ABIS Design Review

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Algae Bloom Imaging Satellite

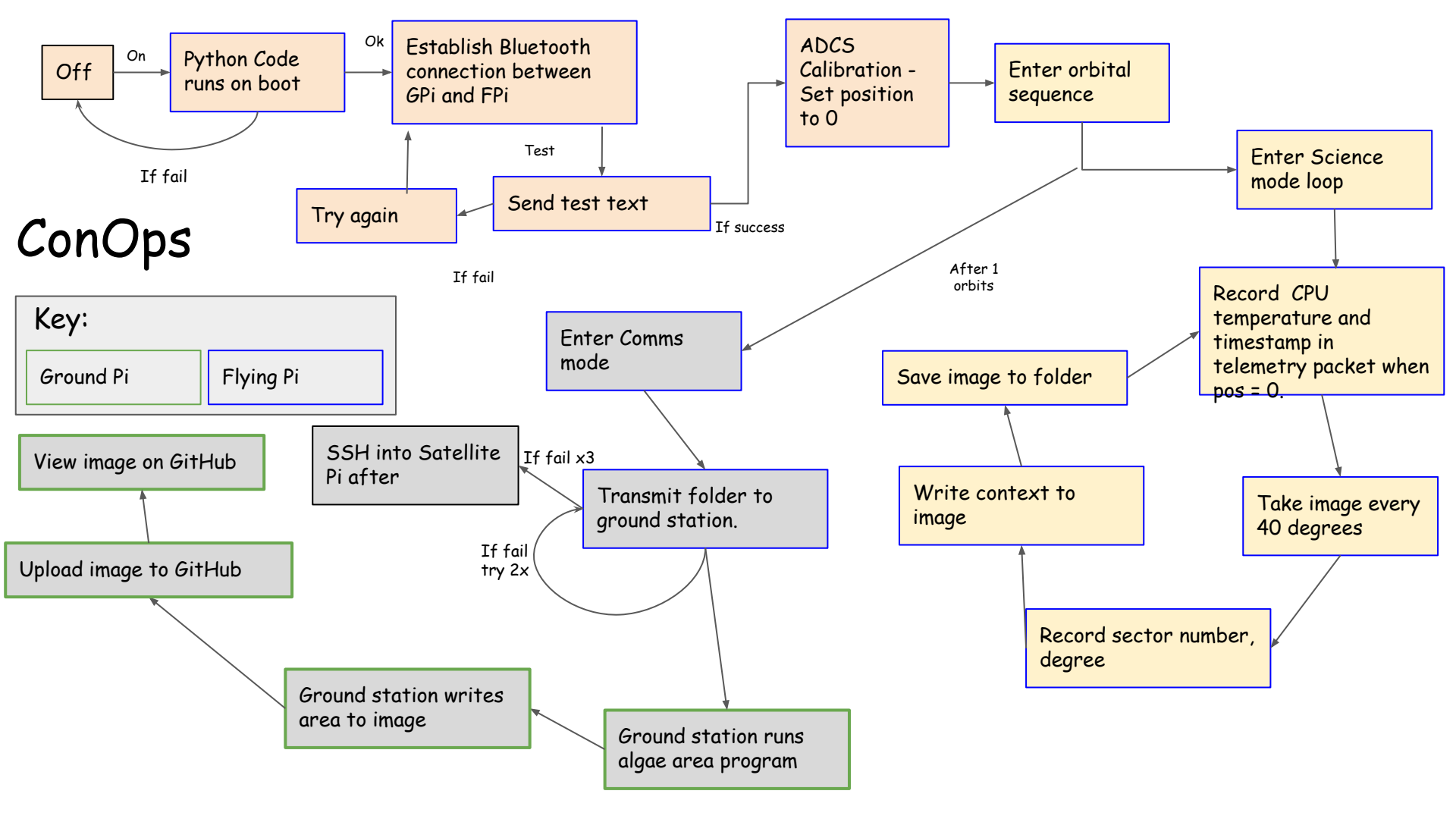
System Requirements

Orbiter Requirements:

- The orbiter shall make an "orbit" once every minute for 10 minutes.
  - Verifiable by making sure that there are 10 orbits in total and each orbit takes one minute.
- The "Cubesat" in the orbiter shall be contained within a 10 cm cubed volume.
  - Verifiable by keeping everything except the solar panel contained inside the CubeSat structure.
- The orbiter shall capture images of red algae blooms by taking a picture on degree intervals..
  - Verifiable by visually checking if each bloom is captured.
- The orbiter shall transmit the images of the algae blooms to the ground station along with location measurements.
  - Verifiable by checking the ground station pi for images of the algae blooms and if they have the measurements.
- The orbiter shall transition between different software modes during different phases of image capture to minimize power consumption.
  - Verifiable by reading print statements.

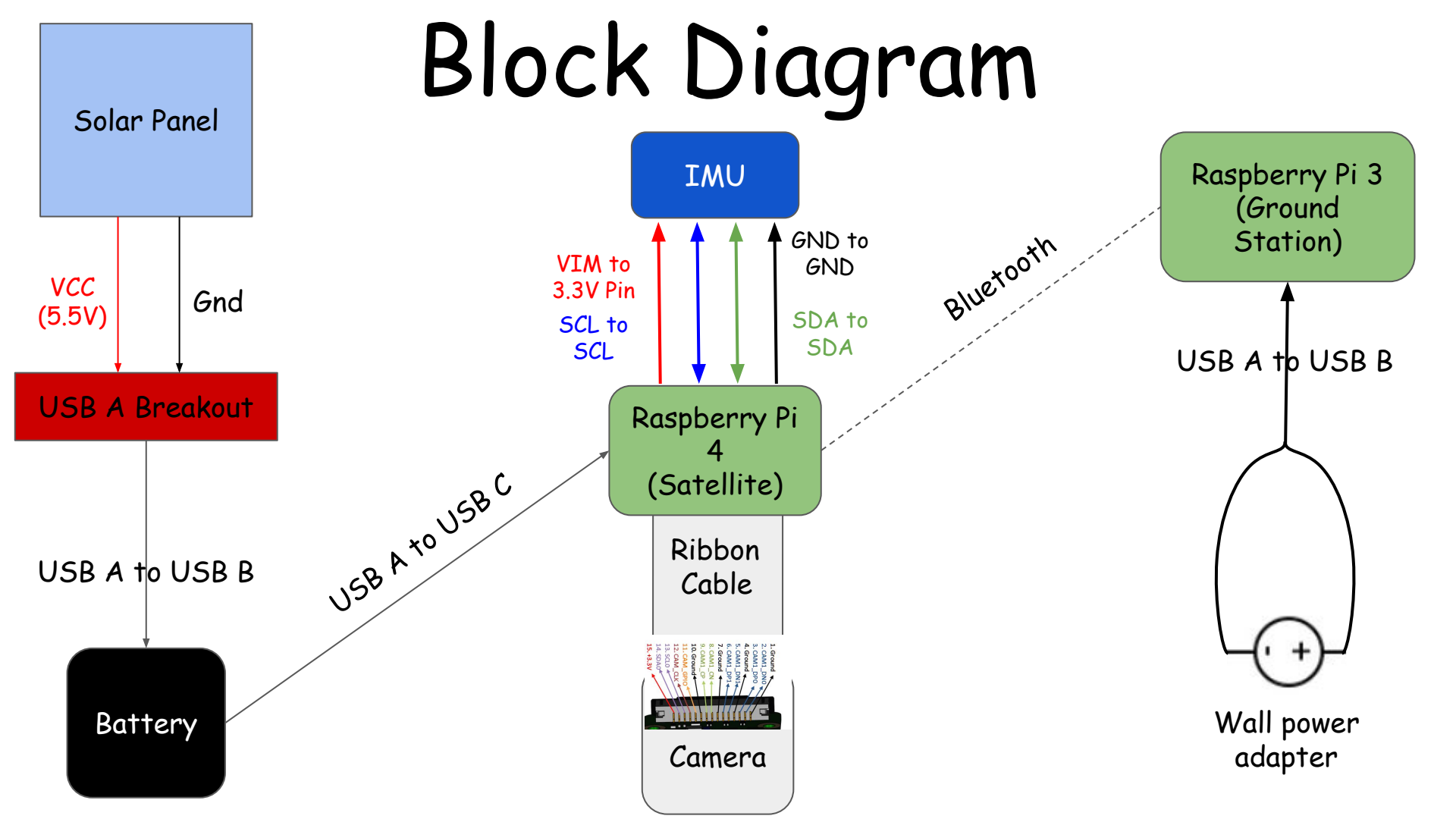
Ground Station

- The ground station shall receive the images and location data wirelessly from the orbiter.
  - Verifiable by checking the storage for images taken by the orbiter and not using a wire to connect the two pis.
- The ground station shall be able to send commands to the orbiter remotely.
  - Verifiable by sending commands to the orbiter and the orbiter follows those commands.
- The ground station shall be able to denoise and analyze the image to determine the area of the algae bloom in square millimeters.
  - Verifiable by comparing the original image to the edited image to test denoising, and if the area outputted matches the actual area.
- The ground station shall add EXIF data containing the bloom area and location to the image and upload the image to github.
  - Verifiable by downloading the images off of github and checking if the image has EXIF data.

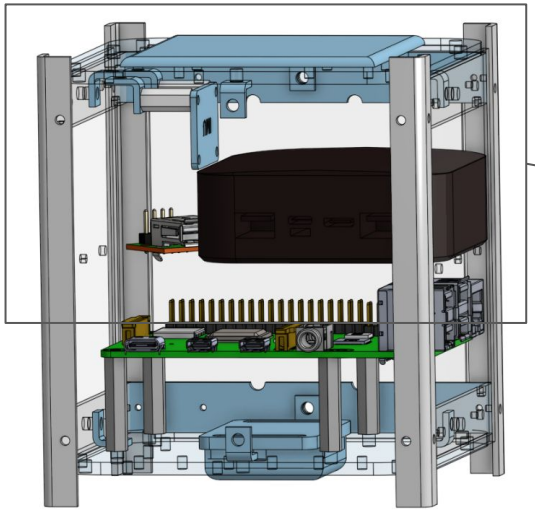

Off
On
Python Code runs on boot
If fail
Ok
Establish Bluetooth connection between GPi and FPi
Test
Send test text
Try again
If fail
If success
ADCS Calibration - Set position to 0
Enter orbital sequence
Enter Science mode loop
After 1 orbits
Record CPU temperature and timestamp in telemetry packet when pos = 0.
Take image every 40 degrees
Record sector number, degree
Write context to image
Save image to folder
Enter Comms mode
Transmit folder to ground station.
If fail try 2x
SSH into Satellite Pi after
If fail x3
Ground station runs algae area program
Ground station writes area to image
Upload image to GitHub
View image on GitHub
Key:
Ground Pi
Flying Pi

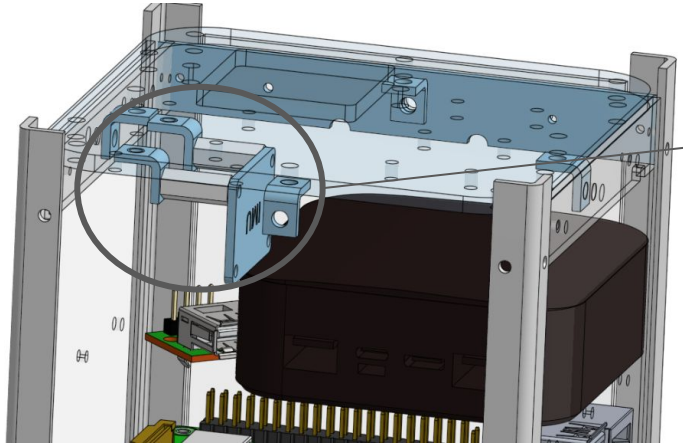
ConOps

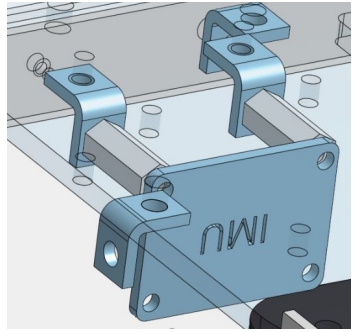
Block Diagram

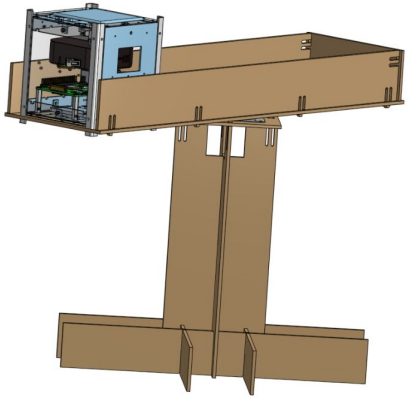


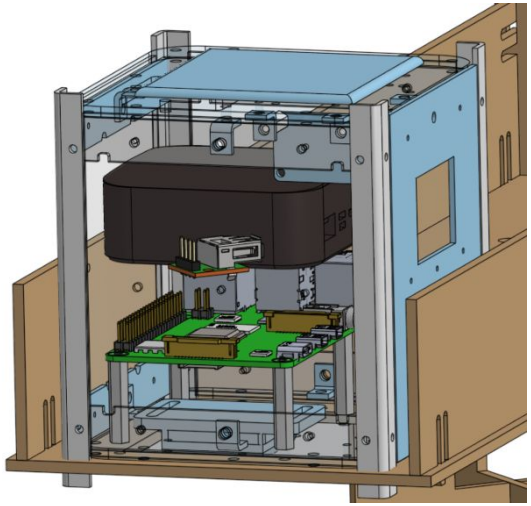
Mechanical Layout

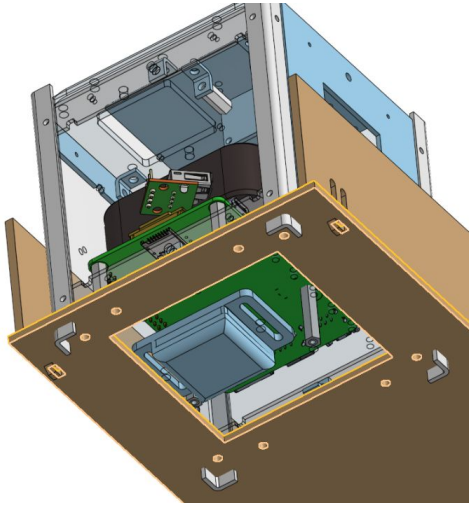




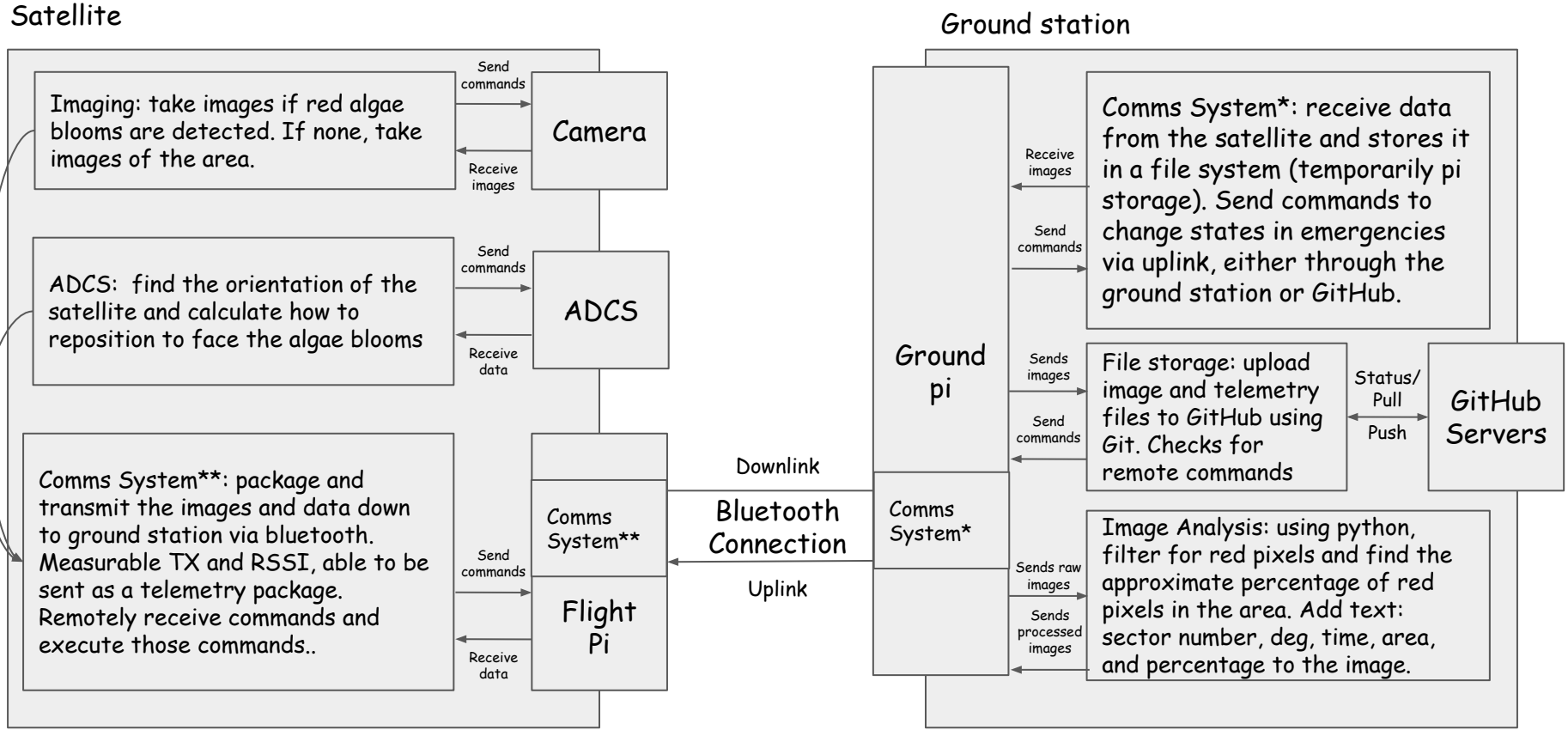




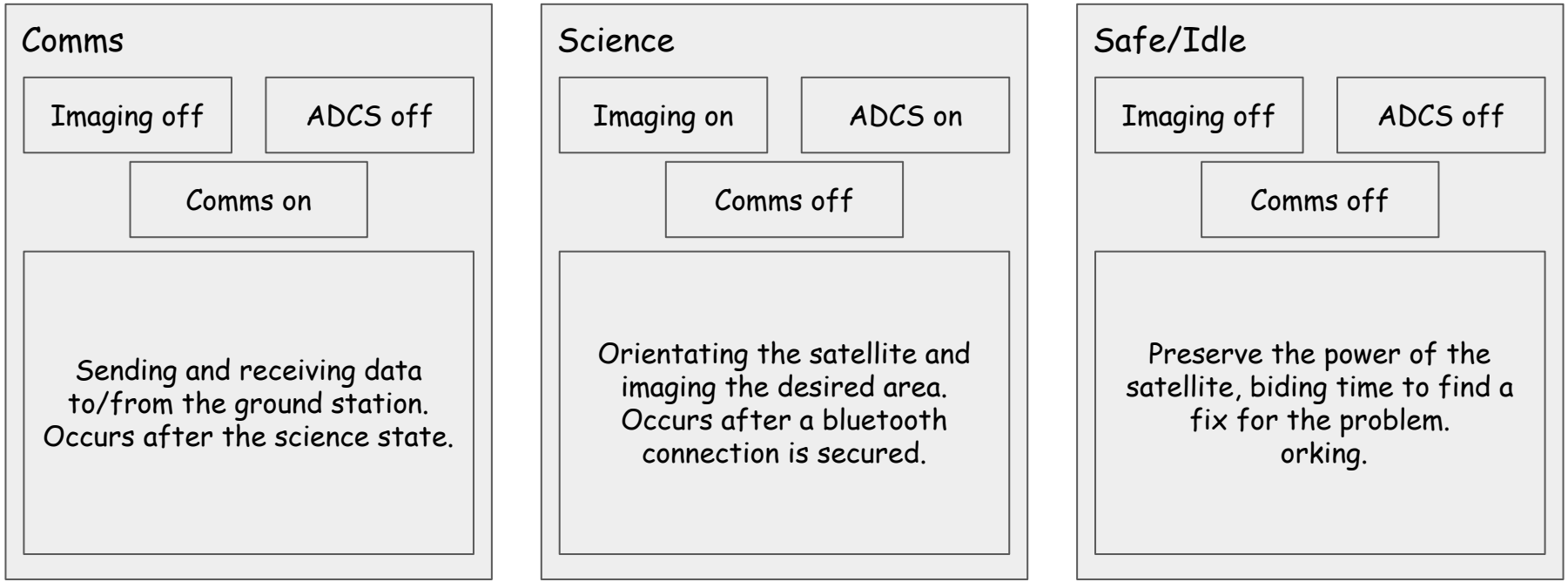




Software Architecture



Software Architecture - States



∫∫∫∫and Test Plan

Software Integration
- Individual functions tested on developer's system
- Developer writes README for program if necessary
- Uploads to GitHub for others' access
- Other team members test code on their systems to see if it works

Building and Testing Flight System
- CAD models shared with team on OnShape
- Test IMU, camera, and transmit functions of the CubeSats separately in mission simulations

Validate and Verify
- Demonstrate camera, IMU, and transmit functions match mission requirements.
- Status data collection also tested separately, and will be pair tested with transmit data function and IMU function

Mass Budget and Bill of Materials

Material	Cost/unit (usd)	Quantity	Cost	Weight/unit (g)	Total Comp Mass (g)	Margin (%)	Mass w/ Margin (g)	Materials
CubeSat	--	--	--	--	--			
Raspberry Pi 4	$35.00	1	$35.00	46	46 g	10	50.6	Mixed
Micro SD Card	$8.00	1	$8.00	2	2 g	10	2.2	Mixed
Raspberry Pi NIOR Camera	$30.00	1	$30.00	3.4	3 g	10	3.74	Mixed
Raspberry Camera Case	$3.00	1	$3.00	15	15 g	10	16.5	Mixed
IMU	$40.00	1	$40.00	9	9 g	10	9.9	Mixed
Power Bank/ Battery	$33.00	1	$33.00	185	185 g	10	203.5	Mixed
Solar Panel with USB Attachm	$15.00	1	$15.00	50	50 g	10	55	Mixed
Right Angle USB Cable	$12.00	1	$12.00	75	75 g	10	82.5	Mixed
Acrylic CubeSat Panels	$2.00	6	$12	30	180 g	10	198	Mixed
Acrylic Side Brackets	$2.00	10	$20.00	4	40 g	10	44	Mixed
Aluminum Corner Rails	$3.00	4	$12.00	10	40 g	10	44	Aluminum
2-56 x 3/16'' Pan Head Screw	$0.32	32	$10.24	1	32 g	10	35.2	Aluminum
4-40 x 1/4'' Pan Head Screws	$0.35	8	$2.80	1	8 g	10	8.8	Aluminum
4-40 x 1/2'' Pan Head Screws	$0.39	8	$3.12	1	8 g	10	8.8	Aluminum
4-40 hex nuts	$0.50	30	$15.00	1	30 g	10	33	Aluminum
2-56 1/2'' Nylon Standoffs	$0.38	4	$1.52	1	4 g	10	4.4	Nylon
4-40 1'' Nylon Standoff	$0.52	4	$2.08	1	4 g	10	4.4	Nylon
4-40 L Bracket	$0.40	10	$4.00	3	30 g	10	33	Aluminum
		Total Cost	$258.76			Subsystem Mass:	837.54	
Orbiter/Images								
MDF parts	$20.00	1	$20.00	800	800 g	10	880	Wood Laminate
Lazy susan bearing	$5.00	1	$5.00	120	120 g	10	132	Aluminum
4-40 x 1/4'' Pan Head Screws	$0.35	4	$1.40	1	4 g	10	4.4	Aluminum
4-40 x 1/2'' Pan Head Screws	$0.39	4	$1.56	1	4 g	10	4.4	Aluminum
4-40 hex nuts	$0.50	8	$4.00	1	8 g	10	8.8	Aluminum
11'' x 17'' Images	$3.00	6	$18.00	7	42 g	10	46.2	Paper
		Total Cost	$49.96			Subsystem Mass:	0	
Ground Station								
Raspberry Pi 3	$35.00	1	$35.00	46	46 g	**10**	50.6	Mixed
Mirco USB Cable	$12.00	1	$12.00	75	75 g	**10**	82.5	Mixed
		Total Cost	$47.00			Subsystem Mass:	133.1	

Power Budget

Spacecraft Subsystem, Unit, Quantity and Power Consumption								
Component/ Use Case	Voltage (V)	Current (A)	Peak Power(W)	Contingency (%)	Peak Power(W) + Contingency	Qty	Comment	Total Power Per Hour (W)
Core Avionics								
Sensor IMU	3.30	0.0027	0.0089	15.00	0.01	1		0.01
Pi Camera	5.00	0.25	1.25	10.00	1.40	1		1.4
Raspberry Pi4	5.00	0.60	3.00	10.00	3.30	1		3.3

		Power Consumption by Spacecraft Mode							
Comm		Sleep		Commissioning		Safe		Nominal	
Duty Cycle	Mode Power	Duty Cycle	Mode Power	Duty Cycle	Mode Power	Duty Cycle	Mode Power	Duty Cycle	Mode Power
0.00%	0.00	0.00%	0.00	100.00%	0.01	100.00%	0.02	100.00%	0.02
0.00%	0	0.00%	0.00	100.00%	1.40	0.00%	0.00	0.00%	0.00
100.00%	3.30	0.00%	0.00	100.00%	3.30	100.00%	3.30	100.00%	3.30

Link Budget and Data Budget

Downlink Budget		Notes	Uplink Budget	
Center Frequency	2400 MHz	based on bluetooth	Center Frequency	2442.5 MHz
Satellite Tramsit Power	-13.01 dBW		Ground Station EIRP	-13.01 dBW
SatelliteTramsit Gain	0 dBi		Distance to Satellite	0.26 m
EIRP	-13.01 dBW		Free Space Loss	28.5 dB
Distance to Earth	0.26 m		Satellite Antenna Gain	0 dBi
Free Space Loss	28.34 dB		Received Power	-17.21 dBM
Ground Antenna Figure of Merit	-0.0644 dB/K		Minimum Received Power	-76 dBM
Signal to Noise Ratio	-12.79 dB		Link Margin	58.79 dB
Data Rate	1000 kbps			
Eb/No	21.084 dB			
Required Eb/No	3 dB			
Link Margin	18.084 dB			
Time to Downlink 1 Image	5sec			
Estimated Size of an Image	135 KB			
Total Data Sent of the Duration of all Orbits	1500 KB			
Images Downlink/Uplink Rate	145.800 MHz			

Top Level (Whole mission duration)