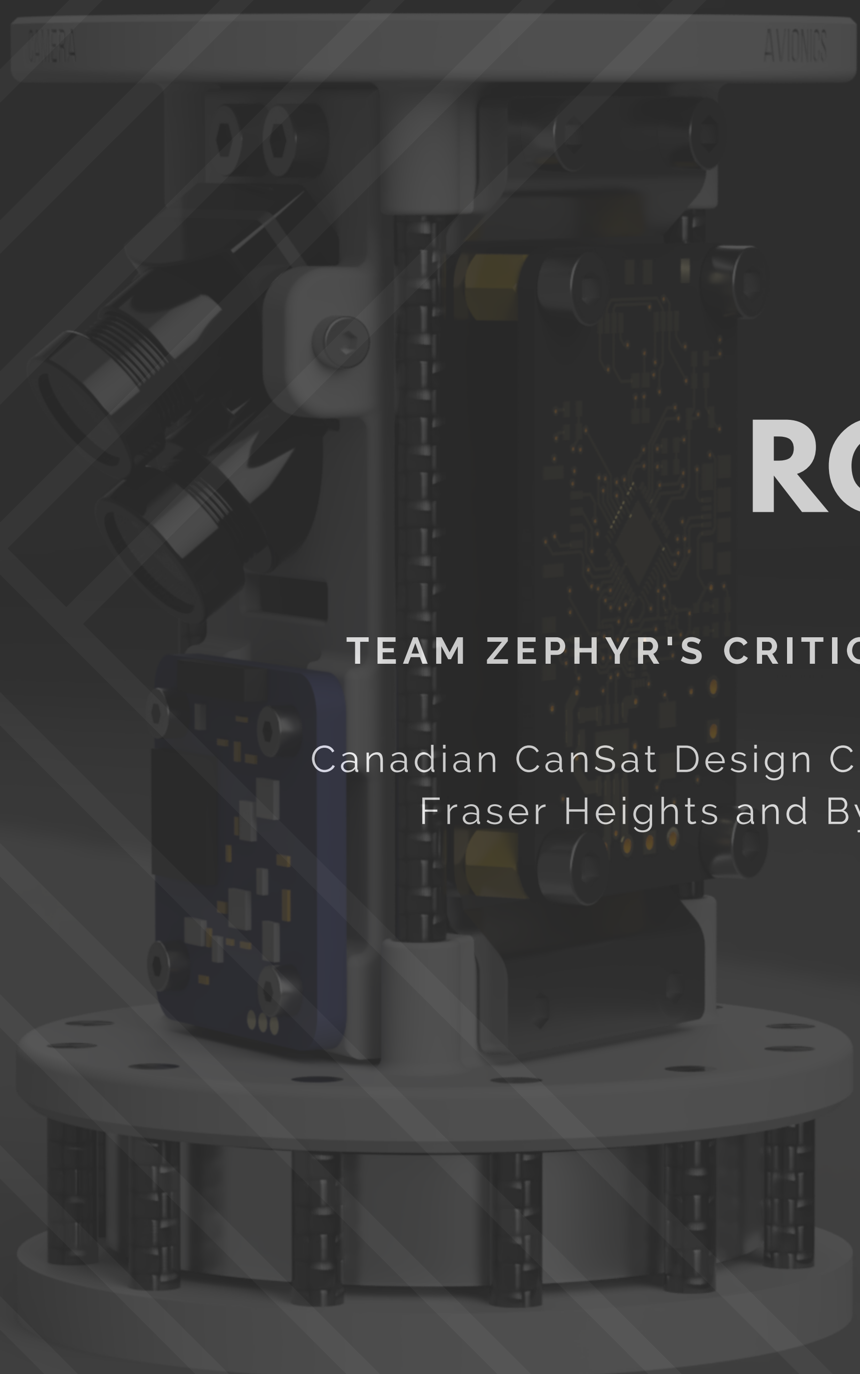


ROTASAT

TEAM ZEPHYR'S CRITICAL DESIGN REVIEW

Canadian CanSat Design Challenge | 2021 - 2022
Fraser Heights and Byrne Creek Secondary

CONTENTS

1 INTRODUCTION

This is the Preliminary Design Report from Team Zephyr for the 2021-22 Canadian CanSat Design Challenge.

In this document we present an initial summary of our mission and the planned development which we will undertake to achieve our mission goals.

1.1 MISSION SUMMARY

1.1.1 Primary Mission

The required primary mission of RotaSat is to log temperature and air pressure data to an SD card in flight after separation from the launch vehicle. This data will also be transmitted to the ground at 915mHz to be displayed on our ground control station (GCS). RotaSat will also log and transmit data in the powered ascent phase of flight.

In addition to the required temperature and pressure data, we are extending our primary mission to transmit additional data points including orientation, angular rates, accelerations, avionics voltage, GPS coordinates and system state

1.1.2 Secondary Mission

The secondary mission is based on the active attitude control systems of every satellite that is launched into orbit. Having control authority over the craft is integral to many missions, even ones in the atmosphere. Here, we aim to be able to redirect where the camera is pointing in real-time.

To do so, we have designed a thirty gram aluminum reaction control wheel to be incorporated into the bottom of the satellite. With a calculated 0.0014875 N*m of torque, it will have more than enough authority to exert control over the 0.35kg craft in 40km/hr winds.
We originally had the idea of recording wind speed and developing an atmospheric model, but that has been relegated to a “tertiary” mission.

2 TEAM ORGANIZATION

2.1 TEAM MEMBERS

Timothy Cai - Team Captain & Hardware Lead

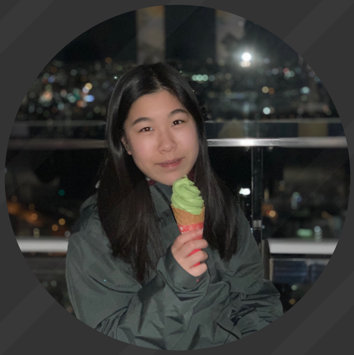
I met Lawrence Reeves through Adam Trumpour last year, when I was looking for guidance on my active-control rocketry project. I was immediately drawn in by the technical and teamwork aspects of the Canadian CanSat design competition, so I began looking for potential members in my community. I currently organize tasks for my fellow members as the captain and handle the majority of the CAD and flight code.

Kentarou Howard - Avionics Lead & Sponsorship Manager

Having worked on a similar active control project to Timothy, I was intrigued when he mentioned his burgeoning satellite team. He just so happened to have an opening, and so I joined as the avionics lead, designing and assembling the satellite computer. I'm also able to apply my experience as the president of a successful FIRST Robotics team in our sponsorship communications.

Brian Zhou - Outreach Co-Lead & Hardware Technician

I joined this team in search of a unique engineering experience, and I've found it in satellites. It's amazing to meet new people and really apply myself to something I'm passionate about. I work on outreach, managing and creating content for the YouTube and TikTok channels, as well as assembling the yagi antenna.



Jessica Tang - GPS Technician & Graphic Designer

Having had research experience in artificial intelligence, I was excited to expand my skill set and apply my passion to engineering projects as the GPS technician, obtaining tracking data from the CanSat in real-time. I hope to challenge myself while working alongside the rest of the team by developing a live-view GPS data visualizer.

Vhea He - GPS/Parachute Technician & Outreach Lead

After hearing about this competition from a friend, I thought that entering this competition would be a great opportunity to apply my skills in programming, as well as explore new fields in engineering. I will be working on tracking the satellite in real-time, parachute deployment as well as managing the team's social media and community presence.

David Liu- Ground Station Technician & Lead Graphic Designer

I heard about the CSDC after it was brought up in conversation with friends. I believed the competition would be an excellent opportunity for me to apply and develop my programming knowledge. I contribute to the team as a member of the ground station software team as well as the team artist.

2.2 TEAM RESOURCES

We have access to 3D-printers, as well as a soldering station with iron and heat guns. At school, we have access to a lathe and mill. We also have a small inventory of assorted electronics components from previous projects. We were also able to obtain advice from a balloon-sat team at UBC Rocket concerning radio technology and hardware choice.

2.3 COLLABORATION REALITIES

We meet online 1-2 times per week to provide updates between subteams (software, hardware, avionics, outreach and sponsorship) to ensure that the whole team is on the same page, as well as set goals for the coming week.

While working remotely, it is extremely important to coordinate with each subteam in order to build the CanSat separately, which is why we use a Discord server. The channeled nature of the server allows us to have organized conversations amongst subteams while allowing other team members to view and contribute to them.

We have also planned for a few in-person meet ups for tasks that cannot be completed apart, such as ground station range testing, holistic software testing as well as recovery system verification. Given that our team is composed of senior students at Fraser Heights Secondary School and Byrne Creek Community School, most of our team members are able to meet each other in person due to the close proximity.

2.4 EDUCATIONAL OUTREACH

Our outreach will mainly consist of posting promotional videos to an online audience. We plan to post weekly video logs (“vlogs”) on Youtube that detail our progress on RotaSat. We also plan to upload exciting satellite trailers on TikTok with the goal of drawing more attention to our Youtube channel. As well, frequent updates will be posted on photo and text-based platforms. Beside our online presence, we plan on promoting the RotaSat mission to clubs and classes at our schools.

3 CANSAT DESIGN

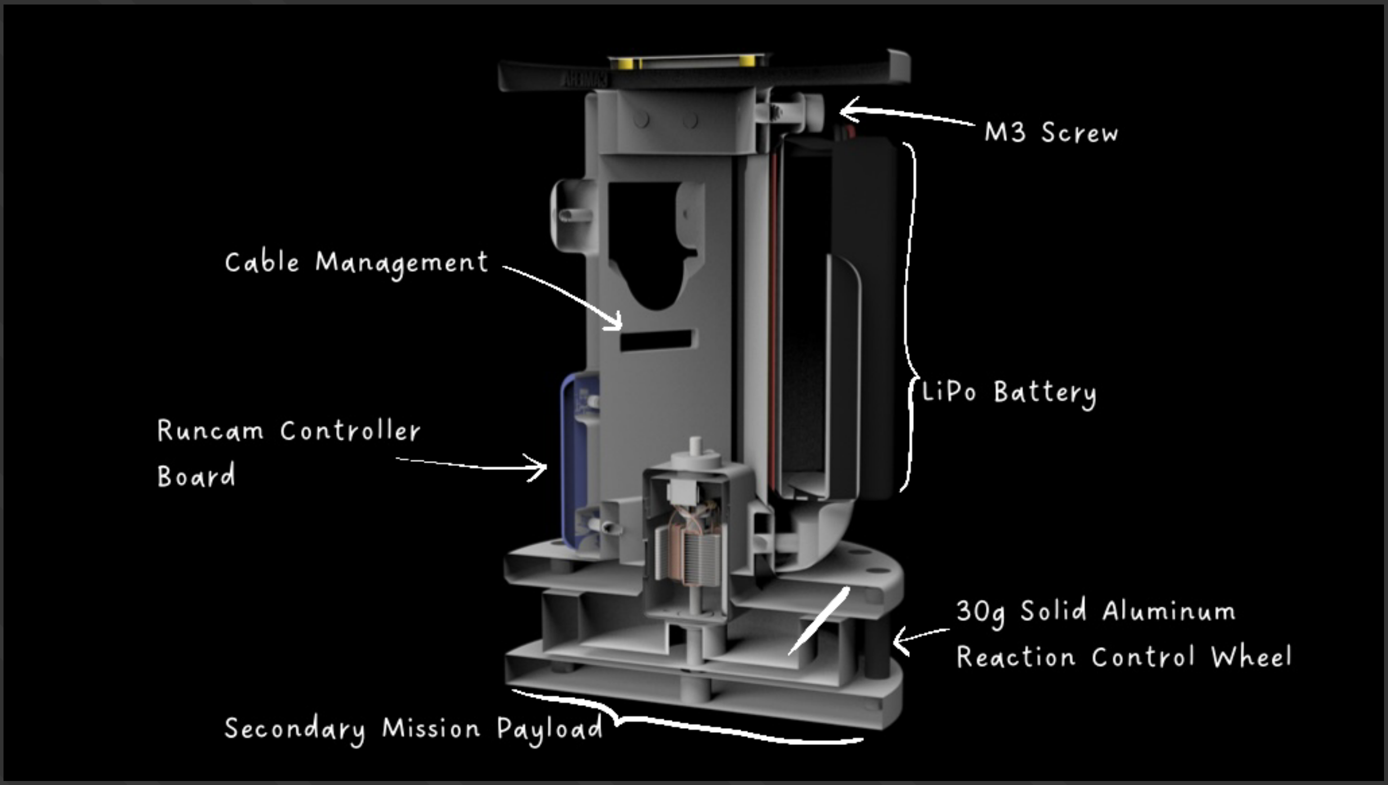
3.1 STRUCTURAL DESIGN AND LAYOUT

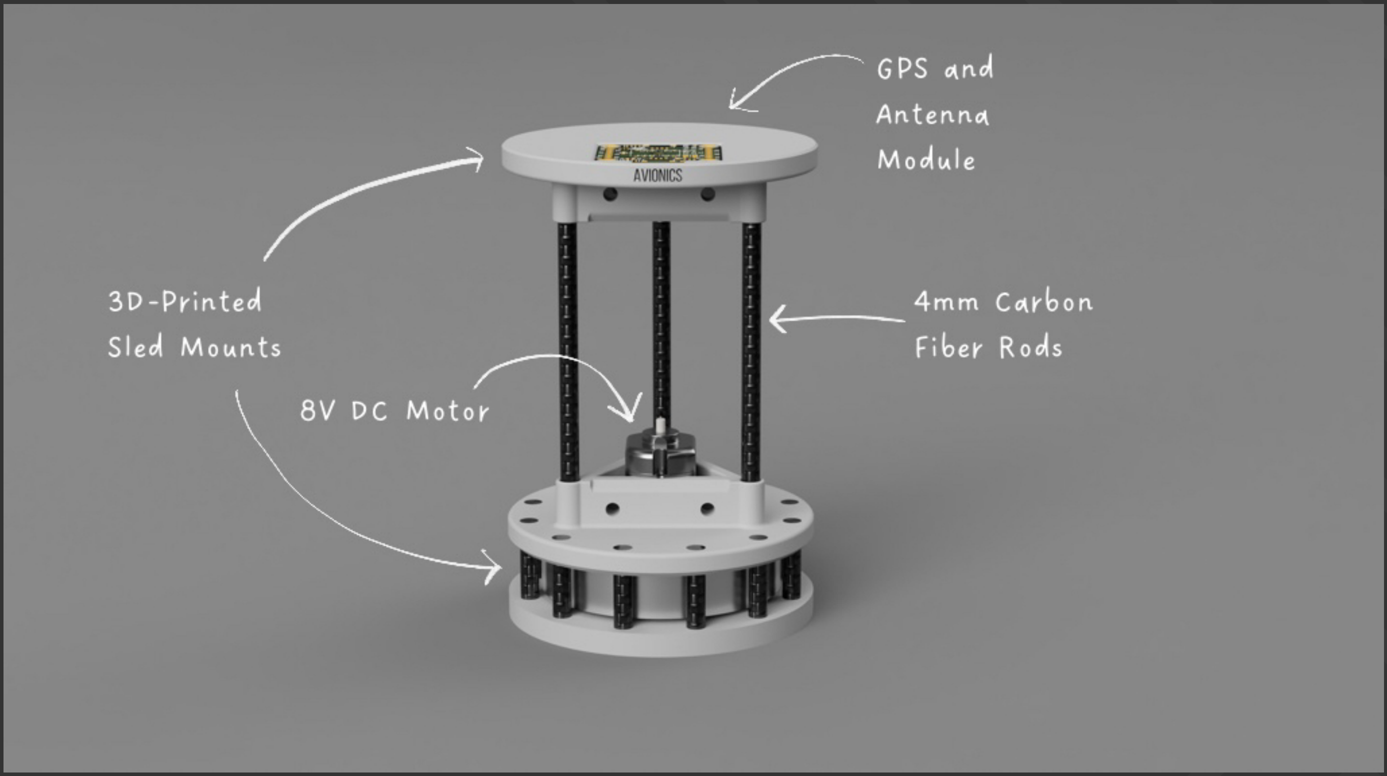
3.1.1 Outer Structure

This satellite is designed with an open layout, without an outer shell. This is due to the weight limit, as well as ease of access to the different component sleds. As well, certain sensors need access to the open air for greater accuracy, such as the barometer and temperature sensor.

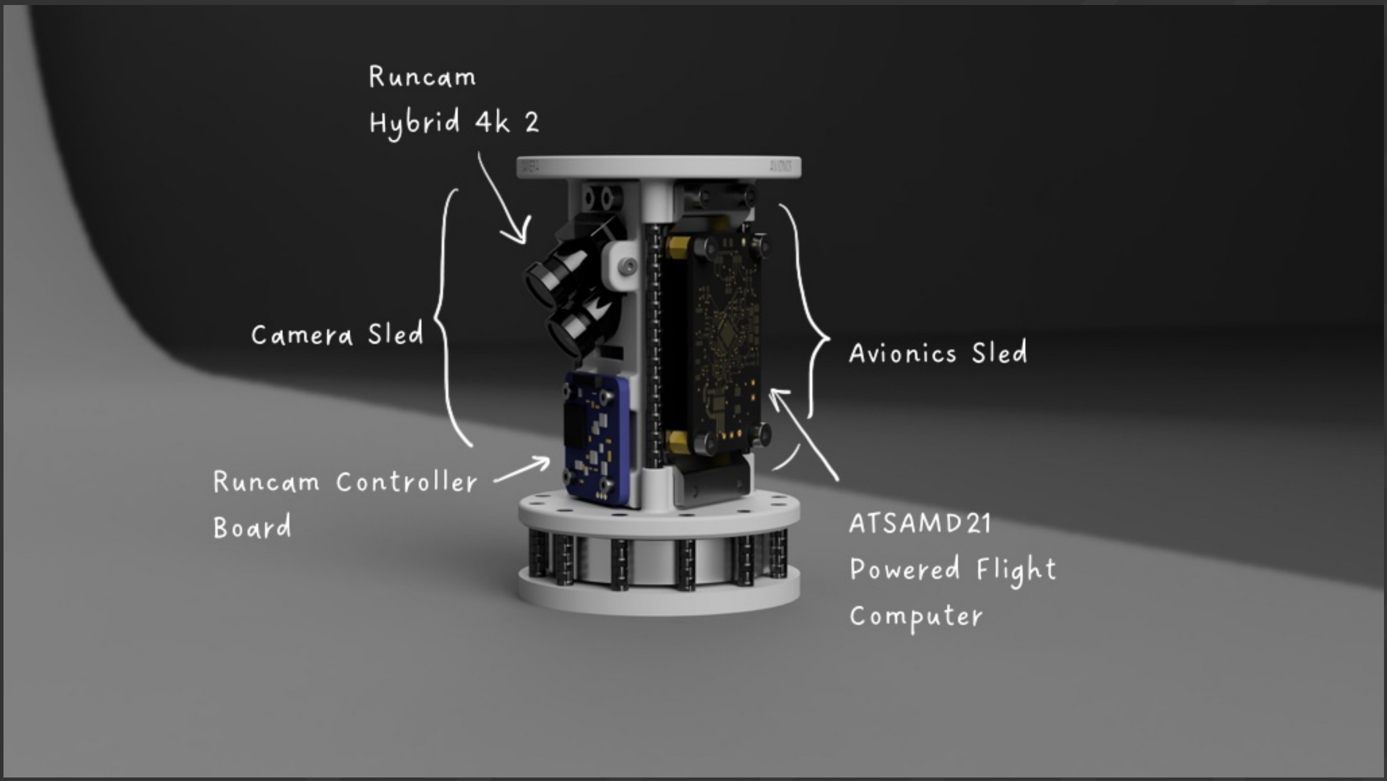
3.1.2 Internal Structure and Configuration

The satellite is designed in a modular fashion, with three component sleds mounted onto the main internal structure. These sleds are the avionics, camera, and battery mounts. They are attached to the inner structure with various M3 bolts. The internal structure itself consists of three carbon fibre rods connected to the mounting points on the top and bottom plates, with the bottom plate being designed to additionally hold a mount for the DC motor.





GPS and Antenna Module
AVIONICS
3D-Printed Sled Mounts
4mm Carbon Fiber Rods
8V DC Motor

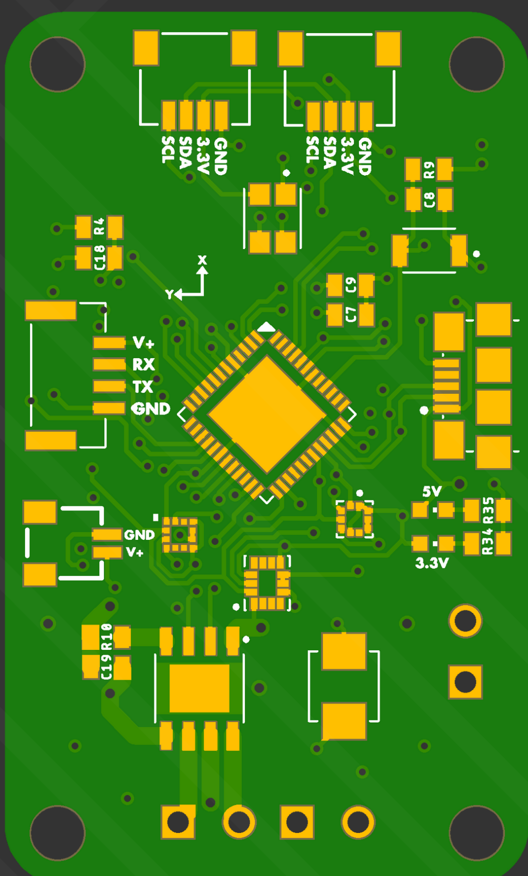


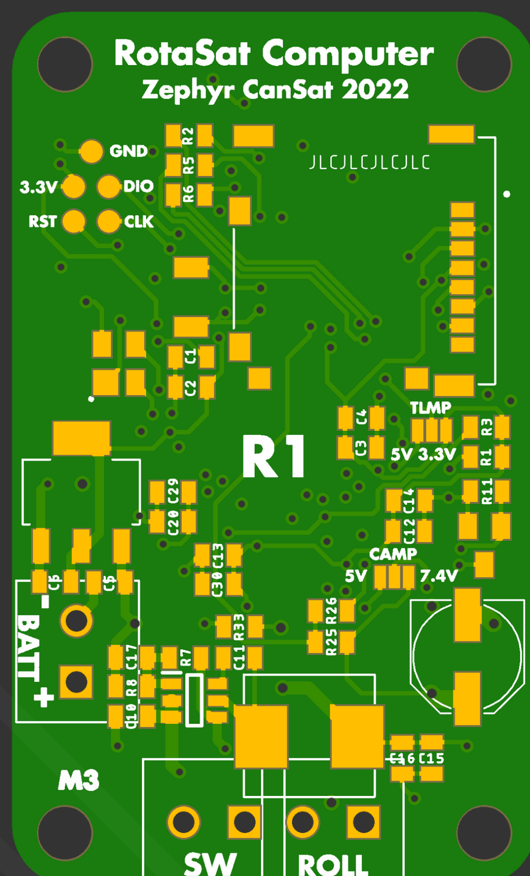
Runcam Hybrid 4k 2
Camera Sled
Avionics Sled
Runcam Controller Board
ATSAMD21 Powered Flight Computer

3.2 CANSAT SUB-SYSTEMS

3.2.1 On-Board Computer

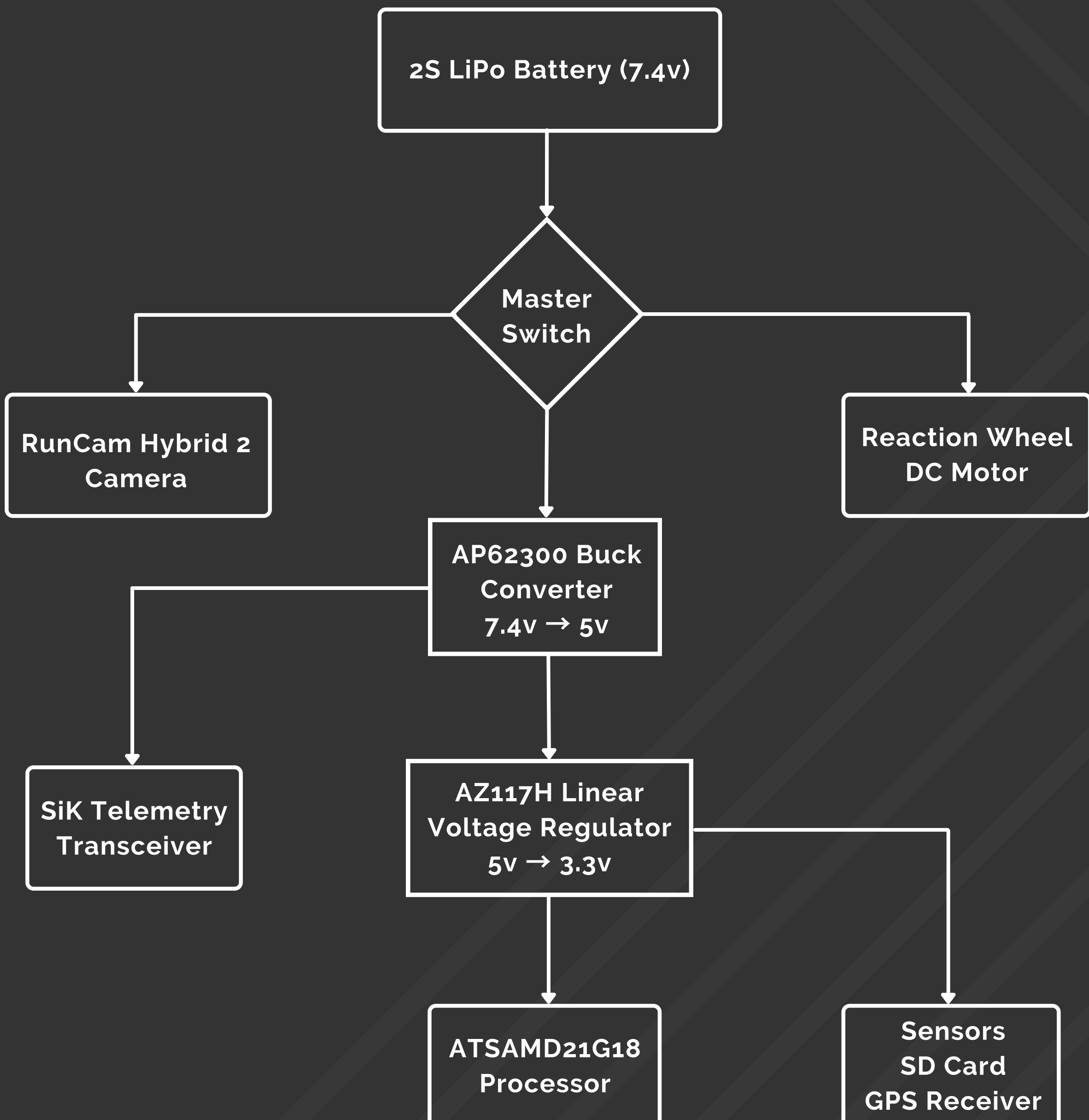
Our main on-board computer will be a single, proprietary board designed for this mission. We believe using proprietary avionics is the best solution as it is the most space and cost efficient. Additionally, using proprietary electronics will give us the best understanding of the systems on the satellite. The computer is a 50mm x 30mm, 4 layer PCB manufactured by JLCPCB. Outer copper layers are 1oz, inner layers are 0.5oz. The PCB is manufactured using a high temperature, flame resistant FR4 material.





3.2.2 Power System

Our main on-board computer will be a single, proprietary board designed for this mission. We believe using proprietary avionics is the best solution as it is the most space and cost efficient. Additionally, using proprietary electronics will give us the best understanding of the systems on the satellite. The computer is a 50mm x 30mm, 4 layer PCB manufactured by JLCPCB.



3.2.3 Descent & Recovery System

After considering many designs, we landed on a simple 12'' parachute attached externally to the forward plate of the satellite. A passive design was chosen due to the reduction of potential ejection problems that may be introduced by an active deployment system. The Adafruit PA1010D GNSS module will be used to record and transmit position, velocity and coordinate data for recovery operations. This GPS module is capable of communicating with GPS, GLONASS, GALILEO and QZSS constellations. The module is positioned on the top of the RotaSat to put the built-in patch antenna in the orientation most optimal for satellite connectivity.

3.2.4 Primary Payload

The Bosch BMP388 is our chosen pressure, temperature and altitude sensor. This sensor was chosen as team members have previous experience using this sensor for other projects. This sensor has a pressure accuracy of ±0.08 hPa and a temperature accuracy of ±0.5 ˚C. The pressure data can be used to estimate altitude to ±0.5 m. Communications will be done over I2C.

The STMicroelectronics LSM6DSLTR inertial measurement unit (IMU) contains three low G accelerometers (±16G Max Range), three gyroscopes (±2000˚/s Max Range), and a temperature sensor with lower accuracy compared to the Bosch BMP388. The data from this IMU will be recorded and transmitted, the temperature data used as a backup to the Bosch BMP388. Communications will be done over I2C.

The Rohm Semiconductor KX134 high G accelerometer unit is included on the computer to measure acceleration during the peak Gs of the powered ascent. The accelerometers in this unit have a max range of ±64G. Communications will be done over I2C.

The mRobotics SiK telemetry transceivers on 915mHz at 100mW transmission power are being used for communications with RotaSat. The transceiver on the satellite is connected to a 2dBi 915mHz whip antenna. Communications will be done over Serial.

A Micro SD card will be used to store flight data in a .csv file. Communications with the Micro SD card can be done over SPI.

3.2.5 Secondary Payload

The reaction wheel will be driven by a F130 DC motor from OSEPP Electronics, with a calculated 0.0014875 N*m of torque, it will have more than enough authority to exert control over the 0.35kg craft in 40km/hr winds.

The reaction wheel is a 30-gram aluminum wheel, turned on a manual lathe to a 52mm diameter. It will be fixed to the shaft of the DC motor using set screws and incorporated into the bottom of the satellite.
The motor will be powered by the Texas Instruments DRV8871 H-Bridge onboard the flight computer using 7.4v and commanded by the active control software.

A RunCam Hybrid 2 will be mounted on RotaSat to capture 4K @30fps video in flight. The RunCam will be powered with 7.4v through the main computer. The computer has the ability to turn the RunCam on and off.

3.3 MISSION RISKS

One of the biggest risks to the satellite is parachute deployment failure. Functionality will be ensured by folding and packaging the parachute efficiently. We will also test the parachute's strength beforehand to ensure reliability under 50N of force.

Loss of telemetry downlink is another potential risk to the mission. Since we are unable to test the ground antenna in CanSat flight conditions, it will be difficult to characterize the antenna's functionality. However, we will conduct ground tests of the telemetry system, hopeful simulating flight conditions and analyzing signal strength data.

Saturation of the reaction wheel is a potential failure point of our secondary mission payload. Saturation happens when the reaction wheel has reached its maximum possible speed and cannot produce any more counter torques on the satellite. Any possible sources of unwanted torques on the satellite are being mitigated. For example, a parachute with a spill hole will be used in order to have a smoother descent with less oscillations.

3.4 BUDGET

After reaching out to multiple companies to support our mission, we have received both monetary and non-monetary aid from sponsorships. EarthDaily Analytics provided $2000, while GHGSat donated $1000. We additionally received manufacturing aid and 500$ from Modern Engineering, alongside PCBs and stencils from JLCPCB. Rocketman Parachutes will be providing the parachute.

Item Name	# bought	Price	Extra Costs
CanSat Kit	1	$100.00	$0.00
4mm Carbon Fibre Rod	1	$20.99	$0.00
GPS Unit	1	$39.99	$0.00
STEMMA QT Connector	1	$1.99	$8.40
2S LiPo 900mAh	1	$24.99	$0.00
KX134 High G Accelerometer	1	$16.91	$0.00
Telemetry Transmit Antenna	1	$11.95	$0.00
Assorted Metal Parts and Machining Time	1	$0.00	$0.00
SiK Telemetry Radios	1	$51.35	$7.90
DRV8871 H Bridge Motor Driver	1	$9.79	
Polyterra Matte Grey PLA	1	$25.99	$0.00
JST SH 4-pin	1	$5.45	
SWD Cable (For Programming)	1	$2.69	
SWD Connector (For Programming)	1	$2.07	$0.00
JST SH 2 Pin Wire	1	$10.47	$1.61
JST SH 2 Pin Connector	3	$1.98	$8.38
0.1uF Decoupling Capacitors	100	$6.10	$24.74
atsamd21 g18	3	$16.65	$23.00
Buzzer	1	$4.09	
Lipo Charger	1	$49.99	$0.00
Battery and Charger Bag	1	$24.90	$0.00
Misc Components		$25	
Runcam Hybrid 4k	1	$140	$0.00
	Total Price	$667.37	out of $700.00

Table 1. CanSat Budget.

ROTASAT

END OF CRITICAL DESIGN REVIEW

Presented By: Team Zephyr