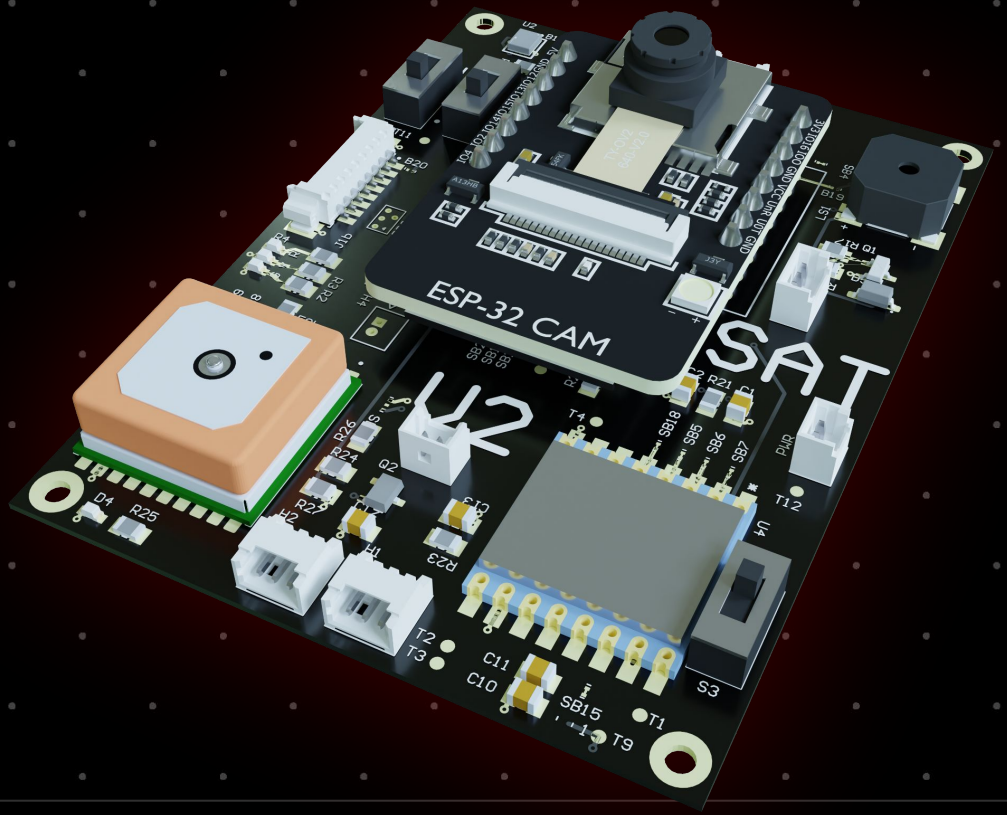
Q-Sat CDR

Critical Design Review

Names: Anton, Jasper, Joel, Taine, William
Team: Questionable Satellites
Date: 2025-02-09

github.com/questionable-innovations/QSAT_2024-2025



Concept Review

The MOST RETRO PSAT

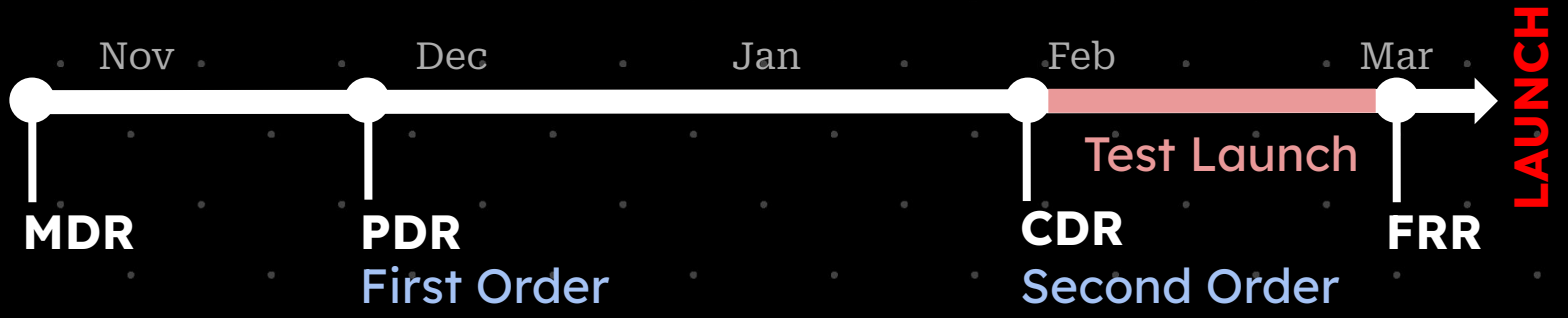
Measures of Effectiveness

1. Number of photos taken
2. Quality of film post-flight
3. Quality of photos post-development

Target: Take at least one photo of identifiable features.

Technical Schedule

Timeline:
- 9th February - 2nd Order & Critical Design Review (CDR)
- 1st March - Test Launch
- 7th March - Launch & Flight Readiness Review (FRR)



High-Level Requirements

Req Code	Description	Parent Requirement	Reasoning
REQ-01	Shall Deploy at apogee	REQ-02, REQ-03	Payload must eject from the rocket body for the camera to take a photo
REQ-02	Shall take up to 4 photos during deployment, and up to 20 photos during descent	Objective	Mission Objective
REQ-03	Shall record time-stamped data and digital photography	Objective	Objective validation and photograph info
REQ-04	Shall be recoverable	Objective	Mission Objective - Film must be recovered for processing

Subsystem Requirements - Electrical

Req Code	Description	Parent Requirement	Reasoning
ELEC-01	Shall supply a maximum of 0.63A to servos (stall current - for winding)	REQ-02	Required for camera operation. (Objective)
ELEC-02	Shall supply a maximum of 400mA to computing and data systems	REQ-02, REQ-03, REQ-04	Should be able to support each digital subsystem all running at max power draw
ELEC-03	Battery must supply at least 1000mAh	ELEC-01	Roughly calculated energy requirements given power draw of components

Subsystem Requirements - Command & Data

Req Code	Description	Parent Requirement	Reasoning
CDH-01	Shall take and store digital photos at the same time as film	REQ-03	Objective validation and photograph info
CDH-02	Shall report live data back to the ground control unit via LoRa	REQ-04	Monitoring to help ensure objective will be attained and unit recovered
CDH-03	Shall store timestamped accelerometer and gyro data as well as when photos are taken	REQ-03	Keeps data for validation and statistics purposes
CDH-04	Shall have a processor to read data and activate shutter	REQ-02	We need a way to interpret the data and send commands to activate shutter servo

Subsystem Requirements - Camera & Environment

Req Code	Description	Parent Requirement	Reasoning
CMEV-01	Shall allow access to film pre & post flight	Objective, REQ-04	Needs access for Pre-launch processing & Post launch Recovery
~~CMEV-02~~	~~Shall not leak light in its modified form~~	~~REQ-04~~	~~If the film is prematurely exposed, then exposing the film for photos will have no effect~~
CMEV-03	Shall not allow for significant damage of camera upon landing	CMEV-01, ~~CMEV-02,~~ REQ-04	Film & camera must be intact to consider recovery a success. So camera can be reused and film can be developed

Subsystem Requirements - Mechanical

Req Code	Description	Parent Requirement	Reasoning
MECH-01	Shall repeatedly reload Film	REQ-02, REQ-03	Film must be reloaded to allow for multiple photos, sometimes more then once per photo
MECH-02	Shall repeatedly activate shutter	REQ-02, REQ-03	Shutter must be repeatedly pressed to take multiple photos
MECH-03	Shall hold all parts stable through flight	REQ-04, REQ-02, REQ-03	Boards, mechanisms & PSat body needs to be held together through flight and deployment to keep internal system stable
MECH-04	Shall fit into rocket body when stowed for flight	Objective	To Allow for launch, the whole PSat must fit in the body alongside the parachute, shock cord & nose cone lip

2. Solution

Mission Design

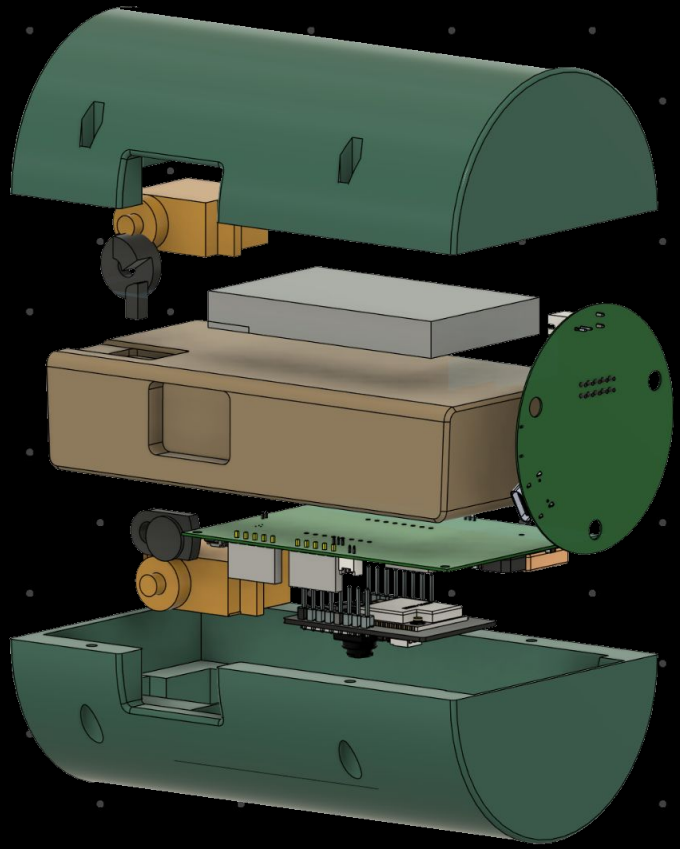
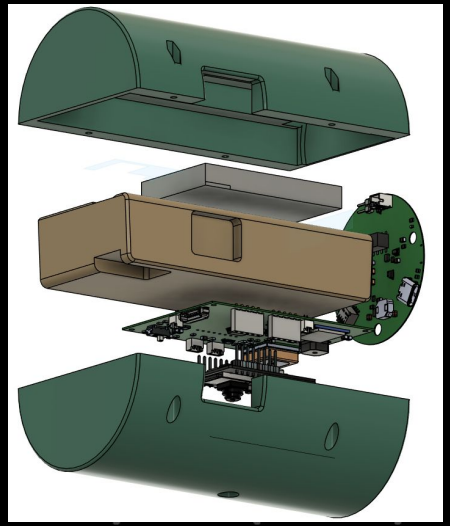
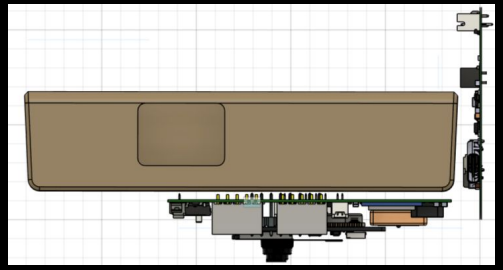
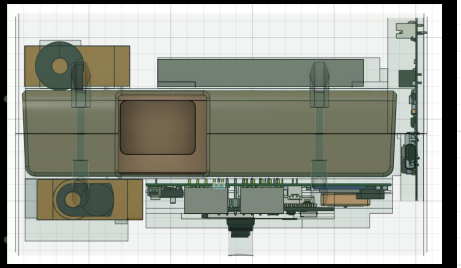
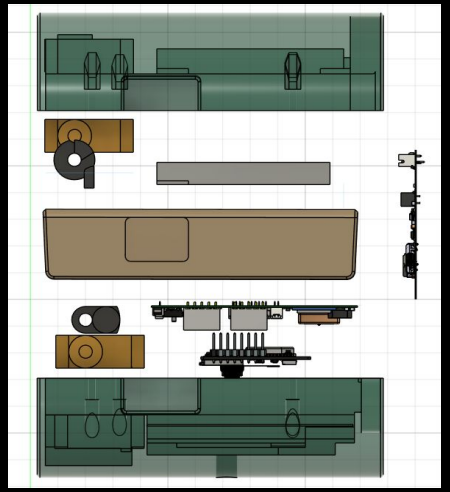


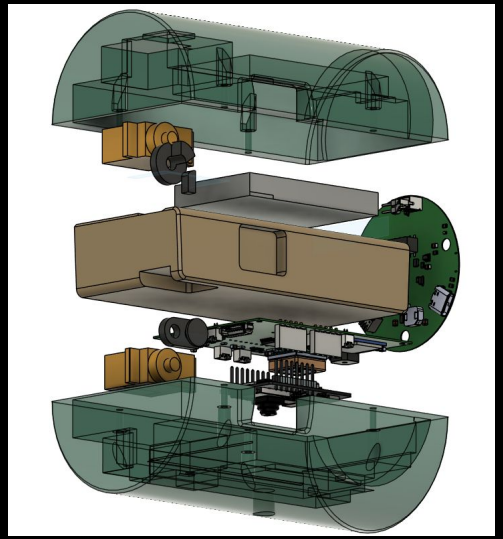
Photo Dump

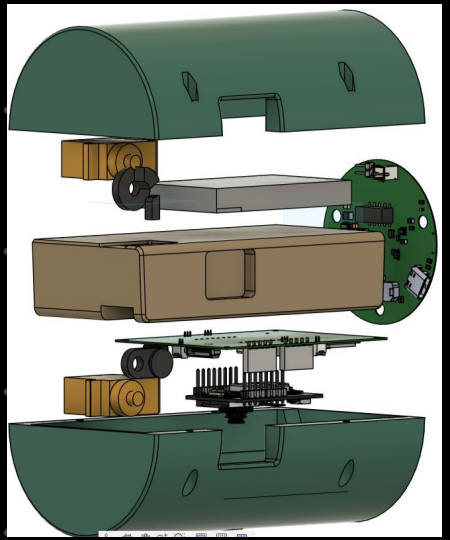


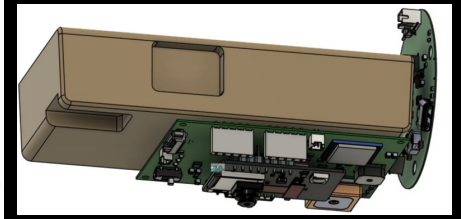


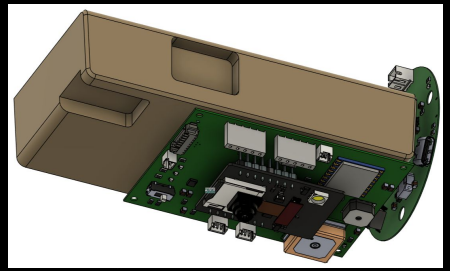


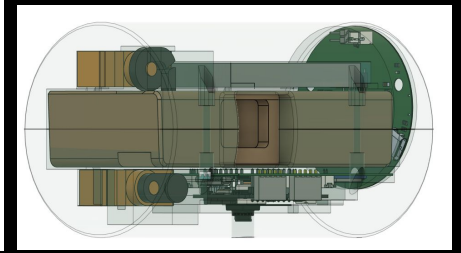












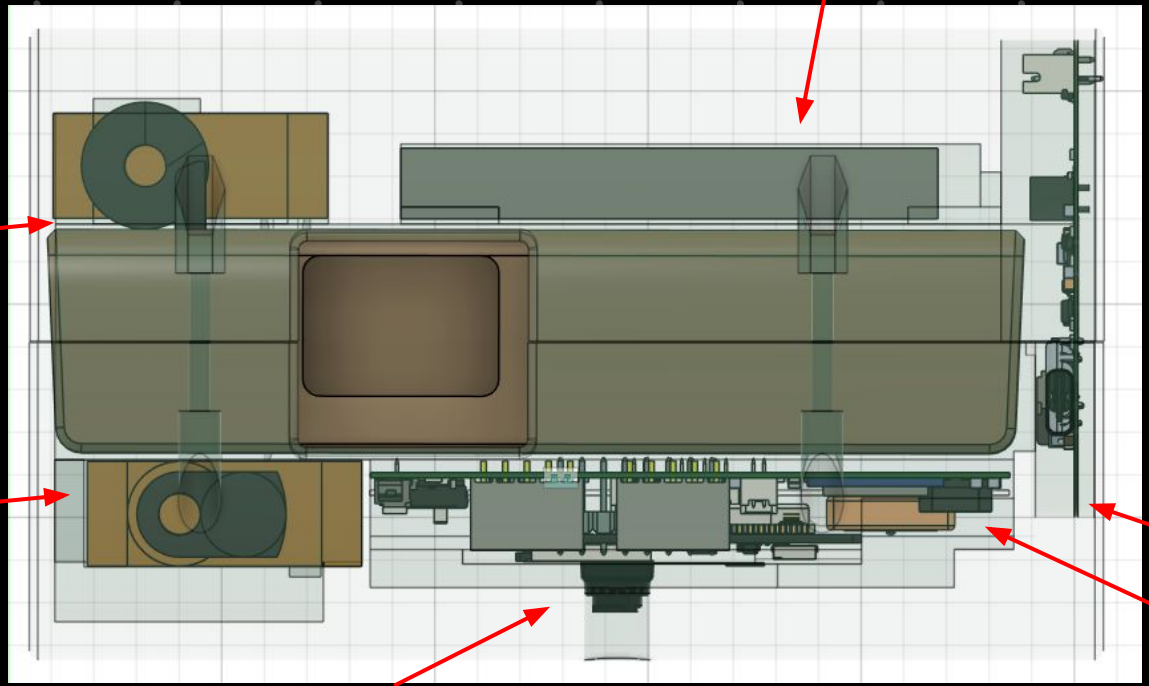
Design Solution Definition - Changes

1. No longer pursuing carbon fibre shell
2. No modifications required on the camera as the viewfinder can be left untouched without restricting the free space we needed.

Design Solution Definition

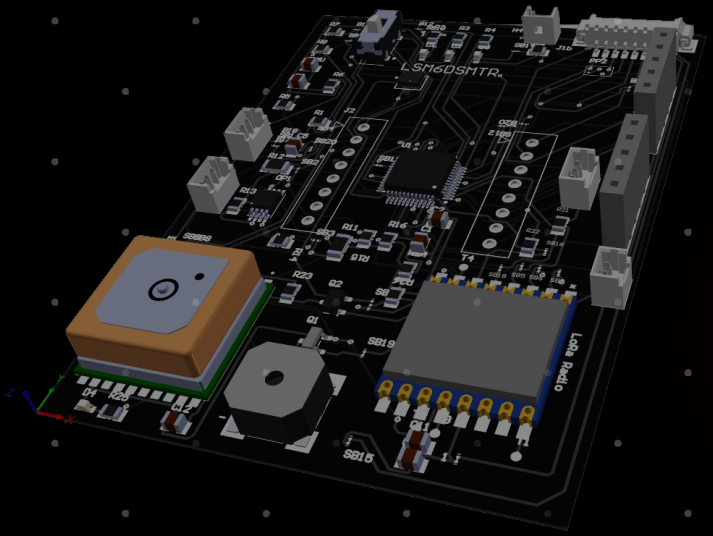
- One member found a small film camera to take photos. We will mount it to a capsule & create a system to automatically take photos.
- There will be a lot of chaotic movement on descent, so need a way to stabilize the camera on descent.
- Photos will look best at apogee, but will have high motion blur at deployment. So the shutter will be programmed to fire at set times.
- Film must be contained onboard, and in the dark at all times. ~~We will be removing the camera's viewfinder which means we cannot rely on the camera's body to block all the light.~~

Design Solution Definition



Electrical Subsystem

CHANGES

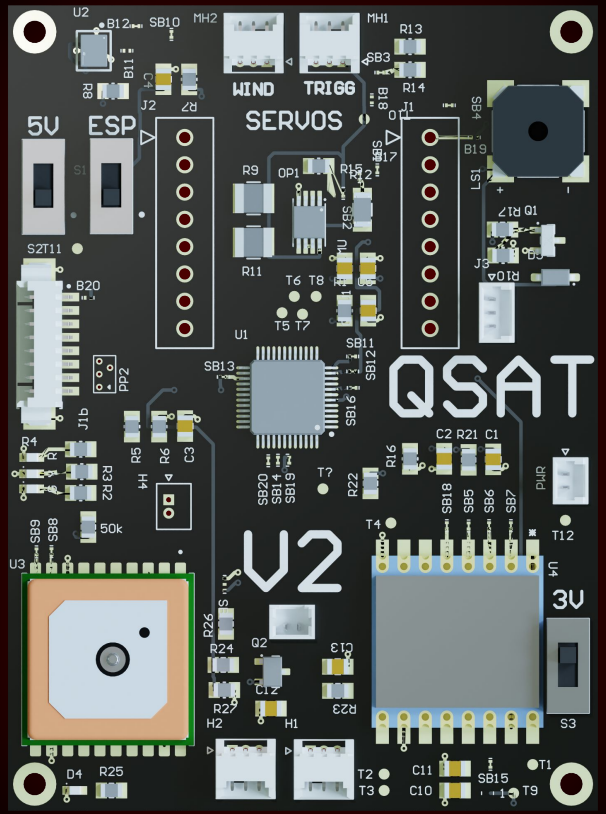


V1

V2

Electrical Subsystem

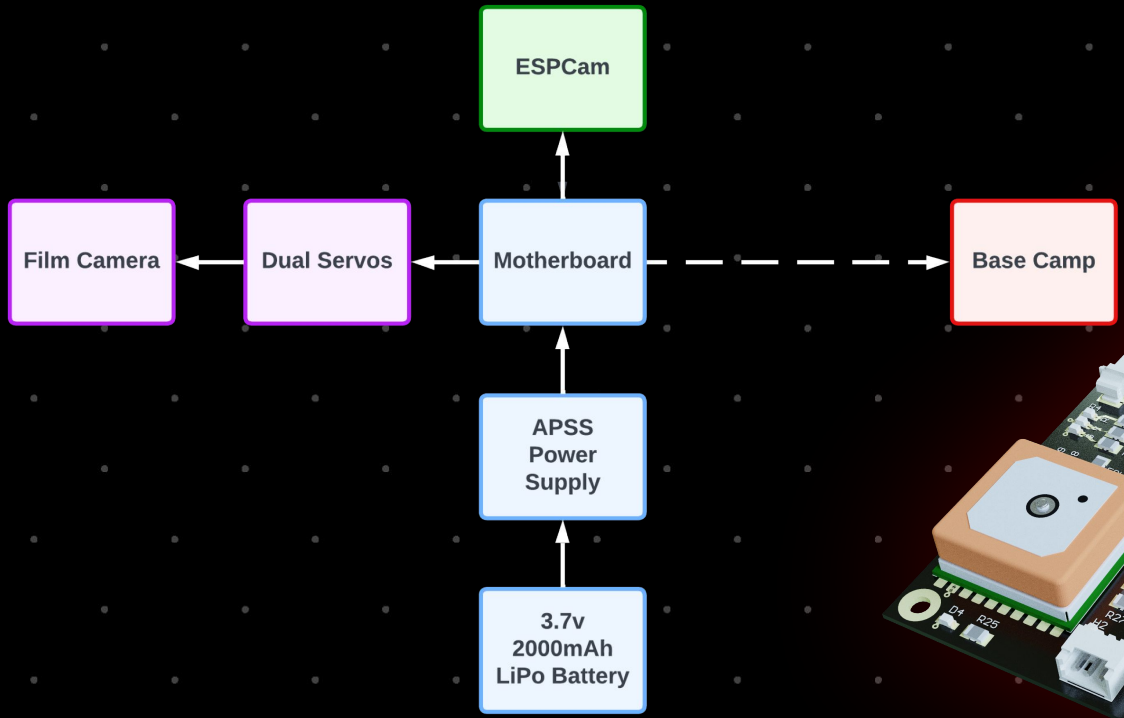
CHANGES



- Sockets moved to better position and angle to align with mechanical components
- Power switches added for 5V, 3V & ESP32
- Save with correct amount of layers
- Repositioned ESP headers slightly
- Added more test pads
- MSP430 pins reconfigured for PWM output after dev board testing (servo)
- ESP-CAM closer to the main board
- Increased resistor power rating for the current sense circuit

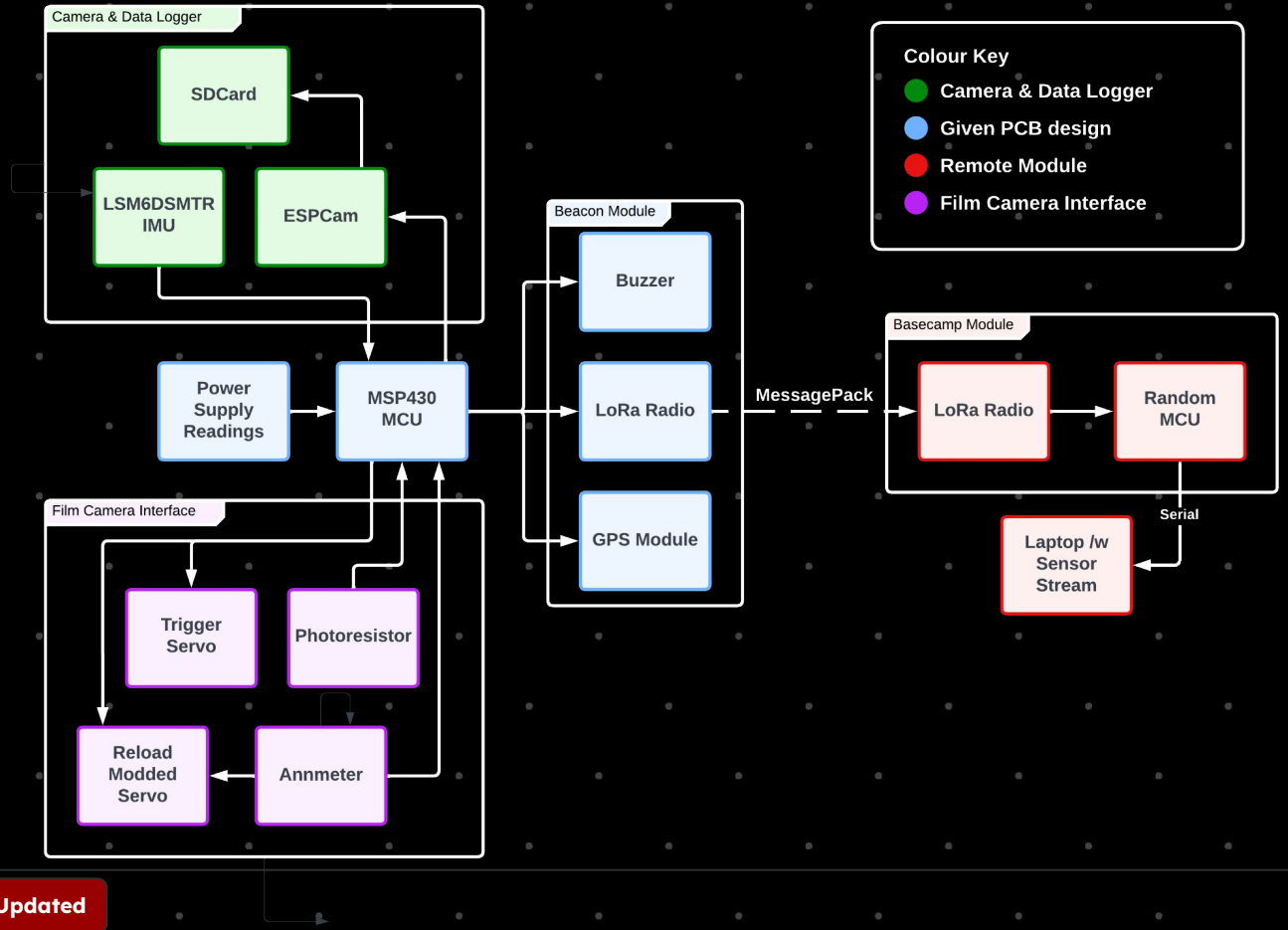
Electrical Subsystem

OVERVIEW



Electrical Subsystem

OPERATIONS



Not Updated

Mechanical Subsystem

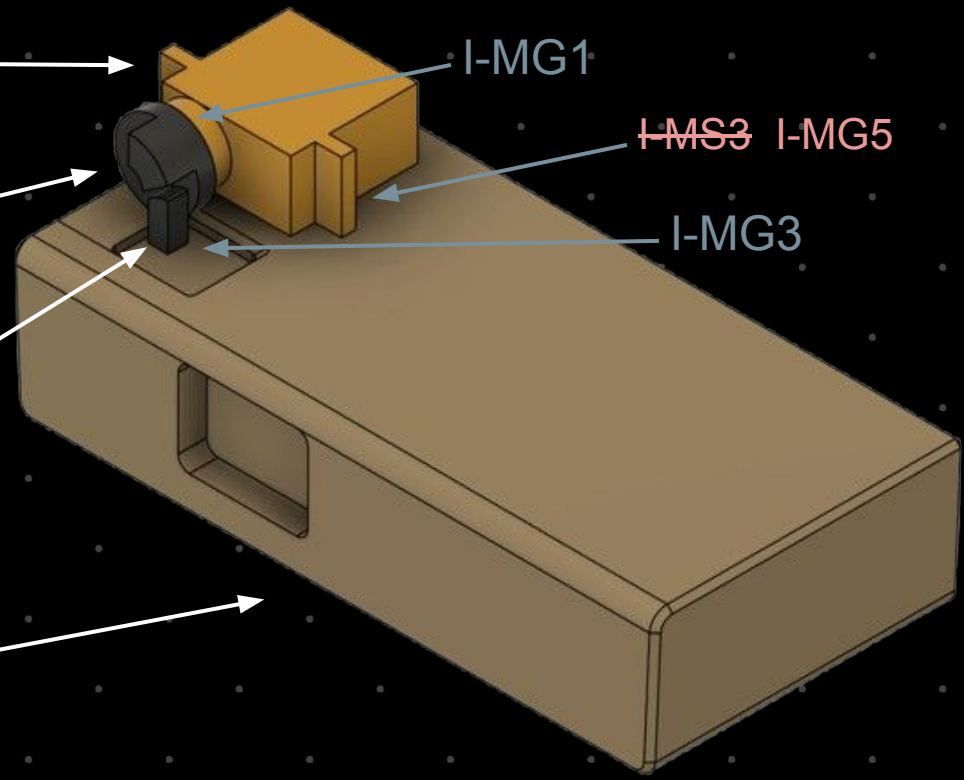
SHUTTER

9 Gram Servo
Supplied
~~2x M2, 6mm Screws~~
Friction Or Glue if needed

Shutter Swing Arm
3D Printed
Used To Push Pusher Arm
Glued Onto Servo Arm

Pusher Arm
3D Printed
Pushes On Shutter Button
Glued Onto Shutter

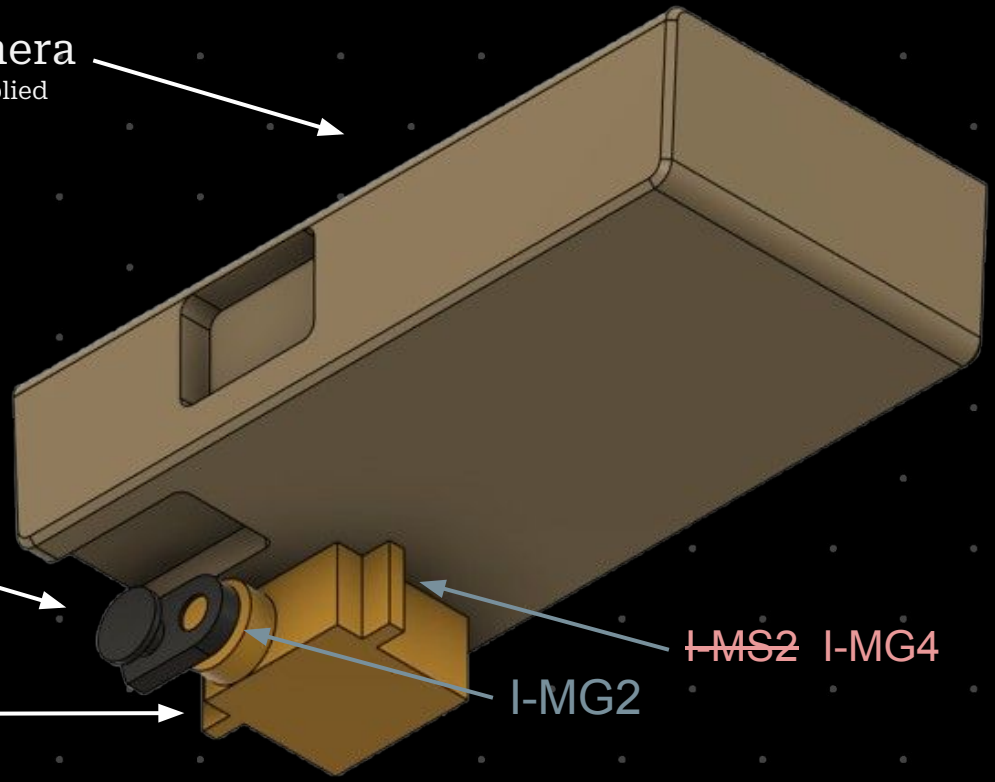
Camera
Supplied



Mechanical Subsystem

RELOADER

Camera
Supplied

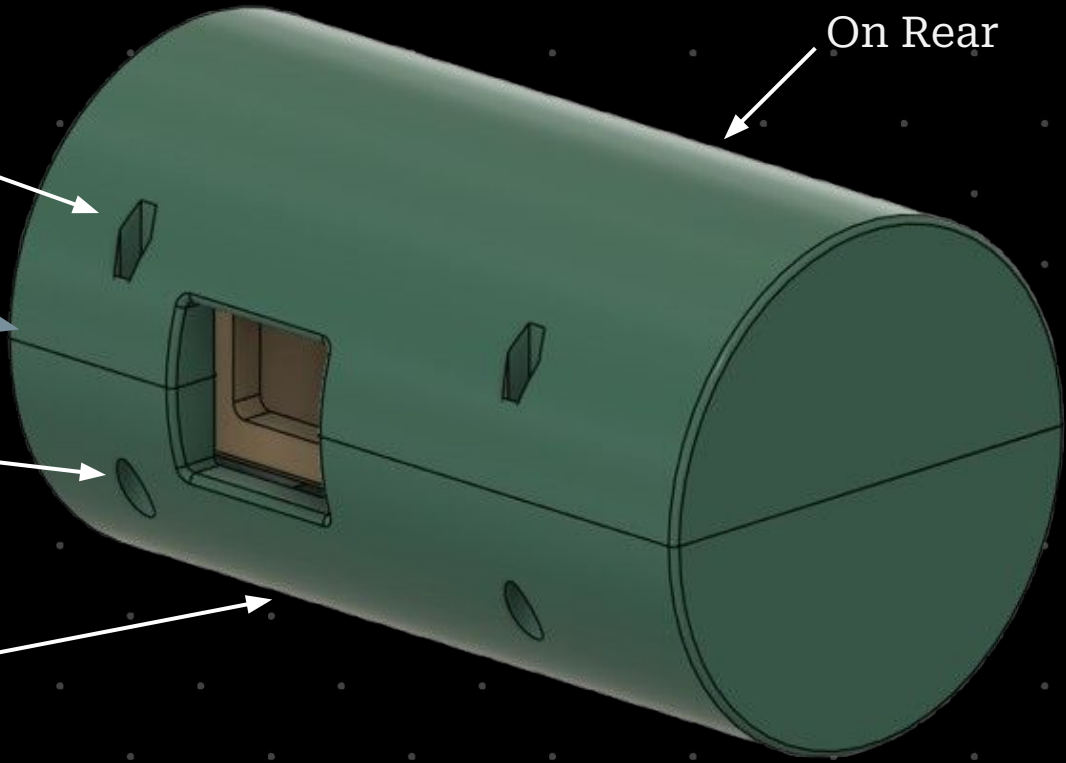


Reloader Swing Arm
3D Printed
Used To Pull Reloader Via Fishing Line
Camera Has Built In Spring For Return
Glued Onto Servo Arm

9 Gram Servo
Supplied
~~2x M2, 6mm Screws~~
Friction Or Glue if needed

Mechanical Subsystem

BODY



Hex Nut
M2.5
Sits In Hex Cavity

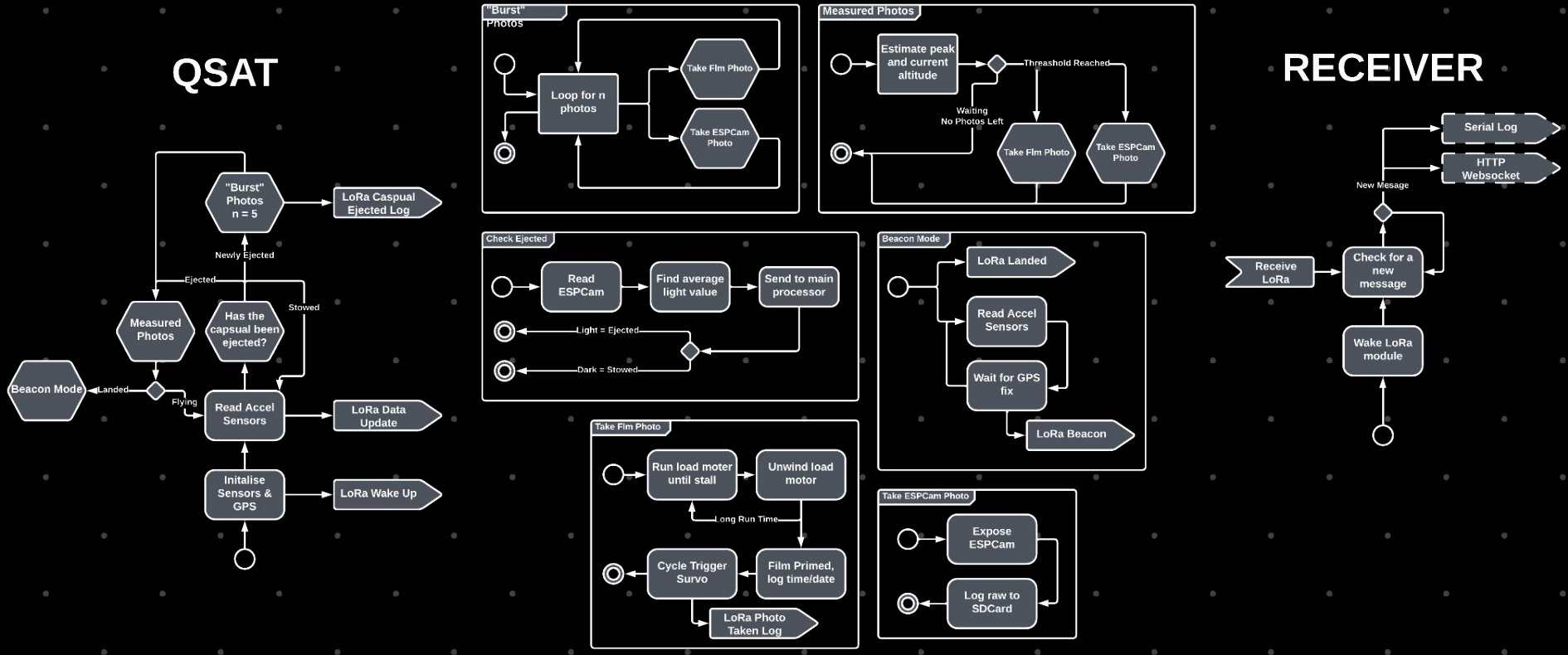
I-MS1

Screws
M2.5
Phillips
20mm long
Sits In Cylindrical Cavity

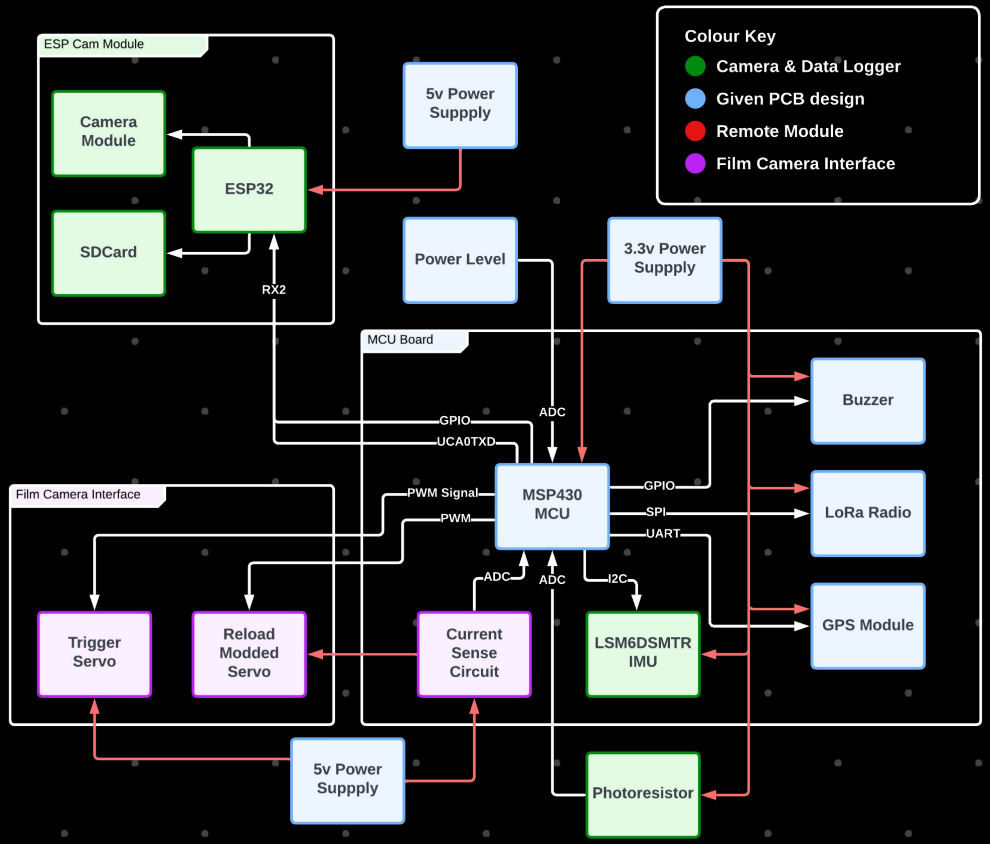
Shells
3D Printed

Same
On Rear

Concept Of Operations



Interface Definitions - Electrical



MSP Pin Definitions

# Pin PT	SIGNAL NAME (1) (2)	SIGNAL TYPE(3)	BUFFER TYPE(4)	POWER SOURCE	RESET STATE AFTER BOR(5)	Useable	USE CLASS	USE NOTES
1	P1.2	I/O	LVCMOS	DVCC	OFF	☑	LoRa	SPI Master Out
	UCB0SIMO	I/O	LVCMOS	DVCC	–			
	UCB0SDA	I/O	LVCMOS	DVCC	–			
	TB0TRG	I	LVCMOS	DVCC	–			
	OA0-(6)	I	Analog	DVCC	–			
	A2	I	Analog	DVCC	–			
	Veref-	I	Analog	DVCC	–			
2	P1.1	I/O	LVCMOS	DVCC	OFF	☑	LoRa	SPI Clock
	UCB0CLK	I/O	LVCMOS	DVCC	–			
	ACLK	O	LVCMOS	DVCC	–			
	OA0O(6)	O	Analog	DVCC	–			
	COMP0_1	I	Analog	DVCC	–			
	A1	I	Analog	DVCC	–			
3	P1.0	I/O	LVCMOS	DVCC	OFF	☐	MSP Config	Vref+
	UCB0STE	I/O	LVCMOS	DVCC	–			
	SMCLK	O	LVCMOS	DVCC	–			
	COMP0_0	I	Analog	DVCC	–			
	A0	I	Analog	DVCC	–			
	Veref+	I	Analog	DVCC	–			
4	TEST	I	LVCMOS	DVCC	OFF	☐	Nothing Assigned	
	SBWTCK	I	LVCMOS	DVCC	–			
5	RST	I/O	LVCMOS	DVCC	OFF	☐	Nothing Assigned	
	NMI	I	LVCMOS	DVCC	–			
	SBWTDIO	I/O	LVCMOS	DVCC	–			
6	DVCC	P	Power	DVCC	N/A	☐	Nothing Assigned	
7	DVSS	P	Power	DVCC	N/A	☐	Nothing Assigned	
8	P2.7	I/O	LVCMOS	DVCC	OFF	☑	LoRa	Lora Reset
	TB0CLK	I	LVCMOS	DVCC	–			
	XIN	I	LVCMOS	DVCC	–			
9	P2.6	I/O	LVCMOS	DVCC	OFF	☑	LoRa	LoRa IRQ (DIO0)
	MCLK	O	LVCMOS	DVCC	–			
	XOUT	O	LVCMOS	DVCC	–			
10	P2.5	I/O	LVCMOS	DVCC	OFF	☑	LoRa	LoRa Configurable DIO1 (RadioLib wants it?)
	COMP1.0	I	Analog	DVCC	–			
11	P2.4	I/O	LVCMOS	DVCC	OFF	☑	ESP32 Cam	Hopefully will be used for OneWire commication with the ESPCam
	COMP1_1	I	Analog	DVCC	–			
12	P4.7	I/O	LVCMOS	DVCC	OFF	☑	Accelerometer	LSM6DSMTR I2C SCL
	UCB1SOMI	I/O	LVCMOS	DVCC	–			
	UCB1SCL	I/O	LVCMOS	DVCC	–			
13	P4.6	I/O	LVCMOS	DVCC	OFF	☑	Accelerometer	LSM6DSMTR I2C SDA
	UCB1SIMO(7)	I/O	LVCMOS	DVCC	–			
	UCB1SDA	I/O	LVCMOS	DVCC	–			
14	P4.5	I/O	LVCMOS	DVCC	OFF	☐	Nothing Assigned	

Pins Updated

APSS

Not Updated

Interface Definitions - Mechanical

Interface Code	Definition
I-MS1	4 screws to hold shell together. M2.5, 20mm long. 92005A077 on McMaster Received by 4 Hex nuts to sandwich shells. 90592A080 on McMaster
~~I-MS2~~ I-MG4	~~2 screws for attaching the Reloader Servo. M2, 6mm long. 94209A343 on McMaster~~ ~~Screws straight into 3D print~~ Friction press fit, or Glue if required.
~~I-MS3~~ I-MG5	~~2 screws for attaching the Shutter Servo. M2, 6mm long. 94209A343 on McMaster~~ ~~Screws straight into 3D print~~ Friction press fit, or Glue if required.
I-MG1	Glued attachment of shutter swing arm to shutter servo. Exact attachment dependant on state of servo on arrival. Most likely superglue
I-MG2	Glued attachment of reloader swing arm to reloader servo. Exact attachment dependant on state of servo on arrival. Most likely superglue
I-MG3	Glued pusher arm to shutter button. Most likely Hot glue to not damage camera too much

Implementation Plans

COMPLETED

- Order 1 Received
- Order 1 Printed
- Order 1 Assembled
- Order 1 Feedback Implemented
- Develop Launch & Recovery Operations

Order 2 Evolution Plans

- Finalise Internal Structure - Update with Order 1 learning. Cable runs, airboxes, light sensor & usb-c.
- Implement Parachute Attachment Points
- ~~Develop Carbon Composite Outer Shell~~
- ~~Cut Down Camera Size~~
- ~~Develop Light Blocking Measures~~
- Submit Order 2
- Print Order 2
- Assemble Order 2
- Test ORder 2
- Assemble Flight Article.

Technical Measures of Effectiveness

- Have we successfully taken a picture?
- Is the film recoverable/processable?
- How many film photos did we capture?
- Are the objects in the film identifiable?

Validation Plans

- Fit Checks - Feb 6th - Completed
  - Whole Team
- Bench test camera mechanism - Feb 6th - Partial Completion Due To Motherboard & Sizing Issue
  - Whole Team
- Bench test camera with spare film - Mid Feb
  - Electrical Team
- Packing Test with Final Layout - Mid Feb
  - Mechanical Team
- Drop test inside engineering - final test with prototype (incase of RUD) - Mid Feb
  - Whole Team

Operational Procedures - Programming

ESPCam	Plug ESPCam programming connector into the ESP PWR header
	Connect 5v, Gnd, TX, and RX to a USBTTL adapter
	Plug the USBTTL adapter into the dev-laptop
	Open PlatformIO on the “QSat_espcam” folder
	Click “Upload & Monitor”, and ensure that the firmware uploads correctly, and starts outputting debug info
	Unplug the USBTTL adapter, and disconnect the programming hardware

Operational Procedures - Programming MSP

MSP430	Ensure the PSU Power is off, and turn power off for the ESPCam
	Connect the JTAG connector to the APSS programming adapter, and the adapter into a TI MSPDebug device.
	Git pull the latest code from the repository on a Linux dev-laptop.
	Plug the TI MSPDebug into the laptop via Micro USB
	Connect the 3V3 power supply to the Dev Power Header
	Open PlatformIO on the “QSat_msp” folder
	Click “Upload & Monitor”, and ensure that the firmware uploads correctly, and starts outputting debug info
	Unplug the 3V3 power supply, and disconnect the programming hardware

Operational Procedures - Pre Launch - Programs

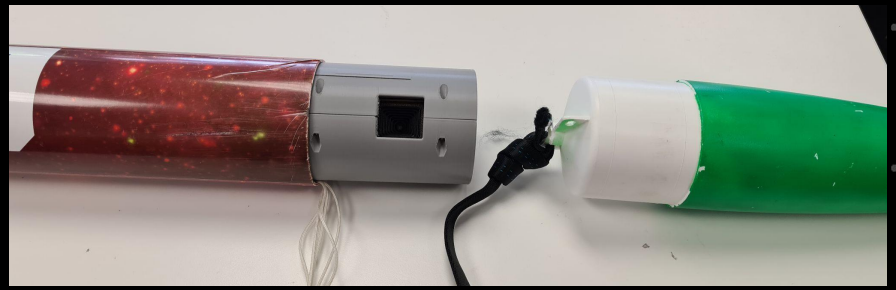
NOTES: Check all lead connections Bring power supply	Charge battery via USB-C port on power supply unit
	Remove RBF bridge
	Enable LoRa base station & logging
	Enable board power and confirm LoRa connection & sensor data
	Follow Operational Procedures - ASSEMBLY

Operational Procedures - Pre Launch - Assembly Part 1

NOTES: Bring screwdrivers, blade, sandpaper, & glue	
	Insert reloader servo, glue if required
	Install ESPcam + Motherboard, aligning the camera with the hole.
	Insert camera, aligned with camera hole
	Insert shutter servo, glue if required
	Insert PSU board, align with cable runs
	Insert battery, aligned with cable runs.
	Put halves together
	Insert nuts into holes using bolt transfer method
	Insert bolts

Operational Procedures - Pre Launch - Assembly Part 2

NOTES:	Ensure PSAT is programmed (see Programming Operational Procedure)
	Ensure PSAT is assembled (see Assembly Part 1 Operational Procedure)
	Remove cone and parachute from rocket
	Place PSAT into rocket
	Attach parachute to PSAT, and the nose cone.
	Place nose cone on top of the rocket.



Operational Procedure -

Q-Sat CDR

Critical Design Review

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Team: Questionable Satellites
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