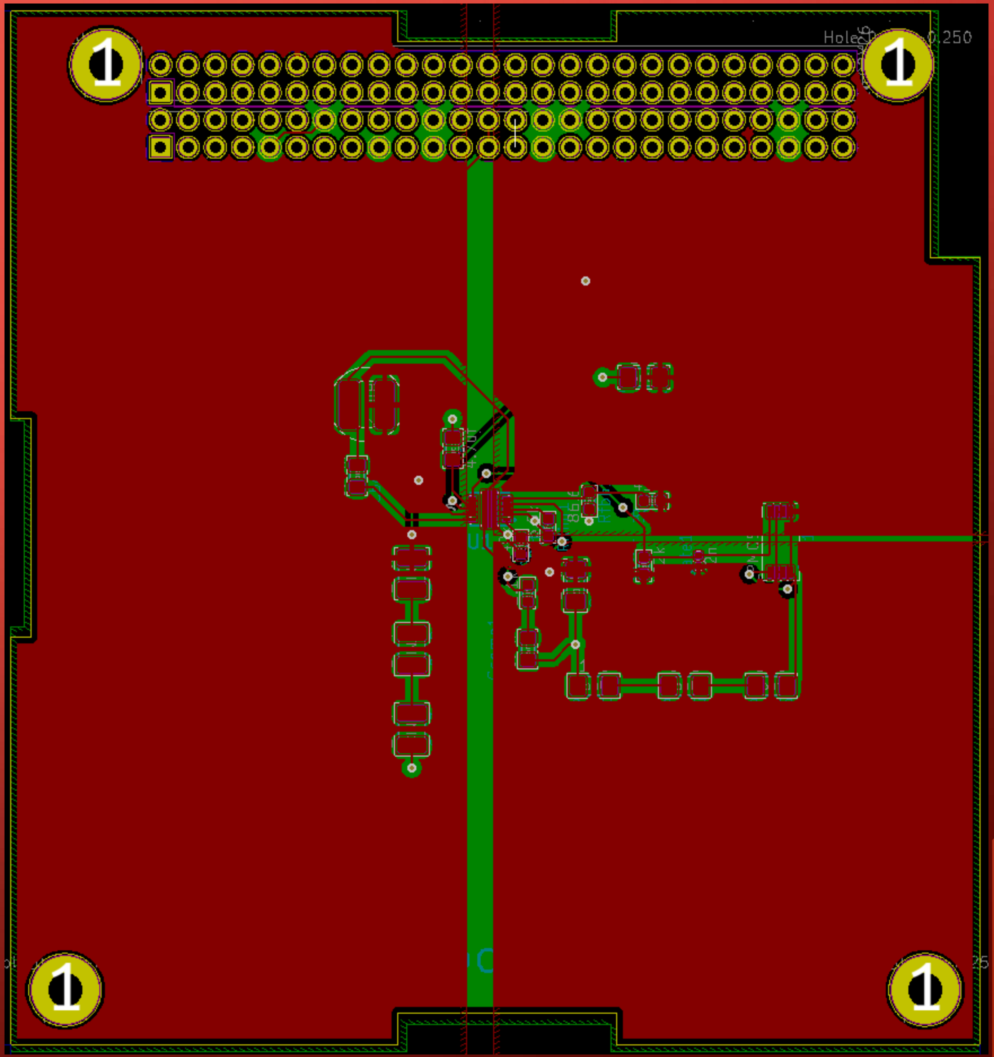


Part	Order #	Step	Page
Passive Detumble (1)	**1**	Determine initial angular rates	3
Passive Detumble (1)	**2**	Initial detumbling	4
Passive Detumble (1)	**3**	Continued detumbling to Y-Thomson	5
Active Detumble (2)	**4**	Magnetometer deployment	6
Active Detumble (2)	**5**	Magnetometer calibration	7
Active Detumble (2)	**6**	Angular rate and pitch angle estimation	8
Active Detumble (2)	**7**	Y-wheel ramp-up test	9
Active Detumble (2)	**8**	Initial Y-momentum activation	10-11
Active Detumble (2)	**9**	Continued Y-momentum activation and magnetometer EKF	11
Active Detumble (2)	~	Adjusting settings to increase Y-momentum performance	12
Active Detumble (2)	**10**	CubeSense sun/nadir commissioning	13
Active Detumble (2)	**11**	EKF activation with sun and nadir measurements included	13
Active Detumble (2)	~	Adjusting settings to troubleshoot sun/nadir sensor parameters	14
Active Detumble (2)	~	Image capturing, saving, and downloading of CubeSense image	14
Active Overpass/Payload/Comms Control (3)	**12**	Adjust pitching angle for payload data and/or better communication	15
Active Overpass/Payload/Comms Control (3)	**13**	Updating satellite data and monitoring errors	16

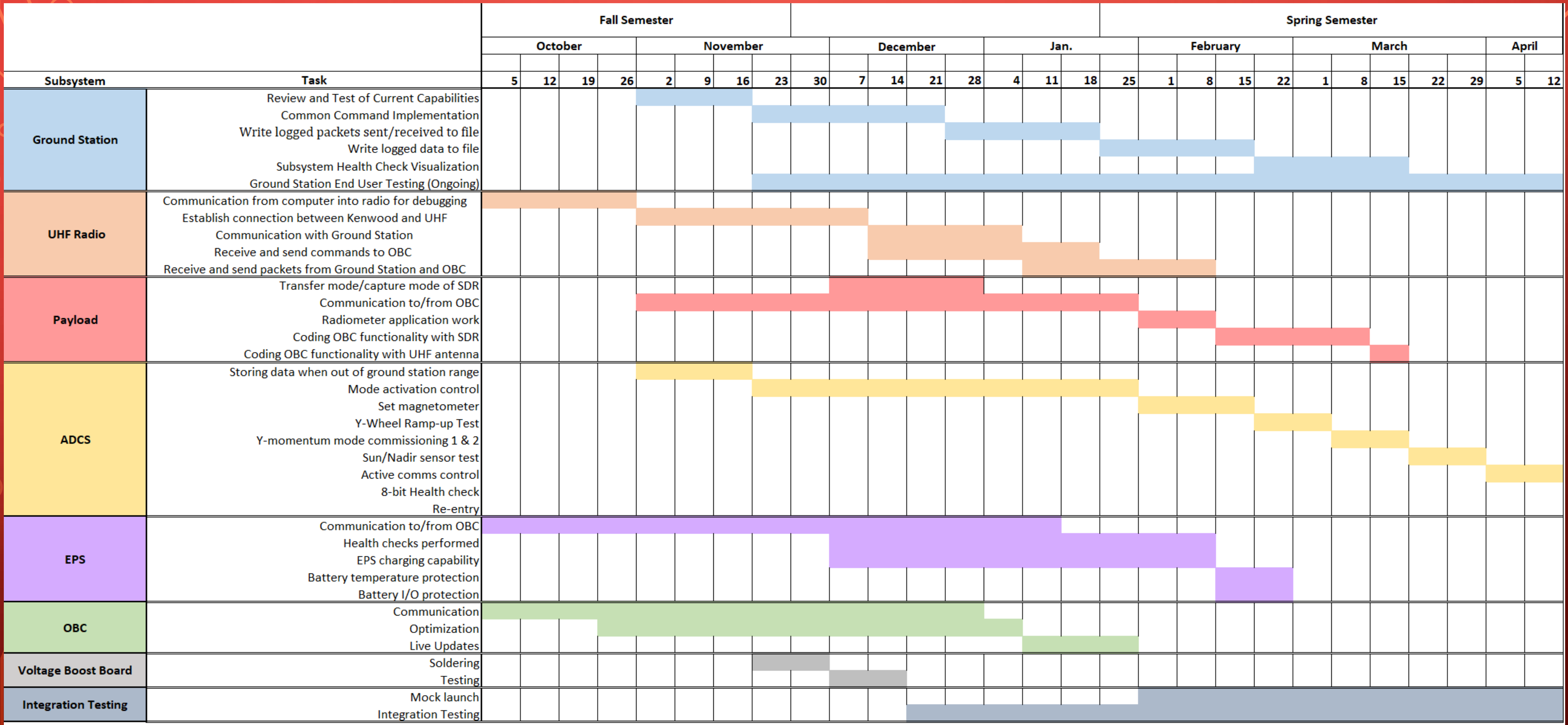
VOLTAGE BOOST BOARD

- Construction and Testing

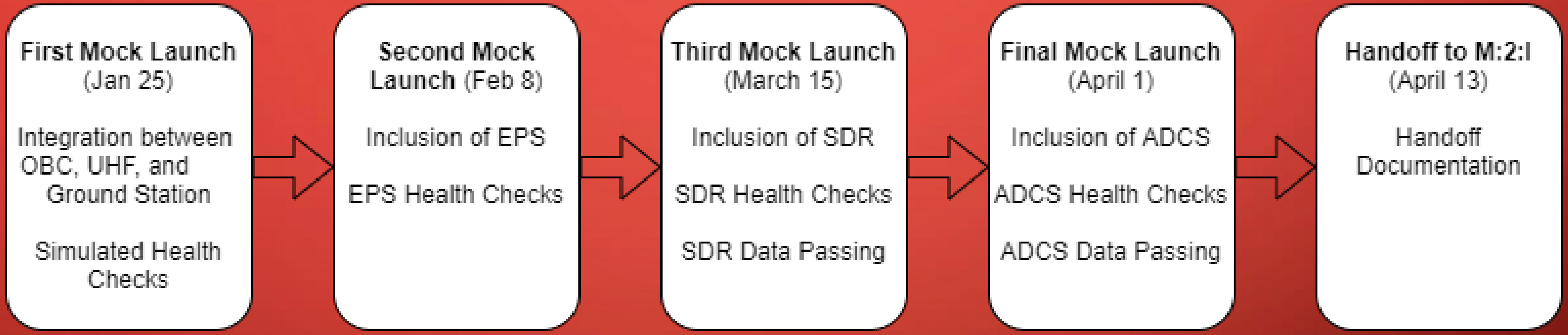




PROJECT TIMELINE/SCHEDULE



TEAM MILESTONES



TEST PLAN

- Subsystem integration will be tested by performing a series of mock launches, which simulate the ejection of the satellite up until the initial health check
- The Ground Station and other subsystems will write unit tests to ensure adherence to communication protocol and packet encoding/decoding
- The Boost Board will be tested by connecting a dummy load and measuring the current for an extended period

EFFORT HOURS

Substem	Task	Description	Hours Estimated	Hours Completed	Projected Completion %
Ground Station	Review and Test of Current Capabilities	Check status of Sending, receiving, interpreting, and responding to data	20	20	95%
	Common Command Implementation	Implementation of common commands to be sent to CySat	20	10	75%
	Write logged packets sent/received to file	Permanent storage of command sent/received and system logs	15	0	0%
	Write logged data to file	Permanent storage of payload data	15	0	0%
	Ground Station Visualization Capabilities	Visualization of Satellite/Subsystems	15	0	0%
	Ground Station End User Testing (Ongoing)	User testing of Ground Station with M:2:I	30	0	0%
	--	Total hours for Ground Station	115	30	28%
UHF Radio	Receive and send packets from computer into radio for debugging	Hello world, Packet structure, addtional functional	30	30	100%
	Establish connection between Kenwood and UHF	Kenwood to UHF Beacon communication	25	6	10%
	Communication with Ground Station	Ability to receive packets sent from Ground Station	15	0	0%
	Receive and send commands to OBC	Line of communctation between the satellite and its users	25	0	0%
	Receive and send packets from Ground Station and OBC	Integration between OBC and Ground Station communcation	25	0	0%
	--	Total hours for UHF Radio	120	36	30%
Payload	Transfer mode/capture mode of SDR	Sending/collecting data via the SDR	20	0	0%
	Communication to/from OBC	Being able to send or receive data between SDR & OBC	45	15	50%
	Radiometer application work	Getting application to run on embedded Linux start up	10	0	0%
	Coding OBC functionality with SDR	Programming the OBC to be able to command the SDR using UART	20	0	0%
	Coding OBC functionality with UHF antenna	Programming the OBC to transfer data using the UHF antenna	20	0	0%
	--	Total hours from Payload	115	15	10%
ADCS	Initial rate estimation	Backup and verification of the Kalman filter output	12	2	30%
	Detumbling	Reduce the total rotation velocity	12	2	30%
	Mode activation control	Major component of programing the ADCS, flow control for op modes	40	20	27%
	Magnometer deployment	Limit the magnetic disturbances caused by the satellite bus	12	2	30%
	Y-momentum mode activation	The mode used for initial commisioning attempts	12	0	0%
	Sun/Nadir sensor test	Testing of sun sensor for determining position	12	0	0%
	Angular rate and ptich estimation	Estimate the values from magnetometer measurements	12	2	30%
	Set magnetometer configuration	Compute magnetometer offset and sensitivity matrix	15	2	20%
	--	Total hours for ADCS	127	30	22%
EPS	Communication to/from OBC	Update I2C to new version	40	10	25%
	Health check	New I2C protocols add more parameters to be checked	25	5	20%
	Charging and discharging	Measure and calculate the energy v. time of the batteries	30	3	10%
	Battery protection	Change operation based on the data from the health check	15	0	0%
	--	Total hours for EPS	110	18	16%
OBC	Communication to all Subsystems	Sending, receiving, interpreting, and responding to all other subsystems	30	0	0%
	Optimization	Use interrupts for UART and I2C	30	15	75%
	Live Updates	Create bootloader that allows for live patches	30	0	0%
	Land Tests	Implement mock mock launch, mock launch, and mock mission	50	0	0%
	--	Total hours for OBC	140	15	19%
Voltage Boost Board	Soldering	Solder Components on Fabricated PCB	10	0	0%
	Testing	Testing for 5V to 7.4V Amplification	10	0	0%
	--	Total hours for Voltage Boost Board	20	0	0%

CONCLUSION

- Mission Design
- On schedule for the April launch date
- Continued progress during the winter term
- Team Progress
- Team Challenges

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Q & A