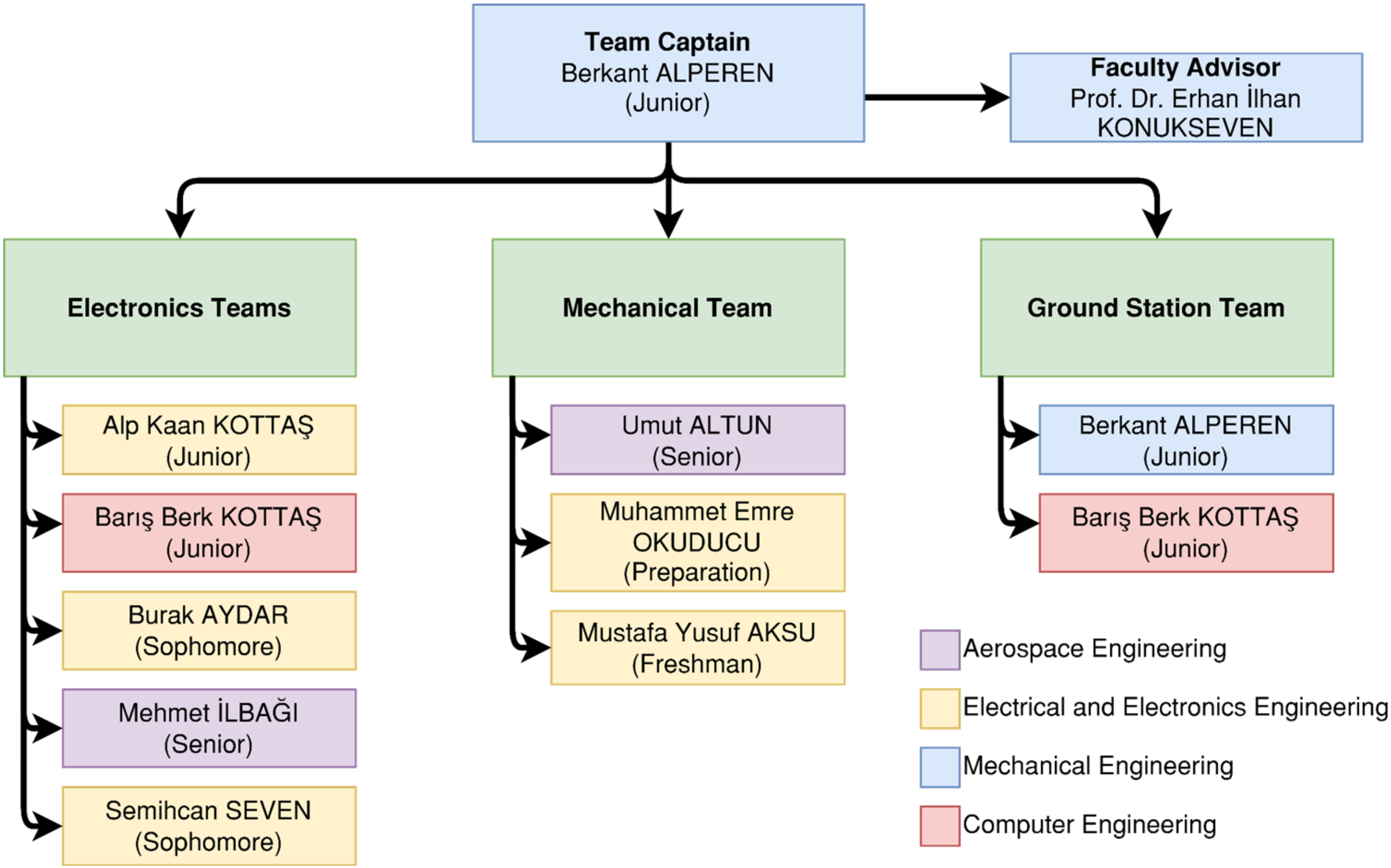
CanSat 2023
Critical Design Review (CDR)

#1068

METUOR SPACE

Presentation Outline

Team Organization



Acronyms

GCS	Ground control system
CNC	Computer numerically controlled
COTS	Commercial off the shelf
GPS	Global positioning system
CONOPS	Concept of operation
FSW	Flight software subsystem
EPS	Electrical power subsystem
DCS	Descent control system

CW	Clockwise
CCW	Counterclockwise

DD	Decimal Degrees
DDM	Degrees Decimal Minutes

ABS,PLA+,PTEG	3D printing materials

SPI	Serial peripheral interface
UART	Universal asynchronous receiver transmitter
ADC	Analog-to-digital converter
DC	Direct current
CDH	Communication and data handling
PCB	Printed circuit board
RTC	Real time clock

GUI	Graphical user interface

All SI Unit system

System Overview

Umut ALTUN

Mission Summary

Mission Objectives:

- Design a Cansat that shall consist of a container and a probe.
- The Cansat shall be launched to an altitude ranging from 670 meters to 725 meters above the launch site and deployed near apogee (peak altitude).
- The Cansat shall descend using a parachute at a rate of 15 m/s.
- At 500 meters, the Cansat shall release a probe that shall open a heat shield that will also be used as an aerobraking device with a descent rate of 20 meters/second or less.
- At 200 meters, the probe shall deploy a parachute and slow the descent rate to 5 meters/second.
- Once the probe has landed, it shall attempt to upright itself and raise a flag 500 mm above the base of the probe when the probe is in the upright position.
- A video camera shall be included and point toward the ground during descent.

Bonus Objectives (Attempted):

- A video camera shall be integrated into the container and point toward the probe. The camera shall record the event when the probe is released from the container. The video shall be recorded and retrieved when the container is retrieved.

  Rationale: We have enough space for the required avionics in our container and these avionics were also light enough to not exceed our mass budget so attempting the bonus objective was rational.

Summary of Changes Since PDR (1/2)

PDR	CDR	Rational/Testing
Most structural elements are to be made out of fiberglass	3D printed parts made out of ABS are used wherever possible	- Cost savings - Manufacturing concerns - Weight savings
12v DC Motor with 2 kg*cm of torque is used	6v DC Motor with 6.6 kg*cm of torque is used	- Faster operation of the heat shield is crucial to the descent control of the CanSat
Motor Holder Plate is 40 mm away from the PCB	Motor holder is 20 mm away from the PCB	- Motor holder plate has been moved down to make room for the larger motor without having to change the overall length of the probe too much.
A “parachute bay” is implemented on the container	“Parachute bay” is removed from the container	- Weight reduction - Manufacturing concerns
Payload Tilt Sensor MPU9250	Payload Tilt Sensor BNO055	- MPU9250 had a high error margin in test measurements.

Summary of Changes Since PDR (2/2)

PDR	CDR	Rational/Testing
Parts are designed for fiberglass manufacturing techniques	Parts are revised such that 3D printing methods are easily applied	- Ease of manufacturing - Rapid prototyping
Parachutes are directly connected to the probe and container	Parachutes are connected to the probe and container via a swivel mount	- Descent stability
Glue to hold motor mount at the desired height	Structural components and glue to hold motor mount at the desired height	- Rigidity and structural integrity
Parts Mostly Unpainted fiberglass	Parts made out of orange and pink ABS wherever possible	- Ease of recovery
Payload EPS battery Orion 18500	Payload EPS battery Samsung INR18650-35E	- Orion 18500 did not satisfy enough instant current to the new heatshield DC Motor.
Payload EPS boost converter voltage 5V	Payload EPS boost converter voltage 6V	- 6V need of the new heatshield DC motor

System Requirement Summary (1/10)

Number	Requirement	Priority	Subsystem	Verification			
				A	I	T	D
1	Total mass of the CanSat (science probe and container) shall be 700 grams +/- 10 grams.	Very High	Mechanical / Electronics	X			
2	CanSat shall fit in a cylindrical envelope of 125 mm diameter x 400 mm length. Tolerances are to be included to facilitate container deployment from the rocket fairing.	Very High	Mechanical	X		X	X
3	The container shall not have any sharp edges to cause it to get stuck in the rocket payload section which is made of cardboard.	Very High	Mechanical		X	X	X
4	The container shall be a fluorescent color; pink, red or orange.	Very High	Mechanical		X		
5	The container shall be solid and fully enclose the science probes. Small holes to allow access to turn on the science probes are allowed. The end of the container where the probe deploys may be open.	Very High	Mechanical		X		X
6	The rocket airframe shall not be used to restrain any deployable parts of the CanSat.	Vey High	Mechanical		X	X	X
7	The rocket airframe shall not be used as part of the CanSat operations.	Very High	Mechanical		X		X
8	The container's parachute shall not be enclosed in the container structure. It shall be external and attached to the container so that it opens immediately when deployed from the rocket.	Very High	Mechanical			X	X

System Requirement Summary (2/10)

Number	Requirement	Priority	Subsystem	Verification			
				A	I	T	D
9	The Parachute shall be fluorescent Pink or Orange	Very High	Mechanical		X		
10	The descent rate of the CanSat (container and science probe) shall be 15 meters/second +/- 5 m/s.	Very High	Mechanical	X		X	
11	0 altitude reference shall be at the launch pad.	Very High	Electronics			X	X
12	All structures shall be built to survive 15 Gs of launch acceleration.	Very High	Mechanical	X		X	
13	All structures shall be built to survive 30 Gs of shock.	Very High	Mechanical	X		X	
14	All electronics and mechanical components shall be hard mounted using proper mounts such as standoffs, screws, or high performance adhesives.	High	Mechanical			X	X
15	All mechanisms shall be capable of maintaining their configuration or states under all forces.	Very High	Mechanical			X	X
16	Mechanisms shall not use pyrotechnics or chemicals.	High	Mechanical		X		X

System Requirement Summary (3/10)

Number	Requirement	Priority	Subsystem	Verification			
				A	I	T	D
17	Mechanisms that use heat (e.g., nichrome wire) shall not be exposed to the outside environment to reduce potential risk of setting vegetation on fire.	High	Mechanical		X		
18	Both the container and probe shall be labeled with team contact information including email address.	Very High	All subsystem		X		
19	Cost of the CanSat shall be under $1000. Ground support and analysis tools are not included in the cost. Equipment from previous years shall be included in this cost, based on current market value.	Very High	All subsystem	X			
20	XBEE radios shall be used for telemetry. 2.4 GHz Series radios are allowed. 900 MHz XBEE radios are also allowed.	Very High	Electronics				X
21	XBEE radios shall have their NETID/PANID set to their team number.	Very High	Electronics			X	X
22	XBEE radios shall not use broadcast mode.	High	Electronics				X
23	The container (if needed) and probe shall include an easily accessible power switch that can be accessed without disassembling the cansat and science probes and in the stowed configuration.	Very High	Mechanical / Electronics		X		

System Requirement Summary (4/10)

Number	Requirement	Priority	Subsystem	Verification			
				A	I	T	D
24	The probe shall include a power indicator such as an LED or sound generating device that can be easily seen or heard without disassembling the cansat and in the stowed state.	Very High	Electronics		X		X
25	An audio beacon is required for the probe. It shall be powered after landing.	Very High	Electronics		X		X
26	The audio beacon shall have a minimum sound pressure level of 92 dB, unobstructed.	High	Electronics		X		X
27	Battery source may be alkaline, Ni-Cad, Ni-MH or Lithium. Lithium polymer batteries are not allowed. Lithium cells must be manufactured with a metal package similar to 18650 cells. Coin cells are allowed.	Very High	Electronics		X		
28	An easily accessible battery compartment shall be included allowing batteries to be installed or removed in less than a minute and not require a total disassembly of the CanSat.	Very High	Mechanical / Electronics		X		X
29	Spring contacts shall not be used for making electrical connections to batteries. Shock forces can cause momentary disconnects.	Very High	Mechanical / Electronics		X		

System Requirement Summary (5/10)

Number	Requirement	Priority	Subsystem	Verification			
				A	I	T	D
30	The Cansat shall operate during the environmental tests laid out in Section 3.5.	Very High	Mechanical / Electronics	X		X	
31	The Cansat shall operate for a minimum of two hours when integrated into the rocket.	Very High	Electronics	X		X	
32	The probe shall be released from the container when the CanSat reaches 500 meters.	Very High	Mechanical / Electronics			X	X
33	The probe shall deploy a heat shield after leaving the container.	Very High	Mechanical / Electronics			X	X
34	The heat shield shall be used as an aerobrake and limit the descent rate to 20 m/s or less.	Very High	Mechanical	X		X	
35	At 200 meters, the probe shall release a parachute to reduce the descent rate to 5 m/s +/-1 m/sec.	Very High	Mechanical / Electronics			X	X

System Requirement Summary (6/10)

Number	Requirement	Priority	Subsystem	Verification			
				A	I	T	D
36	Once landed, the probe shall upright itself.	Very High	Mechanical / Electronics			X	X
37	After uprighting, the probe shall deploy a flag 500 mm above the base of the probe when the probe is in the upright position.	Very High	Mechanical / Electronics			X	X
38	The probe shall transmit telemetry once per second. .	Very High	Electronics	X		X	X
39	The probe telemetry shall include altitude, air pressure, temperature, battery voltage, probe tilt angles, command echo, and GPS coordinates that include latitude, longitude, altitude and number of satellites tracked.	Very High	Electronics / GCS			X	X
40	The probe shall include a video camera pointing down to the ground.	Very High	Mechanical / Electronics		X		
41	The video camera shall record the flight of the probe from release to landing.	Very High	Electronics	X		X	

System Requirement Summary (7/10)

Number	Requirement	Priority	Subsystem	Verification			
				A	I	T	D
42	The video camera shall record video in color and with a minimum resolution of 640x480.	Very High	Electronics			X	X
44	The flight software shall maintain a count of packets transmitted which shall increment with each packet transmission throughout the mission. The value shall be maintained through processor resets.	Very High	Electronics	X		X	
45	The probe shall maintain mission time throughout the whole mission even with processor resets or momentary power loss. .	Very High	Electronics	X		X	
46	The probe shall have its time set to within one second UTC time prior to launch.	High	Electronics		X	X	
47	The probe flight software shall support simulated flight mode where the ground station sends air pressure values at a one second interval using a provided flight profile csv file.	Very High	Electronics / GCS		X	X	X

System Requirement Summary (8/10)

Number	Requirement	Priority	Subsystem	Verification			
				A	I	T	D
48	In simulation mode, the flight software shall use the radio uplink pressure values in place of the pressure sensor for determining the payload altitude.	Very High	Electronics / GCS	X		X	
49	The payload flight software shall only enter simulation mode after it receives the SIMULATION ENABLE and SIMULATION ACTIVATE commands.	Very High	Electronics / GCS		X	X	
50	The ground station shall command the Cansat to start calibrating the altitude to zero when the Cansat is on the launch pad prior to launch.	Very High	Electronics / GCS		X	X	
51	The ground station shall generate csv files of all sensor data as specified in the Telemetry Requirements section.	Very High	GCS		X	X	X
52	Telemetry shall include mission time with 1 second or better resolution.	High	Electronics		X	X	X
53	Configuration states such as zero altitude calibration shall be maintained in the event of a processor reset during launch and mission.	Very High	Electronics			X	X

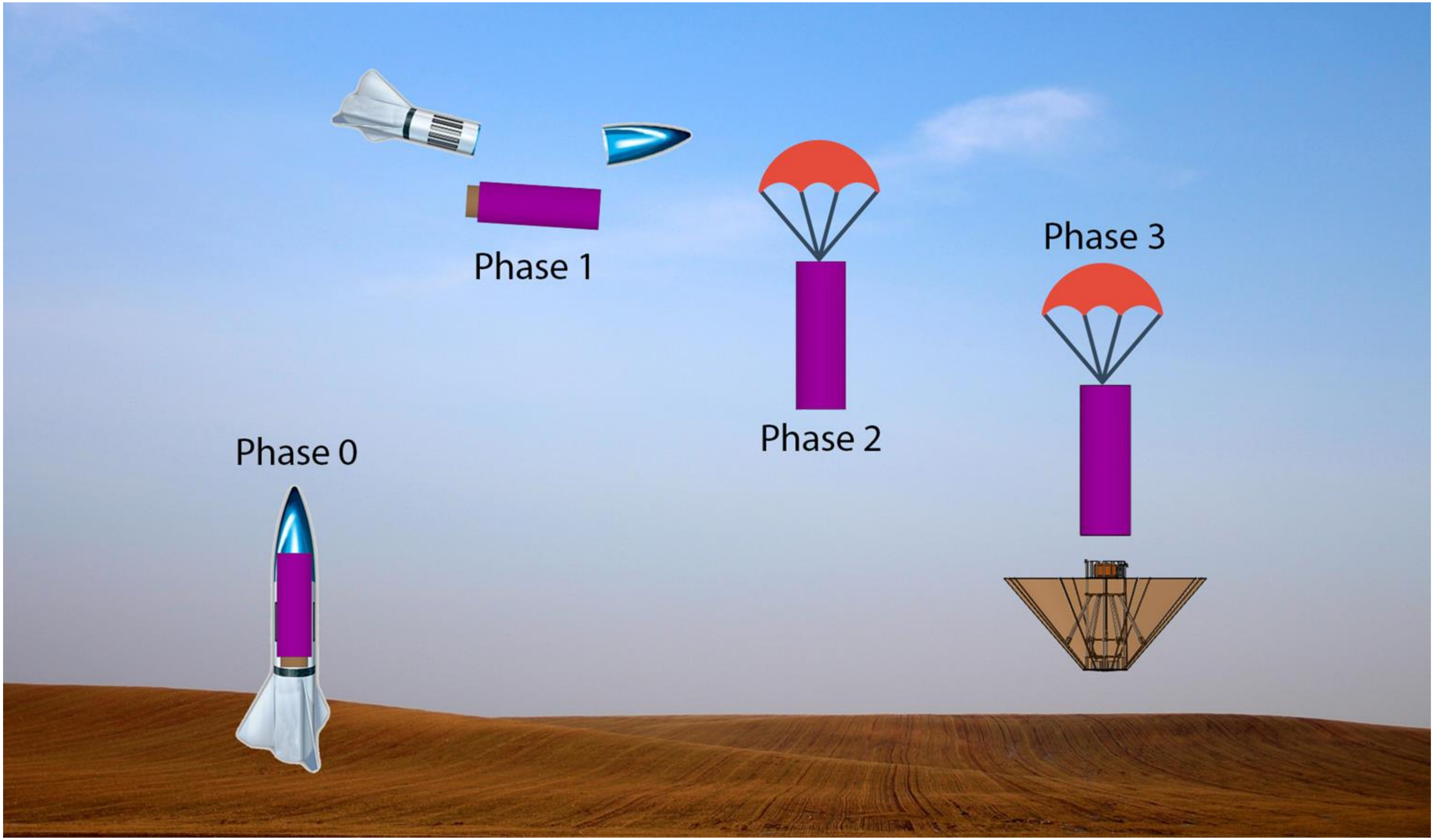
System Requirement Summary (9/10)

Number	Requirement	Priority	Subsystem	Verification			
				A	I	T	D
54	Each team shall develop their own ground station.	Very High	GCS		X		X
55	All telemetry shall be displayed in real time during descent on the ground station.	Very High	GCS		X		X
56	All telemetry shall be displayed in engineering units (meters, meters/sec, Celsius, etc.)	High	GCS	X	X		
57	Teams shall plot each telemetry data field in real time during flight.	High	GCS		X	X	X
58	The ground station shall include one laptop computer with a minimum of two hours of battery operation, XBEE radio and a hand-held antenna.	Very High	GCS	X	X		X
59	The ground station must be portable so the team can be positioned at the ground station operation site along the flight line. AC power will not be available at the ground station operation site.	High	GCS				X

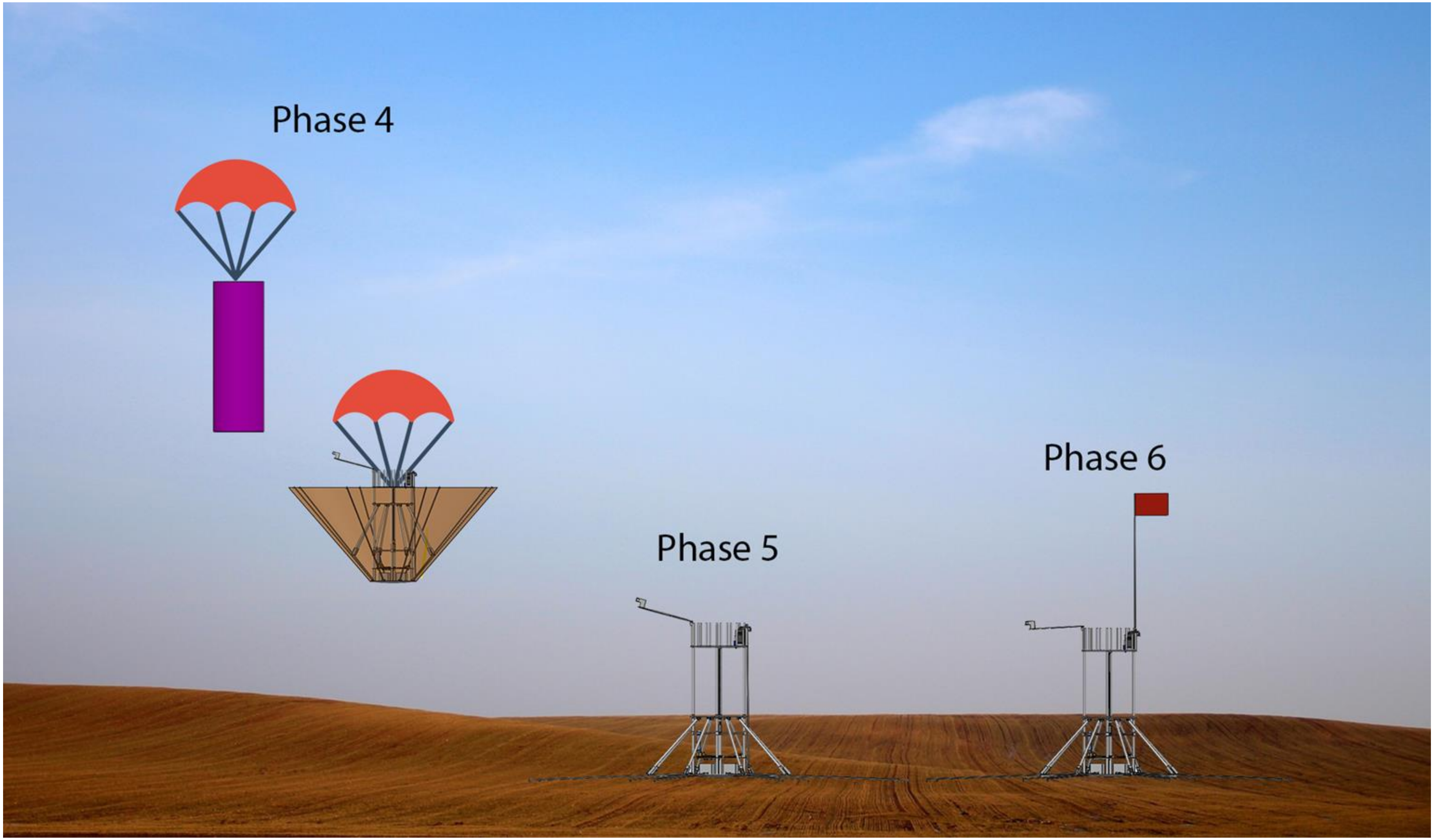
System Requirement Summary (10/10)

Number	Requirement	Priority	Subsystem	Verification			
				A	I	T	D
60	The ground station software shall be able to command the payload to operate in simulation mode by sending two commands, SIMULATION ENABLE and SIMULATION ACTIVATE.	Very High	Electronics / GCS			X	X
61	When in simulation mode, the ground station shall transmit pressure data from a csv file provided by the competition at a 1 Hz interval to the cansat.	Very High	Electronics / GCS	X	X	X	

System Concept of Operations (CONOPS) (1/3)



System Concept of Operations (CONOPS) (2/3)

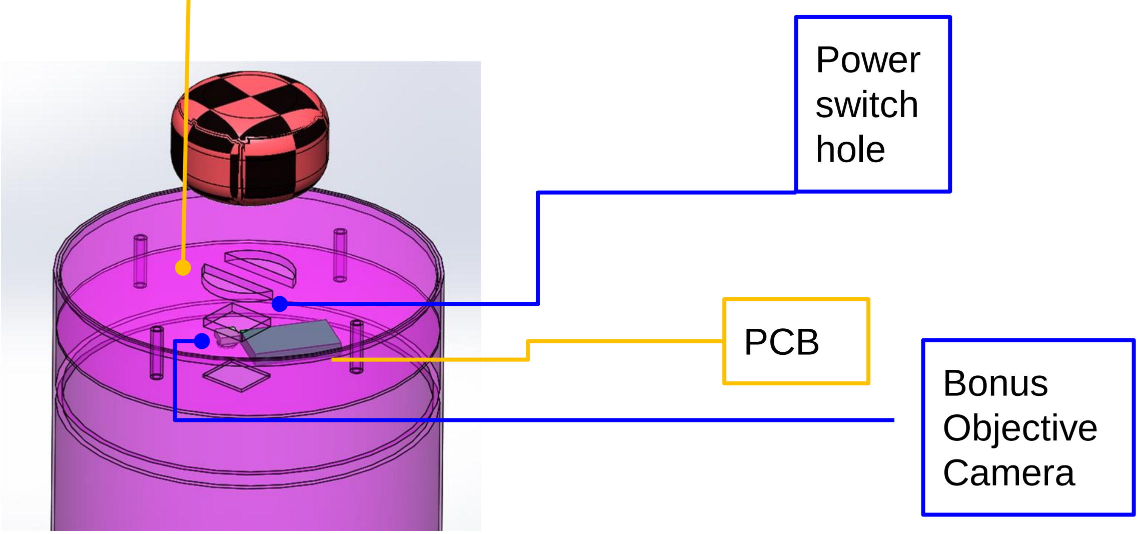


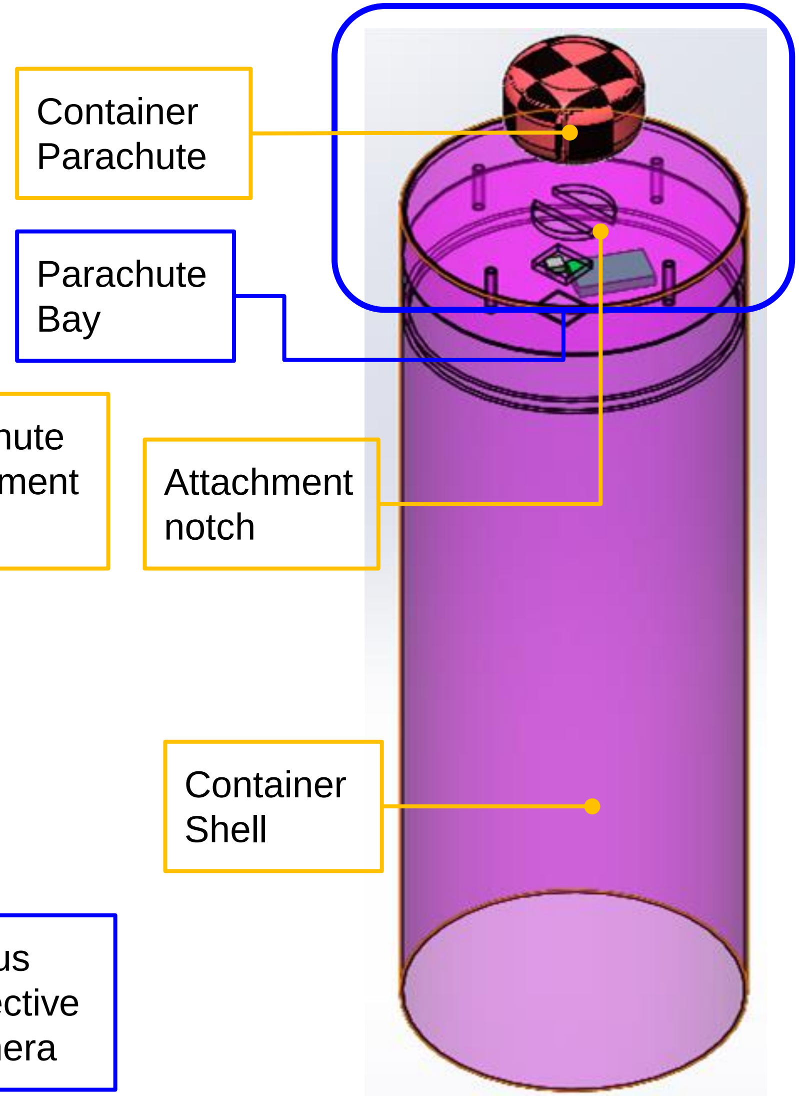
System Concept of Operations (CONOPS) (3/3)

- **Phase 0 (Pre Launch):**
  - CanSat is turned on and GCS connection is established.
  - CanSat is placed in the rocket at launchpad.
  - Sensors are calibrated and data transmission begins.
- **Phase 1 (Apogee):**
  - CanSat is separated from the rocket and container parachute is deployed.
- **Phase 2 (Descent):**
  - CanSat starts to descend at a rate of 15 m/s.
- **Phase 3 (Separation and Aerobraking):**
  - At 500 meters, the probe is released from the container.
  - The container continues to descend separated from the probe.
  - The heat shield is initiated and the probe starts to descend at a rate of 20 m/s.
- **Phase 4 (Probe Parachute Deployment):**
  - At 200 meters, the probe deploys a parachute and slows it descent rate to 5 m/s.
- **Phase 5 (Landing and Upright Operation):**
  - The probe uprights itself after landing.
- **Phase 6 (Flag Mast Operation):**
  - The probe raises a flag 500 mm above its base.
- **Phase 7 (Recovery and Data Reduction):**
  - Audio beacon is turned on.
  - CanSat is recovered with the help of GPS data, audio beacon and fluorescent colors.
  - Data recovered are formatted and submitted.

Container Layout

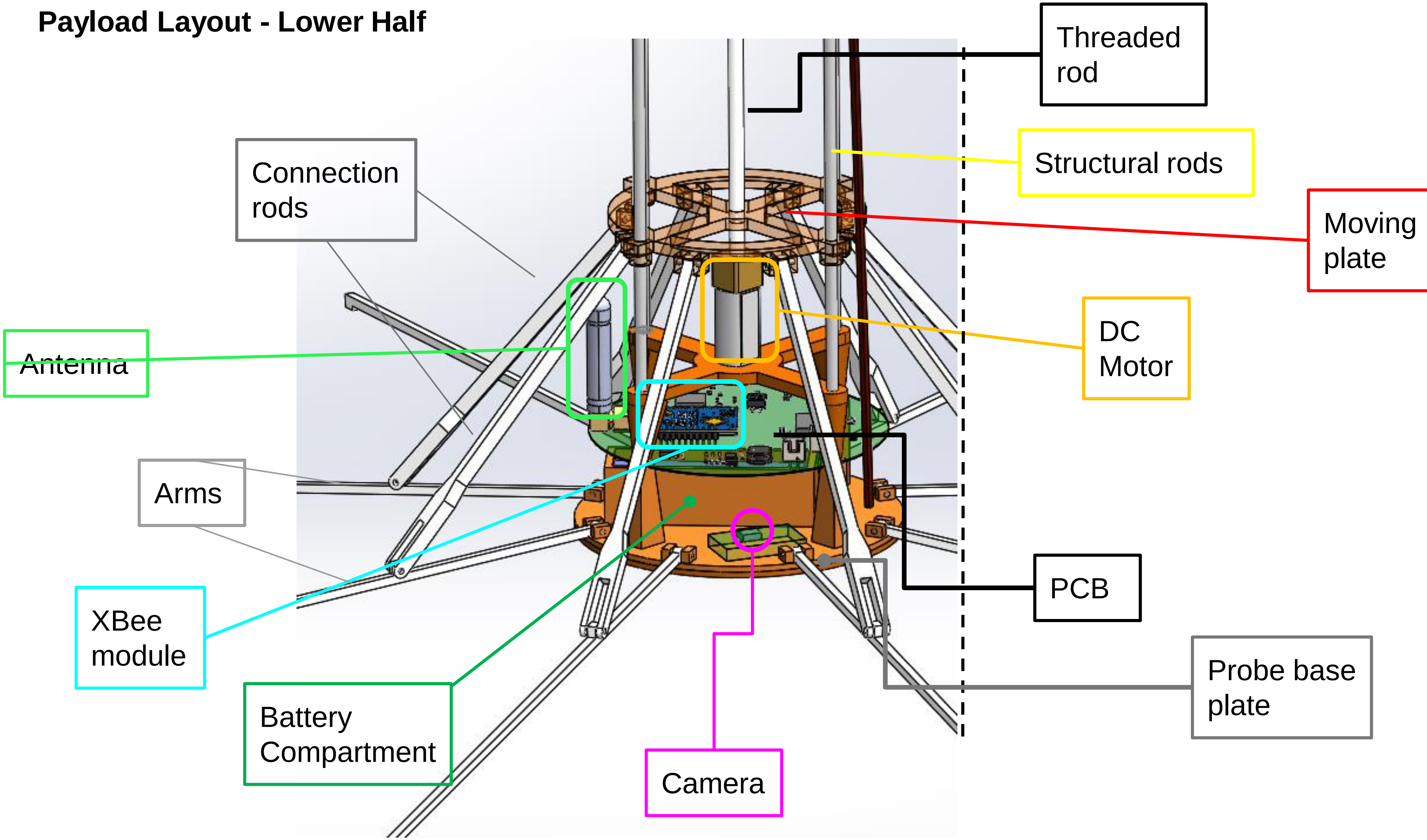
Our container fully encloses the probe, it features a hole that goes through the entire container for the power switches for the container and probe. It has a notch which is used to secure the probe to the container. We also have a camera to record the separation of the probe.





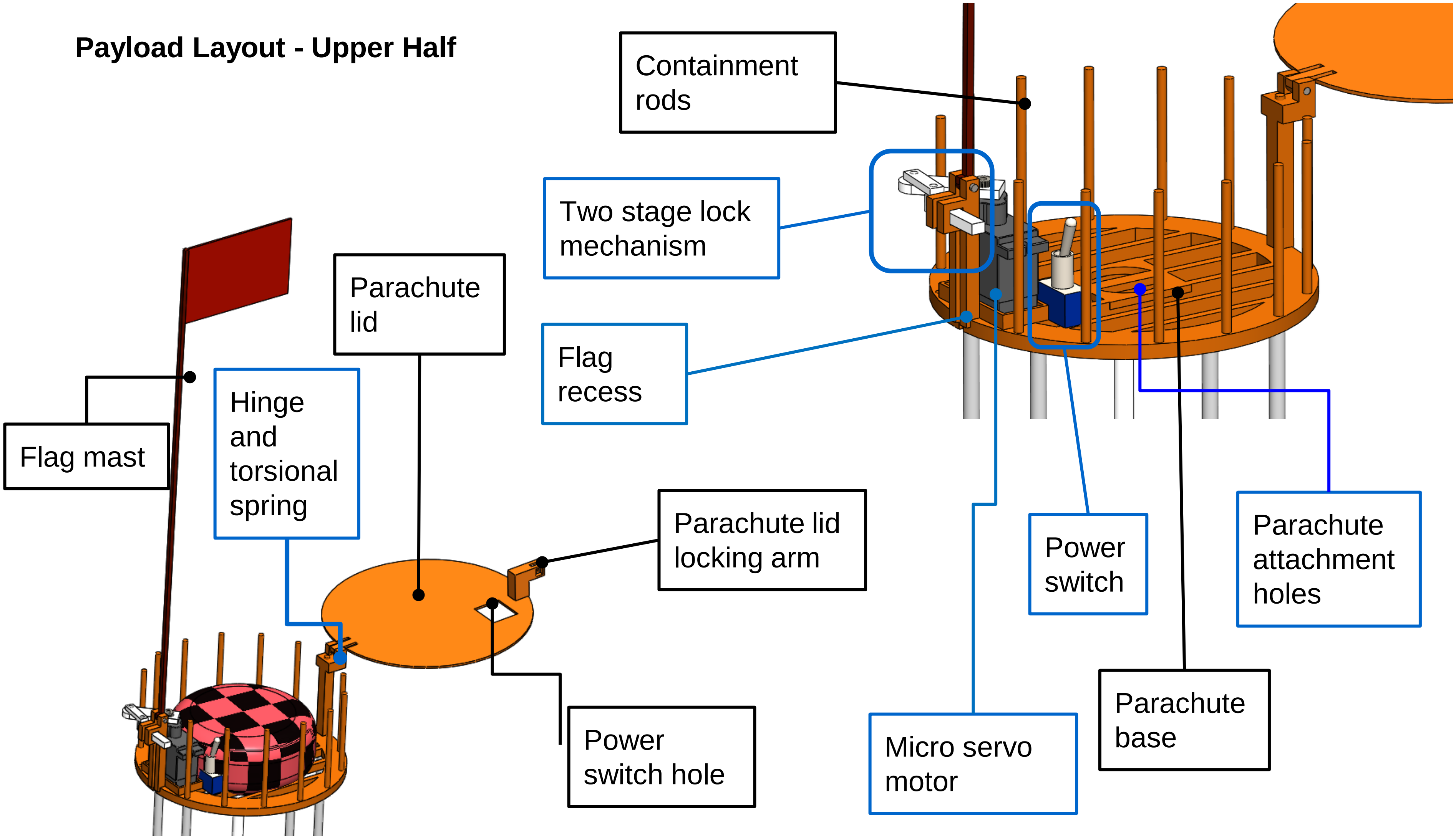
Physical Layout (2/5)

Payload Layout - Lower Half



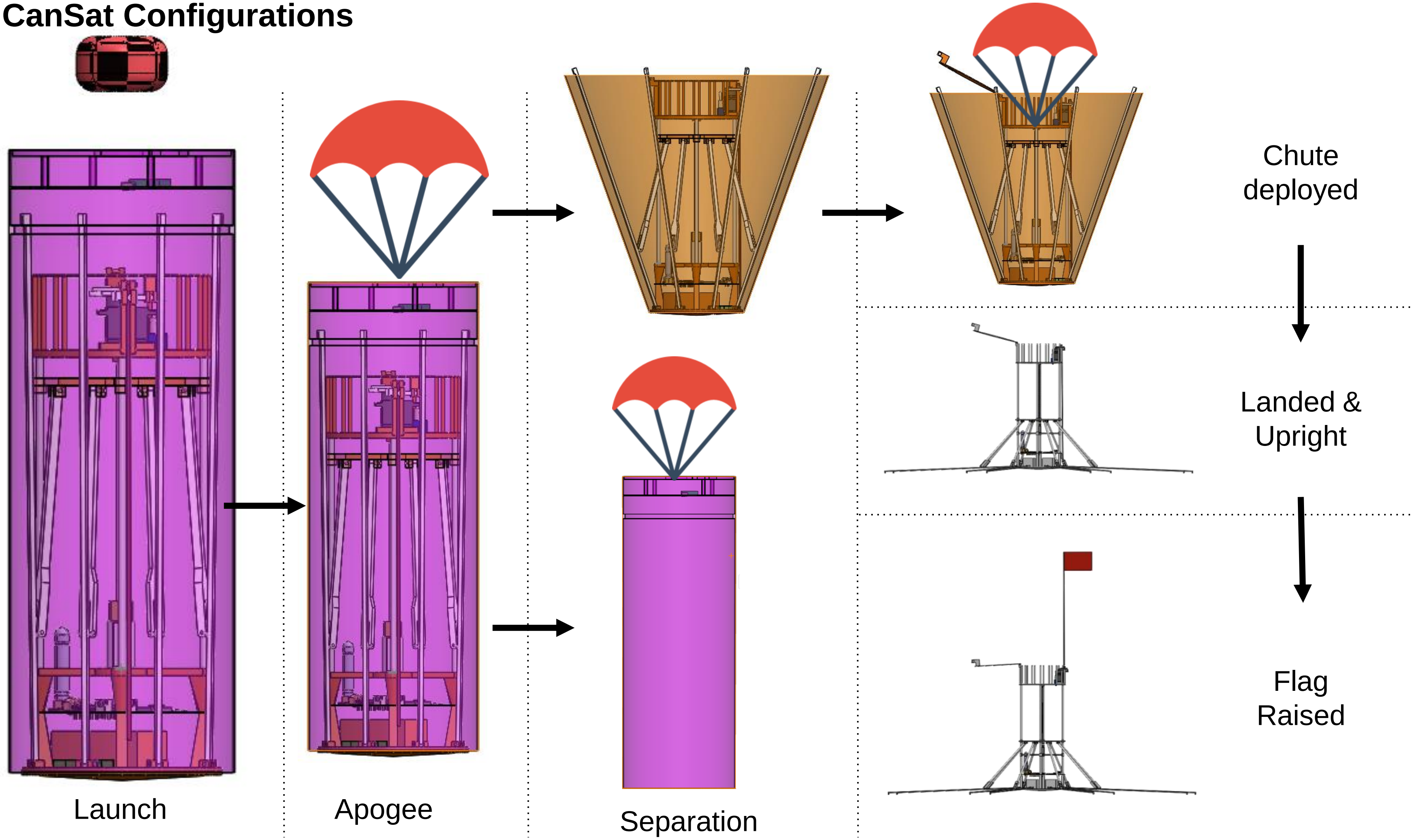
Physical Layout (3/5)

Payload Layout - Upper Half

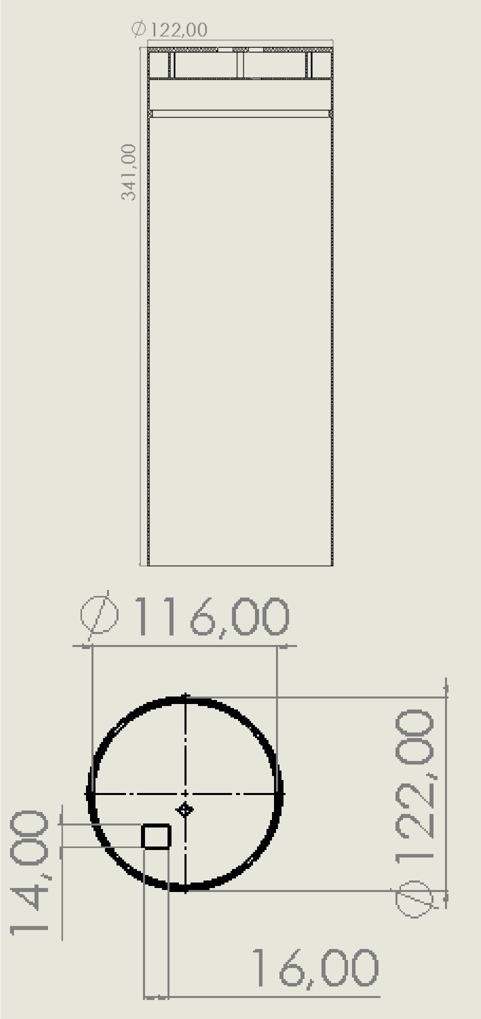


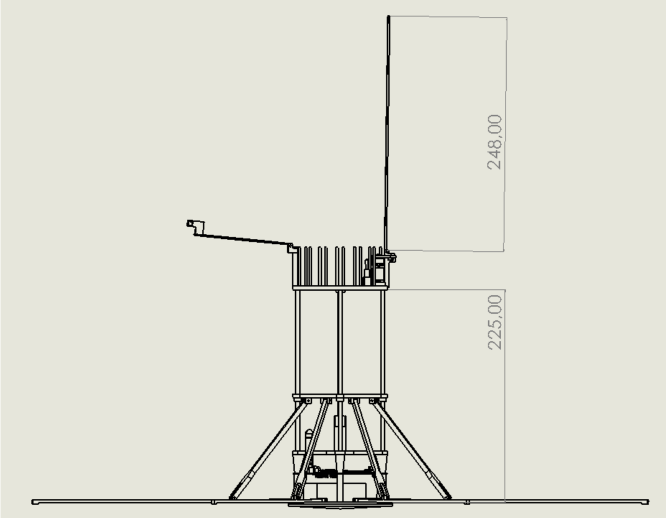
Physical Layout (4/5)

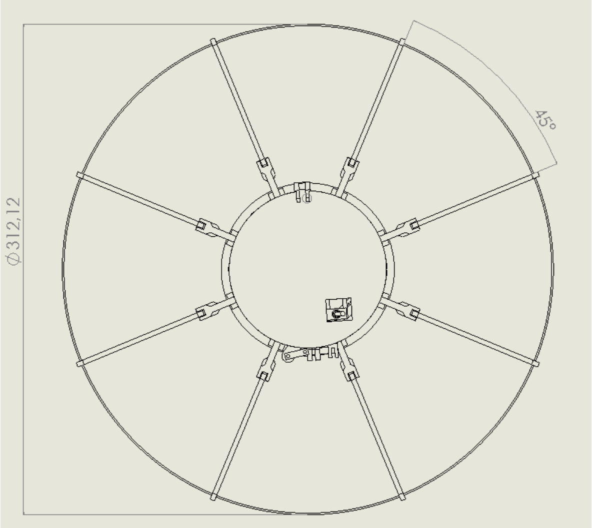
CanSat Configurations



Physical Layout (5/5)



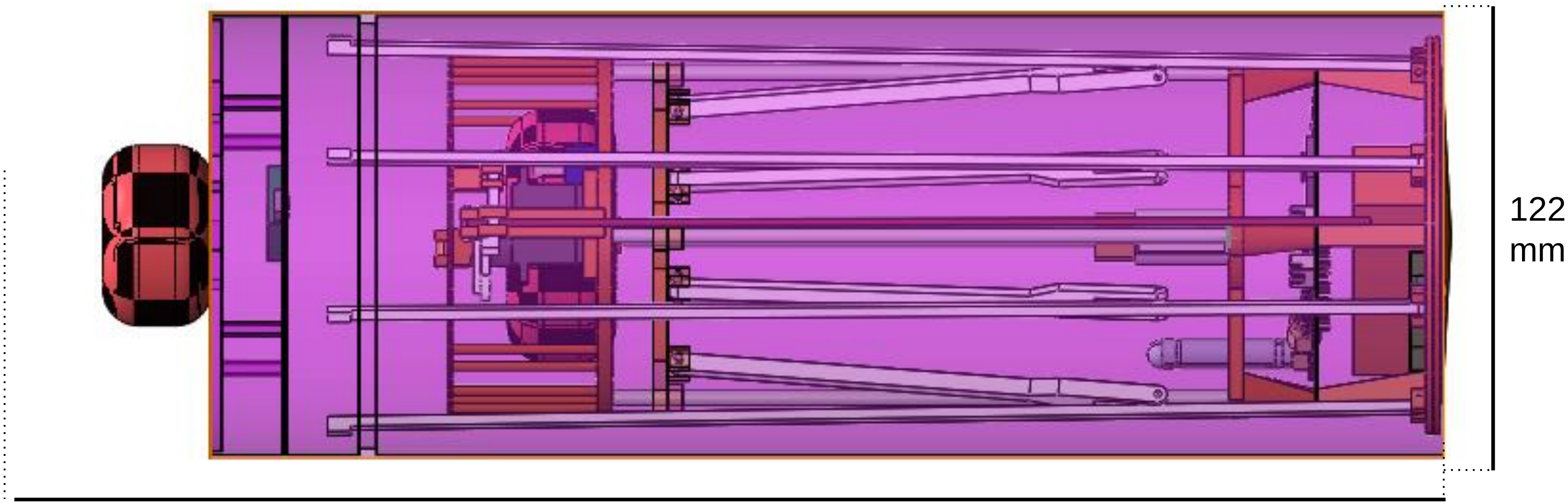




All dimensions are in mm’s

- On the left, dimensions for the container
- On the middle, height dimensions for the payload
- On the right, radial dimensions for the cansat

Launch Vehicle Compatibility



	Envelope	Stowed Container	Clearance
Diameter (mm)	125	122	1.5 *(radially)*
Length (mm)	400	372.84	27.16

The CanSat is designed to have no protrusions and enough clearance to sit within the vehicle payload envelope in stowed configuration to enable safe deployment from the rocket.

Sensor Subsystem Design

Alp Kaan KOTTAŞ

Sensor Subsystem Overview

Sensors	Models	Functions
Air Pressure Sensor	BMP280	- Measure the air pressure and determine altitude
Air Temperature Sensor	BMP280	- Measure the air temperature
GPS Sensor	uBlox NEO-M8N	- Receive the geolocation and time data provided by the satellites - Track the location of the payload
Voltage Sensor	STM32 Onboard ADC	- Measure the battery voltage with a resistor voltage divider
Tilt Sensor	BNO055	- Measure the acceleration, angular velocity, and magnetic field intensity in three mutually perpendicular axis - Obtain the orientation of the probe
Camera	Adafruit Mini Spy Camera	- Record the flight of the probe from release to landing
Bonus Camera	Adafruit Mini Spy Camera	- Record the probe when it is released

Sensor Changes Since PDR

Section	PDR	CDR	Rationale
Payload Tilt Sensor	MPU9250	BNO055	- MPU9250 had a high error margin in test measurements.

Payload Air Pressure Sensor Summary

Model	Interface	Accuracy (hPa)	Operating Pressure Range (hPa)	Size (mm)	Weight (g)	Operating Voltage (V)	Operating Current (uA)	Cost ($)
BMP280	I2C, SPI	±1.00	300-1100	2.0 x 2.5 x 0.95	0.5	3.3	4.2	2.30

Pressure to Altitude Equation

$$h = 44307.694 * \left(1 - \left(\frac{p}{p_0}\right)^{\frac{1}{5.25530}}\right)$$

h = current altitude in m
p = current pressure in Pa
p_0 = pressure at sea level in Pa

The equation above will be used to calculate the altitude using pressure data collected with BMP280.

```
Pressure = bmp280_compensate_P_int64(rawPressure)/256.0;
```

The sensor library is written following the datasheet by our team members. The raw 20-bit pressure value read from pressure output register is passed to a function that is given in the datasheet. The returned value is divided by 256 to get the pressure value in Pascals.

Data Format	
`float pressure, altitude`	
`pressure`	`xx.xx (Pa)`
`altitude`	`xx.xx (m)`

Selected Sensor
BMP280

Reasons
Cost advantages
Experience with the sensor

Payload Air Temperature Sensor Summary

Model	Interface	Accuracy (°C)	Operating Temperature Range (°C)	Size (mm)	Weight (g)	Operating Voltage (V)	Operating Current (uA)	Cost ($)
BMP280	I2C, SPI	±1.0	-40 / 85	2.0 x 2.5 x 0.95	0.5	3.3	4.2	.2.30

Data Format	
`float temperature`	
`temperature`	`xx.xx (°C)`

```
Temperature = bmp280_compensate_T_int32(rawTemperature)/100.0;
```

The sensor library is written following the datasheet by our team members. The raw 20-bit temperature value read from temperature output register is passed to a function that is given in the datasheet, and the returned value is divided by 100 to get the pressure value in degrees Celsius.

Selected Sensor
BMP280

Reasons
Cost advantages
Experience with the sensor

Payload GPS Sensor Summary

Model	Interface	Horizontal Position Accuracy (m)	Maximum Update Rate (Hz)	Antenna Support	Size (mm)	Weight (g)	Operating Voltage (V)	Operating Current (mA)	Cost ($)
NEO-M8N	I2C, SPI, UART	2.5	10	External Passive or Active	12.2 x 16 x 2.4	1.6	3.3	32	31.50

Data Format

```
float latitude, longitude, gps_altitude;
char time[8];
uint8_t gps_sats;
```

latitude	xx.xxxxxxx (DD)
longitude	xxx.xxxxxxx (DD)
gps_altitude	xx.xx (m)
time	“hh:mm:ss”
gps_sats	xx

Selected Receiver
uBlox NEO-M8N

Reasons
Fast update rate
Experience with the module

$$\text{DDM to DD: decimal degrees} = \text{degrees} + \frac{\text{minutes}}{60}$$

The equation above is used to convert the latitude and longitude data given in DDM format by the GPS receiver to DD format.

Payload Voltage Sensor Summary

Model	Interface	Resolution (bits)	Range (V)	Weight (g)	Operating Voltage (V)	Operating Current (uA)	Cost ($)
Onboard ADC	ADC	12	3 - 4.2	Neglected	3.3	Neglected	N/A

Inverse Voltage Divider Equation

$$V_{in} = V_{out} \frac{R_1 + R_2}{R_2}$$

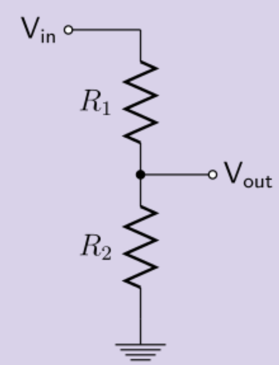
Data Format	
`float bat_voltage`	
`bat_voltage`	`xx.xx (V)`

The nominal voltage of Li-ion batteries are around 3.7 V. However, since the STM32 microcontroller is powered with a 3.3 V regulator, the analog measurements above 3.3 V cannot be measured. Therefore, we plan to use a voltage divider and measure the voltage across R_2. Then, the measurement will be substituted in the equation above to the battery voltage, V_{in}.

$$Resolution = \frac{3.3\ V}{2^{12}} = 0.81\ mV$$

Selected Sensor
Onboard ADC

Reasons
No additional cost



Payload Tilt Sensor Summary

Model	Interface	Size (mm)	Weight (g)	Operating Voltage (V)	Operating Current (mA)	Cost ($)
BNO055	I2C, UART	3.8 x 5.2 x 1.13	0.5	3.3	12.3	45.12

Accelerometer Range (g)	Accelerometer Resolution (bits)	Gyroscope Range (dps)	Gyroscope Resolution (bits)	Magnetometer Range (uT)	Magnetometer Resolution (bits)
±16	14	±2000 dps	16	±1300 (x,y axis)	14

This sensor measures acceleration, angular velocity, magnetic field in three mutually perpendicular axes. Furthermore, it outputs a tilt-compensated absolute orientation data using all the measurements mentioned above.

The operation mode of the sensor will be set to NDOF. The pitch, roll and yaw angles will be obtained from euler angle output registers.

Data Format	
`float ax, ay, az, gx, gy, gz, pitch, yaw, roll`	
`acceleration`	`xx.xx (m/s2)`
`gyroscope`	`xx.xx (dps)`
`orientation angles`	`xx.xx (degrees)`

Selected Sensor
BNO055

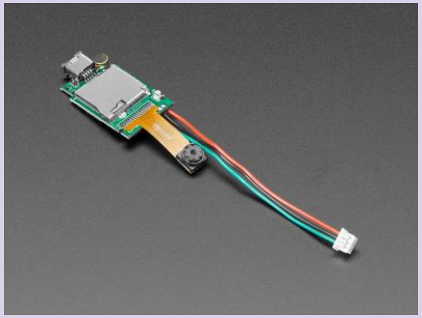
Reasons
Better accuracy
Orientation output

Camera Summary

Model	Interface	Resolution (Pixels)	Micro SD Support	Dimensions (mm)	Weight (g)	Operating Voltage (V)	Operating Current (mA)	Cost ($)
Adafruit 3202 Mini Spy Cam	Discrete	640x480 @ 30 fps	32 GB	28.5x17x4.2 +6.2x6.2x4.4	2.8	6	110	12.5

Selected Camera
Adafruit 3202 Mini
Spy Cam

Reasons
Enough resolution
Weight advantage
Ready to use out of the box



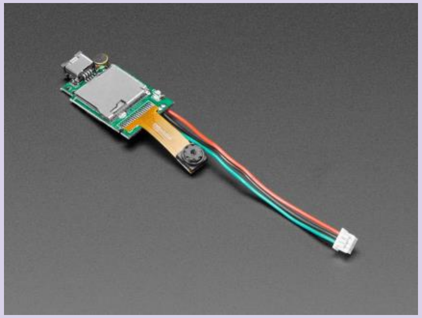
The selected camera meets the requirement of 640x480 pixels in color

Bonus Camera Summary

Model	Interface	Resolution (Pixels)	Micro SD Support	Dimensions (mm)	Weight (g)	Operating Voltage (V)	Operating Current (mA)	Cost ($)
Adafruit 3202 Mini Spy Cam	Discrete	640x480 @ 30 fps	32 GB	28.5x17x4.2 +6.2x6.2x4.4	2.8	6	110	12.5

Selected Camera
Adafruit 3202 Mini Spy Cam

Reasons
Enough resolution
Weight advantage
Ready to use out of the box



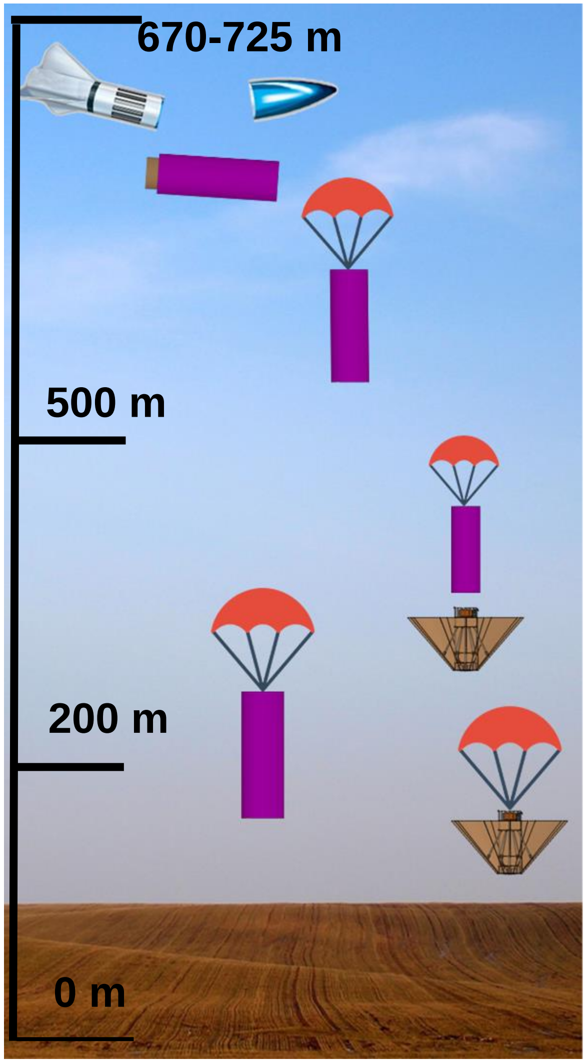
The selected camera meets the requirement of 640x480 pixels in color

Note: We will use an IR/Phototransistor system to communicate probe and container to trigger the camera at the beginning of Phase 3. We will use a CR2032 to power-up bonus camera.

Descent Control Design

Muhammet Emre OKUDUCU

Descent Control Overview

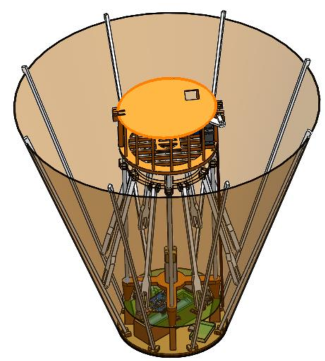


Container separates from the rocket at 670-725 m. The container will descent 15 m/s (±5 m/s) using first parachute.

At 500 meters, the probe is released from the container. The container continues to descend separated from the probe. The heat shield is initiated and the probe starts to descend at a rate of 20 m/s.

At 200 meters, the probe deploys a parachute and slows it descent rate to 5 m/s.

Container Parachute
- Ripstop Nylon parachute.
- Round with 28 cm diameter and spill hole of 3 cm diameter.
- Attached to CanSat, sits passively at the top, deployed on release.



Heat shield
- Ripstop Nylon
- Conic in shape with the base diameter of 50 cm
- Attached close to the tip of the arms and the baseplate of the cansat using tie points and adhesives

Payload Parachute
- Ripstop Nylon parachute.
- Round with 71 cm diameter and spill hole of 8 cm diameter.
- Attached to probe,held by the cover attached to the servo

Descent Control Changes Since PDR(1/2)

PDR	CDR	Rational/Testing
DC Motor with 2 kg*cm of torque	DC Motor with 6.6 kg*cm of torque	- Faster deployment of the heat shield
Parachutes were directly tied to the container and the probe	Parachutes are tied to the container and the probe using swivel mounts	- Descent stability
Fiberglass heat shield arms	Longer ABS heat shield arms	- Weight reduction - Descent stability

Descent Control Changes Since PDR(2/2)

Since we could not produce all of our systems, the functionality and shock tests of the parachutes were carried out with the satellite design, which we made at the prototype level with the same weight as the planned CanSat. We tested the parachute opening by free falling from a height of approximately 7 meters and its resistance to the shock that will occur when opening.

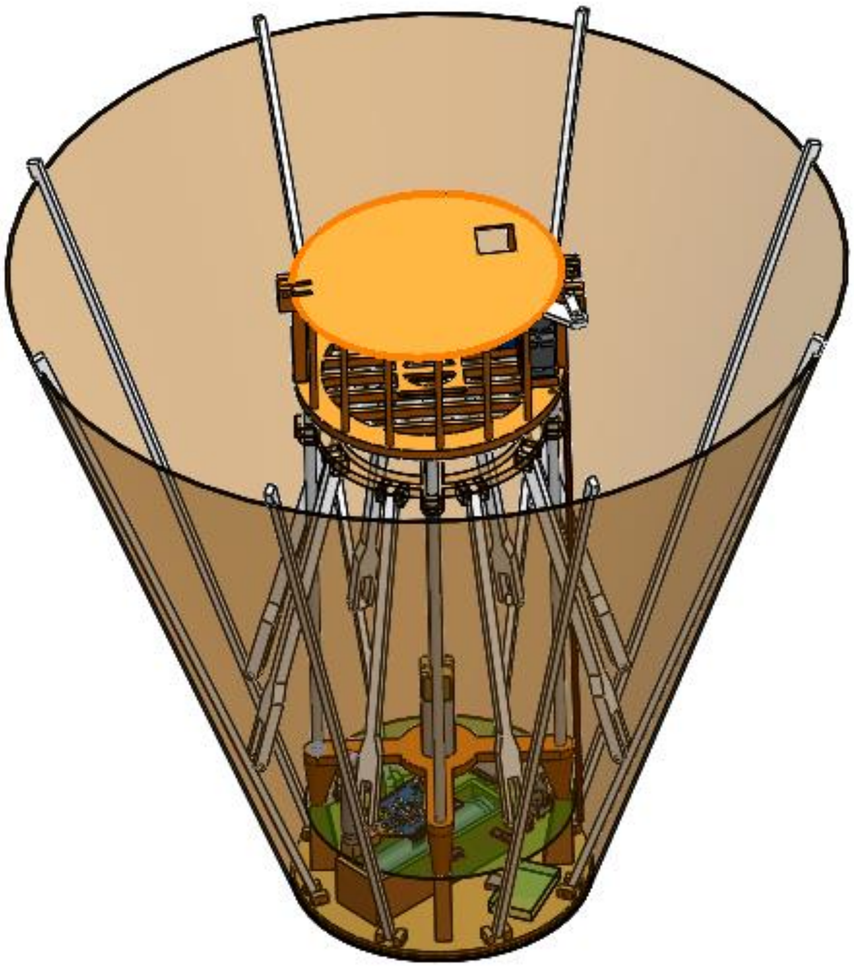
We couldn't test the descent speed accurately because we couldn't drop the system from a sufficient height, but we have successfully completed the functionality and shock test of the parachute.

Container Descent Control Hardware Summary

- The parachute will be folded and attached to the container by swivel. During the PDR stage, we were considering connecting the parachute to the Flemish loop. We didn't expect the CanSat to spin around its axis too much during its descent after separation from the rocket. Now, based on the tests we have conducted, instead of considering the possibility of spinning and subsequent rope shortening, we have decided to connect it with a swivel by making adequate weight calculations.
- The parachute bay will restrict the parachute from getting stuck between the container and the rocket payload envelope.

Parachute Dimensions	
Diameter	31cm
Spill Hole Diameter	34mm
Shroud Line Length	35.65cm
Key Design Considerations	
Shape	Hemispherical
Material	Ripstop Nylon
Shroud Material	Paracord
Number of Shrouds	8
Color: Orange	

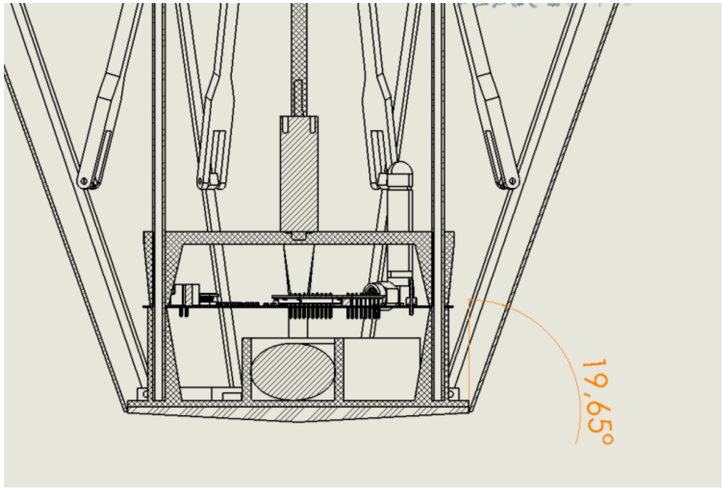
Payload Aerobraking Descent Control Hardware Summary

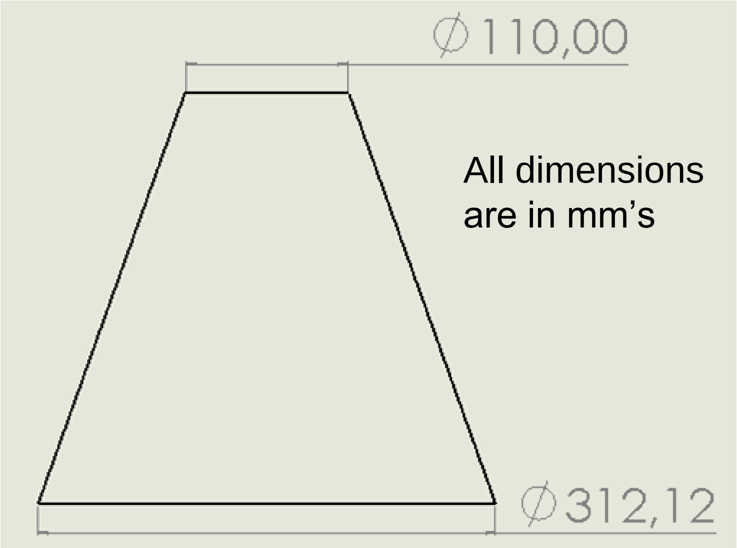


This design uses a DC motor to drive a moving plate up and down to actuate arms that are connected to a moving plate. This moving plate moves to a predetermined height and actively keeps the distance from the center. Arms form a conical aerobraking system formed by a ripstop nylon fabric.

Stability of the aerobraking system is controlled passively, the center of aerodynamic pressure sits higher than the center of mass of the probe, giving it a natural stability. this stability increases with the difference between the two centers giving us the ability to change the center of aerodynamic pressure without changing the design of the aerobraking system.

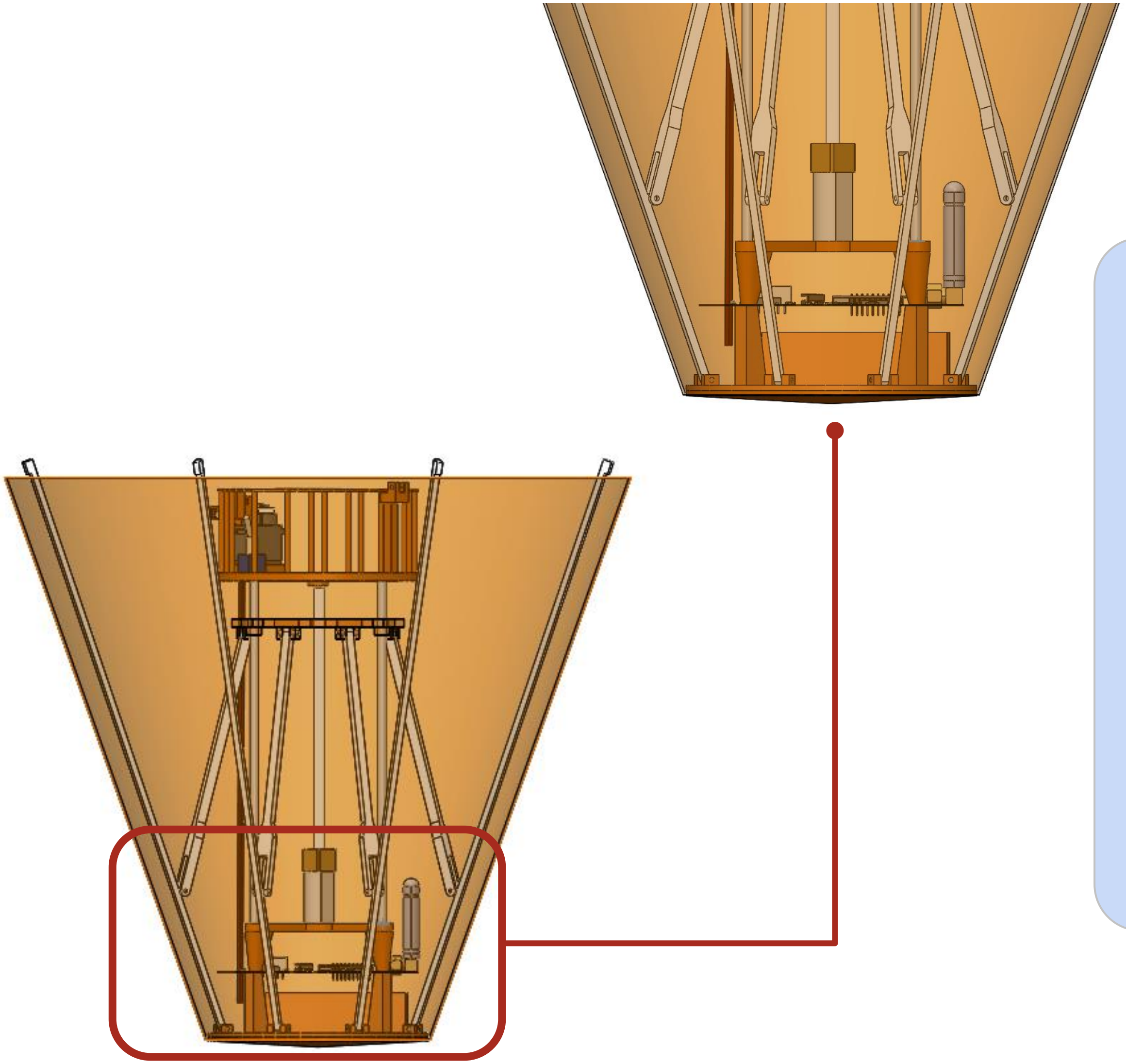
Payload Aerobraking Descent Control Hardware Summary





Aerobraking Dimensions	
Wide diameter	310mm
Narrow diameter	110mm
Angle with probe	19,65°
Key Design Considerations	
Shape	Conical
Material	Nylon
Shroud Material	-
Number of Shrouds	-
Color: Orange	

Payload Descent Stability Control Design



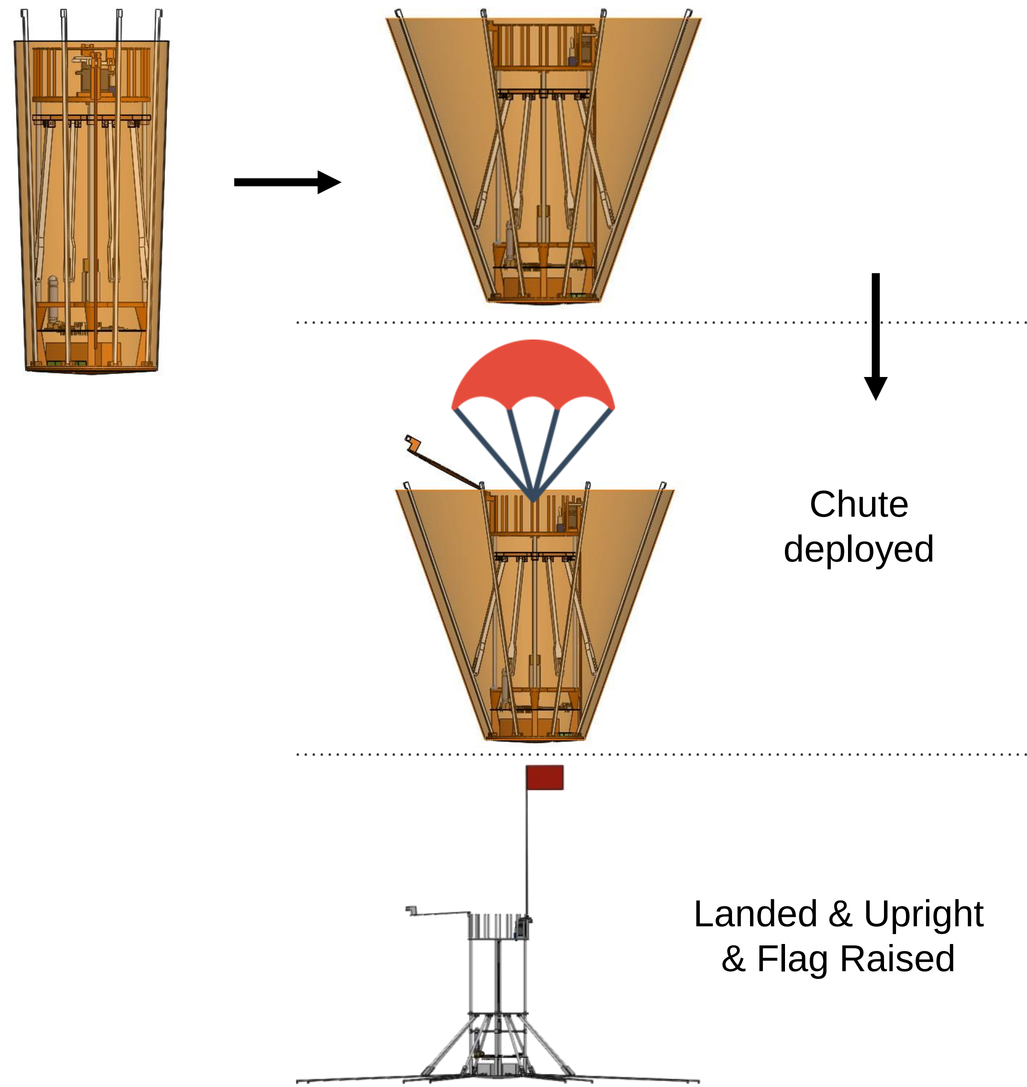
This design uses a high torque DC motor to release the probe from the container and subsequently open the aerobraking system via a plastic threaded rod. The aerobraking system will open up to a preprogrammed level, the descent forces are not expected to be strong enough to close the aerobrake. Stability of the aerobraking system is controlled passively, the center of aerodynamic pressure sits higher than the center of mass of the probe, giving it a natural stability.

Payload Parachute Descent Control Hardware Summary

At 500 meters, the container leaves the payload and the payload begins to fall on its own. The heat shield is initiated and the probe starts to descend at a rate of 20 m/s.

At 200 meters, the payload deploys a parachute and slows it descent rate to 5 m/s.

Stability of the CanSat is ensured by the center of pressure being higher than the center of mass. This is the same principle used in stabilizing rockets. The actual stability will be calculated using Barrowman equations.



Payload Parachute Descent Control Hardware Summary

Parachute Dimensions	
Diameter	77cm
Spill Hole Diameter	86mm
Shroud Line Length	88,55cm
Key Design Considerations	
Shape	Hemispherical
Material	Ripstop nylon
Shroud Material	Paracord
Number of Shrouds	8
Color: Orange	

Descent Rate Estimates (1/4)

Constants		Variables from equations	
g	Acceleration due to gravity = 9.81 m/s²	Fd	Drag force
M	Mass of CanSat = 700g	D_1,D_2	1 st & 2nd parachute diameter
ρ	Density of air = 1.112 kg/m³	V	Terminal velocity of CanSat
Cd_1	Coefficient of drag for round parachute = 0.75	A	Area of the parachute with a spill hole(m²)
π	3.14159	D_3	Heat Shield diameter
Cd_2	Coefficient of drag for heat shield = 0.55		

Descent Rate Estimates (2/4)

Assumptions

- Drag is equal to weight at terminal velocity.
- There is no wind presence or other weather effects.
- When fully deployed, parachutes are fully inflated and contribute to the drag on the CanSat.
- The density of the air at 1000 m (launch location altitude + deploy altitude) is assumed to be 1.112 kg/m^3.
- Drag coefficient for parachutes and heat shield is assumed to be 0.75 and 0,55 respectively.

Formulas

The Formula for drag force: $F_D = \frac{1}{2} C_D \rho A v^2$

Formula for parachute area: $\frac{1}{4} \times \pi \times D^2$

Rearrange for parachute area: $A = \frac{2mg}{C_D \rho v^2}$

Gravitational Force: $F_G = mg = F_D$ at terminal velocity

Descent Rate Estimates (3/4)

Container with Payload

$$V = \sqrt{\frac{2mg}{\rho C_d A}}$$

$$= \sqrt{\frac{2 * 0,7 * 9,81}{1,112 * 0,75 * 0,0732}}$$

V = 14,99 m/s

Container landing speed:

$$= \sqrt{\frac{2 * 0,2 * 9,81}{1,112 * 0,75 * 0,0732}}$$

V= 8,0172 m/s

Payload Aerobraking

$$V = \sqrt{\frac{2mg}{\rho C_d A}}$$

$$= \sqrt{\frac{2 * 0,5 * 9,81}{1,112 * 0,55 * 0,0713}}$$

V= 14,9987 m/s

Payload Parachute Relase

$$V = \sqrt{\frac{2mg}{\rho C_d A}}$$

$$= \sqrt{\frac{2 * 0,5 * 9,81}{1,112 * 0,75 * 0,4705}}$$

V = 5,000 m/s

Descent Rate Estimates (4/4)

Summary

Dimensions	Container Parachute	Payload Parachute	Payload Aerobreaking
Diameter	31cm	77cm	30cm
Spill Hole Diameter	34mm	86mm	-
Shroud Line Length	35.65cm	88,55cm	-
Shape	Hemispherical		Conical
Number of Shrouds	8		-
Desent Rate	**14,99 m/s**	**5,000 m/s**	**14,9987 m/s**

Mechanical Subsystem Design

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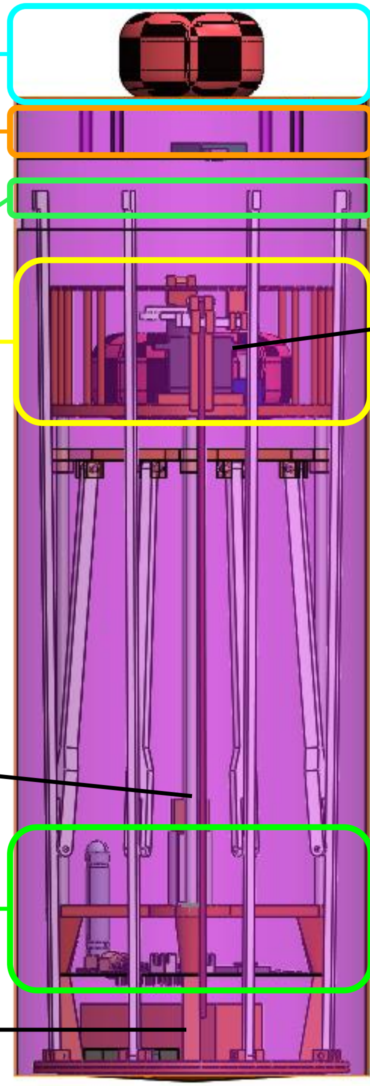
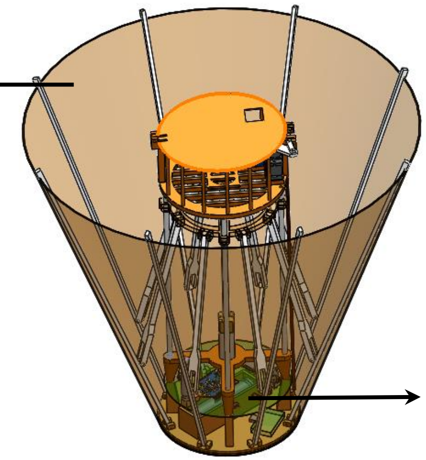
Mechanical Subsystem Overview



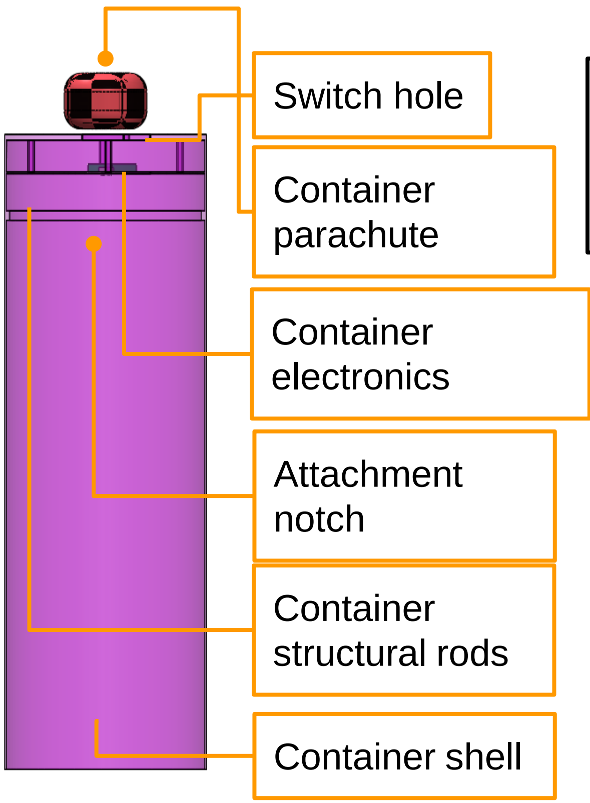


Material	Structural Element
Ripstop Nylon Fabric	Aerobrake, Container Parachute, Probe Parachute
Generic Fabric	Flag
Fiberglass	Probe Structural Rods, Parachute Containment Rods,
ABS Filament	Parachute Containment Base, Servo Arms, Parachute Lid Locking ArmArms, Connection Rods, Motor Plate, Moving Plate, Parachute Lid, Probe Base,
Steel	Threaded Rod, Pins, Springs, Hinges

Mechanical Subsystem Changes Since PDR

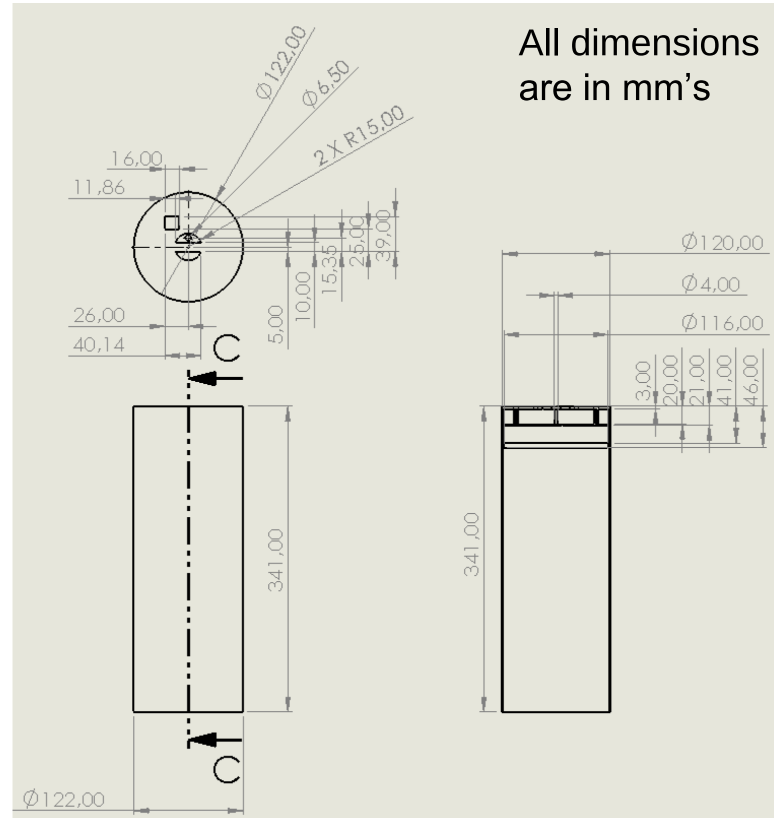
PDR	CDR	Rational/Testing
12V motor with 2 kg*cm of torque is used	6V motor with 6.6 kg*cm torque is used	- Faster deployment of the heat shield - Better uprighting mechanism - More secure connection to the container
Fiberglass structural components	ABS filament structural components with the addition of fiberglass rods	- Ease of manufacturing - Cost - Weight reduction
Thin joints and very crude design	Thicker joints and proper design for pin assembly	- Ease of manufacturing

Container Mechanical Layout of Components



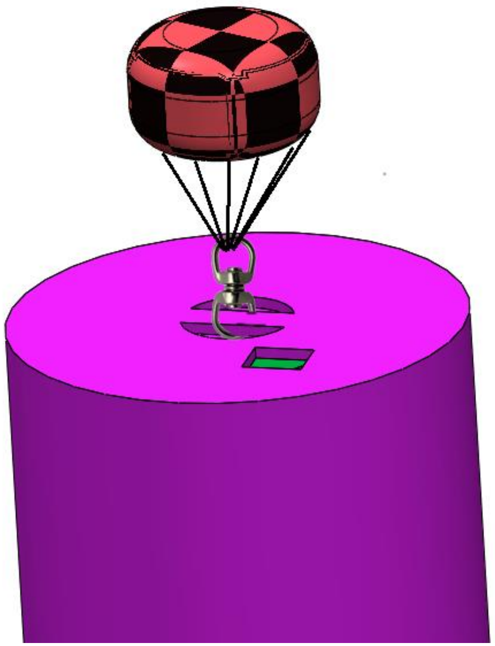
Container Electronics:

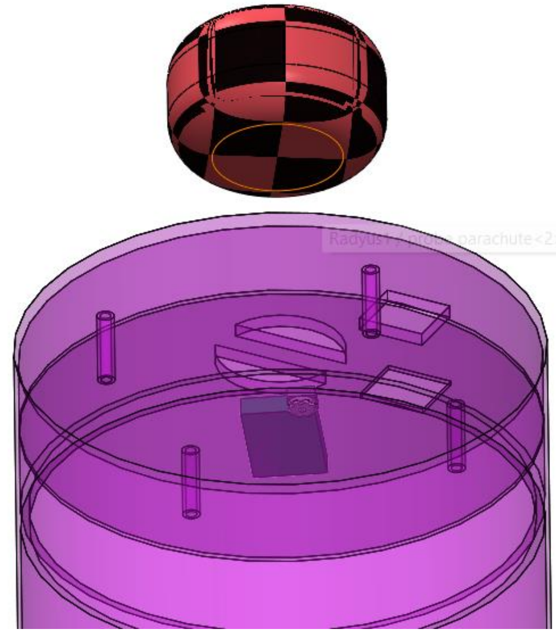
- Adafruit Mini Spy Cam
- Battery



Fiberglass has been replaced by 3D printed ABS due to manufacturability and density concerns, ABS plastic will have sufficient impact resistance and tensile resistance for our application, we suspect that until launch we will have to make many iterations to our probe and container, therefore we have opted to use a cheaper material. An additional factor was the materials required for fiberglass manufacturing is hard to obtain and costly.

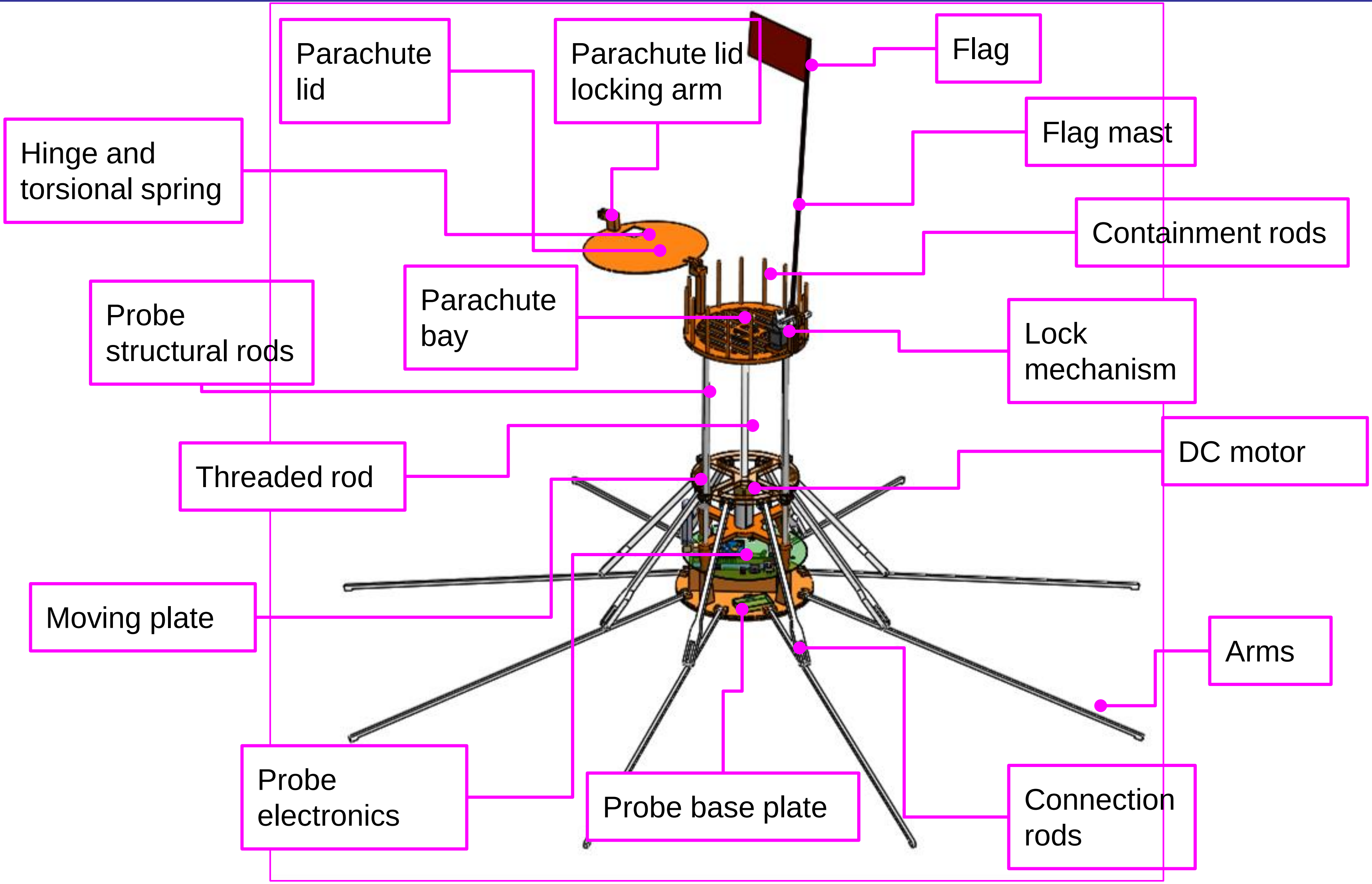
Container Parachute Attachment Mechanism





- The parachute will be folded and attached to the container by a swivel mount
- The top part of the container will be mounted onto the container using the rods and corresponding holes. Adhesives will be applied to secure the top part of the container to the main body
- The strings will be attached directly to the swivel mount.
- The parachute bay will restrict the parachute from getting stuck between the container and the rocket payload envelope.
- The parachute will be released with the CanSat when it deploys and will be opened by the drag force applied by the wind.

Payload Mechanical Layout of Components

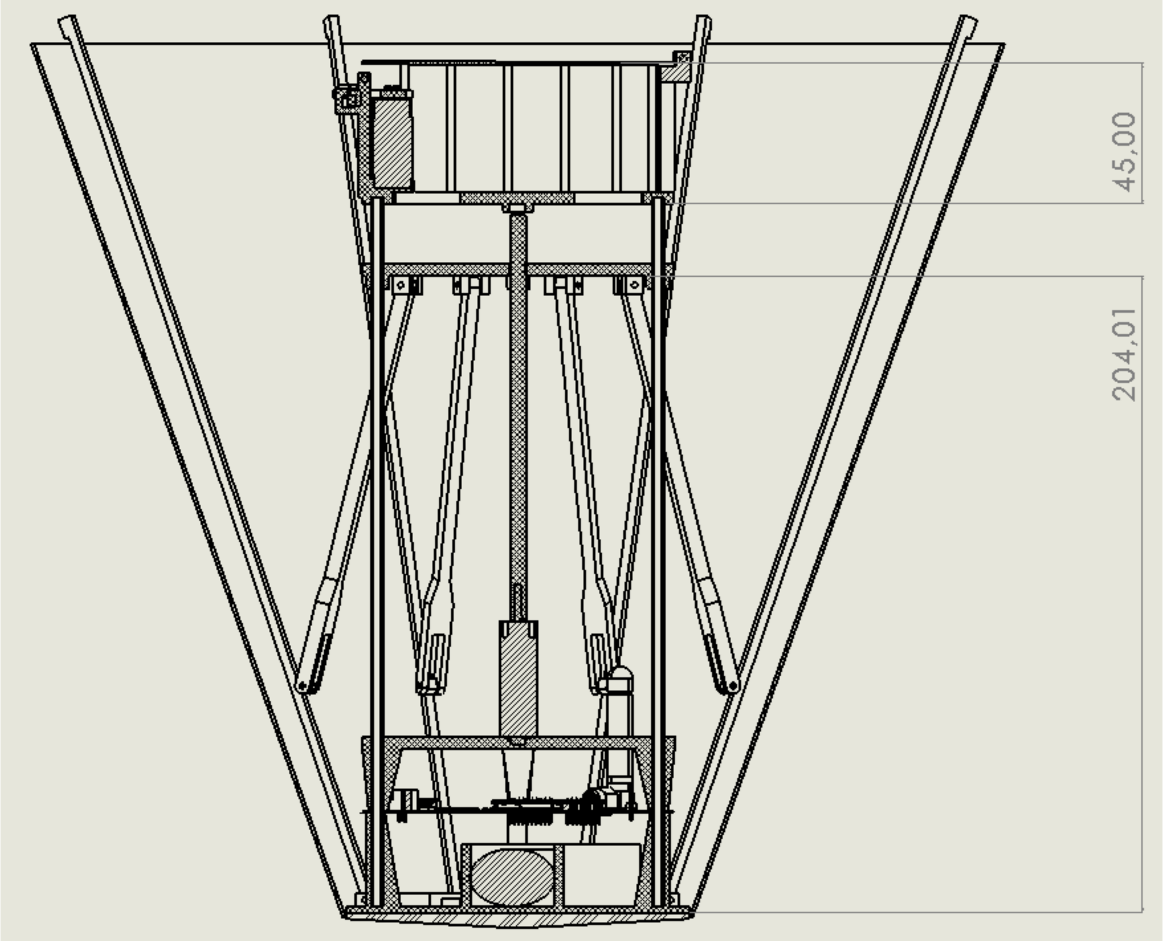


Payload Mechanical Layout of Components

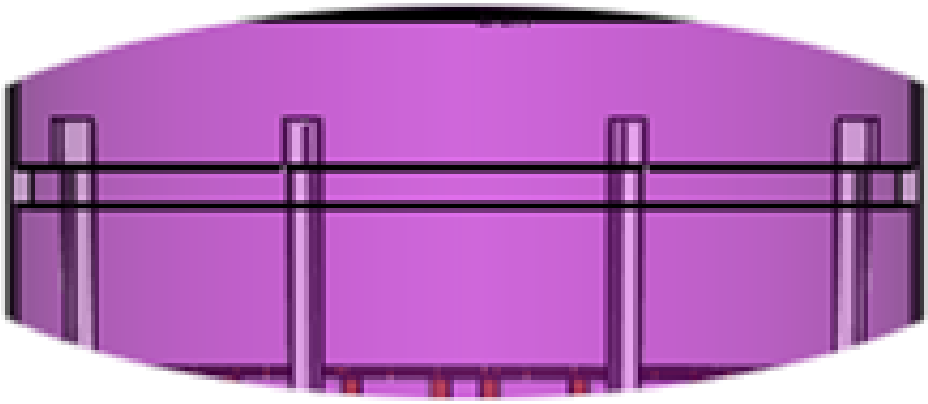
The main driving factor for our probe design was to ensure that the center of mass was as low as possible. We also aimed to utilize all motors such that they have at least two functions in the operation of the probe.

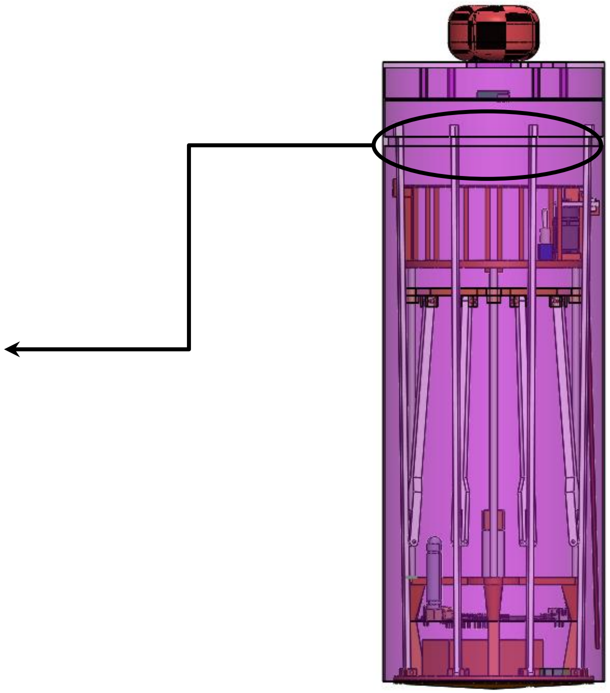
Probe Electronics:

- XBee
- Antenna
- Microcontroller
- Sensors
- Motors
- Battery etc.



Payload Pre Deployment Configuration





Our moving plate/arms system acts as a locking mechanism which is used to secure the probe to the container. The interlocking notches of the arm and container provide a secure connection between the container and probe, which will be confirmed by testing.

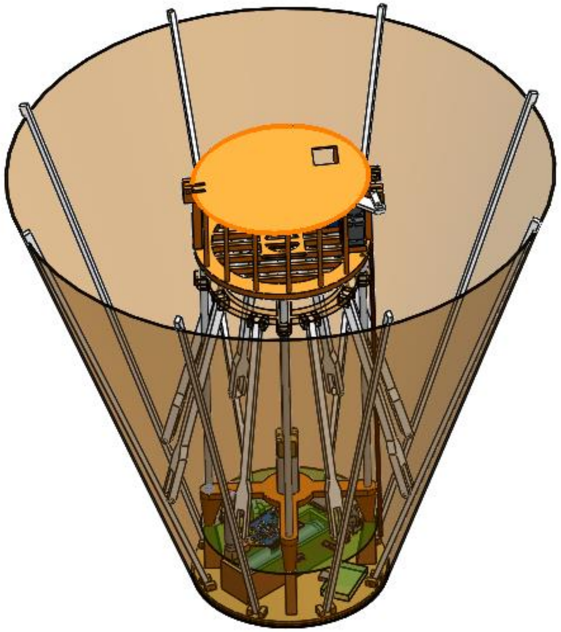
At 500 meters, the probe will retract its arms and fall out of the container.

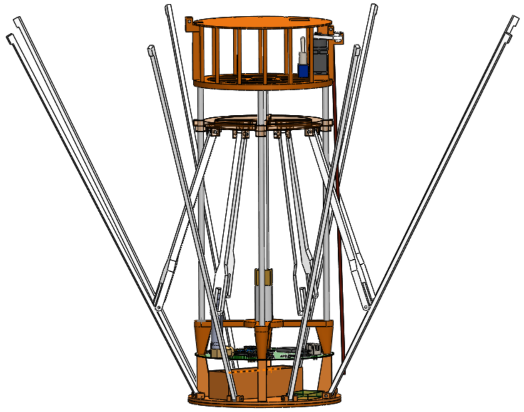
Payload Aerobraking Deployment Configuration

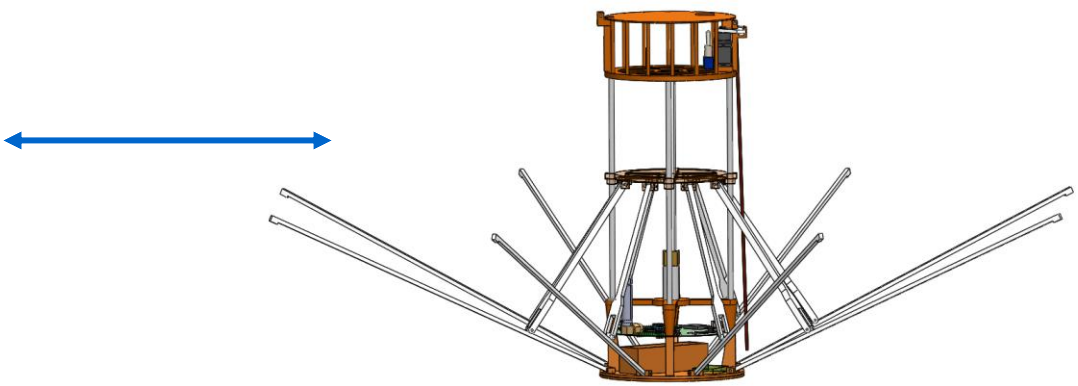
After release, the heat arms will once again expand to the predetermined diameter of 30cm,
which will slow the probe down to 15 m/s.

Expansion of the arms are facilitated by a high voltage dc motor which turns a threaded rod that moves a moving plate. The rods that connect the moving plate and the arms are always located at an angle such that torque is applicable to the arms at any configuration

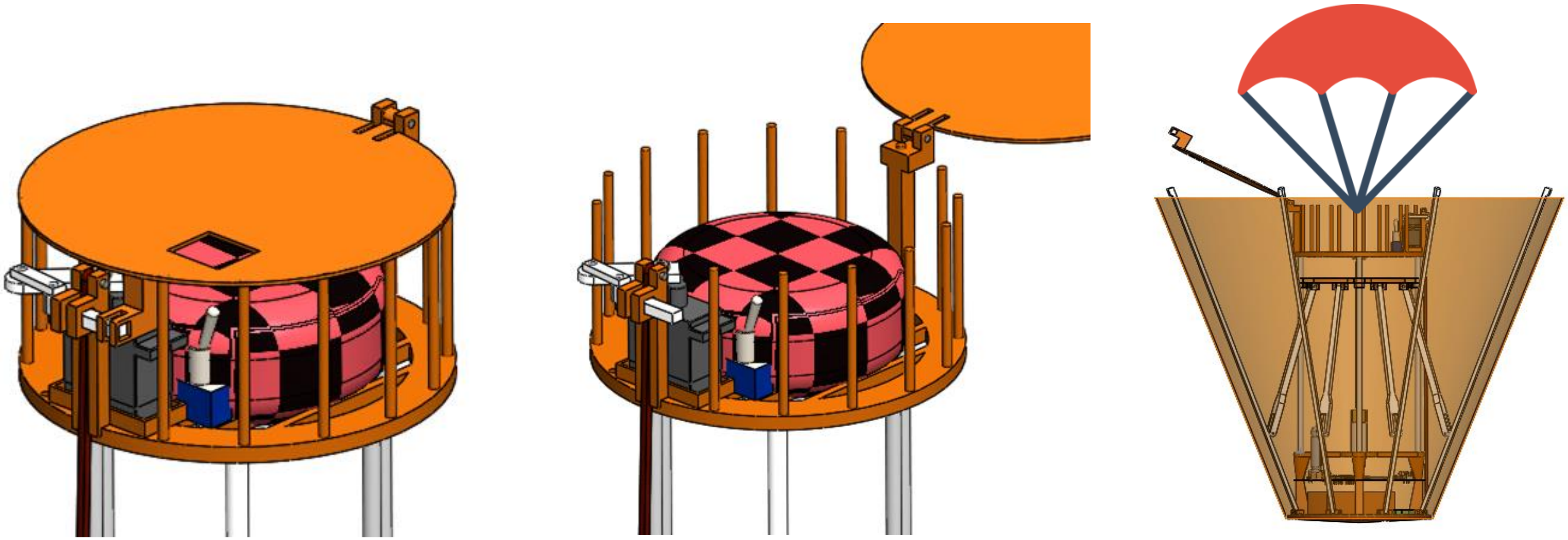
These values will be confirmed by wind tunnel and flight testing.





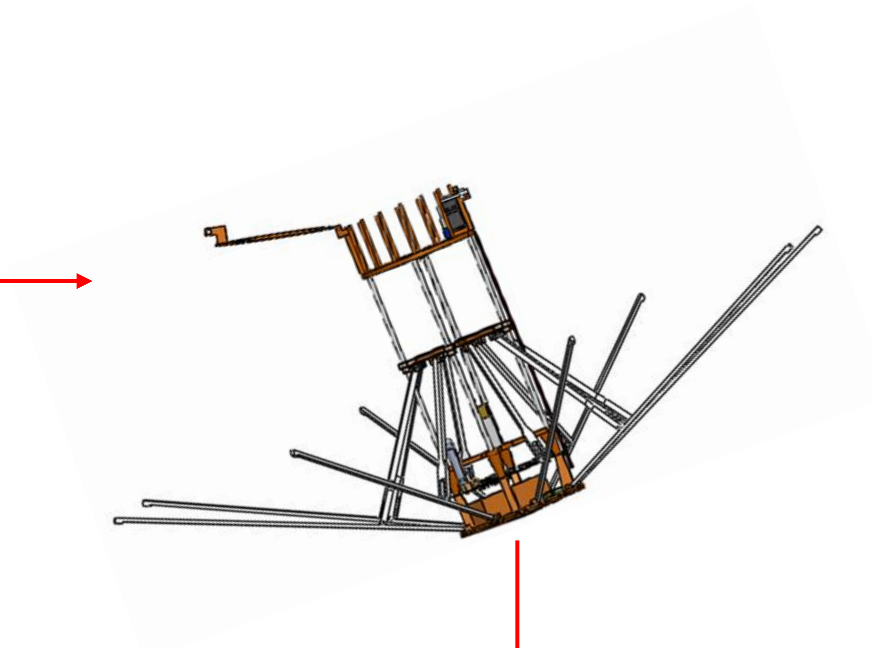


Payload Parachute Deployment Configuration

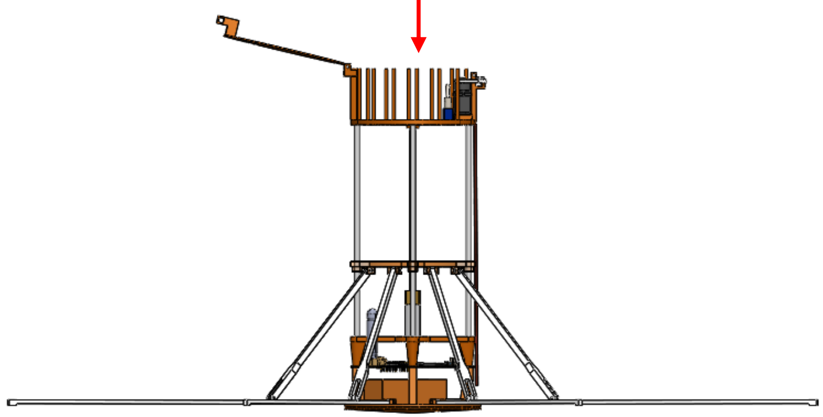


- Initially the servo rod locks the parachute lid in place
- When the predetermined altitude is reached the servo turns a predetermined amount to release the parachute lid
- When the parachute lid is released, the torsional spring located at the hinge of the parachute lid assists the operation.
- After the lid is open, the parachute is free to move and opens with the air resistance.

Payload Uprighting Description

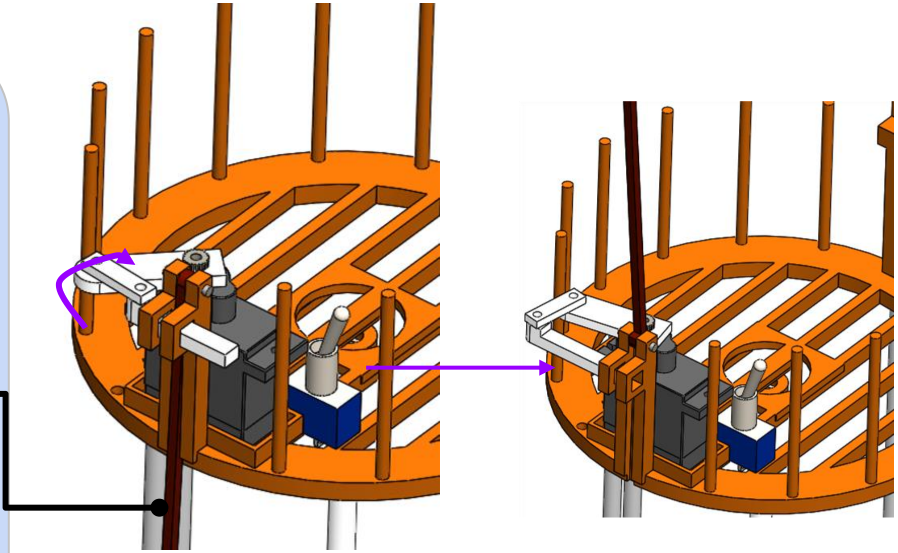


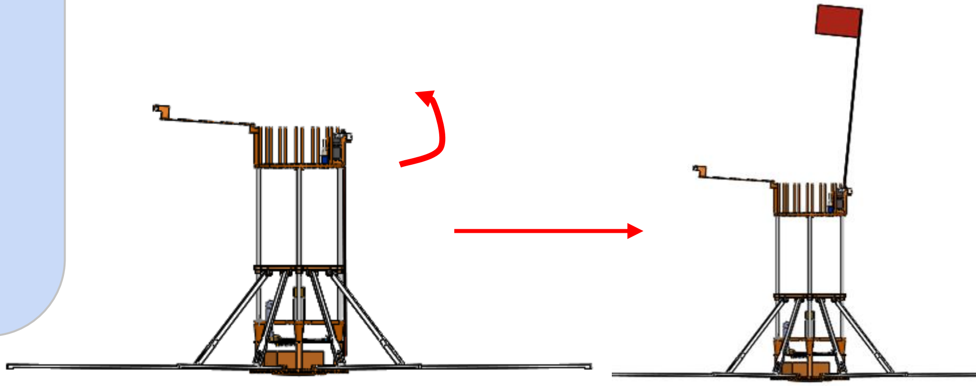
- First, the probe will land on its side.
- Then, the high torque dc motor will gradually move the **arms** to the fully extended position to upright the probe.



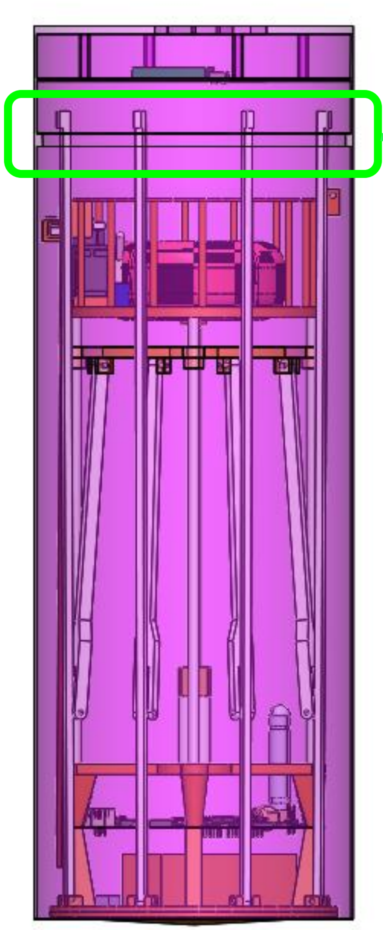
Payload Flag Deployment Configuration

- Servo motor rotates to its final position and releases the flag mast.
- When the flag mast is released, a torsional spring located at its hinge raises it to full mast.
- The flag is made out of generic fabric and will be sewn onto the flag mast
- The pin of the flag mast is located 271 mm above the base of the probe, and the flag mast is 248 mm long, giving the flag a height of 519 mm of height.





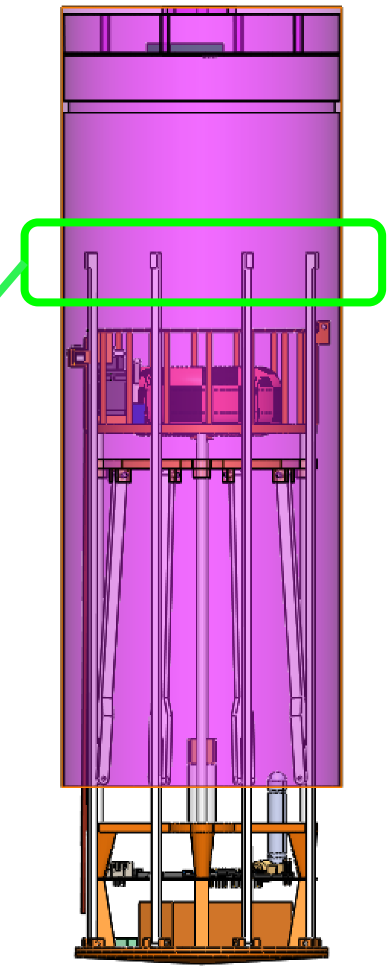
Container Payload Mount



The probe will be secured to the container using the heat shield arms and a notch placed on the container

The container will be separated by retracting the arms inward and the probe falling into a freefall

The mechanism is largely unchanged since PDR.



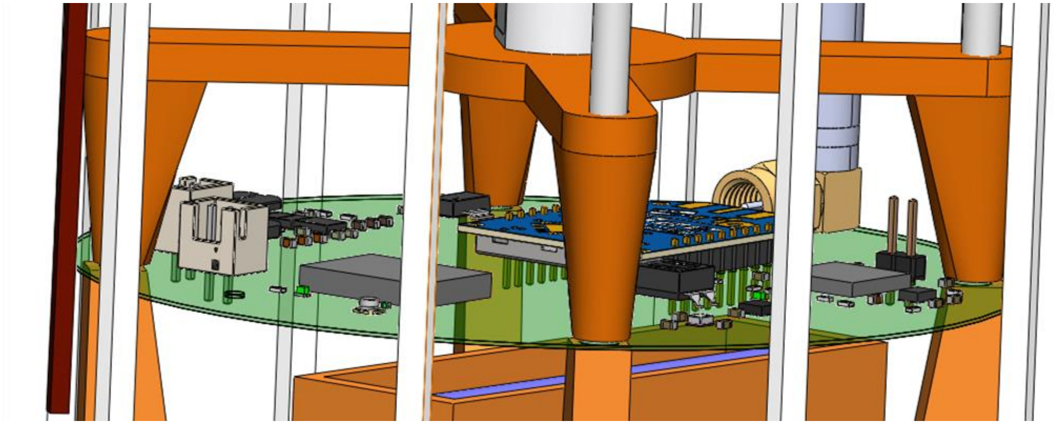
Structure Survivability

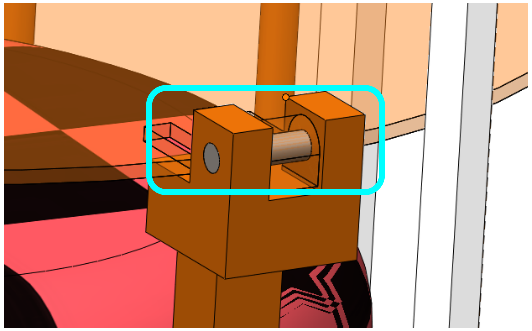
The PCB is secured onto the probe using holes and mounts incorporated into the design. We will use adhesives and tape to fully secure electronic components since the CanSat will be subjected to shocks.

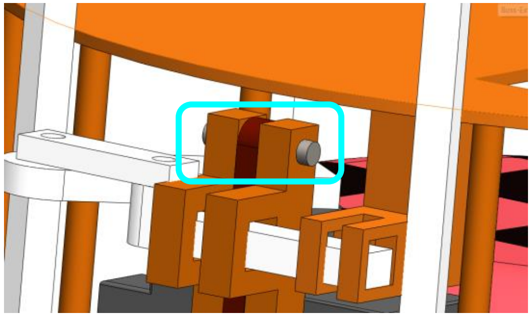
If required, thicker mounting brackets will be incorporated to the 3D printed structural components.

All pims and springs will be made out of steel to ensure survivability

The PCB placement ensures that shocks are always normal to the PCB and the parts soldered onto the PCB are not subject to shear forces.







Mass Budget (1/6)

Payload Mass Budget (1/3)

Component	Mass (g)	Source
Baseplate	75.37	Analysis
Structural Rods	19.28	Analysis
Arms	24.4	Analysis
Connecting Arms	22.8	Analysis
Motor Mounting Plate	12.7	Analysis
Moving Plate	15.33	Analysis
Probe Container Base	20.13	Analysis
Probe Container Rods	9.76	Analysis
Probe Container Lid	8.68	Analysis
Pins	4.5	Datasheet
Torsional Springs	2	Datasheet

Component	Mass (g)	Source
SG90 Servo Motor	9	Datasheet
Servo Motor Connections	3	Analysis
Flag Mast	1.03	Analysis
Flag	3	Datasheet
Sumo CORE Motor	21	Datasheet
Threaded Rod	3.56	Analysis
Probe Parachute	35	Datasheet
Heat Shield Fabric	25	Datasheet
BNO055	0.50	Datasheet
STM32F401RCT6	0.34	Datasheet
Adafruit Camera	2.80	Datasheet

Mass Budget (2/6)

Payload Mass Budget (2/3)

Component	Mass (g)	Source
CMT-8504-100-SMT-TR	0.60	Datasheet
Power Ind.LED	0.10	Datasheet
Infrared Led	0.10	Datasheet
PCB	28	Analysis
Samsung INR18650-35E	50	Datasheet
Payload Antenna	6.70	Datasheet
CR2032 Button Cell	2.92	Measured
XBee Pro S3B	8	Measured
Total	417.7	

Mass Budget (3/6)

Payload Mass Budget (3/3)

Due to our design changes, our probe is 80 grams lighter than the initial design. We have discussed the methods of mitigation in one of the later slides. We believe that this margin is beneficial since it leaves us some room to use additional adhesives or strengthen structural members if necessary.

We have decided to have the margin almost entirely on the probe as it is heavier and it is a much more complex part.

Mass Budget (4/6)

Container Mass Budget

Component	Mass (g)	Source
Container Shell	183	Analysis
Container Parachute	15	Datasheet
Adafruit Mini Spy Camera (Bonus)	2.80	Datasheet
CR2032 Battery (Bonus)	3	Estimated
Total	203.8	

Mass Budget (5/6)

Total Mass Budget

Component	Mass (g)
Payload	417.7
Container	203.8
Total	621.5

Our CanSat weighs approximately 80 grams lighter than the target weight, we have discussed the mitigation plans in the next slide. Detailed mitigation methods will be developed as production progresses further.

Mass Budget (6/6)

Mass Mitigation Methods

If overall mass is higher than anticipated:

- Lower infill 3D printing will be used where possible
- container will be lightened using holes
- Thinner fiberglass rods will be used

If overall mass is lower than anticipated:

- Thicker Parts will be implemented
- Both the container and the probe arms will be elongated
- Additional weights will be added to the base of the probe

Communication and Data Handling (CDH) Subsystem Design

Burak AYDAR

CDH Overview

Type	Component	Functions
Processor	STM32F401RET6	Controlling all the sensors and processing data, triggering events and communicating with the ground station.
SPI Flash Memory	Winbond W25Q32JVSSIQ	Used to store calibration and the state of the CanSat.
RTC	Internal RTC in STM32F401RET6	Keep track of real time to measure the mission time.
GCS Antenna	ZQTMAX Yagi-Uda Antenna	Increase the receiving sensitivity of the XBee
Payload Antenna	Linx Tech. ANT-916-CW-RAH-SMA	Increase the gain of the XBee transmission
Payload Radio	XBee-PRO S3B	Telemetry transmitter
GCS Radio	XBee-PRO S3B	Telemetry receiver

CDH Changes Since PDR

No changes have been made to the CDH subsystem.

Payload Processor & Memory Selection

Microcontroller	Data Bus Width	Boot time	Clock Frequency	Interfaces	Non-volatile Memory	Volatile Memory	Package	Cost ($)
STM32F401RET6	32 bit	85 ms	84 MHz	3 x I2C 4 x SPI 3 x USART	512 kB Flash	96 kB	LQFP 64	5.21

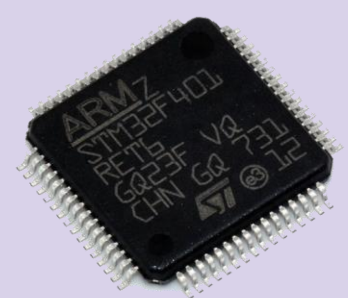
Flash Memory	Max Supported Frequency	Memory Interfaces	Memory	Write cycle time	Package	Cost ($)
Winbond W25Q32JVSSIQ	133 MHz	SPI	32 MB	3 ms	8-SOIC 208 mils	1

Selected Flash Memory
W25Q32JVSSIQ

Reasons
Sufficient memory
Cheaper
Higher availability

Selected Microcontroller
STM32F401RET6

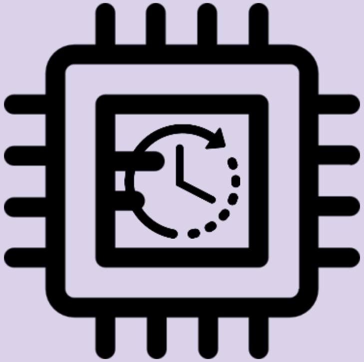
Reasons
Enough data interfaces
Experience with the microcontroller
Enough number of pins



Payload Real-Time Clock

RTC	Reset Tolerance	Weight (g)	Dimensions (mm)	Cost ($)
STM32F401RET6 Embedded RTC	Unaffected by resets	Embedded in the microcontroller	Embedded in the microcontroller	0

Selected RTC	Reasons
STM32F401 RET6 Embedded RTC	- High precision - No extra space, weight and cost since it is embedded - Resolution is better than **1 second in 12 hours.**



Note: A 3V lithium button cell will be connected between VBAT and VSS pins of STM32 as an external backup supply throughout the mission for the RTC.

Payload Antenna Selection

Antenna Selection						
Payload Antenna Model	**Radiation Pattern**	**Gain (dBi)**	**Frequency Range (MHz)**	**Dimensions dia. x h (mm)**	**Weight (g)**	**Cost ($)**
Linx Tech. ANT-916-CW-RAH-SMA	Omni-Directional, Toroidal	2.2	850 - 970	8 x 46.5	6.7	7.87

Selected Antenna

Linx Tech. ANT-916-CW-RAH-SMA

Discussion

The gain/mass of the antenna was the highest that we could find.

Payload Radio Configuration

Radio Model	Operating Frequency	Transmit Power	Rx sensitivity
Xbee-Pro-S3B-900HP	920 MHz	250 mW (24 dBm)	-101 dBm

XBEE Configuration

XBEE Radio Selection: Xbee-Pro-S3B-900HP

NETID: (#1068) Will set it to be the same as our team number.

Transmission Mode: **Unicast** mode will be used instead of Broadcast mode.

Transmission Control

- After CanSat is turned on, communication will start between the ground station and the payload.
- The data transmission frequency will be **1 Hz** throughout the entire mission.
- After the flag mast operation is complete, the packet transmission will be stopped by FSW.

Payload Telemetry Format (1/2)

Data Type	Description
TEAM_ID	assigned team number
MISSION_TIME	time in UTC tracked by rtc
PACKET_COUNT	# of transmitted packets
MODE	F for flight, S for simulation
STATE	operating state
ALTITUDE	altitude relative to the launch site in meters
HS_DEPLOYED*	P if heat shield is deployed
PC_DEPLOYED*	C if parachute is deployed
MAST_RAISED*	M if flag is raised
TEMPERATURE	temperature in celsius

***: N otherwise**

Data Type	Description
PRESSURE	air pressure in kPa
VOLTAGE	battery voltage in Volts
GPS_TIME	time given by GPS
GPS_ALTITUDE	altitude given by GPS
GPS_LATITUDE	latitude given by GPS
GPS_LONGITUDE	longitude given by GPS
GPS_SATS	# of tracked GPS satellites
TILT_X	angle from the x-axis in degrees
TILT_Y	angle from the y-axis in degrees
CMD_ECHO	last command received and processed by FSW

Payload Telemetry Format (2/2)

The data rate of packets will be 1 Hz.

Data Format	Each packet will be sent to the ground station as a string (array of chars) in CSV (comma-separated values) format. - “TEAM_ID, MISSION_TIME, PACKET_COUNT, MODE, STATE, ALTITUDE, HS_DEPLOYED, PC_DEPLOYED, MAST_RAISED, TEMPERATURE, VOLTAGE, PRESSURE, GPS_TIME, GPS_ALTITUDE, GPS_LATITUDE, GPS_LONGITUDE, GPS_SATS, TILT_X, TILT_Y, CMD_ECHO”
Example Payload Frame with Sample Data	“1068, 13:20:22, 23, F, PRE_LAUNCH, 0.09324, N, N, N, 25, 4.2, 92, 09:20:22, 932.021, 39.891388, 32.784721, 8, 0.4023, 0.2014, CAL”

The telemetry data file will be named “Flight_1068.csv”.

The presented format matches the Competition Guide Requirements.

Payload Command Formats (1/2)

Command Data Format	Each command will be sent to GCS as a string (array of chars)

Command Type	Command	Description
CX - Telemetry On/Off	CXON	enables and activates telemetry
	CXOFF	disables and deactivates telemetry
ST - Set Time	CMD,1068,ST,<UTC_TIME>	sets time to the time within 1 second UTC time provided by the ground station
	CMD,1068,ST,GPS	sets time to the time given by GPS
SIM - Simulation Mode	CMD,1068,SIM,ENABLE	enables simulation mode
	CMD,1068,SIM,ACTIVATE	activates simulation mode
	CMD,1068,SIM,DISABLE	disables and deactivates simulation mode
SIMP - Simulated Pressure Data	CMD,1068,SIMP,<PRESSURE>	provides the flight computer with a simulated pressure reading
CAL - Calibrate Altitude to Zero	CAL	calibrates the altitude value to zero

Payload Command Formats (2/2)

Example Commands	CXON: enables and activates telemetry CXOFF: disables and deactivates telemetry CMD,1068,ST,14:25:12: sets time to 14:25:12 on the payload flight computer CMD,1068,ST,GPS: sets time to the time given by GPS CMD,1068,SIM,ENABLE: enables simulation mode CMD,1068,SIM,ACTIVATE: activates simulation mode CMD,1068,SIM,DISABLE: disables and deactivates simulation mode CMD,1068,SIMP,92000: provides the flight computer with a simulated pressure reading that is equal to 92000 Pa. CAL: calibrates the altitude value to 0 relative to the ground level at launch site.

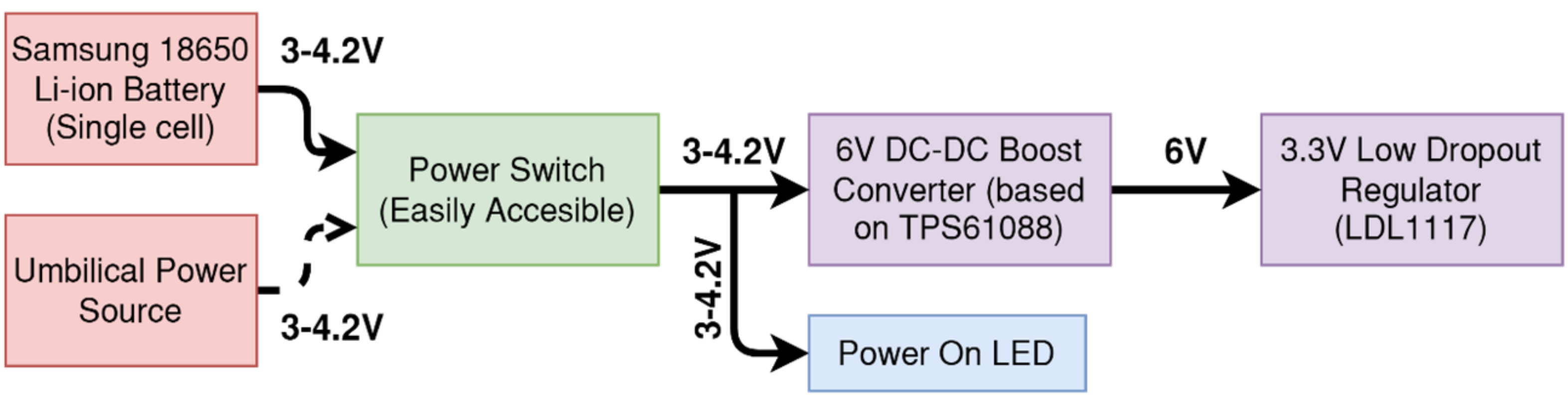
The presented format matches the Competition Guide Requirements.

Electrical Power Subsystem Design

Mehmet İLBAĞI

EPS Overview

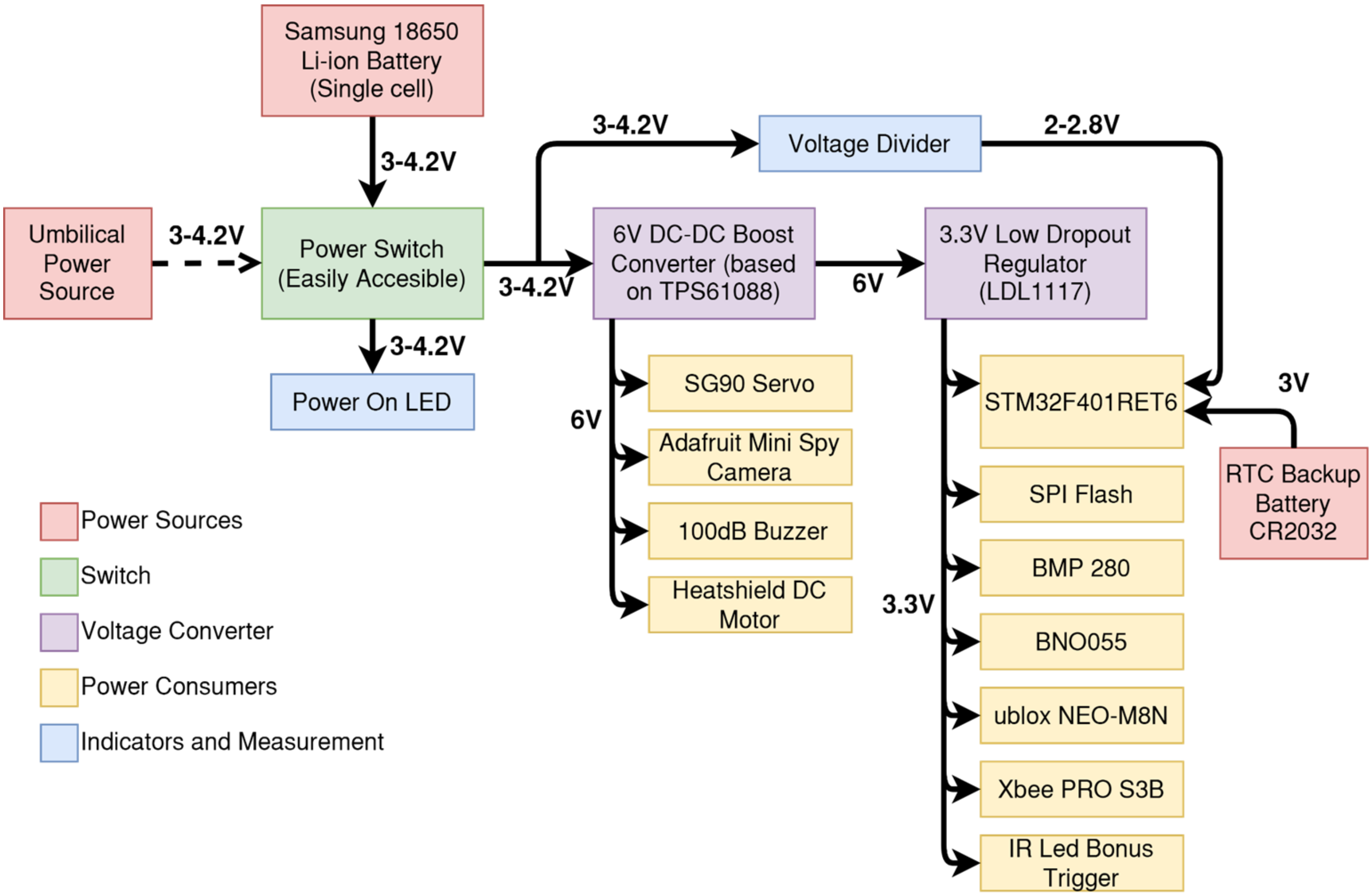
Components	Functions
Samsung INR18650-35E Li-Ion Battery 3.7V	Main power source of the probe.
External Power Switch	Gives ability to turn on and off main power.
6 Volt DC-DC Boost Converter (based on TPS61088)	Supplies power for servos, buzzer, Heatshield DC Motor and 3.3 Volt LDO Regulator.
3.3 Volt LDO Voltage Regulator (LDL1117)	Supplies power for MCU, sensors, XBee and LED.
Power On LED	Power Indicator LED shown outside.
Umbilical Power Source	Cansat power supply for tests.



EPS Changes Since PDR

Section	PDR	CDR	Rationale
Battery	Orion 18500	Samsung INR18650-35E	Orion 18500 Li-ion cell did not satisfy enough instant current to new heatshield DC motor.
Boost Converter	5 Volt output	6 Volt output	We changed our 5V bus to 6V because of the changed heatshield DC motor.

Payload Electrical Block Diagram



Payload Power Source

Cell	Voltage (V)	Capacity (mAh)	Capacity (Wh)	Instant Discharge Current (mA)	Size dia. x h (mm)	Weight (g)	Cost ($)
Samsung INR18650-35E	3.7	3500	20.35	13000	18 X 65	50	11.21

Selected Battery

Samsung INR18650-35E Li-Ion Battery as a single cell

Reasons

- Generates enough instant current for Heatshield DC Motor
- Easily found and replaceable
- Enough capacity for mission

Note: Battery will be used at **single cell** configuration. A cable with connector will be point welded to terminals of battery. Power traces are fused at PCB.

Payload Power Budget (1/2)

Components	Voltage (V)	Current (mA)	Duty Cycles (h:min:sec)	Total Power Consumption (Wh)	Source
XBee Pro S3B	3.3	215	02:00:00	1.419	Datasheet
STM32F401RET6	3.3	15.8	02:00:00	0.104	Datasheet
Adafruit Mini Spy Cam.	6	110	02:00:00	1.32	Datasheet
BMP280	3.3	0.0042	02:00:00	Neglected	Datasheet
BNO055	3.3	12.3	02:00:00	0.081	Datasheet
Heat Shield DC Motor	6	1400	00:15:00	2.1	Measured
Parachute Lock Servo	6	270	00:00:05	0.0019	Measured
uBlox Neo-M8N	3.3	32	02:00:00	0.2112	Datasheet
100 dB Buzzer	6	150	00:30:00	0.45	Datasheet
Power Ind.LED	3.3	20	02:00:00	0.132	Estimated
IR LED Bonus Trigger	3.3	100	00:00:10	Neglected	Estimated

Payload Power Budget (2/2)

Available Total Power (Wh)	20.35
Total Power Consumption (Wh)	5.8191
Power Consumption Margin (Wh)	14.53
Possible Operating Time	**7 hours 15 minutes**
Possible Mission Cycles	**more than 3 missions**

Note: Our margin is highly enough for mission so we are not considered the efficiency of voltage conversions. (55% at 6V to 3.3V and 95% at 3.7V to 6V)

Note: We also have a CR2032 coin cell for the RTC built-in STM32F401RET6. We did not include it in this budget.

Flight Software (FSW) Design

Barış Berk KOTTAŞ

FSW Overview (1/3)

Overview of Flight Software

- The main task of the FSW is to evaluate the data coming from the sensors and to take some actions according to the stage of the cansat.
- "Kalman Filter" will be used during the evaluation of the data coming from the sensor, so that the errors in the incoming data will be minimized.
- Even if the processor is reset with the SPI Flash in the flight computer, the FSW will continue to work from where it left off.

Programming Languages

- C++ language will be used to program the processor.
- Various C libraries will be supported in sensor programming and filtering.

Development Environments

- **STM32CubeIDE**, **STM32CubeMX** and **Keil** are used to program the processor.
- XBee configurations will be made through the **XCTU** program.
- We use **VSCode** to build libraries and optimize our code.

Note: We do not have anything requiring a flight software in the container.

FSW Overview (2/3)

FSW Tasks

PRE_LAUNCH
- CanSat is turned on with a power switch
- Sensor calibrations take place
- Establish the connection to GCS
- Send telemetry and calibration data to GCS and save to flash memory (1 Hz)

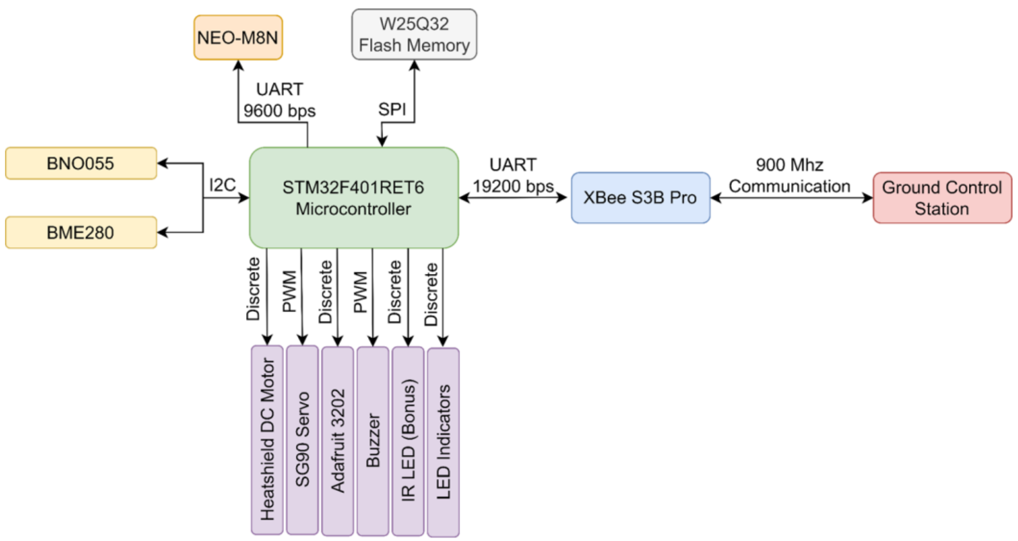
ASCENT
- Start recording the video and save the video to integrated SD module

DESCENT
- Release the probe from the container at 500 meters

AEROBRAKING
- Deploy the probe parachute at 200 meters

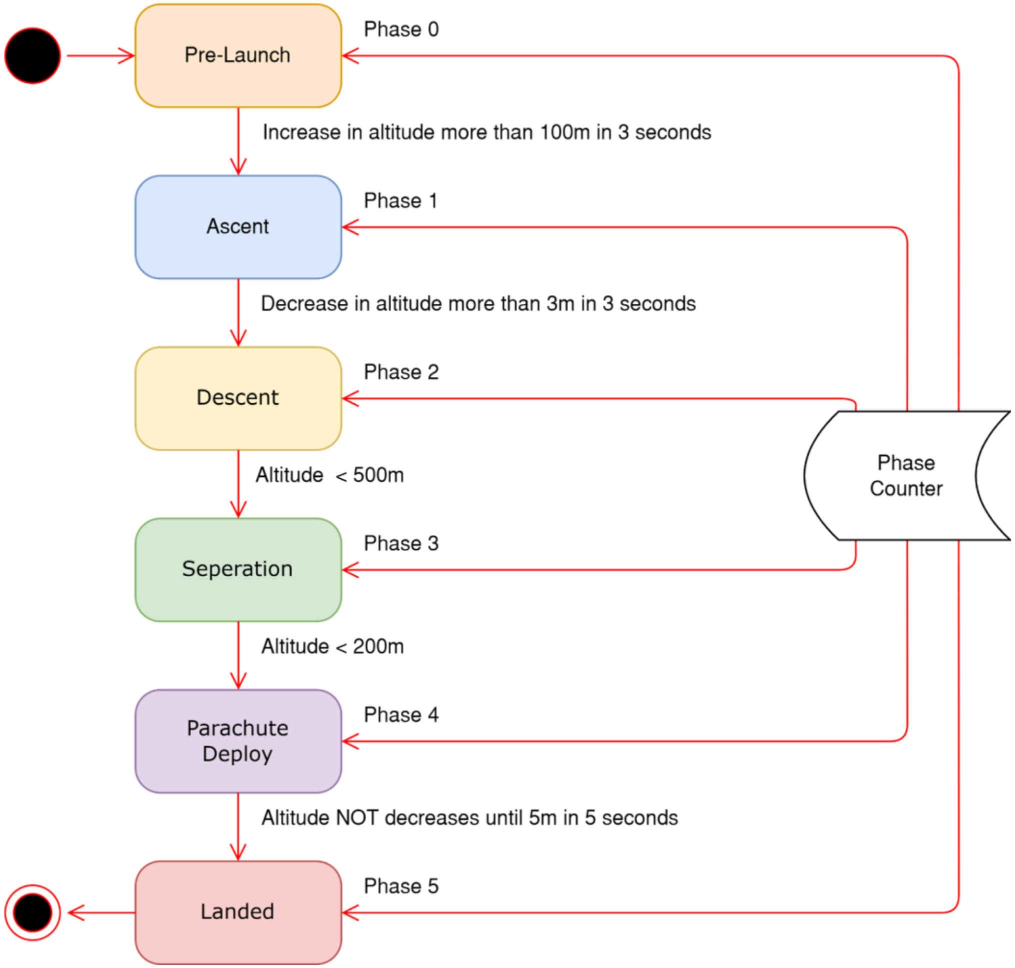
LANDED
- Obtain the orientation and upright the probe if needed
- Raise a flag 500 mm above
- Turn on the audio beacon (buzzer)

Hardware Block Diagram



FSW Overview (3/3)

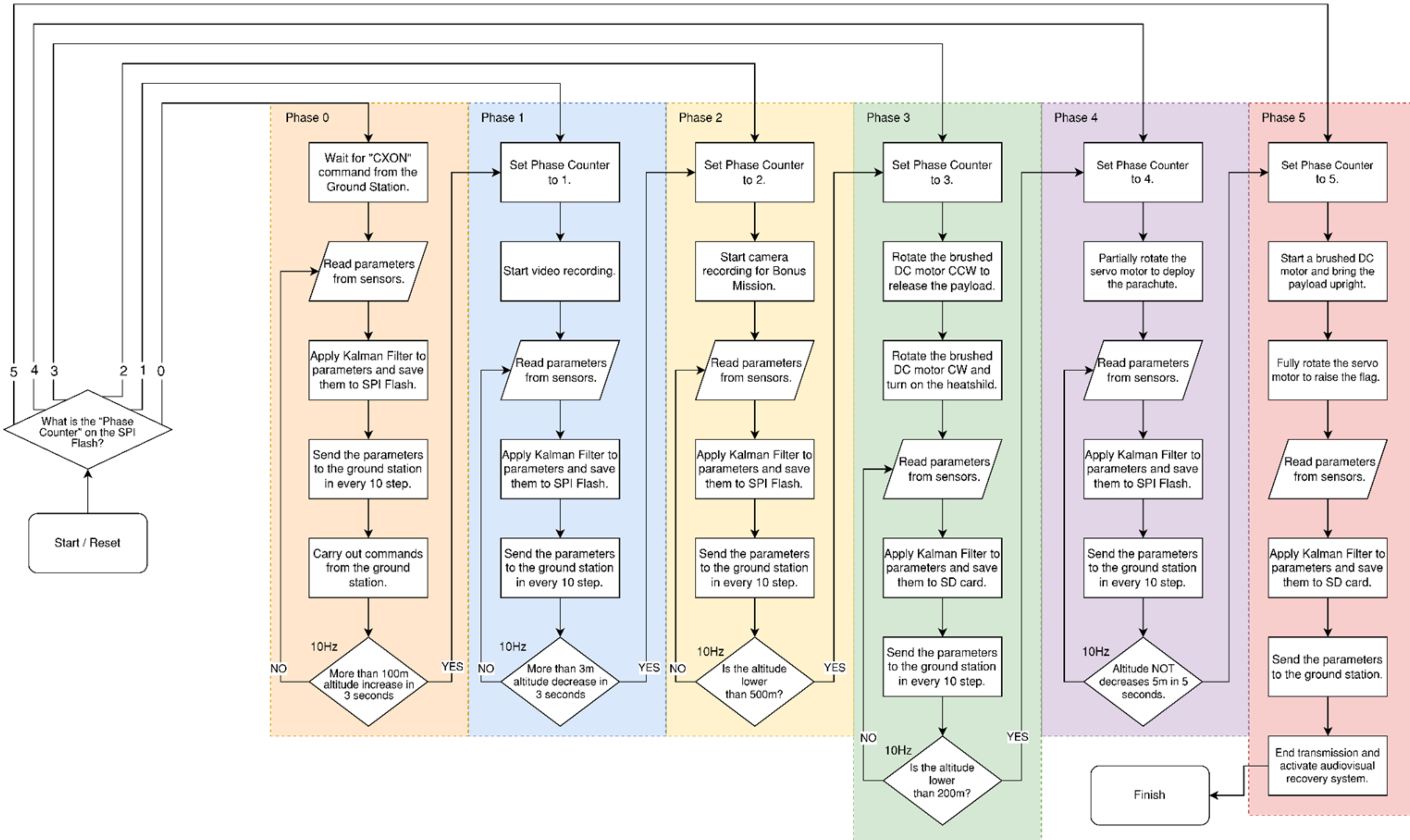
All states writes its phase number into the phase counter as their first job.



FSW Changes Since PDR

No changes have been made to the FSW.

Payload CanSat FSW State Diagram



Payload CanSat FSW State Diagram

The following will be kept in the SPI flash:

Time

Calibration data

Phase counter

High acceleration, high temperature, static shock, excessive vibration and voltage fluctuations can cause the processor to reset.

As a precautionary measure in case of a reset, FSW will regularly perform a phase check and packet number check from the SPI Flash.

When a reset is detected, the phase is detected by the FSW, calibration is adjusted and CanSat continues from where it left off.

Simulation Mode Software

- The SIM commands, ENABLE and ACTIVATE, will be sent to the CanSat to activate the simulation mode.
- Once the simulation mode is activated, the pressure **sensor data will be overridden.** FSW will use the pressure data sent using the SIMP command to calculate the altitude. The pressure data will be taken from a .csv file.
- The other sensor values such as tilt, acceleration, orientation, etc. will not be affected due to the transition between flight and simulation mode. These sensor values will keep getting collected and processed by FSW no matter what.
- Using the SIM command, DISABLE, will be sent to the CanSat to switch the payload back to flight mode. FSW will thereupon resume using the pressure data collected from the sensor.

SIM - Simulation Mode Control Command (CMD,<TEAM_ID>,SIM,<MODE>)
CMD,1068,SIM,ENABLE - disable the flight mode and switch to the simulation mode
CMD,1068,SIM,ACTIVATE - activate the simulation mode
CMD,1068,SIM,DISABLE - disable the simulation mode and switch back to the flight mode

SIMP - Simulated Pressure Data (CMD,<TEAM ID>,SIMP,<PRESSURE>)
CMD,1068,SIMP,100000 - send the given pressure data from GCS to the payload if the simulation mode is activated

- In simulation mode, the ground station will be able send pressure data at 1 Hz.

Software Development Plan (1/2)

Software Development Plan → Write the libraries for selected sensors → Test each sensor separately → Put together the system with all sensors → Write FSW and test algorithms

Prototyping

- The libraries of each sensor will be written in VS Code.
- After all the sensors are confirmed to be working separately, the electronic system will be put together on a breadboard to perform specific tests.
- Finally, PCB will be assembled to perform environmental tests.

Software Subsystem Development Sequence

- Github is used to work collaboratively on our flight software.
- Prepare the FSW state diagram
- Develop the necessary algorithms to accomplish the mission objectives.

FSW Development Team: Alp, Barış and Burak

Test Methodology

- FSW will be tested to confirm whether the algorithms working as intended.
- The following environmental tests will be performed on the electronic system;
  - Drop test
  - Thermal test
  - Vibration test
  - Fit Check
  - Vacuum test

Software Development Plan (2/2)

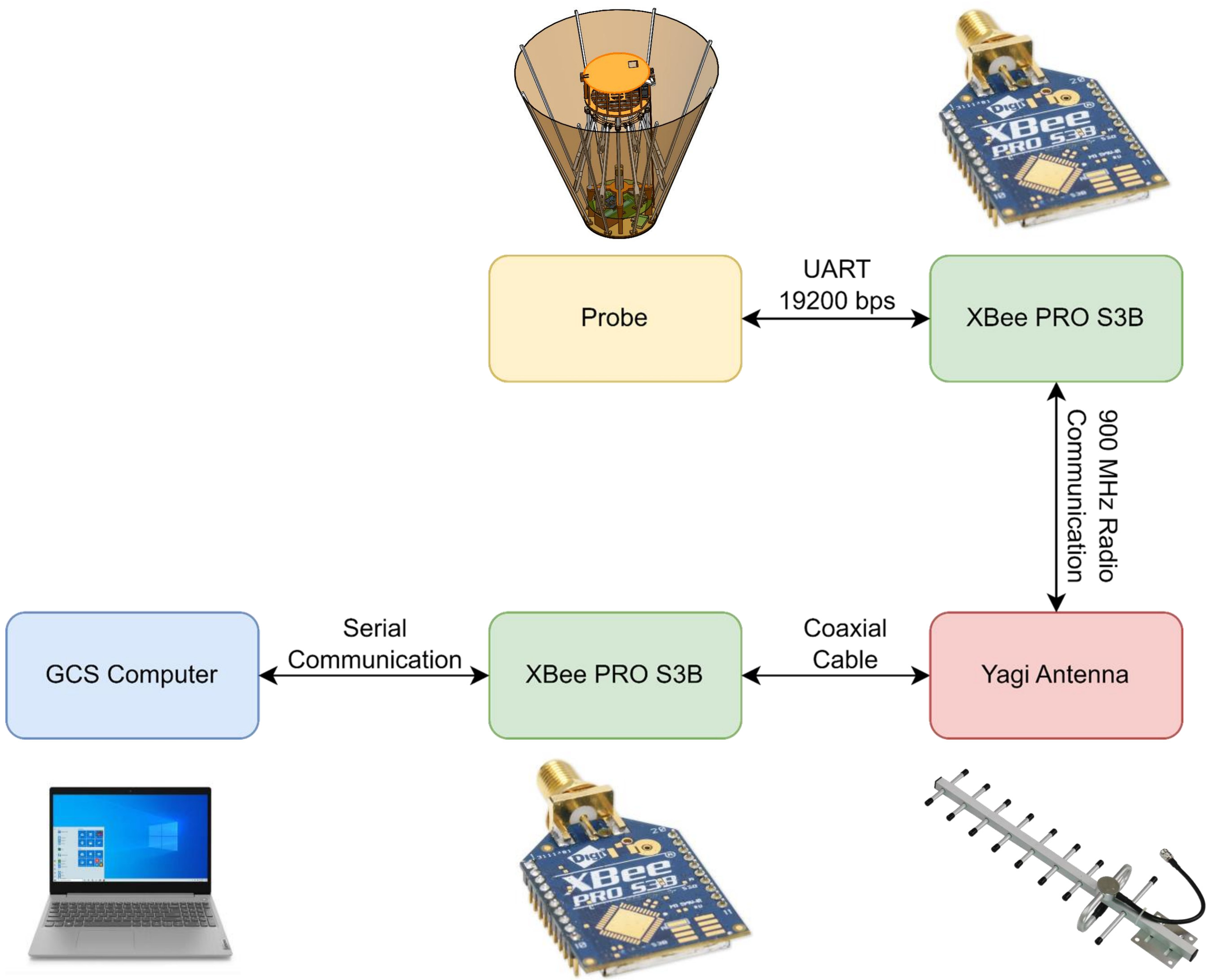
Progress since PDR

- As of now, we have written all the required libraries for each sensor.
- Furthermore, we have confirmed that each sensor is working as expected.
- Very soon, we will test the algorithms and assembly the PCB as soon as possible to perform the environmental tests.

Ground Control System (GCS) Design

Berkant ALPEREN

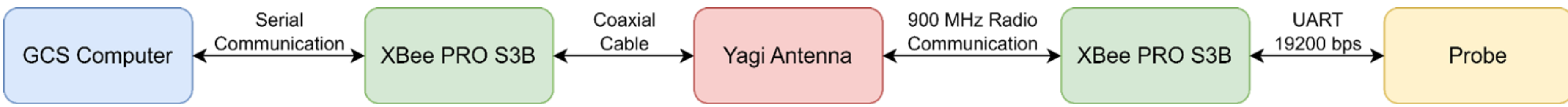
GCS Overview



GCS Changes Since PDR

No changes have been made to the GCS subsystem.

GCS Design



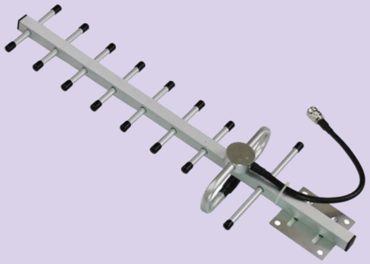
Specifications	
Operation Time	GCS can operate for minimum 2 hours with the internal battery of the laptop.
Overheating Mitigation	We will protect the computer from sunlight with an umbrella.
Auto Update Mitigation	Windows automatic updates will be paused for 5 weeks using the settings app.

GCS Antenna (1/3)

Antenna Selection					
GCS Antenna Model	**Antenna Pattern**	**Gain (dBi)**	**Frequency Range (MHz)**	**Size (cm)**	**Cost ($)**
ZQTMAX Yagi-Uda Antenna	Yagi-Uda Antenna (with folded dipole)	13	806 - 960	50	21.16

Selected Antenna

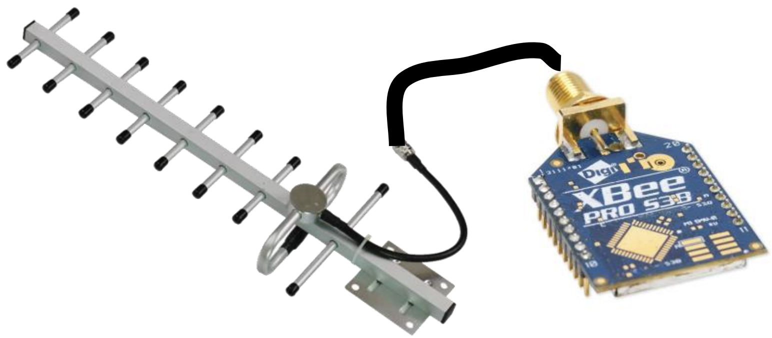
ZQTMAX Yagi-Uda Antenna

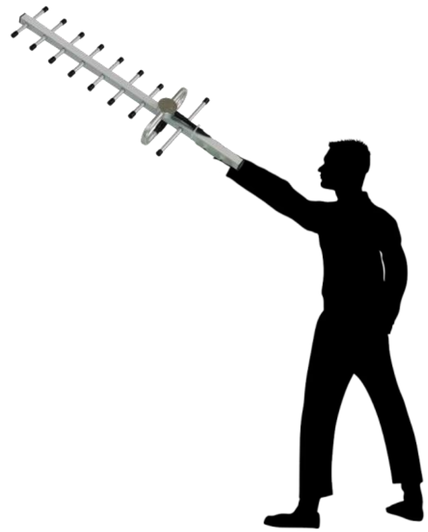


Reasons

- Cheaper
- Better gain

GCS Antenna (2/3)

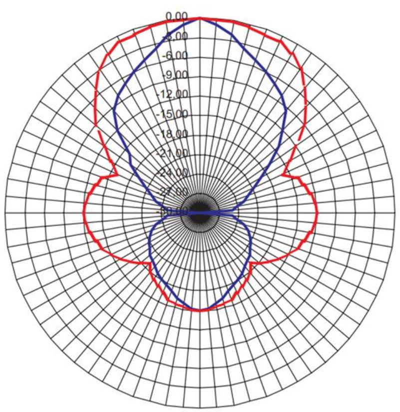




Portability

Our antenna is monolithic and ready to use, it is very easy to transport to the competition area and integrate it into the ground station.

Coverage



GCS Antenna (3/3)

Link Budget and Margin

$$L_{\mathrm{FS}}(\mathrm{dB}) = 20\log_{10}\left(4\pi\frac{\mathrm{distance}}{\mathrm{wavelength}}\right)$$

where; distance = 3000m
wavelength = 0.33m

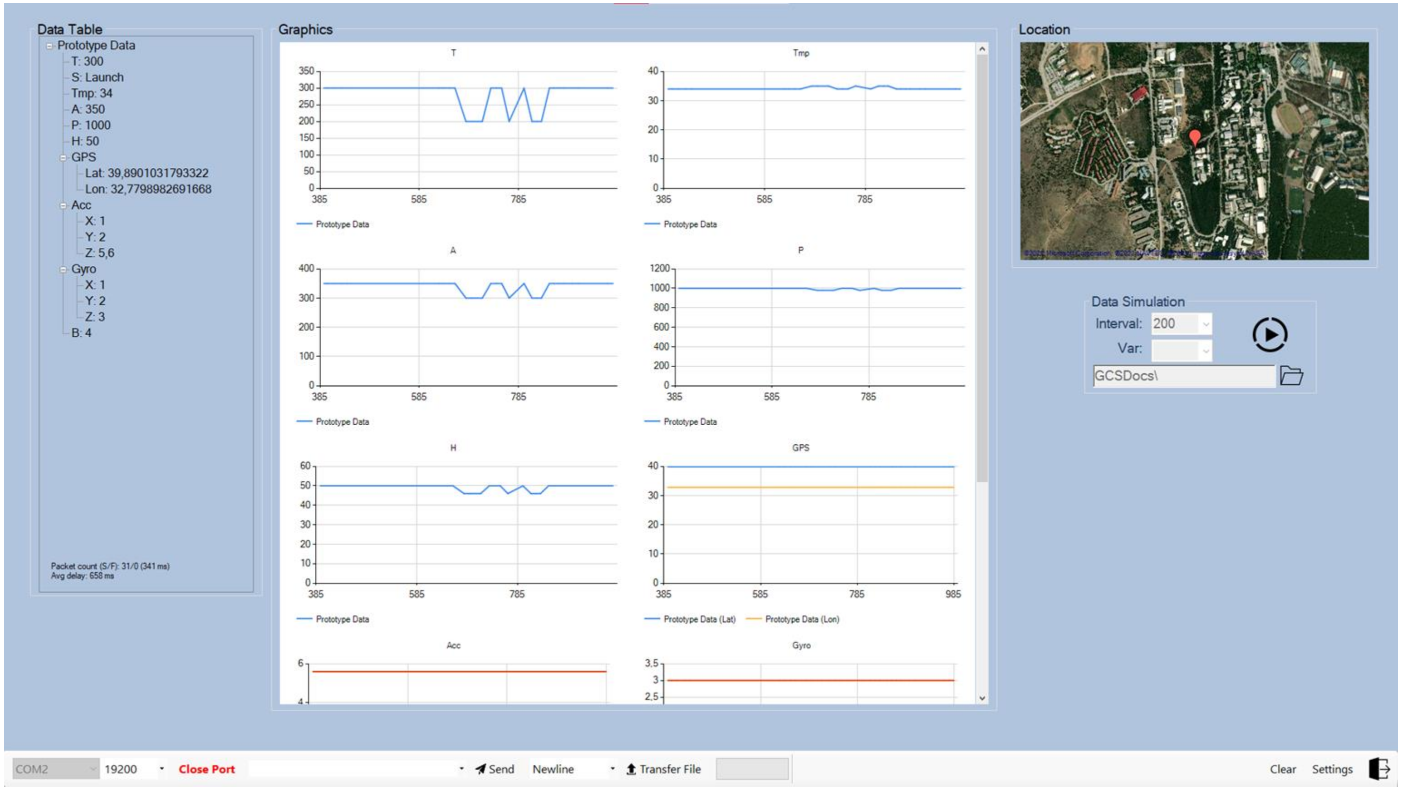
$$P_{\mathrm{RX}} = P_{\mathrm{TX}} + G_{\mathrm{TX}} - L_{\mathrm{TX}} - L_{\mathrm{FS}} - L_M + G_{\mathrm{RX}} - L_{\mathrm{RX}}$$

L_{FS} = 101.156, free space path loss
P_{TX} = 24 dBm, transmitter gain
G_{TX} = 2.3 dBi, transmitter antenna gain
L_{TX} = 1 dB, transmitter losses
L_M = 12 dB, fade margin
G_{RX} = 13 dB, receiver gain
L_{RX} = 1 dB, receiver losses

Available Receiving Power (dB)	-75,956
Xbee Receiving Sensitivity (dB)	-101
Link Budget Margin (dB)	25.04
Link Budget Margin (%)	**> %32**

GCS Software (1/2)

GCS Screenshot



Ground station software is developed on Microsoft Visual Studio .NET Framework using C# in order to achieve high performance throughout the mission. It is advantageous to have multi-threading software to not miss any telemetry packet while rendering multiple charts.

GCS Software (2/2)

- **COTS packages used:** Two NuGet packages are used in developing the GCS software. CSVHelper for data logging and simulation and GMAP for GPS mapping.
- **Telemetry display:** Telemetry data will be displayed as simple text at the TreeView control on the left of the screen. Numeric data will be displayed on “Graphics” panel as well. GPS data will be shown in the map on the right of the screen Real data will be shown with the appropriate scientific units.
- **Plotting:** Plotting will be done in real time using the built-in chart package of .NET Framework. Each numeric variable will have its own **chart**.
- **Command software and interface:** Calibration command will be sent to CanSat using the serial communication panel at the bottom of the screen. All commands will be added to autocomplete library. Verification will be done by checking the data being received from the logs (saved as .csv files) after the command has been sent.
- **Simulation mode:** Simulation file will be selected from the simulation tools panel under the GPS. A timer will be started with a given time interval and will be passing related data to the “data_received” function which handles the data at **1 Hz**. To activate the simulation mode, the serial communication control will be used to send commands to the CanSat.
- **Progress since PDR:**
  - Electronics integration and tests are completed.
  - Simulation software has been completed.
  - Very minor changes have been made to UI, further development will be done.

CanSat Integration and Test

Semihcan SEVEN

CanSat Integration and Test Overview

We will use the following workflow for integration and testing

Subsystem Level Testing → **Integrated Level Testing** → **Simulation Testing** → **Environmental Testing**

Subsystem Level Testing
- Sensors
- CDH
- EPS
- Radio
- FSW
- Mechanical
- Descent Control

Integrated Level Testing
- Descent Testing
- Communications
- Mechanisms
- Deployment

Simulation Testing
- Simulation Mode
- Sensor Mode

Environmental Testing
- Drop Test
- Thermal Test
- Vibration Test
- Fit Check
- Vacuum Test

Subsystem Level Testing Plan (1/3)

Sensor Tests	Test Method
GPS receiver test	The data from the GPS Receiver will be compared and tested with Google Maps.
Payload tilt sensor test	The orientation of the payload will be checked with respect to the Earth's magnetic field
Battery voltage sensor test	Measure and compare the battery with Voltmeter
Air pressure sensor test	Measuring altitude location comparing known altitudes
Air temperature sensor test	Compare measured temperature with thermometer
Camera Test	Record a test video with the module

CDH and Radio Communication Tests	Test Method
Telemetry format test	Use the same XCTU setup, test telemetry data format with some message sent between the two XBees, verification of received data.
Simple transmit test	The telemetry transmission will be tested up to 1 km range for determining antenna range which will provide the distance like field competition.
Range test	Cansat will be taken to a location where two antennas are around 1.5 km away.

Subsystem Level Testing Plan (2/3)

EPS Test	Test Method
Boost converter test	The output voltage of the boost converter will be checked with a multimeter whether it is 6V or not.
Components' power supply test	All components will be checked separately whether they are powered properly or not.
Battery high current test	When power consumption is high, battery will be checked if it withstands the high current.
Battery discharge time test	Battery will be tested if it can supply current at max power consumption.
Voltage regulators	Proper and desired voltage on all power lines under load

FSW Test	Test Method
Testing libraries	Each sensor will be tested.
Change between flight states	States changes will be tested with simulating transition conditions.

Subsystem Level Testing Plan (3/3)

Mechanical Tests	Test Method
Servo Operation Test	Servo will be operated after being installed on the probe to ensure it can reliably release the parachute lid and flag mast.
DC Motor Operation Test	DC motor will be tested throughout its full range of motion - Probe release test - Heat shield extension test - Uprighting test

Descent Control Test	Test Method
Velocity Test	Descent velocity will be tested by dropping CanSat from a high building.
Payload Parachute Test	Payload parachute will be tested with a dummy weight.
Container Parachute Deployment Test	Container will be released from a high building to confirm descent rate calculations
Parachute Testing	Independent parachutes will be tested to ensure that they match the calculated drag forces.

Integrated Level Functional Test Plan

Subsystem	Test
Descent testing	The CanSat will be raised to the altitude of 700 meters using a drone and released, we will measure the time elapsed from release to landing for both the container and the probe to find the average descent rate.
Communications	The communication range of the assembled CanSat will be tested. The distance of the communication will be tested while the container is present and after the payload has left.
Mechanisms	Motor, heat shield, spring and hinge operations will be tested separately. After confirming that all mechanical systems work as expected individually, mechanical systems will be integrated and tested together.
Deployment	A dummy rocket body will be built. The CanSat will be placed inside the dummy body and checked for fit and tolerances. We will test container separation from the body as well as probe deployment from the container using simulated commands.
Simulation	This test will verify that the GCS software is capable of reading a CSV data file and transmitting data to the CanSat at 1 Hz frequency. GCS will be set up and configured. After the communication is set up,commands will be sent to the CanSat and it will be observed if everything works fine.

Environmental Test Plan

Subsystem	Test
Drop Test	CanSat will be tied up to an eyebolt fixed high-up from the ground using a 61 cm non-stretching cord. CanSat will be raised to same level as the eyebolt and then it will be released to generate 30 g’s of shock on the system. It will be verified that all systems work without any problems during the test.
Thermal Test	CanSat will be put in a thermal insulator and turned on. The air temperature will be increased by use of a heat gun. After the temperature reaches 55-60C every part and subsystem of the CanSat will be observed for two hours to ensure they work properly.
Vibration Test	CanSat will be put on a sander and turned on. The sander will be operated at full speed for 5 seconds. During this time it will be observed whether the CanSat shows any disfunction or error in collecting data and whether there are damages on the CanSat. This will be repeated 4 times.
Fit Check	All moving parts will be checked independently to ensure that they move freely. Parts will also be checked if they are connected strong enough.
Vacuum Test	CanSat will be put in a vacuum chamber and turned on. Vacuum chamber will start pulling vacuum and stop when the vacuum represents the peak altitude. The air will be allowed to enter the chamber slowly. The collected data will be monitored during the process.

Test Procedures Descriptions

Test Proc	Test Description	Requirements	Pass Fail Criteria
1	GPS receiver test	39	GPS data is received
2	Payload tilt sensor test	39	Payload's tilt is in accordance with the tilt sensor data
3	Battery voltage sensor test	39	Multimeter gives the same result as ADC value
4	Air pressure sensor test	39	Sensor value is the same as the commercial barometer value
5	Air temperature sensor test	39	Sensor value is the same as thermometer value
6	Camera test	40, 41	Video taken with the camera module is properly recorded
7	Telemetry format test	38, 39	Telemetry data format is as expected
8	Simple transmit test	38	Data transfer is successfully achieved
9	Range test	38	Data transfer is successfully achieved from 3 km
10	Boost converter test	27, 29	The output voltage is 6V.
11	Components' power supply test	-	Voltage difference across every component will be checked

Test Procedures Descriptions

Test Proc	Test Description	Requirements	Pass Fail Criteria
12	Battery high current test	-	Battery current will be checked with multimeter
13	Battery discharge time test	-	Battery max current will be measured to check if it can supply for enough time
14	Voltage regulators		All voltages are as expected on each power line
15	Testing libraries	-	Sensors are working properly
16	Change between flight states	-	Changing transition conditions will cause changing states
17	Servo Operation Test	-	Servo motors are able to lock the parachute
18	DC Motor Operation Test	-	DC motors are able to release the probe, extend the heat shield, and upright the payload
19	Velocity Test	-	Cansat is falling with expected velocity
20	Payload Parachute Test	-	Payload parachute works properly
21	Container Parachute Deployment Test	-	Container parachute deploys properly
22	Parachute Testing	-	Parachutes are able to endure the drag fore

Simulation Test Plan

The ground station will provide simulated pressure data readings to test if the FSW and the mechanical subsystems work properly. When testing, we will check if each transition condition is satisfied successfully.

The simulated pressure data readings will represent a real flight.

Implementation	We will have an if condition such that when the simulation mode is enabled, the sensor data will be overwritten by the data provided by the ground station.

Pseudocode	if SIM_ENABLED:
	getStationData()
	else:
	getSensorData()

Mission Operations & Analysis

Mustafa Yusuf AKSU

Overview of Mission Sequence of Events (1/3)

Arrival	Pre-Launch	Launch
• Arrive at the launch site • Check if the CanSat is physically and functionally okay. • Check if the GCS is functioning properly. • Moving the ground control station to dedicated location.	• Load the payload. • Assembly will be completed. • Antenna will be constructed, and GCS will be set up. • The ground station crew calibrates the altitude to 0.	• CanSat will be stowed. • Executing launch order.
Team Members	**Team Members**	**Team Members**
• **CanSat Crew:** - Umut ALTUN - Alp Kaan KOTTAŞ - M.Burak AYDAR - Emre OKUDUCU • **Ground Station Crew:** - Barış Berk KOTTAŞ - Berkant ALPEREN	• **Ground Station Crew:** - Barış Berk KOTTAŞ - Berkant ALPEREN • **Assembly Team:** - Umut ALTUN - Mehmet İLBAĞI	• **CanSat Crew:** - Umut ALTUN - Alp Kaan KOTTAŞ - M. Burak AYDAR - Emre OKUDUCU - Mehmet İLBAĞI • **Mission Control Officer:** - Berkant ALPEREN

Overview of Mission Sequence of Events (2/3)

Free fall

- CanSat is released and starts descending.
- The ground station team verifies that everything is going smoothly.

Recovery & Telemetry Data Delivery

- Container and probe will land with parachute.
- Heading out to recover the probe.
- Recovery of the probe
- Data log files will be transferred to judges via a USB drive after the launch operations.

Analysis

- State of the payload and container will be checked.
- Received telemetry data will be analyzed.

Team Members

- **Ground Station Crew:**
  - Barış Berk KOTTAŞ
  - Berkant ALPEREN

Team Members

- **Recovery Crew:**
  - Semihcan SEVEN
  - M. Burak AYDAR
  - Emre OKUDUCU
  - Mehmet İLBAĞI

Team Members

- **CanSat Crew:**
  - Semihcan SEVEN
  - Umut ALTUN
  - Alp Kaan KOTTAŞ
  - M. Burak AYDAR
  - Emre OKUDUCU
  - Mehmet İLBAĞI

Overview of Mission Sequence of Events (3/3)

Antenna construction and ground system setup

- An umbrella will be used to protect the GCS from sunlight and rain.
- The ground station will be set up and made working.
- The hand-held antenna will be placed properly after connecting to the workspace and the computer.
- Connection between the GCS and the CanSat will be controlled.

Field Safety Rules Compliance

Ground Station Configuration
- Set up computer, XBee, antenna, etc.
- Check whether the baud rate is selected as 19200 on GCS software
- Ensure the communication is established with probe
- Check the state of CanSat and calibration data

Launch Preparation

This plan is already available on a document published by CanSat competition

CanSat Preparation
- Make sure the battery is fully charged
- Turn on the power switch of electronics
- Monitor the sensor data on GCS software
- Perform mechanical parts to confirm the descent control is working properly

Launch Procedure

This plan is already available on a document published by CanSat competition

CanSat Integration
- Attach container parachute to CanSat
- Lock the payload to the container
- Mount CanSat into the rocket

Development Status
- Mission Operation Manual will be mostly complete after the CanSat is assembled and integrated.
- The final version of the manual will be ready after the tests and rehearsals.
- Each team member will study the manual thoroughly.

CanSat Location and Recovery

CanSat recovery strategy:

- Our container will have a fluorescent pink color. Our probe and parachutes and probe will be fluorescent orange so it can be easily spotted from a distance.
- The whereabouts of the container will be determined by observing the flight path and the latest relevant GPS data.
- The probe will have an easier recovery since it will be transmitting GPS data throughout the mission.
- The sound of the audio beacon will also be an important factor in locating the probe.
- Both the container and the probe will have a label placed on them with the university, team name, team number, contact email information on them. Example:

    Middle East Technical University,
    METUOR Space Team (#1068),
    metuor.uzay@gmail.com

Mission Rehearsal Activities

Ground Control Setup and Communications Testing	→	• GCS will be assembled and powered on • Communications testing will be done to ensure proper operation
Preparing and Powering on the CanSat	→	• Probe will be placed inside the container with the arms fully closed, parachute lid and flag mast fully secured. • Probe will be placed inside the container and turned on via the switch
Placing the CanSat inside the Rocket	→	• CanSat will be placed inside the rocket with extra care such that everything is properly stowed and will not interfere with deployment. • Communications and Sensor Testing
Recovery	→	• We will attempt to secure the CanSat using GPS and the buzzer

Requirements Compliance

Berkant ALPEREN

Requirements Compliance Overview

We have prepared and designed our CanSat by analyzing and identifying the CanSat Mission Guide 2023 . System tests will be done in accordance to CanSat Integration and Test section.

• We comply with 56 requirements based on CanSat Mission Guide 2023.

• There are 5 partial complied requirements that will need more testing. We will build some test satellites to test our concepts.

• There aren't any requirements that we do not comply with.

Green	= Comply
Yellow	= Partial
Red	= No Comply

Requirements Compliance (1/10)

Rqmt Num	Requirement	Comply / No Comply / Partial	X-Ref Slide(s) Demonstrating Compliance	Team Comments or Notes
1	Total mass of the CanSat (science probe and container) shall be 700 grams +/- 10 grams.	Comply	70	We designed it lighter on purpose since it is easy to add mass later.
2	CanSat shall fit in a cylindrical envelope of 125 mm diameter x 400 mm length. Tolerances are to be included to facilitate container deployment from the rocket fairing.	Comply	27	
3	The container shall not have any sharp edges to cause it to get stuck in the rocket payload section which is made of cardboard.	Comply	27	
4	The container shall be a fluorescent color; pink, red or orange.	Comply	124	
5	The container shall be solid and fully enclose the science probes. Small holes to allow access to turn on the science probes are allowed. The end of the container where the probe deploys may be open.	Comply	22	
6	The rocket airframe shall not be used to restrain any deployable parts of the CanSat.	Comply	27	
7	The rocket airframe shall not be used as part of the CanSat operations.	Comply	27	
8	The container's parachute shall not be enclosed in the container structure. It shall be external and attached to the container so that it opens immediately when deployed from the rocket.	Comply	22, 27	

Requirements Compliance (2/10)

Rqmt Num	Requirement	Comply / No Comply / Partial	X-Ref Slide(s) Demonstrating Compliance	Team Comments or Notes
9	The Parachute shall be fluorescent Pink or Orange	Comply	124	
10	The descent rate of the CanSat (container and science probe) shall be 15 meters/second +/- 5 m/s.	Comply	21, 50, 51	
11	0 altitude reference shall be at the launch pad.	Comply	81, 82	
12	All structures shall be built to survive 15 Gs of launch acceleration.	Comply	65	Design has been improved. To be tested
13	All structures shall be built to survive 30 Gs of shock.	Comply	65	Design has been improved. To be tested
14	All electronics and mechanical components shall be hard mounted using proper mounts such as standoffs, screws, or high performance adhesives.	Comply	65	
15	All mechanisms shall be capable of maintaining their configuration or states under all forces.	Comply		To be tested
16	Mechanisms shall not use pyrotechnics or chemicals.	Comply	61	

Requirements Compliance (3/10)

Rqmt Num	Requirement	Comply / No Comply / Partial	X-Ref Slide(s) Demonstrating Compliance	Team Comments or Notes
17	Mechanisms that use heat (e.g., nichrome wire) shall not be exposed to the outside environment to reduce potential risk of setting vegetation on fire.	Comply	-	Our CanSat does not have such systems
18	Both the container and probe shall be labeled with team contact information including email address.	Comply	124	
19	Cost of the CanSat shall be under $1000. Ground support and analysis tools are not included in the cost. Equipment from previous years shall be included in this cost, based on current market value.	Comply	140, 141	
20	XBEE radios shall be used for telemetry. 2.4 GHz Series radios are allowed. 900 MHz XBEE radios are also allowed.	Comply	78	
21	XBEE radios shall have their NETID/PANID set to their team number.	Comply	78	
22	XBEE radios shall not use broadcast mode.	Comply	78	
23	The container (if needed) and probe shall include an easily accessible power switch that can be accessed without disassembling the cansat and science probes and in the stowed configuration.	Comply	22, 24	

Requirements Compliance (4/10)

Rqmt Num	Requirement	Comply / No Comply / Partial	X-Ref Slide(s) Demonstrating Compliance	Team Comments or Notes
24	The probe shall include a power indicator such as an LED or sound generating device that can be easily seen or heard without disassembling the cansat and in the stowed state.	**Comply**	86	
25	An audio beacon is required for the probe. It shall be powered after landing.	**Comply**	86	
26	The audio beacon shall have a minimum sound pressure level of 92 dB, unobstructed.	**Comply**	86	
27	Battery source may be alkaline, Ni-Cad, Ni-MH or Lithium. Lithium polymer batteries are not allowed. Lithium cells must be manufactured with a metal package similar to 18650 cells. Coin cells are allowed.	**Comply**	87	
28	An easily accessible battery compartment shall be included allowing batteries to be installed or removed in less than a minute and not require a total disassembly of the CanSat.	**Comply**	23	
29	Spring contacts shall not be used for making electrical connections to batteries. Shock forces can cause momentary disconnects.	**Comply**	87	

Requirements Compliance (5/10)

Rqmt Num	Requirement	Comply / No Comply / Partial	X-Ref Slide(s) Demonstrating Compliance	Team Comments or Notes
30	The Cansat shall operate during the environmental tests laid out in Section 3.5.	Comply		To be tested
31	The Cansat shall operate for a minimum of two hours when integrated into the rocket.	Comply	88, 89	
32	The probe shall be released from the container when the CanSat reaches 500 meters.	Comply	21, 39, 92, 93	
33	The probe shall deploy a heat shield after leaving the container.	Comply	21, 39, 46	
34	The heat shield shall be used as an aerobrake and limit the descent rate to 20 m/s or less.	Comply	50, 51	
35	At 200 meters, the probe shall release a parachute to reduce the descent rate to 5 m/s +/-1 m/sec.	Comply	46, 50, 51, 92, 93	

Requirements Compliance (6/10)

Rqmt Num	Requirement	Comply / No Comply / Partial	X-Ref Slide(s) Demonstrating Compliance	Team Comments or Notes
36	Once landed, the probe shall upright itself.	**Comply**	21, 39, 62, 92	
37	After uprighting, the probe shall deploy a flag 500 mm above the base of the probe when the probe is in the upright position.	**Comply**	21, 39, 63, 92	
38	The probe shall transmit telemetry once per second.	**Comply**	78, 80	
39	The probe telemetry shall include altitude, air pressure, temperature, battery voltage, probe tilt angles, command echo, and GPS coordinates that include latitude, longitude, altitude and number of satellites tracked.	**Comply**	79, 80	
40	The probe shall include a video camera pointing down to the ground.	**Comply**	23, 36	
41	The video camera shall record the flight of the probe from release to landing.	**Comply**	36, 88	

Requirements Compliance (7/10)

Rqmt Num	Requirement	Comply / No Comply / Partial	X-Ref Slide(s) Demonstrating Compliance	Team Comments or Notes
42	The video camera shall record video in color and with a minimum resolution of 640x480.	**Comply**	36	
44	The flight software shall maintain a count of packets transmitted which shall increment with each packet transmission throughout the mission. The value shall be maintained through processor resets.	**Comply**	76, 79, 80	
45	The probe shall maintain mission time throughout the whole mission even with processor resets or momentary power loss.	**Comply**	76	
46	The probe shall have its time set to within one second UTC time prior to launch.	**Comply**	76	
47	The probe flight software shall support simulated flight mode where the ground station sends air pressure values at a one second interval using a provided flight profile csv file.	**Comply**	97, 108	

Requirements Compliance (8/10)

Rqmt Num	Requirement	Comply / No Comply / Partial	X-Ref Slide(s) Demonstrating Compliance	Team Comments or Notes
48	In simulation mode, the flight software shall use the radio uplink pressure values in place of the pressure sensor for determining the payload altitude.	**Comply**	97	
49	The payload flight software shall only enter simulation mode after it receives the SIMULATION ENABLE and SIMULATION ACTIVATE commands.	**Comply**	97, 118	
50	The ground station shall command the CanSat to start calibrating the altitude to zero when the CanSat is on the launch pad prior to launch.	**Comply**	81, 82, 108	
51	The ground station shall generate csv files of all sensor data as specified in the Telemetry Requirements section.	**Comply**	108	
52	Telemetry shall include mission time with 1 second or better resolution.	**Comply**	76, 79, 80	
53	Configuration states such as zero altitude calibration shall be maintained in the event of a processor reset during launch and mission.	**Comply**	96	

Requirements Compliance (9/10)

Rqmt Num	Requirement	Comply / No Comply / Partial	X-Ref Slide(s) Demonstrating Compliance	Team Comments or Notes
54	Each team shall develop their own ground station.	**Comply**	107, 108	We developed our own ground station.
55	All telemetry shall be displayed in real time during descent on the ground station.	**Comply**	107, 108	
56	All telemetry shall be displayed in engineering units (meters, meters/sec, Celsius, etc.)	**Comply**	107, 108	All the units are in engineering units.
57	Teams shall plot each telemetry data field in real time during flight.	**Comply**	107	
58	The ground station shall include one laptop computer with a minimum of two hours of battery operation, XBEE radio and a hand-held antenna.	**Comply**	101,103, 105	
59	The ground station must be portable so the team can be positioned at the ground station operation site along the flight line. AC power will not be available at the ground station operation site.	**Comply**	101, 105	Our ground station is portable.

Requirements Compliance (10/10)

Rqmt Num	Requirement	Comply / No Comply / Partial	X-Ref Slide(s) Demonstrating Compliance	Team Comments or Notes
60	The ground station software shall be able to command the payload to operate in simulation mode by sending two commands, SIMULATION ENABLE and SIMULATION ACTIVATE.	**Comply**	108	
61	When in simulation mode, the ground station shall transmit pressure data from a csv file provided by the competition at a 1 Hz interval to the CanSat.	**Comply**	108	

Management

Berkant ALPEREN

Status of Procurements

- All sensors and motors have been acquired.
- PCB production is delayed due to a change in the choice of motor and thus, the change in circuit design. We have ordered the PCBs and are waiting for their delivery.
- Materials for mechanical structures have all been acquired and the 3D printed parts are partially printed.
- Parachutes have been ordered from a local seller and are waiting for shipment.

CanSat Budget - Hardware (1/2)

CanSat Cost Budget		
Part Name	**Cost (USD)**	**Status**
3D printed Parts	25	Ordered
Fiberglass Rods	10	Acquired
DC Motor	15	Acquired
Threaded rod	5	Ordered
Pins	5	Ordered
Springs	5	Ordered
Parachutes	65	Ordered
Adhesives	10	Ordered
BNO055	45.95	Acquired
continued …		

CanSat Budget - Hardware (2/2)

continued …		
STM32F401RET6	9.97	Acquired
Adafruit Mini Spy Camera	25	Acquired
BMP280	2.3	Acquired
Parachute Lock Servo	3.5	Acquired
uBlox Neo-M8N	34.23	Acquired
CMT-8504-100-SMT-TR	2.33	Acquired
Power Ind.LED	0	Acquired
Infrared Led	0.2	Acquired
Total Cost (USD)	263.48	

CanSat Budget – Other Costs

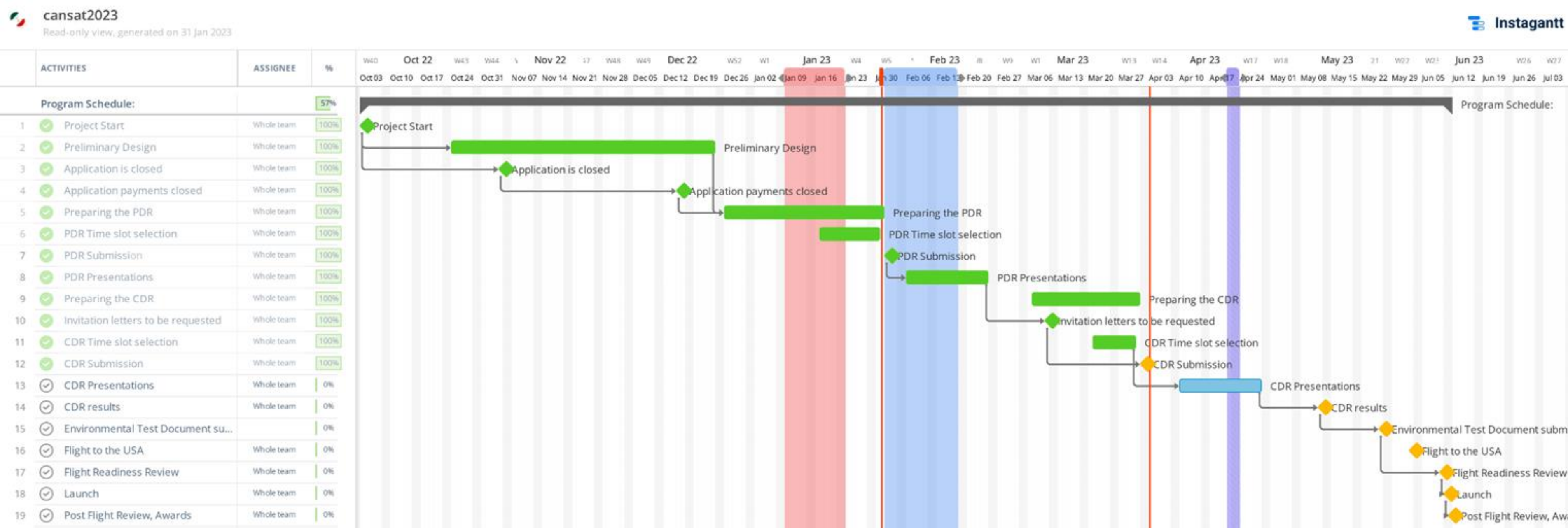
Ground Control Station Costs				
Component	**Description**	**Quantity**	**Cost ($)**	**Actual / Estimate**
Xbee Pro S3B	Comms. module	1	55	Actual
ZQTMAX Yagi-Uda Antenna	GCS Antenna	1	21.16	Actual
Xbee to USB adapter	Adapter	1	7	Estimate
Umbrella	For sun protection	1	20	Estimate

Other Costs		
Description	**Cost (USD)**	**Estimate / Actual**
Flights	12000	Estimate
Visas	1280	Actual
Housing	4000	Estimate
Food	750	Estimate
Car Rental	2500	Estimate
Total	20530	

CanSat Budget – Other Costs

Team Income		
Description	**Amount (USD)**	**Received / In discussion**
Sponsorships (Received)	1500	Partially received, partially in discussion
METU Robotics Society	300	Received
Total	1800	

Program Schedule Overview



Final Exams

Semester Break

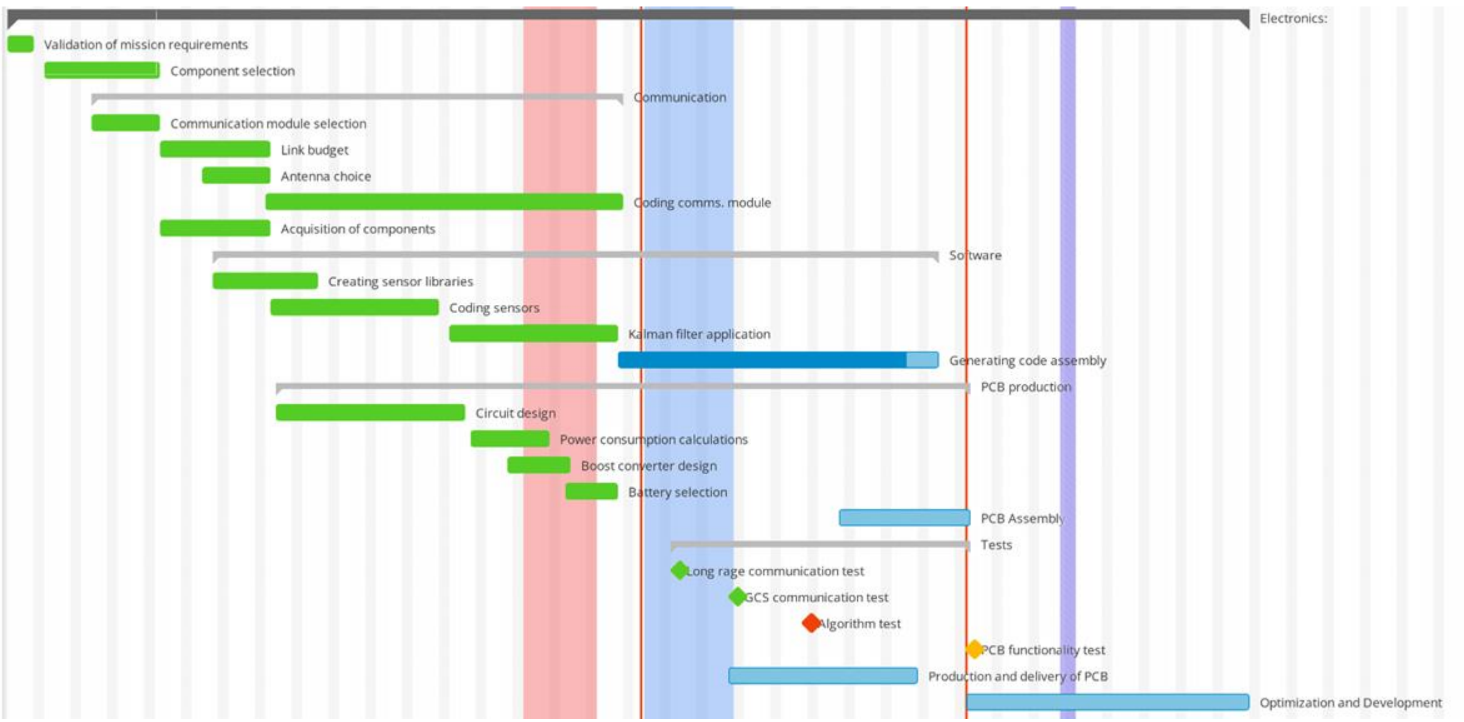
Ramadan Holiday

We arranged our schedule so that we would not have a heavy workload during finals and we used the time after finals and the semester break as an opportunity to further work on this project.

Detailed Program Schedule (1/3)

Electronics

#	Electronics:	Assigned	Progress
21	Validation of mission requirements	MI, BA, AK, BK, SS	100%
22	Component selection	AK, BK, BA, MI, SS	100%
	Communication	AK, BK, BA, MI	100%
24	Communication module selec...	Burak Aydar	100%
25	Link budget	Alp Kotaş	100%
26	Antenna choice	MI, AK	100%
27	Coding comms. module	BK, BA	100%
28	Acquisition of components	Berkant Alperen	100%
	Software	AK, BK, BA, SS	88%
30	Creating sensor libraries	AK, BA, SS	100%
31	Coding sensors	AK, BA, SS, BK	100%
32	Kalman filter application	Burak Aydar	100%
33	Generating code assembly	AK, BA	88%
	PCB production	MI, AK	88%
35	Circuit design	Mehmet Ilbağı	100%
36	Power consumption calculatio...	MI, AK	100%
37	Boost converter design	Mehmet Ilbağı	100%
38	Battery selection	AK, MI	100%
39	PCB Assembly	Mehmet Ilbağı	0%
	Tests	AK, BK, BA, MI, SS	50%
41	Long rage communication test	AK, BK, BA	100%
42	GCS communication test	AK, BK, BA, BA	100%
43	Algorithm test	BA, AK	0%
44	PCB functionality test	MI, BA, AK, BK, SS	0%
45	Production and delivery of PCB	MI, BA	0%
46	Optimization and Development	AK, BK, BA, MI, SS	0%

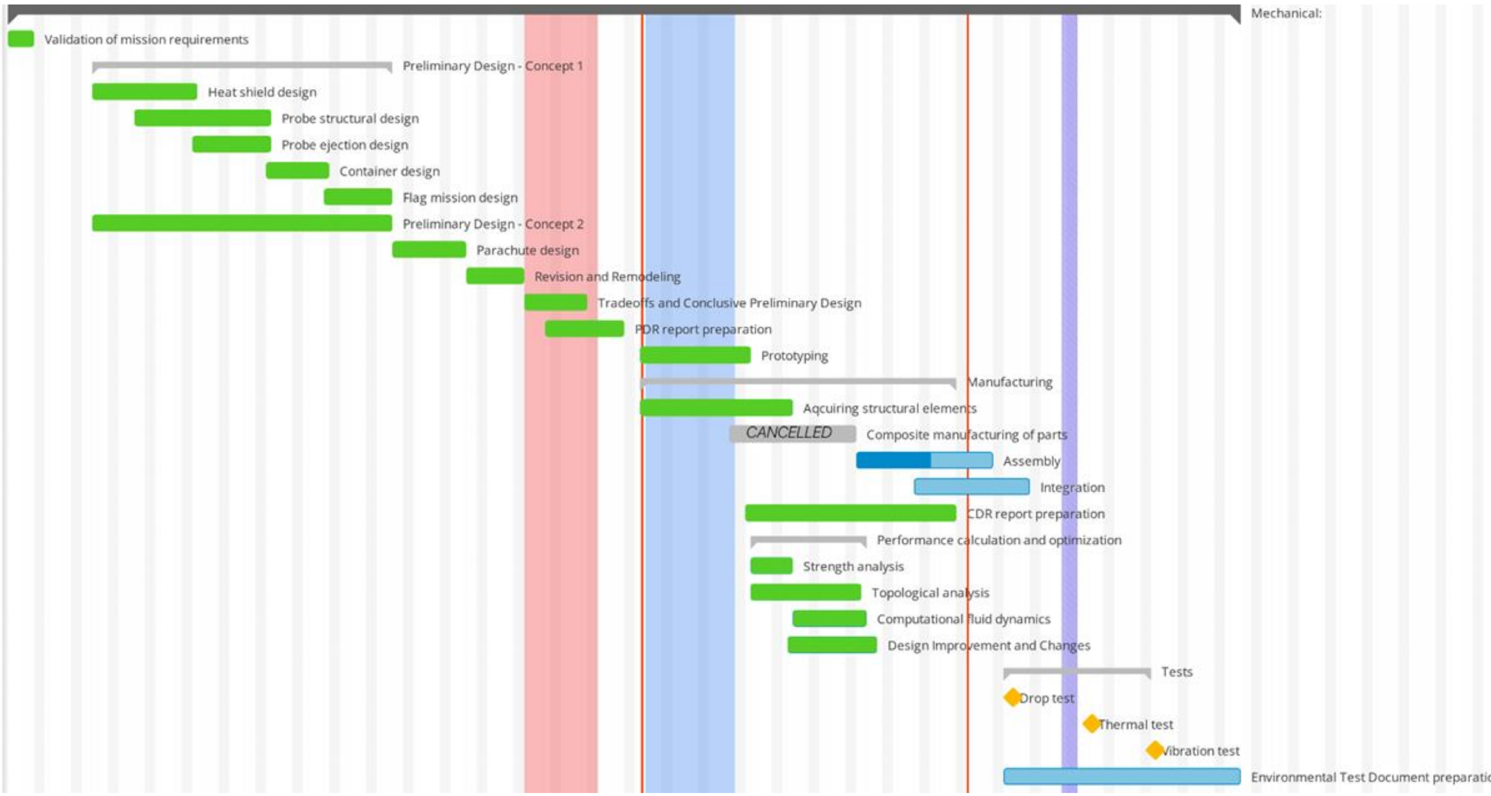


Final Exams | Semester Break | Ramadan Holiday

Detailed Program Schedule (2/3)

Mechanical

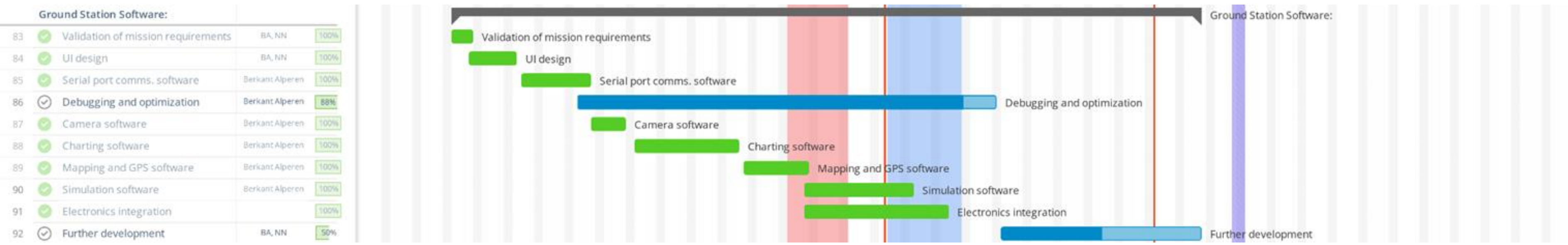
#	Mechanical:		
48	Validation of mission requirements		100%
	Preliminary Design - Concept 1	Umut Altun	100%
50	Heat shield design	Umut Altun	100%
51	Probe structural design	Umut Altun	100%
52	Probe ejection design	Umut Altun	100%
53	Container design	Umut Altun	100%
54	Flag mission design	Umut Altun	100%
	Preliminary Design - Concept 2	Mustafa Y. Aksu	100%
61	Parachute design	UA, MY	100%
62	Revision and Remodeling	MY, UA	100%
63	Tradeoffs and Conclusive Prelimin...	MY, UA	100%
64	PDR report preparation	UA, MY	100%
65	Prototyping	MY, UA	100%
	Manufacturing	UA, MY	29%
67	Aqcuiring structural elements	UA, MY	0%
68	Composite manufacturing of ...	UA, MY	0%
69	Assembly	UA, MY	50%
70	Integration	Whole team	0%
71	CDR report preparation	MY, UA	100%
	Performance calculation and opti...	UA, MY	100%
73	Strength analysis	Mustafa Y. Aksu	100%
74	Topological analysis	Mustafa Y. Aksu	100%
75	Computational fluid dynamics	Umut Altun	100%
76	Design Improvement and Changes	MY, UA	100%
	Tests	Whole team	0%
78	Drop test	Whole team	0%
79	Thermal test	Whole team	0%
80	Vibration test	Whole team	0%
81	Environmental Test Document pr...	Whole team	0%



Final Exams | Semester Break | Ramadan Holiday

Detailed Program Schedule (3/3)

Ground Control System



Final Exams

Semester Break

Ramadan Holiday

Shipping and Transportation

- All CanSat components will be transported in our carry on bags with appropriate cases. If our budget allows, we will produce spare parts and bring them with us. Our CanSat is designed such that minimal amount of tools and supplies are required for assembly.

- Apart from the PCB all of our parts are easily obtainable/manufacturable.

Conclusions (1/2)

Major Accomplished Works:

- The team has been formed and tasks were given to individuals according to competition schedule.
- PDR and CDR is completed.
- Two different preliminary design concepts are done.
- Descent calculations and parachute design are done.
- Final preliminary design is determined after revisions and remodeling and is ready for manufacturing.
- Code libraries for all sensors are created and tested. Communication modules are coded and tested.
- Long range communication test is done.
- GCS communication test is done.
- PCB is designed and ready to be produced.
- Kalman filter is applied.

Major Unfinished Works:

- The team still needs sponsors for travel costs.
- PCB production is delayed due to a change in the choice of motor and thus, the change in circuit design.
- Some of the 3D printed parts are still to be printed, so the assembly and integration is not done yet.
- The code assembly is almost complete, but not finished yet.

Conclusions (2/2)

Testing to complete:
- Drop test
- Thermal test
- Vibration test
- PCB functionality test
- Algorithm test

Flight Software Status:
- All the sensor libraries are complete and confirmed to be working.
- The algorithms and the Kalman filter are complete. However, they are not implemented together yet. Hence, the algorithm tests are not complete.
- As soon as the implementation is complete, we will start testing.

Why are we ready to proceed to next state to development?
- We have finished our procurement process and are now ready to assemble our CanSat. We are absolutely thrilled with the strides we have made in both design and manufacturing, and are confident that we are a top contender for the number one spot in the competition.