CanSat 2019
Critical Design Review (CDR)
Version 1.0

Team # 6160
grizu-263

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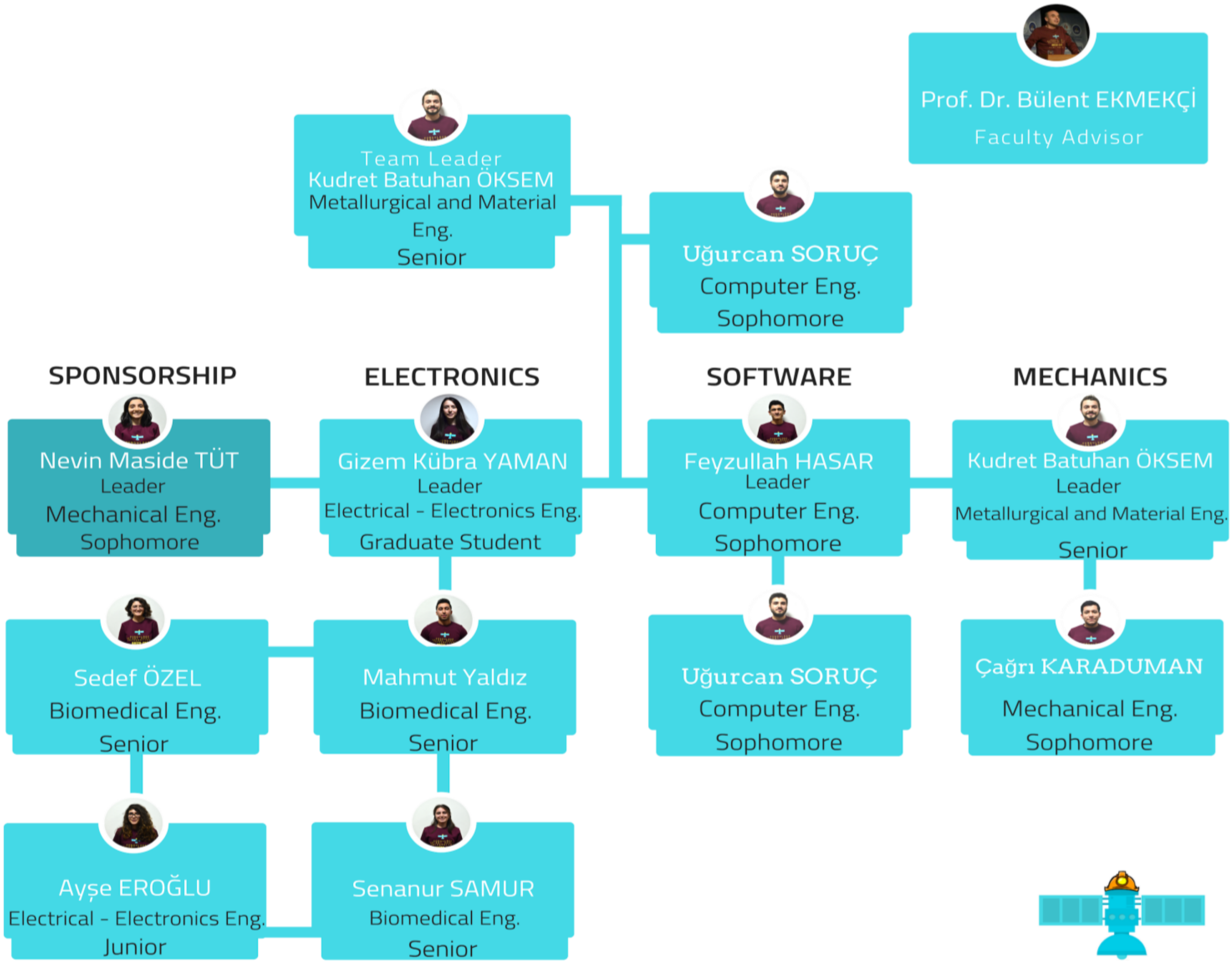
- **Systems Overview –** Gizem Kübra YAMAN
- **Sensor Subsystem Design –** Sedef ÖZEL
- **Descent Control Design –** Çağrı KARADUMAN
- **Mechanical Subsystem Design –** Kudret Batuhan ÖKSEM
- **CDH Subsystem Design –** Ayşe EROĞLU
- **Electrical Power Subsystem Design –** Ayşe EROĞLU
- **Flight Software Design –** Feyzullah HASAR
- **Ground Control System Design –** Uğurcan SORUÇ
- **CanSat Integration and Test –** Mahmut YALDIZ
- **Mission Operations and Analysis –** Senanur SAMUR
- **Requirements Compliance –** Senanur SAMUR
- **Management –** Nevin Maside TÜT

Team Organization



Acronyms (1 of 2)

- **A** – Analysis
- **ABS -** Acrylonitrile-Butadiene-Styrene
- **AC** – Alternate Current
- **ADC –** Analog Digital Converter
- **ANT** – Antenna
- **AVI –** Audio Video Interleave
- **CAD**- Computer Aided Design
- **CC** – Cansat Crew
- **CDH** – Communication and Data Handling
- **COM** – Communication
- **COTS** - Commercial off the shelf
- **D** – Demonstration
- **dB** – Decibel
- **dBi** – Decibel isotropic
- **dBm** – Decibel milliwatt
- **DC** – Direct Current
- **DS-** Data Sheet
- **EEPROM** – Electrically Erasable Programmable Read Only Memory
- **E-** Estimate
- **EPS** – Electrical Power System
- **etc** – et cetera
- **FSW** – Flight Software
- FPS – Frame per second
- **G** – Gravitational Force
- **g** – Gram
- **GB** – GigaByte
- **GCS** – Ground Control System
- **GHz** – GigaHertz
- **GND** – Ground
- **GPIO** – General Purpose Input Output
- **GPS** – Global Positioning System
- **GSC** – Ground Station Crew
- **Hz** – Hertz
- **I** – Inspection
- **I/O -** Input/ Output
- **I2C** – Inter-Integrated Circuit
- **ID** – Identification
- **IDE** – Integrated Development Environment
- **IMU** – Inertial Measurement Unit
- **J** – Joule
- **K** - Kelvin
- **kB** – KiloByte
- **km** – Kilometers
- **kg** - Kilogram
- **M-** Measurement
- **m** – Meter
- **mA**- Milliampere
- **mAh**- Milliampere hour
- **max** – Maximum
- **Mb** – Megabit
- **MB** – MegaByte
- **MCO** – Mission Control Officer
- **MCU** – Microprocessor Control Unit
- **MOM** – Mission Operations Manual
- **MHz** – MegaHertz
- **min**- Minute
- **mm** – Millimeter

Acronyms (2 of 2)

- **ms** – Millisecond
- **mV** – millivolt
- **mW**- MilliWatt
- **nA** – Nanoampere
- **P** - Air/Measured pressure
- **Pa** – Pascal
- **PCB** - Printed Circuit Board
- **PDIP** – Plastic Dual In-Line Package
- **PDR** – Preliminary Design Review
- **PFR-** Post Flight Review
- **Prev** – Previous
- **Pro** – Professional
- **PVC-** Polyvinyl Chloride
- **PWM** – Pulse Width Modulation
- **Po -** Pressure at sea level
- **R** - Specific gas constant dry air
- R_1 - Resistance 1
- R_2 - Resistance 2
- **Rad** – Radian
- **RAM** – Random Access Memory
- **RC** – Recovery Crew
- **RN** – Requirement Number
- **RPM** – Revolution per minute
- **RP-SMA** – Reverse Polarity SubMiniature Version A
- **RTC** – Real Time Clock
- **s** – Second
- **SD** – Secure Digital
- **SOIC**-Small Outline Integrated Circuit
- **SPI-** Serial Peripheral Interface
- **SSD-** Sensor Subsystem Design
- **T** – Test
- T - one periode time
- **Temp** - Temperature
- **UART** – Universal Asynchronous Receiver/ Transmitter
- **USB** – Universal Serial Bus
- **V** – Voltage
- V_{in} – Voltage Source
- V_{out} - Output Voltage
- **VM** – Verification Method
- **Wh** – Watt Hour
- **XAML** – Extensible Application Markup Language
- **XCTU** – Next Generation Configuration Platform for XBee/RF Solutions
- **% -** percent
- **.csv** - Comma-Seperated Values
- **°C** – Centigrade Degree
- **°-** Degree
- **µA** – microampere
- **µT-** microtesla
- ρ **-** Density of dry air

System Overview

Gizem Kübra YAMAN

Mission

CanSat is an auto-gyro controlled container that protects the electronic part and protects the payload.

Mission Objectives

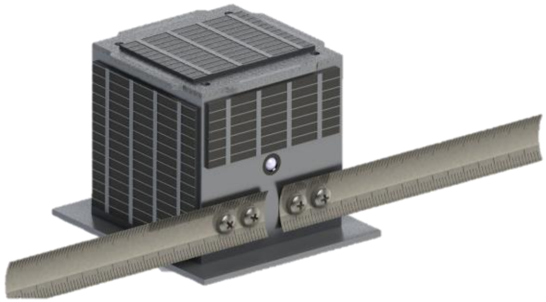
- CanSat consists of 2 parts: payload and container.
- Container protects the payload that will perform the desired mission.
- The launched CanSat will leave the rocket at an altitude of 670 to 725 m.
- CanSat will go down to 450 m with a speed of 20 m/s via the parachute .
- The container will be separated from the auto-gyro controlled payload after 450 m.
- The container will descent via parachute after separation.
- Auto-gyro's descent speed will be 10 to 15 m/s.
- The auto-gyro rotates passively during descent.
- When going under the control of payload auto-gyro, the payload will transmit telemetry, which will include air pressure, outside temperature, battery voltage, GPS position, pitch and roll, auto-gyro blade spin rate.
- After the landing, the payload will be stopped telemetry transmission and starts to give warning sound and light.

Bonus Objective

- The camera will be integrated into the payload. After released payload from the container (450 meters), the camera will start to record video.
- The camera shall point downward 45 degrees from nadir. It shall be spin stabilized and point in one direction relative to the earth’s magnetic field with stability of +/- 10 degrees.
- The video camera resolution will be at least 640x480 pixels and will be colored to 30 frames per second.

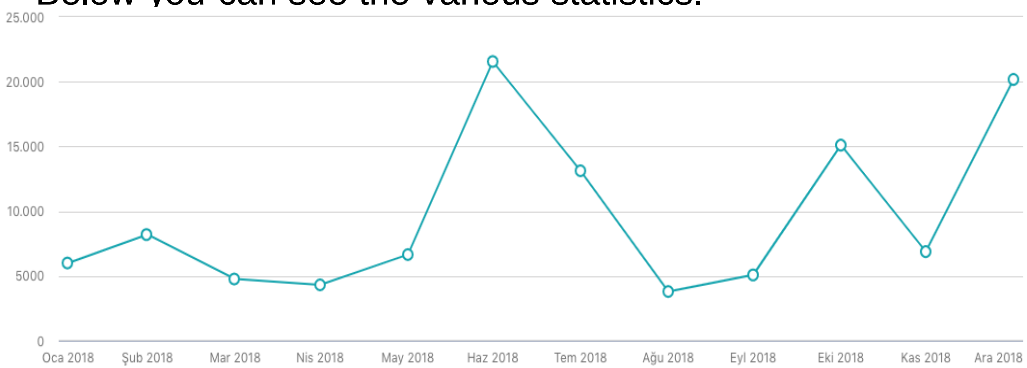
External Objective

- Our goal is to be among the top three in CanSat 2019.
- We have gained an acceptable experience with CanSat Competition and started a new national project to design and produce Turkey's first PocketQube satellite.
- PocketQube will be dimensions of the 5x5x5 cm.
- It will be placed in orbit at an altitude of about 500 km.
- PocketQube and CanSat internet address:
  https://x.grizu-263.space/
  https://grizu-263.space/cansat/



External Objective

- CanSat Competition being introduced in Turkey.
- After the second place we won, we took part in the national press and we made the promotion of the CanSat Competition.
- We reached hundreds of thousands of people on social media.
- Below you can see the various statistics.



LinkedIn Page Statics for 12 Months

Twitter Account Jun 2018 Statics

Our news (CanSat Competition 2018 results) on the most popular national channel CNN Türk.

Summary of Changes Since PDR

CONTAINER		
Mechanics	We changed container size.	
Electronics and Software	SD Card	We changed Sandisk Ultra SD card 4GB. We chose the Sandisk Ultra SD card 16GB.
PAYLOAD		
Mechanics	We changed payload size. We use the new hinges we produce from the 3D printer for the folding mechanism of the propellers. We use one PCB in the payload.	
Electronics and Software	Voltage Sensor	We changed Arduino Nano Analog Pin. We chose Teensy 3.6 with voltage divider method.
	Digital Compass	We used the digital compass sensor to understand the magnetic North of the camera.
	Microcontroller	The microcontroller used was replaced with Teensy 3.6
	RTC Module	The DS1307 RTC was removed, instead of Teensy 3.6 built-in RTC was used.
	SD Card Module	SD Card module removed. The Teensy 3.6 built-in SD card was used.
	SD Card	We changed Sandisk Ultra SD card 4GB. We chose the Sandisk Ultra SD card 16GB.

System Requirement Summary (1 of 5)

Requirement Number	Requirement	Rationale	Priority	VM			
				A	I	T	D
RN#1	Total mass of the CanSat (science payload and container) shall be 500 grams +/- 10 grams.	Competition Requirement	HIGH	√	√		√
RN#2	CanSat shall fit in a cylindrical envelope of 125 mm diameter x 310 mm length. Tolerances are to be included to facilitate container deployment from the rocket fairing.	Competition Requirement	HIGH		√	√	√
RN#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.	Competition Requirement	HIGH		√	√	
RN#4	The container shall be a fluorescent color; pink, red or orange.	Competition Requirement	MEDIUM		√		
RN#5	The rocket airframe shall not be used to restrain any deployable parts of the CanSat.	Competition Requirement	LOW		√		
RN#6	The rocket airframe shall not be used as part of the CanSat operations.	Competition Requirement	HIGH		√		
RN#7	The CanSat shall deploy from the rocket payload section and immediately deploy the container parachute.	Competition Requirement	HIGH		√	√	
RN#8	The descent rate of the CanSat (container and science payload) shall be 20 meters/second +/- 5m/s.	Competition Requirement	HIGH		√	√	√

System Requirement Summary (2 of 5)

Requirement Number	Requirement	Rationale	Priority	VM			
				A	I	T	D
RN#9	The container shall release the payload at 450 meters +/- 10 meters.	Competition Requirement	HIGH		√	√	√
RN#10	The science payload shall descend using an auto-gyro descent control system.	Competition Requirement	HIGH	√	√	√	√
RN#11	The descent rate of the science payload after being released from the container shall be 10 to 15 meters/second.	Competition Requirement	HIGH		√	√	
RN#16	All electronics shall be hard mounted using proper mounts such as standoffs, screws, or high performance adhesives.	Competition Requirement	MEDIUM	√	√		
RN#17	All mechanisms shall be capable of maintaining their configuration or states under all forces.	Competition Requirement	MEDIUM	√		√	
RN#19	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.	Competition Requirement	HIGH	√	√	√	
RN#20	The science payload shall measure altitude using an air pressure sensor.	Competition Requirement	HIGH	√		√	√
RN#21	The science payload shall provide position using GPS.	Competition Requirement	HIGH	√		√	√
RN#22	The science payload shall measure its battery voltage.	Competition Requirement	HIGH	√		√	√

System Requirement Summary (3 of 5)

Requirement Number	Requirement	Rationale	Priority	VM			
				A	I	T	D
RN#23	The science payload shall measure outside temperature.	Competition Requirement	HIGH	√		√	√
RN#24	The science payload shall measure the spin rate of the auto-gyro blades relative to the science vehicle.	Competition Requirement	HIGH	√		√	√
RN#25	The science payload shall measure pitch and roll.	Competition Requirement	HIGH		√		
RN#26	The probe shall transmit all sensor data in the telemetry.	Competition Requirement	HIGH	√	√	√	
RN#27	The Parachute shall be fluorescent Pink or Orange.	Competition Requirement	MEDIUM	√	√		
RN#34	Cost of the CanSat shall be under $1000. Ground support and analysis tools are not included in the cost.	Competition Requirement	LOW	√	√		
RN#35	Each team shall develop their own ground station.	Competition Requirement	HIGH	√	√	√	
RN#36	All telemetry shall be displayed in real time during descent.	Competition Requirement	MEDIUM		√	√	
RN#37	All telemetry shall be displayed in engineering units (meters, meters/sec, Celsius, etc.)	Competition Requirement	HIGH	√			√

System Requirement Summary (4 of 5)

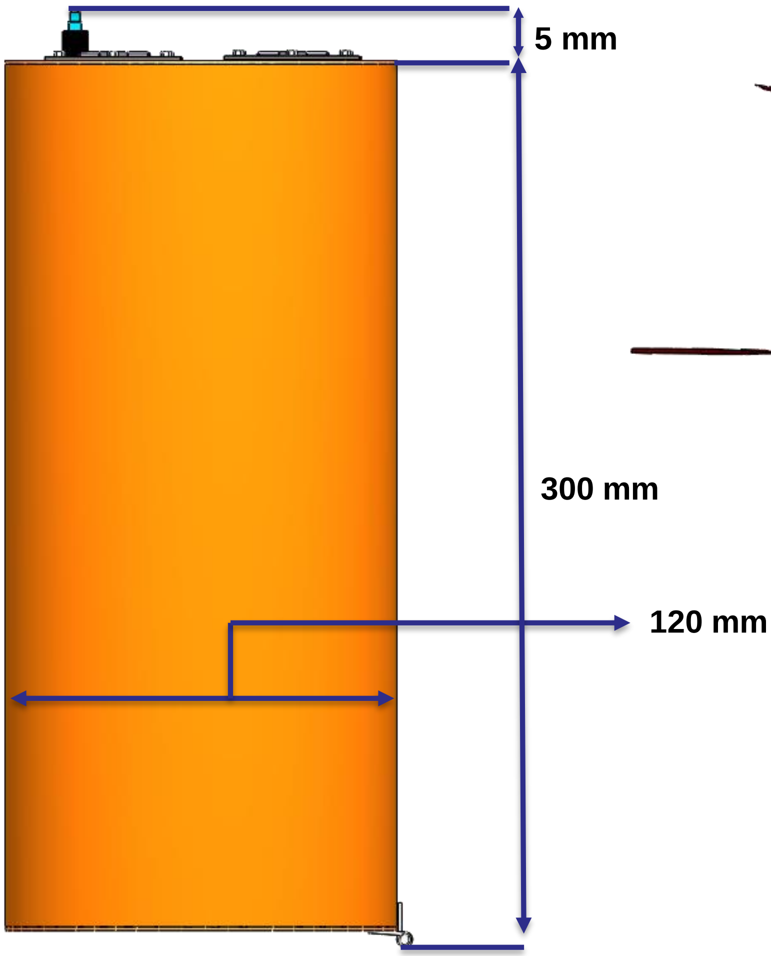
Requirement Number	Requirement	Rationale	Priority	VM A	VM I	VM T	VM D
RN#39	The ground station shall include one laptop computer with a minimum of two hours of battery operation, XBEE radio and a hand-held antenna.	Competition Requirement	HIGH	✓			✓
RN#41	Both the container and probe shall be labeled with team contact information including email address.	Competition Requirement	MEDIUM	✓	✓		
RN#44	No lasers allowed.	Competition Requirement	LOW	✓			
RN#45	The probe must include an easily accessible power switch that can be accessed without disassembling the cansat and in the stowed configuration.	Competition Requirement	MEDIUM	✓	✓	✓	
RN#46	The probe must include a power indicator such as an LED or sound generating device that can be easily seen without disassembling the cansat and in the stowed state.	Competition Requirement	MEDIUM	✓	✓	✓	
RN#47	An audio beacon is required for the probe. It may be powered after landing or operate continuously.	Competition Requirement	HIGH	✓		✓	
RN#48	The audio beacon must have a minimum sound pressure level of 92 dB, unobstructed.	Competition Requirement	HIGH	✓		✓	
RN#49	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.	Competition Requirement	HIGH	✓	✓		

System Requirement Summary (5 of 5)

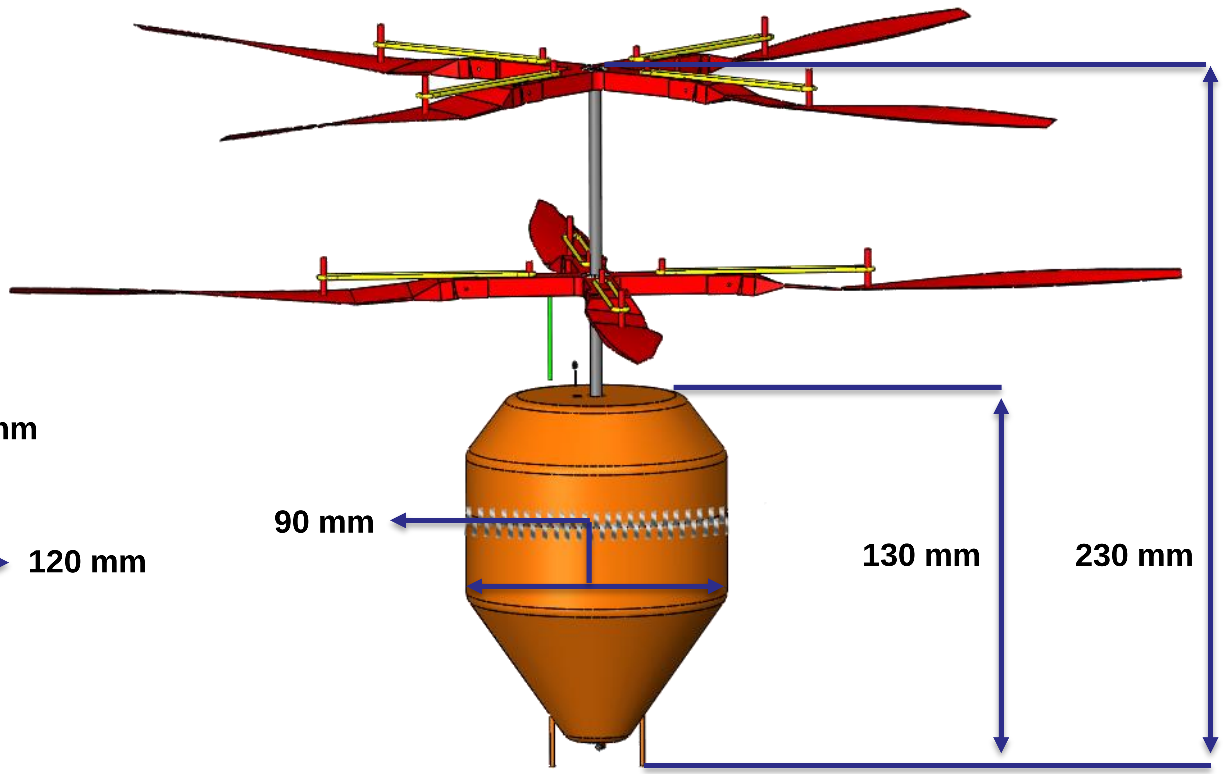
Requirement Number	Requirement	Rationale	Priority	VM			
				A	I	T	D
RN#50	An easily accessible battery compartment must be included allowing batteries to be installed or removed in less than a minute and not require a total disassembly of the CanSat.	Competition Requirement	HIGH	√	√		
RN#51	Spring contacts shall not be used for making electrical connections to batteries. Shock forces can cause momentary disconnects.	Competition Requirement	MEDIUM	√	√		
RN#52	The auto-gyro descent control shall not be motorized. It must passively rotate during descent.	Competition Requirement	HIGH	√		√	√
RN#55	Payload/Container shall operate for a minimum of two hours when integrated into rocket.	Competition Requirement	HIGH	√	√		
BONUS	A video camera shall be integrated into the science payload to record the descent after being released from the container. The camera shall point downward 45 degrees from nadir of the science payload. It shall point in one direction relative to the earth's magnetic field with a stability of +/- 10 degrees in all directions during descent. Direction does not matter as long as it is in one direction. The payload can pick the direction. Video shall be in color with a minimum resolution of 640x480 pixels and 30 frames per second. The direction the camera is pointed relative to earth's magnetic north shall be included in the telemetry.	To fulfill bonus objective	HIGH	√	√		

Payload Physical Layout (1 of 6)

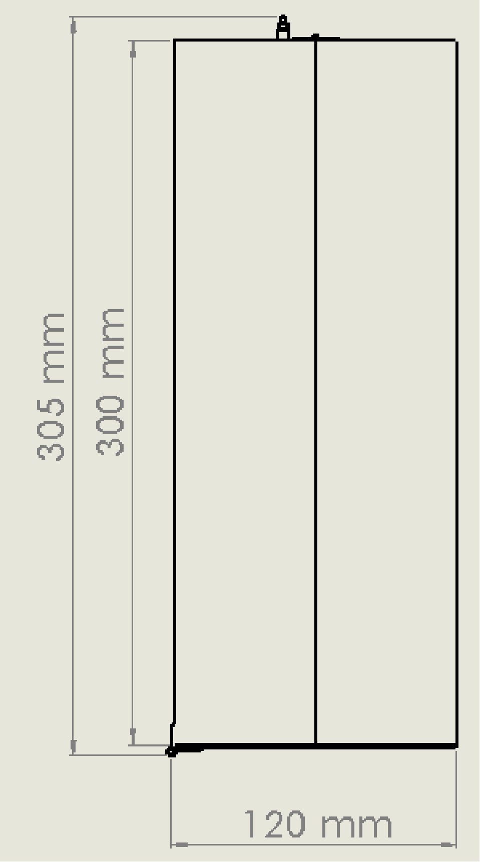
Container Dimensions



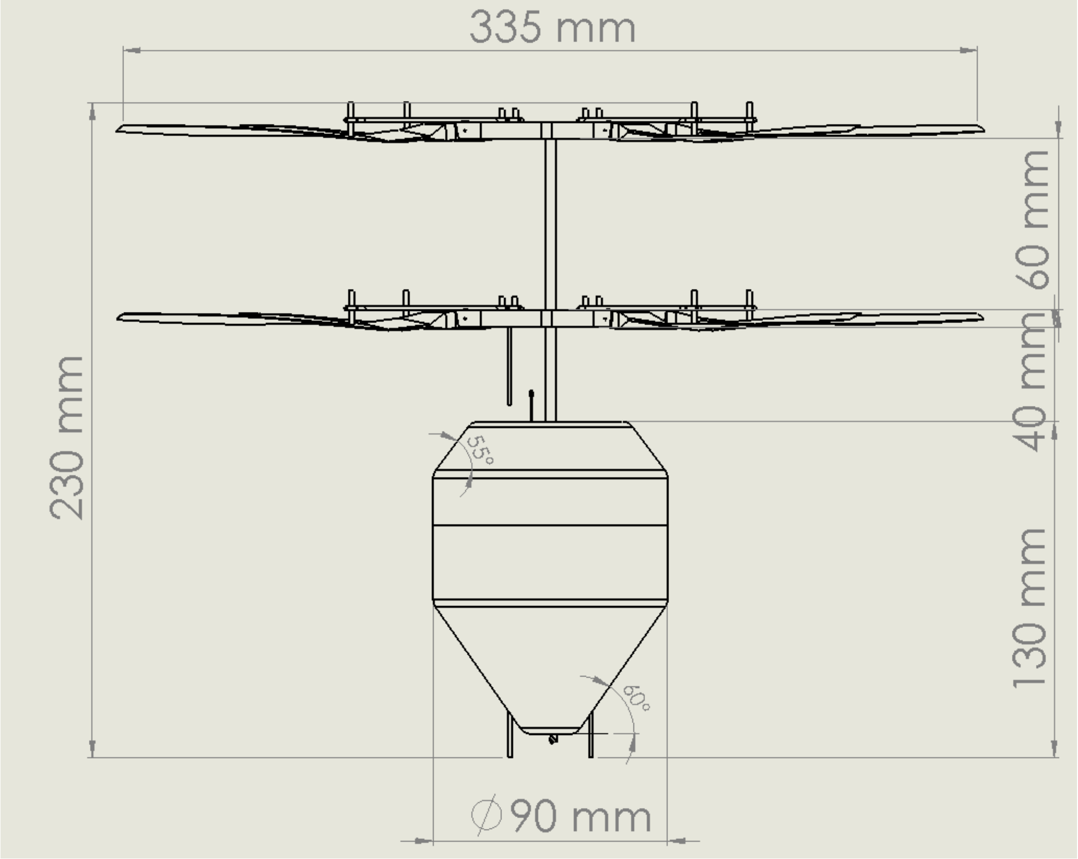
Payload Dimensions



Container Dimensions

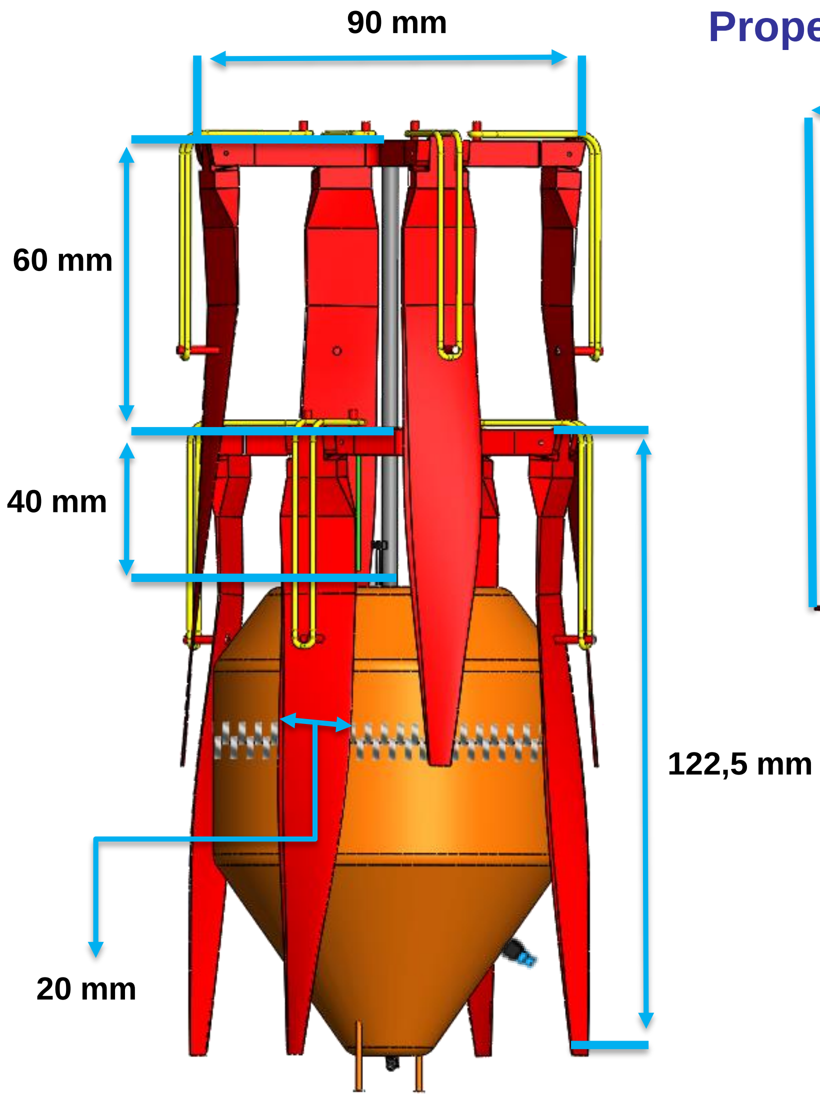


Payload Dimensions

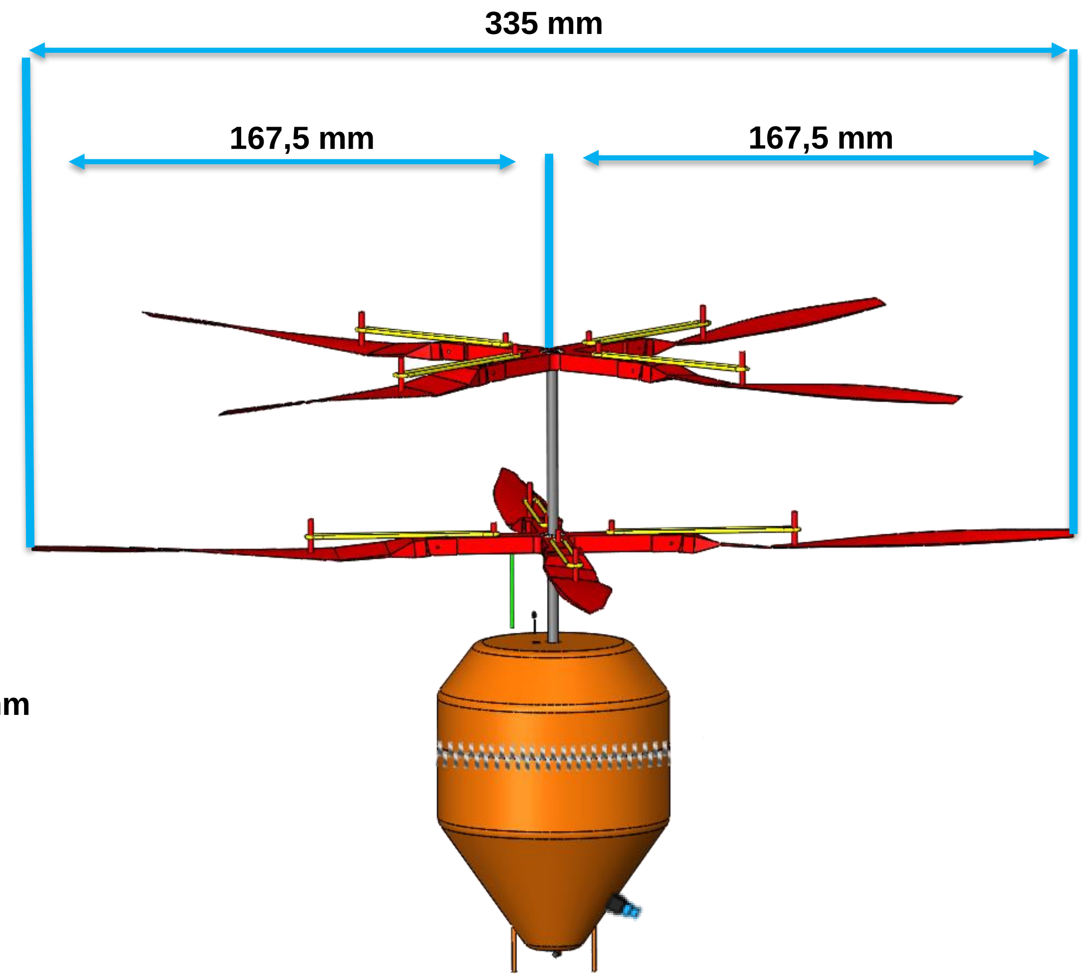


- **Container and payload technical drawings.**
- **Pictures were drawn with CAD program.**
- **All measurements are in mm.**

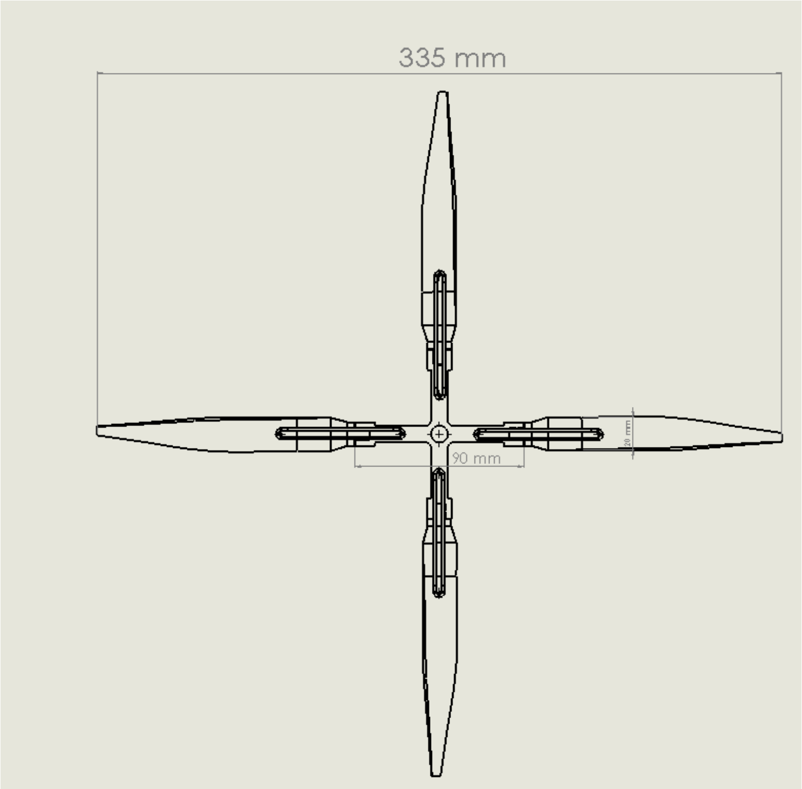
Payload Physical Layout (3 of 6)

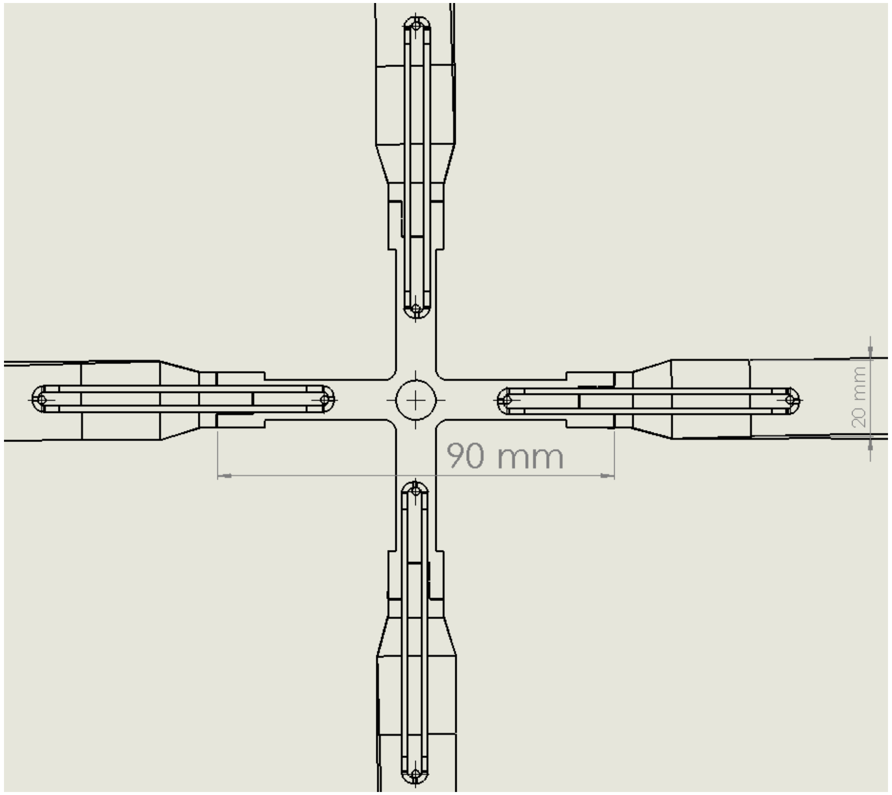


Propellers Dimensions



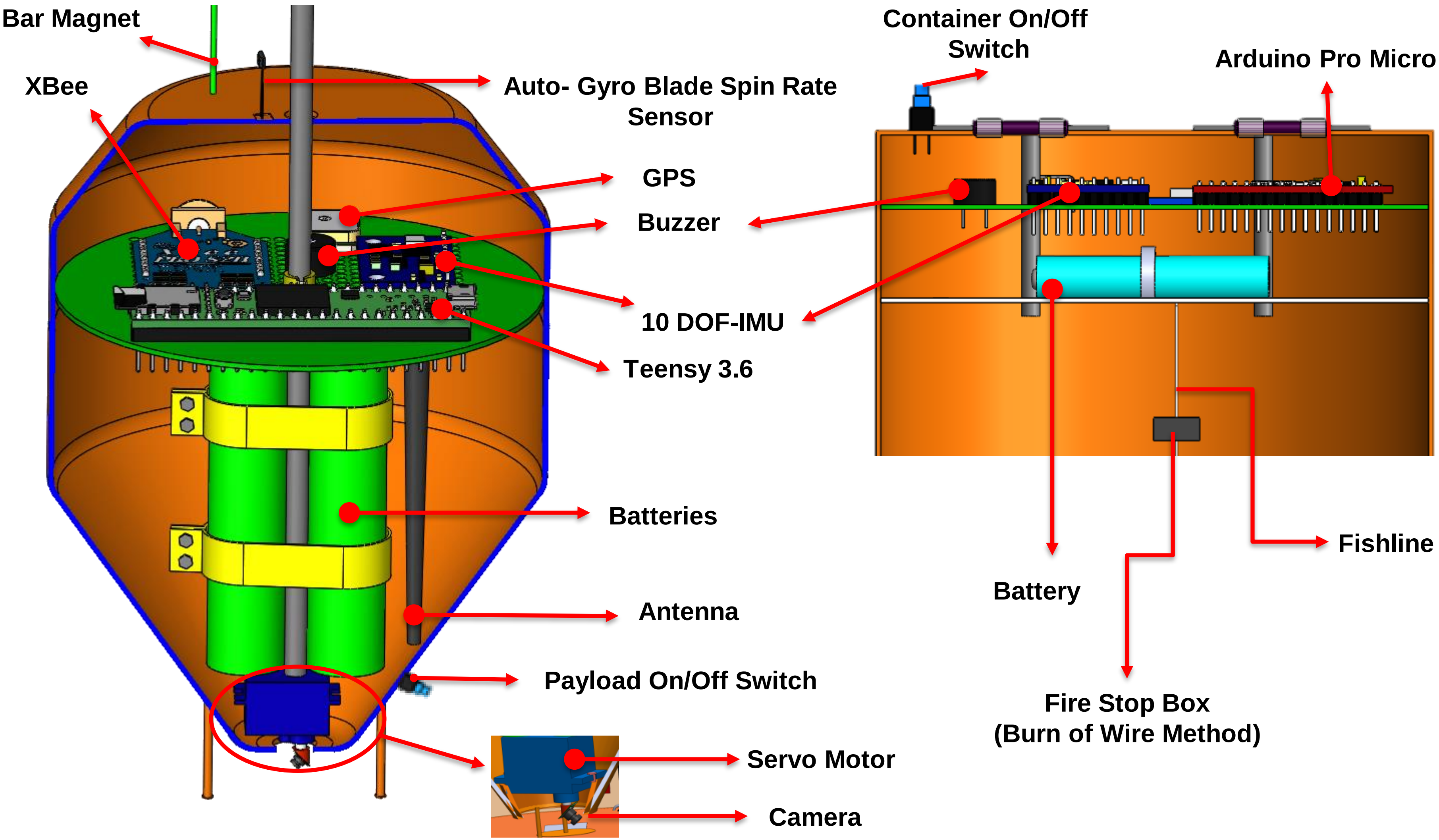
- **Propellers Dimensions**





- **Propellers technical drawings.**
- **Payload has two propellers.**
- **The propellers will be folded with the hinges.**
- **The propellers will be opened by stretched fabric elastic.**

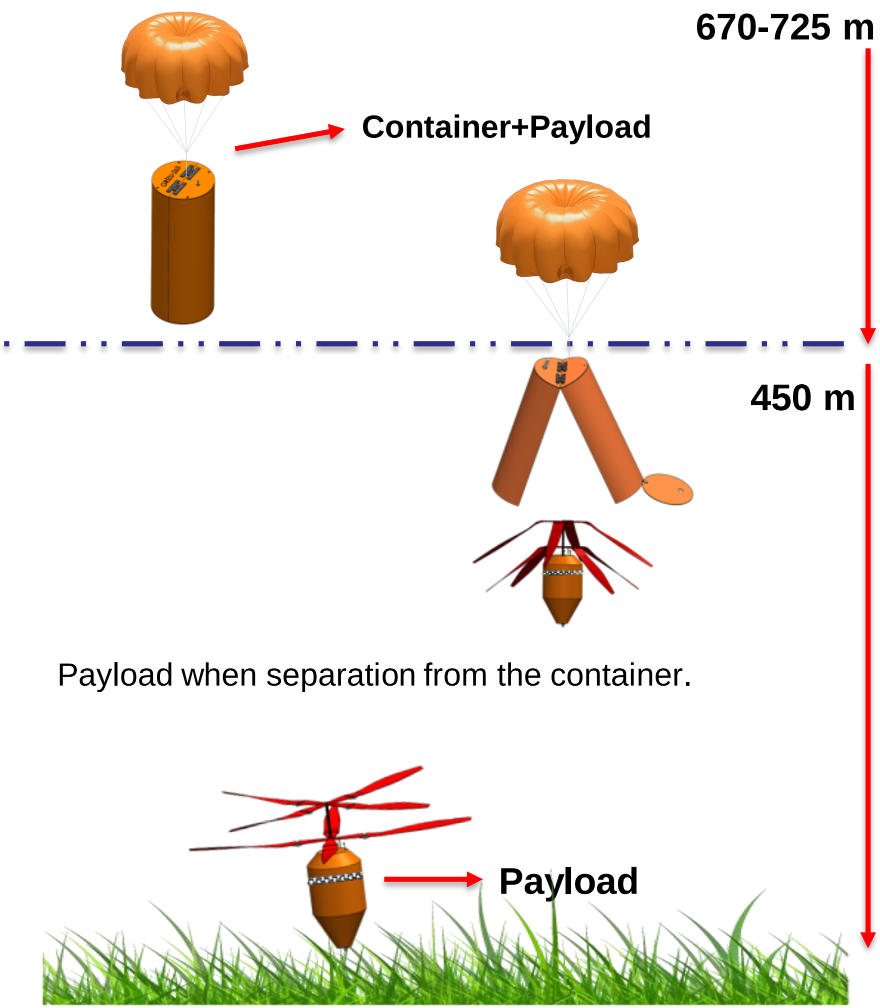
Placement of Major Components (Payload and Container)



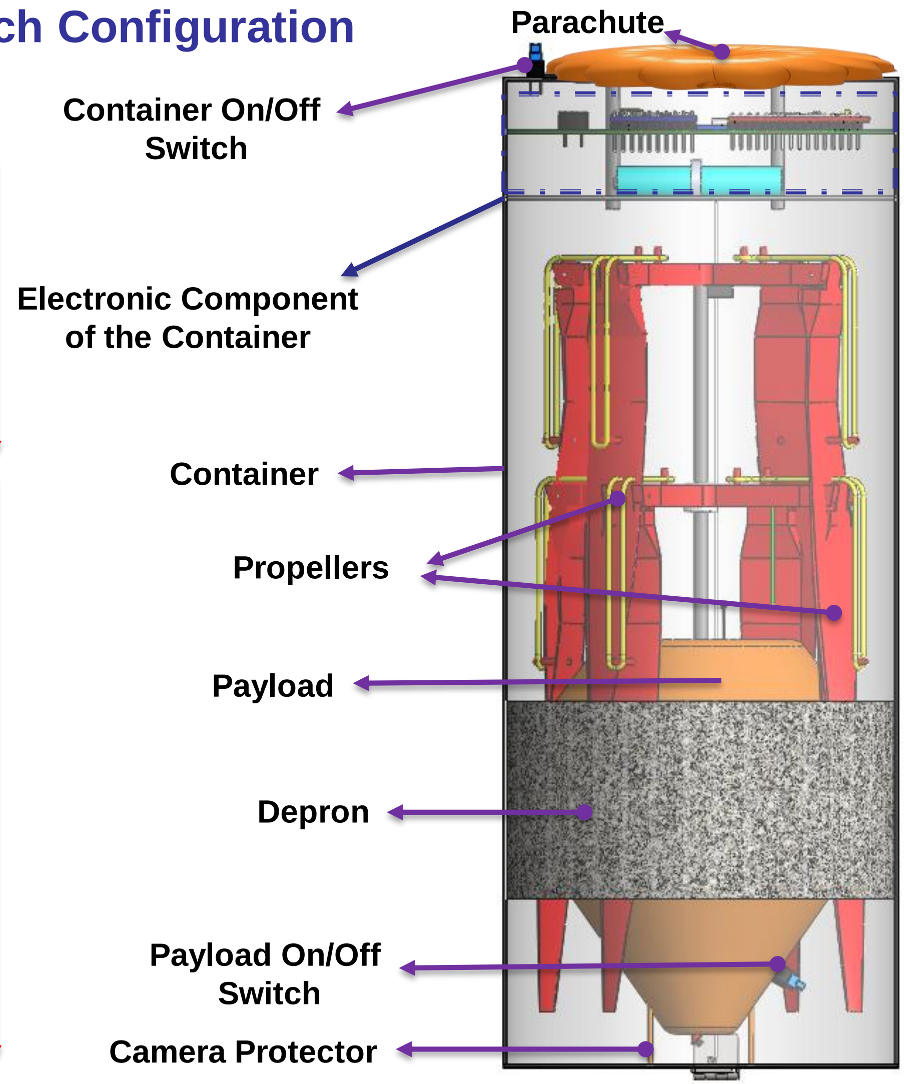
Payload Physical Layout (6 of 6)

Deployed and Launch Configuration

Immediately after the CanSat separation from the rocket.



Payload when separation from the container.



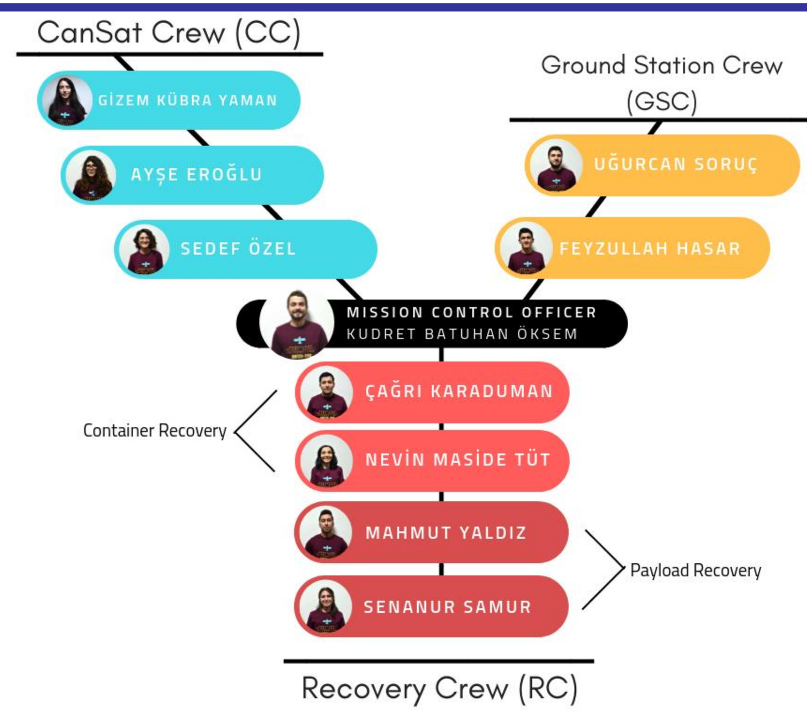
System Concept of Operations (1 of 3)

Pre - Launch Activities

- Arrival at the launch site.
- CanSat Assemble.
- Set-up ground station.

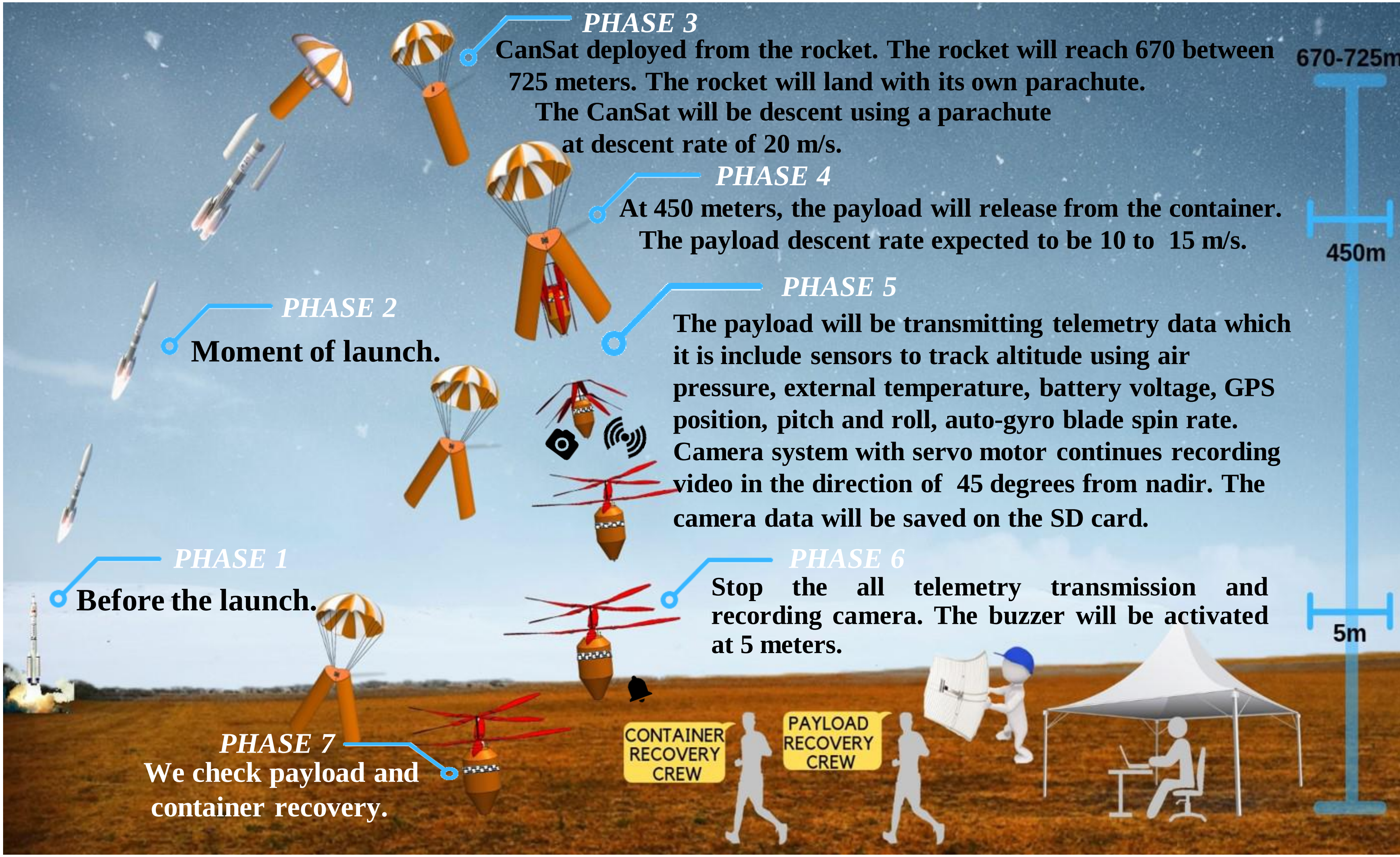
Launch Day Activities

- Communication verifies will be controlled between the ground station and payload.
- Weight and fit Check will be done by CC.
- CanSat’s will be inspected for safety.
- All mechanisms will be reviewed.
- The CanSat will be placed in the Rocket after the checklist was controlled by MCO.
- All flight operations will be checked by MCO.
- After the flight, the SD card will be delivered to the judge.



Mission Control Officer: Informs flight coordinator when the team and CanSat are ready for the flight.
Ground Station Crew: Those are responsible for monitoring the ground station for telemetry reception and sending commands to CanSat.
Recovery Crew: People who are looking for CanSat in the competition area.
CanSat Crew: Those who are preparing CanSat.

System Concept of Operations (2 of 3)



System Concept of Operations (3 of 3)

Pre-Launch

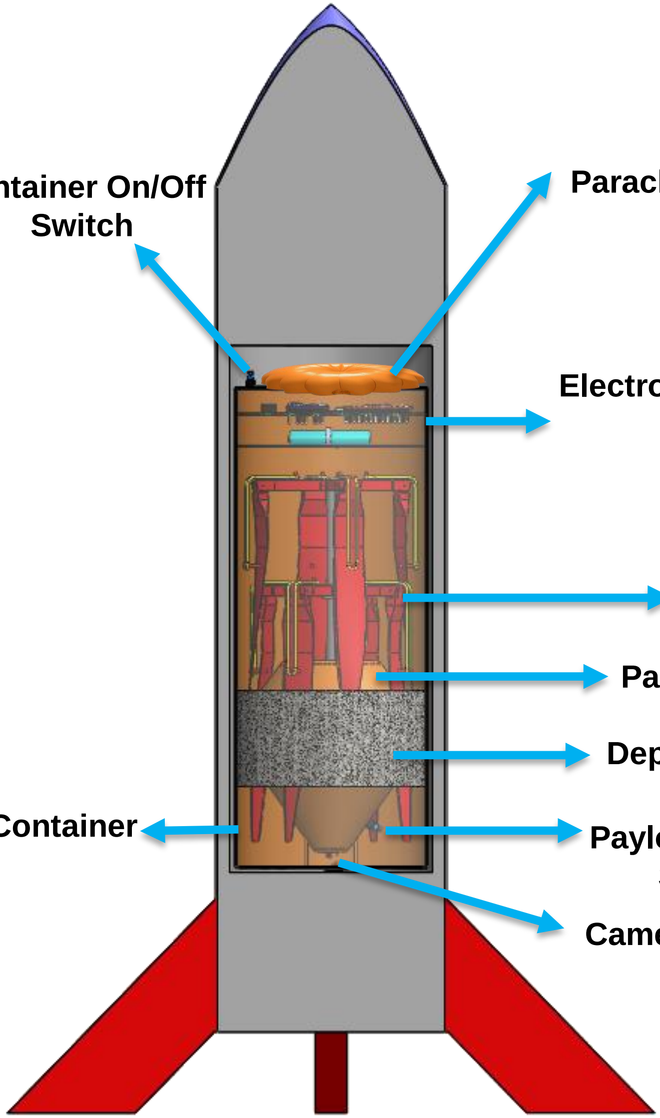
- Set-up ground station system.
- We will have a power bank for a cooling fan.
- The payload system will be calibrated with the command sent from the ground station.
- Communication tests.
- Check of mechanical systems.
- We will use an umbrella in the area.

Launch

- CanSat placed into the rocket.
- Rocket launch.
- The electronic system will start sending data.
- CanSat separated from the rocket (between 670-725 meters).
- The parachute will be opened.
- The speed up to 450 m is 20 m/s.
- The release of the payload at 450 m.
- The payload will descent passively with the propellers.
- The payload speed will be between 10 to 15 m/s.
- The camera starts to record video at 450 meters.
- The buzzer will be activated in 5 meters.
- Telemetry transmission will stop when buzzer starting.

Post-Launch

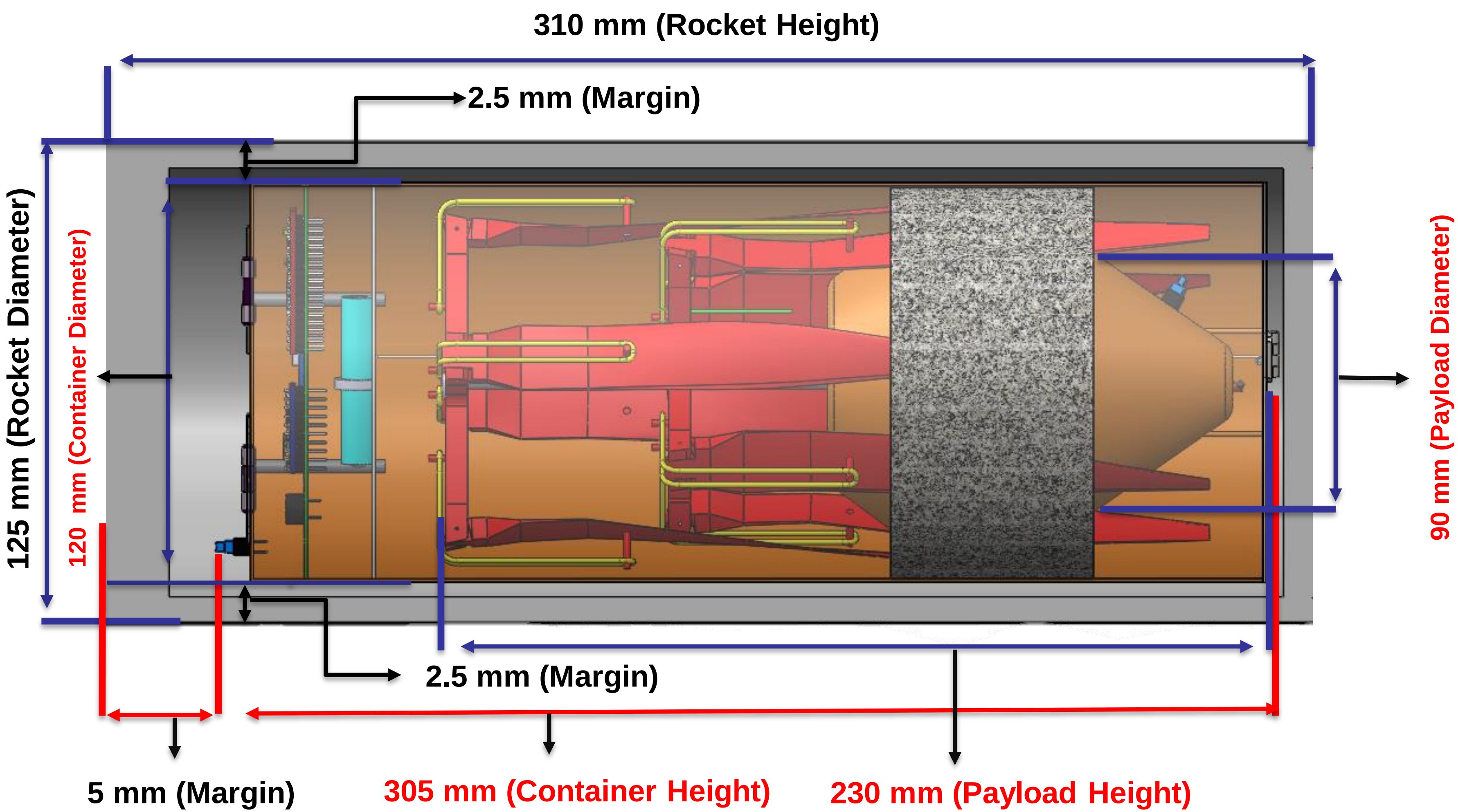
- The location of the payload will be find via GPS and buzzer.
- The location of the container will be find via buzzer.
- We will take the SD card from the payload and container.
- Take video recording.
- To analyze the data.
- Delivery of received data to the jury.
- Preparation for PFR.



Dimensions (mm) Section	Height (mm)	Diameter (mm)
Rocket (Requirement Dimensions)	310	125
CanSat	305	120
Payload	230	90

- The CanSat consists of 2 parts: The payload and the container.
- The container dimensions have been changed to prevent rocking inside the rocket.
- Margins of 5 mm are given for height and 5 mm for width.

Margins of 5 mm are given for height and 5 mm for width.



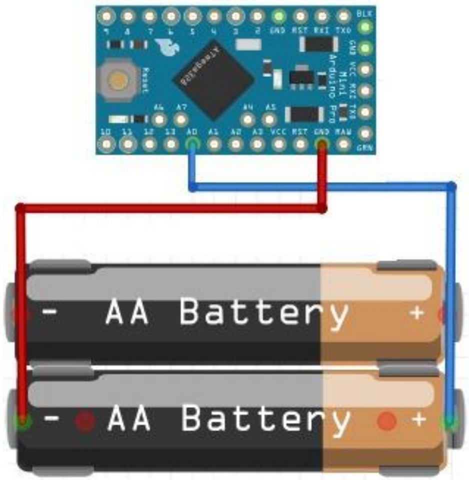
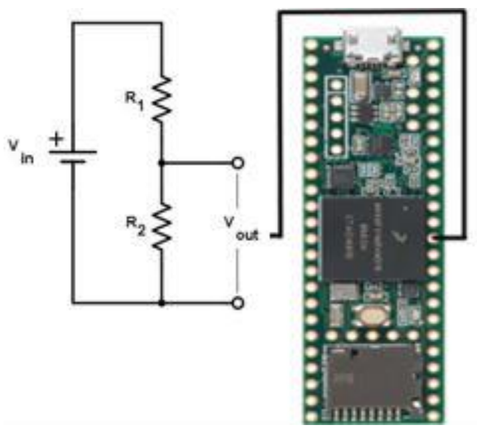
Sensor Subsystem Design

SEDEF ÖZEL

Sensor Subsystem Overview

NO	SENSOR TYPE	MODEL	PURPOSE	FUNCTION
1	Inertial Measurement Unit Sensor	BMP280 + MPU-9255	We will use this sensor because there are many sensors in it. BMP280 sensor will measure the temperature, pressure. MPU-9255 will be used as gyroscope, accelerometer ,and magnetometer.	To measure air pressure, air temperature, altitude and tilt.
2	GPS	NEO-7M	We will use NEO-7M to measure the longitude, latitude ,and altitude. The update rate of NEO-7M is higher and its power consumption is much less than other GPS sensors.	To measure location, altitude and satellite count data.
3	Voltage Measure	Teensy 3.6 Analog Pin	Instead of using a sensor, we used Teensy 3.6 to provide the voltage divider function. Because it is easy to use and more lucrative.	To measure of battery voltage.
4	Auto-gyro Blade Spin Rate	US1881 Hall Effect	The US1881 Hall Effect sensor will be used to qualify the blade spin rate of the propellers due to the magnetic field between the bar magnet and the hall effect sensor.	To measure of Auto-gyro blade spin rate.
5	Camera	SQ11	We will use this camera because it has a wide angle lens.	To record video.
6	Air Pressure Sensor (Container)	BMP280	We will use the BMP280 sensor inside the container to measure the air pressure.	To measure of air pressure.

Sensor Changes Since PDR

PDR	CDR	Rationale
Arduino Nano Analog Pin 	**Teensy 3.6 Analog Pin** 	• We changed Arduino Nano Analog Pin. Instead of we choose Teensy 3.6. • We used Teensy 3.6 to provide the voltage divider function. • Faster processing • More I/O pin

This sensor is not used in the PDR.	**HMC5883L Digital Compass**	NWe used the compass sensor to understand the magnetic North of the camera.

Sensor Subsystem Requirements (1 of 2)

Number	Requirement	Rationale	Priority	VM			
				A	I	D	T
RN#13	All electronic components shall be enclosed and shielded from the environment with the exception of sensors.	Competition requirement	HIGH	✓	✓		
RN#14	All structures shall be built to survive 15 Gs of launch acceleration.	Competition requirement	MEDIUM	✓			✓
RN#15	All structures shall be built to survive 30 Gs of shock.	Competition requirement	HIGH	✓			✓
RN#16	All electronics shall be hard mounted using proper mounts such as standoffs, screws, or high performance adhesives.	Competition requirement	HIGH	✓	✓		
RN#20	The science payload shall measure altitude using an air pressure sensor.	Competition requirement	HIGH	✓		✓	✓
RN#21	The science payload shall provide position using GPS.	Competition requirement	HIGH	✓		✓	✓

Sensor Subsystem Requirements (2 of 2)

Number	Requirement	Rationale	Priority	VM			
				A	I	D	T
RN#22	The science payload shall measure its battery voltage.	Competition requirement	HIGH	✔		✔	✔
RN#23	The science payload shall measure outside temperature.	Competition requirement	HIGH	✔		✔	✔
RN#24	The science payload shall measure the spin rate of the auto-gyro blades relative to the science vehicle.	Competition requirement	HIGH	✔		✔	✔
RN#25	The science payload shall measure pitch and roll.	Competition requirement	HIGH		✔		
SSR#1	Use of 10-DOF IMU	Less space on the PCB	MEDIUM	✔		✔	✔
SSR#2	When selecting a servo motor for the bonus mission, the servo motor must rotate continuous.	To stabilisation of camera	MEDIUM			✔	✔

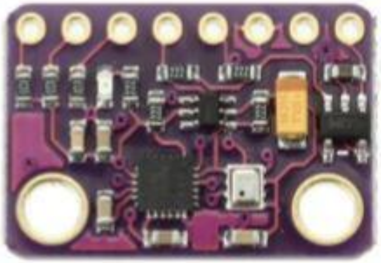
Payload Air Pressure Sensor Summary

Sensor Name	Interface	Pressure Range (hPa)	Size (mm)	Mass (g)	Accuracy (Pa)	Operating Voltage (V)	Operating Current (µA)	Data Format (bit)
BMP280	I2C,SPI	300 – 1100	2x2.5x0.9	2	0.16	1.71 – 5.5	325	20

WHY	• Small size • Included on the 10-DOF IMU board • Its low power consumption

$$p_0 = \frac{p}{\left(1 - \frac{altitude}{44330}\right)^{5.255}}$$

P: Measured Pressure (hPa)
Po: Pressure at sea level (hPa)



BMP280 TEST

```
Temperature = 29.26 *C
Pressure = 101010.36 Pa
Approx altitude = 26.23 m

Temperature = 29.26 *C
Pressure = 101009.17 Pa
Approx altitude = 26.33 m

Temperature = 29.26 *C
Pressure = 101010.17 Pa
Approx altitude = 26.25 m

Temperature = 29.26 *C
Pressure = 101007.51 Pa
Approx altitude = 26.47 m

Temperature = 29.26 *C
Pressure = 101008.52 Pa
Approx altitude = 26.38 m
```

Payload Air Temperature Sensor Summary

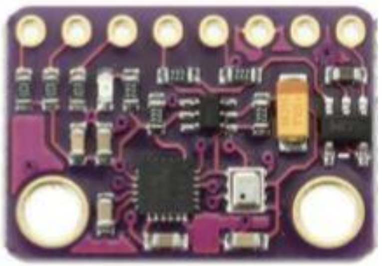
Sensor Name	Interface	Operating Temperature (°C)	Size (mm)	Mass (g)	Accuracy (°C)	Operating Voltage (V)	Operating Current (µA)	Data Format (bit)
BMP280	I2C,SPI	-40 ~ +85	2x2.5x0.9	2	0.01	1.71 – 5.5	325	20

WHY	
WHY	• Small size • Included on the 10-DOF IMU board

Correction Method: Temperature sensor will be calibrated by comparing taken data with the known temperature on ground station before the launch.

$$T = \frac{P}{R \; x \; \rho}$$

ρ = Density of dry air (kg/m^3)
P = Air pressure (Pa)
R = Specific gas constant dry air (287,05$\frac{J}{kg.K}$)
T = Temperature (K)



BMP280 TEST

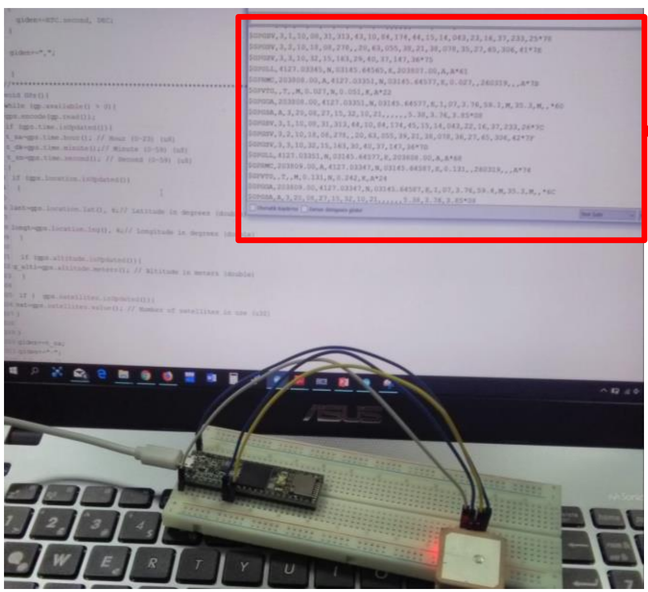
```
Temperature = 29.26 *C
Pressure = 101010.36 Pa
Approx altitude = 26.23 m

Temperature = 29.26 *C
Pressure = 101009.17 Pa
Approx altitude = 26.33 m

Temperature = 29.26 *C
Pressure = 101010.17 Pa
Approx altitude = 26.25 m

Temperature = 29.26 *C
Pressure = 101007.51 Pa
Approx altitude = 26.47 m

Temperature = 29.26 *C
Pressure = 101008.52 Pa
Approx altitude = 26.38 m
```

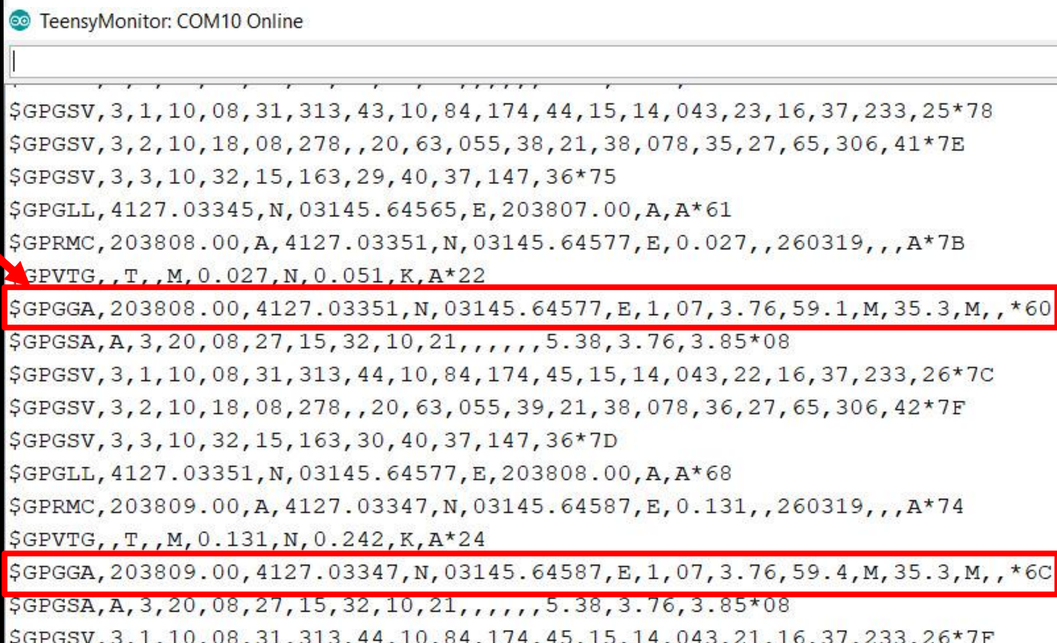
GPS Sensor Summary (1 of 2)

Sensor Name	Interface	Mass (g)	Operating Voltage (V)	Operating Current (mA)	Max Update Rate (Hz)	Horizontal Accuracy (m)	Channels	Data Format (bit)
NEO-7M	UART	16	3.2 - 5	40	10	2.5	56	8

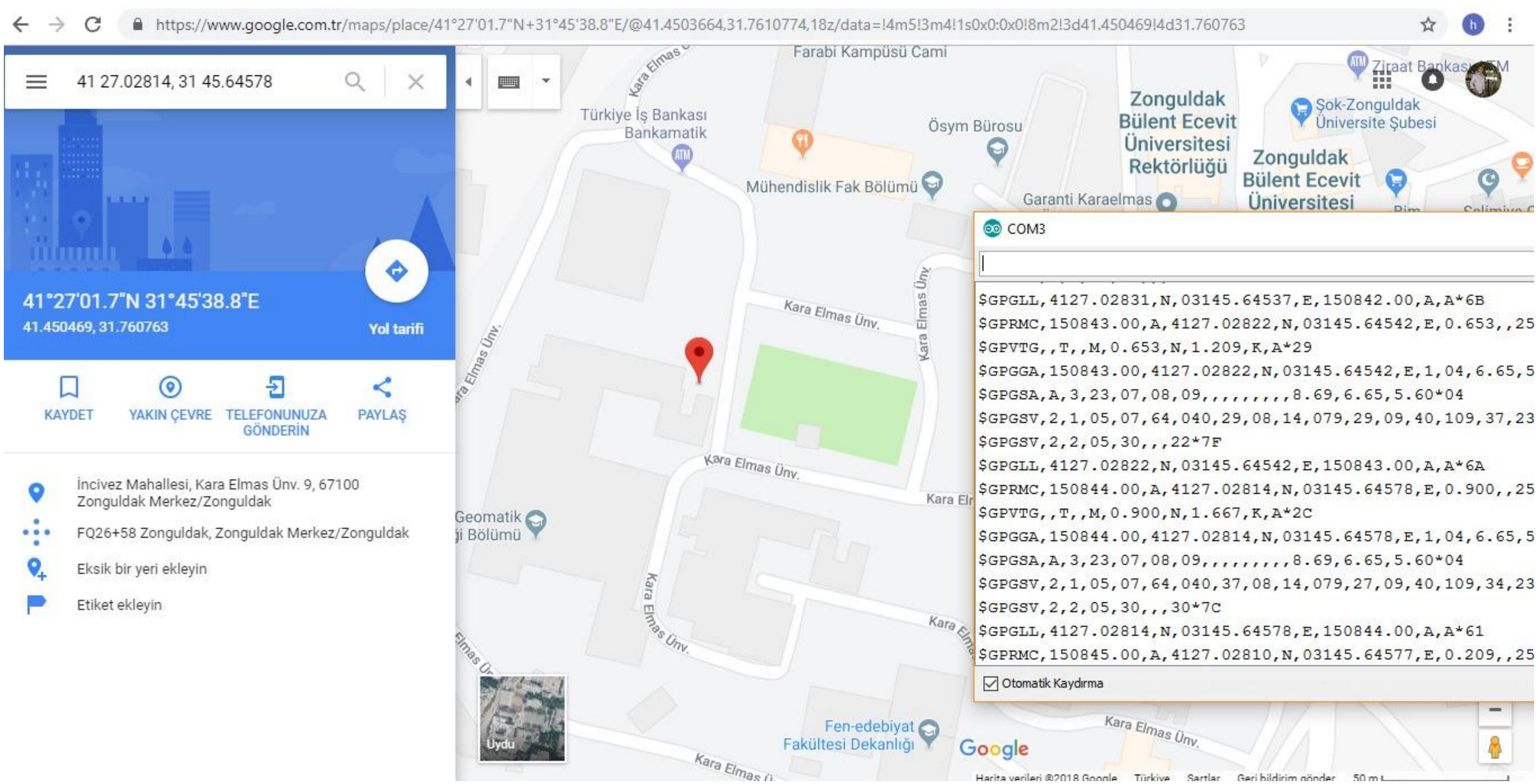
WHY	
WHY	• GPS update rate high • Power consumption is very low during tracking • Supports 56-channel GPS • Up to 10 Hz update rate

- The GPS receiver must use the NMEA 0183 GGA message format.





GPS Sensor Summary (2 of 2)

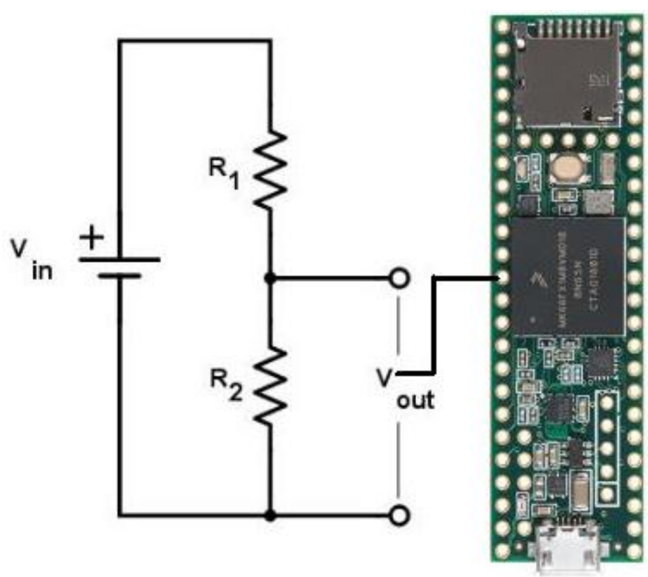


Coordinate calculations of GPS, are in degrees and decimal minutes (DMM). We entered this unit on Google Maps and found that our location is correct. When we look at the search part of Google Maps in the picture, we enter the degrees and decimal minutes (DMM) and the data itself is converted to degrees, minutes and seconds (DMS). So the numbers on that search box and the coordinate data from the GPS look different. They indicate the same place in two but their units are different.

Payload Voltage Sensor Summary

Sensor Name	Interface	Mass (g)	Measurement Voltage (V)	Accuracy (V)	Data Format
Teensy 3.6 Analog Pin	Analog	No extra space needed	0 - 25	0.01	Analog

WHY	• This method is simpler, lighter and smaller • Instead of using a sensor, the analog pin of the Teensy 3.6 will be used.



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

V_{in} = Voltage Source

V_{out} = Output Voltage

R_1 = Resistance 1

R_2 = Resistance 2

A voltage divider circuit is a very common circuit that takes a higher voltage and converts it to a lower one by using a pair of resistors. The formula for calculating the output voltage is based on Ohm's Law.

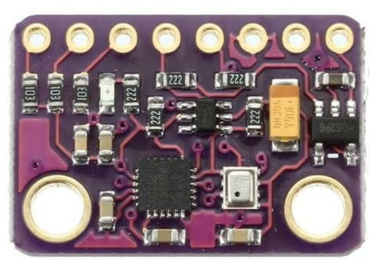
Pitch/Roll Sensor Summary

Sensor Name	Interface	Mass (g)	Operating Voltage (V)	Working Current (mA)	Accuracy	Magnetometer full-scale range (µT)	Data Format (bit)
MPU-9255	I2C,SPI	2	3.3 – 5.5	3.2	High (16-bit)	±4800	16

WHY	
	• Low working current • Included on the 10-DOF IMU board • 400 kHz Fast Mode I2C for communicate • 16-bit ADCs for digitizing the gyroscope, accelerometer and magnetometer outputs

The sensor data registers contain the latest gyroscope, accelerometer, magnetometer, auxiliary sensor. They are read-only registers and are accessed via the serial interface. Data from these registers may be read anytime.

X Magnetometer Data : 2 Bytes
Y Magnetometer Data : 2 Bytes
Z Magnetometer Data : 2 Bytes



MPU-9255 TEST

```
Pitch = -6.11 Roll = -4.42 Yaw = -1.81
Pitch = -6.74 Roll = -4.42 Yaw = -3.33
Pitch = -7.35 Roll = -4.42 Yaw = -4.58
Pitch = -7.77 Roll = -4.42 Yaw = -5.55
Pitch = -7.67 Roll = -4.07 Yaw = -6.42
Pitch = -7.25 Roll = -3.77 Yaw = -6.77
Pitch = -6.12 Roll = -3.61 Yaw = -6.94
Pitch = -5.86 Roll = -3.61 Yaw = -6.75
Pitch = -4.95 Roll = -4.81 Yaw = -6.18
Pitch = -4.42 Roll = -5.63 Yaw = -5.68
Pitch = -4.04 Roll = -6.51 Yaw = -5.06
Pitch = -3.69 Roll = -7.25 Yaw = -4.36
Pitch = -3.69 Roll = -7.25 Yaw = -4.09
Pitch = -4.90 Roll = -5.76 Yaw = -5.26
Pitch = -5.70 Roll = -5.17 Yaw = -6.21
Pitch = -6.10 Roll = -5.17 Yaw = -6.53
```

Equation:

$$(B_P - V)^T (B_P - V) = B^2$$

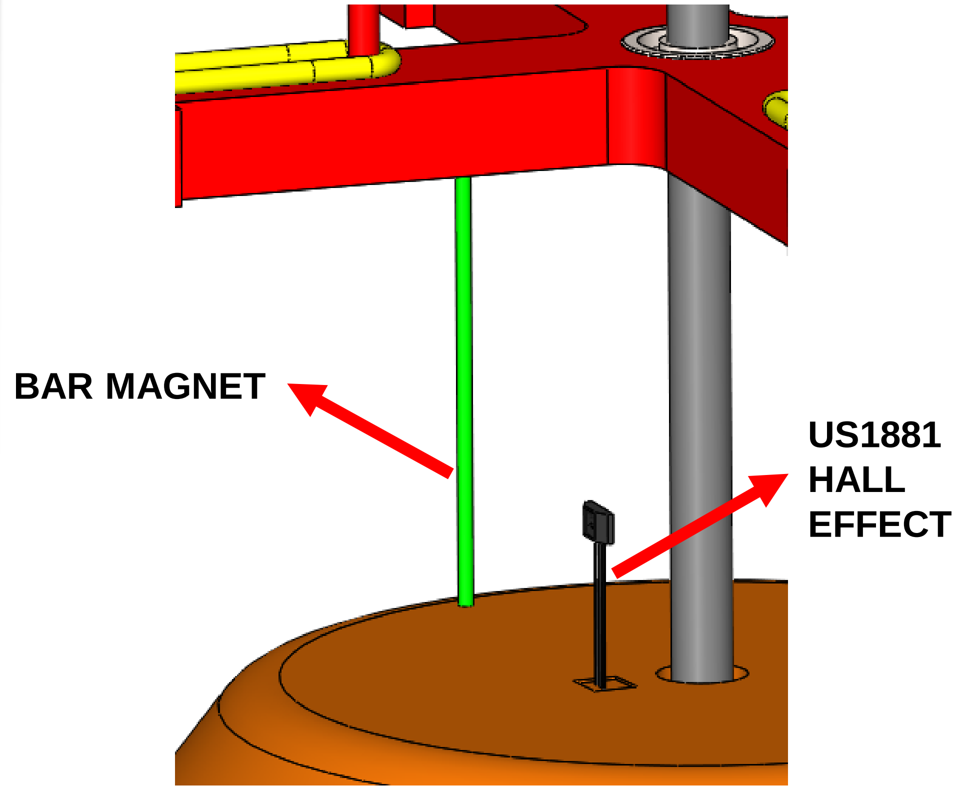
Auto-Gyro Blade Spin Rate Sensor Summary

Sensor Name	Interface	Mass (g)	Operating Voltage (V)	Typical Output Current (mA)	Accuracy (mV/G)	Data Format
US1881 Hall Effect	Analog	<1	2.7 - 5	5	2.5	Analog

WHY	• High stabilisation • Wide operating voltage range • High magnetic sensitivity • Low current consumption

$$\text{RPM} = \frac{1}{T} \times 60 \text{ (1/min)}$$

T = one periode time



Bonus Objective Camera Summary (1 of 3)

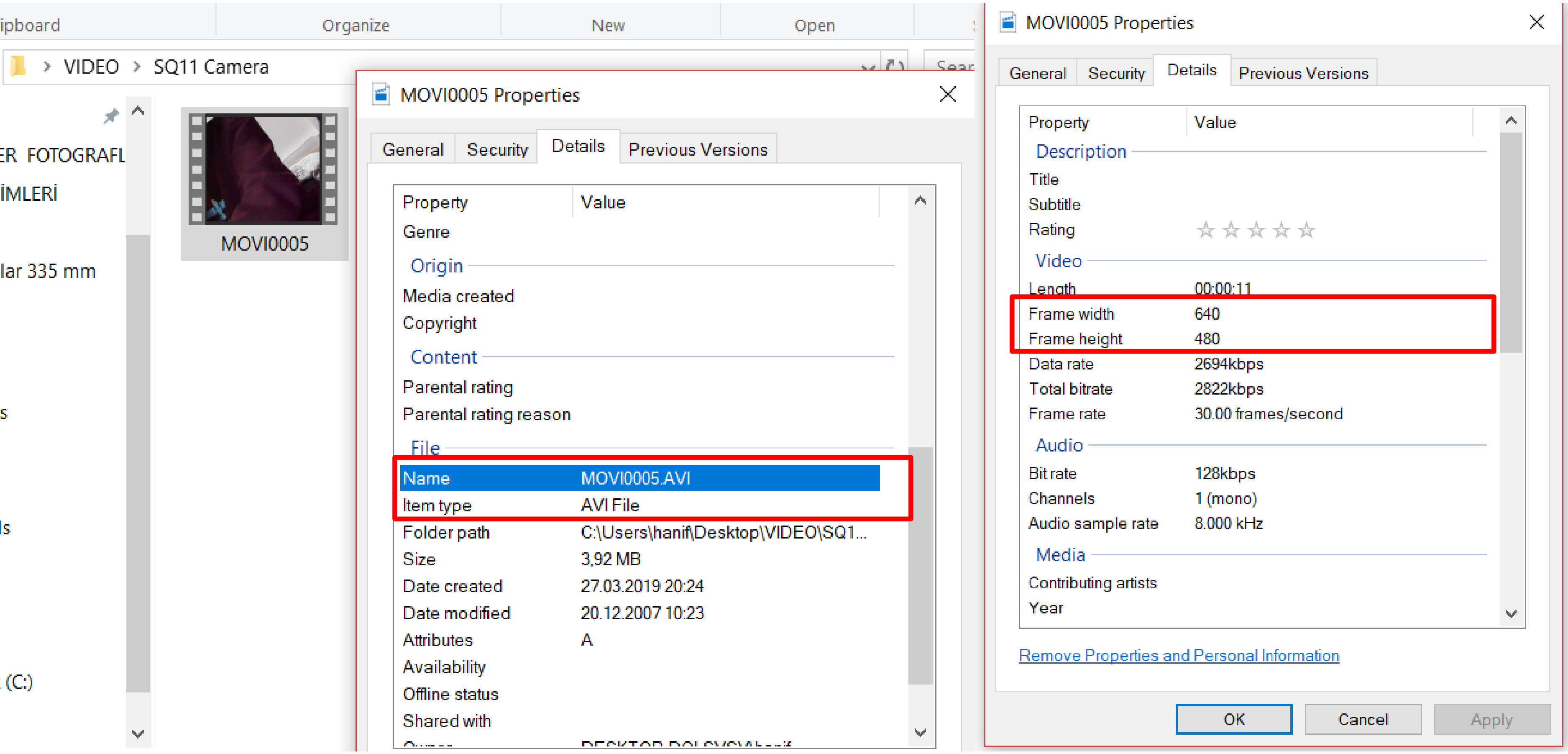
Sensor Name	Interface	Mass (g)	Operating Voltage (V)	Range of Vision (°)	Video Resolution (pixel)	Data Format
SQ11	Digital	4	5	3.2	640x480	Digital

WHY	
WHY	• Wide angle lens • Video file type: AVI • Video frame rate: 30 FPS • Easy to communicate with MCU

The camera will be controlled via switching by transistor circuit from the microcontroller. The camera itself has an internal SD card.
The camera will record video throughout the mission.

This image taken from SQ11.

Bonus Objective Camera Summary (2 of 3)



- This photo contains video file type, frame width and height information of the camera.
- We provided the requirements of the competition.

Bonus Objective Camera Summary (3 of 3)

Sensor Name	Interface	Operating Voltage (V)	Size (mm)	Maximum Output Rate (Hz)	Accuracy (°)	Data Format (bit)
HMC5883L Digital Compass	I2C	2.16 – 3.6	3.0x3.0x0.9	160	1 to 2	16

WHY	• The compass sensor is used to understand the earth's magnetic north direction of the camera.HMC5883L has a self-test feature to check if it is working correctly.

Sensor Name	Spin Rate (RPM)	Operating Voltage (V)	Work Angle (°)	Data Format
Feetech FS5106R Servo Motor	95	6	Continuous	Analog

WHY	• High spin rate the RPM • High work angle • Used the servo motor for camera stabilisation

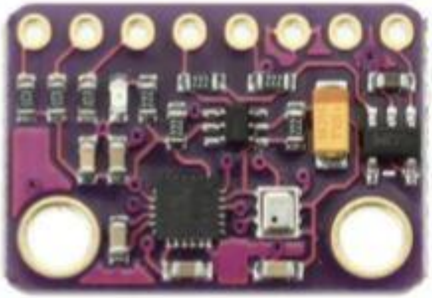
Container Air Pressure Sensor Summary

Sensor Name	Interface	Pressure Range (hPa)	Size (mm)	Mass (g)	Accuracy (Pa)	Operating Voltage (V)	Operating Current (µA)	Data Format (bit)
BMP280	I2C,SPI	300 – 1100	2x2.5x0.9	2	0.16	1.71 – 5.5	325	20

WHY	• Small size • Included on the 10-DOF IMU board • Its low power consumption

$$p_0 = \frac{p}{\left(1 - \frac{altitude}{44330}\right)^{5.255}}$$

P: Measured Pressure (hPa)
Po: Pressure at sea level (hPa)



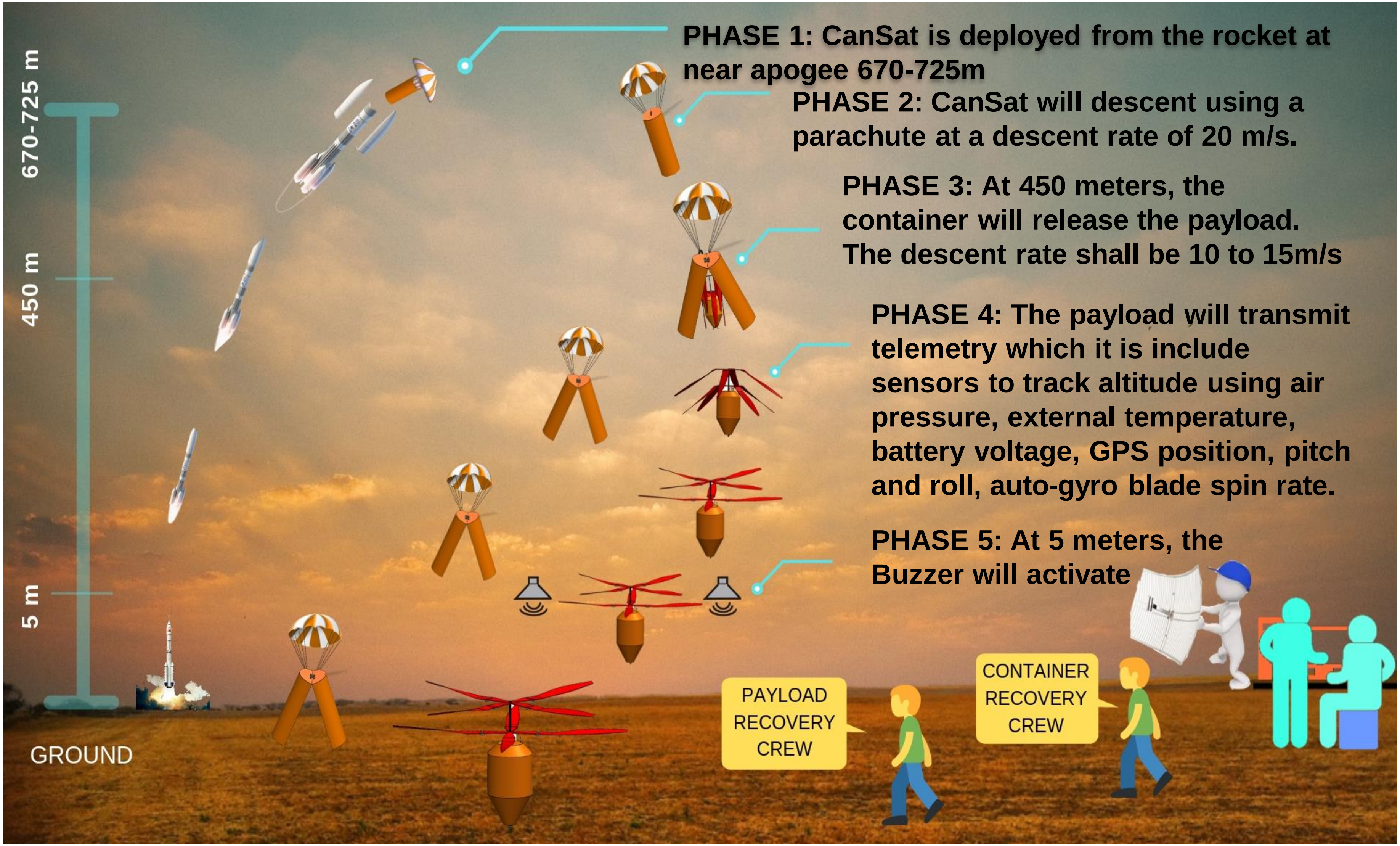
BMP280 TEST

```
Temperature = 29.26 *C
Pressure = 101010.36 Pa
Approx altitude = 26.23 m

Temperature = 29.26 *C
Pressure = 101009.17 Pa
Approx altitude = 26.33 m

Temperature = 29.26 *C
Pressure = 101010.17 Pa
Approx altitude = 26.25 m

Temperature = 29.26 *C
Pressure = 101007.51 Pa
Approx altitude = 26.47 m

Temperature = 29.26 *C
Pressure = 101008.52 Pa
Approx altitude = 26.38 m
```

Descent Control Design

Çağrı KARADUMAN

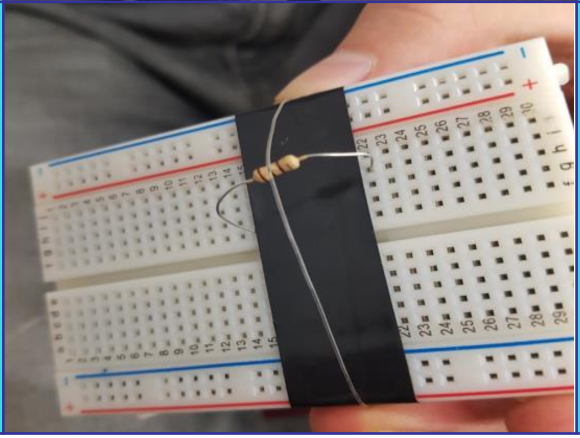
Descent Control Overview



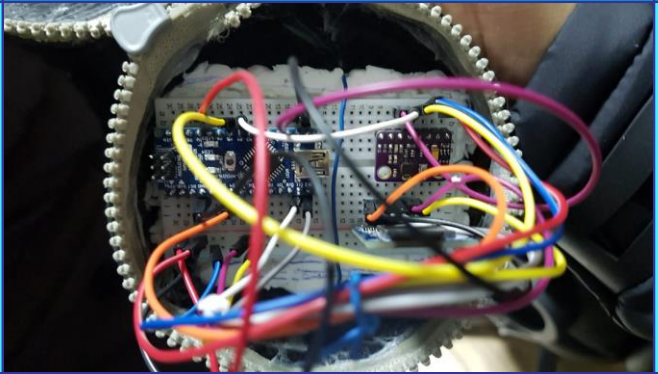
Descent Control Changes Since PDR (1 of 3)

- **No changes in descent control in CDR. Because everything was calculated correctly in PDR.**

Prototype testing

Test name		Procedure	Picture	Pass / Fail
1	Parachute descent test	• The CanSat (payload + container) released from 25 m. • The parachute opening mechanism tested. Completed landing at a speed of close to 20 m/s.		Pass
2	Payload burn wire separation mechanism test	• The wire pulls a current of 1.4A • The wire breaks in 1 second.		Pass

Prototype testing

	Test name	Procedure	Picture	Pass / Fail
3	The data transmission test	• The electronic circuits in the payload have heightened with the drone to the at 400 m. Then released from drone and data transmission tested.		Pass
4	The auto gyro passive descent control mechanism test	• Autogyro has Double propeller with 8 wings system. • Tested at 200 m altitude • Completed landing at a speed of close to 15m/s.		Pass

Descent Control Requirements (1 of 2)

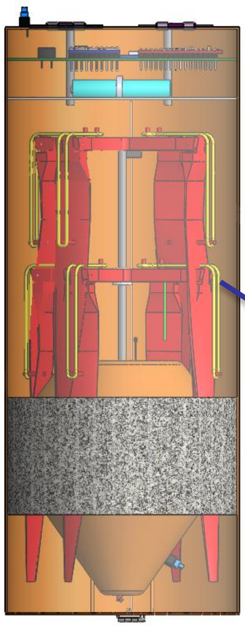
Number	Description	Rationale	Priority	VM			
				A	I	T	D
RN#1	Total mass of the CanSat (science payload and container) shall be 500 grams +/- 10 grams	Competition requirement	HIGH	✓	✓		✓
RN#2	CanSat shall fit in a cylindrical envelope of 125 mm diameter x 310 mm length. Tolerances are to be included to facilitate container deployment from the rocket fairing.	Competition requirement	HIGH		✓	✓	✓
RN#4	The container shall be a fluorescent color; pink, red or orange.	Competition requirement	MEDIUM		✓		
RN#5	The rocket airframe shall not be used to restrain any deployable parts of the CanSat.	Competition requirement	LOW		✓		
RN#6	The rocket airframe shall not be used as part of the CanSat operations	Competition requirement	HIGH		✓		
RN#7	The CanSat shall deploy from the rocket payload section and immediately deploy the container parachute.	Competition requirement	HIGH		✓	✓	
RN#8	The descent rate of the CanSat (container and science payload) shall be 20 meters/second +/- 5m/s.	Competition requirement	HIGH		✓	✓	✓

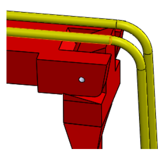
Descent Control Requirements (2 of 2)

Number	Description	Rationale	Priority	VM			
				A	I	T	D
RN#10	The science payload shall descend using an auto-gyro/ passive helicopter recovery descent control system.	Competition requirement	HIGH	✓	✓	✓	✓
RN#11	The descent rate of the science payload after being released from the container shall be 10 to 15 meters/second.	Competition requirement	HIGH		✓	✓	
RN#12	All descent control device attachment components shall survive 30 Gs of shock.	Competition requirement	HIGH	✓	✓		
RN#24	The science payload shall measure the spin rate of the auto-gyro blades relative to the science vehicle.	Competition requirement	HIGH	✓		✓	✓
RN#27	The Parachute shall be fluorescent Pink or Orange.	Competition requirement	LOW	✓	✓		
RN#34	Cost of the CanSat shall be under $1000. Ground support and analysis tools are not included in the cost.	Competition requirement	MEDIUM	✓	✓		
RN#52	The auto-gyro descent control shall not be motorized. It must passively rotate during descent.	Competition requirement	HIGH	✓		✓	✓

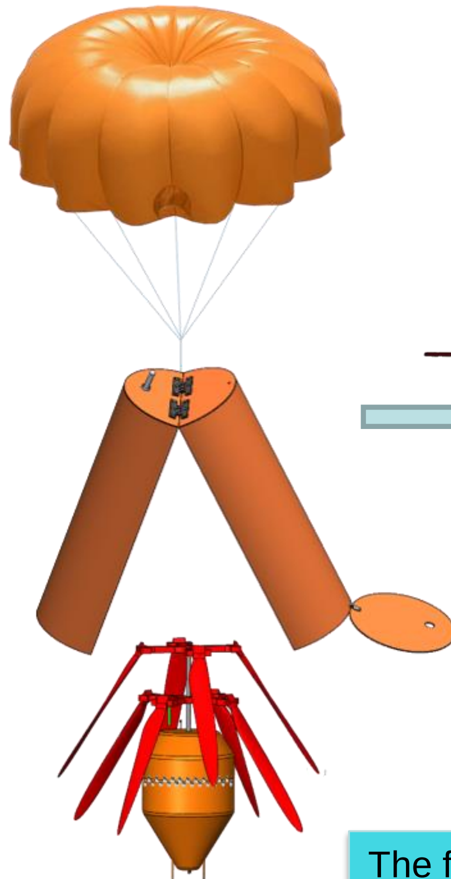
Payload Descent Control Hardware Summary (1 of 2)

Before Payload Deployment

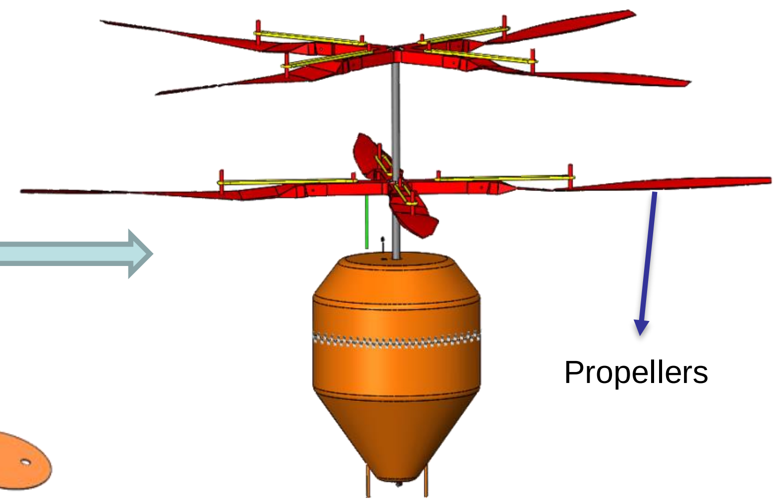




Foldable Propellers

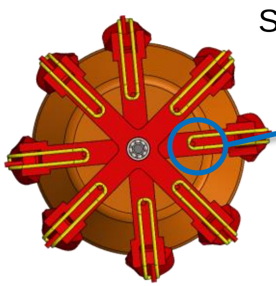


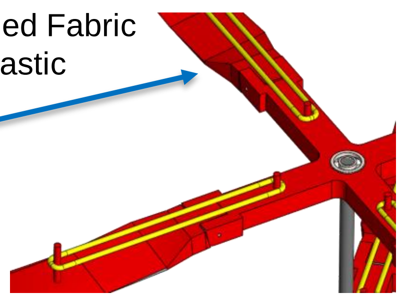
After Payload Deployment



Propellers

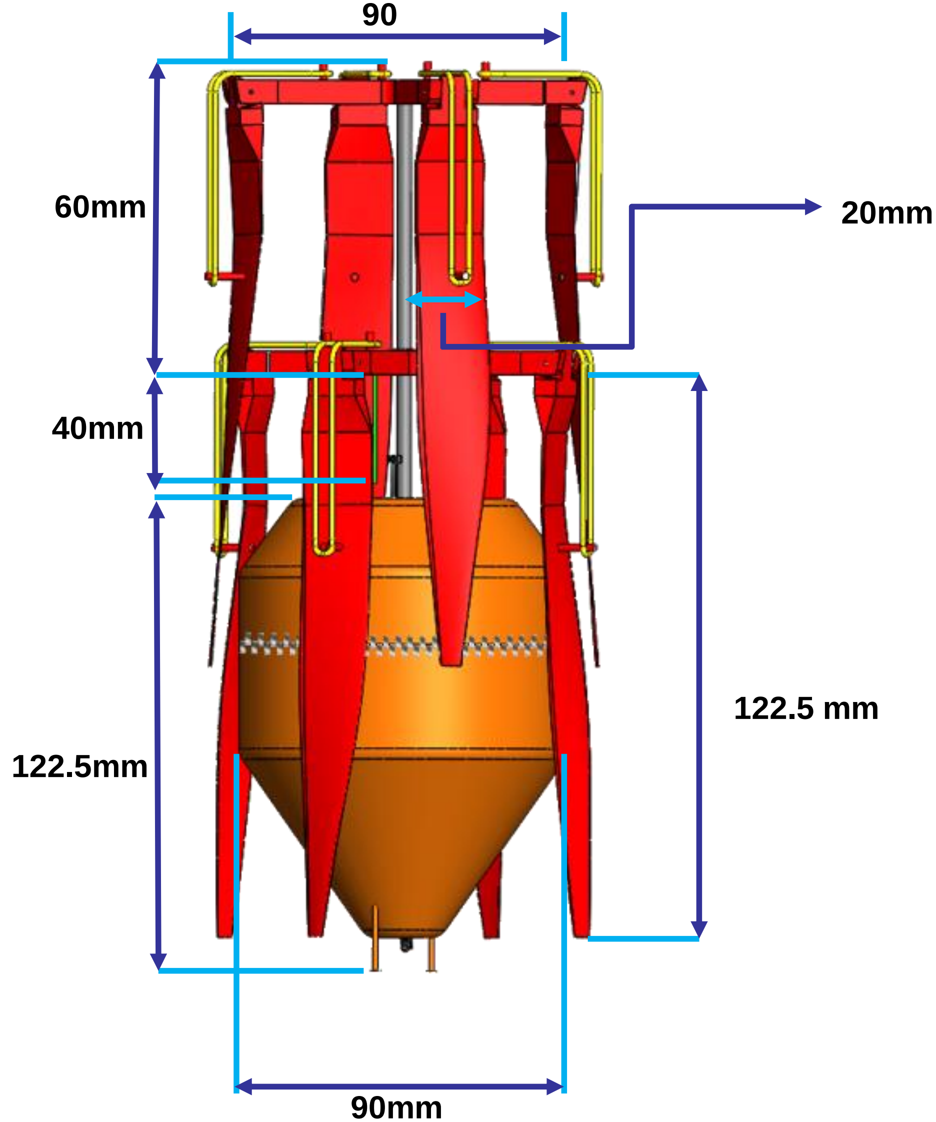
Stretched Fabric Elastic





The fabric elastic stretched propellers folded help by the hinge and placed in the container .The auto-gyro system will be opened with the tensile force of the fabric elastic.

Payload Descent Control Hardware Summary (2 of 2)



- **Key design considerations:**

-Heavy parts such as batteries end electronic components were mounted as close to the nose as possible to attract the center of gravity to the nose.

-Center of gravity positioning as passive control was used.

-Two propellers rotate in the opposite direction will be used that prevent Rolling and provide descent stability control.

- **Color selection(s):**

-Propellers color is red.

-Payload body color is orange.

- **For active components:**

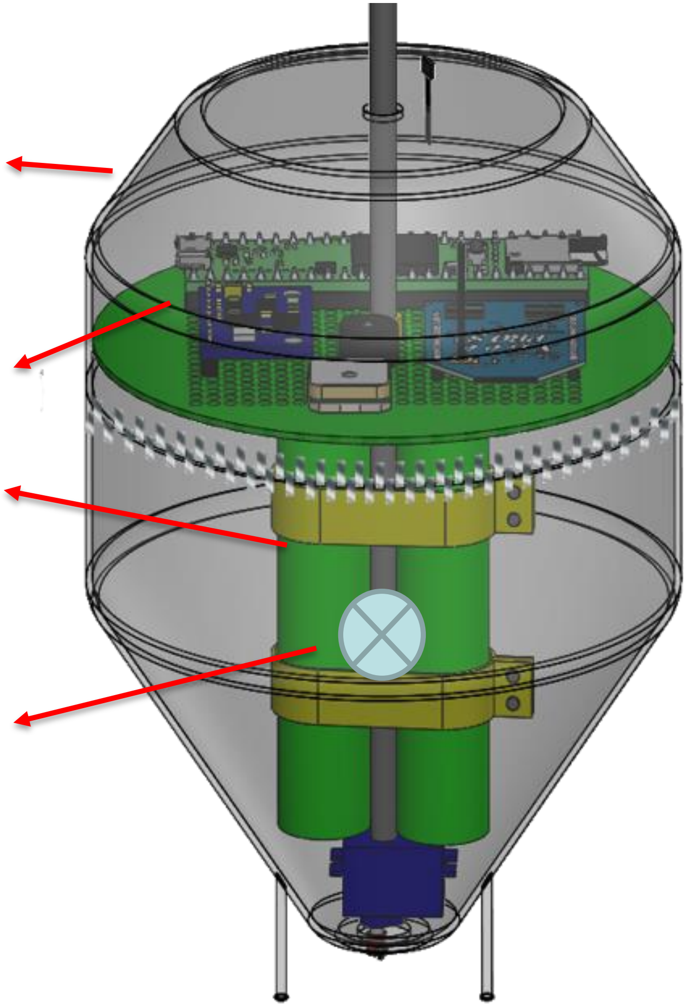
-No active components are used in payload descent control.

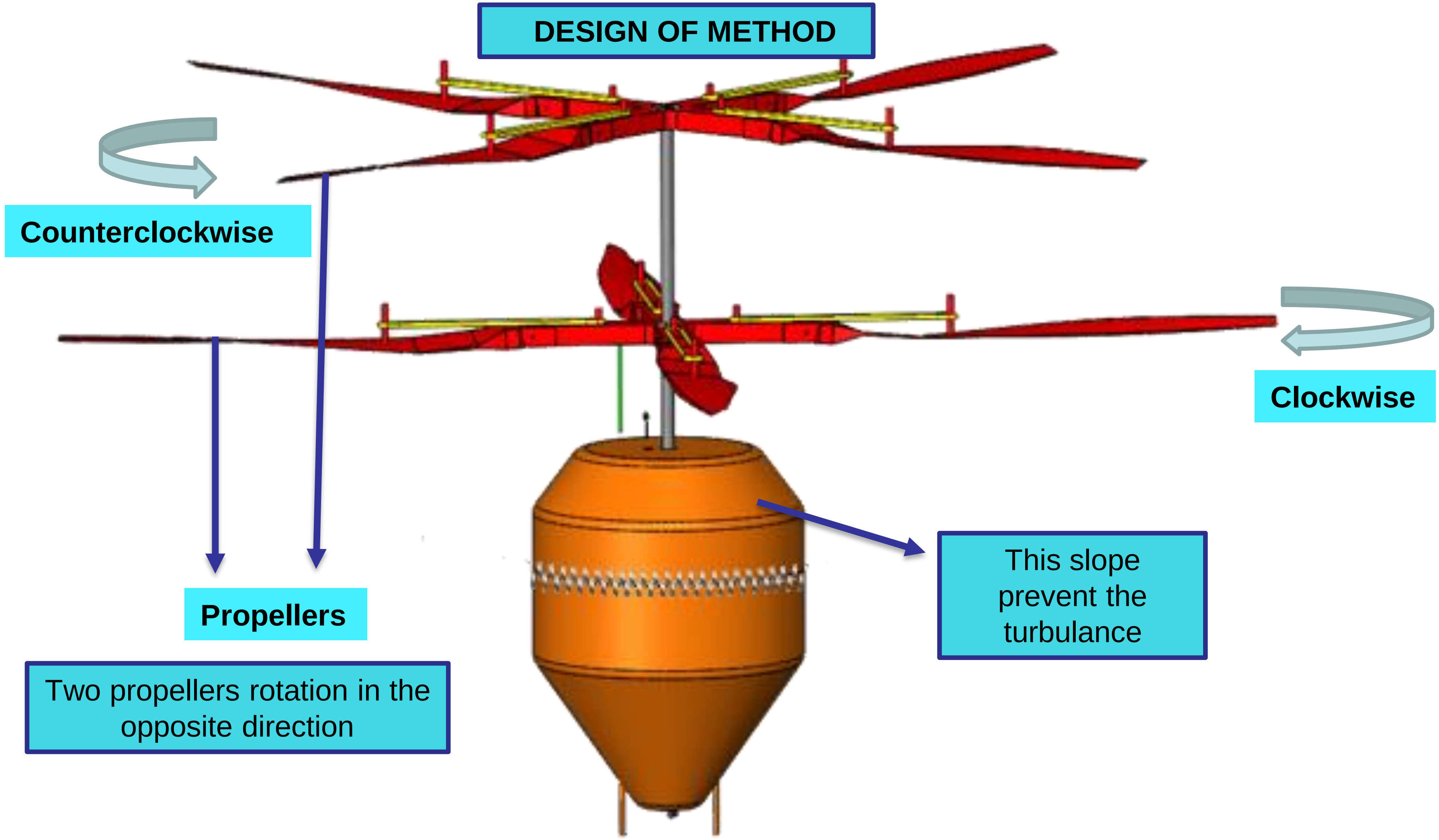
- It will be controlled passively not any motorized mechanism used. Autogyro payload provide it.
- Reversely rotating propellers obtain the moment balance.The use of two propellers has reduced the velocity of descent.
- Reverse rotating propellers protect to payload descent stability so that, its keep from tumbling.Passive control is provided via the position of the center of mass.
- The heavy parts such as batteries electronic circuits were mounted as close to the bottom as possible to attract the gravity center. Nadir direction is provided like that.

The payload has slope to prevent the turbulence.

Battery and electronic circuit

Center of mass position




DESIGN OF METHOD
Counterclockwise
Clockwise
Propellers
Two propellers rotation in the opposite direction
This slope prevent the turbulance

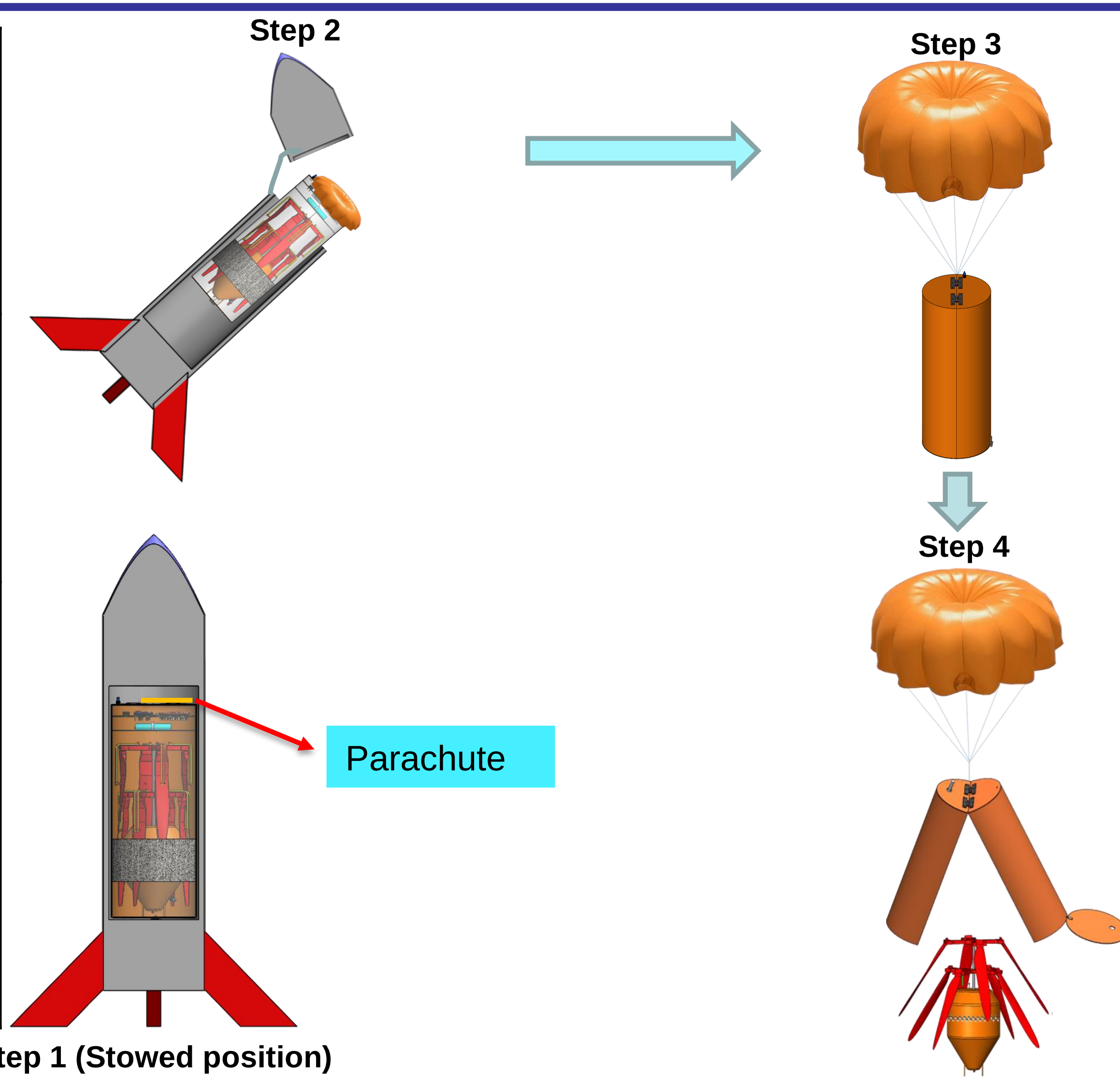
Container Descent Control Hardware Summary (1 of 3)

Step 1 (Stowed position)
The payload is placed in the container, the parachute is attached to the container by ropes, folded over and placed on the container.

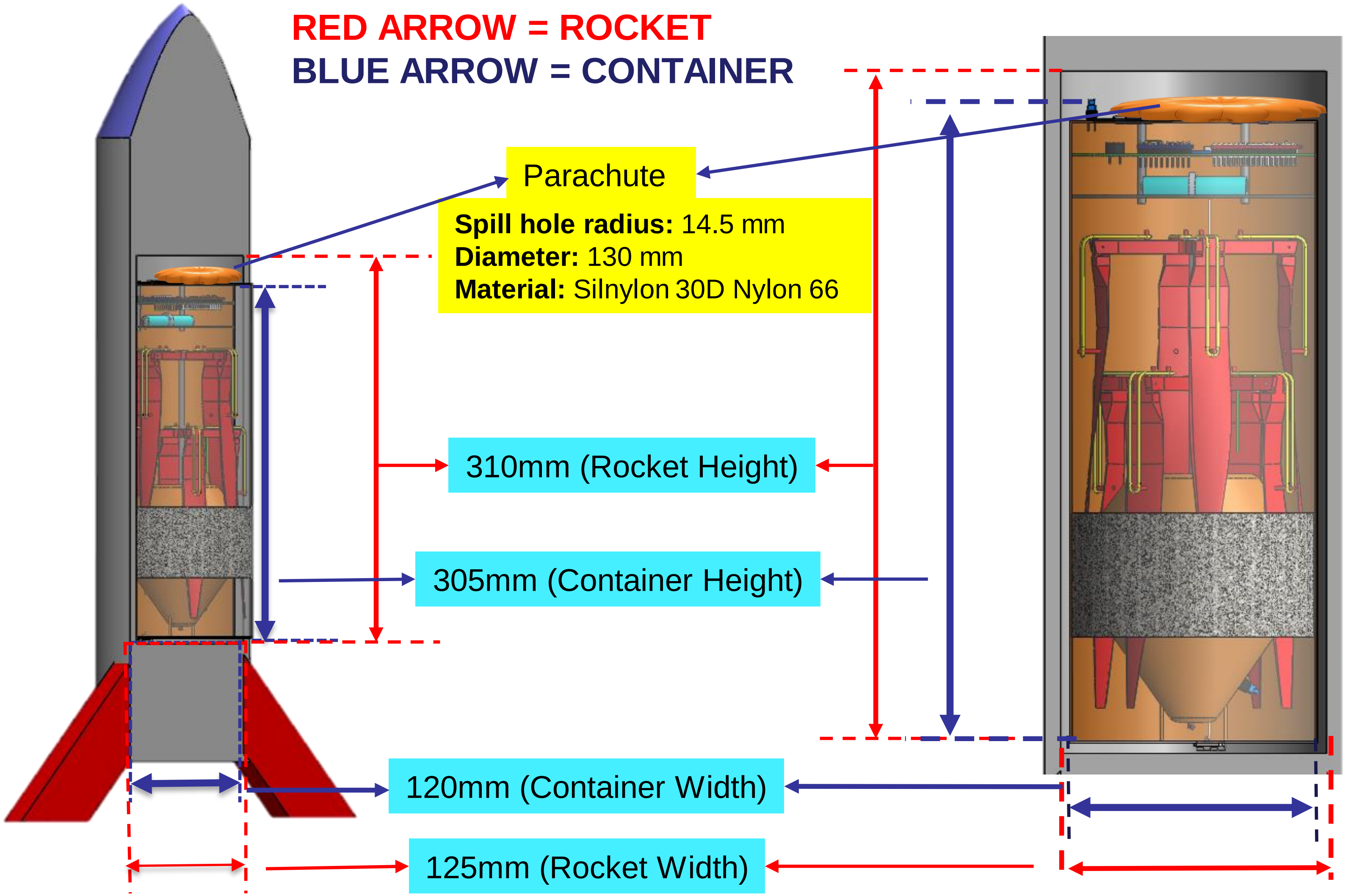
Step 2 (at 670-725 m)
1. Rocket arrived to 670-725m.
2. Container separate from the rocket (670-725m).

Step 3 (at 670-725 m)
The parachute on the top of the container is opened by air resistance.

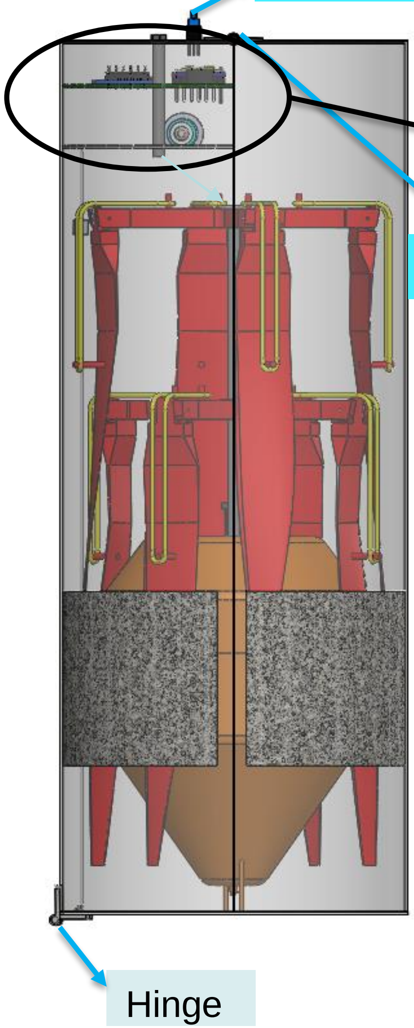
Step 4 (at 450m)
Container opened by burn wire method and payload release from the container.

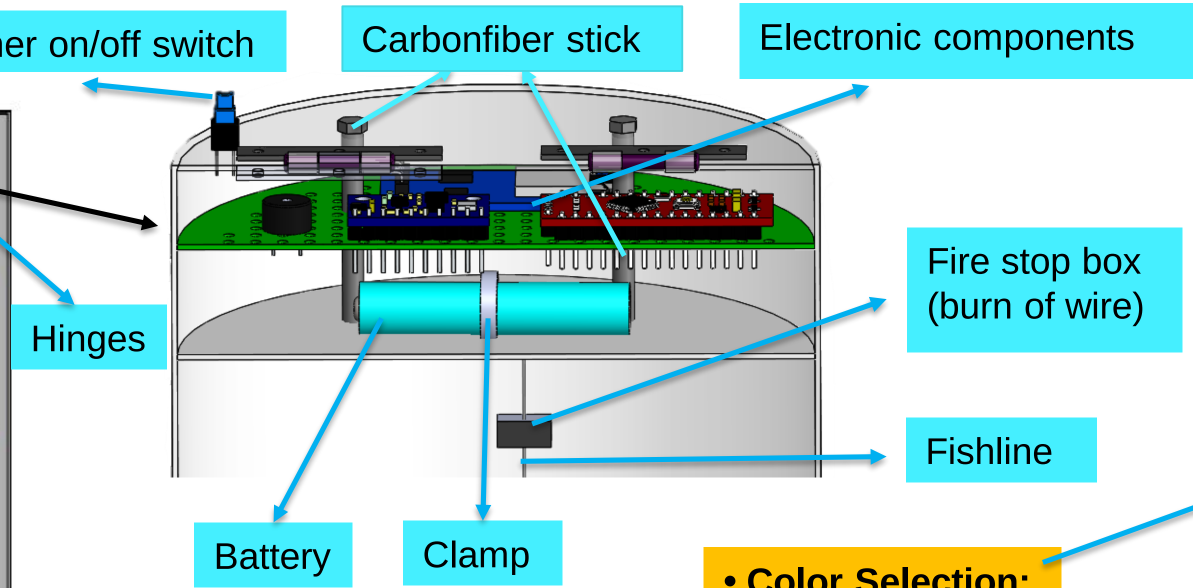


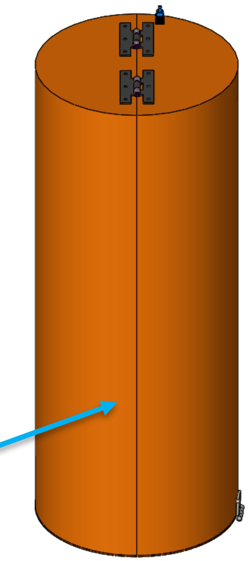
Container Descent Control Hardware Summary (2 of 3)



Container Descent Control Hardware Summary (3 of 3)







- **Color Selection:**
  -Container color is orange

- **Key design considerations:**
  -Depron was used to keep the payload stable in the container. The container opens and the electronic circuit is on the upper side to prevent the cables block the payload.
  -Keeps the bottom cover of fishline. When activated burn of wire method, fishline is broken and the bottom cover will open.
- **For active components:**
  -No active components are used in container descent control.

Container + Payload post separation

$$S_p = \frac{2 \times m \times g}{\rho \times V^2 \times C_{D_p}}$$

$$S_p = \frac{2 \times (0.5\ kg) \times (9.81\ m/s^2)}{(1.225 kg/m^3) \times (20 m/s\ )^2 \times (1.5)}$$

$$S_p = 0.01334\ m^2$$

$$S_p = \frac{1}{4} \times \pi \times D^2$$

$$D = \sqrt{\frac{4 \times S}{\pi}}$$

$\boldsymbol{S_p}$= *Area of the parachute with a spill hole* (m^2)
$\boldsymbol{D}$ = *The diameter of the parachute* (mm)
$\boldsymbol{V}$ = *Descent speed* (m/s)
$\boldsymbol{\pi}$ = *3.14159265359*
$\boldsymbol{C_{D_p}}$= *1.5 (Drift coefficient of parachute)*
$\boldsymbol{\rho}$ = *1.225* kg/m^3 *(Air density at +15°C from sea level)*
$\boldsymbol{m} = 500\ g$ *(Container+Payload)*
$\boldsymbol{g} = 9.81\ m/s^2$
$\boldsymbol{S_{s_h}}$ = *Spill hole area*

- **Area of the spill hole is chosen to be 5% of the total parachute projected area.**
- **Project area of spill hole:**

$$\boldsymbol{S \times 5\% \ = 0.01334\ m^2 \times 0.05 = 0.0006555\ m^2}$$

Spill hole radius $= \sqrt{\frac{S_{Sh}}{\pi}} = \sqrt{\frac{0.0006555\ m^2}{\pi}} = \boldsymbol{0.0145\ m = 14.5 mm}$

$$D = \sqrt{\frac{4 \times 0.01334\ m^2}{\pi}} \Rightarrow D = 0.1303\ m \cong 130\ mm$$

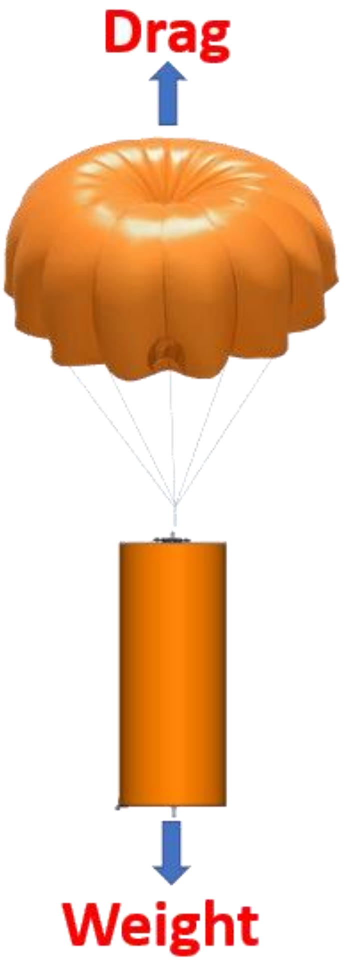
Container+Payload post separated calculation

Landing velocity of container with parachute.

$$V = \sqrt{\frac{2 \times F_{Drag}}{\rho \times S_p \times C_d}} \Rightarrow F_{Drag} = m \times g$$

$$V = \sqrt{\frac{2 \times (0.5\ kg) \times (9.81 m/s^2)}{(1.225 kg/m^3) \times (0.01334\ m^2) \times (1.5)}}$$

$$V = 20.005\ \mathrm{m/s} \cong 20\ \mathrm{m/s}$$



Container following released from the Payload

$$S_p = \frac{2\times m\times g}{\rho\times V^2\times C_{D_p}} \Rightarrow V = \sqrt{\frac{2\times m\times g}{\rho\times S_p\times c_{d_p}}}$$

$$V = \sqrt{\frac{2\times(0.160\ kg)\times(9.81\ m/s^2)}{(1.225kg/m^3)\times 0.01334\ m^2\times(1.5)}}$$

$$\boxed{V = 11.3167\ m/s}$$

$\boldsymbol{S_p}$= Area of the parachute with a spill hole (m^2)

$\boldsymbol{V}$ = Descent speed (m/s)

$\boldsymbol{C_{D_p}}$= 1.5 (Drift coefficient of parachute)

$\boldsymbol{\rho}$ = 1.225 kg/m^3 (Air density at +15°C from sea level)

$\boldsymbol{m} = 160\ g$ (Container)

$\boldsymbol{g} = 9.81\ m/s^2$

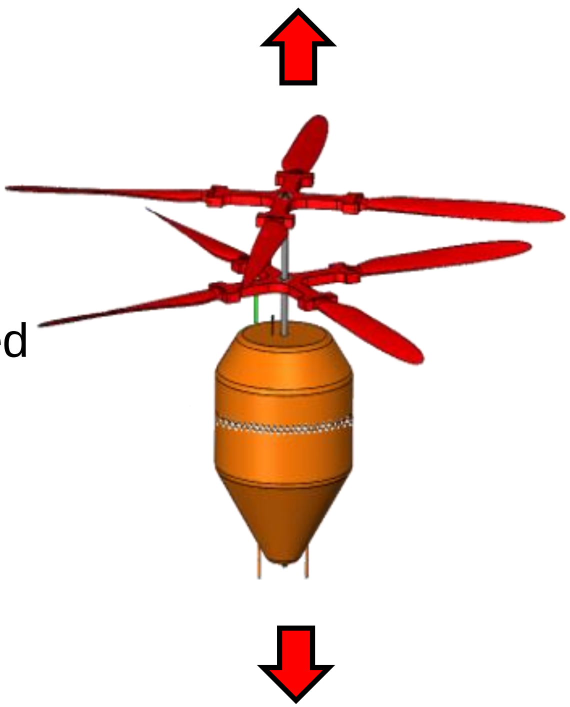
Container descent speed after being released

Payload following separation from the Container

The Lifting force acting on a body in a air flow can be calculated

$$F_L = \frac{1}{2} \times C_L \times \rho \times V^2 \times A$$

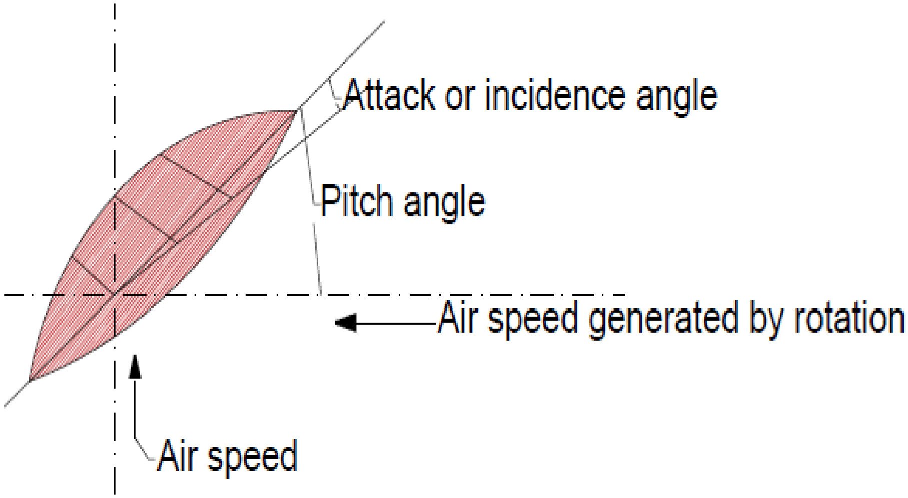
F_L *= Lifting force (N)*
C_L *= Lifting coefficient*
ρ *= Density of air (kg/m³)*
V *= Air flow velocity (m/s)*
A *= Body area (m²)*

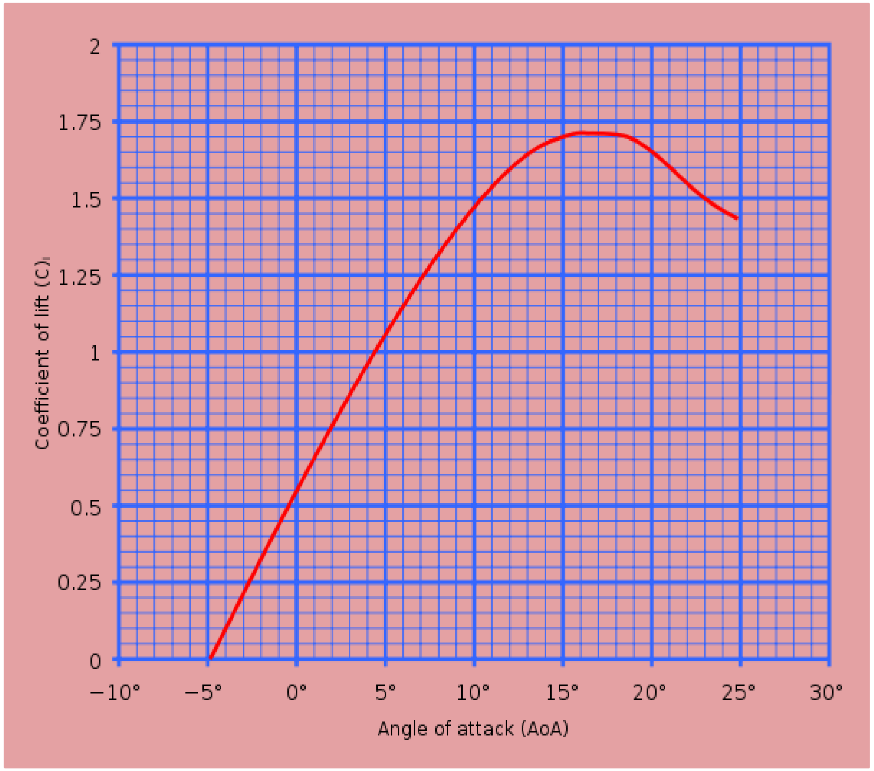


The Drag force acting on a body in air flow can be calculated

$$F_D = \frac{1}{2} \times C_D \times \rho \times V^2 \times A$$

F_D *= Drag force (N)*
C_D *= Drag coefficient*
ρ *= Density of air (kg/m3)*
V *= Air flow velocity (m/s)*
A *= Body area (m2)*





- Pitch's angular change in rotation speed. As long as we keep the angle wide we can get the maximum rotation speed.
- Coefficient C_L(Lift coefficient) contains all the complex dependencies and is usually determined experimentally.

Source: www.wikiwand.com

So we choose efficient pitch angle and lift coefficent.
Pitch angle $\cong 15°$
$C_L \cong 1.7$

Descent Rate Estimates (6 of 9)

$$F_L + F_d - F_w = 0 \Longrightarrow F_L + F_d = F_w$$

$$\frac{1}{2}(C_d + C_L)\rho A V^2 = mg$$

$$A = \frac{2 \times m \times g}{\rho \times V^2 \times (C_d + C_L)}$$

$\boldsymbol{m} = 340\ g$ (Mass of payload)
$\boldsymbol{C_D} = 0.045$ for airfoil
$\boldsymbol{C_L} = 1.7$
$\boldsymbol{\rho} = 1.225\ kg/m^3$ (Air density at +15 °C from sea level)
$\boldsymbol{g} = 9.81\ m/s^2$
$\boldsymbol{A}$ = Area (Total wings area)

$$\mathrm{A} = \frac{2 \times (0.340\mathrm{kg}) \times (9.81 m/s^2)}{(1.225\mathrm{kg/m^3}) \times (10 m/s)^2 \times (0.045 + 1.7)}$$

Total Wings Area

$$A = 0.031207\ m^2 = 31207 mm^2$$

Payload descent velocity

$$V = \sqrt{\frac{2 \times m \times g}{\rho \times A \times (C_d + C_L)}}$$

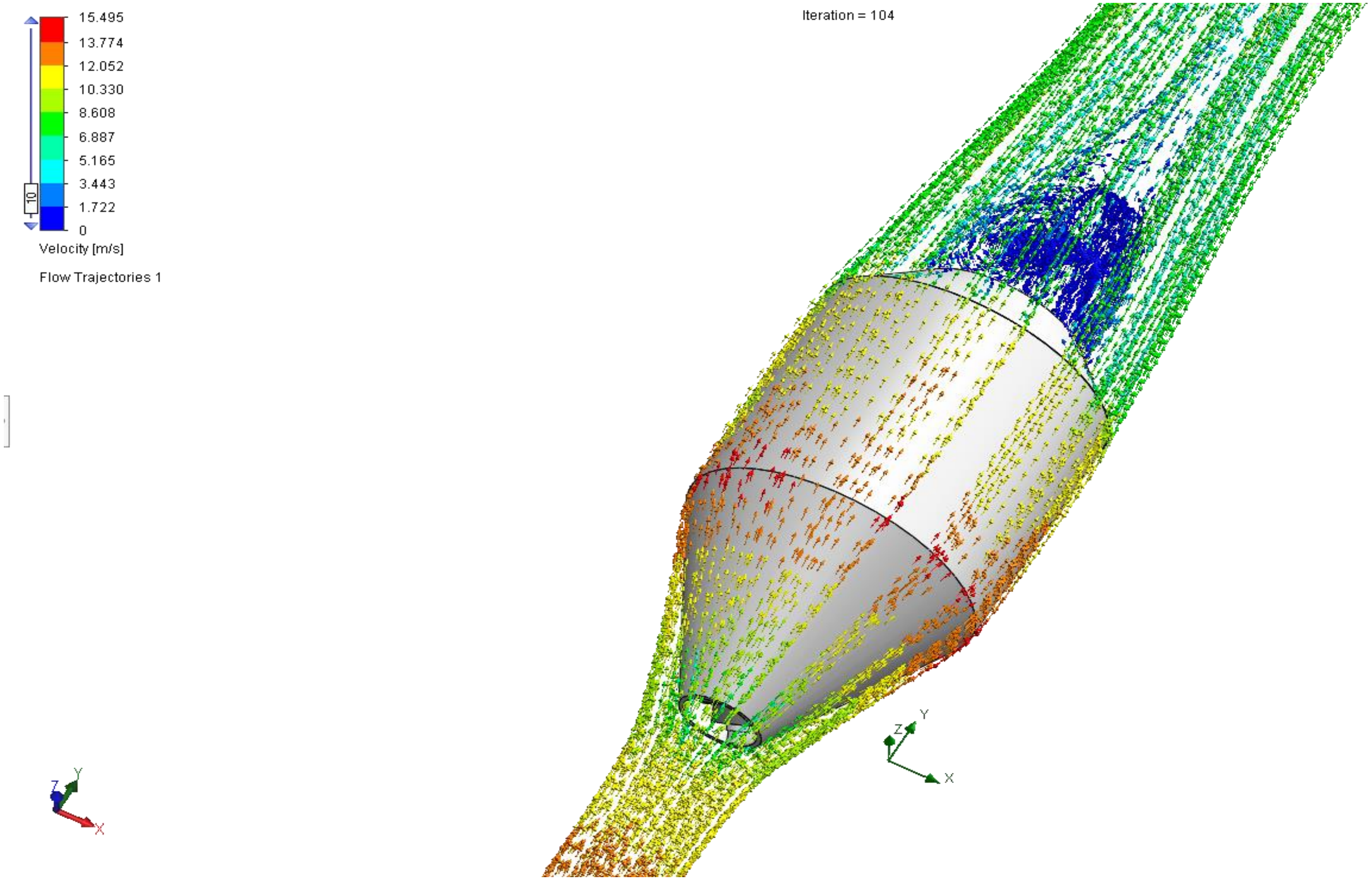
$m = 340g$ (payload)
$A = 0.031207\ m^2$
$g = 9.81\ m/s^2$
$C_D = 0.045$ for airfoil
$C_L = 1.7$

$$\mathrm{V} = \sqrt{\frac{2 \times (0.340\ kg) \times (9.81 m/s^2)}{(1.225\ kg/m^3) \times (0.031207\ m^2) \times (0.045+1.7)}}$$

$$\boldsymbol{V = 10.00\ m/s}$$

We reached our the speed limit based on the calculated wing area.

Flow Simulation



Payload body flow simulation in falling time. The wind speed is shown in the simulation according to the colors.

Final Results

As a result of physical and mathematical operations;

Container + Payload post separation

- ✓ ***Spill hole diameter:*** *29 mm*
- ✓ ***The diameter of the parachute:*** *130 mm*
- ✓ ***Descent speed:*** $20\ m/s$

Container following released from the payload

- ✓ ***Container descent speed after released :*** $11.3167\ m/s$

Payload following separation from the Container

- ✓ ***Pitch angle :*** *15º*
- ✓ ***Area of wing :*** $0.031207\ m^2$
- ✓ ***Payload descent speed :*** $10.00\ m/s$

Mechanical Subsystem Design

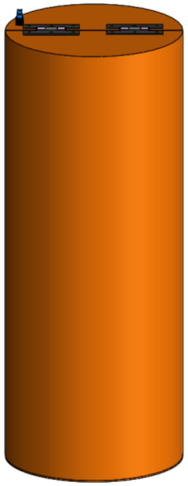
Kudret Batuhan OKSEM

Mechanical Subsystem Overview

All component mass is 500 g (Payload, container, auto-gyro system and all electrical components).

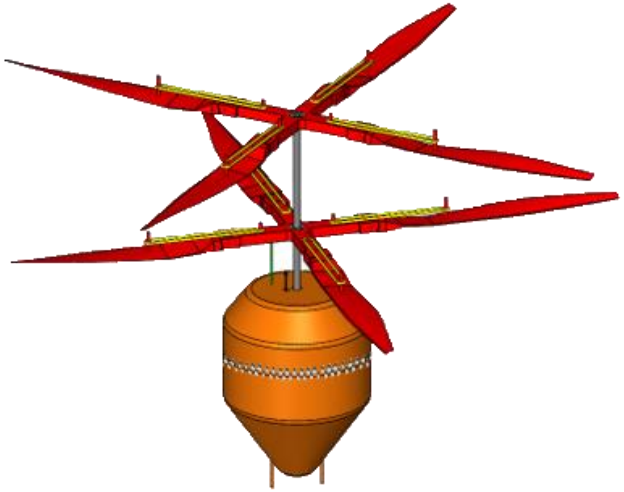
Container

- Container material is fiberglass.
- Container dimension is 305 mm in lenght and 120 mm in diameter.
- Container's pre payload release descent rate is 20 m/s , container velocity after being released is 10 m/s. The decrease in descent velocity will be provided via the parachute.
- The diameter of the parachute is around 130 mm with a spill hole diameter of 29 mm.



Payload

- Payload material is fiberglass.
- Payload dimension is 90 mm in diameter x 230 mm in length.
- The Payload descent rate is between 10 to 15 m/s .
- The Passive control is provided by the auto-gyro system and adjusting the center of mass .
- Auto-gyro propeller material is carbon fiber and axle material is carbon fiber stick.
- We use fabric elastics for deploying the propellers.
- Batteries and electronic components are easily reached by means of zipper.



Mechanical Subsystem Changes Since PDR

PDR	CDR	Rationale
• Payload dimension is 70 mm in diameter and 187 mm in length.	• Payload dimension is 90 mm in diameter and 230 mm in length.	We have enlarged the diameter of the payload body because Teensy 3.6 is larger than the Arduino Nano. We increased the length between the two propellers to regulate the air flow more uniformly on the propellers.
• We use plastic hinge for folding propellers.	• We use the new hinges we produce from the 3D printer for the folding mechanism of the propellers	For faster and easier production
• Container dimension is 240 mm in length and 94 mm in diameter.	• Container dimension is 305 mm in length and 120 mm in diameter.	The diameter of the container is increased prevent rocking in the rocket.
• We use two PCB in the payload	• We use one PCB in the payload	Electronic components fit into one PCB because we've increased the payload diameter

Mechanical Sub-System Requirements (1 of 3)

Number	Description	Rationale	Priority	VM			
				A	I	T	D
RN#1	Total mass of the CanSat (science payload and container) shall be 500 grams +/- 10 grams	Competition requirement	HIGH	✓	✓		✓
RN#2	CanSat shall fit in a cylindrical envelope of 125 mm diameter x 310 mm length. Tolerances are to be included to facilitate container deployment from the rocket fairing.	Competition requirement	HIGH		✓	✓	✓
RN#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.	Competition requirement	HIGH		✓	✓	
RN#4	The container shall be a fluorescent color; pink, red or orange.	Competition requirement	MEDIUM		✓		
RN#5	The rocket airframe shall not be used to restrain any deployable parts of the CanSat.	Competition requirement	MEDIUM		✓		
RN#6	The rocket airframe shall not be used as part of the CanSat operations.	Competition requirement	MEDIUM		✓		
RN#7	The CanSat shall deploy from the rocket payload section and immediately deploy the container parachute.	Competition requirement	HIGH		✓	✓	

Mechanical Sub-System Requirements (2 of 3)

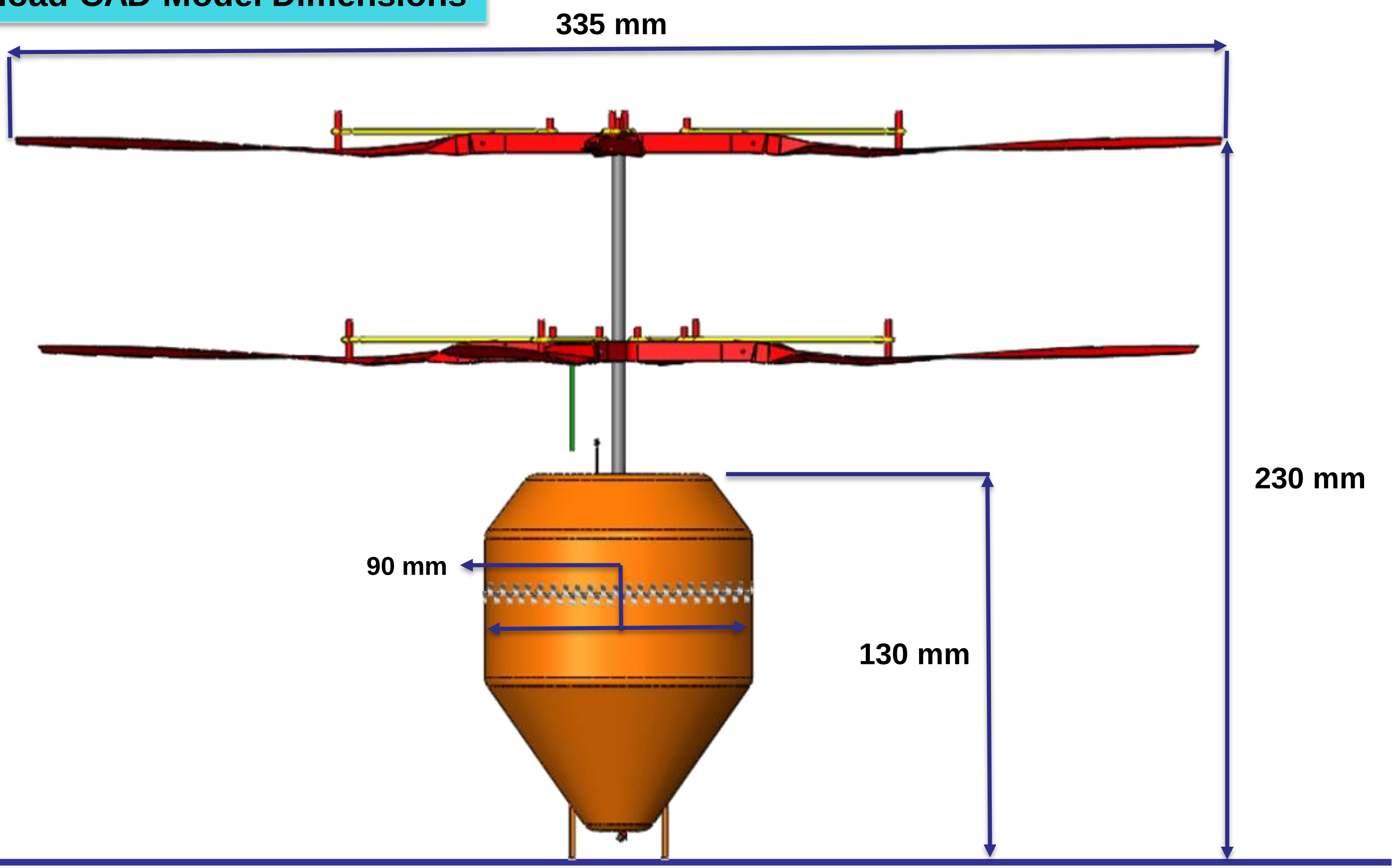
Number	Description	Rationale	Priority	VM			
				A	I	T	D
RN#9	The container shall release the payload at 450 meters +/- 10 meters.	Competition requirement	HIGH		✓	✓	✓
RN#12	All descent control device attachment components shall survive 30 Gs of shock.	Competition requirement	HIGH	✓	✓		
RN#13	All electronic components shall be enclosed and shielded from the environment with the exception of sensors.	Competition requirement	HIGH	✓	✓		
RN#14	All structures shall be built to survive 15 Gs of launch acceleration.	Competition requirement	HIGH	✓		✓	
RN#15	All structures shall be built to survive 30 Gs of shock.	Competition requirement	HIGH	✓		✓	
RN#16	All electronics shall be hard mounted using proper mounts such as standoffs, screws, or high performance adhesives.	Competition requirement	HIGH	✓	✓		
RN#17	All mechanisms shall be capable of maintaining their configuration or states 8 under all forces.	Competition requirement	HIGH	✓		✓	

Mechanical Sub-System Requirements (3 of 3)

Number	Description	Rationale	Priority	VM			
				A	I	T	D
RN#18	Mechanisms shall not use pyrotechnics or chemicals.	Competition requirement	HIGH	√	√		
RN#19	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.	Competition requirement	MEDIUM	√	√	√	
RN#34	Cost of the CanSat shall be under $1000. Ground support and analysis tools are not included in the cost.	Competition requirement	MEDIUM	√	√		
RN#50	An easily accessible battery compartment must be included allowing batteries to be installed or removed in less than a minute and not require a total disassembly of the CanSat.	Competition requirement	HIGH	√	√		
RN#54	The CANSAT must operate during the environmental tests laid out in Section 3.5.	Competition requirement	HIGH	√	√	√	

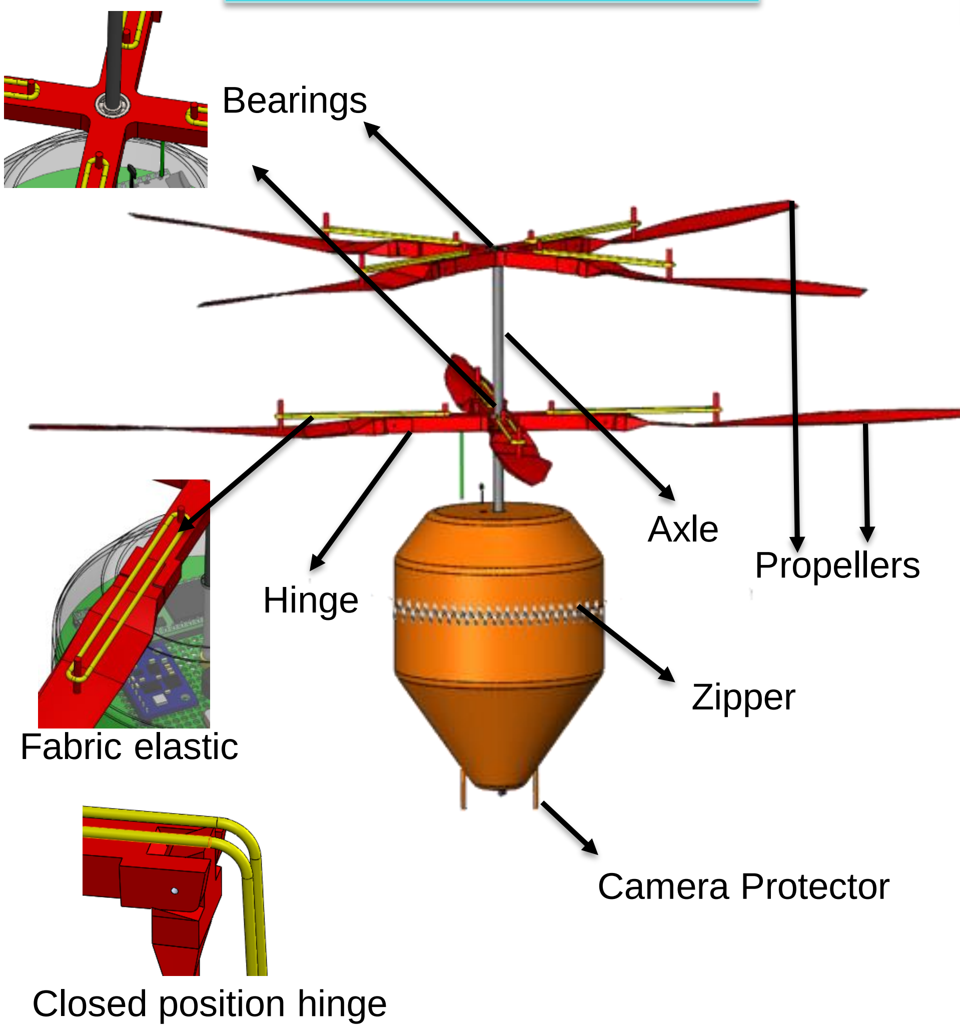
Payload Mechanical Layout of Components (1 of 3)

Payload CAD Model Dimensions

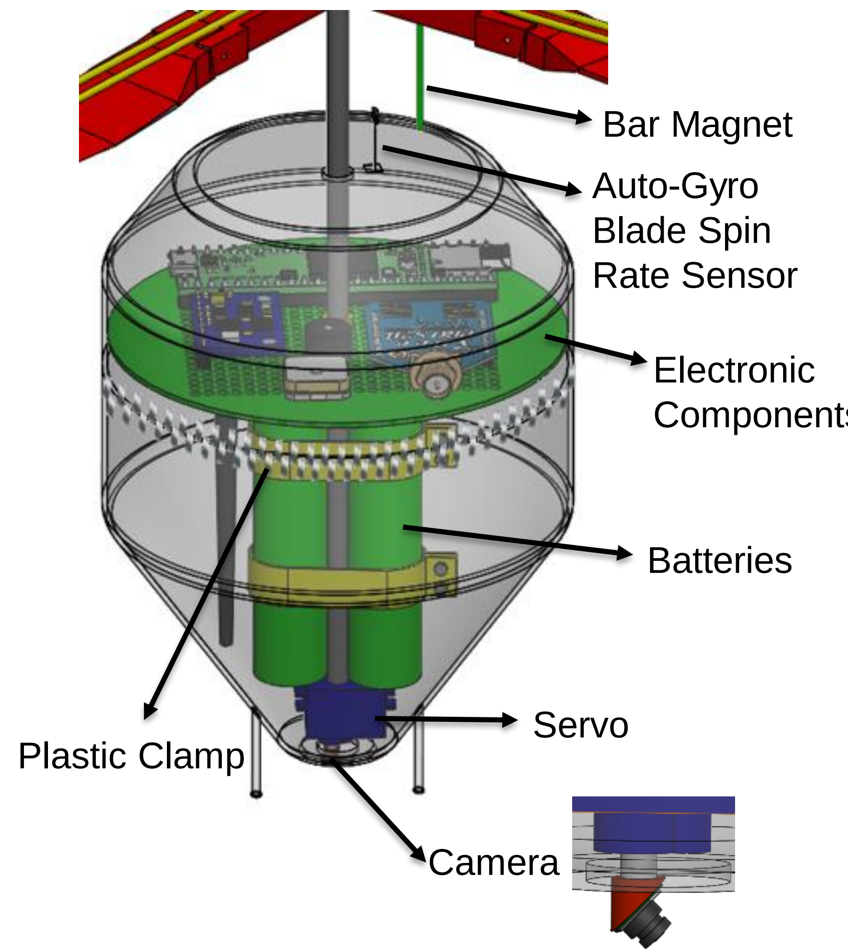


Payload Mechanical Layout of Components (2 of 3)

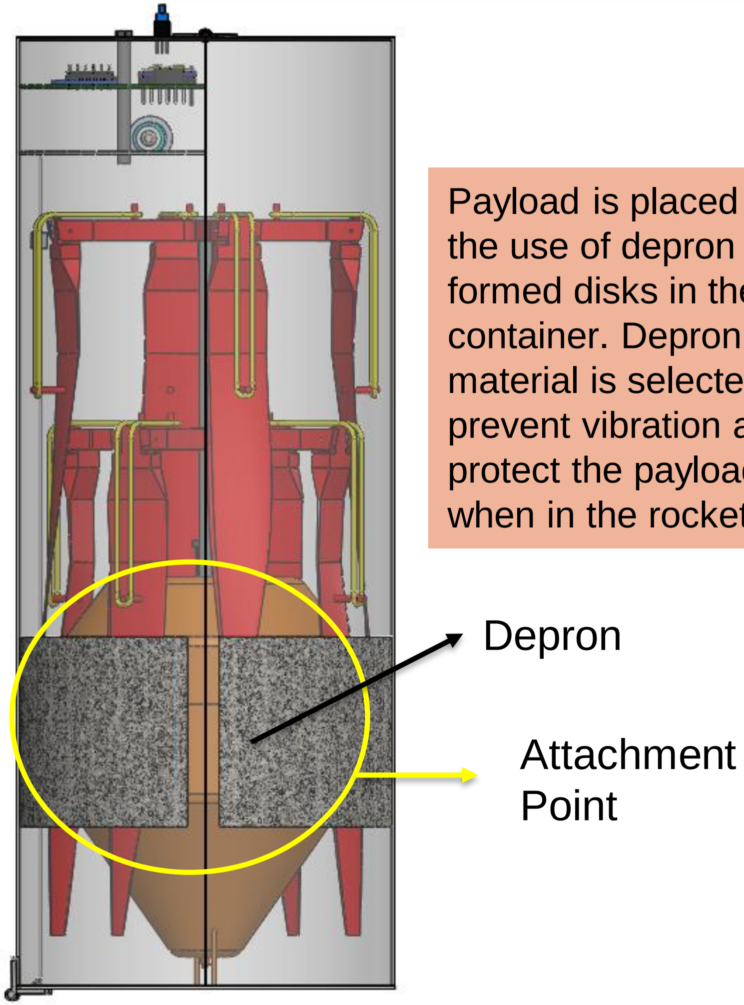
Major Mechanical Parts



Location of Electrical Components



Payload Attachment Point



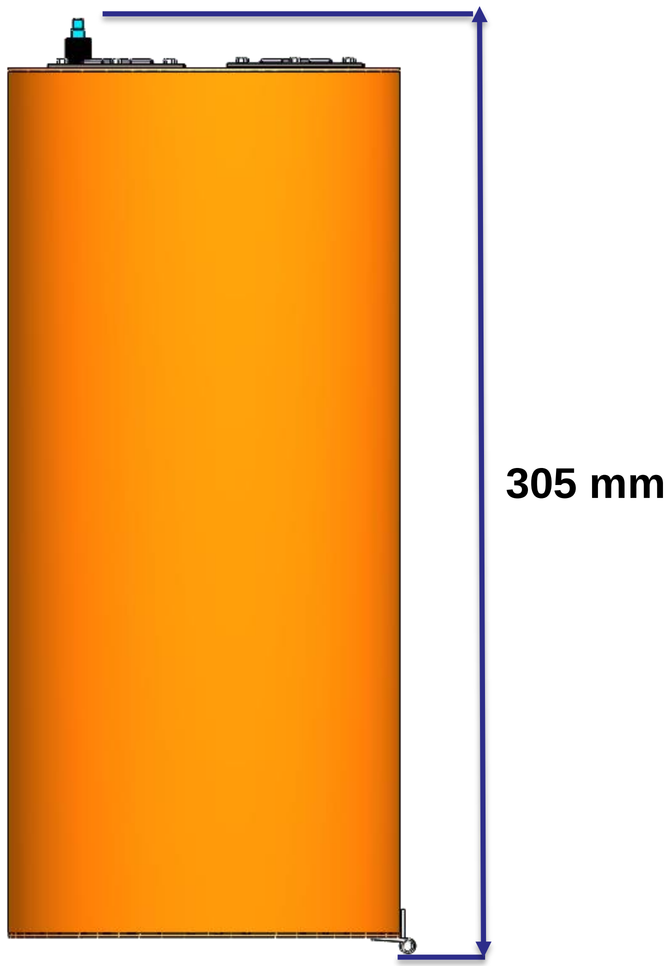
Payload is placed with the use of depron formed disks in the container. Depron material is selected to prevent vibration and protect the payload when in the rocket.

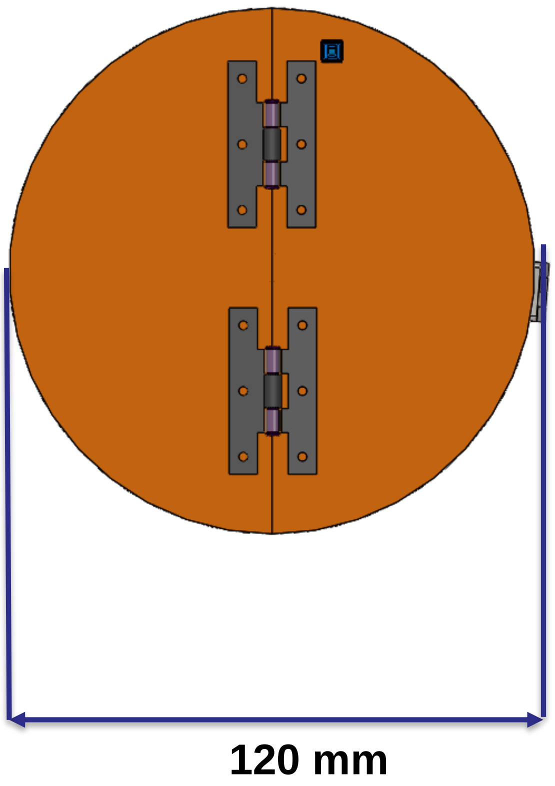
Material Selections

PART	MATERIAL	RATIONALE
Payload Body	Fiberglass	• Strong • Light
Axle	Carbon Fiber	• Higher impact resistance • Very durable
Propellers	Carbon Fiber	• Higher impact resistance • Very durable
Plastic Hinge	PLA	• Fast production • Cheap
Fabric elastic	Rubber	• Easy to supply • Usefull
Bearing	Steel	• Longer durability • Less friction force

Container Mechanical Layout of Components (1 of 3)

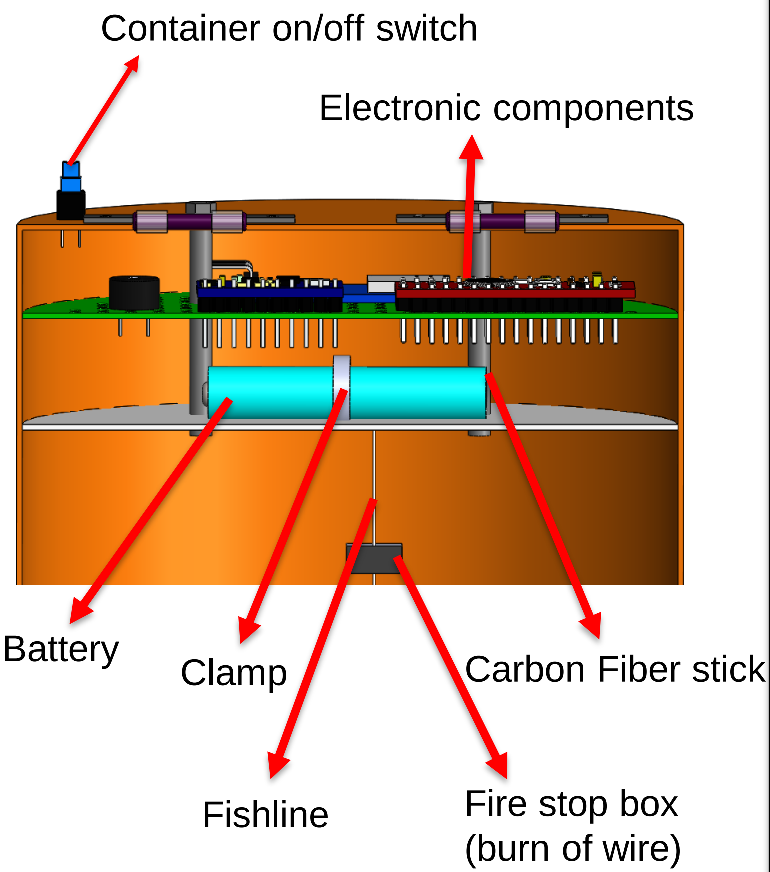
Container CAD Model Dimensions



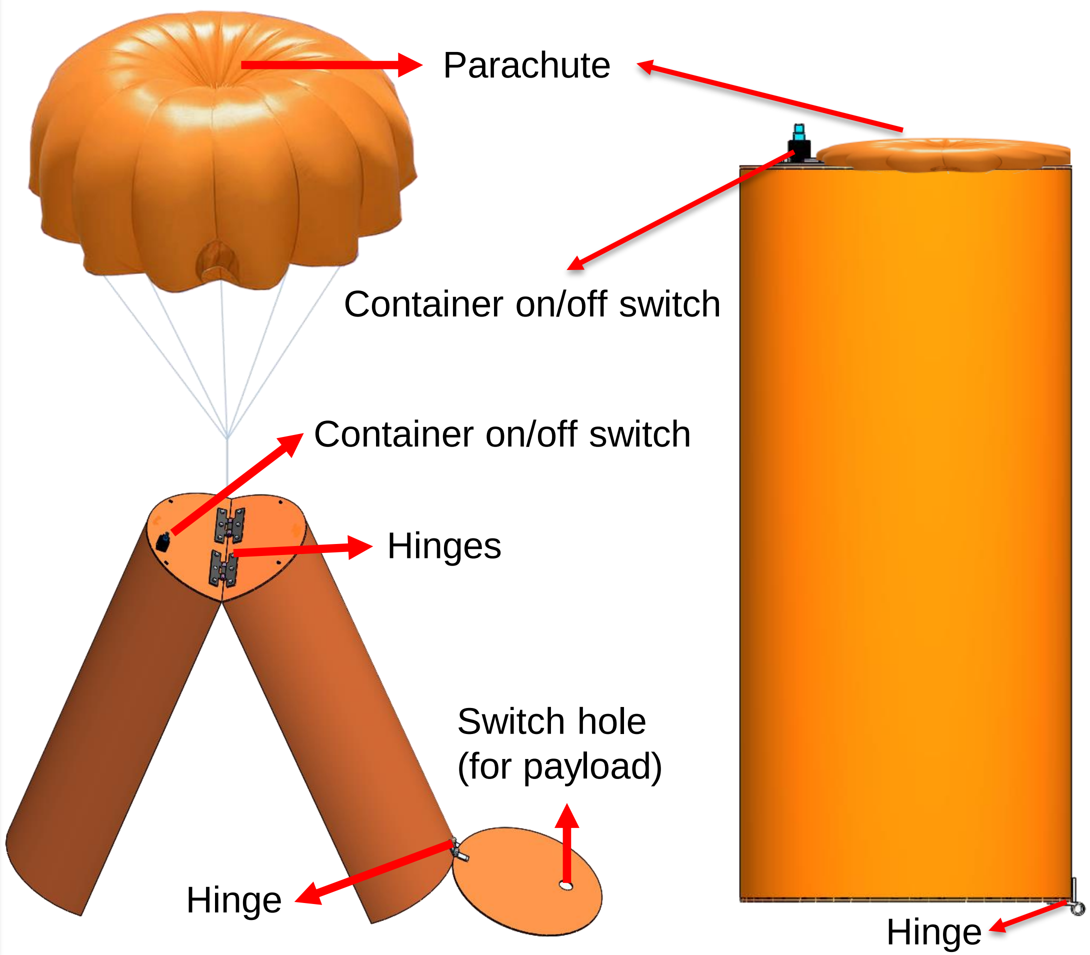


Container Mechanical Layout of Components (2 of 3)

Location of Electrical Components

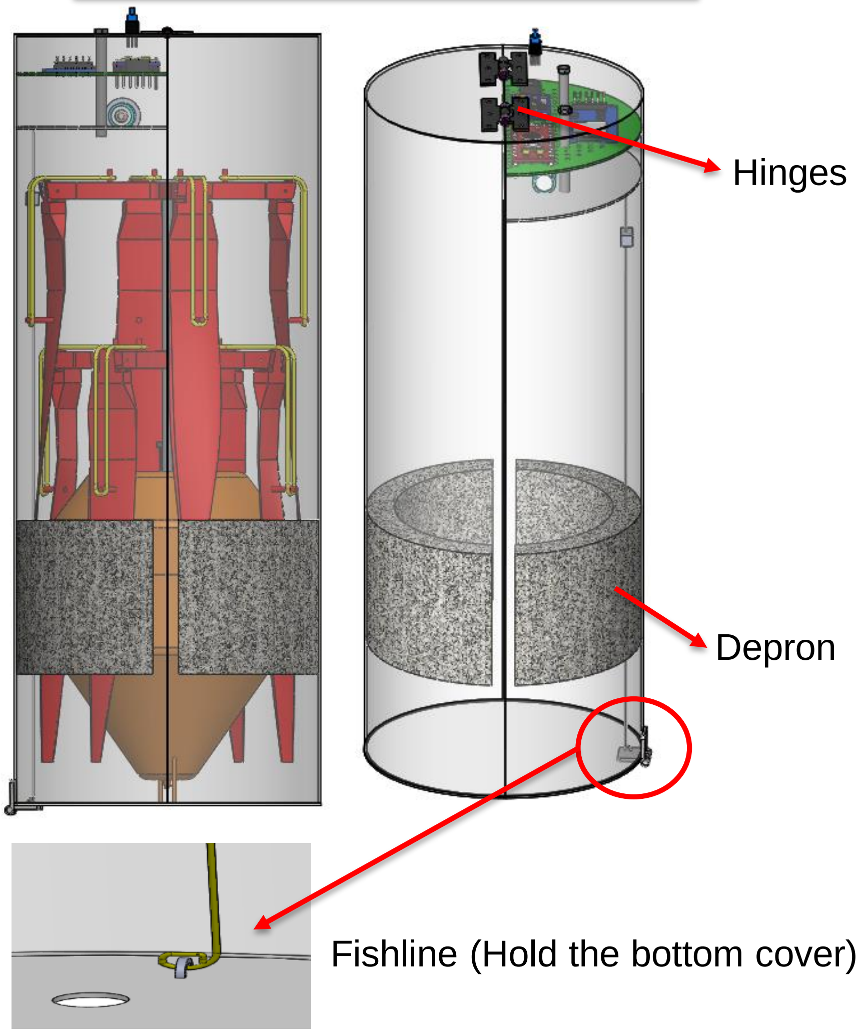


Location of Major Mechanical Parts



Container Mechanical Layout of Components (3 of 3)

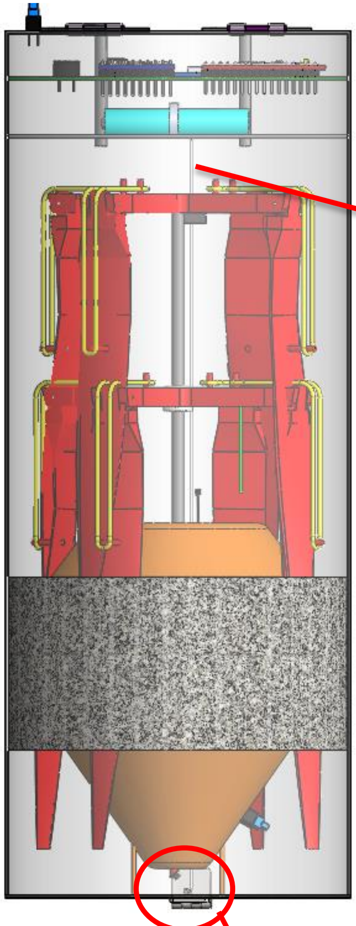
Container Attachment Point

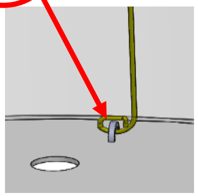


Container Material Selection

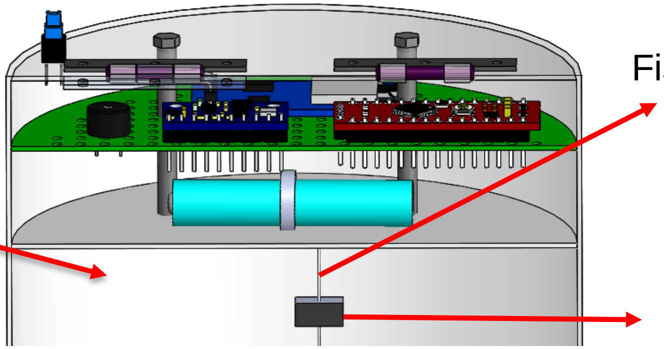
PART	MATERIAL	RATIONALE
Container	Fiberglass	• Strong • Light
Hinge	Steel	• Resistant to weight • Long-term use
Parachute	Silnylon 30D Nylon 66	• Easy to supply • It has high air resistance • Strong, high abrasion resistant fabric
Payload stabilizer	Depron	• Vibration isolator • Shock absorber

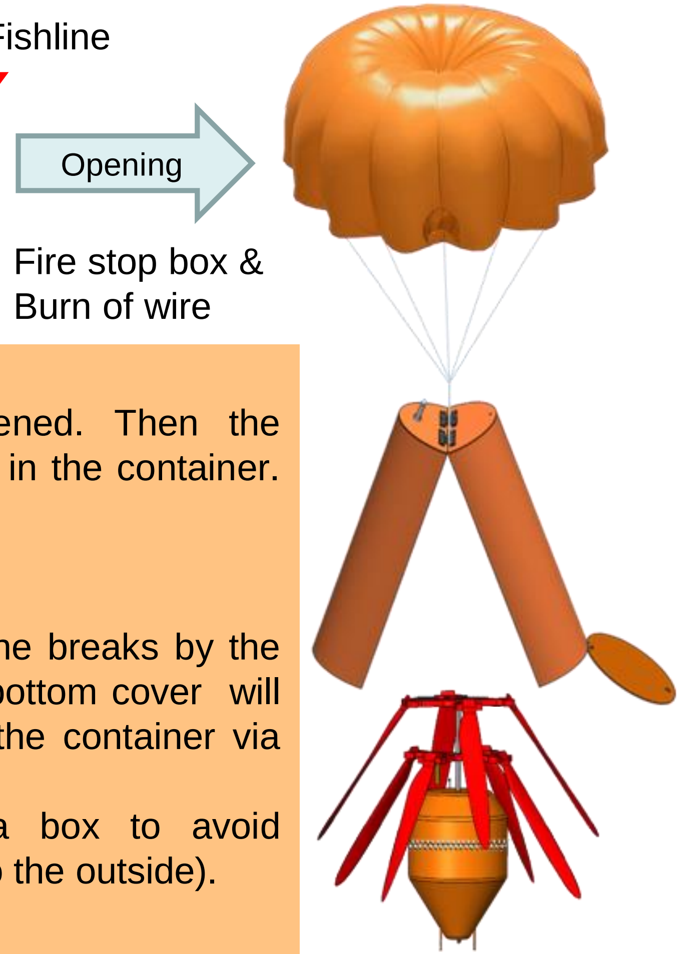
Payload Release Mechanism (1 of 2)





Fishline attachment point





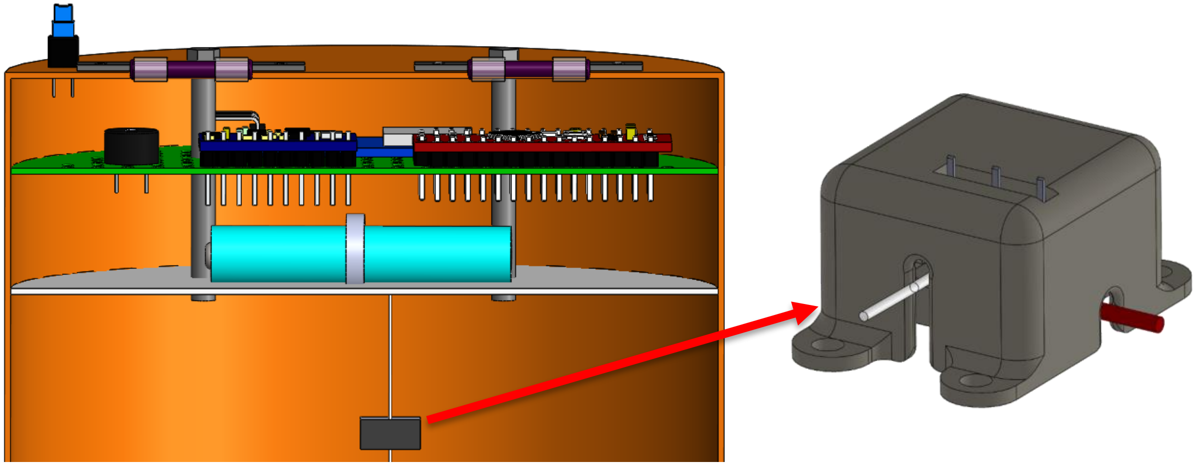
CONNECTION METHOD

Firstly, container's cover will be opened. Then the payload with folded propellers will stowed in the container. Finally the container is closed.

RELEASE METHOD

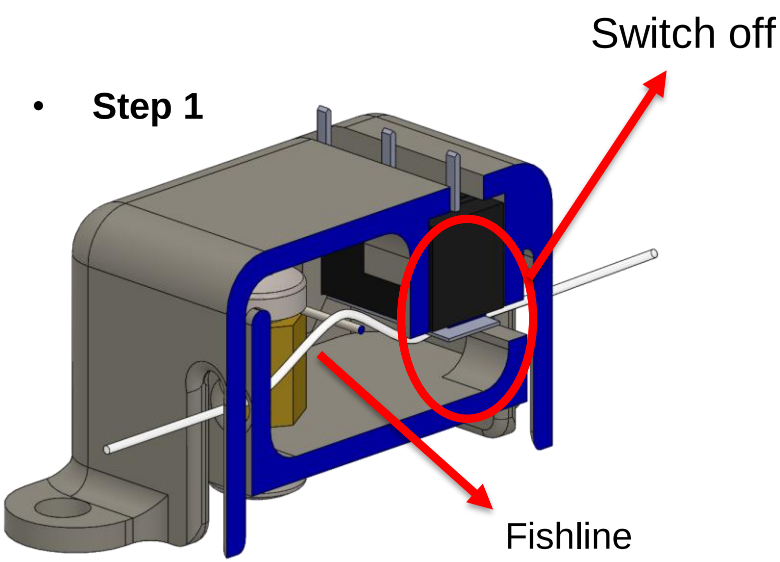
- When the CanSat reaches 450 m fishline breaks by the burn of wire method and the container bottom cover will be opened. The payload release from the container via force of gravity.
- The burn of wire is protected in a box to avoid enviromental damage (not be exposed to the outside).
- The burn of wire pulls a current of 1.4 A.
- The fishline breaks under a second.

Payload Release Mechanism (2 of 2)

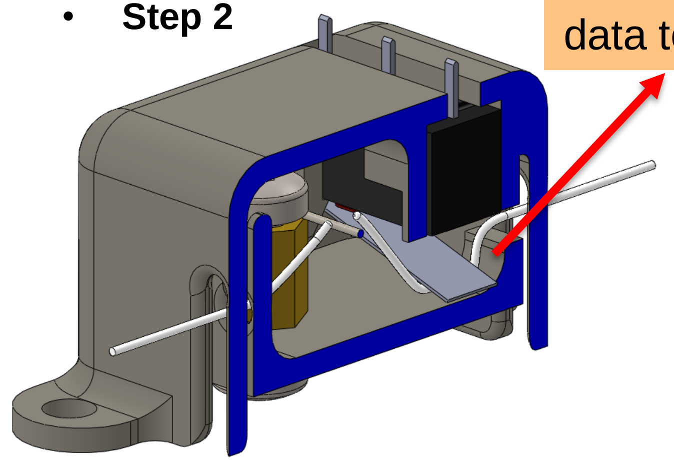


We use burn of wire method for convenient re-use. When fishline breaks, switch activates and sends data to Teensy 3.6. Then current flow to the wire will be stopped. We will use fire stop box for safety.

- **Step 1**



- **Step 2**



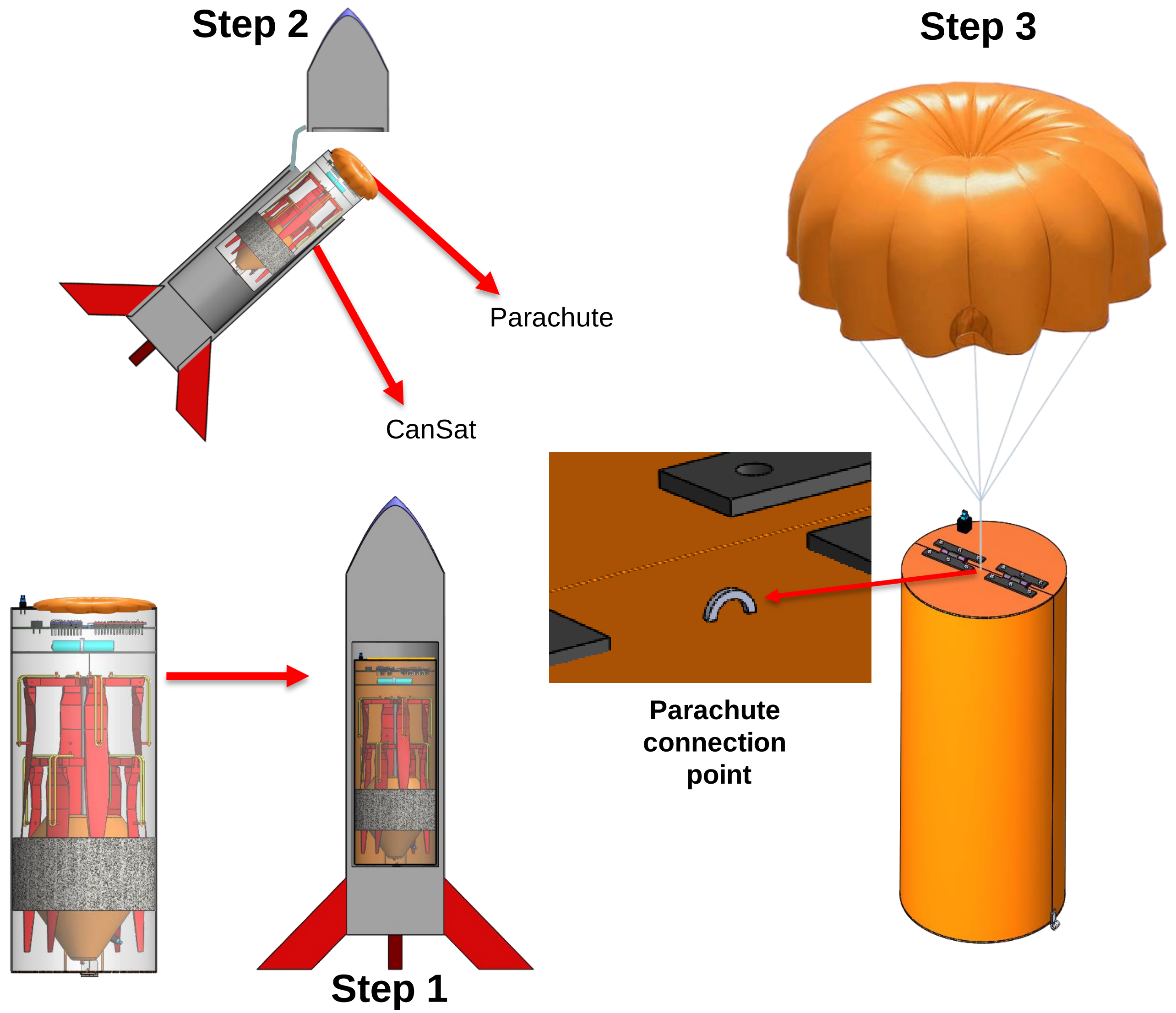
Fishline breaks and switch active (Sending data to Teensy 3.6).

Container Parachute Release Mechanism

Step 1
The payload is placed in the container, parachute is attached to the container by ropes, folded over and placed on the container.

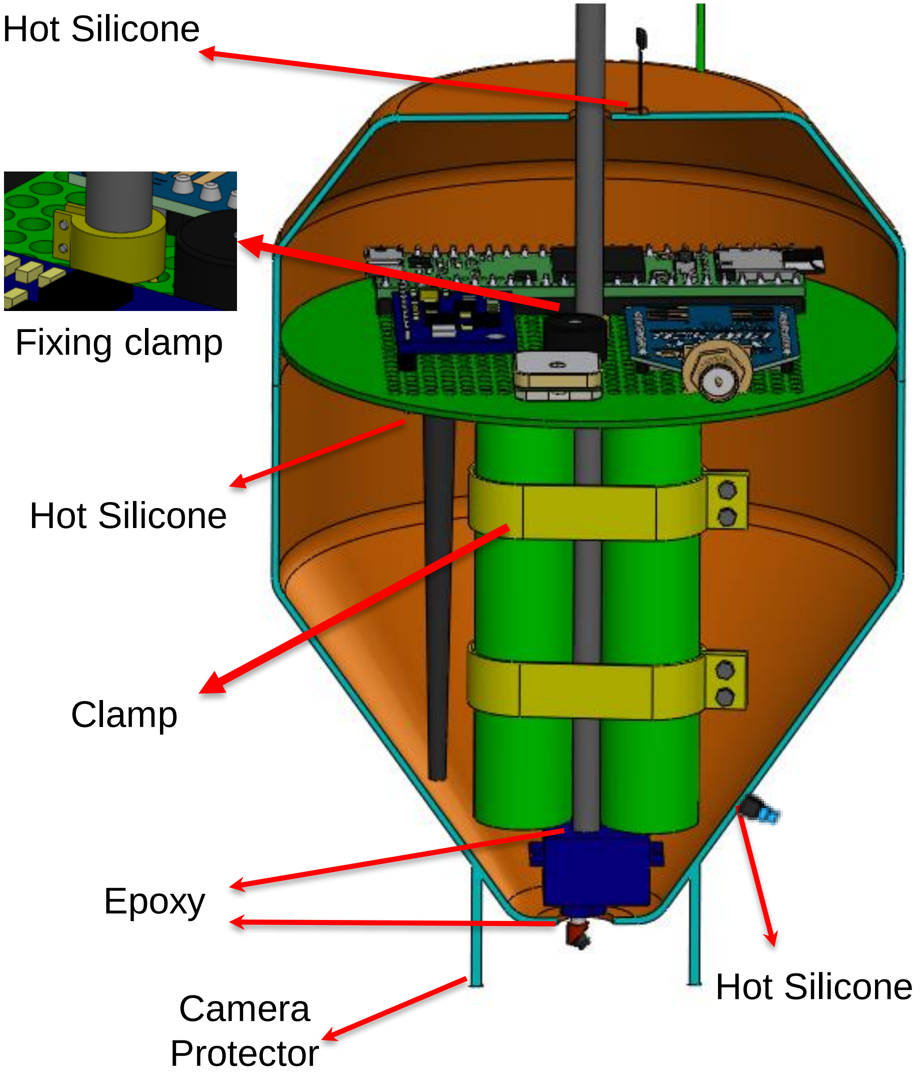
Step 2 (at 670-725 m)
1. Rocket arrived to 670-725 m.
2. Container separate from the rocket (670-725 m).

Step 3 (at 670-725 m)
The parachute on the top of the container is opened by air resistance.



For Payload

Connection • Electronic components are successfully fixed by solder on the PCB.
Enclosure • Plastic clamps were used to fix the PCB. • Batteries fixed with plastic clamp on the axle.
Mounting • The servo mounted to the payload with epoxy. The camera is placed on the servo motor. • Blade spin rate sensor mounted with hot silicone. • Payload on/off switch mounted with hot silicone.
Descent Control Attachments • We will use auto-gyro system for payload.



We are planning to do shock force and acceleration tests on 3-25 April .

Structure Survivability (2 of 2)

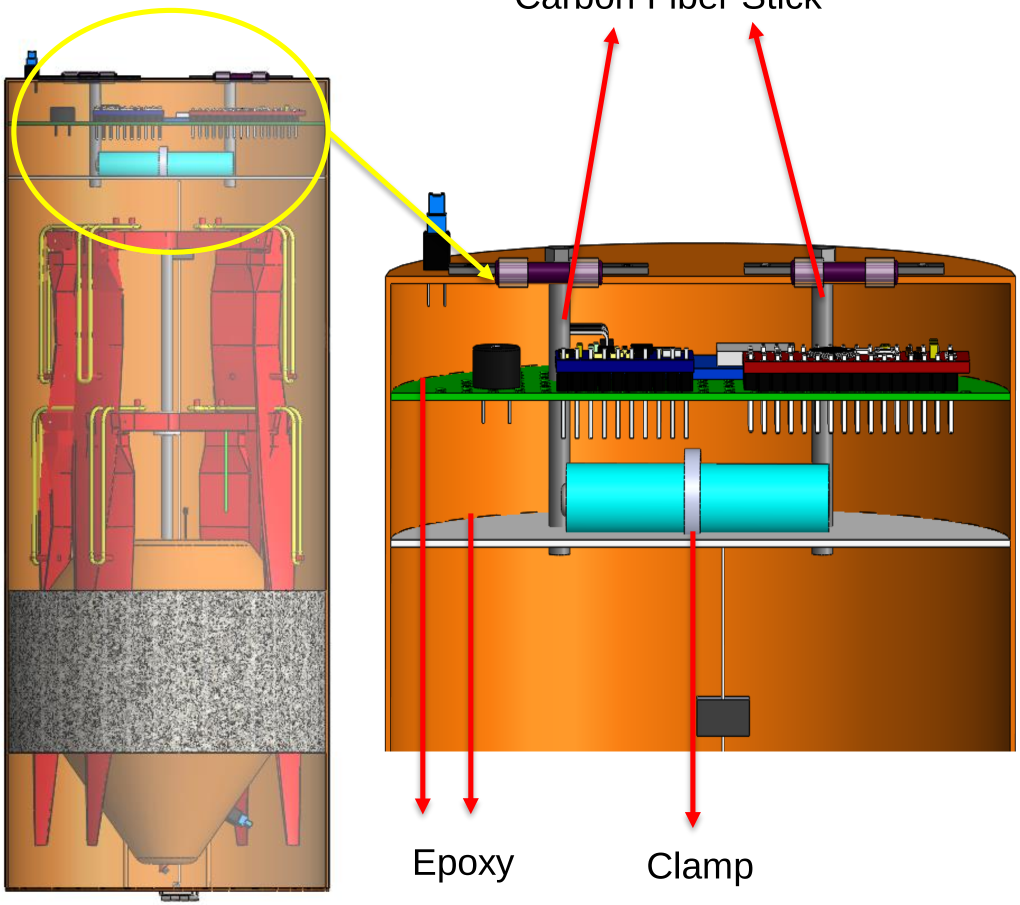
For Container

Connection
- Electronic components are successfully fixed by solder on the PCB.

Enclosure
- PCB fixed with carbon fiber stick in the container.
- Battery fixed with plastic clamp

Mounting
- PCB's outer surface mounted by the epoxy (high performance adhesives) on the inner surface of container.

Descent Control Attachment
- We will use a parachute for container landing control.



We are planning to do shock force and acceleration tests on 3-25 April.

Mass Budget (1 of 4)

ELECTRONIC COMPONENTS

	Part Name	Quantity:	Unit Weight(g):	Weight (g) :	Determination:
PAYLOAD	SD Card(SanDisk Ultra)	2	1	2	M
	Teensy 3.6V	1	4.8	4.8	DS
	Battery (SonyVTC6)	2	48.5	97	DS
	PCB	1	15	15	E
	DC-DC Converter (MP23070N)	2	2	4	M
	10-DOF IMU (MPU-9255 + BMP280)	1	2	2	M
	GPS (NEO-7M)	1	13	13	M
	Compass Sensor hmc5883l	1	6	6	DS
	Coin Cell(CR2032 3V)	1	1.2	1.2	DS
	Telemetry Module(Xbee Pro S1 & Antenna)	1	13	13	DS
	Hall Effect (US1881)	1	<1	<1	DS
	Camera(SQ11)	1	4	4	M
	Servo Motor (Feetech FS5106R)	1	39	39	DS
	Switch (IC139)	1	2	2	DS
	Reset Button	1	<1	<1	M
	Buzzer	1	5	5	DS

CE: CAD Estimate M: Measurement
DS: Data Sheet E: Estimate

TOTAL	210 g

Mass Budget (2 of 4)

STRUCTURAL ELEMENTS

	Part Name	Quantity:	Unit Weight(g):	Weight (g) :	Determination:
PAYLOAD	Payload Body	1	50.2	50.2	CE
	Zipper	1	6	6	M
	Wings	8	6	48	CE
	Axle	1	3	3	M
	Plastic Hinge	8	1	8	M
	Plastic Clamp	4	1	4	M
	Ball Bearing	2	4	8	DS

Measurement (Mainstays Digital Glass Kitchen Food Scale):
Capacity: 5 kg
Sensivity: 1 g

TOTAL	127.2 g

CE: CAD Estimate
M: Measurement

DS: Data Sheet
E: Estimate

PAYLOAD ELECTRONIC + PAYLOAD STRUCTURAL = PAYLOAD MASS

210 g + 127.2 g = 337.2 g

Mass Budget (3 of 4)

ELECTRONIC ELEMENTS

	Part Name:	Quantity:	Unit Weight(g):	Weight (g) :	Determination:
CONTAINER	SD Card Module	1	6	6	DS
	SD Card(SanDisk Ultra)	1	1	1	M
	Arduino Pro Micro	1	7	7	DS
	Battery(ORION 14500 AA)	1	19,5	19,5	DS
	PCB	1	7.5	7.5	E
	DC-DC Converter (MP23070N)	1	2	2	M
	10-DOF IMU(MPU-9255+BMP280)	1	2	2	M
	Switch(KTS102)	1	2	2	DS
	Buzzer	1	5	5	DS

TOTAL	52 g

STRUCTURAL ELEMENTS

CONTAINER	Container Body	1	73	73	M
	Parachute	1	10	10	DS
	Depron	0.04 m^3	209	8	E
	Hinge	3	2	6	M
	Fire Stop Box	1	5	5	CE
	Carbon Fiber Stick	2	1	2	M

CE: CAD Estimate
M: Measurement

DS: Data Sheet
E: Estimate

TOTAL	104g

CONTAINER ELECTRONIC + CONTAINER STRUCTURAL = CONTAINER MASS

52 g + 104 g = 156 g

Mass Budget (4 of 4)

Electronic Components	262 g
Structural Components	231.2 g
Total Mass	493.2 g
Margins	6.8 g

Reasons of Uncertainties:
The weights of materials such as screws, epoxy electronic cables can not be predicted precisely. When we consider such materials, 6.8 g of margin is added.
RN#1: Total mass of the CanSat (science payload and container) shall be 500 grams +/- 10 grams.

MARGIN	
Mass Requirement - Total Mass = Margin	**500 g - 493.2 g = 6.8 g**

Total Payload Mass= 337.2 g + 2.8 g (Margin) = 340 g **Total Container Mass = 156 g + 4 g (Margin) = 160 g**

The amount of fiberglass material used for the container is higher than the payload, so more margin is added to the container.

Correction Methods	
If weight of Cansat < 490 g	The wall thickness of the container will be increased.
If weight of CanSat > 510 g	The wall thickness of the container will be decreased.

Communication and Data Handling (CDH) Subsystem Design

Ayse EROGLU

CDH Overview (1 of 2)

Payload Overview

Teensy 3.6 This is a microcontroller that is used to control all components

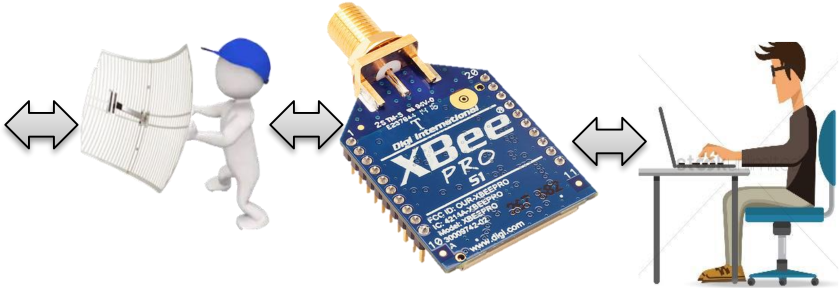
SQ11 This is a camera module that is used for bonus mission (camera has an internal SD card module)

XBee Pro S1 This is an RF Module that is used for communication to the ground station.

SanDisk Ultra 16 GB memory card used to record telemetry data

SanDisk Ultra 16 GB This is a memory card that is used to record video for bonus mission. It is located on the camera..

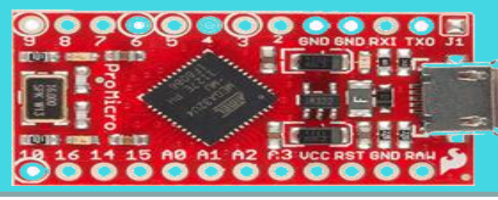
A24-HASM-450
We use an external antenna to increase the gain of the RF module.



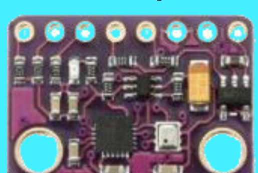
CDH Overview (2 of 2)

Container Overview

ARDUINO PRO MICRO : Required for release mechanism, calculate altitude and buzzer operation.



ELECTRONIC COMPONENTS : IMU-10DOF is required to measure pressure and temperature.



SD CARD : It will be used to save taken data from IMU-10DOF.

CDH Changes Since PDR (1 of 2)

1-) Payload Microcontroller

Processor	Boot Time (Second)	Processor Speed (MHz)	RAM (KB)	Flash Memory (kB)	Operating Voltage (V)	Data Interface	Price ($)	Selected
Arduino Nano	7-9	16	2	3	5	- 14 Digital Pins - 6 PWM Pins - 1 Serial Pins - 1 SPI Pins - 1 I2C Pins	27	✗
Teensy 3.6	2-3	180	256	1024	3.3	- 62 Digital Pins - 6 Serial Pins - 3 SPI Pins - 4 I2C Pins - 22 PWM Pins	29.85	✓

REASONS = Teensy 3.6 is low operating voltage, high processor speed, high flash memory, high RAM and included on the RTC. Also have a 32-bit processor. We are replacing the microcontroller we have used in PDR.

CDH Changes Since PDR (2 of 2)

2-) Payload Real-Time Clock

Model	Operating Voltage (V)	Interface	Size (mm)	Weight (g)	Price ($)	Selected
DS1307	5	I2C	25.8x21.7x5	2.3	1.50	✖
TEENSY 3.6 RTC	3	I2C	Included on the Microcontroller		Free	✔

REASONS = Teensy 3.6 RTC is low operating voltage, free, no size and weight.

3-) Payload and Container Memory

Model	Memory (GB)	Interface	Speed (Mb/s)		Price ($)	Selected
			Write	Read		
SanDisk Ultra SD Card 4GB	4	SPI	75	80	5	✖
SanDisk Ultra SD Card 16GB	16	SPI	75	80	4	✔

REASONS = SanDisk Ultra 16 GB is high memory capacity because of more memory required for video recording also more available in the stores.

CDH Requirements (1 of 2)

Requirement Number	Requirement	Rationale	Priority	VM			
				A	I	T	D
RN#20	The science payload shall measure altitude using an air pressure sensor	Competition Requirement	HIGH	√		√	√
RN#21	The science payload shall provide position using GPS.	Competition Requirement	HIGH	√		√	√
RN#22	The science payload shall measure its battery voltage.	Competition Requirement	HIGH	√		√	√
RN#23	The science payload shall measure outside temperature.	Competition Requirement	HIGH	√		√	√
RN#24	The science payload shall measure the spin rate of the auto-gyro blades relative to the science vehicle	Competition Requirement	HIGH	√		√	√
RN#25	The science payload shall measure pitch and roll.	Competition Requirement	HIGH		√		
RN#26	The probe shall transmit all sensor data in the telemetry	Competition Requirement	HIGH	√	√	√	
RN#29	The ground station shall generate a csv file of all sensor data as specified in the telemetry section.	Competition Requirement	HIGH	√	√	√	
RN#30	Telemetry shall include mission time with one second or better resolution. Mission time shall be maintained in the event of a processor reset during the launch and mission.	Competition Requirement	HIGH	√		√	

CDH Requirements (2 of 2)

Requirement Number	Requirement	Rationale	Priority	VM			
				A	I	T	D
RN#31	XBEE radios shall be used for telemetry. 2.4 GHz Series radios are allowed. 900 MHz XBEE Pro radios are also allowed.	Competition Requirement	HIGH	√	√	√	
RN#32	XBEE radios shall have their NETID/PANID set to their team number.	Competition Requirement	MEDIUM	√	√		
RN#33	XBEE radios shall not use broadcast mode.	Competition Requirement	MEDIUM	√	√		
RN#36	All telemetry shall be displayed in real time during descent.	Competition Requirement	HIGH		√	√	
RN#37	All telemetry shall be displayed in engineering units (meters, meters/sec, Celsius, etc.)	Competition Requirement	HIGH	√			√
RN#38	Teams shall plot each telemetry data field in real time during flight.	Competition Requirement	HIGH	√	√	√	
RN#42	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.	Competition Requirement	HIGH	√	√		

Payload Processor & Memory Selection (1 of 2)

Processor	Boot Time (Second)	Processor Speed (MHz)	RAM (KB)	Flash Memory (kB)	Operating Voltage (V)	Data Interface	Power Consumption (Wh)	Data Bus Width (bit)	Price ($)
Teensy 3.6	2-3	180	256	1024	3.3	62 Digital Pins 6 Serial Pins 3 SPI Pins 4 I2C Pins 22 PWM Pins	0.522	32	29.85

Final Selected Model

Teensy 3.6

- Low Operating Voltage
- Suitable Processor Speed
- Suitable Flash Memory
- Suitable RAM
- Included on the RTC
- Included on the SD Card Slot

Boot Time = **The program is determined by time it takes to open the program after loading it to the microcontroller.**

Payload Processor & Memory Selection (2 of 2)

Model	Memory (GB)	Interface	Speed (MB/s)		Price ($)
			Write	Read	
SanDisk Ultra SD 16GB	16	SPI	75	80	4

Final Selected Model

SanDisk Ultra SD 16 GB

- Suitable Memory Capacity
- More available in the stores
- Speed of Write and Read

Payload Real-Time Clock

Model	Operating Voltage (V)	Interface	Size (mm)	Weight (g)	Price ($)
TEENSY 3.6 RTC	3	I2C	Included on the Microcontroller		Free

Final Selected Model

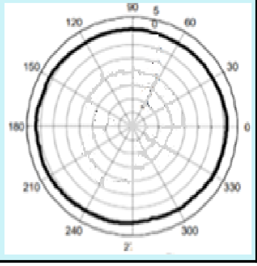
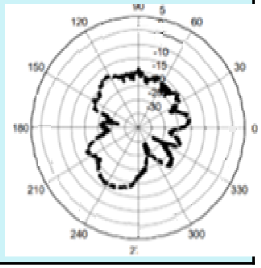
Teensy 3.6 RTC

- Free because Included on the Microcontroller
- Low Operating Voltage
- No Size and Weight

HARDWARE

The RTC has a built-in power detection circuit that detects power failures and automatically switches to a backup source. **The RTC is an always powered block that remains active in all low power modes and is powered by the battery power supply**. The battery power supply ensures that the RTC registers retain their state during chip power-down and that the RTC time counter remains operational. So **saves the data to the EEPROM in Teensy 3.6 during the power failure and the data aren't reset.**

Payload Antenna Selection

Payload Antenna	Range (km)	Frequency (GHz)	Gain (dBi)	Connector Type	Mass (g)	Price ($)	Patterns	
							Vertical	Horizontal
A24-HASM-450	1.75	2.4	2.14	RP-SMA	10	9.2		

Final Selected Model

A24-HASM-450

- Acceptable Size
- Easy Connection
- Suitable Range
- Suitable dBi
- Suitable Mass

A24-HASM-450 antenna was used in the tests and the tests were successfully completed. 10 grams of antenna weight isn't a problem for our general CanSat system. Range, frequency, gain values are as adequate for system performance.

Payload Radio Configuration (1 of 2)

Model	Supply Voltage (V)	Sensitivity (dBm)	Current (mA)		Transmit Power Output (mW)	Operating Frequency (GHz)	Price ($)
			Transmit	Receive			
XBee Pro S1	2.8 - 3.4	-100	215	55	63	2.4	36

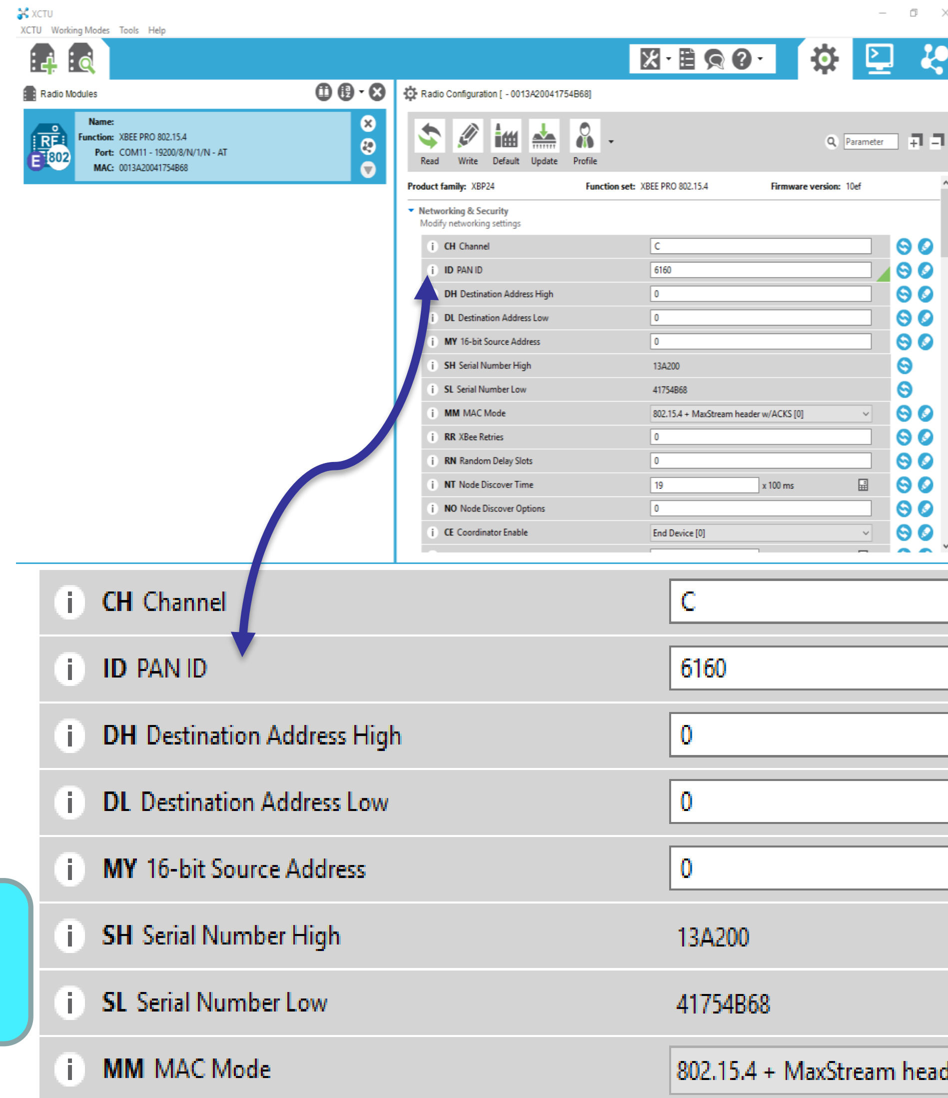
Final Selected Model

XBee Pro S1

- Suitable Working Current
- Suitable Sensitivity
- Low Supply Voltage
- Suitable Transmit Power Output
- Suitable Operating Frequency

Transmission Control

The selected model is XBee Pro S1. The calibration command is transmitted from the ground station to the Payload via Xbee Pro S1, explorer module, antenna.Payload, every second during the flight (1 Hz) will send the telemetry package to the ground station. Data will be simultaneously saved to SD card. **When Payload is into the rocket, Xbee on CanSat will send the data to Xbee on the Ground Station and data transmission continues until the buzzer will be activated at the last 5 meters. After data transmission will be stopped.**



Other tests related to communication are detailed in the ‘’ CanSat Integration and Test ‘’ section.

NETID:6160
CAST MODE:Unicast

Data Format

TEAM ID , MISSION TIME , PACKET COUNT , ALTITUDE , PRESSURE , TEMP , VOLTAGE , GPS TIME , GPS LATITUDE , GPS LONGITUDE , GPS ALTITUDE , GPS SATS , PITCH , ROLL , BLADE SPIN RATE , SOFTWARE STATE , BONUS DIRECTION

Example Data Format

6160 , 15 , 60 , 550.6 , 1079.4 , 40 , 12.67 , 12:10:01 , 42.1526 , 73.8061 , 102.5 , 22 , 75 , 82 , 35 , 6 , 7

Data will be transmitted at a rate of 1 Hz in bursts.

The telemetry data file shall be named as follows:
Flight_6160.csv

The presented telemetry format match the Competition Guide requirements

TEAM ID	is the assigned team identification
MISSION TIME	is the time since initial power up in seconds.
PACKET COUNT	is the count of transmitted packets, which is to be maintained through processor reset.
ALTITUDE	is the altitude in units of meters and must be relative to ground level. The resolution must be 0.1 meters.
PRESSURE	is the measurement of atmospheric pressure in units of pascals. The resolution must be 0.1 pascals.
TEMP	is the sensed temperature in degrees C with one tenth of a degree resolution.
VOLTAGE	is the voltage of the CanSat power bus. The resolution must be 0.01 volts.
GPS TIME	is the time generated by the GPS receiver. The time must be reported in UTC and have a resolution of a second.
GPS LATITUDE	is the latitude generated by the GPS receiver in decimal degrees with a resolution of 0.0001 degrees

Payload Telemetry Format (3 of 4)

GPS LONGITUDE	is the longitude generated by the GPS receiver in decimal degrees with a resolution of 0.0001 degrees.
GPS ALTITUDE	is the altitude generated by the GPS receiver in meters above mean sea level with a resolution of 0.1 meters
GPS SATS	is the number of GPS satellites being tracked by the GPS receiver. This must be an integer number.
PITCH	is the tilt angle in the pitch axis in degrees. The resolution must be 1 degree.
ROLL	is the tilt angle of the roll axis in degrees. The resolution must be 1 degree.
BLADE SPIN RATE	is the rate the auto-gyro blades spin relative to the science payload. The units must be in revolutions per minute (rpm). The resolution must be 1 rpm.
SOFTWARE STATE	is the operating state of the software. (boot, idle, launch detect, deploy, etc.)
BONUS DIRECTION	is the direction the camera is pointed relative to earth's magnetic north specified in degrees.

Payload Telemetry Format (4 of 4)

INCOMING DATA TO GROUND STATION

REAL-TIME PLOTTING	JUST SHOWN	OTHER
ALTITUDE	TEAM ID	GPS LATITUDE (SHOW ON MAP)
PRESSURE	MISSION TIME	GPS ALTITUDE (SHOW ON MAP)
TEMP	PACKET COUNT	GPS LONGITUDE (SHOW ON MAP)
VOLTAGE	SOFTWARE STATE	PITCH (SHOW IN 3D)
BLADE SPIN RATE	GPS TIME	ROLL (SHOW IN 3D)
BONUS DIRECTION	GPS SATS	

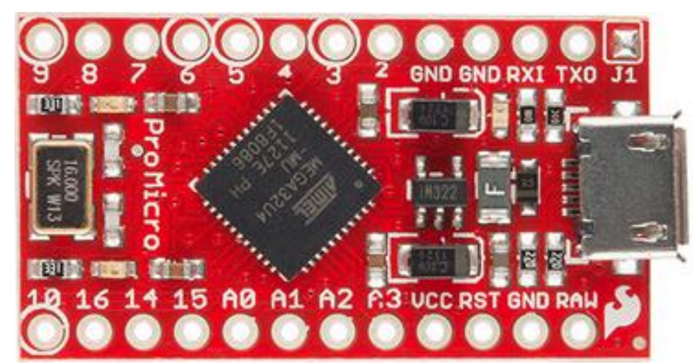
Container Processor & Memory Selection (1 of 2)

Processor	Boot Time (Seconds)	Processor Speed (MHz)	RAM (Byte)	Flash Memory (kB)	Operating Voltage (V)	Data Interface	Power Consumption (Wh)	Data Bus Width (bit)	Price ($)
Arduino Pro Micro	7-9	16	2048	32	5	12 Digital Pins 4 Analog Pins 5 PWM Pins	0.19	8	19.95

Final Selected Model

Arduino Pro Micro

- Suitable Flash Memory
- More Pin Count
- Suitable RAM Capacity
- Suitable Processor Speed



Container Processor & Memory Selection (2 of 2)

Model	Memory (GB)	Interface	Speed (MB/s)		Price ($)
			Write	Read	
SanDisk Ultra SD 16GB	16	SPI	75	80	4

Final Selected Model

SanDisk Ultra SD 16 GB

- Suitable Memory Capacity
- More available in the stores
- Speed of Write and Read

SD card is used with **Arduino SD card Module (Connector Type SPI)**

Electrical Power Subsystem Design

Ayşe EROGLU

PAYLOAD COMPONENTS

All sensors in the payload will be connected to the MCU with powered by a lithium-ion battery.

A 3V battery will also be used for the built-in RTC.

An external on/off switch is used to control system power for payload.

We will be obtained to 3.3V via voltage regulator and XBee will be supplied with this voltage value.

The Battery voltage is measured by voltage sensor connected to the MCU.

We will use reset button for payload reset.

The voltage regulator is used to arrange voltage arriving from the battery.

Temperature, air pressure, altitude and tilt will be taken from the IMU sensor powered by 5V line.

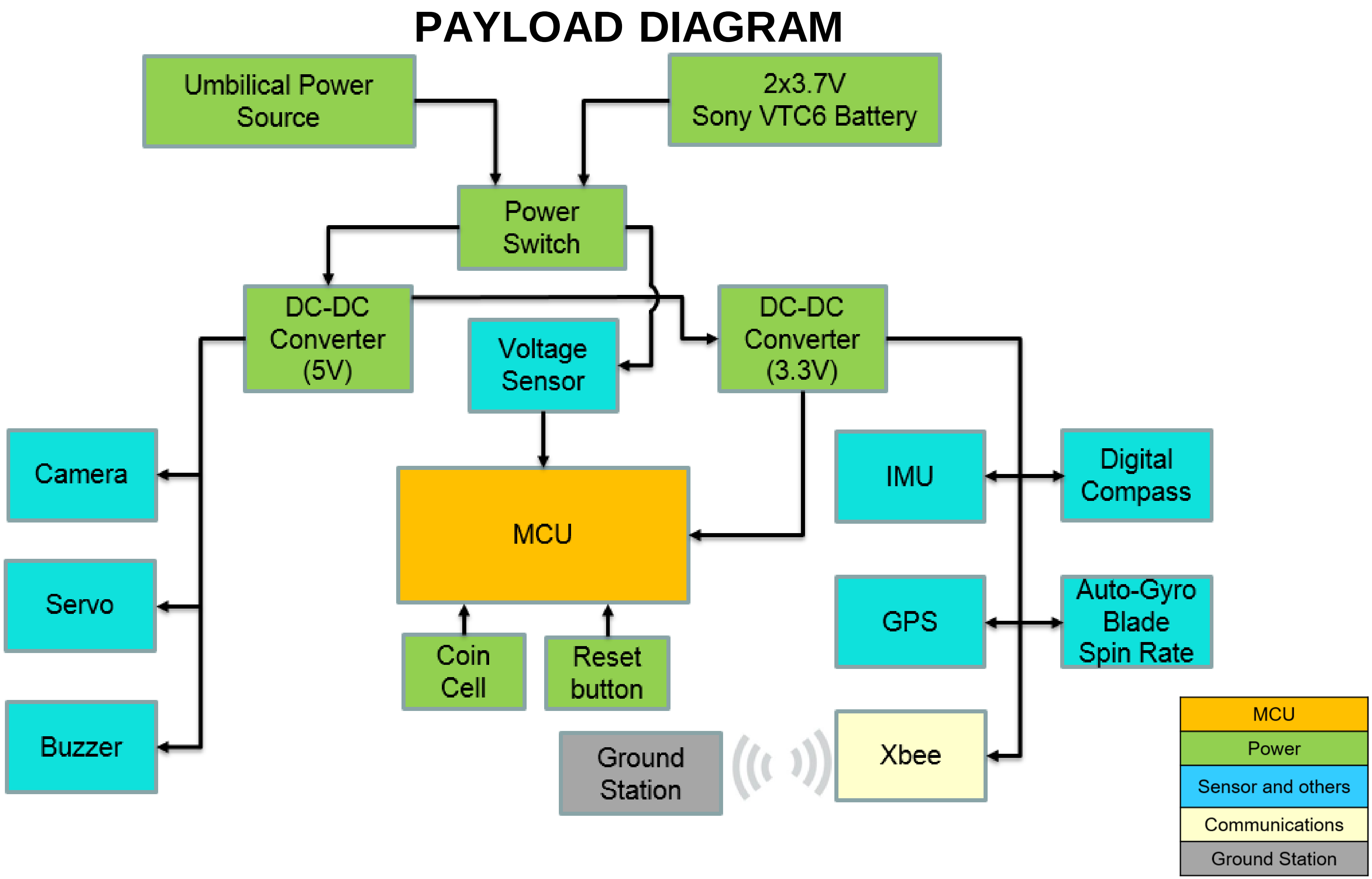
We will use a servo motor and Digital Compass with powered by 5V line for camera stabilization and changing of camera direction.

The blade spin rate of the propeller will be measured with a hall effect sensor.

The umbilical power source is used for the external supply.

92 dB buzzer will be used for Payload recovery.

We will use GPS with powered by 5V line to find the location of the payload.

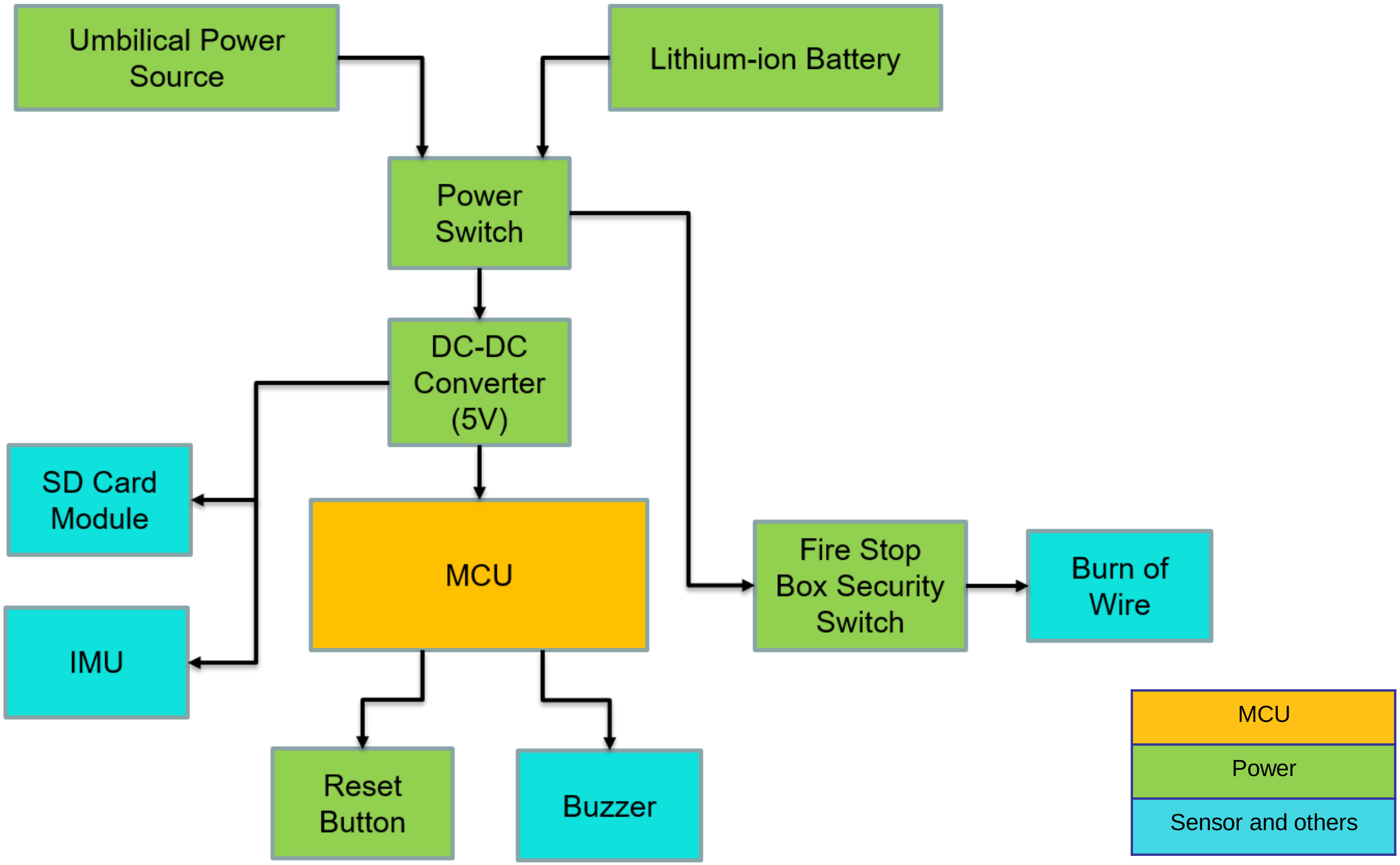


PAYLOAD DIAGRAM
Umbilical Power Source
2x3.7V Sony VTC6 Battery
Power Switch
DC-DC Converter (5V)
Voltage Sensor
DC-DC Converter (3.3V)
Camera
MCU
IMU
Digital Compass
Servo
GPS
Auto-Gyro Blade Spin Rate
Coin Cell
Reset button
Buzzer
Ground Station
Xbee
MCU
Power
Sensor and others
Communications
Ground Station

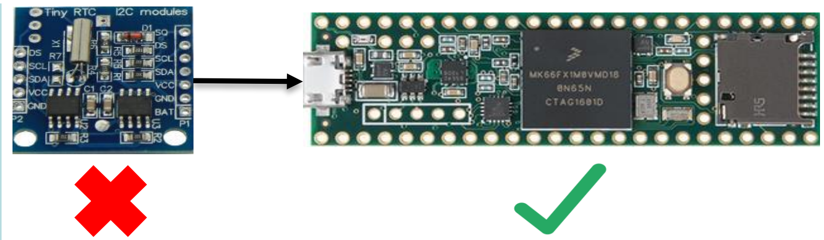
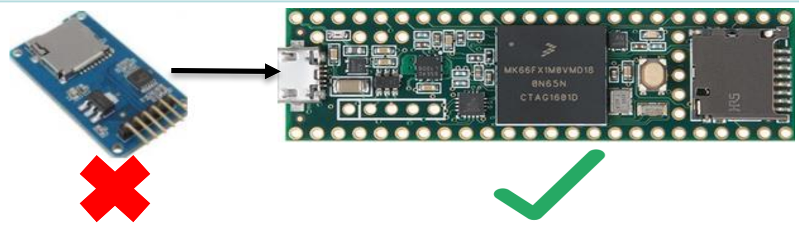
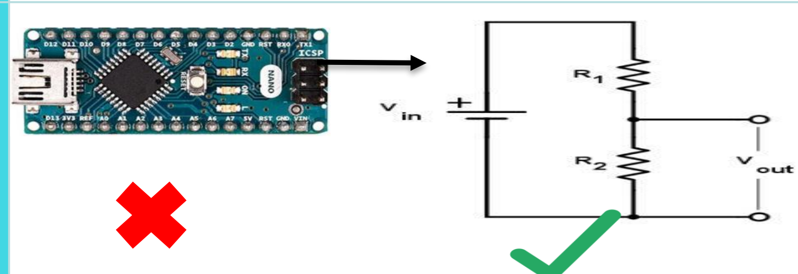
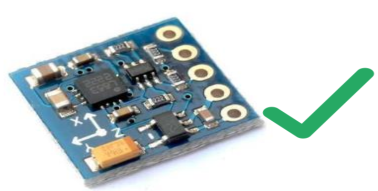
CONTAINER COMPONENTS

- All sensors in the container will be connected to the Arduino Pro Micro with powered by a lithium-ion battery.
- The umbilical power source is used for the external supply.
- An external on/off switch is used to control system power for container.
- The burn of wire method will be used for separation payload from the container
- The battery voltage is measured by the Arduino Pro Micro analog pin.
- We will use reset button for container reset.
- The voltage regulator is used to arrange voltage arriving from the battery.
- 92 dB buzzer will be used for container recovery.
- We will be used IMU with powered by 5V line for separation system control.

CONTAINER DIAGRAM



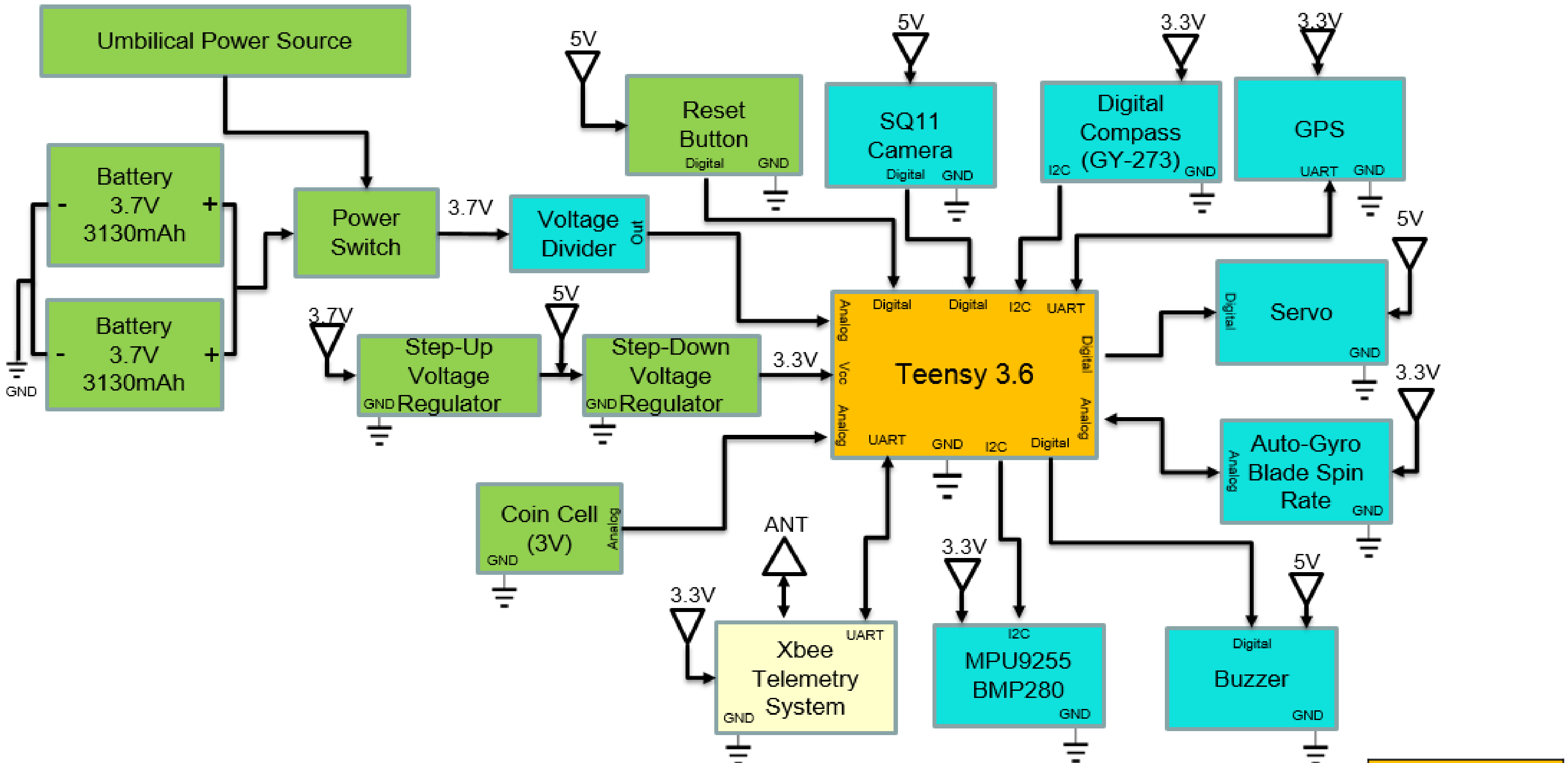
EPS Changes Since PDR

	SENSOR	WHY
The DS1307 RTC was removed.		• Low power consumption. • The DS1307 RTC was removed, instead of Teensy 3.6 built-in RTC was used. • PCB field gain. • Low weight
SD Card Module removed (Paylaod)		• SD Card Module removed(Paylaod). The Teensy 3.6 built-in SD card Module was used. • PCB field gain. • Low weight
Voltage divider added		• A maximum 3.3V input voltage can be applied to the analog pin of Teensy 3.6 therefore, a voltage sensor is used.
Digital Compass added		• The compass sensor is used to understand the magnetic north direction of the camera.

EPS Requirements

Requirements Number	Requirement	Rational	Priority	VM			
				A	I	T	D
RN#20	The science payload shall measure altitude using an air pressure sensor.	Competition Requirement	MEDIUM	√		√	√
RN#22	The science payload shall measure its battery voltage.	Competition Requirement	MEDIUM	√		√	√
RN#45	The probe must include an easily accessible power switch that can be accessed without disassembling the cansat and in the stowed configuration.	Competition Requirement	HIGH	√	√	√	
RN#46	The probe must include a power indicator such as an LED or sound generating device that can be easily seen without disassembling the cansat and in the stowed state	Competition Requirement	MEDIUM	√	√	√	
RN#47	An audio beacon is required for the probe. It may be powered after landing or operate continuously.	Competition Requirement	HIGH	√		√	
RN#49	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.	Competition Requirement	HIGH	√	√		
RN#51	Spring contacts shall not be used for making electrical connections to batteries. Shock forces can cause momentary disconnects.	Competition Requirement	MEDIUM	√	√		
RN#52	The auto-gyro descent control shall not be motorized. It must passively rotate during descent.	Competition Requirement	HIGH	√		√	√
RN#55	Payload/Container shall operate for a minimum of two hours when integrated into rocket.	Competition Requirement	MEDIUM	√	√		

Payload Electrical Block Diagram

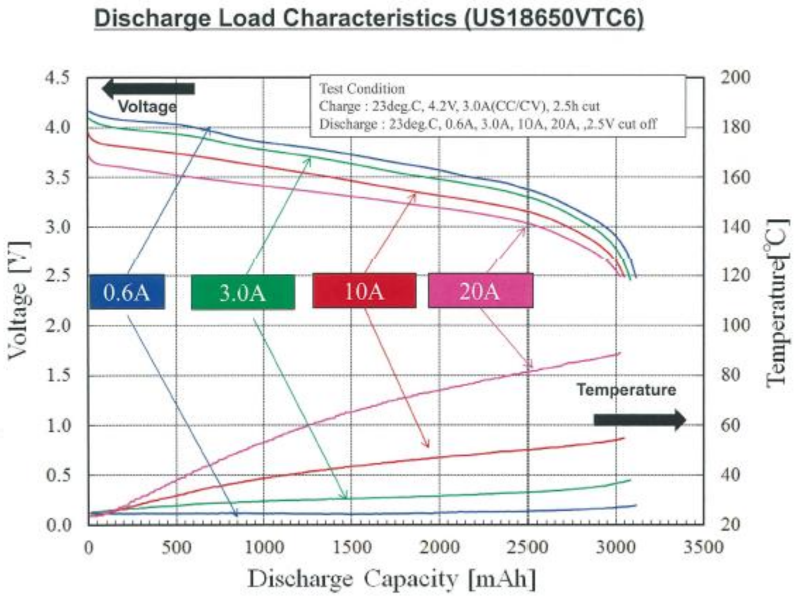


MCU
Power
Sensor and others
Communications

- Electronic system will be on/off by a switch.
- When the system is powered on, the led turn light.
- Buzzer will be activated for 1 second.

Payload Power Source

Model	Sony VTC 6
Battery configuration	Parallel (2p)
Nominal Voltage	3.7 V
Typical Voltage	2.5-4.2 V
Nominal Internal Impedance	13 mΩ Typ.
Average Weight	46.5 g
Typical Volume	17.3 cm^3
Operating Temperature Range	−20°C to 60°C (−4°F to 140°F)
Battery Chemistry	Lithium-ion
Capacity	3130 mAh
Generated Current	10 A



Source: *Sony VTC 6 Datasheet*

Payload Power Budget (1 of 2)

Components	Power Consumption (Wh)	Current (mA)	Voltage (V)	Duty Cycles (hr:min:sec)	Source
Teensy 3.6	0.522	79.13	3.3	02:00:00	Data sheet
Buzzer	0.1	80	5	00:15:00	Data sheet
SQ11-Camera	0.033	200	5	00:02:00	Measurement
10-DOF IMU	0.03	4.42	3.3	02:00:00	Data sheet
Telemetry Module	2.244	340	3.3	02:00:00	Data sheet
Neo 7M GPS	0.264	40	3.3	02:00:00	Data sheet
Servo	0.166	1000	5	00:02:00	Data sheet
Auto-Gyro Blade Spin Rate	0.033	5	3.3	02:00:00	Data sheet
HMC5883L Digital Compass	0.000011	0.1	3.3	00.02.00	Data sheet

Payload Power Budget (2 of 2)

Available Power(Max)	23.162 Wh
Total Power Consumption	3.392 Wh
Margins	19.769 Wh

Available Power(Max) -Total Power Consumption = Margins

- **The margin is changing showed according to the current consumption by sensors at different work temperature.**

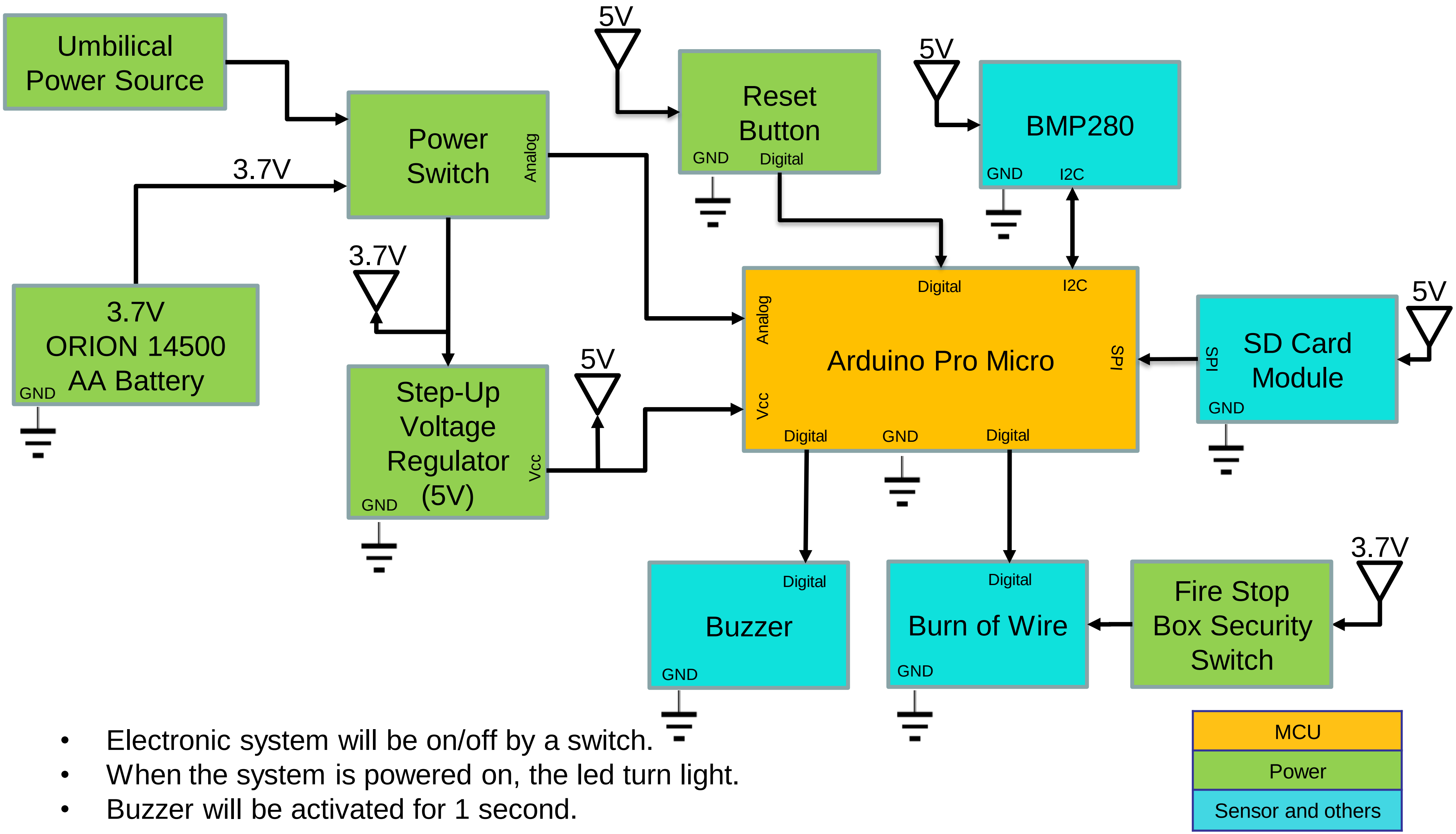
Payload Power Strategy:

(Battery Capacity(Max) / Current Consumption) * 0.707 = Battery operating time

((6260mAh) / (1748.65mA))*0.707 = 2.53h

- **The system will be powered directly with a battery.**
- **The system will work for more than two hours.**

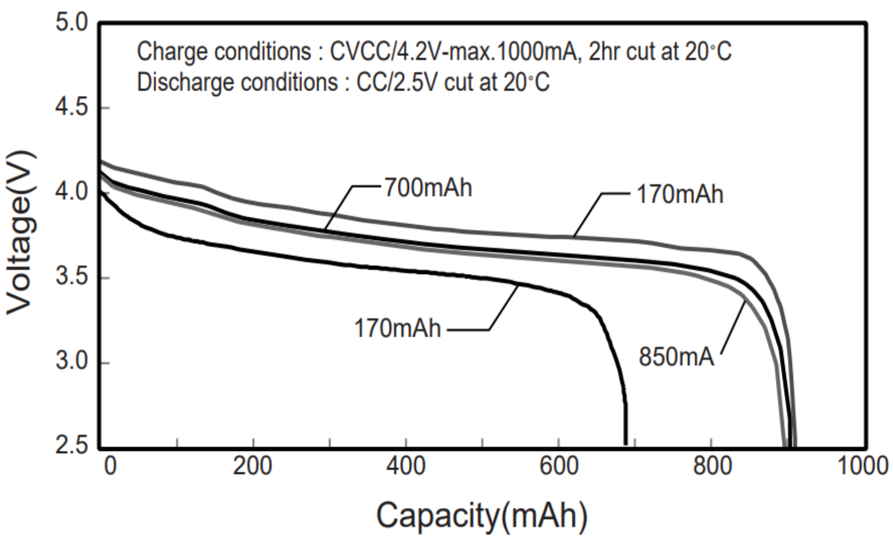
Container Electrical Block Diagram



- Electronic system will be on/off by a switch.
- When the system is powered on, the led turn light.
- Buzzer will be activated for 1 second.

Container Power Source

Model	Orion 14500 AA
Battery configuration	Series (1s)
Nominal Voltage	3.7 V
Typical Voltage	2.5-4.2 V
Average Weight	19.5 g
Dimensions	14,5 x 50,0 mm
Operating Temperature Range	−20°C to 60°C (−4°F to 140°F)
Battery Chemistry	Lithium-ion
Capacity	900 mAh
Generated Current	9 A



Source: *Orion 14500 AA Datasheet*

Container Power Budget

Components	Power Consumption (Wh)	Current (mA)	Voltage (V)	Duty Cycles (hr:min:sec)	Source
Microcontroller	0.19	19	5	02:00:00	Data sheet
Burn of Wire	0.001946	1400	3.7	00:00:01	Measurement
Buzzer	0.1	80	5	00:15:00	Data sheet
10-DOF IMU	0.0442	4.42	5	02:00:00	Data sheet
SD Card Module	0.00016	0.016	5	02:00:00	Measurement

Available Power(Max)	3.33 Wh
Total Power Consumption	0.336 Wh
Margins	2.99 Wh

Container Power Strategy:
(Battery Capacity(Max) / Current Consumption)*0.707 = Battery operating time
(900mAh / 103.436mA)*0.707= 6.15 h

- The system will be powered directly with a battery
- The System will work for more than two hours
- The Burn of wire method draw current less than one second so this current is not calculated.

Flight Software (FSW) Design

Feyzullah HASAR

FSW Overview (1 of 4)

- **Overview of the CanSat FSW design**

The necessary data from the sensors will be transmitted to the MCU. The data will be stored on the SD-card and transmitted to the ground station via XBee.

- **Programming languages**

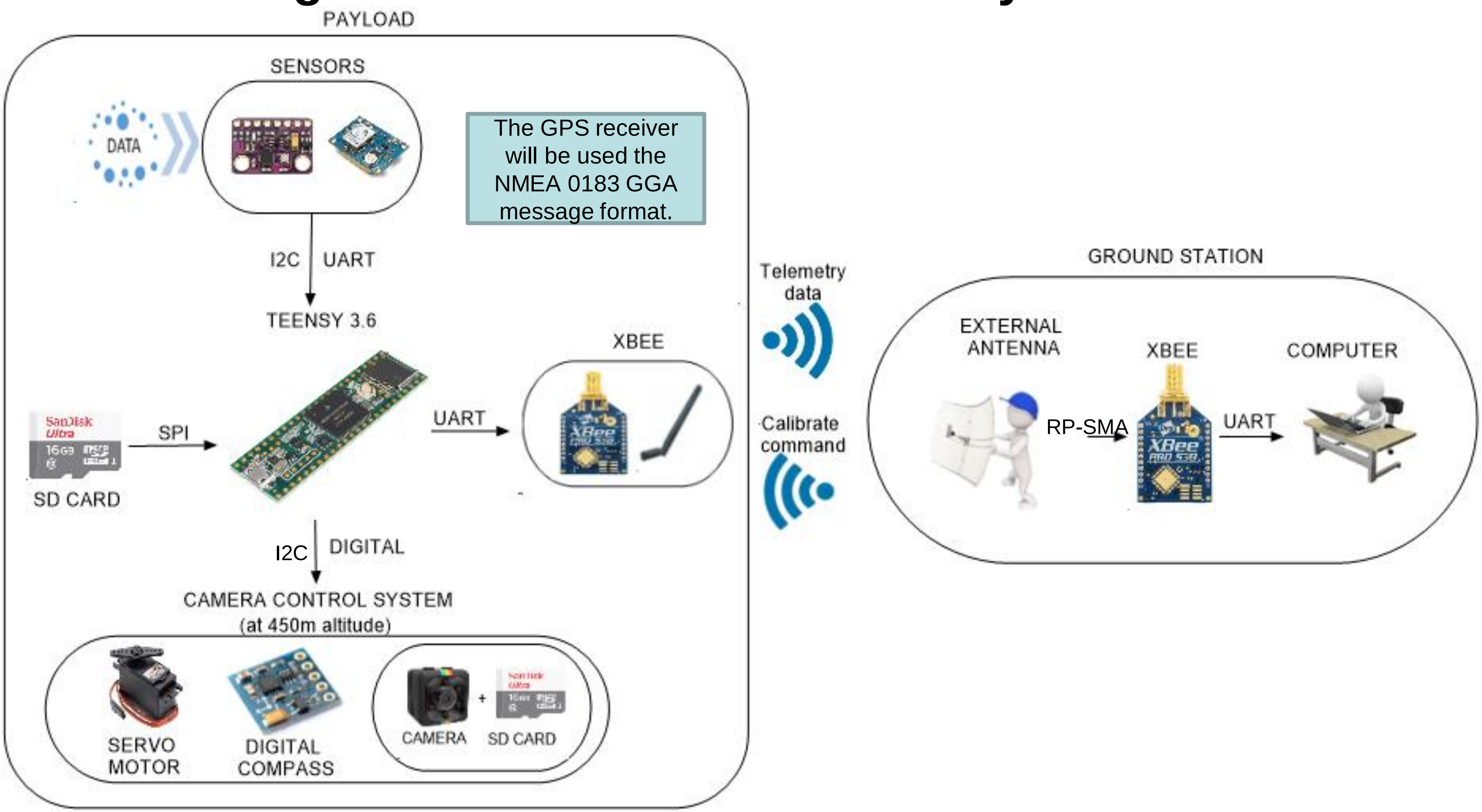
C/C++ programming languages

- **Development environments**

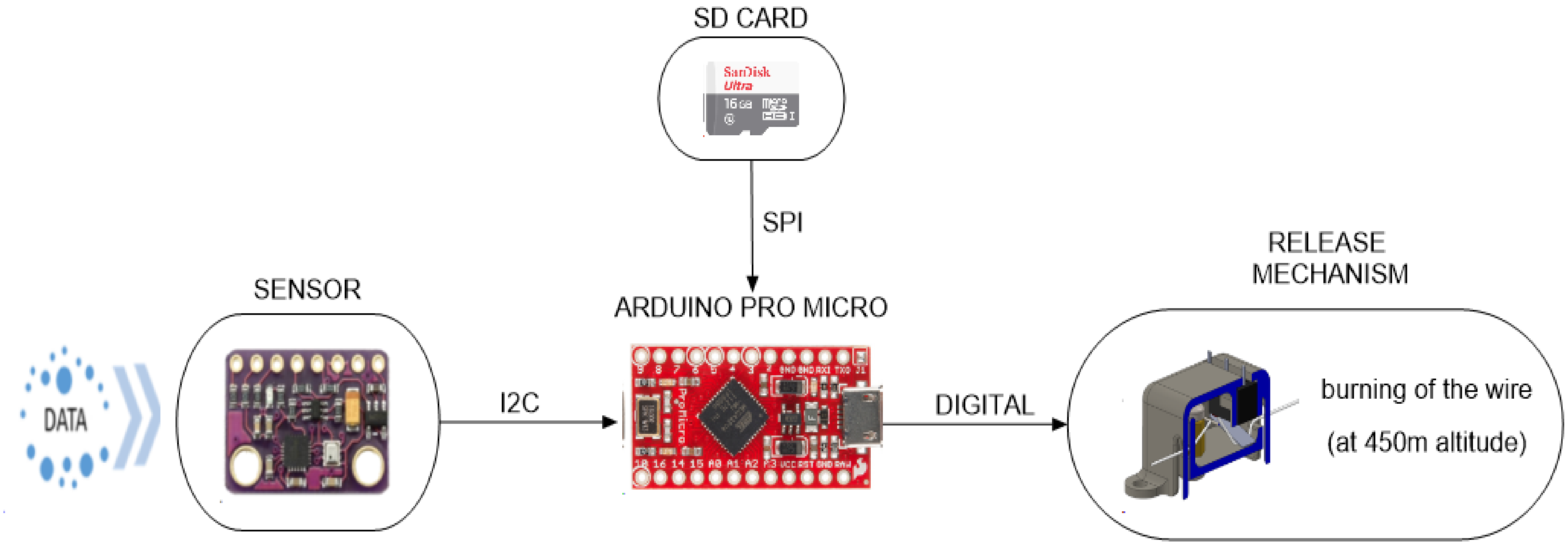
Arduino IDE

ClickCharts by NCH software

- **FSW Design of Basic Flow Chart for Payload**



- **FSW Design of Basic Flow Chart for Container**



- **Brief summary FSW tasks**

- ✓ The electronic system is activated by the power (on / off) button.
- ✓ If "System calibrate" command is received from ground station, EEPROM will be reset, the reference altitude will be determined, roll and pitch angles to zero and system will be calibrated.
- ✓ The data will be gathered from sensors in the container. Those will be saved to the SD card in the container.
- ✓ All necessary data gathered from the sensors will be sent to the ground station in real time via XBee. All necessary data simultaneously will be saved on the SD card that place in the payload.
- ✓ CanSat will launch with the rocket and will release from the rocket after completing the rocket rise and then parachute will be opened.
- ✓ Payload will be released from container via burning of wire at 450 meters (+/-10 meters). Then it will start record video in payload.
- ✓ The buzzer will be activated when the altitude drop below 5 m. Data transmission will be stopped. The buzzer will continue to be ringing until the electronic system is turned off by the power (on / off) button.
- ✓ The mission will be completed.

FSW Changes Since PDR

We used Teensy 3.6 instead of Arduino Nano.

Because;

- It has an internal RTC module,
- It has internal SD-card module,
- The Teensy 3.6 has more flash memory than the Arduino Nano.

Compass sensor has been added to the camera control system.

- We used the compass sensor to understand the magnetic North of the camera.

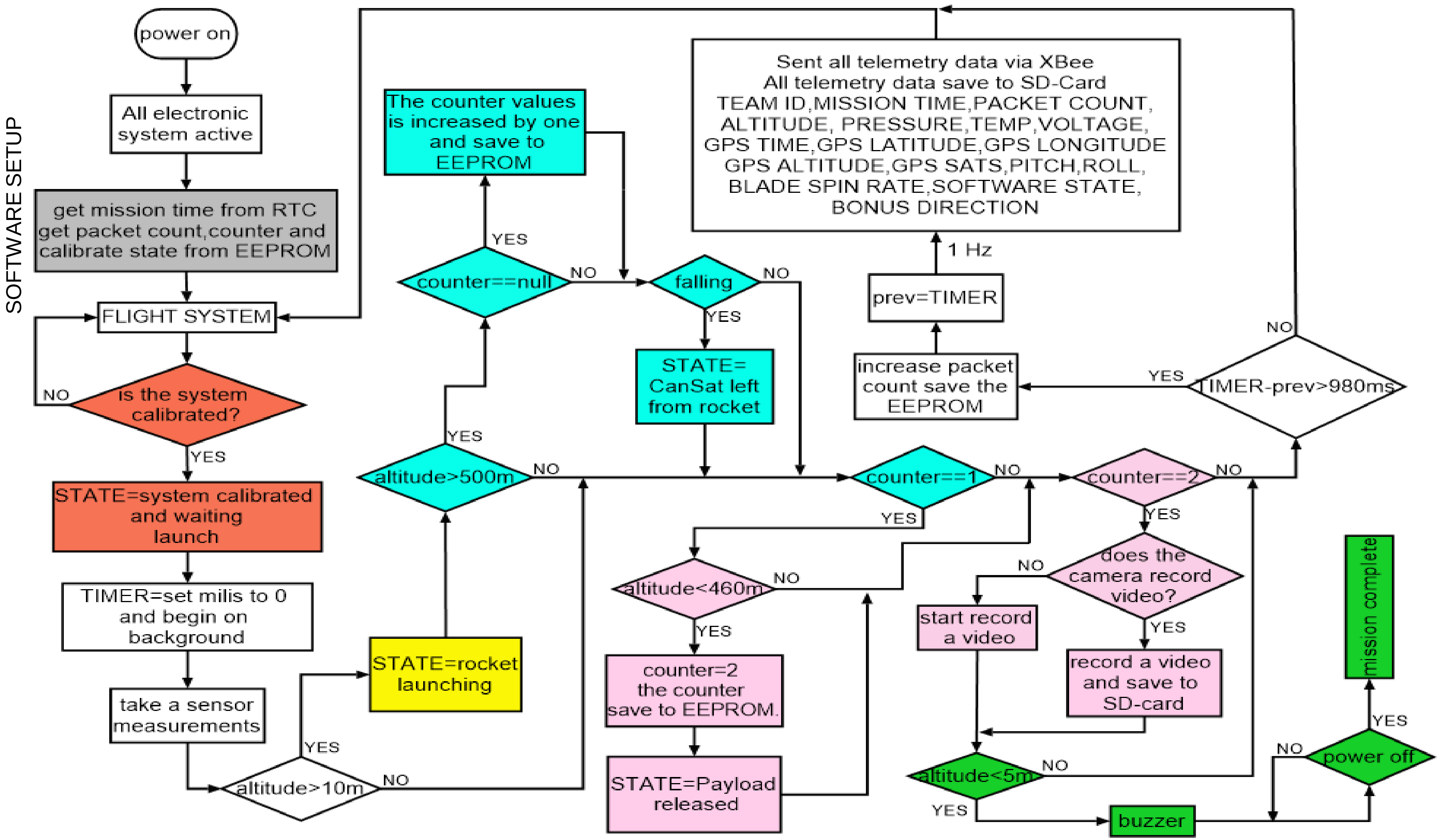
FSW Requirements (1 of 2)

Number	Desciption	Rationale	Priority	VM			
				A	I	T	D
RN#9	The container shall release the payload at 450 meters +/- 10 meters.	Competition Requirement.	HIGH		✓	✓	✓
RN#20	The science payload shall measure altitude using an air pressure sensor	Competition Requirement	HIGH	✓		✓	✓
RN#21	The science payload shall provide position using GPS.	Competition Requirement	HIGH	✓		✓	✓
RN#22	The science payload shall measure its battery voltage.	Competition Requirement	HIGH	✓		✓	✓
RN#23	The science payload shall measure outside temperature.	Competition Requirement	HIGH	✓		✓	✓
RN#24	The science payload shall measure the spin rate of the auto-gyro blades relative to the science vehicle.	Competition Requirement	HIGH	✓		✓	✓
RN#25	The science payload shall measure pitch and roll	Competition Requirement	HIGH		✓		
RN#26	The probe shall transmit all sensor data in the telemetry	Competition Requirement	HIGH	✓	✓	✓	

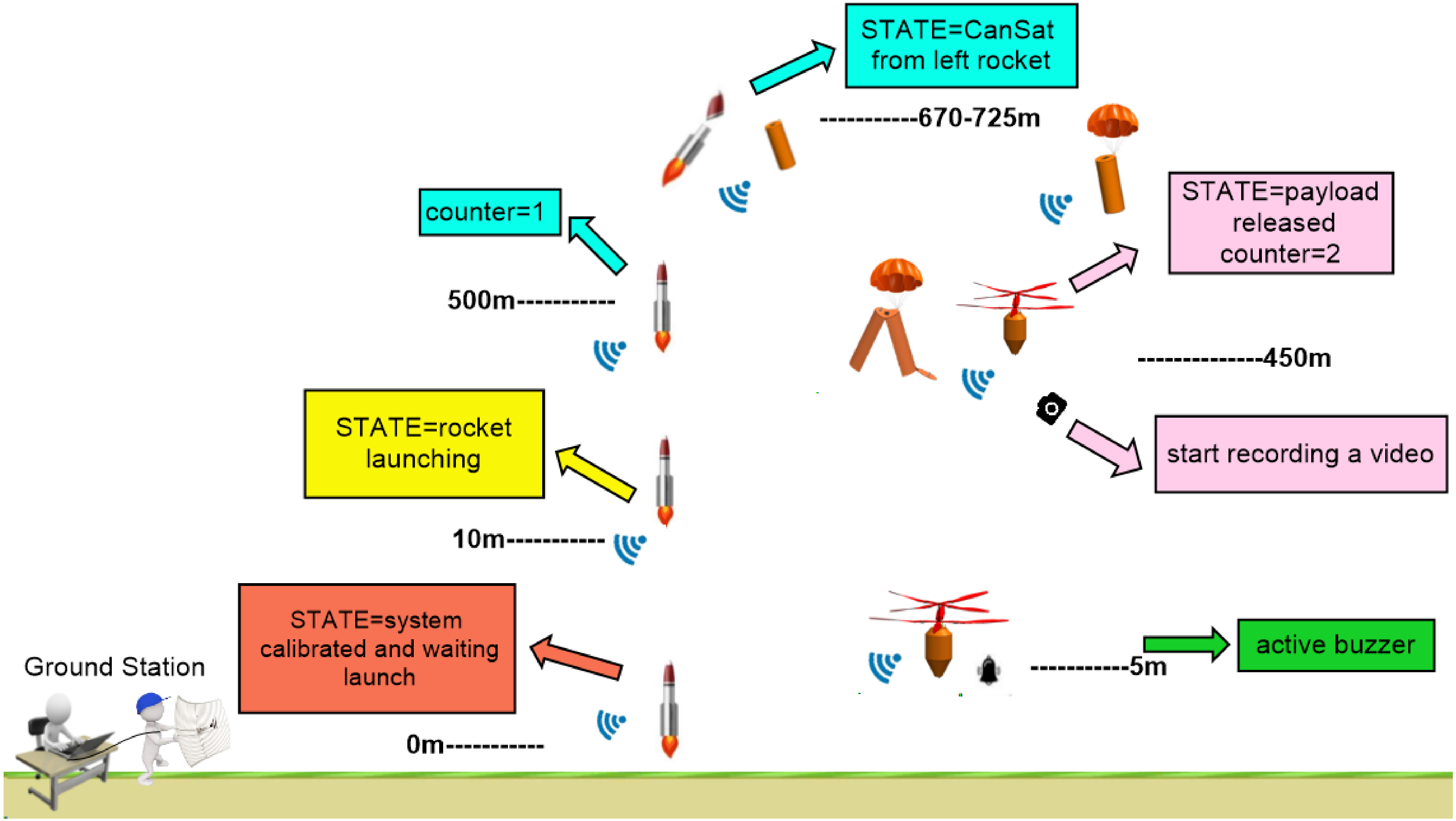
FSW Requirements (2 of 2)

Number	Descption	Rationale	Priority	VM			
				A	I	T	D
RN#28	The ground station shall be able to command the science vehicle to calibrate barometric altitude, and roll and pitch angles to zero as the payload sits on the launch pad.	Competition Requirement	HIGH	✓	✓		
RN#30	Telemetry shall include mission time with one second or better resolution. Mission time shall be maintained in the event of a processor reset during the launch and mission	Competition Requirement	HIGH	✓		✓	
RN#36	All telemetry shall be displayed in real time during descent.	Competition Requirement	HIGH		✓	✓	
RN#37	All telemetry shall be displayed in engineering units (meters, meters/sec, Celsius, etc.)	Competition requirement.	MEDIUM	✓			✓
RN#42	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.	Competition requirement.	HIGH	✓	✓		
RN#53	The GPS receiver must use the NMEA 0183 GGA message format.	Competition requirement.	MEDIUM	✓	✓		

Payload CanSat FSW State Diagram (1 of 3)



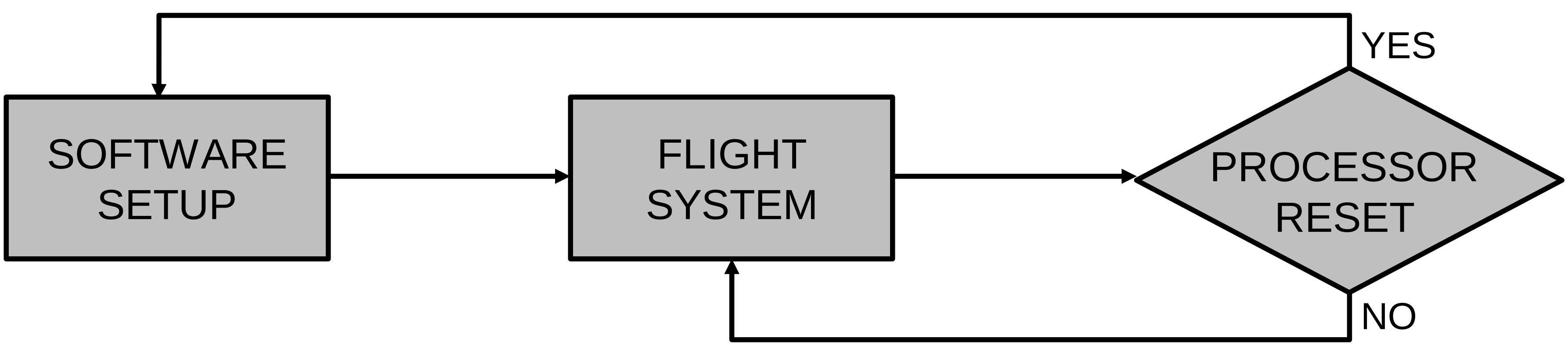
Display of FSW sub functions running during flight according to colors in payload flow chart.



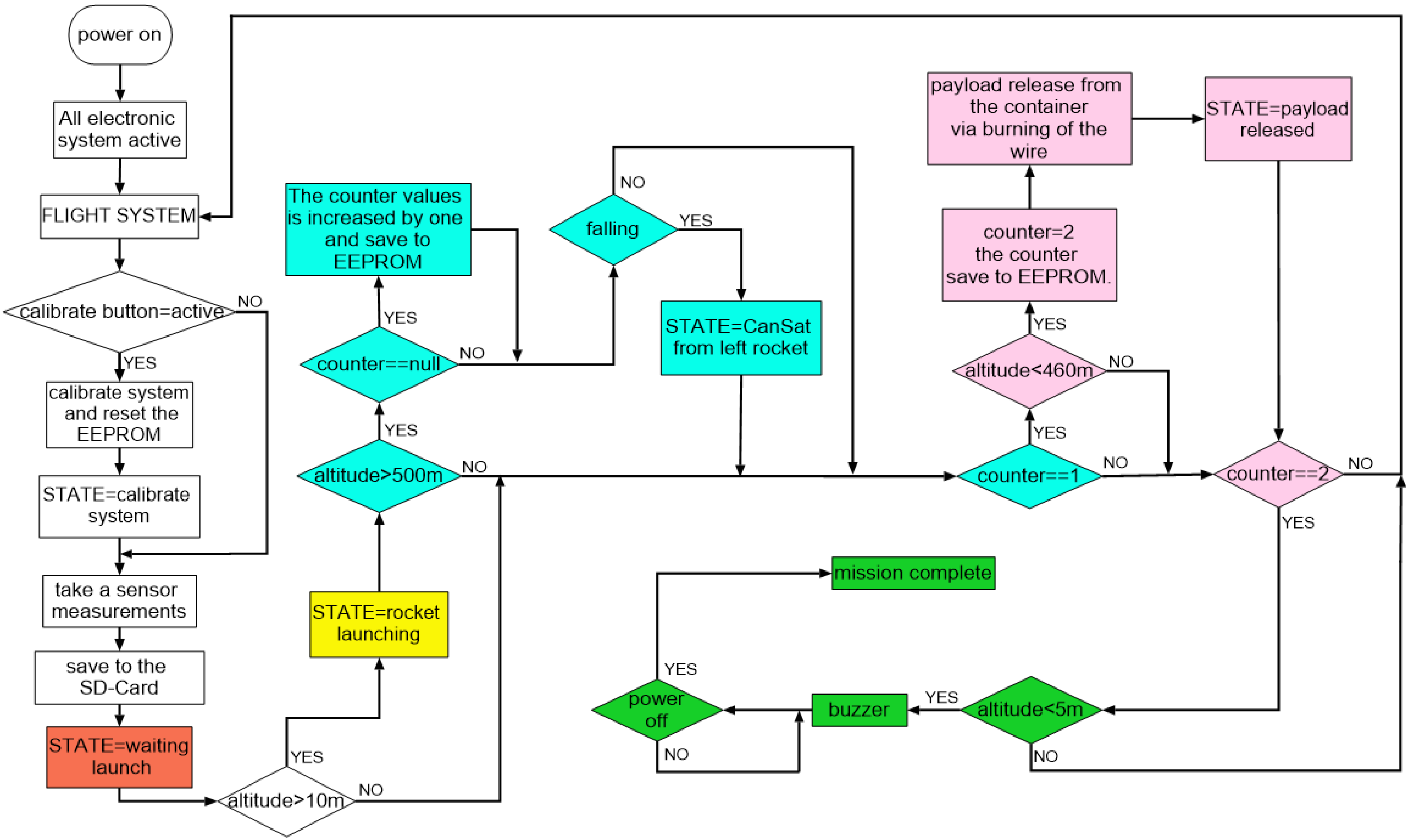
Payload CanSat FSW State Diagram (3 of 3)

Processor Reset Control For Payload

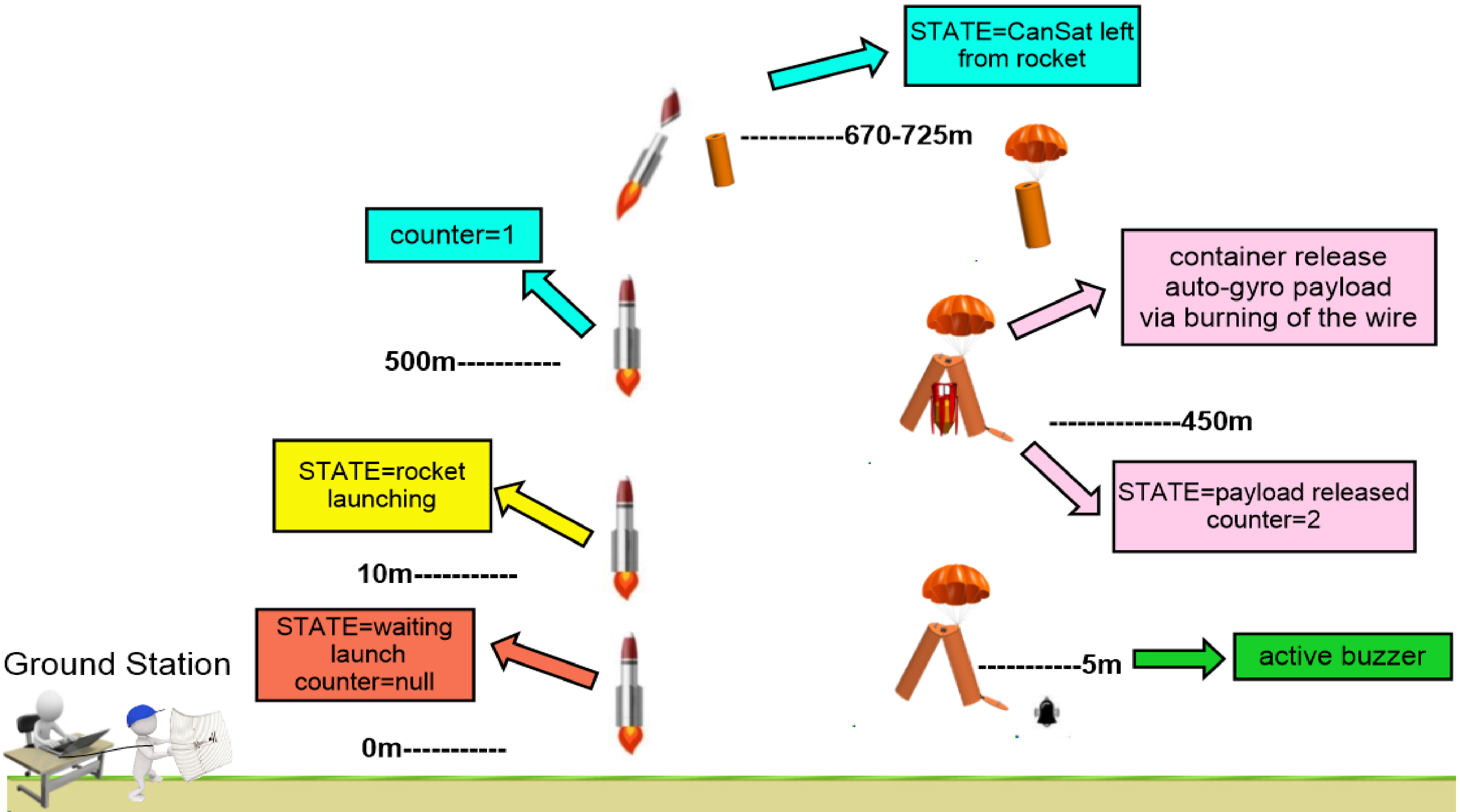
- The processor is reset when there is a temporary power failure.
- The processor will save the required data MCU's EEPROM, in this way data loss will be prevented.
- RTC data is stored in the internal EEPROM of the Teensy 3.6 module. RTC data will be protected when there is an instantaneous power failure.
- Mission time, calibrate state, packet count and counter data will be saved in EEPROM.
- If the processor is reset, data recovered in the software installation section.



Container CanSat FSW State Diagram (1 of 3)



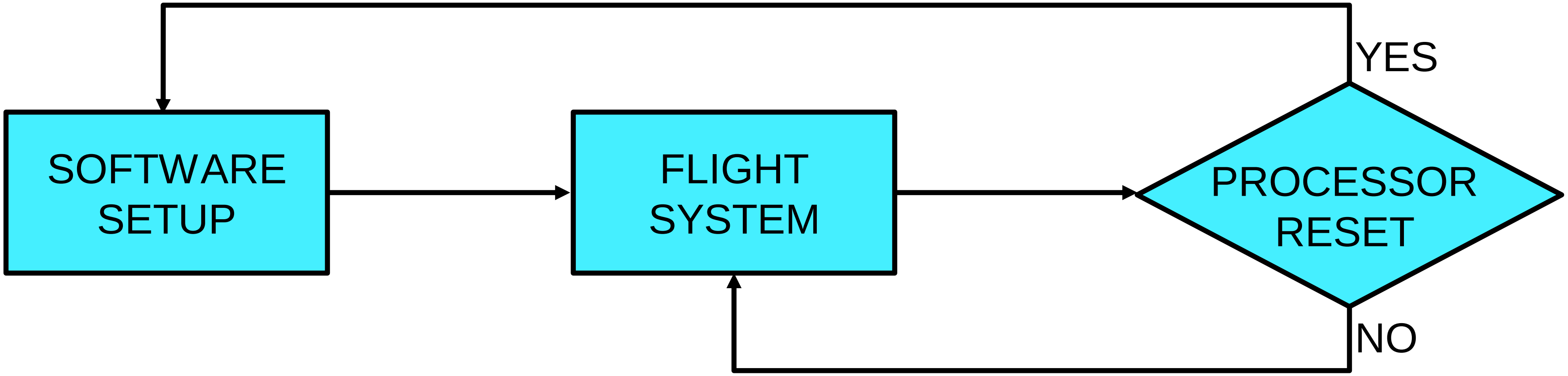
Display of FSW sub functions running during flight according to colors in container flow chart.



Container CanSat FSW State Diagram (3 of 3)

Processor Reset Control for Container

- The processor is reset when there is a temporary power failure.
- The processor saves necessary data on its internal EEPROM; in this way, data loss will be prevented.
- Mission time, packet count and counter data will be saved to EEPROM.



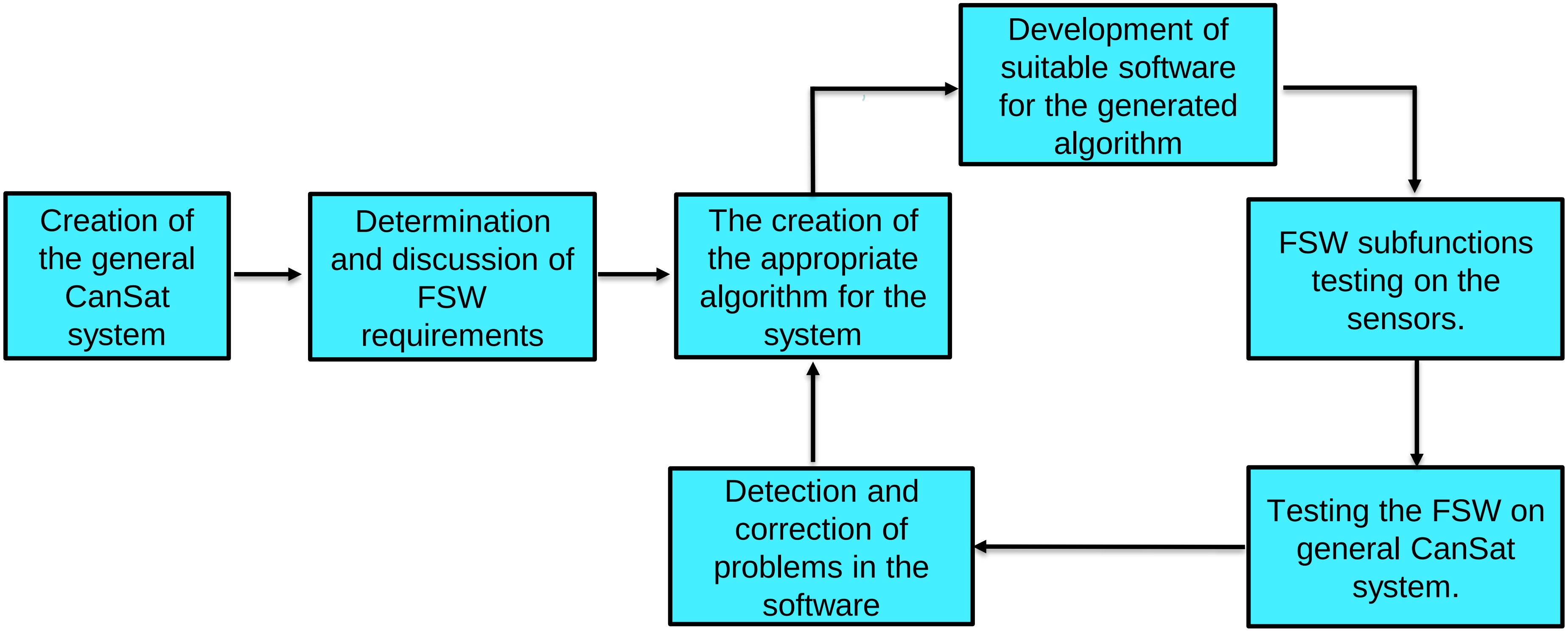
Prototyping and prototyping environments

The required software is installed in Teensy 3.6. → Each sensor tested separately on breadboard. → The data stream is checked from the Serial monitor.

Test methodology

Testing the sensors to be used in the system. → Installation of necessary software in Teensy 3.6 → Checking the accuracy of the data coming from the sensors. → Checking whether the FSW meets the CanSat competition requirements. → Testing the FSW on the general CanSat system.

Software subsystem development sequence



Development team

Feyzullah HASAR
Uğurcan SORUÇ

Software Development Plan (3 of 3)

Progress since PDR

Collection and processing necessary data

- ✓ Data were taken from the sensors used in the FSW system.
- ✓ Created of appropriate software for using camera.
- ✓ The altitude data were calibrated to control the release mechanism.
- ✓ The data from the sensors is saved on the SD card.

Communication

- ✓ The connection was made between XBee and ground station.
- ✓ Calibration of the system was tested via the calibration command get from the ground station.

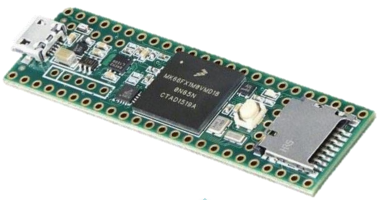
Ground Control System (GCS) Design

Uğurcan SORUÇ

GCS Overview

PAYLOAD

Teensy 3.6



XBee Pro S1

Antenna

Data transmission from the payload to the ground station

- XBee Pro S1 in payload transfers data from Teensy 3.6 to the XBee Pro S1 in the ground station.
- Then data are transferred to the computer using the explorer module.

Data transmission from the ground station to the payload

- The calibration command is transmitted from the ground station to the Payload via XBee Pro S1, explorer module and antenna.

Ground Station Antenna

GROUND STATION

Computer

Explorer Module

XBee Pro S1

GCS Changes Since PDR

- No changes have been made.

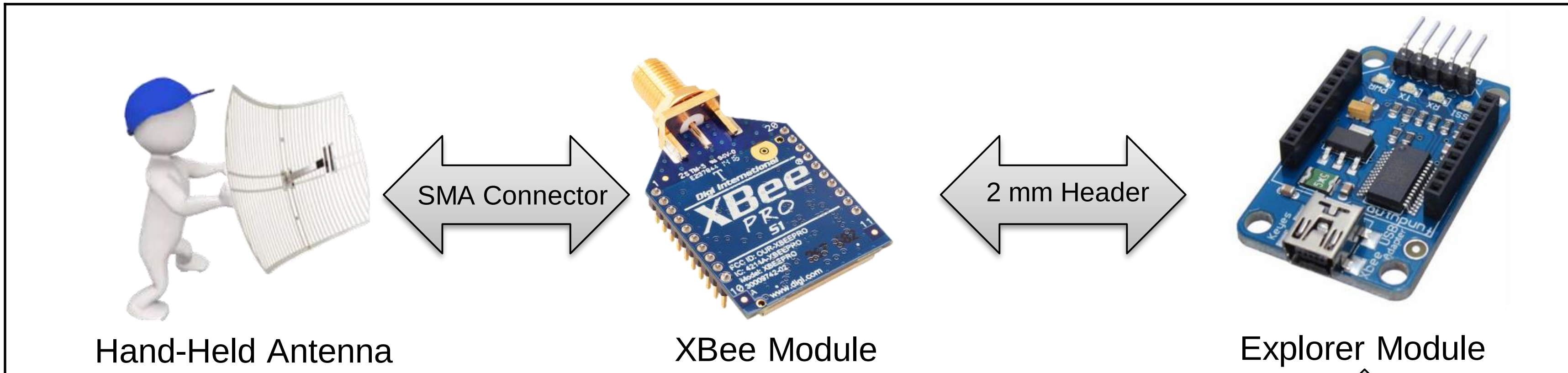
GCS Requirements (1 of 2)

Number	Description	Rationale	Priority	VM			
				A	I	T	D
RN#28	The ground station shall be able to command the science vehicle to calibrate barometric altitude, and roll and pitch angles to zero as the payload sits on the launch pad.	Competition Requirement	HIGH	✓	✓		
RN#29	The ground station shall generate a csv file of all sensor data as specified in the telemetry section.	Competition Requirement	HIGH	✓	✓	✓	
RN#30	Telemetry shall include mission time with one second or better resolution. Mission time shall be maintained in the event of a processor reset during the launch and mission.	Competition Requirement	MEDIUM	✓		✓	
RN#31	XBEE radios shall be used for telemetry. 2.4 GHz Series radios are allowed. 900 MHz XBEE Pro radios are also allowed.	Competition Requirement	MEDIUM	✓	✓	✓	
RN#32	XBEE radios shall have their NETID/PANID set to their team number.	Competition Requirement	MEDIUM	✓	✓		
RN#33	XBEE radios shall not use broadcast mode.	Competition Requirement	MEDIUM	✓	✓		
RN#35	Each team shall develop their own ground station.	Competition Requirement	HIGH	✓	✓	✓	

GCS Requirements (2 of 2)

Number	Description	Rationale	Priority	VM			
				A	I	T	D
RN#36	All telemetry shall be displayed in real time during descent.	Competition Requirement	HIGH		✓	✓	
RN#37	All telemetry shall be displayed in engineering units (meters, meters/sec, Celsius, etc.)	Competition Requirement	HIGH	✓			✓
RN#38	Teams shall plot each telemetry data field in real time during flight.	Competition Requirement	HIGH	✓	✓	✓	
RN#39	The ground station shall include one laptop computer with a minimum of two hours of battery operation, XBEE radio and a hand-held antenna.	Competition Requirement	HIGH	✓			✓
RN#40	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.	Competition Requirement	HIGH	✓	✓		
RN#42	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.	Competition Requirement	MEDIUM	✓	✓		
GCS#1	The link budget must be calculated. According to this calculation, antenna selection should be made.	To select the appropriate antenna	HIGH	✓	✓		

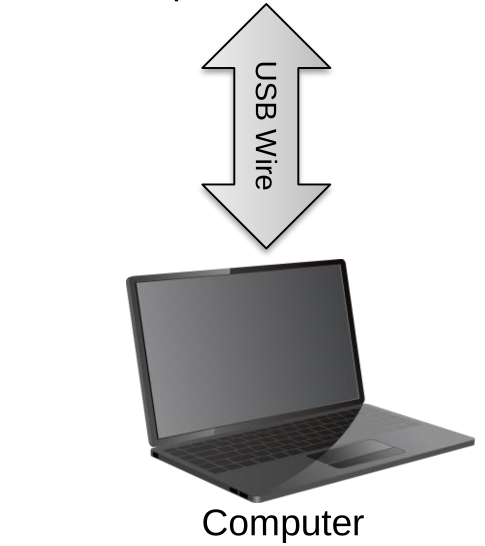
GCS Design



Specifications

★ The computer has got at least 2 hours battery power.

- ➢ Fan and umbrella will be used to protect the computer from high temperature.
- ➢ Power bank using for a fan. (For not to consume the computer battery)
- ➢ Updates will be disabled and the computer will be disconnected from the internet.



Telemetry display screen shots

- We use charts, labels, listview for analyzing the incoming data from the payload.
- The data "," between them transferred to Ground Station will be saved as a .csv file at the end of the mission by adding.
- Telemetry data as a .csv file, the screenshot of the interface, media data recorded on the SD card on the camera will be presented to the jury in the USB memory at the end of the mission.

Listview

Team ID	Mission Time	Packet Count	Altitude	Pressure	Temp	Voltage	GPS Time	GPS Latitude	GPS Longitude	GPS Altitude	GPS Sats	Pitch	Roll	Blade Spin Rate	Software State	Bonus Direction
6160	15:10:11	0	450.5	100	31.5	0,6	15.10	47.5621	34.1308	450.3	21	5	4	8	1	2
6160	15:10:12	1	400.1	100	30.1	0,6	15.10	47.5621	34.1308	400.6	21	2	-4	10	2	5
6160	15:10:13	2	300.4	102	30.0	0,6	15.10	47.5621	34.1308	300.7	21	3	1	9	3	1
6160	15:10:14	3	200.2	101	30.2	0,6	15.10	47.5621	34.1308	200.0	21	1	0	7	3	0
6160	15:10:15	4	155.0	98	32.3	0,6	15.10	47.5621	34.1308	155.1	21	5	0	7	3	0
6160	15:10:16	5	110.7	105	31.4	0,6	15.10	47.5621	34.1308	110.1	21	3	0	7	3	0
6160	15:10:17	6	69.7	100	30.6	0,6	15.10	47.5621	34.1308	69.4	21	-4	2	6	4	0
6160	15:10:18	7	34.9	103	30.8	0,6	15.10	47.5621	34.1308	34.8	21	8	3	9	4	6
6160	15:10:19	8	14.1	103	30.9	0,6	15.10	47.5621	34.1308	14.7	21	1	5	7	5	7
6160	15:10:20	9	2.2	103	29.1	0,6	15.10	47.5621	34.1308	2.8	21	0	1	8	5	8
6160	15:10:21	10	0.0	101	30.5	0,6	15.10	47.5621	34.1308	0.0	21	2	9	9	6	10

Labels

Team ID : 6160 GPS Sats: 23 Packet Count : 10 Mission Time : 15:10:21

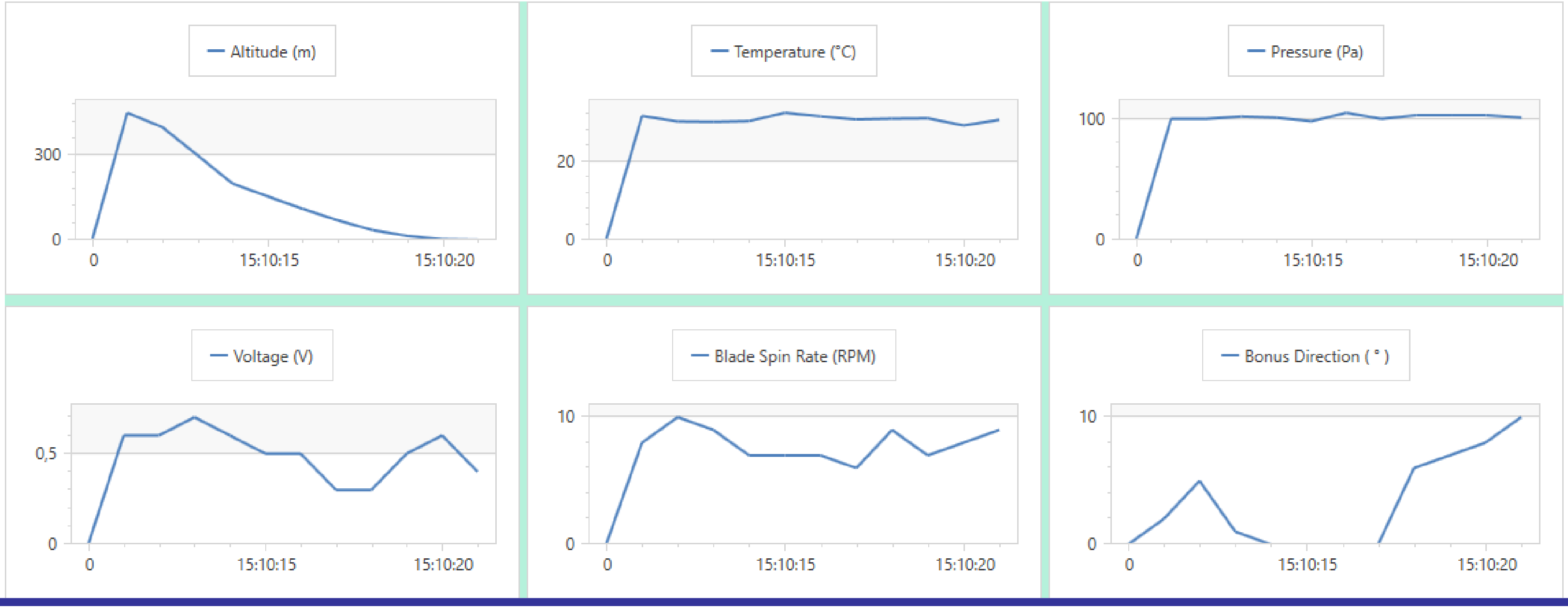
Commercial off the shelf (COTS) software packages used

- Visual Studio (Community Version)
- XCTU (Xbee Program Software (Free))

Real-time plotting software design

- With C#, we draw the data we read from the serial port in real time using the graphical structures in XAML.

Charts



Progress since PDR

- XBees and antenna distance tests were performed in 1 km range.
- The development of the interface has been completed and will be tested.

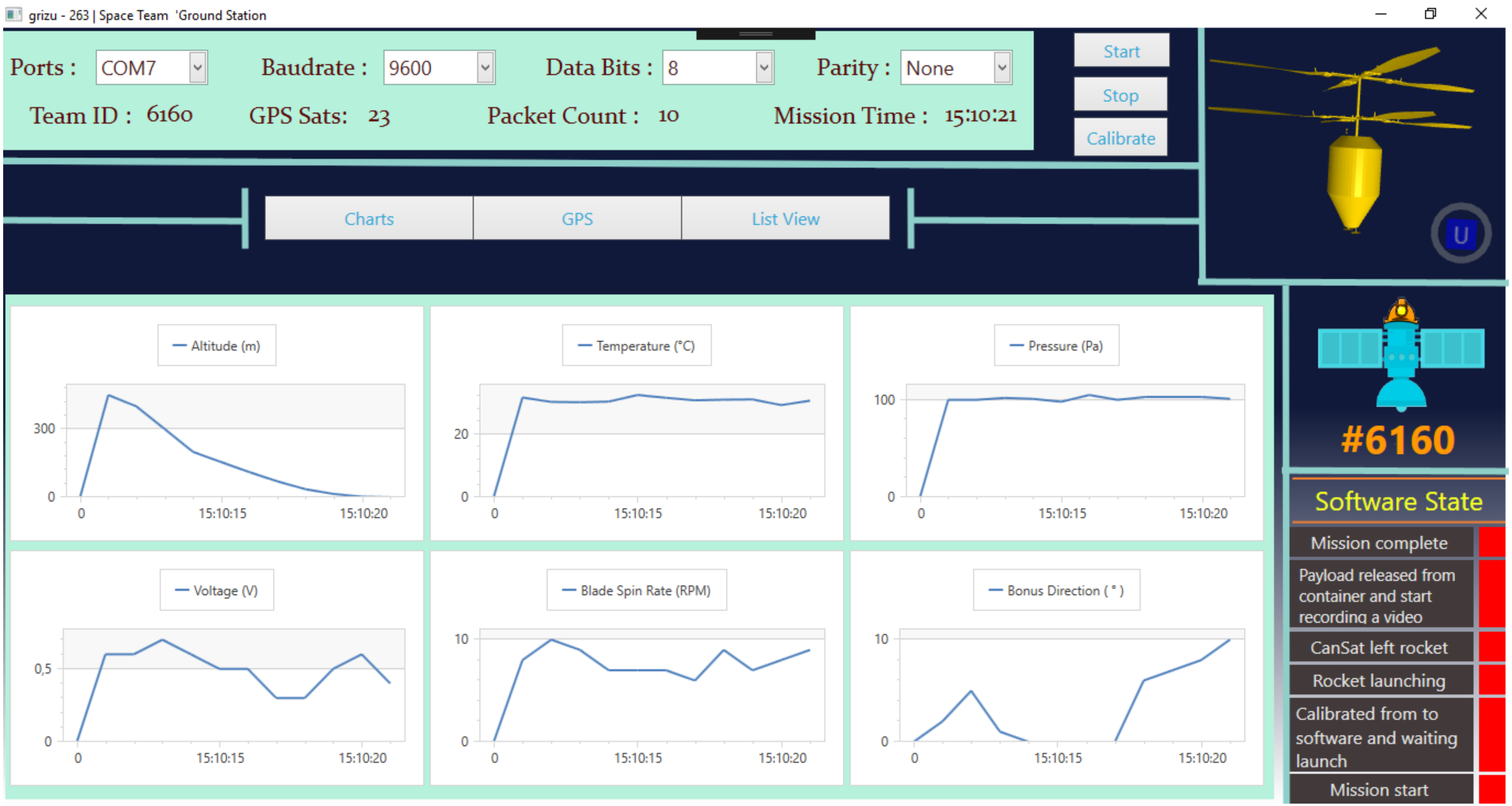
Command software and interface

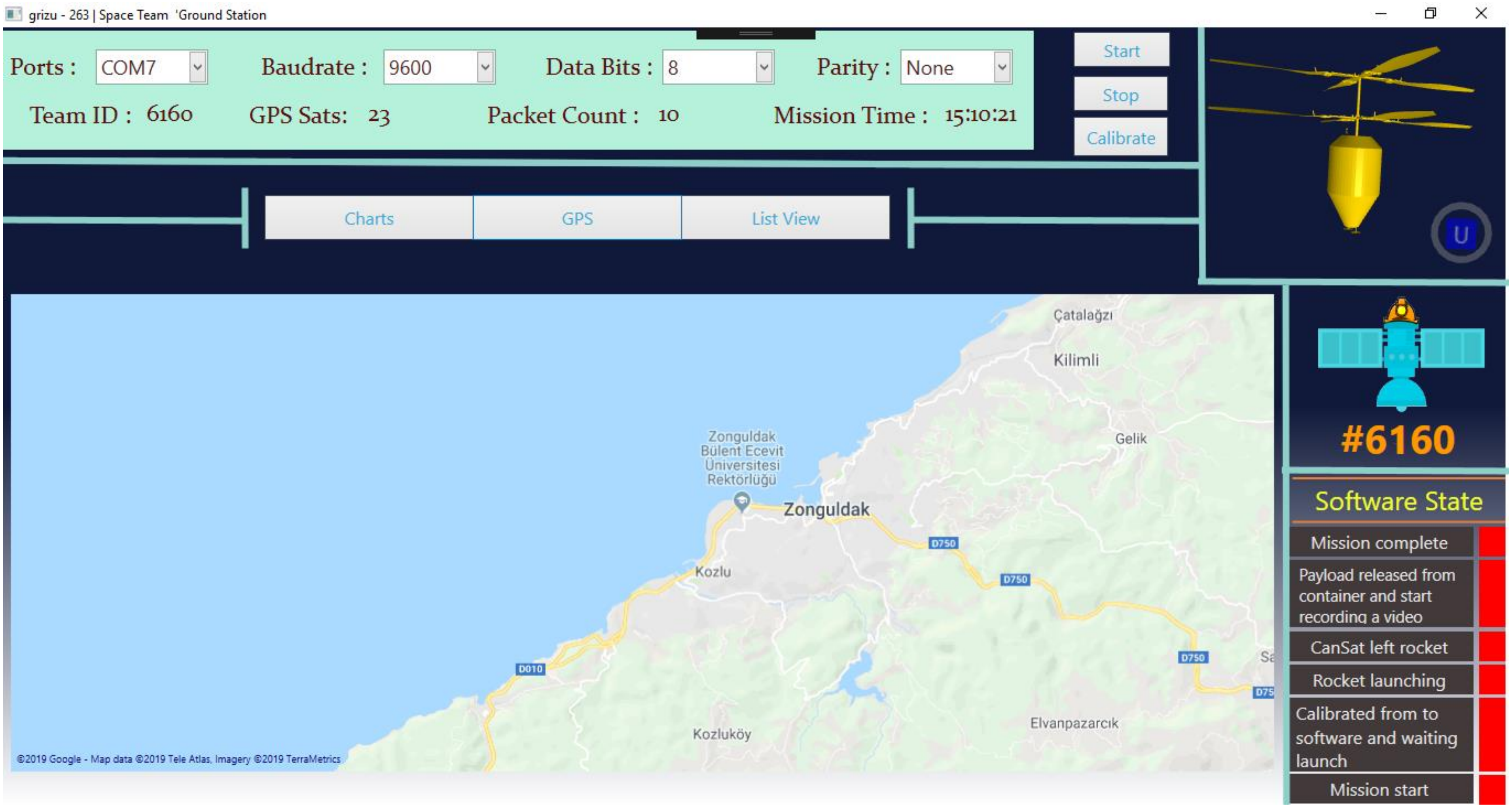
The interface prepared with C#. The data read from the serial port is shown in the interface and saved to the .csv file.

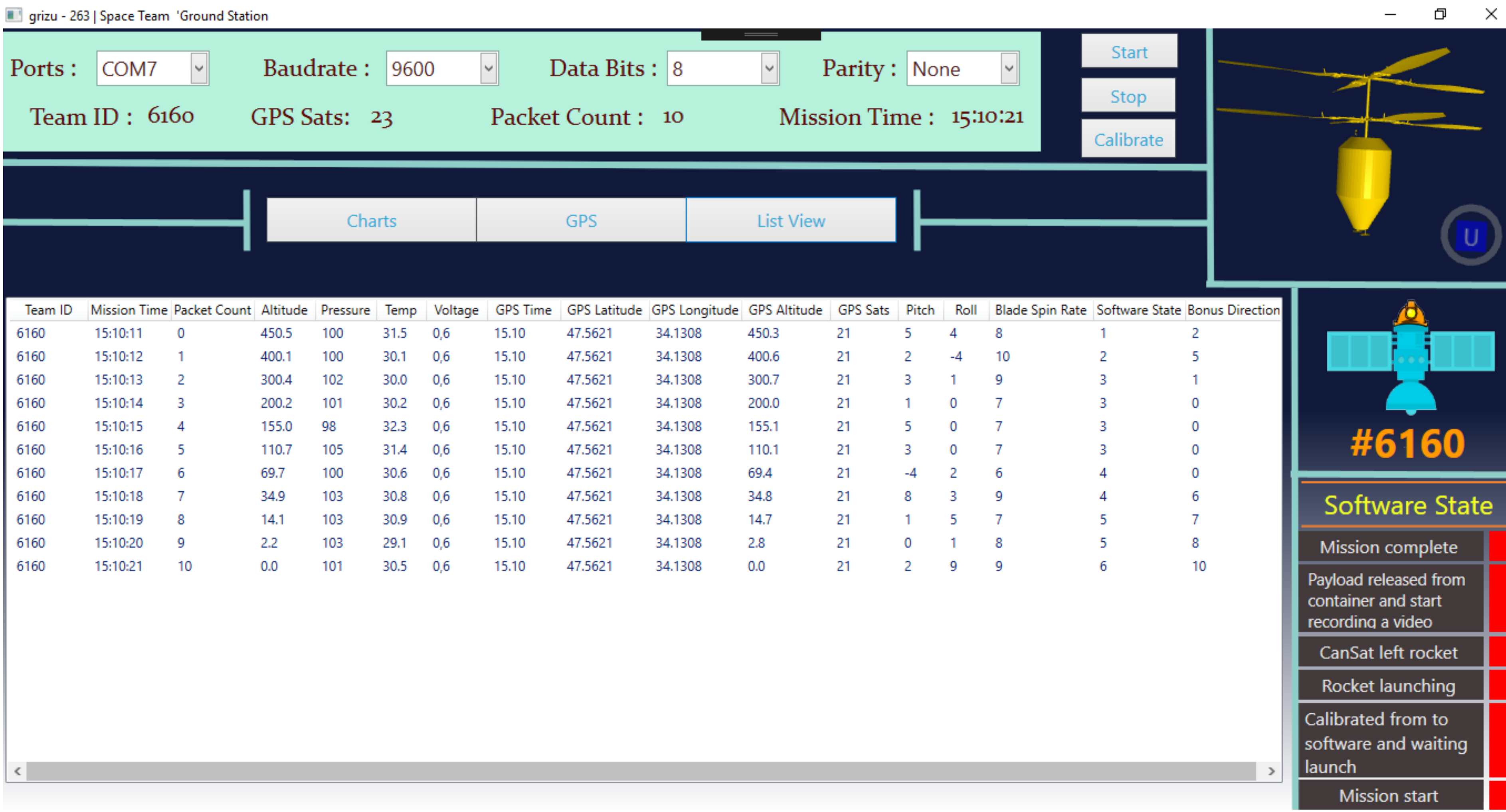
Calibration Command

The payload will be **calibrated from the ground station**. For this added a button to the GCS interface. The calibration verification will be performed according to the telemetry data sent from the barometric sensor and row/pitch angles in the payload to the ground station.

GCS Software (4 of 6)




grizu - 263 | Space Team 'Ground Station
Ports : COM7
Baudrate : 9600
Data Bits : 8
Parity : None
Team ID : 6160
GPS Sats: 23
Packet Count : 10
Mission Time : 15:10:21
Start
Stop
Calibrate
Charts
GPS
List View
Çatalağzı
Kilimli
Zonguldak Bülent Ecevit Üniversitesi Rektörlüğü
Zonguldak
Gelik
Kozlu
Kozluköy
Elvanpazarcık
D750
D010
©2019 Google - Map data ©2019 Tele Atlas, Imagery ©2019 TerraMetrics
#6160
Software State
Mission complete
Payload released from container and start recording a video
CanSat left rocket
Rocket launching
Calibrated from to software and waiting launch
Mission start



Team ID	Mission Time	Packet Count	Altitude	Pressure	Temp	Voltage	GPS Time	GPS Latitude	GPS Longitude	GPS Altitude	GPS Sats	Pitch	Roll	Blade Spin Rate	Software State	Bonus Direction
6160	15:10:11	0	450.5	100	31.5	0,6	15.10	47.5621	34.1308	450.3	21	5	4	8	1	2
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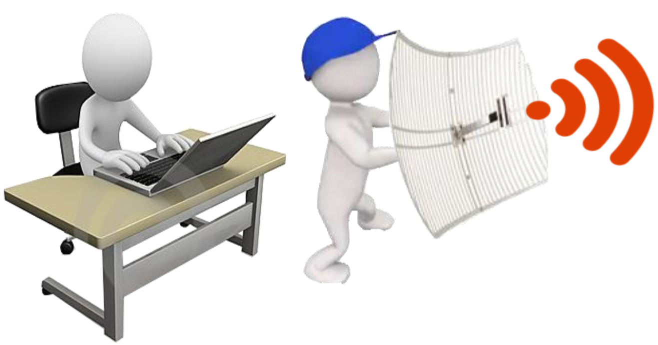
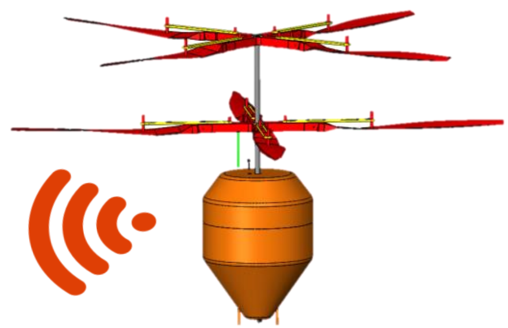
6160	15:10:14	3	200.2	101	30.2	0,6	15.10	47.5621	34.1308	200.0	21	1	0	7	3	0
6160	15:10:15	4	155.0	98	32.3	0,6	15.10	47.5621	34.1308	155.1	21	5	0	7	3	0
6160	15:10:16	5	110.7	105	31.4	0,6	15.10	47.5621	34.1308	110.1	21	3	0	7	3	0
6160	15:10:17	6	69.7	100	30.6	0,6	15.10	47.5621	34.1308	69.4	21	-4	2	6	4	0
6160	15:10:18	7	34.9	103	30.8	0,6	15.10	47.5621	34.1308	34.8	21	8	3	9	4	6
6160	15:10:19	8	14.1	103	30.9	0,6	15.10	47.5621	34.1308	14.7	21	1	5	7	5	7
6160	15:10:20	9	2.2	103	29.1	0,6	15.10	47.5621	34.1308	2.8	21	0	1	8	5	8
6160	15:10:21	10	0.0	101	30.5	0,6	15.10	47.5621	34.1308	0.0	21	2	9	9	6	10

GCS Antenna (1 of 2)

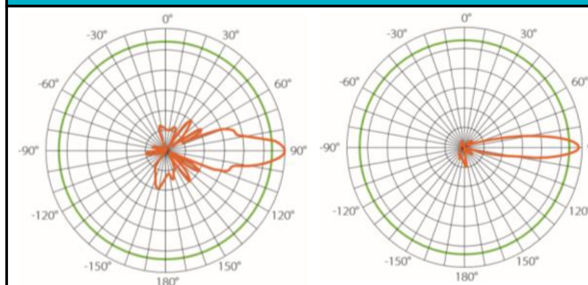
Model	Spread	Frequency Range (GHz)	Gain (dBi)	Polarization	Range (km)	Size (mm)	Weight (kg)
TL-ANT2424B	Directional	2.4	24	Vertical Horizontal	4.44	1000 x 600	3.5

Hand-Held Antenna





Antenna Patterns



Vertical Horizontal

Source: *TL-ANT2424B Datasheet*

Final Selection: TL-ANT2424B

- Setting angle is important for us because for the signal source (Payload) is moving.
- **It is directional antenna.**
- Enough gain.
- We got better results in our tests.

- We're buying the antenna. The weight and sizes of our antenna are suitable for hand-held and portable. So we will keep the antenna.
- The antenna range is 4.4 km. That means this antenna appropriate with range requirement.

Simple Link Budget Calculation

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

$\mathbf{P_{RX}}$ = Received Power (dBm)
$\mathbf{P_{TX}}$ = Transmitter Power Output (dBm)
$\mathbf{G_{TX}}$ = Transmitter Antenna Gain (dBi)
$\mathbf{G_{RX}}$ = Receiver Antenna Gain (dBi)
$\mathbf{L_{FS}}$ = Free Space Loss (dB) = 20 x log(f) + 20 x log(d) + 32.44 dB = 100.04
Fade Margin = L_{FS} (dB) - P_{RX} (dBm) = 44(dB)

Xbee Transmit Power = 18 dBm
Xbee Receiver sensitivity = -100 dBm

f = Frequency (MHz)
d = Distance (km)

d = 1 km

(Distance link **predictions**)

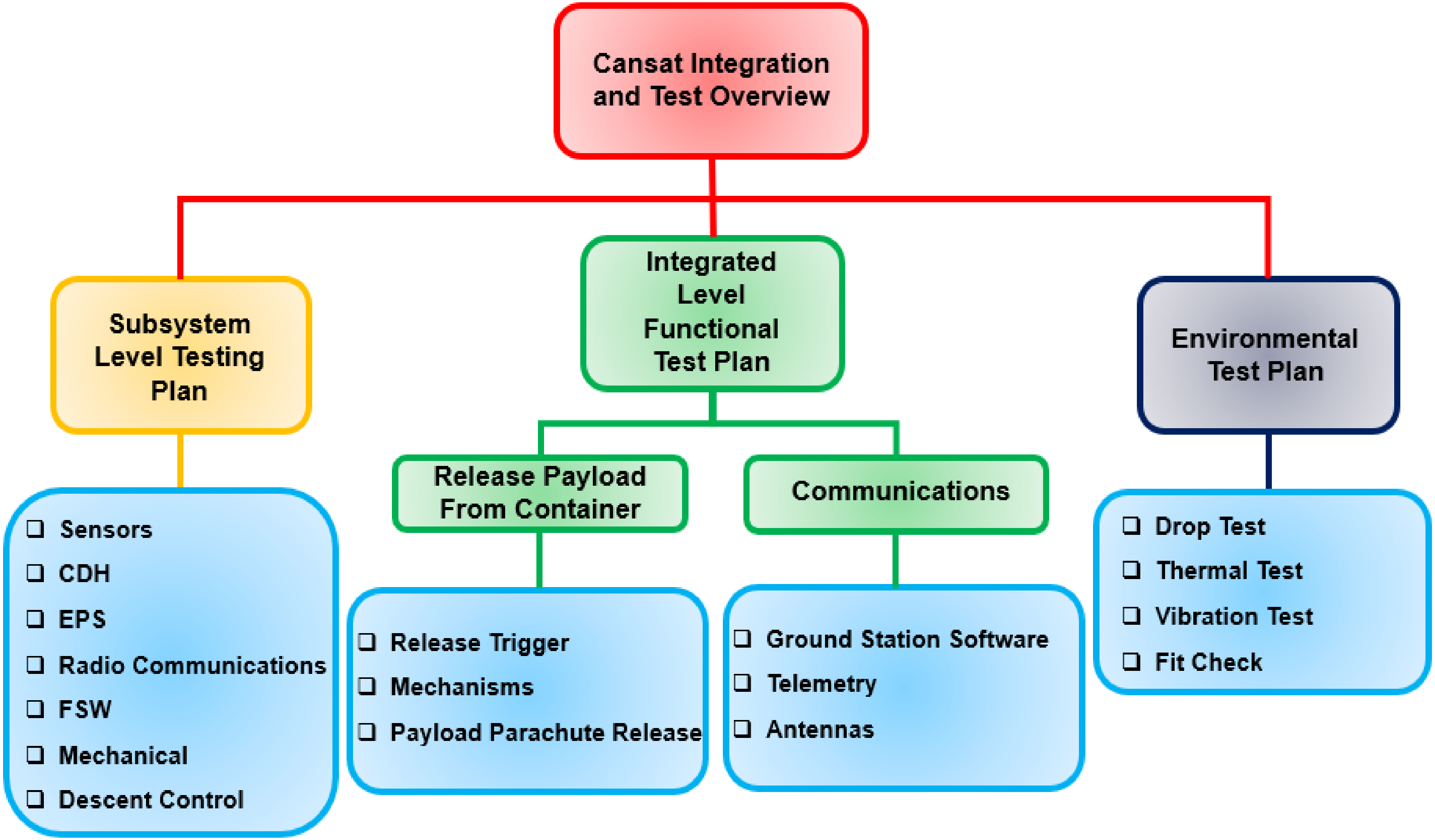
$$P_{RX} + \text{Fade Margin} = 18\ dBm + 24\ dBi + 2.1\ dBi + 44\ dB - 100.04\ dB = -\mathbf{11.94\ dBm}$$

Calculated P_{RX} + Fade Margin is -11.94 dBm > -100 dBm, which gives us **reliable margin**

CanSat Integration and Test

Mahmut YALDIZ

CanSat Integration and Test Overview (1 of 6)



CanSat Integration and Test Overview (2 of 6)

Subsystem level testing

Testing of Sensors

- Firstly all electronic circuits were installed on the breadboard.
- The robustness of all sensors was tested.
- All sensors was calibrated with the appropriate test software.

Testing of Radio Communications

- After the set of the electronic circuit on a breadboard, the data transmission were tested on various distance and environmental conditions with XBee.
- The sufficiency of the antenna at the desired distances was tested.

Testing of EPS

- The 3.7-volt batteries were connected in parallel as described in EPS.
- Calculated voltage and current level were tested with the multimeter in practice.
- Battery up time was checked (must be 2 hours).

Testing of Mechanical

- The passive auto-gyro system and the folding mechanism of propellers were checked.
- Payload release mechanism was checked.
- It was checked whether the total mass is 500 g according to requirements.
- Container parachute release mechanism was checked.

Subsystem level testing

Testing of FSW

- The accuracy of taken the data from the sensors were checked.
- The calibration command was transmitted from the ground station to the payload and tested whether or calibrate of the system.
- The sending of the data in the appropriate order to the ground station was tested.
- In case of microcontroller was reset, data recovery algorithms were tested.
- The CanSat system was released from 400 meters and all tests were done.

Testing of CDH

- The communication was tested between the receiver and transmitter with XBee in the XCTU program.
- The data transmission was checked at various distances.
- The gain test of the antenna was tested with the XCTU program.

Testing of Descent Control

- Payload integrated with propellers without electronic circuit was released from 400 meters via drone.
- Then the electronic circuit was placed on the payload and separated from 400 meters via drone.
- The propeller's tests were done from various altitude.
- Parachute system was tested like the propellers system and its aerodynamic suitability was checked.

Integrated Functional Level Testing

Release Payload From Container

Release Trigger

- Release mechanism was done with the burning of wire method.
- The wire is given a current of 1.4A.
- Wire breakage and breaking off time were checked.
- Wire burning test was carried out successfully.

Mechanisms

- The whole system was tested by releasing from 400 meters via drone.
- Release mechanism of the auto-gyro system from the container and folding mechanism of propellers were checked.

Container Parachute Release

- The parachute was stowed on the container.
- The container was released from 400 meters via drone.
- The container has dropped by parachute up to 300 meters.
- The payload was released from the container at 300 meters with the burning of the wire method.

CanSat Integration and Test Overview (5 of 6)

Integrated Functional Level Testing

Communications

Ground Station Software

- We have tested the ground station setup and how many time to take computer's battery will last.
- The calibration command was transmitted from the ground station to the payload and tested whether or calibrate of the system.
- The sending of the data in the appropriate order to the ground station was tested.

Telemetry

- The accuracy of the data sent to the ground station was checked.
- The speed of sending data was checked.
- The communication was tested between the receiver and transmitter XBee in the XCTU program.
- The telemetry data format accuracy was checked.

Antennas

- The distance test of the antenna was tested with the XCTU program.
- Connectivity issues were tested with XBee.

CanSat Integration and Test Overview (6 of 6)

Environmental Testing

Drop Test

- CanSat will be connected to a 61 cm Kevlar cord and released from 2 meters.
- All component assemblies and power failure will be checked.
- CanSat's attachment points were checked.

Thermal Test

- This test will be carried out to determine if any material has been spun, changed its characteristics or whether it works at temperatures up to 35 ° C.
- CanSat will be kept at 60 °C for 2 hours in a foam-insulated thermal box.

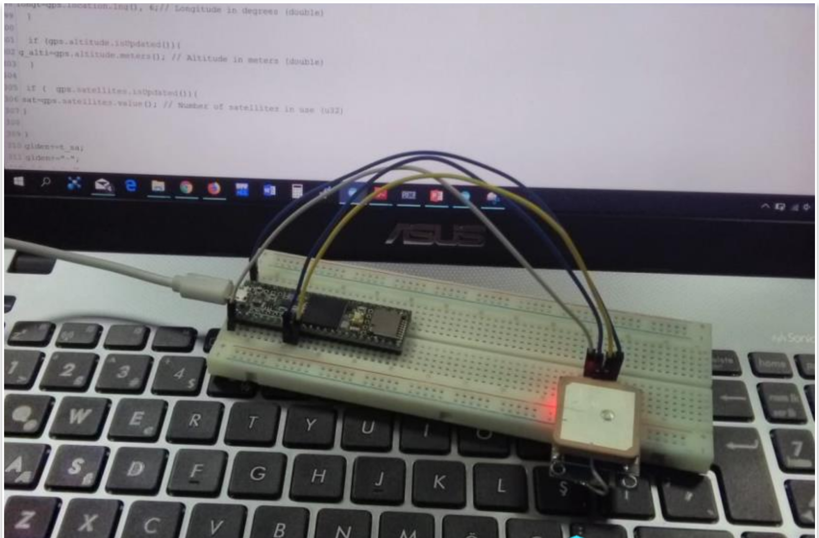
Vibration Test

- Vibration is generated by using Orbit Sander in this test.
- The assembly integrity of all components, assembly connections, structural integrity, and battery connections are tested.

Fit Check

- A cylindrical container with a diameter of the 125 mm x 310 mm will be prepared and checked whether CanSat passing through this plate.

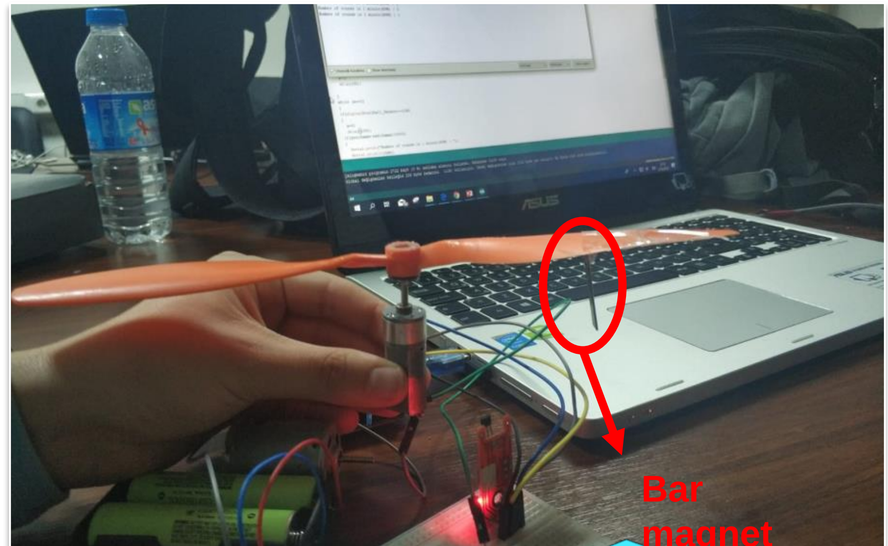
SENSORS



Firstly all electronic circuits were created on breadboard.The accuracy of **GPS** sensor was tested. The received data from GPS was controlled according to NMEA 0183 GGA message format.

It was confirmed the max voltage is 3.3V from the output of the **voltage sensor**.

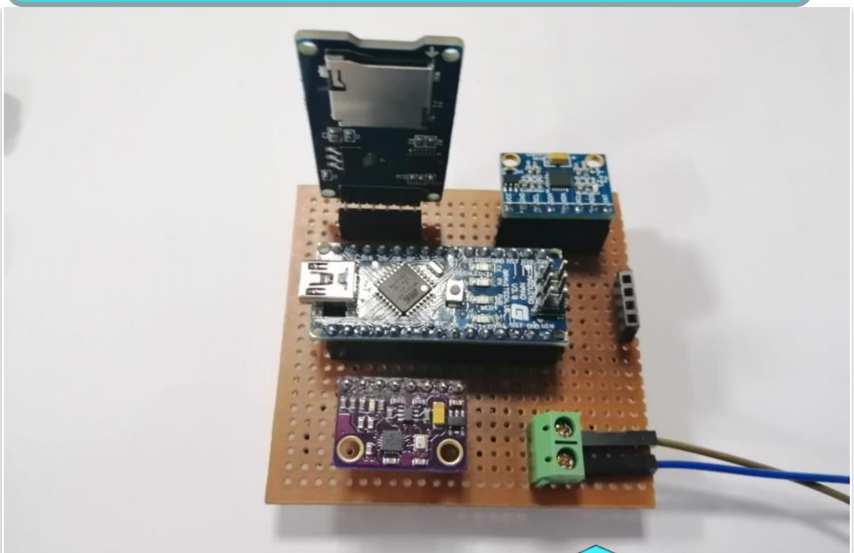
Resolution of selected **camera for bonus mission** was tested whether 640x480 pixel.



Firstly bar magnet was placed under the propeller. **Blade spin rate sensor** was connected to the electronic circuit. Speed control was done thanks to the propeller rotated.

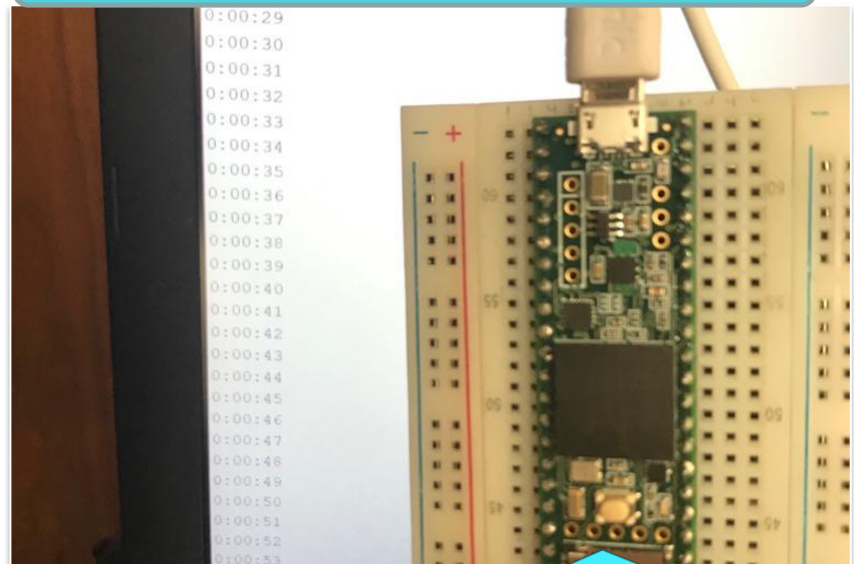
10 DOF IMU was created on the breadboard.Temperature, pressure, altitude, acceleration values were displayed and checked on serial port screen.

EPS



Prototype circuit was installed on the perforated plate. It was checked if it works with the required power supply.
The burn of wire circuit was installed.
The mosfet used in circuit was triggered with 3.3V checked of mosfet's operation.
The break time of the wire was measured.

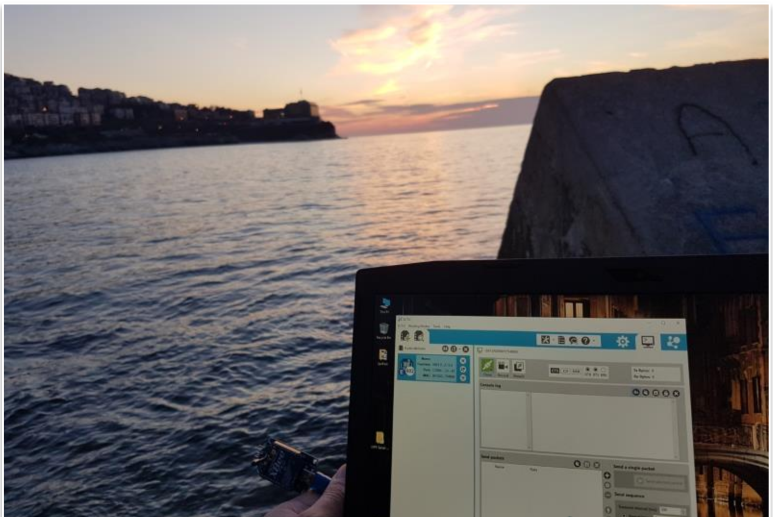
CDH



The necessary software was installed on the Teensy 3.6 microcontroller using the Ardunio IDE.

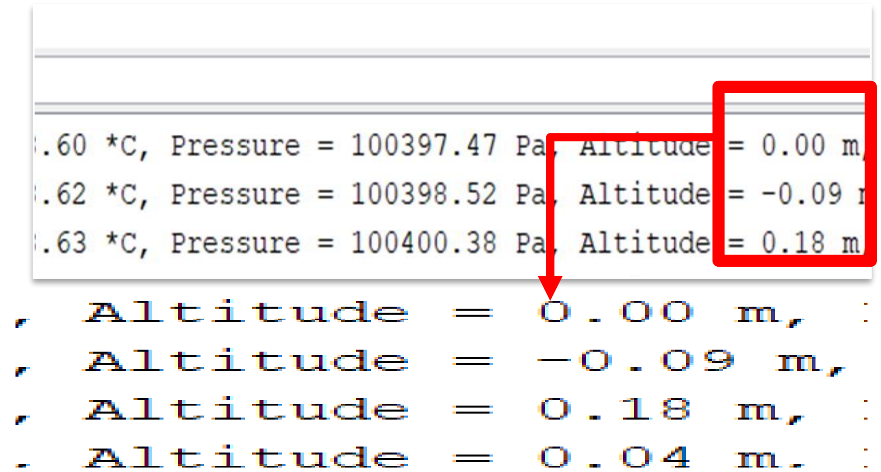
The RTC data from Teensy 3.6 for mission time was viewed on the serial monitor.

RADIO COMMUNICATION



The necessary connection between XBee and explorer module was done.
After, XBee setting was done over XCTU software. NETID/PANID, baud rate etc. accuracy was checked.
Data received from the sensors on the circuit were transmitted to the ground station via XBee.
The data was checked from the computer in the ground station. (distanced approximately 1.2 km).

FSW



The altitude data was calibrated to check the payload separation from the container.

MECHANICAL

Auto-gyro tests were performed via drone using various propellers.

The required speed was checked with the auto-gyro tests performed.

The wings folding mechanism was tested with the fabric elastic.

DESCENT CONTROL

The parachute was designed according to calculated measurement.

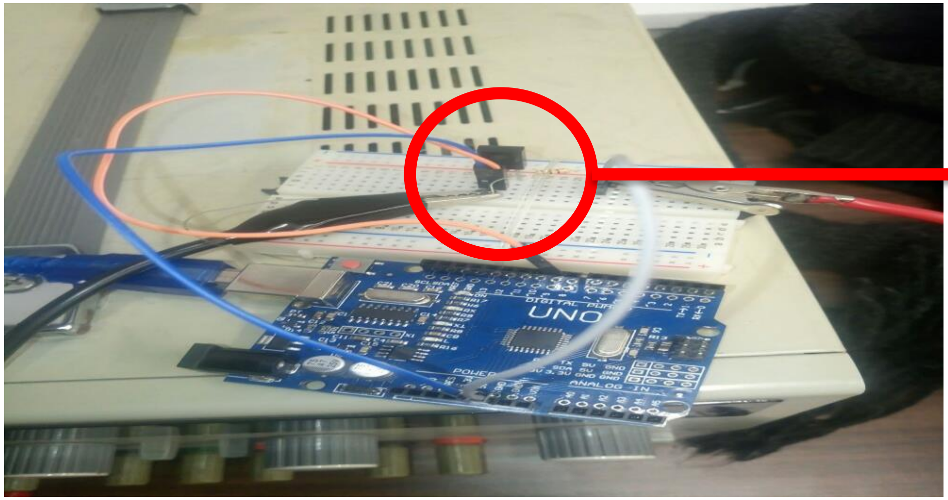
A load of 500 g was placed under the parachute then this system was free fall from 25 meters.

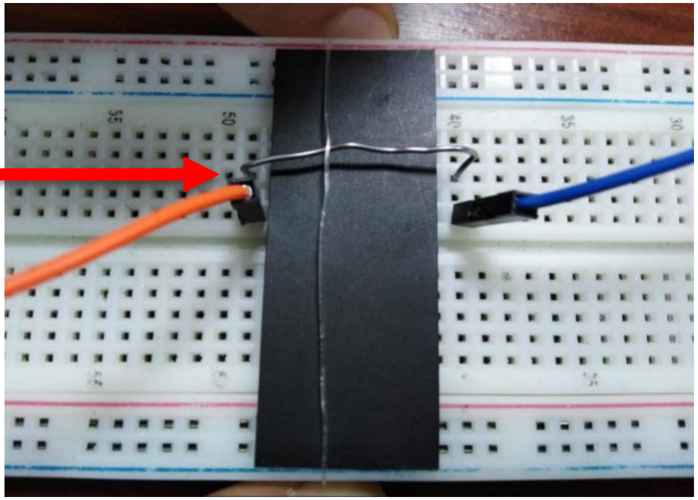
Payload integrated with propellers was separated at 25 meters without any electronic circuit on it.

The propeller's tests were completed with the via these free falls and sensors.

DESCENT TESTING

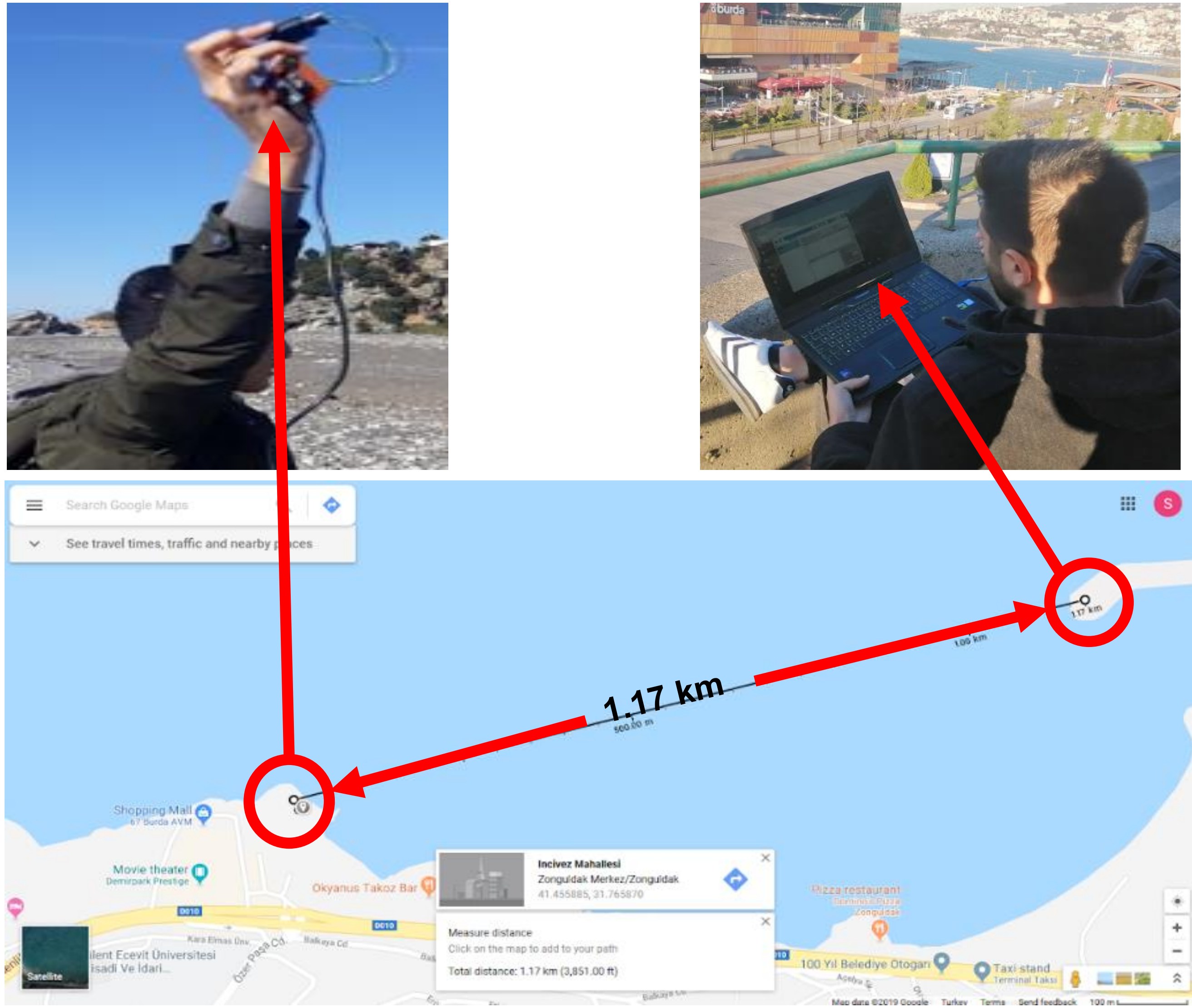
- CanSat’s release mechanism is performed with the burn of wire method.
- Sufficient power will be given to the wire for this process.
- The wire will be placed in a fire stop box inside the CanSat.
- As soon as the opening occurs, the power of the wire will be cut off automatically by the switch.
- The wire will be operated for a very short period and it will not be heated at full power.





COMMUNICATIONS

- Communications of Xbee (distance, reflections, different environmental conditions, etc.)
- The whole system implemented was taken to a certain altitude using the drone and a communication test was performed.
- Transmission with XBees was tested when the drone reaches the required altitude.
- We tested how far the antenna can connect.



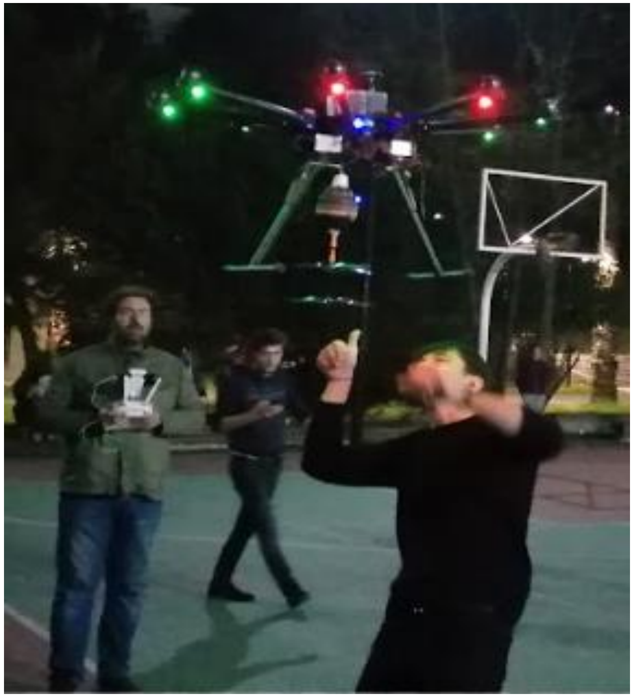
MECHANISMS

- The container was released for 400 meters and our opening mechanisms (released of the container, separation of the payload from the container, folding of propellers stretched fabric elastic) was checked.

CanSat

DEPLOYMENT

- CanSat was carried to 400 meters via the drone. The container was descent from 400 meters to 300 meters via the parachute.
- After 300 meters, the payload was released from the container and descent with the propellers and the release mechanism was tested.



DROP TEST

Drop test image from last year

It will be confirmed that telemetry is received before starting the test.

CanSat will be connected to the non-stretching cord 61 cm long and will be released from 2 meters.

It will be confirmed that CanSat is not losing power.

CanSat will be checked for any damage.

Telemetry data will be checked.

Environmental Test Plan (2 of 4)

THERMAL TEST

Thermal test image from last year

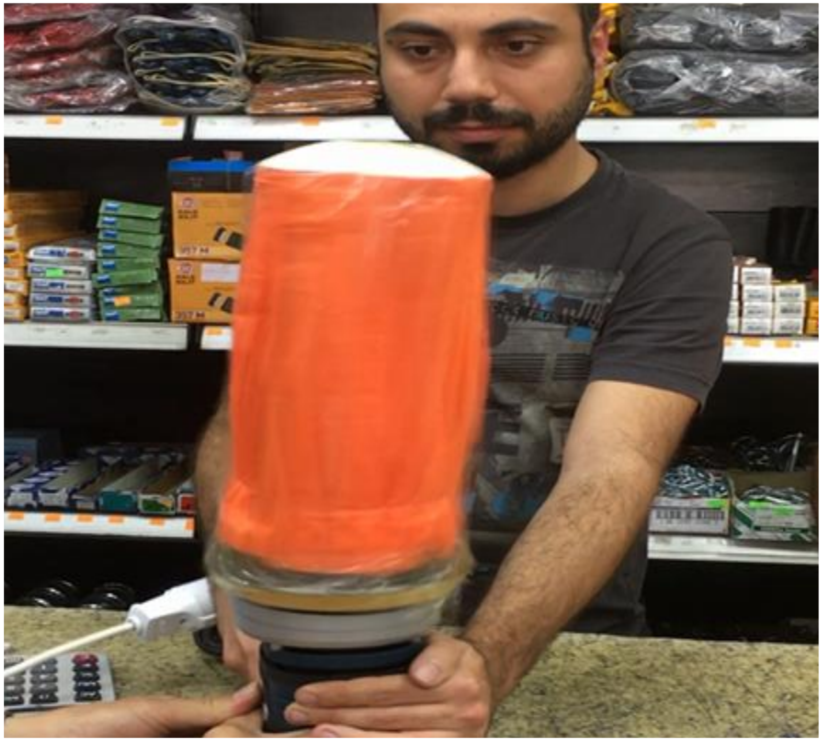
CanSat will be opened and placed in a foam-insulated thermal box.

The temperature of the a foam-insulated thermal box with a hair dryer will be increased to 60 ° C.

CanSat will remain in a foam-insulated thermal box for 2 hours.

Final of the test, the composite materials, epoxy bindings and the circuit will be checked.

VIBRATION TEST


Vibration test image from last year

It will be verified that the accelerometer data is collected before starting the test.

CanSat will be placed on the orbit sander ,and the sanding machine will wait at full speed for 5 seconds. These processes will be repeated four times.

CanSat damage and its function will be examined, and the accelerometer data will be checked.

FIT CHECK

Fit Check image from last year

A cylindrical container will be prepared 125 mm x 310 mm and the accuracy of the dimensions formed cylindrical envelope will be controlled by a caliper.

A cylindrical envelope will be controlled by CanSat dimensions.

Test Procedures Descriptions (1 of 7)

Part	Objective	Procedure	Requirements	Pass/Fail Criteria	Pass Fail
Air pressure sensor	Verify accuracy of altitude, pressure readings	All the sensors are installed on the breadboard. The accuracy of the sensor data was checked. The accuracy of the results obtained was accessed.	20	The getting value is equal to the actual altitude and the pressure	✓
Air temperature sensor	Verify accuracy of temperature readings		23	The data verifies the actual air temperature	✓
GPS Sensor	Verify accuracy of location readings		21,53	If the data from the GPS confirms our truth position	✓
Blade Spin Rate Sensor	Verify accuracy of blade spin rate readings		24	If the load confirms the accuracy of the rotation speed	✓

Test Procedures Descriptions (2 of 7)

Part	Objective	Procedure	Requirements	Pass/Fail Criteria	Pass Fail
Voltage Sensor	to measure of battery voltage	All the sensors are installed on the breadboard. The accuracy of the sensor data was checked. The accuracy of the results obtained was accessed.	22	Voltage sensor is connected to electronic circuit and the value is read with voltmeter.	✓
Camera	to record video		Bonus Object	To record video with the camera and the resolution of 640x480 pixels was checked.	✓

Test Procedures Descriptions (3 of 7)

Part	Objective	Procedure	Requirements	Pass/Fail Criteria	Pass Fail
EPS	To obtain desired voltage from two batteries connected in parallels for CanSat.	After installation of all circuits, short circuit tests were conducted to check any wrong connections. Power capability will be tested when CanSat spending maximum voltage.	16	Verify that the batteries supply CanSat with the desired voltage	✓
CDH	Check whether communications provided.	To verify transmission of data between XBees on XCTU.	20,21,22,23,24, 25,31,32,33	Verify that data transmission is provided	✓
CDH	Check XBee's and antenna's range.	To test connection from different ranges.	31,39	If data receive to GCS from 400 m	✓
FSW	Software control of release mechanisms.	To test burn of wire mechanism on breadboard control via MCU.	9,30,38	If the wire mechanism breaks when power is applied.	✓

Test Procedures Descriptions (4 of 7)

Part	Objective	Procedure	Requirements	Pass/Fail Criteria	Pass Fail
FSW	To test stable operation of the system and provide the relevant requirements.	To observe on ground station interface.	29,30	If communication between payload and interface is provided	✓
FSW	Stable operation of the system and provide the relevant requirements.	To observe transmission speed on ground station interface.	30,31	if the data comes appropriate sequence and speed to the ground station.	✓
GCS-FSW	Check that the interface is whether working properly.	To test receive data from serial port place on interface.	20,21,22,23,24, 25,30,35,36,39	If telemetry data is displayed in real time	✓
GCS	Control the presented format match the Competition Guide requirements.	The compliance of the data from receive software according to the requirement of the competition guide.	20,21,22,23,24, 25,35,39,53	If the presented format match the Competition requirements.	✓

Test Procedures Descriptions (5 of 7)

Part	Objective	Procedure	Requirements	Pass/Fail Criteria	Pass Fail
GCS-CDH	Measure the range of the antenna	To measure distance while receiver and transmitter antennas connecting.	35,39	If received data from 400m	✓
Drop Test	To test the durability of the CanSat's all attachment point.	Cansat will be connected to a 61 cm kevlar cord and released from 2 meters. Component assemblies and parachute attachment points will be tested.	12,14,15,51,54	If Cansat still works after the drop tests	Not tested yet.
Vibration Test	To test integrity of all components and battery connections.	Cansat will be placed on orbit sander,and orbit sander will be operated at different frequencies.	12,14,15,16,17, 51	If Cansat can remain one piece and durable.	Not tested yet.

Test Procedures Descriptions (6 of 7)

Part	Objective	Procedure	Requirements	Pass/Fail Criteria	Pass Fail
Thermal Test	To verify that payload and its container can operate in a warm environment.	CanSat will be on power and placed in the foam-insulated thermal box. The system will be tested for 2 hours. Its temperature durability to 60°C will be tested.	16,17	If CanSat still works well after maximum temperature	Not tested yet.
Fit Check	To verify that Cansat has the desired dimensions.	CanSat will be passed through a metal cylindrical envelope of 125 mm x 310 mm and the suitability of the dimensions will be verified.	1,2	If CanSat is within the desired measurement values.	Not tested yet.

Test Procedures Descriptions (7 of 7)

Part	Objective	Procedure	Requirements	Pass/Fail Criteria	Pass Fail
Descent Test	To verify that the container and payload fall at the desired speed.	The payload and container were released from a height of 25 m.	8,11	If the container and payload are falling at the desired speed	✔
Release Mechanisms Level Testing	This is to test the release trigger mechanism the burn of wire system on Cansat.	CanSat was raised to 400 meters by drone. 300m was the default to enable the release trigger mechanism. When the CanSat reached 300 meters, the payload released from the container.	7,9,10,12,14, 15,17	If the payload is released at the desired height and the release mechanism is working correctly	✔

Mission Operations & Analysis

Senanur SAMUR

Overview of Mission Sequence of Events (1 of 5)

ARRİVAL

- Check launch and CanSat.(Whole team)
- Arrival at the launch location.
- Set up of ground station system.(GSC)

PRE- LAUNCH

- Software calibration command will send by ground station (GSC).
- Checking size and weight of CanSat(MCO).
- Check communication (GSC).
- Camera calibration according to the magnetic field of the north earth.
- Check propeller(CC).
- Check separation mechanism (CC-GSC).
- Drop test(MCO-GSC-CC).
- Check safety (MCO).

LAUNCH

- Rocket liftoff.
- The electronic system will be started sending data.
- CanSat will be separated from the rocket(between 670-725 meters).
- The parachute will open.
- The speed up to 450 m is 20m/s.
- The release of the payload at 450 meters.
- The payload will be descent passively with the propellers.
- Payload speed should be between 10-15 m/s.
- The camera will be started to record video at 450 meters.
- The buzzer will be started to ring before falling.
- Telemetry transmission will stop when buzzer starting.

Overview of Mission Sequence of Events (2 of 5)

FLIGHT RECOVERY

- Payload we'll take the SD card and back up video on GSC.
- Get backed up telemetry data from SD card (GSC).
- Delivery of received data to the jury (MCO).

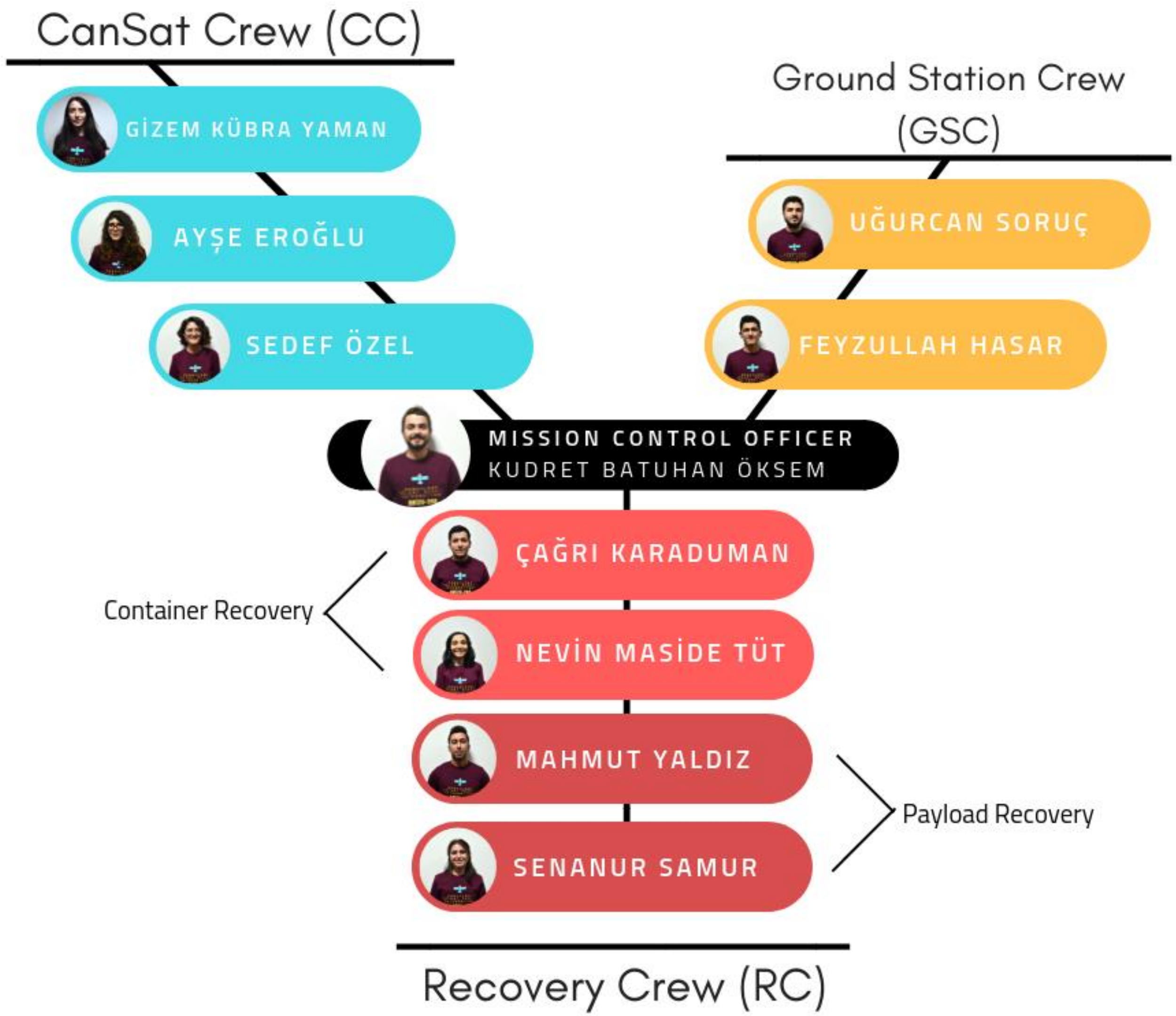
DATA ANALYSIS

- Check camera data (GSC-MCO).
- Checking and backing up telemetry data plot outliers (GSC-MCO).
- Check of real-time graphics (GSC-MCO).

POST FLIGHT REVIEW

- Preparation of post-flight review presentation file (Whole team).
- Delivery of the PFR file to the Jury(MCO).
- Explaining the PFR file to other participants(MCO).

Overview of Mission Sequence of Events (3 of 5)



Overview of Mission Sequence of Events (4 of 5)

Set up ground station system and Antenna construction **(GSC)**	A laptop battery will work for at least 2 hours. Preparation and installation of equipment required for the ground station. (antenna, laptop, power bank, cooler fan, etc.)
	A communication test will be done after necessary installations.
	Our antenna will be suitable for hand-held and portable.
	We will have the antenna to receive the data.
	The antenna is connected with SMA connector to XBee and XBee is connected to computer with USB.
	We will update Windows for latest version before establish ground station
	PC will not have internet connection.

Overview of Mission Sequence of Events (5 of 5)

CanSat assemble	Electronic circuits will be assemble(CC).
	Check auto-gyro systems (folding mechanism of propellers)(CC).
	Payload will be stowed into container. Then parachute will be folded and placed top of the container(MCO-CC).
	The on/off switch will be opened and CanSat will be run(CC-MCO).
CanSat Test	CanSat weight test.It will be 500 g(CC).
	CanSat size and fit Check(CC).
	Drop test(CC).
	Separation mechanism test(CC).
	The antenna and communication tests(GSC).
	Calibration of sensors and check electronic systems(GSC-CC).
	Check of data analysis(GSC).
	Final CanSat system test(CC-MCO-GSC).

Mission Operations Manual Checklist

Configuring the ground station
- Communication test
- Antenna Check
- Safety tests

Preparing the CanSat
- CanSat assemble
- Separation mechanism control
- Weight and size control
- Drop test
- Auto-gyro system test

Integrating the CanSat into the rocket
- Fit check
- Check stowed parachute

The launch preparation procedures
- Launch procedure
- Removal procedure

MOM

- It will be two copies of the MOM file before launch.(MCO)

DEVELOPMENT PLAN

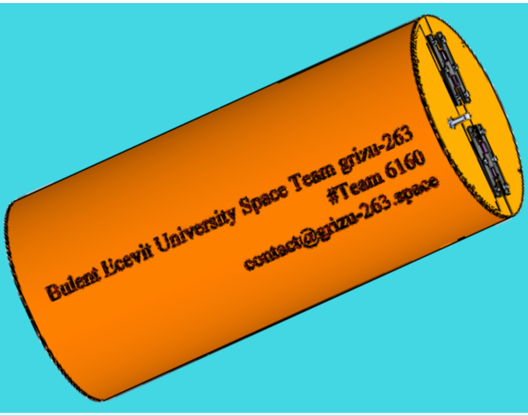
- May 15 will be final prototyping.
- A test flight will be conducted on May 25 .

How can find container?

We will use buzzer and this buzzer will started reaches 5 meters.

Which fluorescent color container?

We choose fluorescent orange color for container .



Container return address

The necessary contact information will be written on the container.

Zonguldak Bülent Ecevit University Space Team

grizu-263 #Team 6160

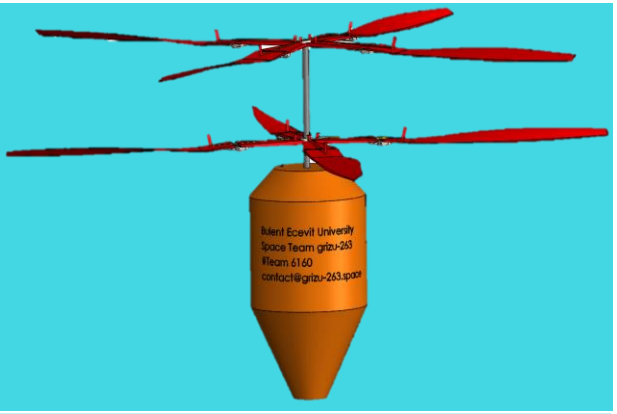
contact@grizu-263.space

How can find payload?

- We will use buzzer and this buzzer will start reaches 5 meters. When the buzzer started, data transfer stop between payload and ground station.
- Second method , we will use Global Positioning System(GPS) for find payload.

Which fluorescent color payload?

- We choose fluorescent orange color for payload.



Payload return address

The necessary contact information will be written on the payload.

Zonguldak Bülent Ecevit University Space Team

grizu-263 #Team 6160

contact@grizu-263.space

Mission Rehearsal Activities(1 of 2)

Description of mission operations

Ground system radio link Check procedures (GSC)	• Check XBee settings from the software interface. • Check antenna and XBee communications. • Check calibration command software.
Powering on/off the CanSat (CC)	• The on / off switch on the CanSat is opened ,and CanSat is operated.
Launch configuration preparations (CC-MCO)	• Auto-gyro system control. • Separation mechanism control. • Fit check. • Check if CanSat is ready to receive data.

Description of mission operations

Loading the CanSat in the launch vehicle (CC-MCO)	• CanSat is placed on the rocket by the MCO-CC with final checks.
Telemetry processing, archiving, and analysis (GSC-MCO)	• All telemetry data is analyzed in the ground station interface. • The data saved on SD card and .csv format file. • Its correctness and stability will be checked. • Telemetry file(.csv format) will be delivered to jury(MCO).
Recovery (RC)	**Payload and Container** • We will be used buzzer and this buzzer will start reaches 5 meters. When the buzzer started, data transfer stops between payload and ground station. **Payload** • We will be used the Global Positioning System(GPS) for find.

The purpose of this section is to summarize and cross reference the compliance to the CanSat Competition Mission Guide requirements.

Requirements Compliance

Senanur Samur

Requirements Compliance Overview

Our design has been prepared in accordance with CanSat 2019 requirements. The required tests were successfully completed.

Mechanical Team

- Parachute opening mechanism has been successfully tested for the container.
- The payload separation from the container was successfully tested.
- Propeller selection for passive fall was made and folding mechanism of propellers were successfully tested.
- The CanSat passive descent test was completed.
- The CanSat size and weight were checked.

Electrical and Software Team

- Data from the sensors is successfully sent to the ground station at a frequency of 1 Hz.
- The buzzer and GPS were tested to find the payload.
- Prototype circuit was installed for tests of EPS and tests were successfully done.
- The algorithms developed for container and payload have been successfully run.
- Calibration command transmission test was successfully done from the ground station.
- Ground station computer batteries were tested to run at least 2 hours.
- Appropriate camera tests were performed for the bonus task.

CanSat designed according to the requirements passed all tests successfully. No problems were encountered in the tests.

Requirements Compliance

Rqmt Num	Requirement	Comply / No Comply / Partial	X-Ref Slide(s) Demonstrating Compliance	Team Comments or Notes
1	Total mass of the CanSat (science payload and container) shall be 500 grams +/- 10 grams.	Comply	74,93	OK
2	CanSat shall fit in a cylindrical envelope of 125 mm diameter x 310 mm length. Tolerances are to be included to facilitate container deployment from the rocket fairing.	Comply	23,24,33,177	OK
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	28,177	OK
4	The container shall be a fluorescent color; pink, red or orange.	Comply	63,192	OK
5	The rocket airframe shall not be used to restrain any deployable parts of the CanSat.	Comply	62	OK
6	The rocket airframe shall not be used as part of the CanSat operations.	Comply	32,81,84	OK

Requirements Compliance

Rqmt Num	Requirement	Comply / No Comply / Partial	X-Ref Slide(s) Demonstrating Compliance	Team Comments or Notes
7	The CanSat shall deploy from the rocket payload section and immediately deploy the container parachute.	Comply	33,51,87	OK
8	The descent rate of the CanSat (container and science payload) shall be 20 meters/second +/- 5m/s.	Comply	65,74	OK
9	The container shall release the payload at 450 meters +/- 10 meters.	Comply	28, 30, 51	OK
10	The science payload shall descend using an auto-gyro descent control system.	Comply	57,60,168	OK
11	The descent rate of the science payload after being released from the container shall be 10 to 15 meters/second	Comply	70, 74	OK
12	All descent control device attachment components shall survive 30 Gs of shock.	Comply	176	OK

Requirements Compliance (3 of 9)

Rqmt Num	Requirement	Comply / No Comply / Partial	X-Ref Slide(s) Demonstrating Compliance	Team Comments or Notes
13	All electronic components shall be enclosed and shielded from the environment with the exception of sensors.	Comply	28,32	OK
14	All structures shall be built to survive 15 Gs of launch acceleration.	Comply	176	OK
15	All structures shall be built to survive 30 Gs of shock.	Comply	176	OK
16	All electronics shall be hard mounted using proper mounts such as standoffs, screws, or high performance adhesives.	Comply	88	OK
17	All mechanisms shall be capable of maintaining their configuration or states under all forces.	Comply	88,176	OK
18	Mechanisms shall not use pyrotechnics or chemicals.	Comply	91	OK

Requirements Compliance (4 of 9)

Rqmt Num	Requirement	Comply / No Comply / Partial	X-Ref Slide(s) Demonstrating Compliance	Team Comments or Notes
19	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	27,83	OK
20	The science payload shall measure altitude using an air pressure sensor.	Comply	39	OK
21	The science payload shall provide position using GPS.	Comply	41,42	OK
22	The science payload shall measure its battery voltage.	Comply	43	OK
23	The science payload shall measure outside temperature.	Comply	40	OK
24	The science payload shall measure the spin rate of the auto-gyro blades relative to the science vehicle.	Comply	45	OK

Requirements Compliance (5 of 9)

Rqmt Num	Requirement	Comply / No Comply / Partial	X-Ref Slide(s) Demonstrating Compliance	Team Comments or Notes
25	The science payload shall measure pitch and roll.	Comply	44	OK
26	The probe shall transmit all sensor data in the telemetry	Comply	128,130,145	OK
27	The Parachute shall be fluorescent Pink or Orange.	Comply	83	OK
28	The ground station shall be able to command the science vehicle to calibrate barometric altitude, and roll and pitch angles to zero as the payload sits on the launch pad.	Comply	131,145,152	OK
29	The ground station shall generate a csv file of all sensor data as specified in the telemetry section.	Comply	152	OK
30	Telemetry shall include mission time with one second or better resolution. Mission time shall be maintained in the event of a processor reset during the launch and mission.	Comply	138,140	OK

Requirements Compliance (6 of 9)

Rqmt Num	Requirement	Comply / No Comply / Partial	X-Ref Slide(s) Demonstrating Compliance	Team Comments or Notes
31	XBEE radios shall be used for telemetry. 2.4 GHz Series radios are allowed. 900 MHz XBEE Pro radios are also allowed.	Comply	145,149	OK
32	XBEE radios shall have their NETID/PANID set to their team number.	Comply	106	OK
33	XBEE radios shall not use broadcast mode.	Comply	106	OK
34	Cost of the CanSat shall be under $1000. Ground support and analysis tools are not included in the cost.	Comply	209,210,211,212	OK
35	Each team shall develop their own ground station.	Comply	153, 154, 155	OK
36	All telemetry shall be displayed in real time during descent.	Comply	131,153	OK

Requirements Compliance (7 of 9)

Rqmt Num	Requirement	Comply / No Comply / Partial	X-Ref Slide(s) Demonstrating Compliance	Team Comments or Notes
37	All telemetry shall be displayed in engineering units (meters, meters/sec, Celsius, etc.)	Comply	153	OK
38	Teams shall plot each telemetry data field in real time during flight.	Comply	153, 154, 155	OK
39	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	145,149	OK
40	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	149,189	OK
41	Both the container and probe shall be labeled with team contact information including email address.	Comply	192,193	OK
42	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	137,140	OK

Requirements Compliance

Rqmt Num	Requirement	Comply / No Comply / Partial	X-Ref Slide(s) Demonstrating Compliance	Team Comments or Notes
44	No lasers allowed.	Comply	32	**OK**
45	The probe must include an easily accessible power switch that can be accessed without disassembling the cansat and in the stowed configuration.	Comply	27,28,32	OK
46	The probe must include a power indicator such as an LED or sound generating device that can be easily seen without disassembling the cansat and in the stowed state.	Comply	27,28	OK
47	An audio beacon is required for the probe. It may be powered after landing or operate continuously..	Comply	192,193	OK
48	The audio beacon must have a minimum sound pressure level of 92 dB, unobstructed.	Comply	116	OK
49	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.	Comply	116,121	OK

Requirements Compliance (9 of 9)

Rqmt Num	Requirement	Comply / No Comply / Partial	X-Ref Slide(s) Demonstrating Compliance	Team Comments or Notes
50	An easily accessible battery compartment must be included allowing batteries to be installed or removed in less than a minute and not require a total disassembly of the CanSat.	Comply	27	OK
51	Spring contacts shall not be used for making electrical connections to batteries. Shock forces can cause momentary disconnects.	Comply	120,124	OK
52	The auto-gyro descent control shall not be motorized. It must passively rotate during descent.	Comply	60	OK
53	The GPS receiver must use the NMEA 0183 GGA message format.	Comply	129	OK
54	The CANSAT must operate during the environmental tests laid out in Section 3.5	Comply	174,175,176,177	OK
55	Payload/Container shall operate for a minimum of two hours when integrated into rocket.	Comply	126	OK

Management

Nevin Maside Tüt

Status of Procurements

Electronic Components	Quantity	Order Date - Delivery Date	Status
US1881 (Hall Effect)	1	12.14.2018 - 12.21.2018	Received
IC139 Switch	2	12.14.2018 - 12.21.2019	Received
Swivel joint, Flanged (12 cable)	1	12.14.2018 - 12.21.2018	Received
Step-Up Regulator 5V	2	12.14.2018 - 12.21.2018	Received
Polar 10uF Capacitor	1	12.14.2018 - 12.21.2018	Received
Polar 100uF Capacitor (set 12 pcs)	1	12.14.2018 - 12.21.2018	Received
Xbee USB Explorer	2	12.14.2018 - 12.21.2018	Received
NEO-7M GPS	1	12.14.2018 - 12.21.2018	Received
Magnetic Buzzer 3.6V 8.5mm 92 dBA	2	12.14.2018 - 12.21.2018	Received
IRF1404 N Channel Power Mosfet TO-220	3	12.14.2018 - 12.21.2018	Received
Feetech FS5106R Servo	1	12.14.2018 - 12.21.2018	Received
BMP280	1	12.14.2018 - 12.21.2018	Received
IMU (BMP280+MPU9255)	1	12.14.2018 - 12.21.2018	Received
GY-273 HMC5883L Digital Compass	1	12.14.2018 - 12.21.2018	Received
SQ11 Camera	1	12.14.2018 - 12.21.2018	Received
ORION 14500 AA	1	12.14.2018 - 12.21.2018	Received
Sony VTC6	2	12.14.2018 - 12.21.2018	Received
DC-DC Converter 3.3V	1	12.14.2018 - 12.21.2018	Received
SanDisk Ultra SD Card 16GB	3	12.14.2018 - 12.21.2018	Received
XBee USB Explorer	1	12.14.2018 - 12.21.2018	Received
SD-Card Module	1	12.14.2018 - 12.21.2018	Received
A24-HASM-450	1	12.14.2018 - 12.21.2018	Received
Teensy 3.6	1	12.14.2018 - 12.21.2018	Received
Mechanical Components	**Quantity**	**Order Date - Delivery Date**	**Status**
Fiberglass	1m2	03.01.19 - 03.15.19	Received
Silnylon 30D NYLON 66	1m2	03.01.19 - *	-
Steel hinge x3	30mm x 10mm	03.01.19 - 03.22.19	Received
Auto -Gyro payload			
Wing x8	335mmx 20mm x 1 mm	03.01.19 - 03.08.19	Received
Ball bearing x2	3mm x 6mm x 2.5mm	03.01.19 - 03.15.19	Received
Carbon fiber axle	1000mm x 3mm	02.22.19 - 02.27.19	Received
Fiberglass	1m2	03.01.19 - 03.15.19	Received
Plastic hinge x8	20mm x 10mm	02.28.19 - 03.08.19	Received
Bar magnet	3mm x10mm	03.01.19 - 03.15.19	Received

- All the necessary electronics for Container and Payload were ordered and delivered a month ago
- All the necessary raw materials for the mechanics were ordered and delivered a month ago.
- Production is being done.
- We have no problem with maintaining the products and budgeting.

Ground Station

- TL-ANT2424B (from previous year)
- XBee Pro S1 for ground station.(quantity 2, date: 12.14.2018 – 12.21.2018 received)
- We use our computer.
- We use our developed software.

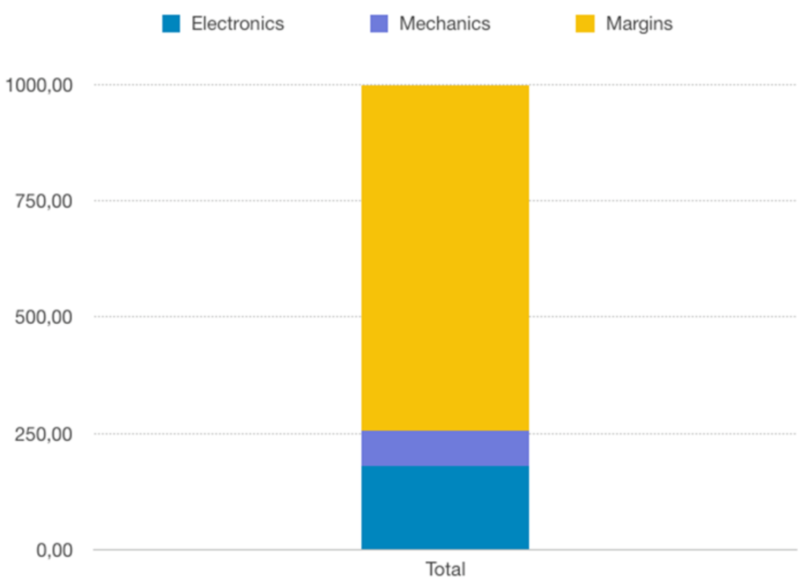
CanSat Budget – Hardware (1 of 3)

Electronics Hardware

Electronics Components	Quantity	Unit Price	Price (Total)	Considerations
US1881 (Hall Effect)	1	$0,50	$0,50	Actual
IC139 Switch	2	$0,38	$0,76	Actual
Swivel joint, Flanged (12 cable)	1	$16,95	$16,95	Actual
Step-Up Regulator 5V	2	$2,44	$4,88	Actual
Polar 10uF Capacitor	1	$0,02	$0,02	Actual
Polar 100uF Capacitor (set 12 pcs)	1	$0,33	$0,33	Actual
Xbee USB Explorer	2	$8,63	$17,26	Actual
NEO-7M GPS	1	$16,40	$16,40	Actual
Magnetic Buzzer 3.6V 8.5mm 92 dBA	2	$0,98	$1,96	Actual
IRF1404 N Channel Power Mosfet TO-220	3	$1,47	$4,41	Actual
Feetech FS5106R Servo	1	$16,97	$16,97	Actual
BMP280	1	$4,53	$4,53	Actual
IMU (BMP280+MPU9255)	1	$2,87	$2,87	Actual
GY-273 HMC5883L Digital Compass	1	$4,04	$4,04	Actual
SQ11 Camera	1	$3,41	$3,41	Actual
ORION 14500 AA	1	$3,58	$3,58	Actual
Sony VTC6	2	$25,94	$51,88	Actual
DC-DC Converter 3.3V	1	$0,92	$0,92	Actual
SanDisk Ultra SD Card 16GB	3	$3,92	$11,76	Actual
XBee USB Explorer	1	$8,63	$8,63	Actual
SD-Card Module	1	$0,72	$0,72	Actual
A24-HASM-450	1	$0,78	$0,78	Actual
Teensy 3.6	1	$5,23	$5,23	Actual
Total			**$178,79**	

Mechanics Components

Mechanical Components	Quantity	Unit Price	Price (Total)	Considerations
Fiberglass	1 m^2	$9,33	$6,00	Estimate
Silnylon 30D Nylon 66	1 m^2	$12,50	$12,50	Actual
Steel Hinge x3	30mm*10mm	$1,50	$4,50	Actual
Science Payload Components				
Wing x8	335mm*20mm*1mm	$3,92	$31,36	Actual
Ball Bearing x2	3mm*6mm*2,5mm	$3,00	$6,00	Actual
Carbon Fiber Axle	1000mm*3mm	$10,00	$2,00	Estimate
Fiberglass	1 m^2	$9,33	$3,60	Estimate
Plastic Hinge x8	20mm*10mm	$1,00	$8,00	Actual
Bar Magnet	3mm*10mm	$1,50	$1,50	Actual
Total			**$75,46**	



Electronics	178,79
Mechanical	75,46
Exact Total	**$253,75**
Margin	$746,25

Electronics / Mechanical Components

CanSat Requirement Cost – Exact Total = Margin

$1000 - $253.75 = $746.25

CanSat Budget – Other Costs

GROUND STATION

Part	Model	Quantitiy	Price	Price (Total)	Considerations
Computer	-	1	Our Own Computer	-	Actual
XBEE	Pro S1	1	$36,00	$36,00	Actual
ANTENNA	TL-ANT2424B	1	$98,76	$98,76	Actual
Total				$134,76	

OTHER

	Quantity	Price (Total)	Considerations
Prototyping		$150,00	Estimate
Test facilities and equipment		University Budget	
Rental	Car x 2	$800,00	Estimate
Computers		Our Own Computers	
Travel (Flight Ticket)	8 person	$4.000,00	Estimate
VISA (USA)	8 person	$1.280,00	Estimate
Hotel	8 person	$2.250,00	Estimate
CanSat Competition Fee		$100,00	Actual
Total		$8.580,00	

Bulent Ecevit University met the money needed for CanSat to produce grizu-263. We have completed sponsorship negotiations for travel and all other necessary expenses. All agreements will be approved for acceptance into the competition. Turkish Airlines agrees to be our transportation sponsor. We will not have a problem this year in terms of the budget.

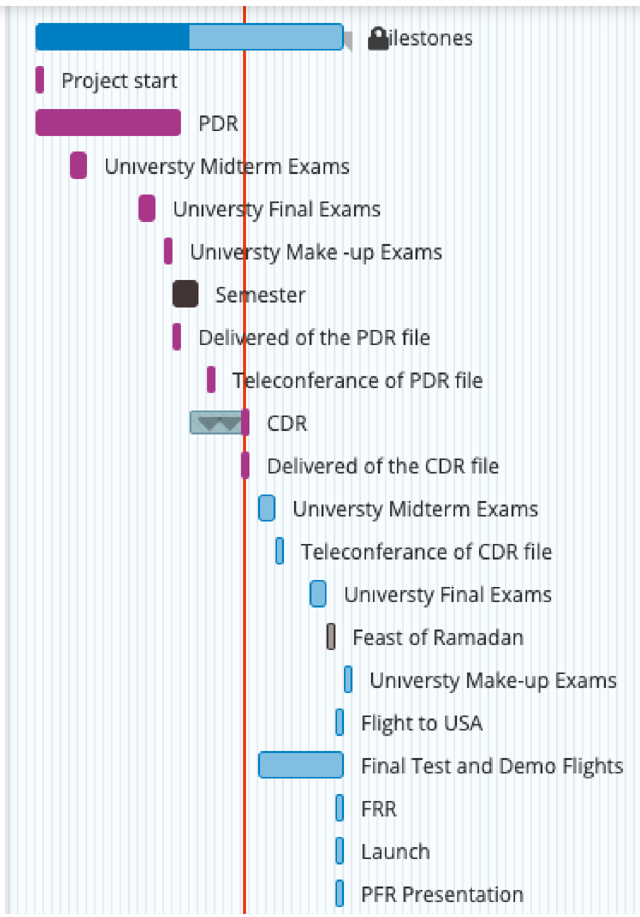
INCOME

		Price (Total)
Sponsors	Turkish Airlines	Flight Ticket
	ERDEMİR	$4.000,00
Grants	Zonguldak Bulent Ecevit University	$2.750,00
Total		$6.750,00

Program Schedule Overview

Milestones

Task	Start	End	Progress
Milestones	08/Oct	23/Jun	50%
Project start	08/Oct	08/Oct	100%
PDR	12/Oct	31/Jan	100%
Universty Midterm Exams	07/Nov	16/Nov	100%
Universty Final Exams	31/Dec	11/Jan	100%
Universty Make -up Exams	21/Jan	25/Jan	100%
Semester	28/Jan	11/Feb	100%
Delivered of the PDR file	31/Jan	31/Jan	100%
Teleconferance of PDR file	27/Feb	27/Feb	100%
CDR	11/Feb	29/Mar	100%
Delivered of the CDR file	29/Mar	29/Mar	100%
Universty Midterm Exams	11/Apr	20/Apr	0%
Teleconferance of CDR file	25/Apr	25/Apr	0%
Universty Final Exams	20/May	02/Jun	0%
Feast of Ramadan	04/Jun	06/Jun	0%
Universty Make-up Exams	17/Jun	23/Jun	0%
Flight to USA	11/Jun	11/Jun	0%
Final Test and Demo Flights	12/Apr	15/Jun	0%
FRR	14/Jun	14/Jun	0%
Launch	15/Jun	15/Jun	0%
PFR Presentation	16/Jun	16/Jun	0%



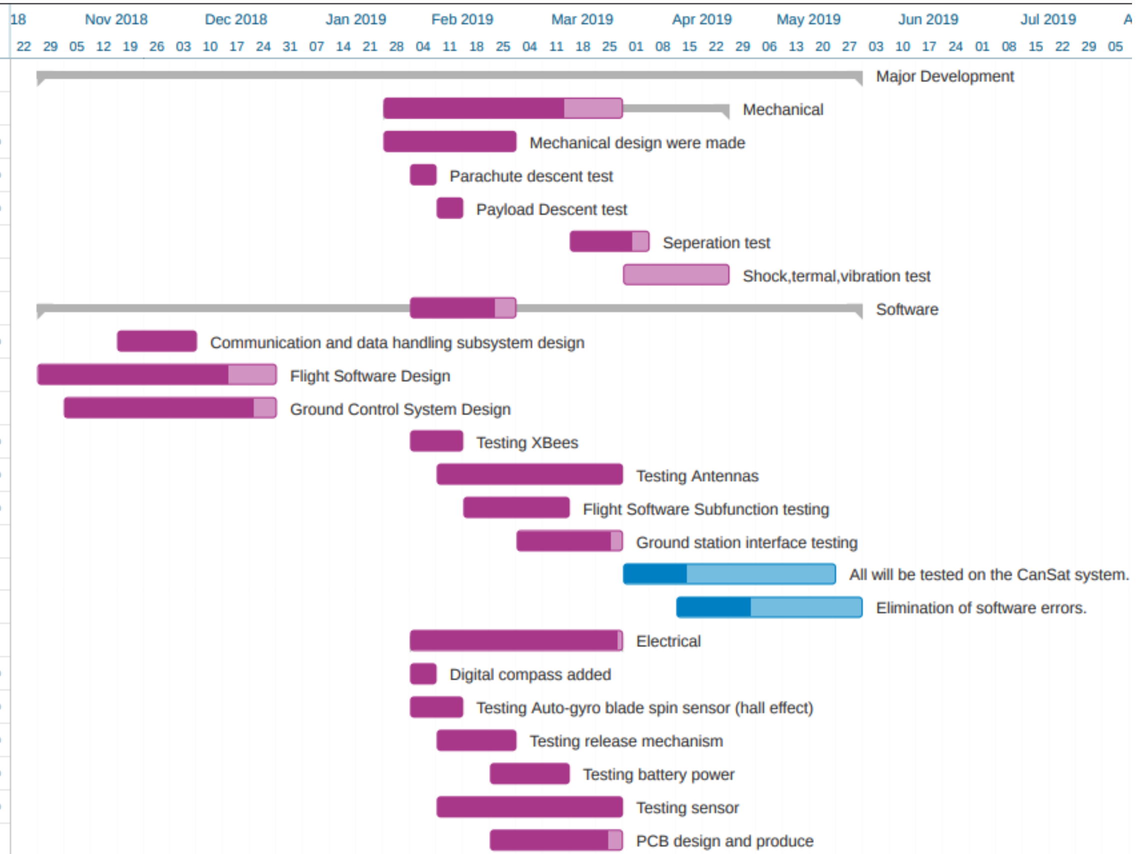
Unfinished Works

Holiday

Finished Works

Major Development

	Major Development	Start Date	Due Date	Task Prog.
	Major Development	30/Oct	01/Jun	85%
	Mechanical	01/Feb	25/Mar	76%
2	Mechanical design were made	31/Jan	28/Feb	100%
3	Parachute descent test	06/Feb	10/Feb	100%
4	Payload Descent test	11/Feb	13/Feb	100%
5	Seperation test	22/Mar	02/Apr	80%
6	Shock,termal,vibration test	03/Apr	25/Apr	0%
	Software	05/Feb	25/Feb	81%
8	Communication and data handling subsy…	23/Nov	03/Dec	100%
9	Flight Software Design	30/Oct	30/Dec	80%
10	Ground Control System Design	11/Nov	26/Dec	90%
11	Testing XBees	07/Feb	14/Feb	100%
12	Testing Antennas	14/Feb	25/Mar	100%
13	Flight Software Subfunction testing	22/Feb	15/Mar	100%
14	Ground station interface testing	10/Mar	25/Mar	90%
15	All will be tested on the CanSat system.	05/Apr	20/May	30%
16	Elimination of software errors.	15/Apr	01/Jun	40%
	Electrical	05/Feb	25/Mar	98%
18	Digital compass added	05/Feb	10/Feb	100%
19	Testing Auto-gyro blade spin sensor (hall…	08/Feb	15/Feb	100%
20	Testing release mechanism	17/Feb	25/Feb	100%
21	Testing battery power	27/Feb	15/Mar	100%
22	Testing sensor	15/Feb	25/Mar	100%
23	PCB design and produce	01/Mar	25/Mar	90%



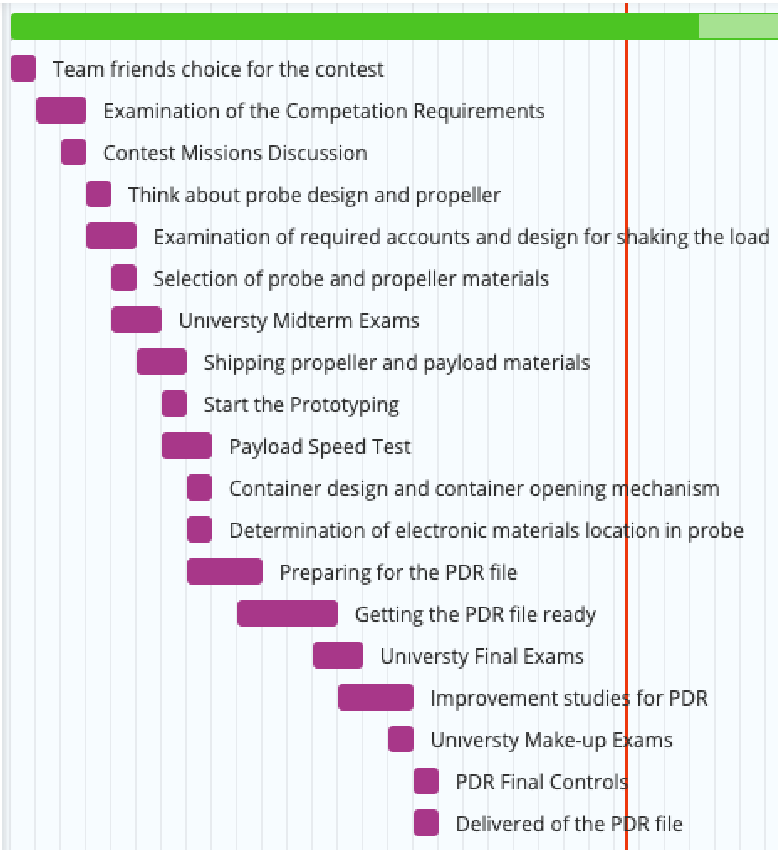
Finished Works

Unfinished Works

Detailed Program Schedule (2 of 9)

Mechanical

	Task	Start	End	Progress
	Mechanical	08/Oct	23/Jun	76%
☑	Team friends choice for the contest	08/Oct	12/Oct	100%
☑	Examination of the Competation R...	21/Oct	22/Oct	100%
☑	Contest Missions Discussion	23/Oct	24/Oct	100%
☑	Think about probe design and pro...	30/Oct	01/Nov	100%
☑	Examination of required accounts ...	01/Nov	05/Nov	100%
☑	Selection of probe and propeller ...	05/Nov	07/Nov	100%
☑	Universty Midterm Exams	07/Nov	16/Nov	100%
☑	Shipping propeller and payload m...	17/Nov	23/Nov	100%
☑	Start the Prototyping	23/Nov	25/Nov	100%
☑	Payload Speed Test	25/Nov	26/Nov	100%
☑	Container design and container o...	26/Nov	28/Nov	100%
☑	Determination of electronic mater...	28/Nov	30/Nov	100%
☑	Preparing for the PDR file	30/Nov	11/Dec	100%
☑	Getting the PDR file ready	11/Dec	31/Dec	100%
☑	Universty Final Exams	31/Dec	11/Jan	100%
☑	Improvement studies for PDR	11/Jan	21/Jan	100%
☑	Universty Make-up Exams	21/Jan	25/Jan	100%
☑	PDR Final Controls	30/Jan	30/Jan	100%
☑	Delivered of the PDR file	31/Jan	31/Jan	100%



Finished Works

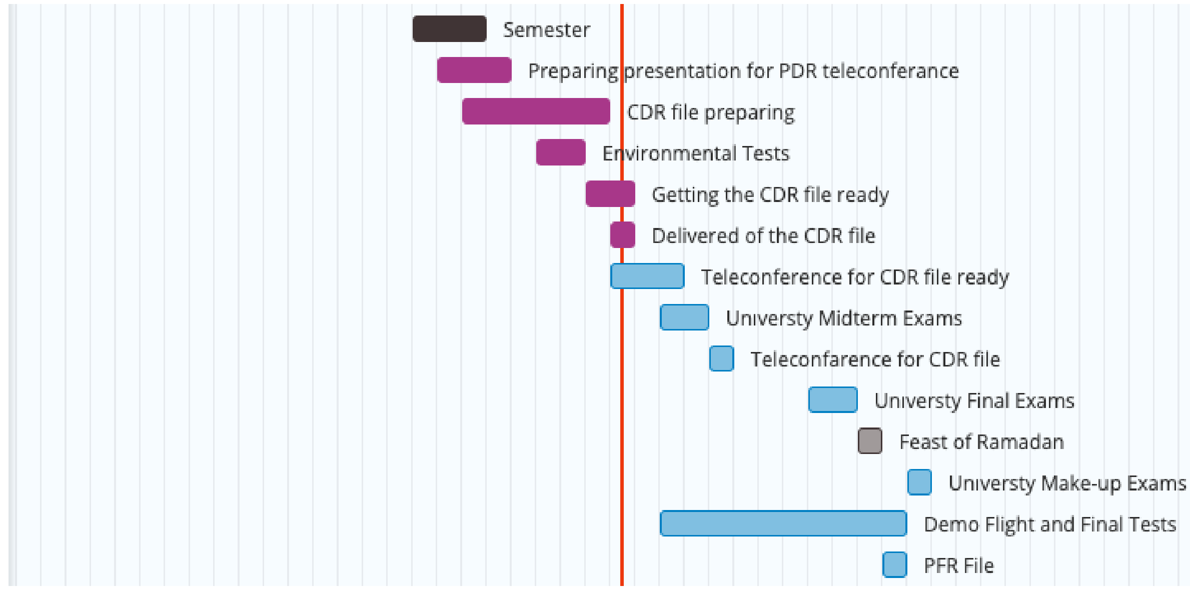
Holiday

Unfinished Works

Detailed Program Schedule (3 of 9)

Mechanical

	Task	Start	End	Progress
☑	Semester	28/Jan	11/Feb	100%
☑	Preparing presentation for PDR tel...	07/Feb	20/Feb	100%
☑	CDR file preparing	11/Feb	20/Mar	100%
☑	Environmental Tests	07/Mar	14/Mar	100%
☑	Getting the CDR file ready	20/Mar	28/Mar	100%
☑	Delivered of the CDR file	29/Mar	29/Mar	100%
☐	Teleconference for CDR file ready	30/Mar	10/Apr	0%
☐	Universty Midterm Exams	11/Apr	20/Apr	0%
☐	Teleconfarence for CDR file	25/Apr	25/Apr	0%
☐	Universty Final Exams	20/May	02/Jun	0%
☐	Feast of Ramadan	04/Jun	06/Jun	0%
☐	Universty Make-up Exams	17/Jun	23/Jun	0%
☐	Demo Flight and Final Tests	12/Apr	15/Jun	0%
☐	PFR File	16/Jun	16/Jun	0%



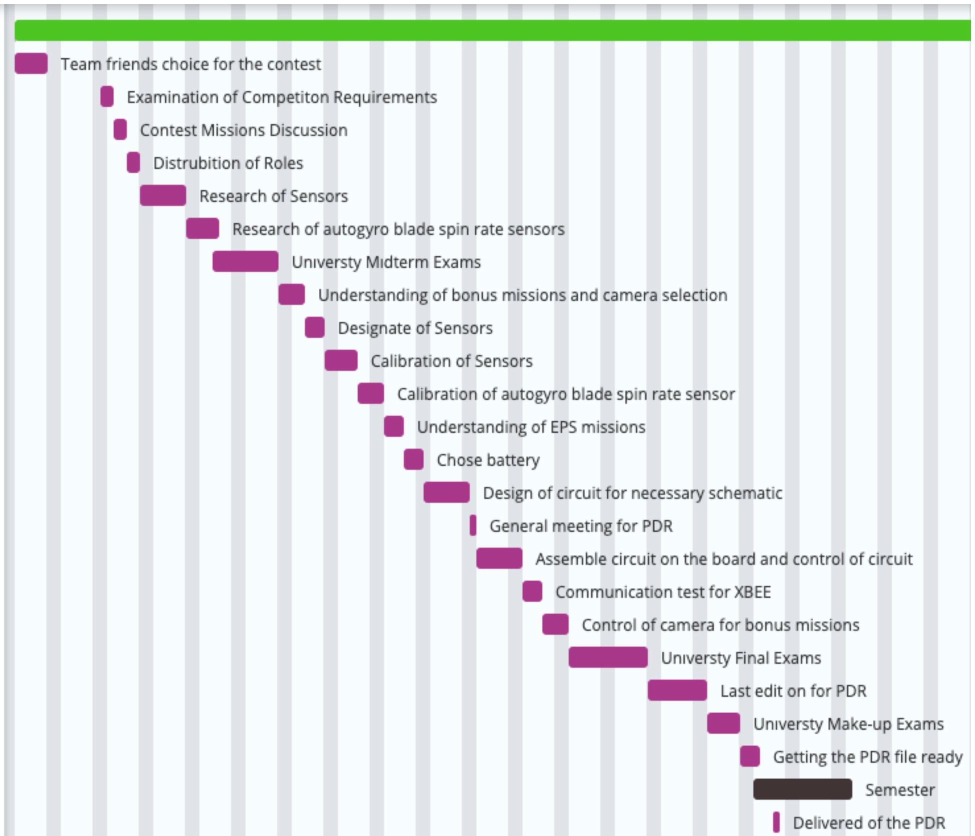
Finished works

Unfinished works

Holiday

Electrical and Electronics

#	Task	Start	End	Progress
	Electrical and Electronics	08/Oct	23/Jun	80%
1	Team friends choice for the contest	08/Oct	12/Oct	100%
2	Examination of Competiton Requi...	21/Oct	22/Oct	100%
3	Contest Missions Discussion	23/Oct	24/Oct	100%
4	Distrubition of Roles	25/Oct	26/Oct	100%
5	Research of Sensors	27/Oct	02/Nov	100%
6	Research of autogyro blade spin r...	03/Nov	07/Nov	100%
7	Unıversty Midterm Exams	07/Nov	16/Nov	100%
8	Understanding of bonus missions ...	17/Nov	20/Nov	100%
9	Designate of Sensors	21/Nov	23/Nov	100%
10	Calibration of Sensors	24/Nov	28/Nov	100%
11	Calibration of autogyro blade spin...	29/Nov	02/Dec	100%
12	Understanding of EPS missions	03/Dec	05/Dec	100%
13	Chose battery	06/Dec	08/Dec	100%
14	Design of circuit for necessary sch...	09/Dec	15/Dec	100%
15	General meeting for PDR	16/Dec	16/Dec	100%
16	Assemble circuit on the board and...	17/Dec	23/Dec	100%
17	Communication test for XBEE	24/Dec	26/Dec	100%
18	Control of camera for bonus missi...	27/Dec	30/Dec	100%
19	Unıversty Final Exams	31/Dec	11/Jan	100%
20	Last edit on for PDR	12/Jan	20/Jan	100%
21	Unıversty Make-up Exams	21/Jan	25/Jan	100%
22	Getting the PDR file ready	26/Jan	28/Jan	100%
23	Semester	28/Jan	11/Feb	100%
24	Delivered of the PDR	31/Jan	31/Jan	100%



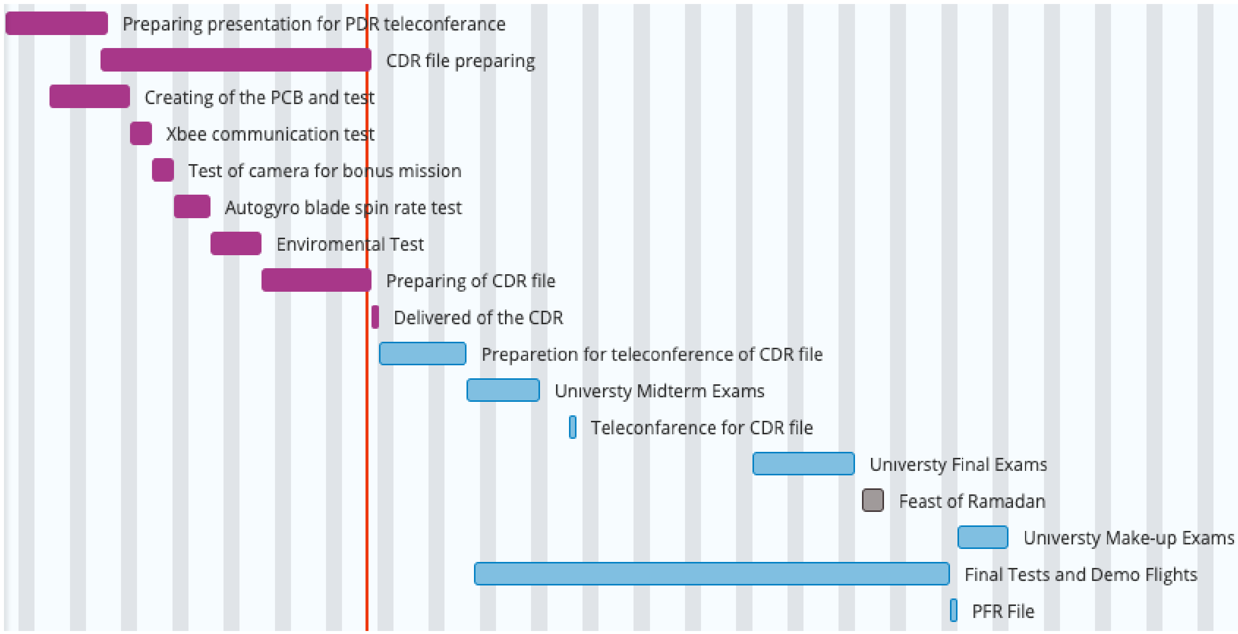
Finished Works

Holiday

Unfinished Works

Electrical and Electronics

☑	Preparing presentation for PDR tel...	07/Feb	20/Feb	100%	
☑	CDR file preparing	20/Feb	28/Mar	100%	
☑	Creating of the PCB and test	13/Feb	23/Feb	100%	
☑	Xbee communication test	24/Feb	26/Feb	100%	
☑	Test of camera for bonus mission	27/Feb	01/Mar	100%	
☑	Autogyro blade spin rate test	02/Mar	06/Mar	100%	
☑	Enviromental Test	07/Mar	13/Mar	100%	
☑	Preparing of CDR file	14/Mar	28/Mar	100%	
☑	Delivered of the CDR	29/Mar	29/Mar	100%	
☐	Prepaaretion for teleconference of ...	30/Mar	10/Apr	0%	
☐	Universty Midterm Exams	11/Apr	20/Apr	0%	
☐	Teleconferance for CDR file	25/Apr	25/Apr	0%	
☐	Universty Final Exams	20/May	02/Jun	0%	
☐	Feast of Ramadan	04/Jun	06/Jun	0%	
☐	Universty Make-up Exams	17/Jun	23/Jun	0%	
☐	Final Tests and Demo Flights	12/Apr	15/Jun	0%	
☐	PFR File	16/Jun	16/Jun	0%	



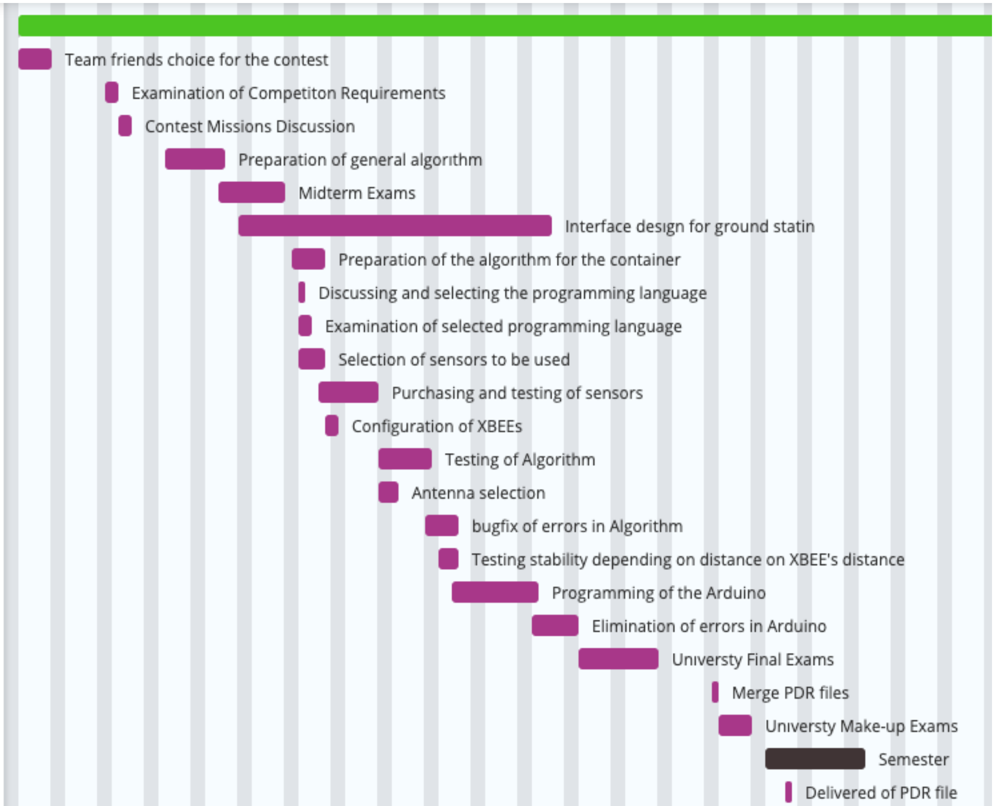
Holiday

Finished Works

Unfinished Works

Software

Software	08/Oct	23/Jun	79%
Team friends choice for the contest	08/Oct	12/Oct	100%
Examination of Competiton Requi...	21/Oct	22/Oct	100%
Contest Missions Discussion	23/Oct	24/Oct	100%
Preparation of general algorithm	30/Oct	07/Nov	100%
Midterm Exams	07/Nov	16/Nov	100%
Interface design for ground statin	10/Nov	26/Dec	100%
Preparation of the algorithm for t...	18/Nov	22/Nov	100%
Discussing and selecting the progr...	19/Nov	19/Nov	100%
Examination of selected program...	19/Nov	20/Nov	100%
Selection of sensors to be used	19/Nov	22/Nov	100%
Purchasing and testing of sensors	22/Nov	30/Nov	100%
Configuration of XBEEs	23/Nov	24/Nov	100%
Testing of Algorithm	01/Dec	08/Dec	100%
Antenna selection	01/Dec	03/Dec	100%
bugfix of errors in Algorithm	08/Dec	12/Dec	100%
Testing stability depending on dist...	10/Dec	12/Dec	100%
Programming of the Arduino	12/Dec	24/Dec	100%
Elimination of errors in Arduino	24/Dec	30/Dec	100%
Universty Final Exams	31/Dec	11/Jan	100%
Merge PDR files	20/Jan	20/Jan	100%
Universty Make-up Exams	21/Jan	25/Jan	100%
Semester	28/Jan	11/Feb	100%
Delivered of PDR file	31/Jan	31/Jan	100%



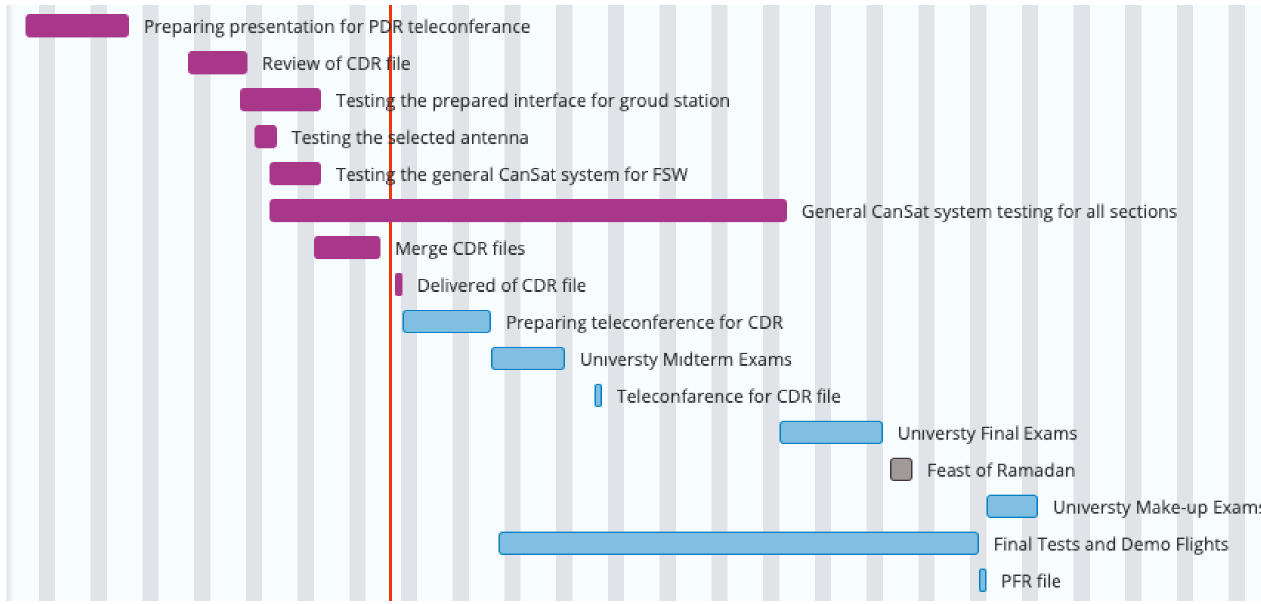
Holiday

Finished Works

Unfinished Works

Software

Preparing presentation for PDR tel...	07/Feb	20/Feb	100%	
Review of CDR file	01/Mar	08/Mar	100%	
Testing the prepared interface for ...	08/Mar	18/Mar	100%	
Testing the selected antenna	10/Mar	12/Mar	100%	
Testing the general CanSat system...	12/Mar	18/Mar	100%	
General CanSat system testing for...	12/Mar	20/May	100%	
Merge CDR files	18/Mar	26/Mar	100%	
Delivered of CDR file	29/Mar	29/Mar	100%	
Preparing teleconference for CDR	30/Mar	10/Apr	0%	
Universty Midterm Exams	11/Apr	20/Apr	0%	
Teleconfarence for CDR file	25/Apr	25/Apr	0%	
Universty Final Exams	20/May	02/Jun	0%	
Feast of Ramadan	04/Jun	06/Jun	0%	
Universty Make-up Exams	17/Jun	23/Jun	0%	
Final Tests and Demo Flights	12/Apr	15/Jun	0%	
PFR file	16/Jun	16/Jun	0%	



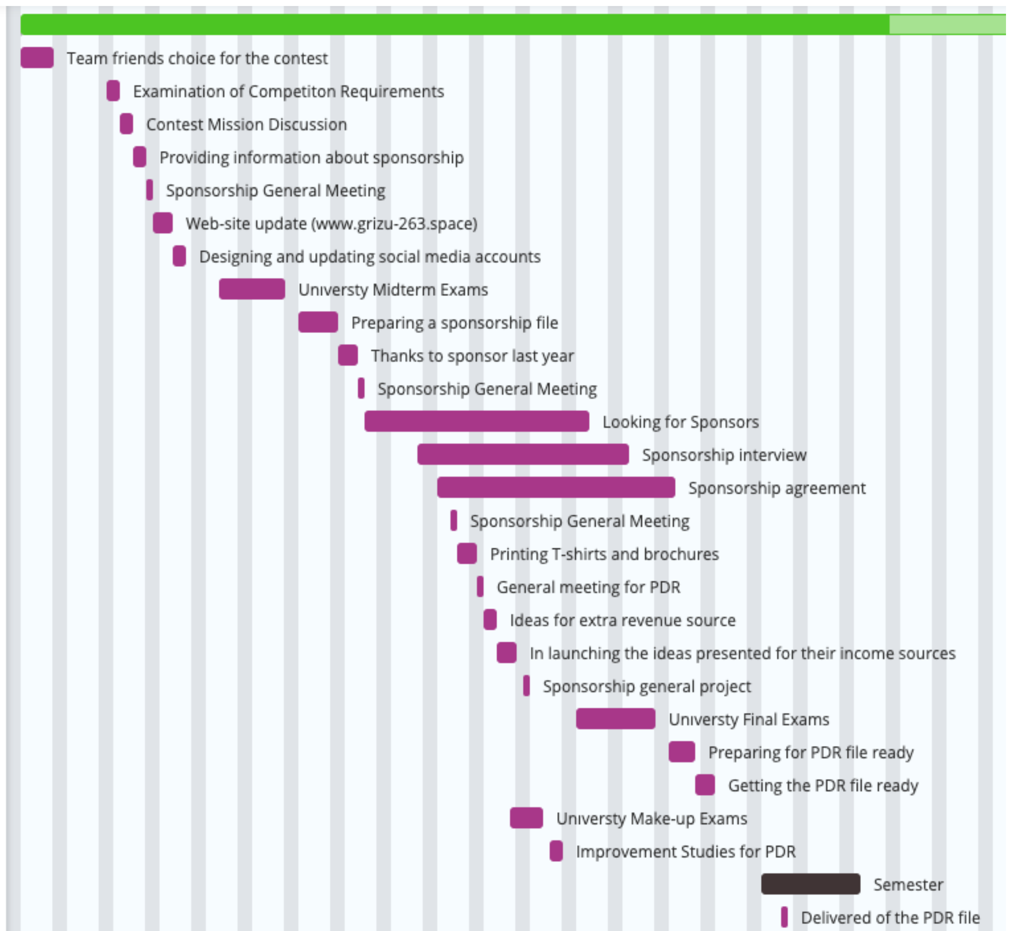
Holiday

Finished Works

Unfinished Works

Sponsorship

Sponsorship	08/Oct	23/Jun	76%
Team friends choice for the contest	08/Oct	12/Oct	100%
Examination of Competiton Requi...	21/Oct	22/Oct	100%
Contest Mission Discussion	23/Oct	24/Oct	100%
Providing information about spon...	25/Oct	26/Oct	100%
Sponsorship General Meeting	27/Oct	27/Oct	100%
Web-site update (www.grizu-263.s...	28/Oct	30/Oct	100%
Designing and updating social me...	31/Oct	01/Nov	100%
Universty Midterm Exams	07/Nov	16/Nov	100%
Preparing a sponsorship file	19/Nov	24/Nov	100%
Thanks to sponsor last year	25/Nov	27/Nov	100%
Sponsorship General Meeting	28/Nov	28/Nov	100%
Looking for Sponsors	29/Nov	01/Jan	100%
Sponsorship interview	07/Dec	07/Jan	100%
Sponsorship agreement	10/Dec	14/Jan	100%
Sponsorship General Meeting	12/Dec	12/Dec	100%
Printing T-shirts and brochures	13/Dec	15/Dec	100%
General meeting for PDR	16/Dec	16/Dec	100%
Ideas for extra revenue source	17/Dec	18/Dec	100%
In launching the ideas presented f...	19/Dec	21/Dec	100%
Sponsorship general project	23/Dec	23/Dec	100%
Universty Final Exams	31/Dec	11/Jan	100%
Preparing for PDR file ready	14/Jan	17/Jan	100%
Getting the PDR file ready	18/Jan	20/Jan	100%
Universty Make-up Exams	21/Dec	25/Dec	100%
Improvement Studies for PDR	27/Dec	28/Dec	100%
Semester	28/Jan	11/Feb	100%
Delivered of the PDR file	31/Jan	31/Jan	100%



Holiday

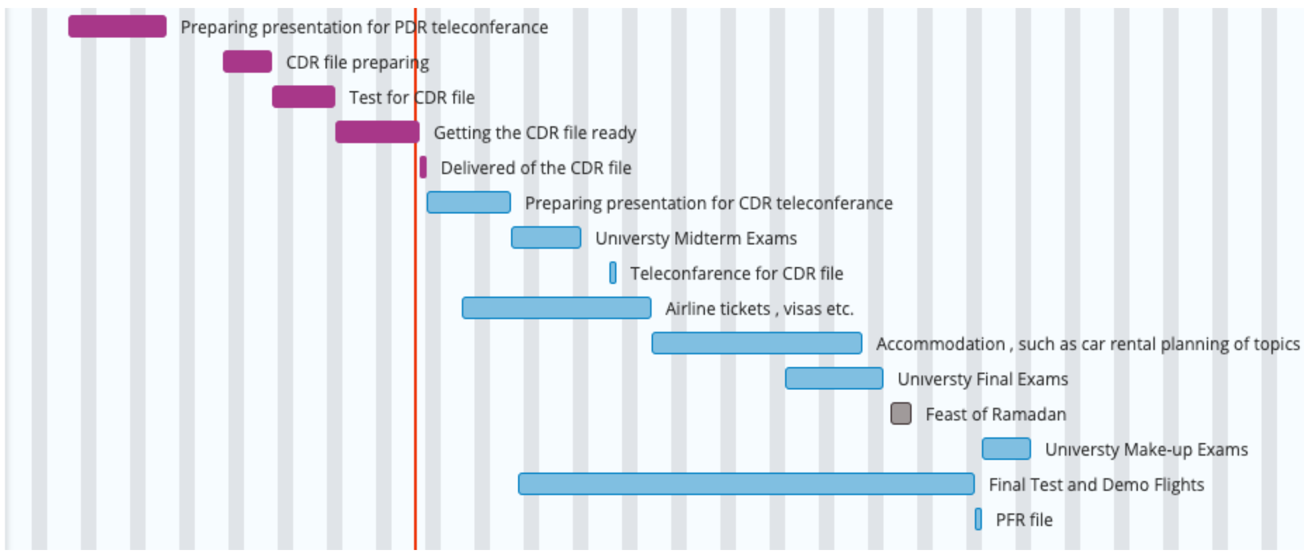
Finished Works

Unfinished Works

Detailed Program Schedule (9 of 9)

Sponsorship

	Task	Start	End	Progress
☑	Preparing presentation for PDR tel...	07/Feb	20/Feb	100%
☑	CDR file preparing	01/Mar	07/Mar	100%
☑	Test for CDR file	08/Mar	16/Mar	100%
☑	Getting the CDR file ready	17/Mar	28/Mar	100%
☑	Delivered of the CDR file	29/Mar	29/Mar	100%
☐	Preparing presentation for CDR te...	30/Mar	10/Apr	0%
☐	Universty Midterm Exams	11/Apr	20/Apr	0%
☐	Teleconferance for CDR file	25/Apr	25/Apr	0%
☐	Airline tickets , visas etc.	04/Apr	30/Apr	0%
☐	Accommodation , such as car rent...	01/May	30/May	0%
☐	Universty Final Exams	20/May	02/Jun	0%
☐	Feast of Ramadan	04/Jun	06/Jun	0%
☐	Universty Make-up Exams	17/Jun	23/Jun	0%
☐	Final Test and Demo Flights	12/Apr	15/Jun	0%
☐	PFR file	16/Jun	16/Jun	0%



Holiday

Finished Works

Unfinished Works

Shipping and Transportation

• First of all, we will go to Istanbul which is our boarding place. We will go between Zonguldak and Istanbul with personal cars.

•We will put our equipment in the "hard case" bag on the journey of Istanbul - America put the emblem and contact addresses of our team on top of the bag and deliver the package to the cargo section of the plane. We will inform the authorities about this. Turkish Airlines, which is our sponsor of the flight, also said they will show sensitivity.

• In America, we will rent a car and we will bring our packages to where the arbiter is going. We hope to have a safe and trouble-free journey in this way.

Conclusions

Accomplishments :

- All sensors determined, procured and tested.
- By drone, the auto-gyro stability and descent test were done.
- The PCB is designed according to the power budget.

- XBee and antenna communication successfully. Through our interface software, calibration command transmission and receiving the telemetry data from the sensors have been completed.

- Mechanical design was made.
- All materials are defined, supplied.
- Prototypes were prepared.
- The descent test is completed via the drone at 400 meters.

Unfinished Works :

- FSW and GCS software system will be tested again on the CanSat system as a whole.
- The PCB isn’t produced.
- Separation tests were not performed at 700 m.
- Acceleration and shock force tests were not performed.
- Environmental tests not performed.

Testing to complete :

- Testing XBees communication successful.
- The antenna range has been tested.
- Ground station interface has been tested.

Flight software status :

- FSW subsystems have been tested.
- FSW system will be tested again on the CanSat system as a whole on 15th May.