CanSat 2020
Critical Design Review (CDR)
Version 1.0

Team # 7840
grizu-263

Presentation Outline (3 of 8)

Presentation Outline (5 of 8)

7. Electrical Power Subsystem (EPS) Design - 109

8. Flight Software (FSW) Design - 123

9. Ground Control System (GCS) Design - 136

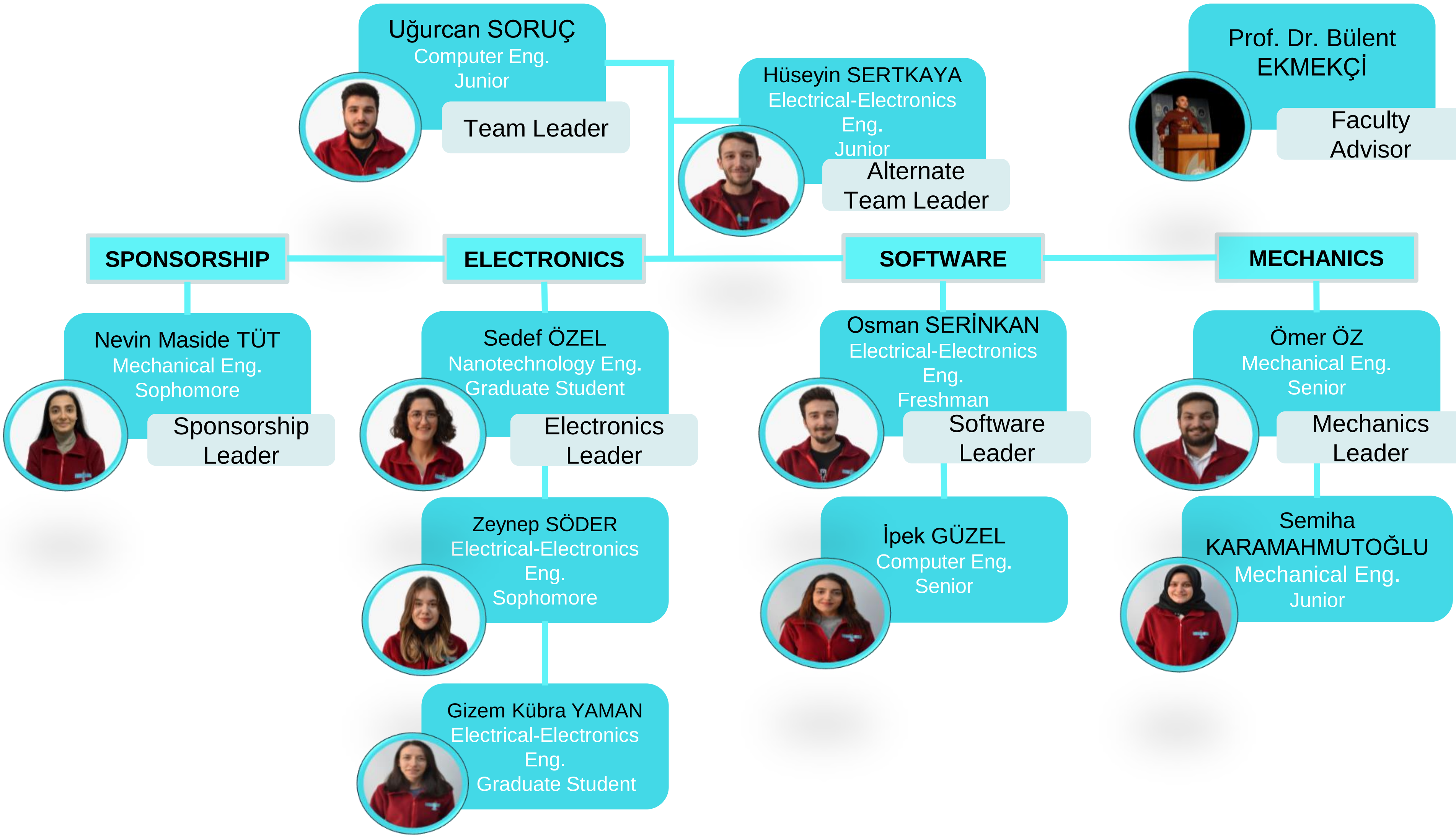
10. CanSat Integration and Test - 148

Presentation Outline (7 of 8)

Presentation Outline (8 of 8)

- **Systems Overview –** Nevin Maside TÜT
- **Sensor Subsystem Design –** Zeynep SÖDER
- **Descent Control Design –** Semiha KARAMAHMUTOĞLU
- **Mechanical Subsystem Design –** Ömer ÖZ
- **CDH Subsystem Design –** Sedef ÖZEL
- **Electrical Power Subsystem Design –** Hüseyin SERTKAYA
- **Flight Software Design –** Osman SERİNKAN
- **Ground Control System Design –** İpek GÜZEL
- **CanSat Integration and Test –**Gizem Kübra YAMAN
- **Mission Operations and Analysis –** Uğurcan SORUÇ
- **Requirements Compliance –** Uğurcan SORUÇ
- **Management –** Nevin Maside TÜT

Team Organization



Acronyms (1 of 2)

- **A** – Analysis
- **ABS** – Acrylonitrile Butadiene Styrene
- **AC** – Alternate Current
- **ANT** – Antenna
- **Aoa** – Angle of Attack
- **AR** – Aspect Ratio
- **CC** – CanSat Crew
- **CDH** – Communication and Data Handling
- **CDR** – Critical Design Review
- **CRC** – Container Recovery Crew
- **cm** – Centimeter
- **D** – Demonstration
- **dB** – Decibel
- **dBi** – Decibel Isotropic
- **dBm** – Decibel Milliwatt
- **DC** – Direct Current
- **DS** – Datasheet
- **E** – Estimate
- **EEPROM** – Electrically Erasable Programmable Read Only Memory
- **Eng -** Engineering
- **EPS** – Electrical Power Subsystem
- **EXTRN-** Extra Requirements Number
- **FSW** – Flight Software
- **g** – Grams
- **GB** – Giga Byte
- **GCS** – Ground Control System
- **GSC** – Ground Station Crew
- **GHz** – Giga Hertz
- **GND** – Ground
- **GPS** – Global Positioning System
- **GR** – Glide Ratio
- **Gs** – Gigashock
- **h** – Hours
- **hPa** – Hecto Pascal
- **Hz** – Hertz
- **I** – Inspection
- **I2C** – Inter-Integrated Circuit
- **ID** – Identification Number
- **IDE** – Integrated Development Environment
- **IMU** – Inertial Measurement Unit
- **kB** – Kilo Byte
- **kg** – Kilogram
- **km** – Kilometer
- **kPa** – Kilo Pascal
- **m** – Meter
- **mA** – Milli Ampere
- **mAh** – Milli Ampere Hour
- **Mb** – Megabit
- **MCO** – Mission Control Officer
- **MCU** – Microcontroller Unit
- **Mech -** Mechanism
- **mg** – Milligram
- **MHz** – Mega Hertz
- **min** – Minute
- **mm** – Millimeter
- **MOM** – Mission Operations Manuel

Acronyms (2 of 2)

- **MPa** – Mega Pascal
- **ms** – Millisecond
- **MS** – Measurement
- **mW** – Milli Watt
- **N** – Newton
- **Pa** – Pascal
- **PCB** – Printed Circuit Board
- **PDR** – Preliminary Design Review
- **PFR** – Post Flight Review
- **PM** – Particulate Matter
- **PRC** – Payload Recovery Crew
- **Prev** – Previous
- **PWM** – Pulse Width Modulation
- **r** – Radius
- **RAM** – Random Access Memory
- **RC** – Recovery Crew
- **RF** – Radio Frequency
- **RN** – Requirement Number
- **RP- SMA** – Reverse Polarity SubMiniature Version A
- **RTC** – Real Time Clock
- **s** – Second
- **SD** – Secure Digital
- **SMA** – SubMiniature Version A
- **SPI** – Serial Peripheral Interface
- **Ssh** – Spill Hole Area
- **T** – Test
- **TEMP** – Temperature
- **UART** – Universal Asynchronous Receiver/Transmitter
- **USB** – Universal Serial Bus
- **UTC** – Coordinated Universal Time
- **V** – Voltage
- **VM** – Verification Method
- **Wh** – Watt hours
- **WS** – Wingspan
- **XCTU** – Next Generation Configuration Platform for XBee/RF Solutions
- C_D – Drag Coefficient
- C_L – Lift Coefficient
- g – Gravitational Force
- Sp – Area of the Parachute with a Spill Hole
- ρ – Air Density
- V – Descent Speed
- **%** – Percent
- **.csv** – Comma-Separated Value
- **°C** – Centigrade Degree
- **°** – Degree
- **µA** – Micro Ampere
- **µm** – Micrometer

System Overview

Nevin Maside TÜT

Mission Summary (1 of 4)

Mission

- The CanSat will consist of a container and a payload.
- The payload shall be a delta wing glider that will glide in a circular pattern, once released.

Mission Objectives

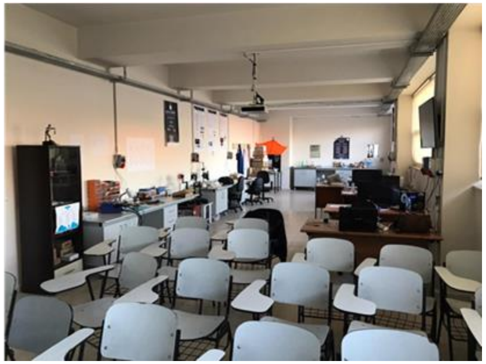
- The CanSat shall be launched to an altitude ranging from 670 meters to 725 meters above the launch site and deployed near apogee (peak altitude). The Orientation of deployment is not controlled and is most definitely violent.
- The CanSat container must protect the payload from damage during the launch and deployment.
- Once the CanSat is deployed from the rocket, the CanSat shall descent using a parachute at a descent rate of 20 m/s (±5 m/s). At 450 meters (±10 m), the container shall release the payload.
- The payload shall glide in a circular pattern with a radius of 250 meters collecting sensor data for one minute and remain above 100 meters after being released.
- The payload shall monitor altitude, airspeed and the payload shall be a particulate/dust sensor to detect particulates in the air while gliding.
- Afterwards, the payload shall deploy a parachute to cause the payload to stop gliding and drop to the ground at a rate of 10 m/s (±5 m/s).

Bonus Objective

- A video camera shall be integrated into the payload and point toward the coordinates provided for the duration of the glide time.
- Video shall be in color with a minimum resolution of 640x480 pixels and 30 frames per second.
- The video shall be recorded and retrieved when the payload is retrieved.

External Objectives

- 3D simulation was added to the software.
- Our goal is to be first in CanSat 2020.
- Through our success in the CanSat competition, we signed a sponsorship agreement with ERDEMİR Company and we expanded our team and moved into our new lab.
- The recognition of the team has increased in Turkey after we came second place for the second time. The awareness of CanSat Competition is also increased nationwide.




Milliyet
BASINDA GÜVEN
Karanlık maden ocaklarından uzayın sonsuz derinliklerine uzanan bir Zonguldak hikayesi
UZAYDA GRİZU PARLAMASI
263 madenci anısına


ürkiye'nin ilk cep uydusu:
GRİZU 263-A

External Objectives

- We came first in the model satellite competition held within the scope of TEKNOFEST event held in Turkey.
- We have gained a pleasant experience with CanSat Competition and started a new national project to design and produce Turkey's first PocketQube satellite.
  - PocketQube will have dimensions of the 5x5x5 cm.
  - It will be placed in Low Earth Orbit at an altitude (500 km).
  - We have completed the ground station installation for PocketQube.
  - The PocketQube satellite is under the production phase (prototype 75%).

  At the same time, our satellite ground station is completed, and it is operational now.

- PocketQube and CanSat internet address:

  https://grizu263.beun.edu.tr/

External Objectives

- Coronavirus has affected our country as well as all over the world. We also produced face visors and breathing apparatus by the use of our 3D printers to fit the needs quickly for the hospitals in Zonguldak.
- We made presentations on various topics together with our teammates during the pandemic period.

Summary of Changes Since PDR

CONTAINER	
Electronics	The electronic circuit was removed from the container.
Mechanics	We have change the container size.
PAYLOAD	
Electronics	The separation of the payload from the container will be provided with the melt stop box added to the payload.
Mechanics	The diameter of the payload parachute and spill hole has changed. The diameter of the payload parachute and spill hole has changed.
	Melt stop box will be added to the payload for separation.
	We will use the new hinges for the folding mechanism of the wing. The use of our 3D printers able us to produces the hinges.
Software	Release mechanism will be activated from the payload.

System Requirement Summary (1 of 7)

Requirement Number	Requirement	Rationale	Priority	VM			
				A	I	T	D
RN#1	Total mass of the CanSat (science payload and container) shall be 600 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	HIGH		✓		
RN#5	The container shall be solid and fully enclose the science payload. Small holes to allow access to turn on the science payload is allowed. The end of the container where the payload deploys may be open.	Competition Requirement	HIGH		✓	✓	
RN#6	The rocket airframe shall not be used to restrain any deployable parts of the CanSat.	Competition Requirement	MEDIUM		✓		✓
RN#7	The rocket airframe shall not be used as part of the CanSat operations.	Competition Requirement	HIGH		✓		✓
RN#8	The container parachute shall not be enclosed in the container structure. It shall be external and attached to the container so that it opens immediately when deployed from the rocket.	Competition Requirement	HIGH		✓	✓	✓

System Requirement Summary (2 of 7)

Requirement Number	Requirement	Rationale	Priority	VM			
				A	I	T	D
RN#9	The descent rate of the CanSat (container and science payload) shall be 20 meters/second +/- 5m/s.	Competition Requirement	HIGH		√	√	√
RN#10	The container shall release the payload at 450 meters +/- 10 meters.	Competition Requirement	HIGH		√	√	√
RN#11	The science payload shall glide in a circular pattern with a 250 m radius for one minute and stay above 100 meters after release from the container.	Competition Requirement	HIGH	√	√	√	√
RN#12	The science payload shall be a delta wing glider.	Competition Requirement	HIGH	√	√		√
RN#13	After one minute of gliding, the science payload shall release a parachute to drop the science payload to the ground at 10 meters/second, +/- 5 m/s.	Competition Requirement	HIGH	√	√	√	
RN#18	All electronics shall be hard mounted using proper mounts such as standoffs, screws, or high-performance adhesives.	Competition Requirement	MEDIUM	√	√		
RN#19	All mechanisms shall be capable of maintaining their configuration or states under all forces.	Competition Requirement	HIGH	√		√	
RN#20	Mechanisms shall not use pyrotechnics or chemicals.	Competition Requirement	HIGH	√	√		
RN#21	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	√	√	√	

System Requirement Summary (3 of 7)

Requirement Number	Requirement	Rationale	Priority	VM			
				A	I	T	D
RN#22	The science payload shall measure altitude using an air pressure sensor.	Competition Requirement	HIGH	√		√	√
RN#23	The science payload shall provide position using GPS.	Competition Requirement	HIGH	√		√	√
RN#24	The science payload shall measure its battery voltage.	Competition Requirement	HIGH	√		√	√
RN#25	The science payload shall measure outside temperature.	Competition Requirement	HIGH	√		√	√
RN#26	The science payload shall measure particulates in the air as it glides.	Competition Requirement	HIGH	√		√	√
RN#27	The science payload shall measure air speed.	Competition Requirement	HIGH	√		√	√
RN#28	The science payload shall transmit all sensor data in the telemetry.	Competition Requirement	HIGH	√	√	√	√
RN#29	Telemetry shall be updated once per second.	Competition Requirement	HIGH		√	√	
RN#30	The Parachutes shall be fluorescent Pink or Orange.	Competition Requirement	MEDIUM	√	√		

System Requirement Summary (4 of 7)

Requirement Number	Requirement	Rationale	Priority	VM			
				A	I	T	D
RN#31	The ground system shall command the science vehicle to start transmitting telemetry prior to launch.	Competition Requirement	HIGH	√	√	√	
RN#32	The ground station shall generate a csv file of all sensor data as specified in the telemetry section.	Competition Requirement	HIGH	√	√	√	
RN#33	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#34	Configuration states such as if commanded to transmit telemetry shall be maintained in the event of a processor reset during launch and mission.	Competition Requirement	HIGH	√	√	√	
RN#35	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#36	XBEE radios shall have their NETID/PANID set to their team number	Competition Requirement	MEDIUM	√	√		
RN#37	XBEE radios shall not use broadcast mode.	Competition Requirement	HIGH	√	√		

System Requirement Summary (5 of 7)

Requirement Number	Requirement	Rationale	Priority	VM			
				A	I	T	D
RN#38	Cost of the CanSat shall be under $1000. Ground support and analysis tools are not included in the cost.	Competition Requirement	MEDIUM	√	√		
RN#39	Each team shall develop their own ground station.	Competition Requirement	MEDIUM	√	√	√	
RN#40	All telemetry shall be displayed in real time during descent.	Competition Requirement	HIGH				
RN#41	All telemetry shall be displayed in engineering units (meters, meters/sec, Celsius, etc.).	Competition Requirement	HIGH	√			√
RN#42	Teams shall plot each telemetry data field in real time during flight.	Competition Requirement	HIGH	√	√	√	√
RN#44	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#45	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#46	Both the container and probe shall be labeled with team contact information including email address.	Competition Requirement	MEDIUM	√			√
RN#47	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	√	√		

System Requirement Summary (6 of 7)

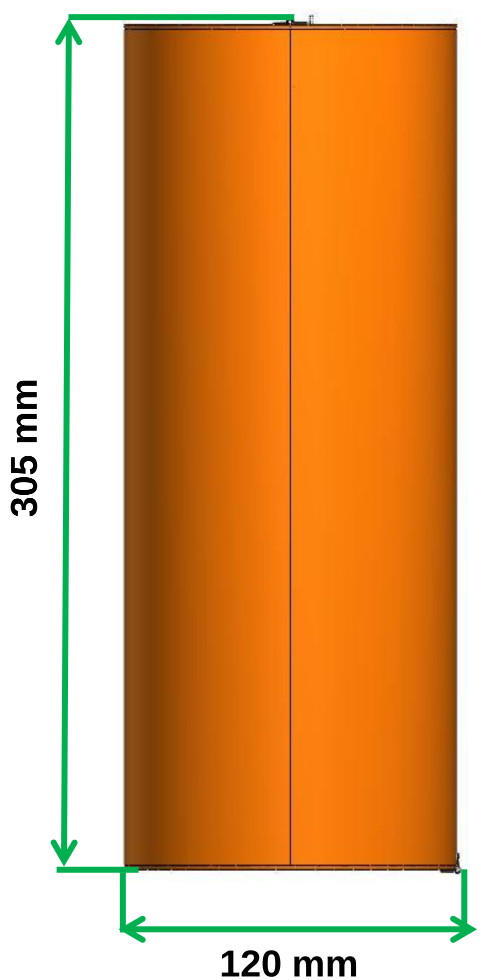
Requirement Number	Requirement	Rationale	Priority	VM			
				A	I	T	D
RN#48	No lasers allowed.	Competition Requirement	MEDIUM	√			
RN#49	The probe must include an easily accessible power switch that can be accessed without disassembling the CanSat and in the stowed configuration.	Competition Requirement	MEDIUM	√	√	√	
RN#50	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#51	An audio beacon is required for the probe. It may be powered after landing or operate continuously.	Competition Requirement	HIGH	√		√	
RN#52	The audio beacon must have a minimum sound pressure level of 92 dB, unobstructed.	Competition Requirement	HIGH	√		√	
RN#53	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#54	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	√	√		

System Requirement Summary (7 of 7)

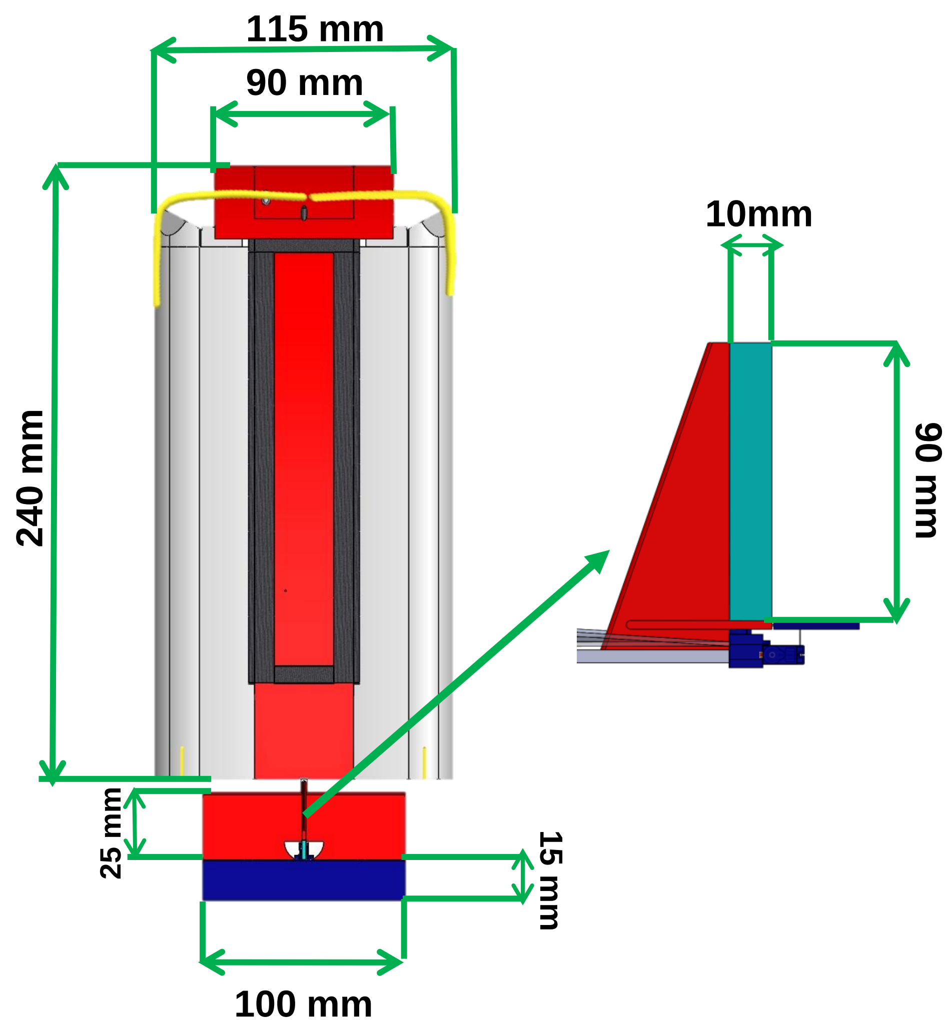
Requirement Number	Requirement	Rationale	Priority	VM			
				A	I	T	D
RN#55	Spring contacts shall not be used for making electrical connections to batteries. Shock forces can cause momentary disconnects.	Competition Requirement	MEDIUM	√	√		
RN#56	The CanSat must operate during the environmental tests laid out in Section 3.5.	Competition Requirement	HIGH	√	√	√	√
RN#57	Payload/Container shall operate for a minimum of two hours when integrated into rocket.	Competition Requirement	HIGH	√	√		
EXTRN#1	A gyro sensor should be used to obtain pitch, roll yaw data.	To perform active control	HIGH	√		√	√
EXTRN#2	Active control must be provided by using rudder and elevator in servo motor control.	To perform active control	HIGH	√	√	√	
EXTRN#3	The selected battery should meet the current requirements drawn by the system.	To withstand high current	HIGH	√		√	√
EXTRN#4	A video camera shall be integrated into the payload and point toward the coordinates provided for the duration of the glide time. Video shall be in color with a minimum resolution of 640x480 pixels and 30 frames per second. The video shall be recorded and retrieved when the payload is retrieved. Points will be awarded only if the camera can maintain pointing at the provided coordinates for 30 seconds uninterrupted.	To fulfill bonus objective	HIGH		√	√	

Payload Physical Layout (1 of 8)

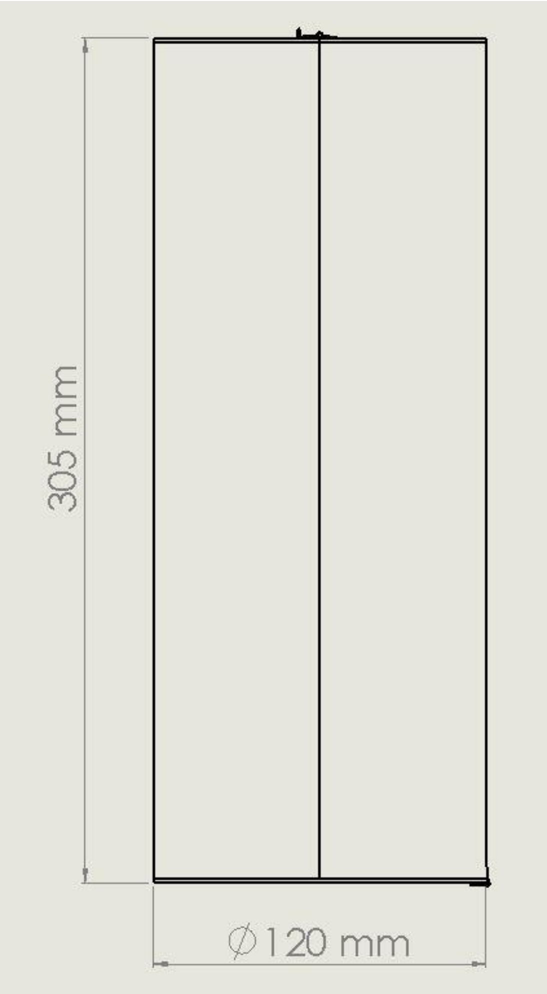
Container Dimensions



Payload Dimensions

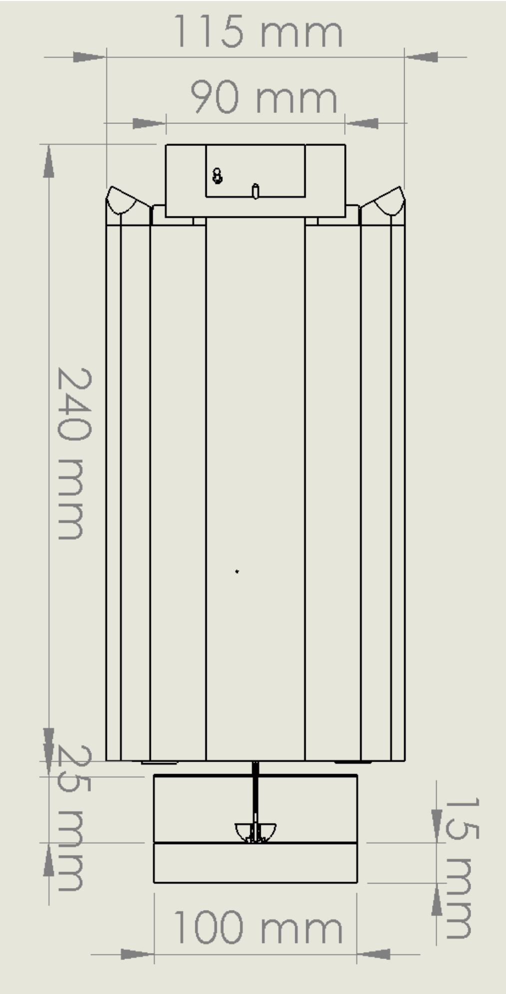


Container Dimensions

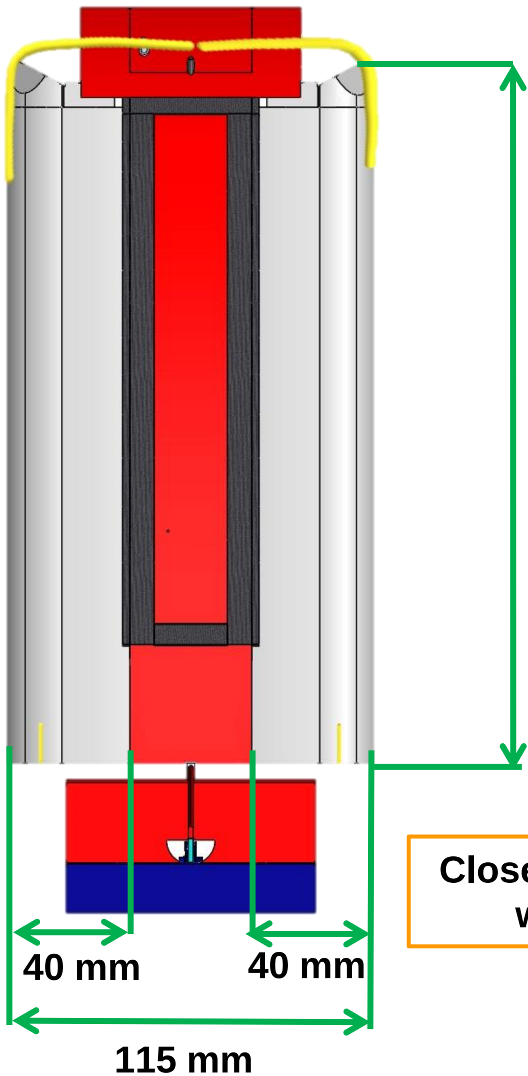


- **Container and payload technical drawings.**
- **Pictures were drawn with CAD program.**
- **All measurements units are in mm.**

Payload Dimensions

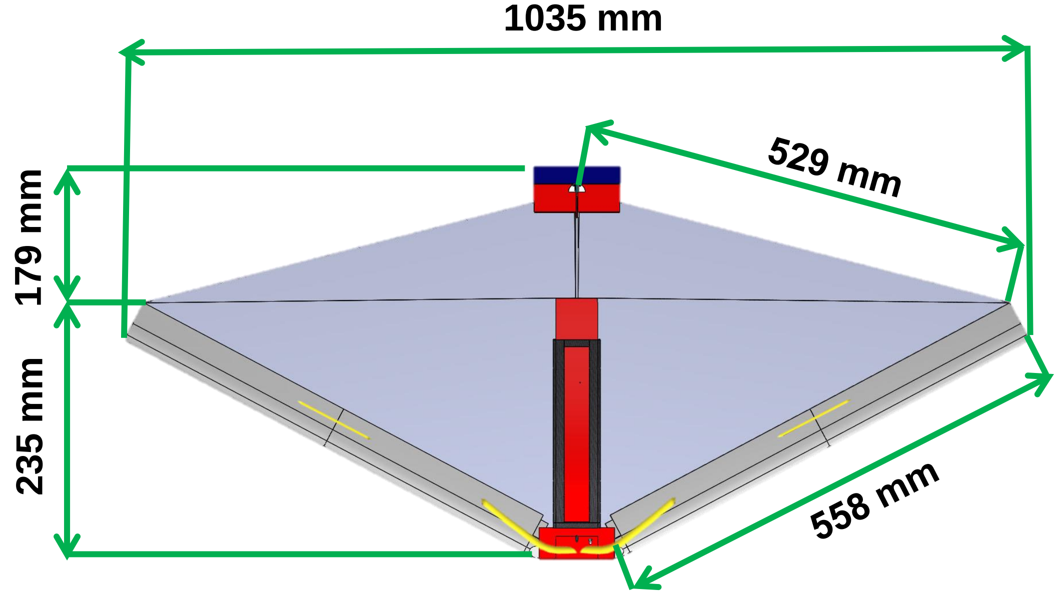


Payload Physical Layout (3 of 8)



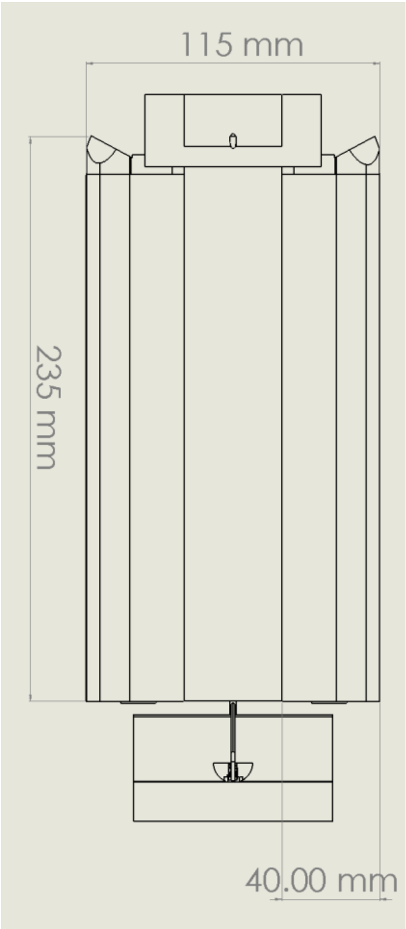
Close view of wing

Wing Dimensions

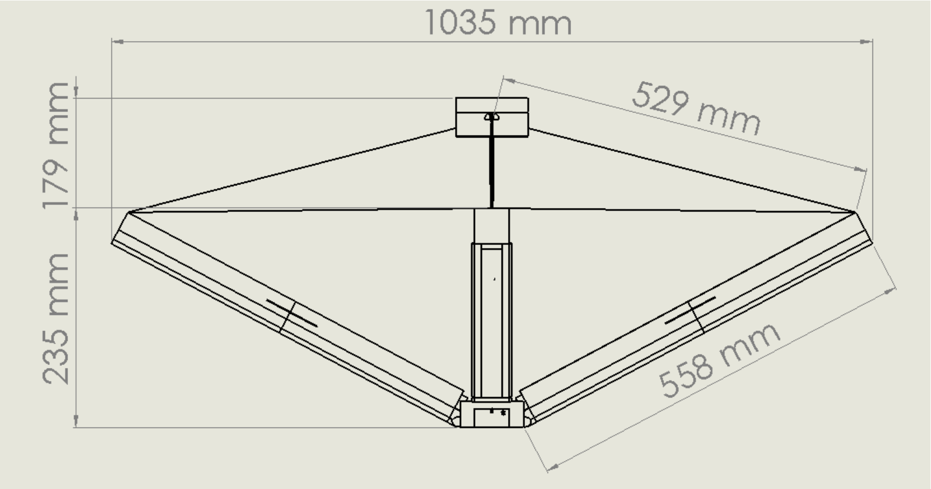


Open view of wing

Wing Dimensions



Close view of wing



Open view of wing

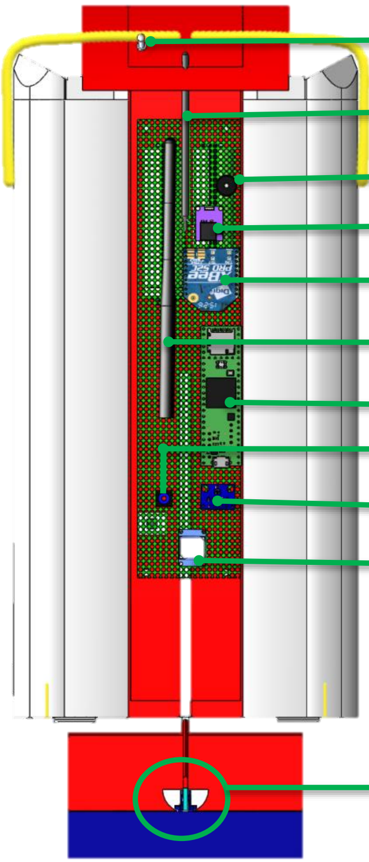
- **Wing technical drawings.**
- **The wing will be opened with the use of hinge, rotating joint and stretched fabric elastic.**
- **All measurements units are in mm.**

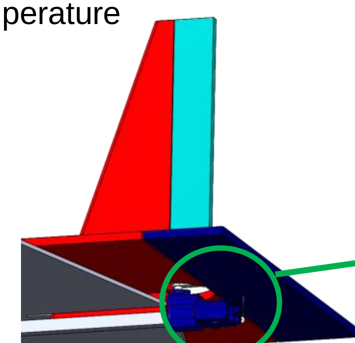
Payload Physical Layout (5 of 8)

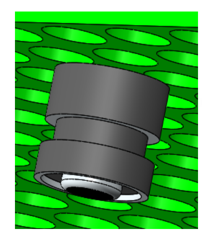
Payload Placement of Major Electronic Components

Top view of Electronic circuit

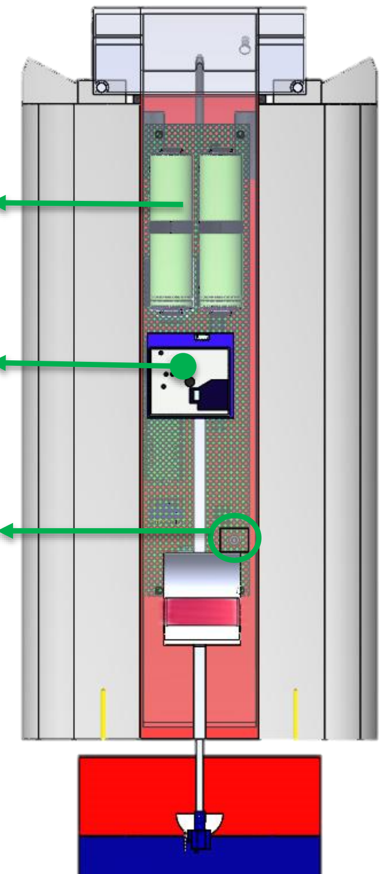
Bottom view of Electronic circuit







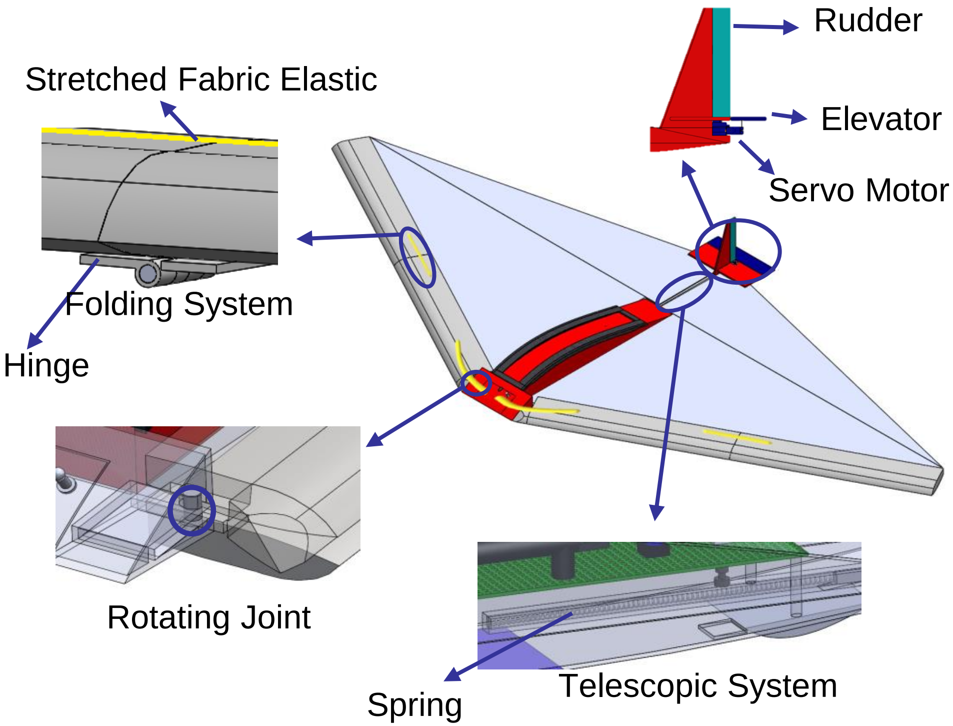
Camera



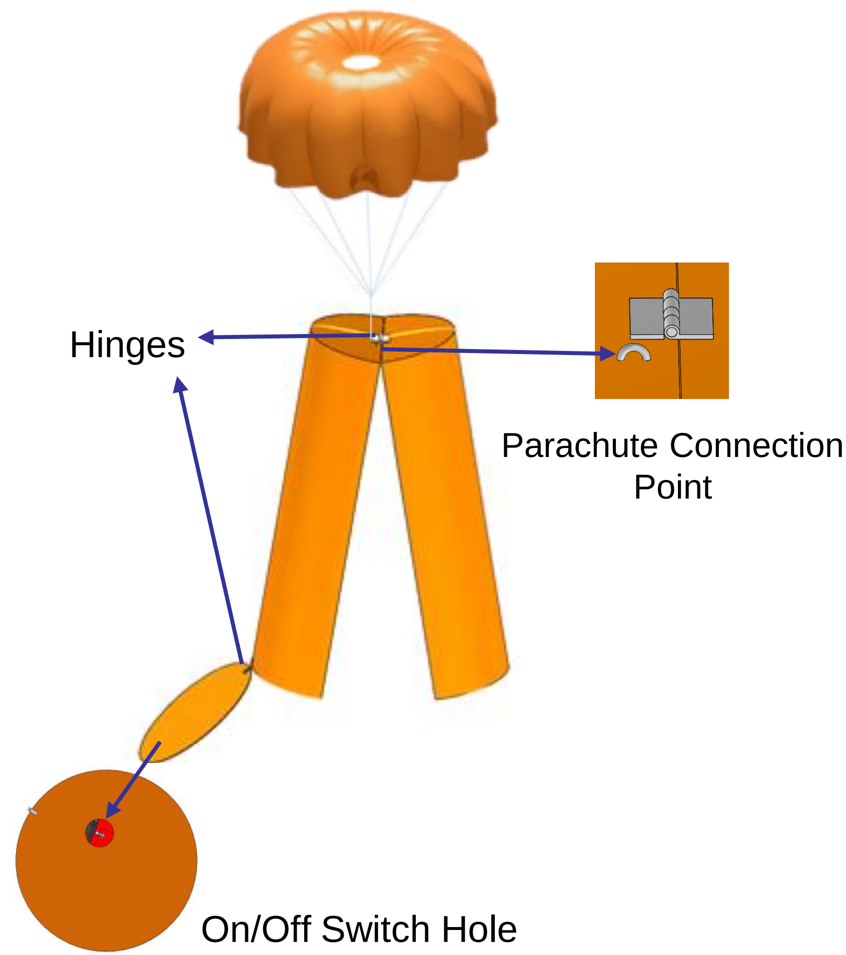
The container will not have any electronic components.

Payload Physical Layout (6 of 8)

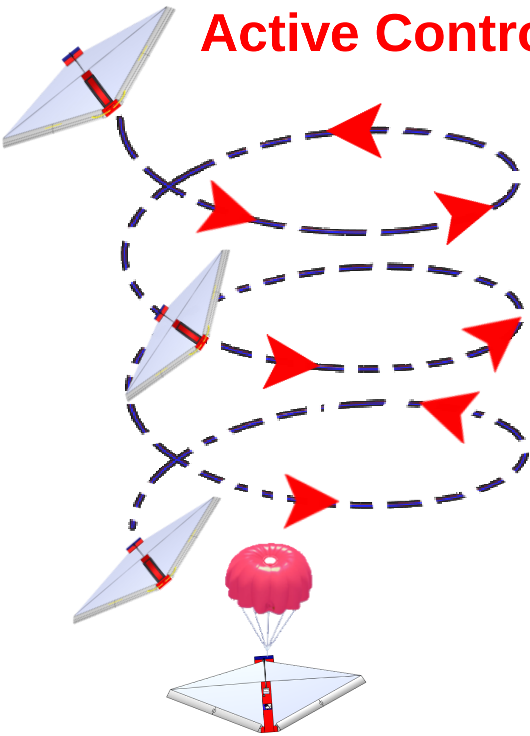
Payload Placement of Major Mechanical Components

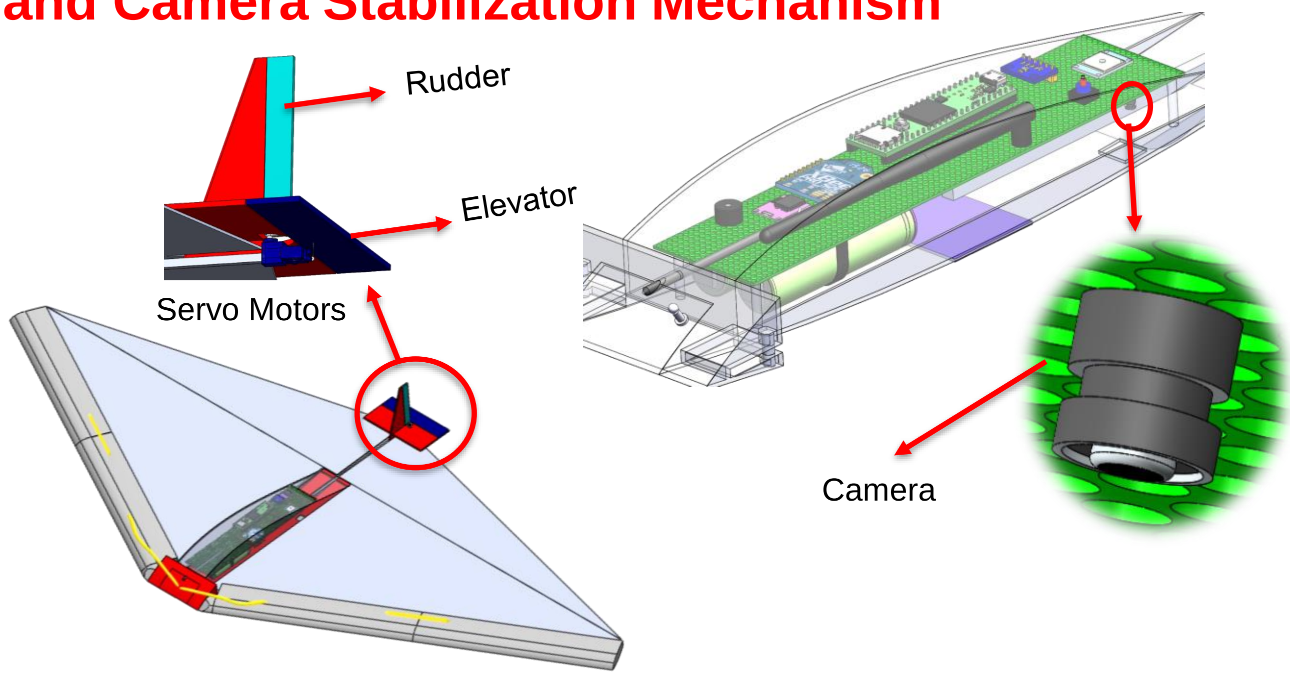


Container Placement of Major Mechanical Components



Active Control and Camera Stabilization Mechanism

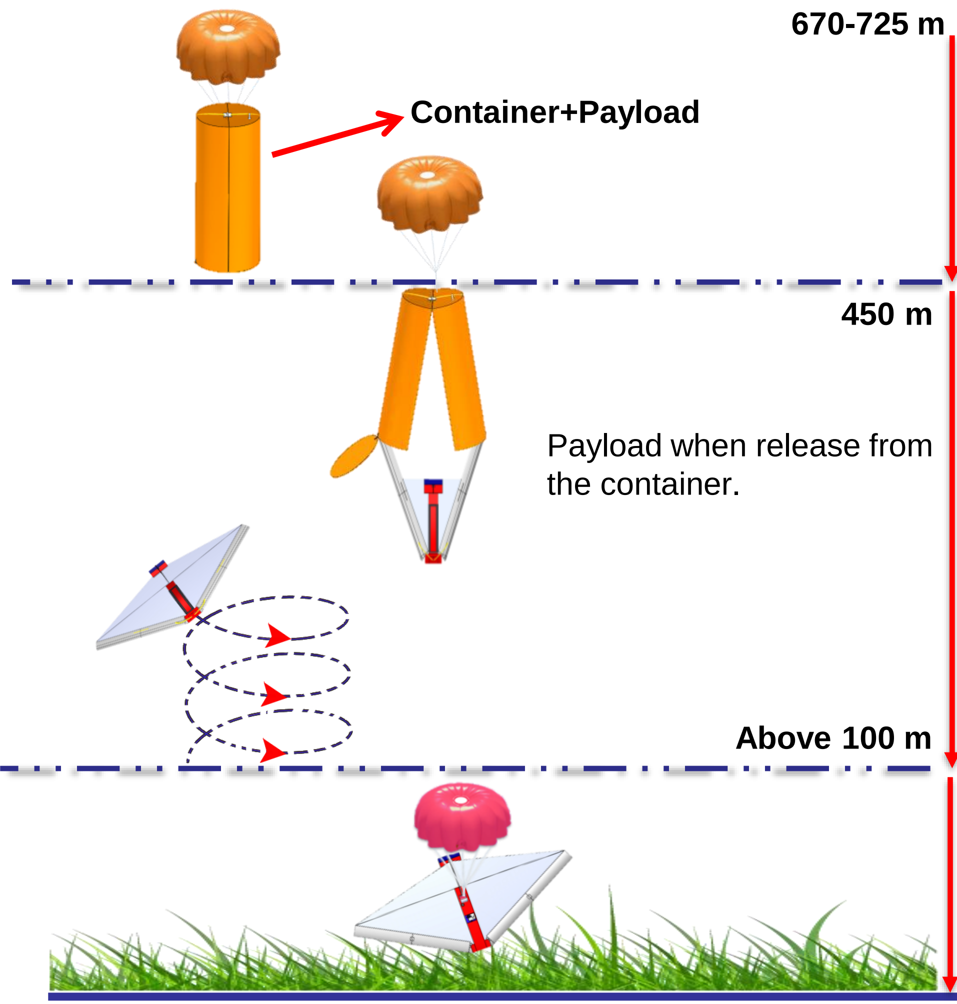




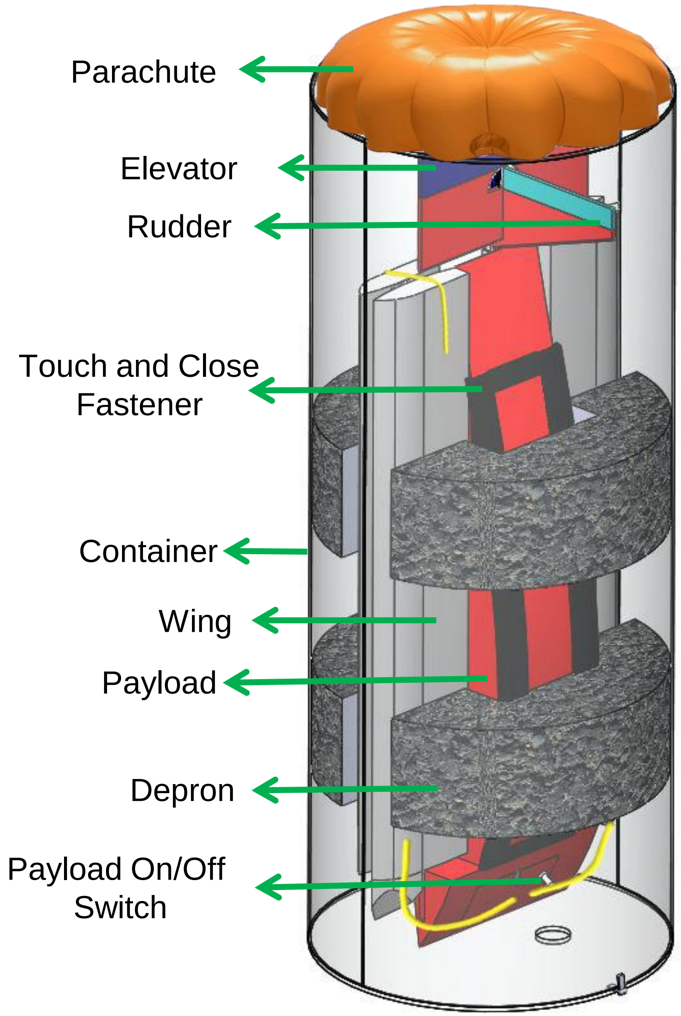
- We will achieve camera stabilization by the use of active payload control.
- We will use rudder elevator and servo motors to control payload orientation.
- The camera will be fixed to the payload to capture the Earth direction.
- The payload separated from the container at 450 m then the servo motors actively control the rudder and elevators to make 250 m rotation regarding reference point.
- The camera will record for at least 30 seconds while making the turn.

Deployed Configuration

Immediately after the CanSat separation from the rocket.



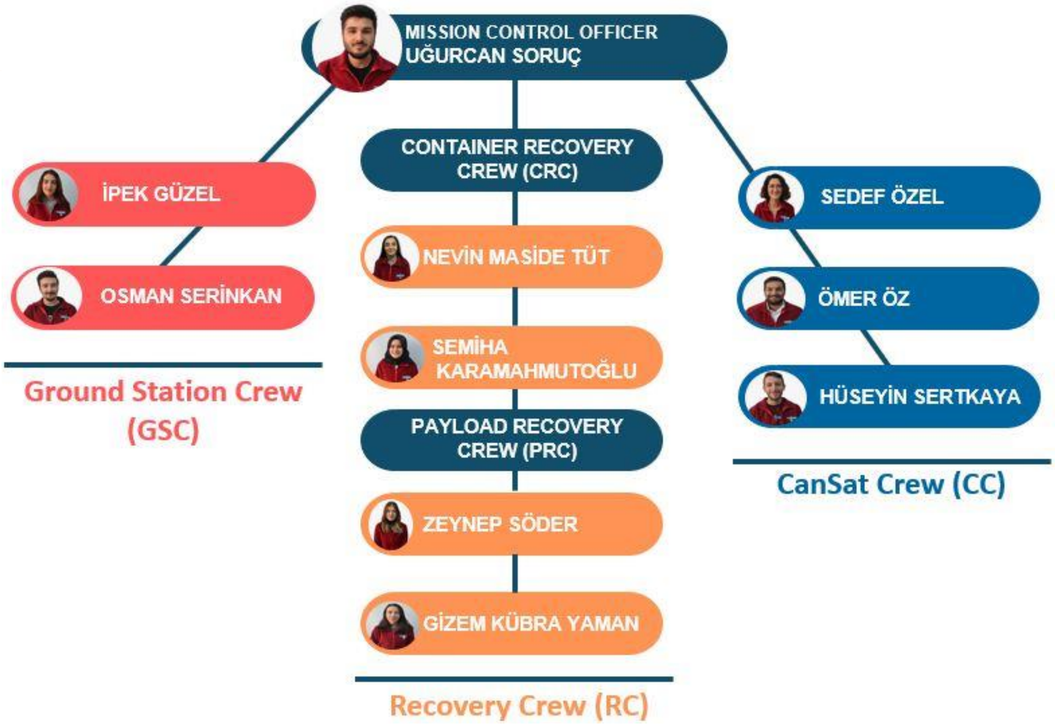
Launch Configuration



System Concept of Operations (1 of 3)

Launch Day Activities

- Arrival at the launch site.
- CanSat assemble.
- Set-up ground station.
- Verify communications with the payload.
- Mechanisms will be reviewed.
- CanSat's will be inspected for safety.
- CanSat must pass the envelop test.
- Weight and fit check test.
- Placement of the CanSat into the rocket communication test with the CanSat.
- Place the rocket into the assigned launch pad the team mission control officer execute launches flight procedures.
- 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)

Pre Launch

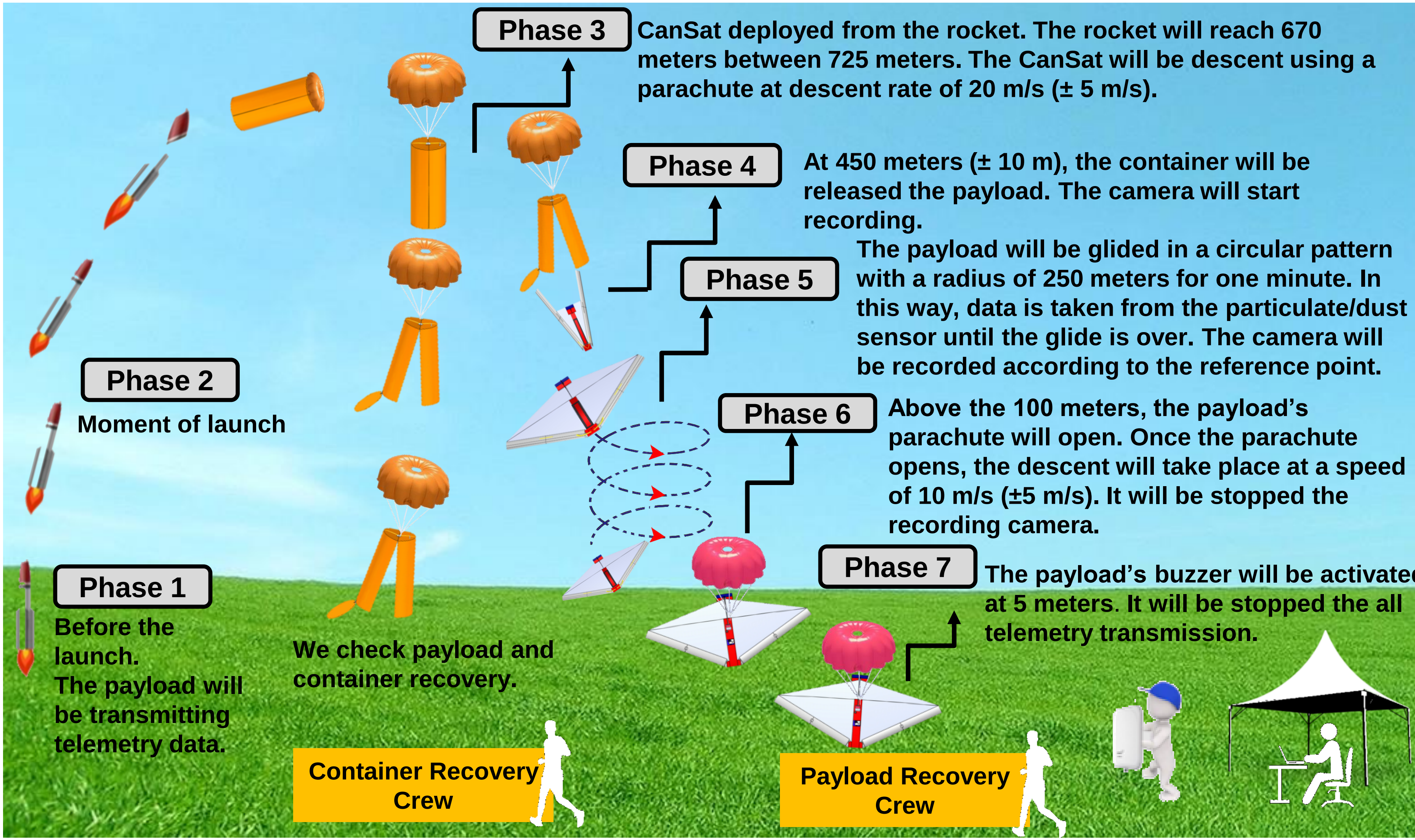
- Set-up ground station system.
- Check of mechanical systems.
- Communication tests will be conducted.
- The system will be calibrated with the command sent to the ground station and data transfer will be started.
- CanSat will be placed into the rocket.

Launch

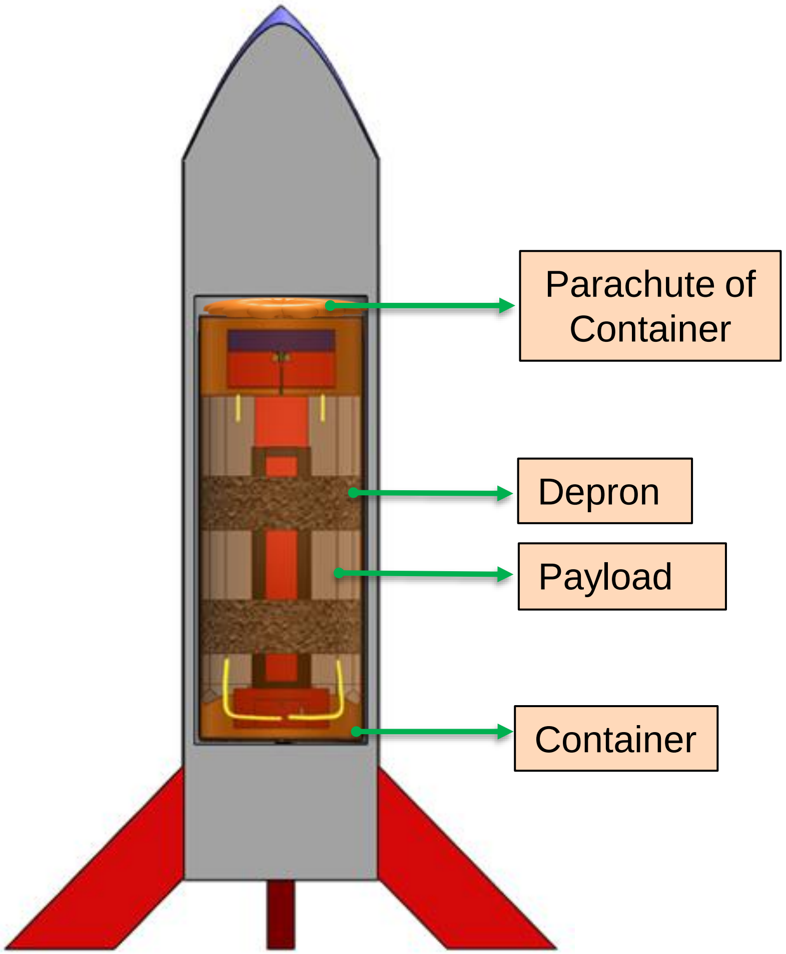
- Rocket launch.
- CanSat separated from the rocket (between 670-725 meters).
- The parachute will be opened.
- The descent rate of the CanSat shall be 20 m/s (± 5m/s).
- The container will be released the payload at 450 meters (±10 meters).
- The payload shall glide in a circular pattern with a 250 m radius for one minute and stay above 100 meters after release from the container.
- The parachute of payload opens; the descent will take place at a speed of 10 m/s (±5 m/s).
- Data transmission will be stopped, and buzzer will be activated 5 meters before the end of the flight.

Post Launch

- The location of the payload will be found via GPS and buzzer.
- We will take the SD cards from the payload.
- Delivery of received data to the judge.
- Telemetry data from the SD card will be analyzed.
- Preparation for PFR.


Phase 1
Before the launch.
The payload will be transmitting telemetry data.
Phase 2
Moment of launch
Phase 3
CanSat deployed from the rocket. The rocket will reach 670 meters between 725 meters. The CanSat will be descent using a parachute at descent rate of 20 m/s (± 5 m/s).
Phase 4
At 450 meters (± 10 m), the container will be released the payload. The camera will start recording.
Phase 5
The payload will be glided in a circular pattern with a radius of 250 meters for one minute. In this way, data is taken from the particulate/dust sensor until the glide is over. The camera will be recorded according to the reference point.
Phase 6
Above the 100 meters, the payload's parachute will open. Once the parachute opens, the descent will take place at a speed of 10 m/s (±5 m/s). It will be stopped the recording camera.
Phase 7
The payload's buzzer will be activated at 5 meters. It will be stopped the all telemetry transmission.
We check payload and container recovery.
Container Recovery Crew
Payload Recovery Crew

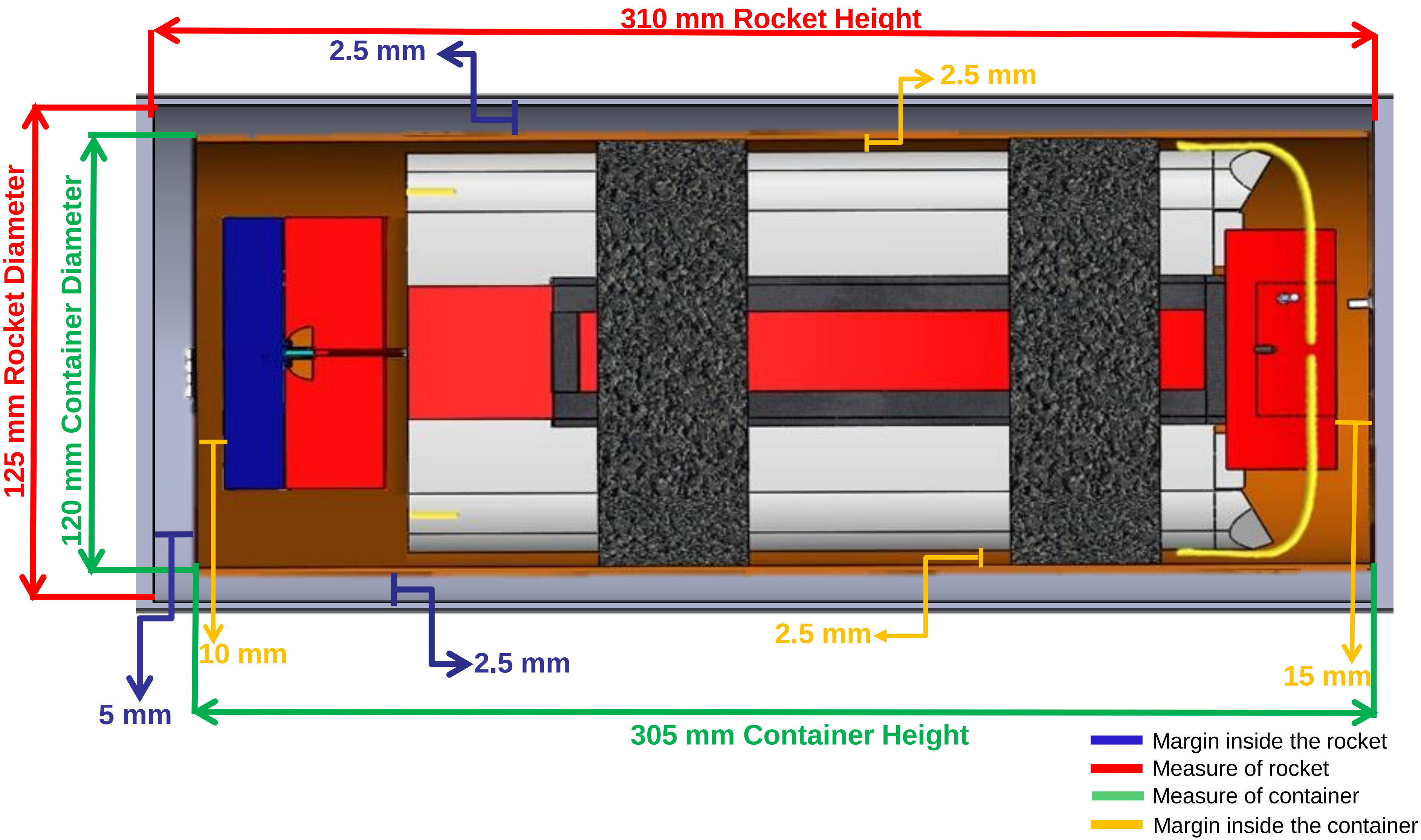
Launch Vehicle Compatibility (1 of 2)



Dimensions (mm) / Section	Height (mm)	Length (mm)
Rocket (Requirement Dimensions)	310	125
CanSat	305	120
Payload	280	115

- The CanSat consists of 2 parts: The payload and the container.
- The CanSat margins of 5 mm are given for height and 5 mm for length. We give 5 mm margins to make it easy to release from the rocket.
- The container's dimensions have been designed to prevent shaking of the container in the rocket.
- **There is no sharp protrusion on the container.**

Launch Vehicle Compatibility (2 of 2)



Sensor Subsystem Design

Zeynep SÖDER

Sensor Subsystem Overview

NO	SENSOR TYPE	MODEL	PURPOSE	FUNCTION
1	Inertial Measurement Unit Sensor	10-DOF IMU (BMP280 + MPU-9255)	We will be used this sensor because there are many sensors in it. The BMP280 sensor is used to measure temperature and air pressure. We will be used MPU-9255 for active control.	To measure air pressure, air temperature. To measure pitch, roll, yaw.
2	GPS	NEO – 7M	We will be used NEO-7M to measure the longitude, latitude and altitude. The NEO-7M has a higher update rate and less power consumption.	To measure location, altitude and satellite count data.
3	Voltage Measurement	Teensy 3.6 Analog Pin	Instead of using a sensor, we will be used Teensy 3.6 analog pin to provide the voltage divider function. Because it is easy to use and more lucrative.	To measure of battery voltage.
4	Air Speed Sensor	APM 2.6 Air Speed Sensor Kit MPXV7002DP	We will be used APM 2.6 sensor kit to measure air speed. The pressure difference occurs between the front and side holes. The air speed is calculated by measuring the pressure difference.	To measure air pressure and air speed.
5	Particulate/Dust Sensor	Sharp GP2Y10	We will be used Sharp GP2Y10 to measure the amount of particulate matter (PM) suspended in air.	To measure particle size and concentration.
6	Camera	SQ11	We will be used this camera to record video during the mission process.	To record video.

Sensor Changes Since PDR

PDR	CDR	Rationale
• We will be used the electronic circuit for the container.	• The container will not have any electronics components.	• The test we carried out on the breadboard showed that the payload circuit can also perform the separation task priorly performed by the container circuit.
• The payload will be separated from the container with the melt stop box on the container.	• The separation of the payload from the container will be provided with the melt stop box added to the payload.	• The separation of the payload from the container and the opening of the payload’s parachute will be performed by the use of two different melt stop box in the payload. Since no electronic components will be used in the container.

Sensor Subsystem Requirements (1 of 2)

Requirement Number	Requirement	Rationale	Priority	VM			
				A	I	T	D
RN#15	All electronic components shall be enclosed and shielded from the environment with the exception of sensors.	Competition Requirement	HIGH		√	√	√
RN#16	All structures shall be built to survive 15 Gs of launch acceleration.	Competition Requirement	HIGH	√	√	√	
RN#17	All structures shall be built to survive 30 Gs of shock.	Competition Requirement	HIGH	√	√	√	
RN#18	All electronics shall be hard mounted using proper mounts such as standoffs, screws, or high-performance adhesives.	Competition Requirement	MEDIUM	√	√		
RN#22	The science payload shall measure altitude using an air pressure sensor.	Competition Requirement	HIGH	√		√	√
RN#23	The science payload shall provide position using GPS.	Competition Requirement	HIGH	√		√	√
RN#24	The science payload shall measure its battery voltage.	Competition Requirement	HIGH	√		√	√

Sensor Subsystem Requirements (2 of 2)

Requirement Number	Requirement	Rationale	Priority	VM			
				A	I	T	D
RN#26	The science payload shall measure particulates in the air as it glides.	Competition Requirement	HIGH	✓		✓	✓
RN#27	The science payload shall measure air speed.	Competition Requirement	HIGH	✓		✓	✓
EXTRN#1	A gyro sensor should be used to obtain pitch, roll, yaw data.	To perform active control	HIGH	✓		✓	✓
EXTRN#2	Active control must be provided by using rudder and elevator in servo motor control.	To perform active control	HIGH	✓	✓	✓	
EXTRN#4	A video camera shall be integrated into the payload and point toward the coordinates provided for the duration of the glide time. Video shall be in color with a minimum resolution of 640x480 pixels and 30 frames per second. The video shall be recorded and retrieved when the payload is retrieved. Points will be awarded only if the camera can maintain pointing at the provided coordinates for 30 seconds uninterrupted.	To fulfill bonus objective	HIGH		✓	✓	

Payload Air Pressure Sensor Summary

Payload Air Pressure Sensor	BMP280	
Size (mm)	Length	20.08
	Width	14.03
	Height	1.5
Weight (g)	2	
Operating Voltage (V)	1.71 – 5.5	
Operating Current (µA)	325	
Pressure Range (hPa)	300 – 1100	
Sensitivity (Pa)	0.16	
Accuracy (hPa)	± 1.7	
Interface	I2C,SPI	
Data Format	XXXXXX (Pa)	

Equations

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

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

Data Output

Pressure: 101309 Pa
Pressure: 101303 Pa
Pressure: 101308 Pa
Pressure: 101293 Pa
Pressure: 101279 Pa
Pressure: 101282 Pa
Pressure: 101283 Pa

Correction Method

BMP280 measures according to sea level and gives the altitude accordingly. For calibration, the pressure of our location will be measured and the zero point will be accepted.

Data Processing Algorithm

START → Calibration Data From EEPROM → Read Uncompensated Pressure Value → Read Calculated True Pressure Value → Output Pressure Value

Payload Air Temperature Sensor Summary

Payload Air Temperature Sensor	BMP280	
Size (mm)	Length	20.08
	Width	14.03
	Height	1.5
Weight (g)	2	
Operating Voltage (V)	1.71 – 5.5	
Operating Current (µA)	325	
Operating Temperature (°C)	-40 ~ +85	
Sensitivity (°C)	0.01	
Accuracy (°C)	± 1	
Interface	I2C,SPI	
Data Format	XX.XX (°C)	

Equations

ρ = Density of dry air (kg/m³)
P = Air pressure (Pa)
R = Specific gas constant dry air $(287{,}05\frac{J}{kg.K})$
T = Temperature (°C)

$$T = \frac{P}{R \times \rho}$$

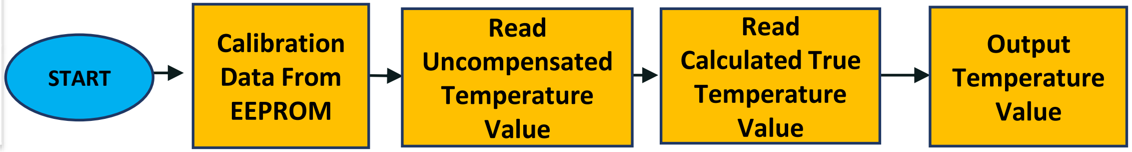
Data Output

Temp: 27.67 *C
Temp: 27.72 *C
Temp: 27.85 *C
Temp: 28.05 *C
Temp: 28.27 *C

Correction Method

The sensor must be calibrated to achieve the best possible accuracy. Therefore, the temperature sensor will be calibrated by comparing the data from the sensor with the temperature at the measurement point.

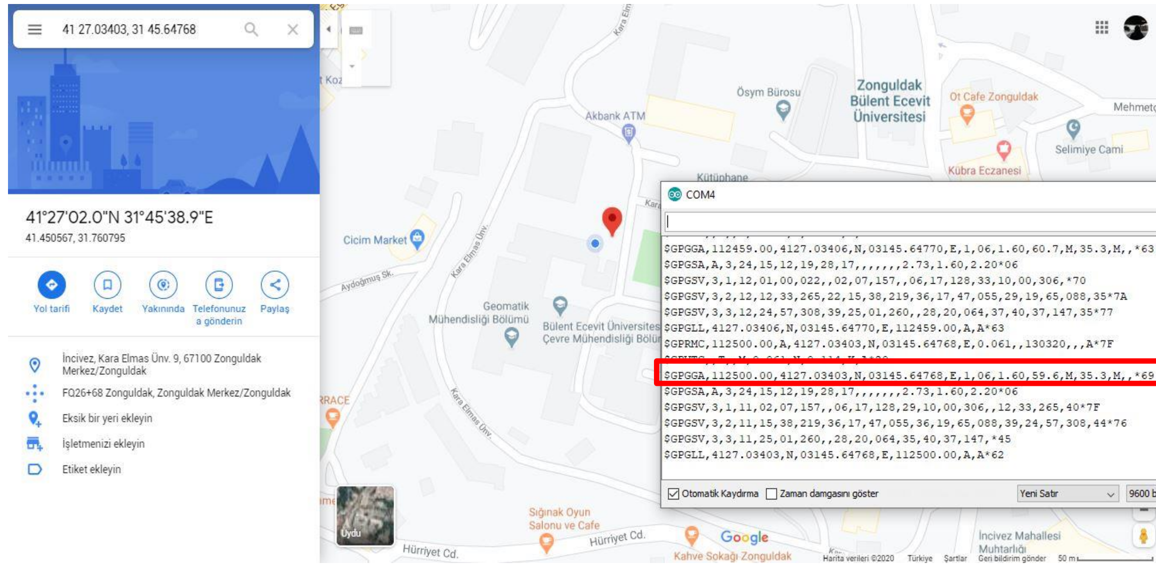
Data Processing Algorithm



GPS Sensor Summary

GPS Sensor	NEO-7M	
Size (mm)	Length	16
	Width	12
	Height	3
Weight (g)	16	
Operating Voltage (V)	2.7 – 5	
Operating Current (µA)	35	
Max Update Rate (Hz)	10	
Sensitivity (dBm)	-161	
Accuracy (m)	±2.5	
Interface	UART	
Data Format	**Latitude,Longitude:** XX.XXXXX (°) **Altitude:** XX.XX (m)	

Data Output



Correction Method

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. ★ **We don't use a formula to calculate GPS.**

Data Processing Algorithm

START → Calibration Data From EEPROM → Read Uncompensated GPS Value → Read True GPS Value → Output GPS Value

Payload Voltage Sensor Summary

Payload Power Voltage Sensor	Teensy 3.6 Analog Pin
Size (mm)	No extra area needed
Weight (g)	<1
Measurement Voltage (V)	0 – 3.30
Output Current (mA)	10
Accuracy (V)	0.05
Interface	Analog
Data Format	X.XX (V)

Equations

V_{in} = Voltage Source

V_{out} = Output Voltage

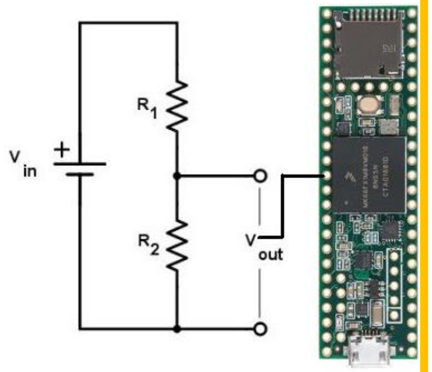
R_1 = 10 kΩ

R_2 = 20 kΩ

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

Data Output

```
Voltage =3.27
Voltage =3.27
Voltage =3.27
Voltage =3.27
Voltage =3.27
Voltage =3.27
Voltage =3.27
Voltage =3.27
```



Correction Method

The voltage divider circuit will be used. The output voltage equals the input voltage scaled by a ratio of resistors.

Data Processing Algorithm

START → Read Analog Pin in Teensy 3.6 → Calculated True Voltage Value → Output Voltage Value

Air Speed Sensor Summary

Air Speed Sensor	APM 2.6 Air Speed Sensor Kit MPXV7002DP	
Size (mm)	Length	11
	Width	17
	Height	12
Weight (g)	15	
Operating Voltage (V)	4.75 – 5.25	
Operating Current (mA)	10	
Range (km/h)	360	
Accuracy (kPa)	±5%	
Interface	Analog	
Data Format	XX.XX (m/s)	

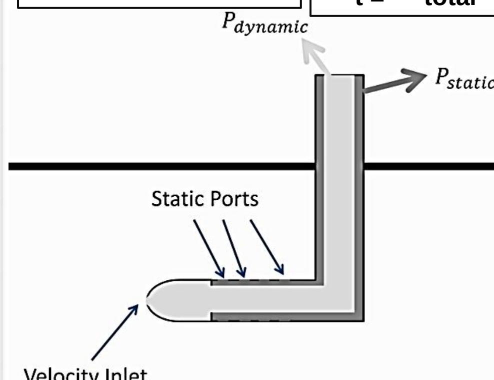
Equations

ρ = Density
P = Pressure
V = Velocitiy

$P_d = P_{dynamic}$
$P_s = P_{static}$
$P_t = P_{total}$

Bernoulli's Equation:

$P_{dynamic} + P_{static} = \text{Total Pressure}$



$$P_t = P_s + \rho \times \frac{V^2}{2}$$

$$V = \sqrt{\frac{2\,(P_t - P_s)}{\rho}}$$

Data Output

```
Velocity: 7.26 m/s
Velocity: 7.54 m/s
Velocity: 8.08 m/s
Velocity: 8.13 m/s
```

Correction Method

This sensor has an output voltage proportional to the pressure. Therefore, the pressure of our location will be measured and calibrated. The MPXV 7002 DP sensor converts the voltage value to pressure difference. Then flow velocity is calculated with the use of measured pressure difference.

Data Processing Algorithm

START → Calibration Data From EEPROM → Read Uncompensated Air Speed Value → Read Calculated True Air Speed Value → Output Air Speed Value

Particulate/Dust Sensor Summary

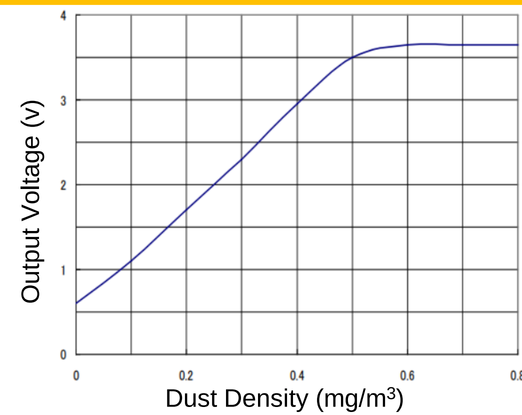
Particulate/Dust Sensor	Sharp GP2Y10 Optical Dust Sensor	
Size (mm)	Length	46
	Width	30
	Height	17.6
Weight (g)	20	
Operating Voltage (V)	4.5 – 5.5	
Current Consumption (mA)	20	
Detectable range of concentration (mg/m³)	0.1	
Accuracy/Particle size (µm)	0.5	
Interface	Analog	
Data Format	X.XX (mg/m³)	

Equations

$\Delta \mathbf{V} = \mathrm{Vout} - \mathrm{Voc}$
Voc = Output at no dust
Vout = Output at measuring dust
K = Sensivity

$$Dust\ Density\ (mg/m^3) = (\Delta V/K)\ x\ 100$$

Data Output



DustDensity= 0.26mg/m3
DustDensity= 0.28mg/m3
DustDensity= 0.33mg/m3
DustDensity= 0.47mg/m3
DustDensity= 0.60mg/m3
DustDensity= 0.53mg/m3

Correction Method

The graph is just an example. Output voltage versus dust density graph obtained after calibration by use of a reference dust particulate. We increased dust density in our tests and achieved a linear output like in the graph.

Data Processing Algorithm

START → Calibration Data From EEPROM → Read Uncompensated Dust Density Value → Read Calculated True Dust Density Value → Output Dust Density Value

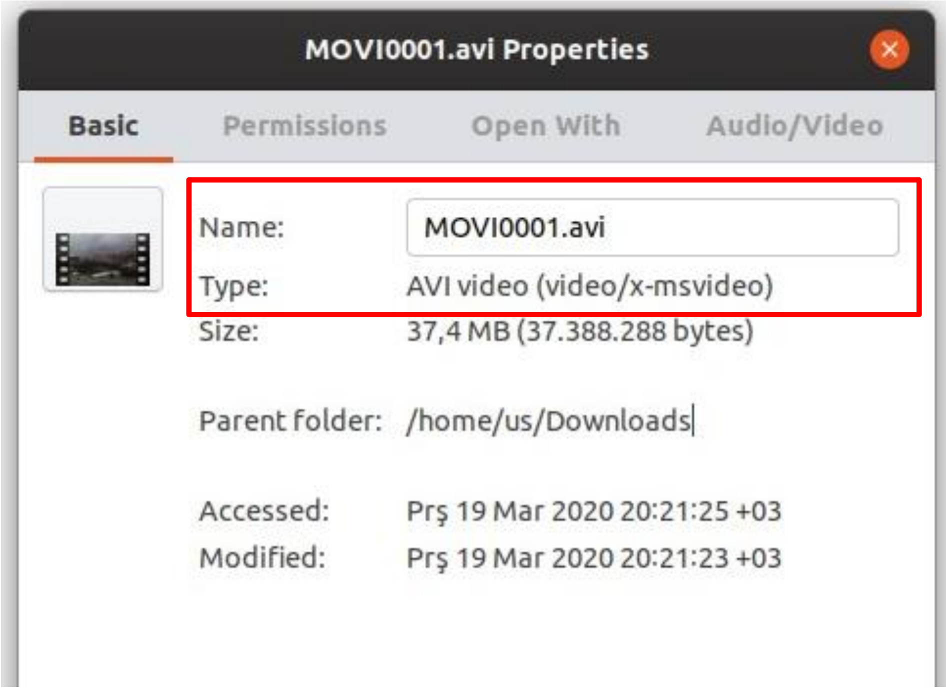
Bonus Objective Camera Summary (1 of 2)

Camera	SQ11	
Size (mm)	Length	22
	Width	22
	Height	22
Weight (g)	4	
Operating Voltage (V)	5	
Range of Vision (◦)	50	
Video Resolution (pixel)	640x480	
Interface	Digital	
Data Format	Digital	

This image taken from SQ11 Camera.

- The camera will be controlled via switching by transistor circuit from the microcontroller. The camera itself has an internal SD card module.
- The camera will be fixed to the payload. **The payload flight will be actively controlled according to the given reference point.** Thus the camera will be provided to look in the reference point.
- The camera will be recorded the reference point provided for at least 30 seconds.

Bonus Objective Camera Summary (2 of 2)



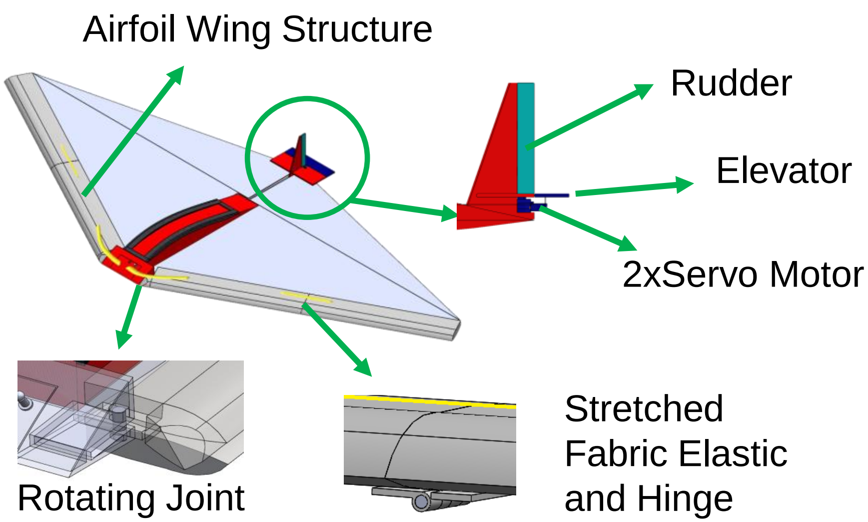
- This photo contains video file type, frame width and height information of the camera.
- Resolution and megapixel values are suitable for the competition requirements.

Container Air Pressure Sensor Summary

★ **The container will not have any electronic components.**

Descent Control Design

Semiha KARAMAHMUTOĞLU



PAYLOAD DESCENT CONTROL SYSTEM

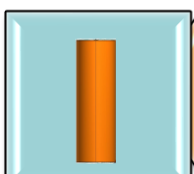
- The delta wings of the payload will be opened with rotating joints, hinges and stretched fabric elastic. The width of the payload will be reached 1035 mm. The length of the payload will be reached 414 mm with the telescopic system.
- Active control will be provided by the elevator and the rudder (servo motor will be used).
- The payload wing frame will be constructed by the use of carbon fiber sticks. The top surface of the payload wing will be covered with Silnylon 30D Nylon 66.

CONTAINER PARACHUTE

•It will be 143 mm diameter. It includes a spill hole diameter of 32 mm to stabilize parachute container.
•The parachute will be made from Silnylon 30D Nylon 66.

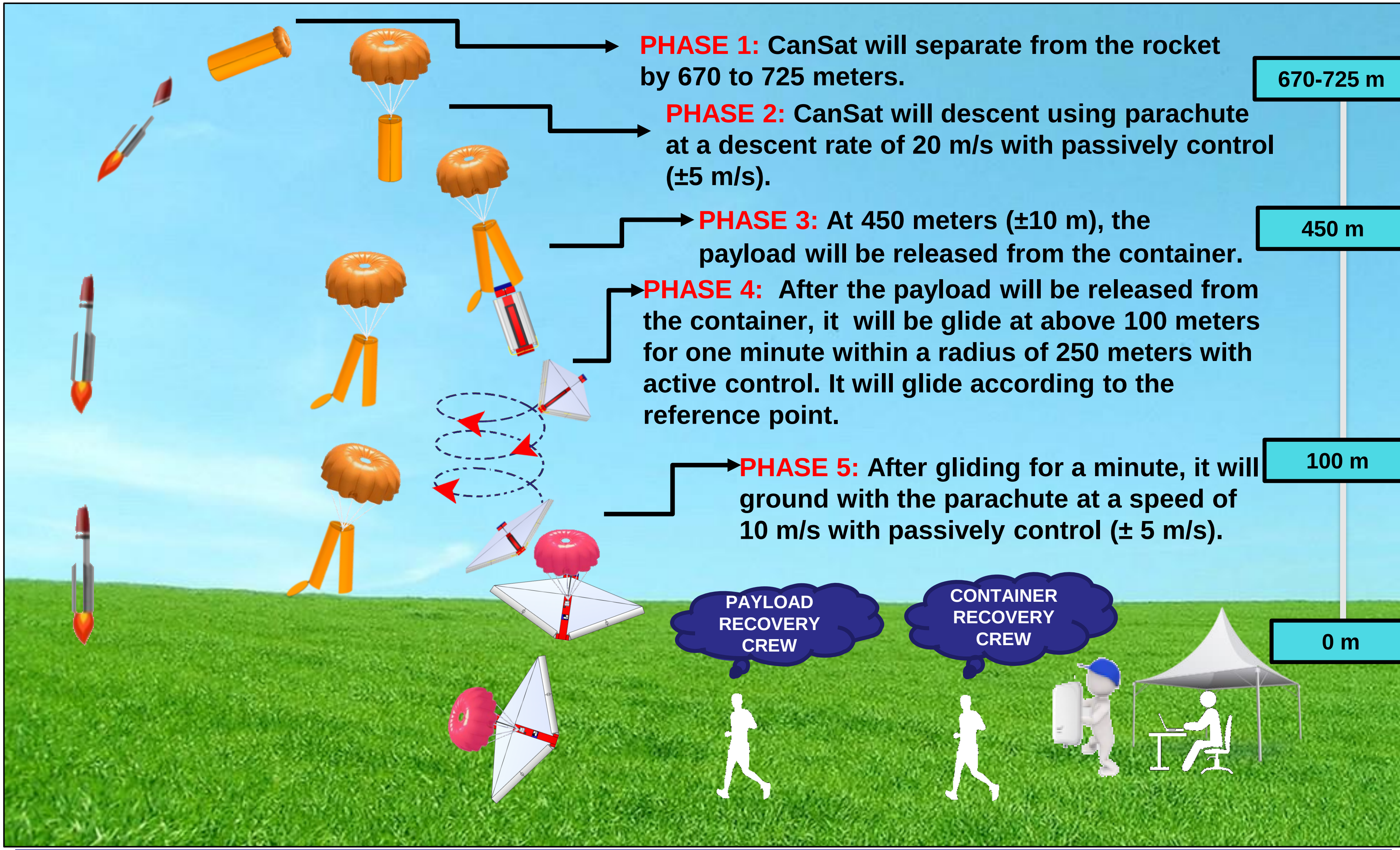
PAYLOAD PARACHUTE

- It will be 263.83 mm diameter. It includes a spill hole diameter of 59 mm to stabilize parachute payload.
- The parachute will be made from Silnylon 30D Nylon 66.



CONTAINER DESCENT CONTROL SYSTEM

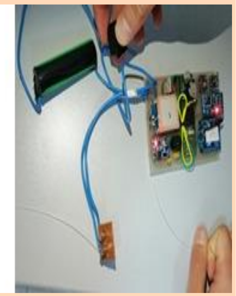
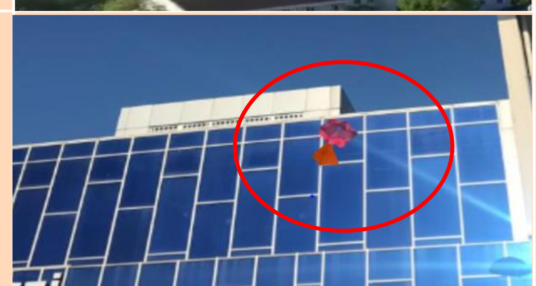
- The container will be 305 mm height and 120 mm in diameter.
- The CanSat will be descent using a parachute at a descent rate of 20 m/s (± 5 m/s). At 450 meters (± 10 m), payload will be separated from the container.
- The container will be made from fiberglass.


PHASE 1: CanSat will separate from the rocket by 670 to 725 meters.
670-725 m
PHASE 2: CanSat will descent using parachute at a descent rate of 20 m/s with passively control (±5 m/s).
PHASE 3: At 450 meters (±10 m), the payload will be released from the container.
450 m
PHASE 4: After the payload will be released from the container, it will be glide at above 100 meters for one minute within a radius of 250 meters with active control. It will glide according to the reference point.
100 m
PHASE 5: After gliding for a minute, it will ground with the parachute at a speed of 10 m/s with passively control (± 5 m/s).
PAYLOAD RECOVERY CREW
CONTAINER RECOVERY CREW
0 m

Descent Control Changes Since PDR (1 of 3)

PDR	CDR	Rationale
We use the electronic circuit in the container.	The electronic circuit has been removed from the container.	The test we carried out on the breadboard showed that the payload circuit can also perform the separation task priorly performed by the container circuit.
Separation of the payload from the container will be ensured by the melt stop box in the container.	Separation of the payload from the container will be ensured by the melt stop box in the payload.	We decided not to use an electronic circuit in the container. We will perform the separation of the payload from the container with the additional melt stop box placed in the payload.
Weight of payload 471.1 g	Weight of payload 511.1 g	We found that the payload frame is nonpersistent during the prototype tests.Therefore, the wall thickness of the frame system was increased.
Payload parachute will be 253 mm diameter. It includes a spill hole diameter of 56 mm to stabilize parachute payload.	Payload parachute will be 263. 83 mm diameter. It includes a spill hole diameter of 59 mm to stabilize parachute payload.	We strengthened the frame to counteract payload damage. Parachute dimensions increased in calculations to keep the descent rate in a desired rate.

Descent Control Changes Since PDR (2 of 3)

Prototype Testing			
Test Name	Procedure	Picture	Pass/Fail
Release Mechanisms Level Testing	• The release mechanism activated from payload by the melt of the fishline method will be tested. • The release of the payload from the container at the desired altitude will be tested. • Separation of the payload from the container will be ensured by the melt stop box in the payload. • The trigger of the separation mechanism tested on the electronic circuit.	 	✓
Testing of CanSat Parachute Opening	• The CanSat (payload + container) released from 25 meters. • The parachute opening tested. The parachute descent speed was calculated of close to 20 m/s.		✓
Testing of Payload Parachute Opening	• The payload released from 25 meters. • The parachute opening tested. • The payload parachute speed was found to be close to 10 m/s.		✓

Descent Control Changes Since PDR (3 of 3)

Prototype Testing			
Test Name	**Procedure**	**Picture**	**Pass/Fail**
Payload Folding Mechanism Test	• A new folding mechanism is designed and manufactured for the payload to fit well into the container. • The wing's folding mechanism was tested with the rotating joint ,hinges and stretched fabric elastic.		✓
Opened and Folded Test of Telescopic System	• The springs system of the telescopic system was tested. • The telescopic system was opened and folded easily.		✓
Testing of Delta Wing	• Delta wing stability tested. • It provided a stable flight through to lifting force.		✓
Testing of Circular Pattern	• The turn of the payload at a radius of 250 meters was tested with elevator ,rudder and servo motors. • Delta wing stability tested.		✓

Descent Control Requirements (1 of 2)

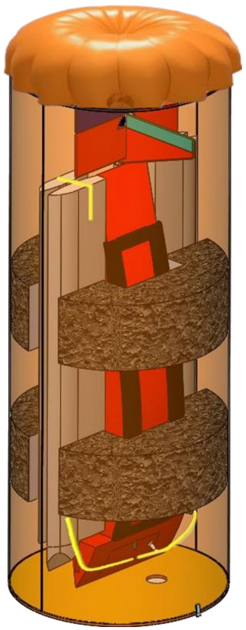
Requirement Number	Requirement	Rationale	Priority	VM			
				A	I	T	D
RN#1	Total mass of the CanSat (science payload and container) shall be 600 grams +/- 10 grams.	Competition Requirement	HIGH	√	√	√	
RN#2	CanSat shall fit in a cylindrical envelope of 125 mm diameter x 310 mm length. Tolerances are to 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	HIGH		√		
RN#5	The container shall be solid and fully enclose the science payload. Small holes to allow access to turn on the science payload is allowed. The end of the container where the payload deploys may be open.	Competition Requirement	HIGH		√	√	
RN#6	The rocket airframe shall not be used to restrain any deployable parts of the CanSat.	Competition Requirement	MEDIUM		√		√
RN#7	The rocket airframe shall not be used as part of the CanSat operations.	Competition Requirement	HIGH		√		√
RN#8	The container parachute shall not be enclosed in the container structure. It shall be external and attached to the container so that it opens immediately when deployed from the rocket.	Competition Requirement	HIGH		√	√	√

Descent Control Requirements (2 of 2)

Requirement Number	Requirement	Rationale	Priority	VM			
				A	I	T	D
RN#9	The descent rate of the CanSat (container and science payload) shall be 20 meters/second +/- 5m/s.	Competition Requirement	HIGH		√	√	√
RN#10	The container shall release the payload at 450 meters +/- 10 meters.	Competition Requirement	HIGH		√	√	√
RN#11	The science payload shall glide in a circular pattern with a 250 m radius for one minute and stay above 100 meters after release from the container.	Competition Requirement	HIGH	√	√	√	√
RN#12	The science payload shall be a delta wing glider.	Competition Requirement	HIGH	√	√		√
RN#13	After one minute of gliding, the science payload shall release a parachute to drop the science payload to the ground at 10 meters/second, +/- 5 m/s.	Competition Requirement	HIGH	√	√	√	
RN#14	All descent control device attachment components shall survive 30 Gs of shock.	Competition Requirement	HIGH	√	√	√	
RN#19	All mechanisms shall be capable of maintaining their configuration or states under all forces	Competition Requirement	HIGH	√		√	
RN#30	The Parachutes shall be fluorescent Pink or Orange.	Competition Requirement	HIGH	√	√		
EXTRN#2	Active control must be provided by using rudder and elevator in servo motor control.	To perform active control	HIGH	√		√	√

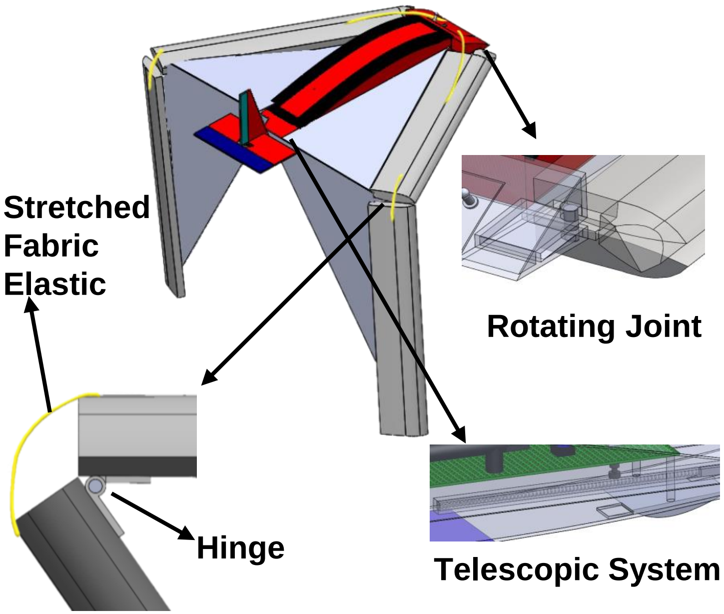
Payload Descent Control Hardware Summary (1 of 3)

Stowed Configuration



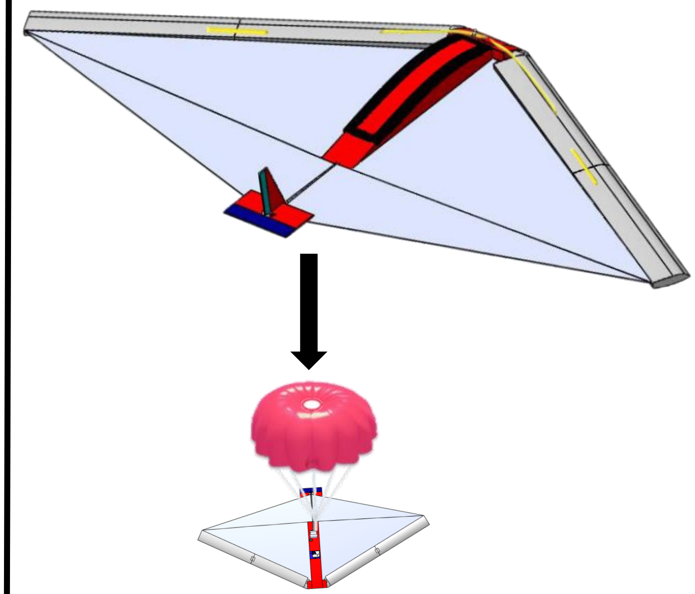
- The payload will be placed in the container.
- The payload will be separated from the container with the use of the melt of fishline method.

Deployment Method



- The payload will release from the container and the wings will be opened by the use of hinge, rotating joint and stretched fabric elastic. The telescopic system will be opened by a small spring.
- This opening mechanism will take place at 450 meters.

Deployed configuration



- The payload's wings are shown in the open position. The payload's descent and rotation rate actively controlled with the use of an elevator and a rudder.
- The parachute will be opened at above 100 meters.
- Finally, after gliding for one minute, it will ground with the parachute at a speed of 10 m/s.

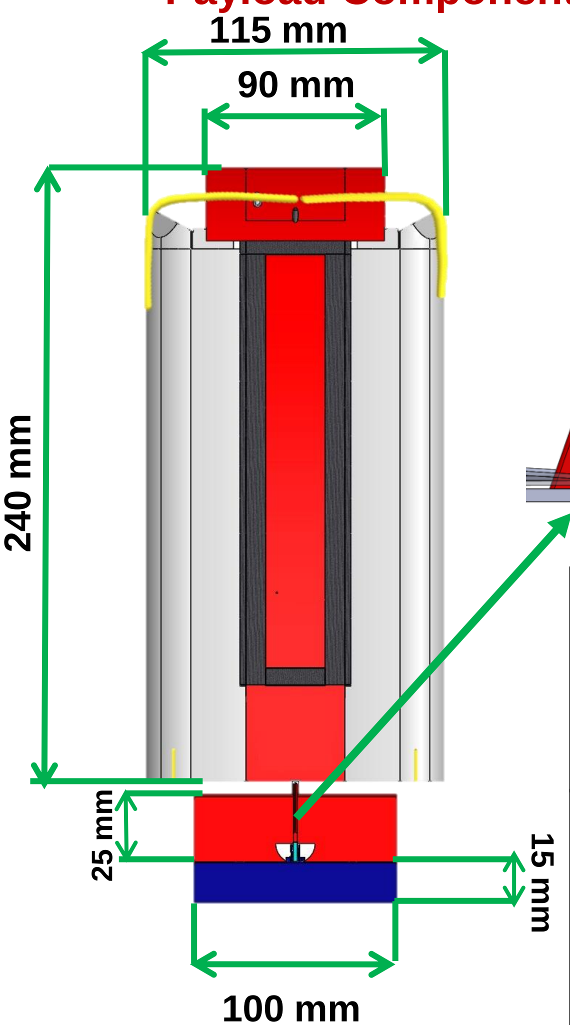
Key Design Considerations:
- The wing will be airfoil for more stable flight and lifting force.
- The body of the payload is designed in an airfoil structure to reduce friction force.
- The hinges must be firm because they must be able to hold the wing as a whole.
- Rotating joint and telescopic system was designed to increase the wing area.

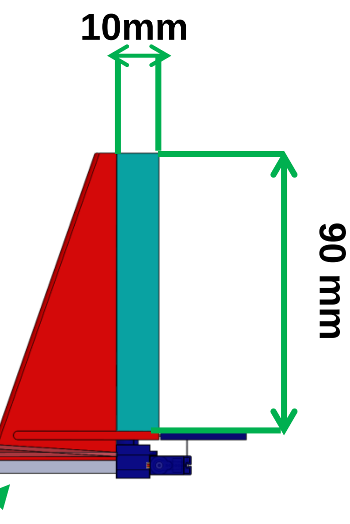
Color selection:
- The payload body's color red and the delta wing's color grey.
- Elevator's color dark blue.
- Rudder's color green.
- The color of the payload parachute is fluorescent pink.

Active components:
- Rudder and elevator will be used for active control. These components will be controlled by servo motors.
- The rudder will be used to steer.
- The elevator will be used to manage the lifting force.

Passive components:
- The hinge, stretched fabric elastic, telescopic system and rotating joints used in the opening mechanism are the passive components.
- The payload parachute is also a passive component.

Payload Component Sizing





PAYLOAD PARACHUTE
Spill hole diameter: 59 mm
Parachute diameter: 263.83 mm
Material: Silnylon 30D Nylon 66

Payload Descent Control Hardware Summary (3 of 3)

SENSORS		ACCURACY
GPS (NEO–7M)		2.5 m
Air Pressure Sensor (BMP280)		0.16 Pa
10 DOF IMU (MPU-9255)	Gyroscope	131 °/s
	Accelerometer	16,3 g
	Magnetometer	0.6 µT

SENSORS	DATA FORMATS
GPS (NEO–7M)	**Latitude, Longitude:** XX.XXXXX (°) **Altitude:** XX.XX (m)
Air Pressure Sensor (BMP280)	XXXXXX (Pa)
MPU-9255	Pitch / Roll / Yaw XX,X / XX,X / XX,X

10 DOF IMU (MPU-9255)

```
void MPU() {
  mpu.read_acc();
  mpu.read_gyro();
  mpu.read_mag();
  Serial.print("AX: ");
  Serial.print(mpu.ax);
  Serial.print(" AY: ");
  Serial.print(mpu.ay);
  Serial.print(" AZ: ");
  Serial.print(mpu.az);
  Serial.print(" GX: ");
  Serial.print(mpu.gx);
  Serial.print(" GY: ");
  Serial.print(mpu.gy);
  Serial.print(" GZ: ");
  Serial.print(mpu.gz);
  Serial.print(" MX: ");
  Serial.print(mpu.mx);
  Serial.print(" MY: ");
  Serial.print(mpu.my);
  Serial.print(" MZ: ");
  Serial.println(mpu.mz);
```

GPS (NEO-7M)

```
void GPS(){while (gp.available() > 0){
  gps.encode(gp.read());
  if (gps.time.isUpdated()){
  gps_sec=gps.time.second();
  gps_min=gps.time.minute();
  gps_hour=gps.time.hour();}
  if(gps.location.isUpdated()){
  gps_langit=gps.location.lat();
  gps_longit=gps.location.lng();}
  if(gps.altitude.isUpdated()){
  gps_alt=gps.altitude.meters();
  gps_sats=gps.satellites.value();}
  }
}
```

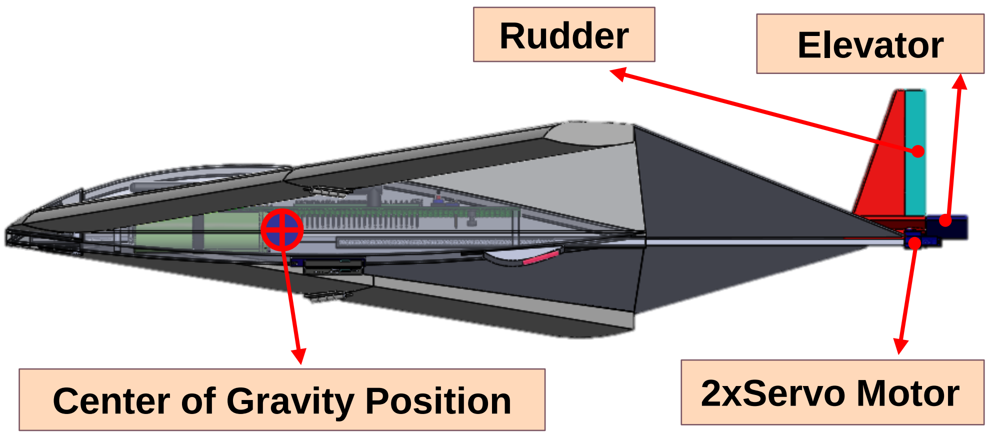
Air Pressure Sensor (BMP280)

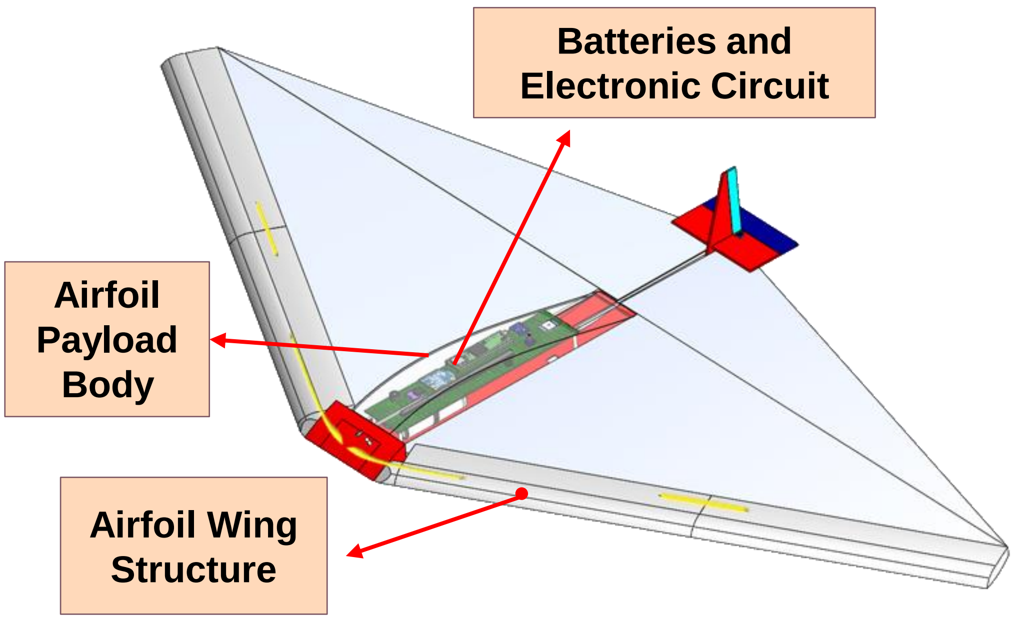
```
void BMP(){
 payload_temp=bmp.readTemperature();
 payload_pres=bmp.readPressure();
 payload_alt=bmp.readAltitude(1013.25)-reference_alt;
   }
```

Data Processing Overview

- The altitude will be measured from the data obtained from the **Air Pressure Sensor (BMP280).** Then the active control and the camera will be activated.
- Then the location data received from **GPS(NEO-7M)** will be compared with the location data received from the competition.
- The servo motors will be directed according to the pitch, roll, yaw angles at **10 DOF IMU(MPU-9255)**.

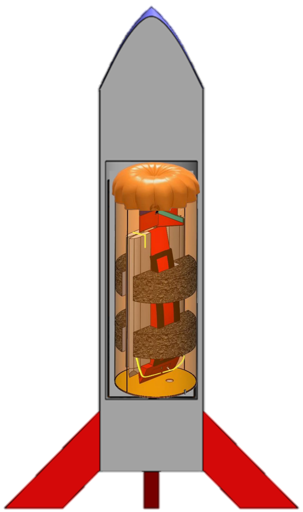
Payload Descent Stability Control Design





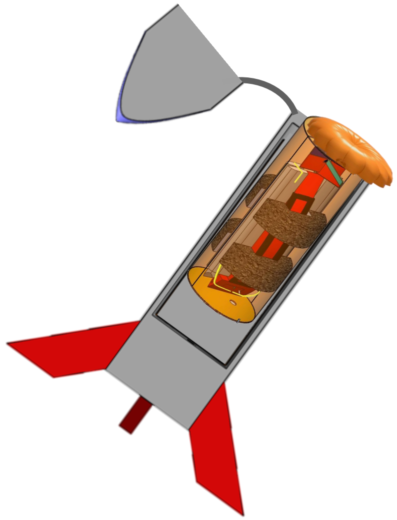
- **<u>Nadir direction will be provided by using an elevator with active control.</u>**
- **<u>The payload will be protected from rolling using the rudder and with the position of the center of gravity. Stable descent will take place.</u>**
- The rudder and elevator will be controlled actively (servo motors will be used).
- The payload wing structure and body have an airfoil structure. The lifting force will obtain by the pressure difference arising from the airfoil structure. Stable descent will take place.
- Necessary descent speed will be adjusted by using an elevator.
- Direction during descent will be provided the rudder.

Container Descent Control Hardware Summary (1 of 2)



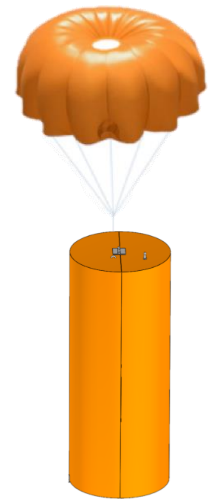
Step 1: Stowed Configuration

- Parachute will be folded and placed over the container and then attached to the container by the ropes.
- The CanSat will be placed in the rocket.



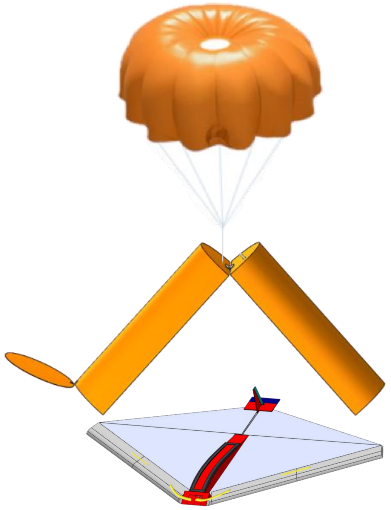
Step 2: Stowed Configuration

- The rocket will be reached to (670-725 meters).
- The CanSat will be separated from the rocket (670-725 meters).



Step 3: Deployment Method

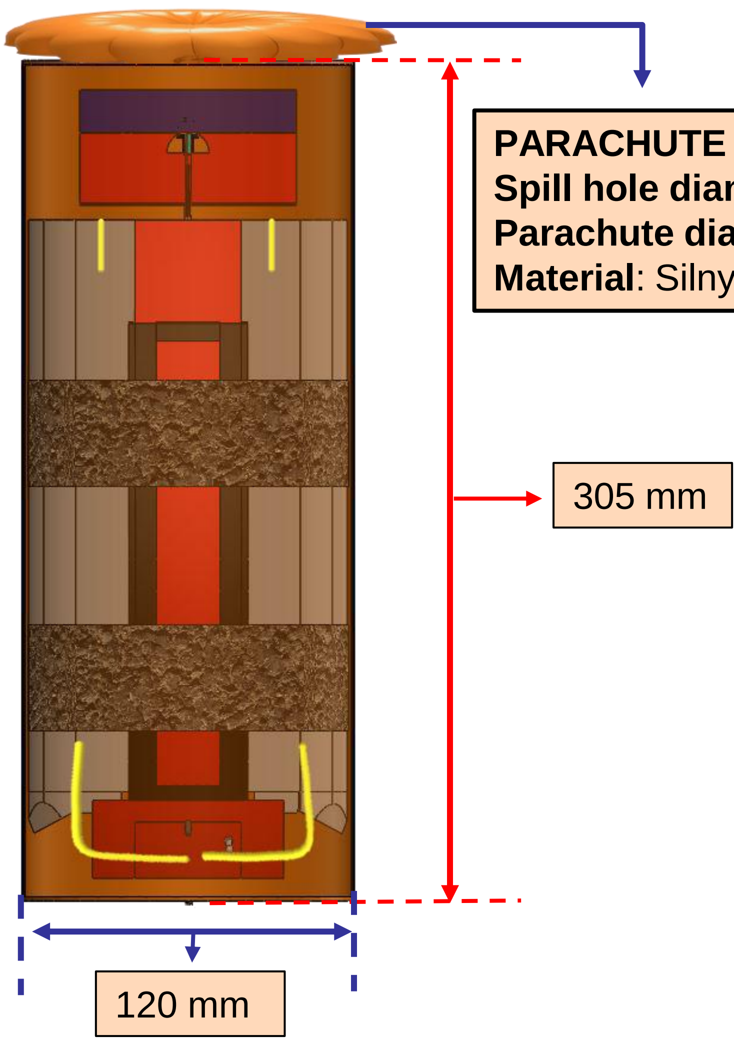
- The parachute on the top of the container will be opened by air resistance.
- The CanSat will be descent at a speed of 20 m/s.



Step 4: Deployed Configuration

- The container opened by the melt of fishline method and at 450 meters (±10 meters), the payload will be released from the container.

Container Descent Control Hardware Summary (2 of 2)



Key Design Considerations:

- The deprons are fixed to the container with epoxy and the deprons will keep the payload stable.
- Fishline keeps the bottom cover of the container. Fishline melts and the bottom cover will open when the melt of the fishline method activated.

Color selection:

- The container color is fluorescent orange.
- The container's parachute color is fluorescent orange.

Active components:

- No active components are used in container descent control.

Passive components:

- The hinges and stretched fabric elastic used in the opening mechanism of the container are passive components.
- Container's parachute is a passive component.

There is no electronic circuit in the container.

Container + Payload Post Separation

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

$$S_p = \frac{2 \times (0.6\ kg) \times (9.81\ m/s^2)}{(1.225\ kg/m^3) \times (20\ m/s)^2 \times 1.5}$$

$$S_p = 0.01602\ m^2$$

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

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

$\boldsymbol{S_p} = 0.01602\ m^2$ (Area of the parachute with a spill hole)
$\boldsymbol{D} = 143$ mm (The diameter of the parachute)
$\boldsymbol{V} = 20\ m/s$ (Descent speed)
$\boldsymbol{\pi} = 3.14159$
$\boldsymbol{C_D} = 1.5$ (Drag coefficient of round type parachute)
$\boldsymbol{\rho} = 1.225\ kg/m^3$ (Air density at +15°C from sea level)
$\boldsymbol{m} = 0.6\ kg$ (Container + Payload)
$\boldsymbol{g} = 9.81\ m/s^2$
$\boldsymbol{S_{S_h}} = 0.00080\ m^2$ (Spill hole area)

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

$$S_{S_h} = S_p \times 5\% \longrightarrow 0.01602\ m^2 \times 0.05 = 0.00080\ m^2$$

$$\text{Spill Hole Radius} = \sqrt{\frac{S_{sh}}{\pi}} = \sqrt{\frac{0.00080}{\pi}} = 0.01596\ m = 15.96766\ mm \cong 16\ mm$$

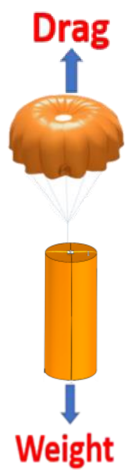
$$D = \sqrt{\frac{4 \times 0.01602\ m^2}{\pi}} \longrightarrow D = 0.14281\ m \cong 143\ mm$$

Descent Rate Estimates (2 of 7)

Descent Speed Rates

Descent Speed Formula

$$V = \sqrt{\frac{2 \times F_{Drag}}{\rho \times S_p \times C_D}}$$



$$\boldsymbol{F_{Drag}} = \boldsymbol{F_{Weight}}$$

$\boldsymbol{S_p} = 0.01602\ m^2$(Area of the parachute with a spill hole)
$\boldsymbol{V}$ = Descent speed (m/s)
$\boldsymbol{C_D} =$ 1.5 (Drag coefficient of round type parachute)
$\boldsymbol{\rho} = 1.225\ kg/m^3$ (Air density at +15°C from sea level)
$\boldsymbol{m} =$ $0.081\ kg$ (Container)
$\boldsymbol{m} =$ $0.6\ kg$ (Container + Payload)
$\boldsymbol{g} = 9.81\ m/s^2$

Descent Speed for Container + Payload

$$V = \sqrt{\frac{2 \times (0.6\ kg) \times (9.81\ m/s^2)}{(1.225\ kg/m^3) \times (0.01602\ m^2) \times 1.5}}$$

$$V = 19.99770\ m/s \cong \mathbf{20\ m/s}$$

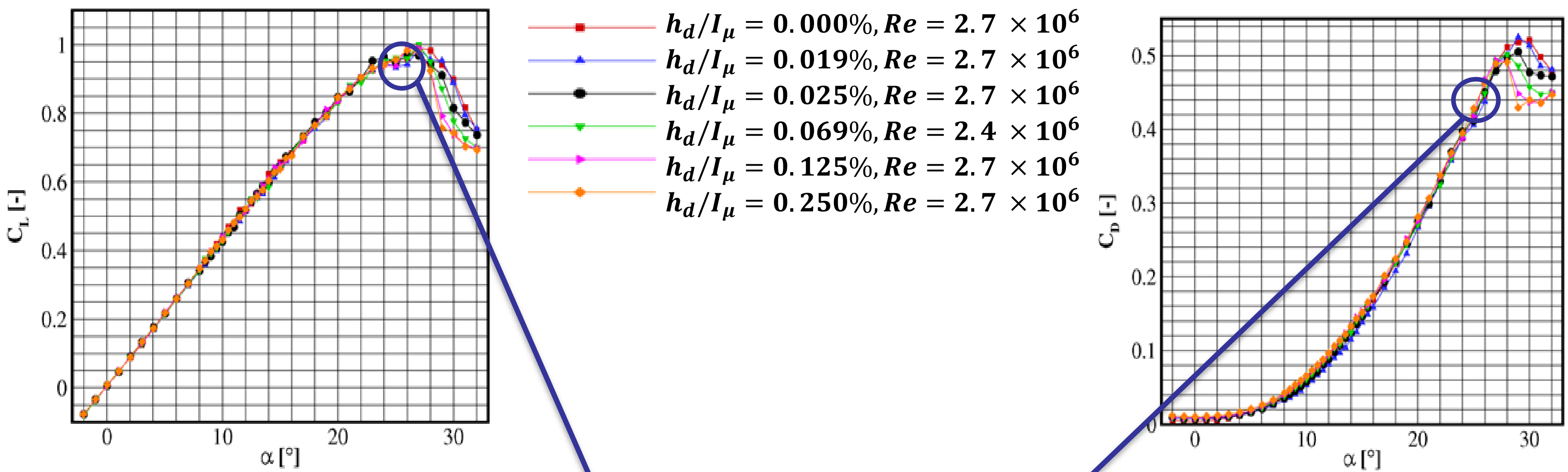
Container Following Release From The Payload

$$V = \sqrt{\frac{2 \times (0.081\ kg) \times (9.81\ m/s^2)}{(1.225\ kg/m^3) \times (0.01602\ m^2) \times 1.5}}$$

$$V = 7.34762\ m/s \cong \mathbf{7.35\ m/s}$$

Drag and Lift Coefficient Graphics of Diamond Delta Wing

Lift Coefficient Graphic **Drag Coefficient Graphic**



****We selected the 26° angle of attack for efficient lift and drag coefficient.***

$$C_L = 0.95$$
$$C_D = 0.44$$

- **Source:** https://www.mdpi.com/2226-4310/5/3/98/htm

Delta Wing Payload Calculations

$$V_{Vertical} = \frac{\Delta x}{t} = \frac{450\,m - 100\,m}{60\,s} = \frac{350\,m}{60\,s} = \mathbf{5.83\,m/s}$$

$$\mathrm{F}(\mathrm{m} \times g) = \frac{1}{2} \times C_D \times \rho \times A \times V_{Horizontal}^2$$

$$V_{Horizontal} = \sqrt{\frac{2(m \times g)}{C_D \times \rho \times A}} = \sqrt{\frac{2 \times (0.5111\,kg) \times (9.81\,m/s^2)}{0.44 \times (1.225\,kg/m^3) \times (0.21424\,m^2)}}$$

$$V_{Horizontal} = 9.31875 \cong \mathbf{9.32\,m/s}$$

$\boldsymbol{AR} = 5$ (Aspect ratio)

$\boldsymbol{GR} =$ Glide ratio $\left(\frac{V_{\mathrm{Vertical}}}{V_{\mathrm{Horizontal}}}\right)$

$\boldsymbol{WS} = 1.035\,m$ (Wingspan)

$\boldsymbol{A} = 0.21424\,m^2$ (Wing area)

$\boldsymbol{Aoa} = 26°$ (Angle of attack)

$\boldsymbol{C_D} = 0.44$ (Drag coefficient)

$\boldsymbol{C_L/C_D} =$ Lift/Drag Ratio

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

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

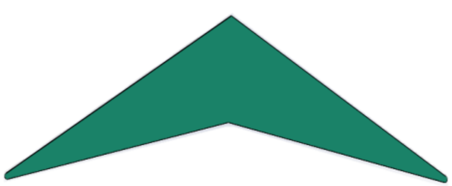
$\boldsymbol{m} = 0.5111\,kg$ (Payload)

$$\mathrm{AR} = \frac{\mathrm{WS}^2}{\mathrm{A}} = \frac{(1.035\,m)^2}{0.21424\,m^2} = 5$$

$$\mathrm{C_L/C_D} = \frac{0.95}{0.44} = 2.15909 \cong 2.16$$

$$V_{Payload} = \sqrt{5.83^2 + 9.32^2} = 10.99323 \cong \mathbf{11\,m/s}$$

$$\mathrm{GR} = \frac{V_{Vertical}}{V_{Horizontal}} = \frac{5.83}{9.32} = 0.62553 \cong 0.63$$

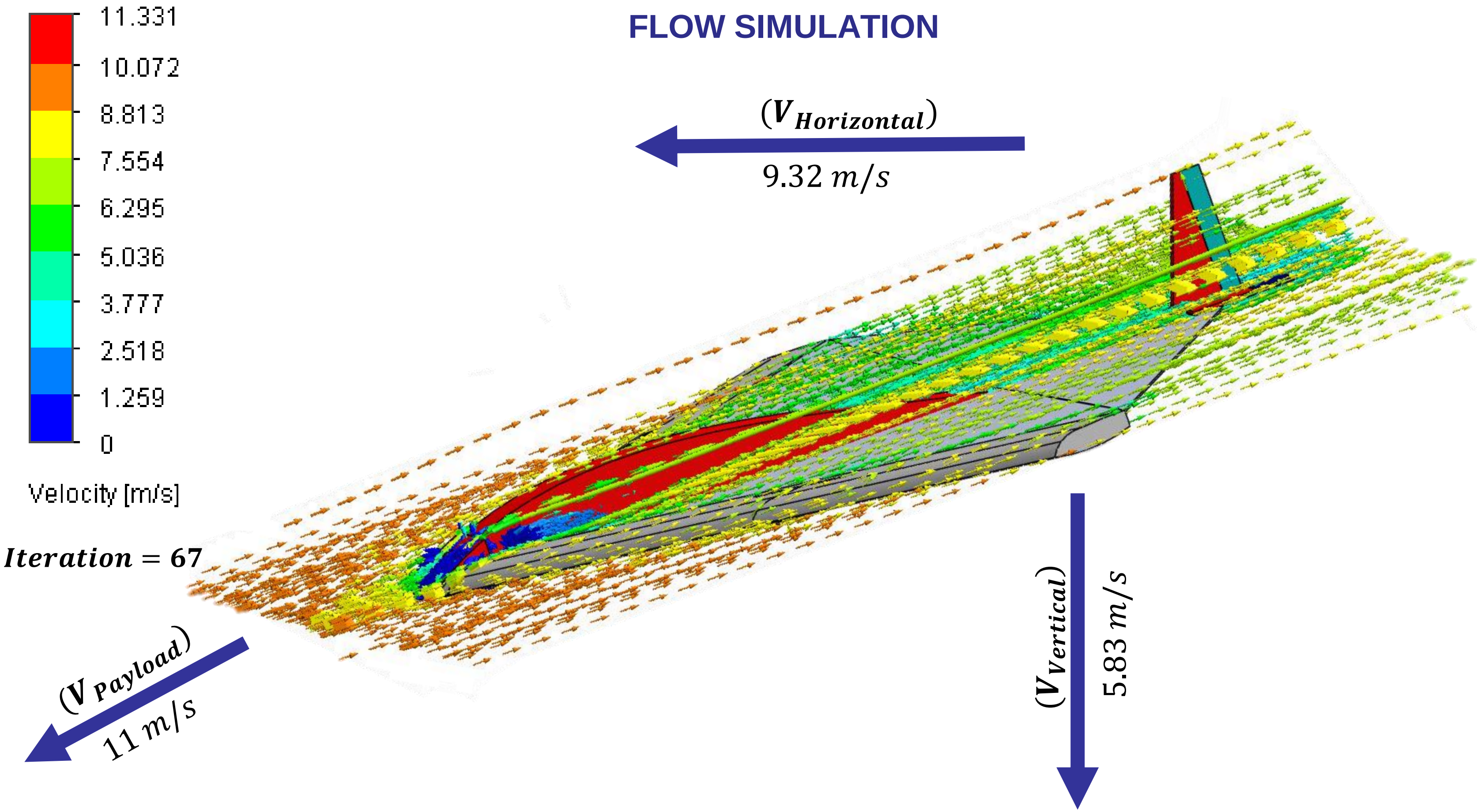


(Aspect ratio 6.8)
High aspect ratio

(Aspect ratio 4.4)
Low aspect ratio

(We observe high and low aspect ratio difference in photos)

- ***At low aspect ratio, the lift coefficient is low, but maneuverability is high, so an optimum value between low and high aspect ratio is chosen for this mission.***



- Glider flow simulation in descent time. The wind speed is shown in the simulation according to the colors.
- This simulation proves to us that our payload is of an airfoil form.

Descent Rate Estimates (6 of 7)

Payload Parachute Calculations

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

$$S_p = \frac{2 \times (0.5111\ kg) \times (9.81\ m/s^2)}{(1.225\ kg/m^3) \times (10\ m/s)^2 \times 1.5}$$

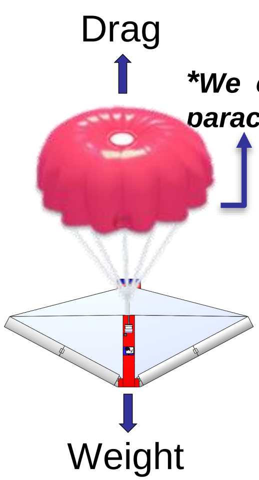
$$S_p = 0.05457 m^2 \Rightarrow S_p = \frac{1}{4} \times \pi \times D^2$$

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

$\boldsymbol{S_p} = 0.05457\ m^2$ (Area of the parachute with a spill hole)
$\boldsymbol{D} =$ The diameter of the parachute (mm)
$\boldsymbol{V} = 10\ m/s$ (Descent speed)
$\boldsymbol{\pi} = 3.14159$
$\boldsymbol{C_D} = 1.5$ (Drag coefficient of round type parachute)
$\boldsymbol{\rho} = 1.225\ kg/m^3$ (Air density at $+15°C$ from sea level)
$\boldsymbol{m} = 0.5111\ kg$ (Payload)
$\boldsymbol{g} = 9.81\ m/s^2$
$\boldsymbol{S_{S_h}} = 0.00273\ m^2$ (Spill hole area)

$$Ss_h = S_P \times 5\% \Rightarrow 0.05457\ m^2 \times 0.05 = 0.00273\ m^2$$

Spill Hole Radius $= \sqrt{\frac{Ss_h}{\pi}} = \sqrt{\frac{0.00273}{3.14159}} = 0.02947\ m = 29.47\ mm \cong 29.5\ mm$



**We choose the fluorescent pink color parachute for this mission.*

$$D = \sqrt{\frac{4 \times 0.05457}{3.14159}} \Rightarrow D = 0.26383 m \cong 263.83\ mm$$

$$V = \sqrt{\frac{2 \times m \times g}{\rho \times S_p \times C_D}} \qquad V = \sqrt{\frac{2 \times (0.5111\ kg) \times (9.81\ m/s^2)}{(1.225\ kg/m^3) \times (0.05457\ m^2) \times 1.5}}$$

$$V = 10.00027\ m/s \cong 10\ m/s$$

FINAL RESULTS

CanSat (Container + Payload) Post Separation

- *Spill hole diameter:* $32\ mm$
- *The diameter of parachute:* $143\ mm$
- *Descent speed:* $20\ m/s$

Container Following Release From The Payload

- *Container descent speed after released of the payload:* $7.35\ m/s$

Payload Following Separation From The Container

- *Angle of attack:* $26°$
- *Area of delta wing:* $0.21424\ m^2$
- *Speed of payload:* $11\ m/s$

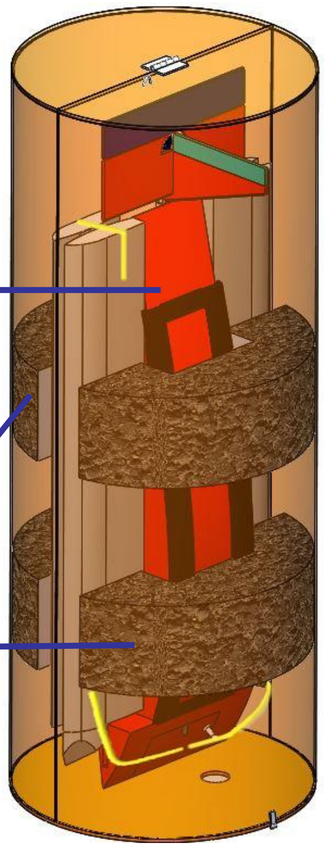
Payload Parachute Calculations

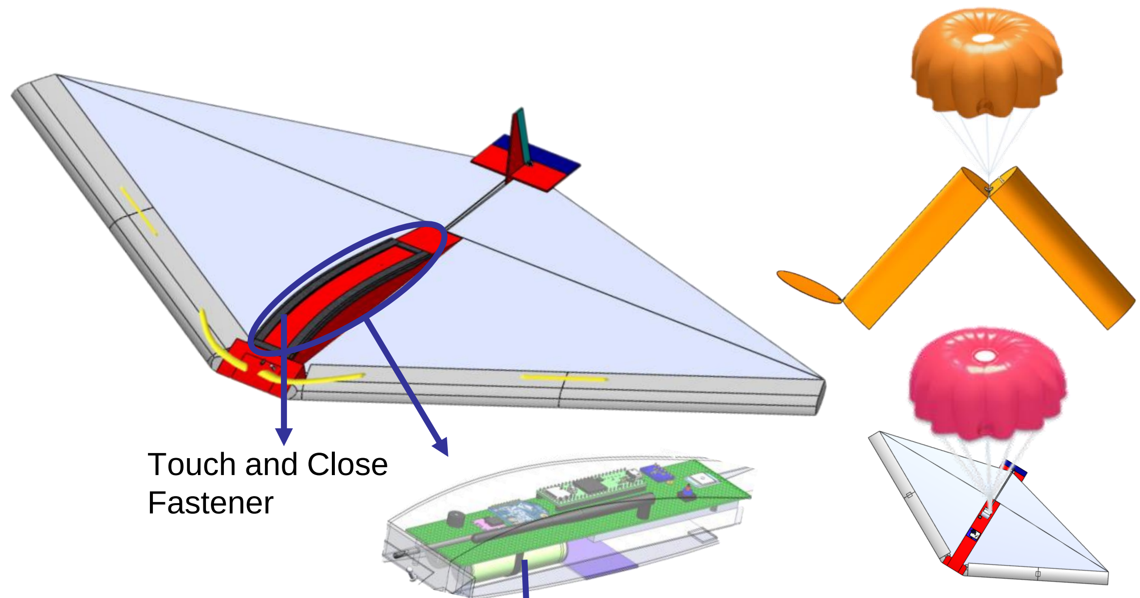
- *Spill hole diameter:* $59\ mm$
- *The diameter of the parachute:* $263.83\ mm$
- *Descent speed:* $10\ m/s$

Mechanical Subsystem Design

Ömer ÖZ

Mechanical Subsystem Overview





PAYLOAD
Body Material: Fiberglass. The part in front of the camera will be made of plexiglass for image acquisition. **Color:** The payload color is red and the delta wings colors are grey. **Delta Wing Material:** Silnylon 30D Nylon 66. **Delta Wing Structural:** Stretched fabric elastic, hinges, carbon fiber sticks. **Parachute Material:** Silnylon 30D Nylon 66. •The active rotation of the payload is provided by the elevator and the rudder on the wings. •Rudder and elevator will be controlled by servo motors. •There will be a telescopic system in the payload. This system will extend the wing area. •The batteries and electronic components will be easily reached by touch and close fastener.

CONTAINER
Body Material: Fiberglass **Body Color:** Fluorescent orange **Parachute Material:** Silnylon 30D Nylon 66.

Mechanical Subsystem Changes Since PDR

PDR	CDR	RATIONALE
We use the electronic circuit in the container.	The electronic circuit has been removed from the container.	The test we carried out on the breadboard showed that the payload circuit can also perform the separation task priorly performed by the container circuit.
Separation of the payload from the container will be triggered by the melt stop box in the container.	A melt stop box will be added to the payload. Separation of the payload from the container will be triggered by the melt stop box in the payload.	We removed the electrical circuit from the container.
The container dimension is 300 mm in length and 120 mm in diameter.	The container dimension is 305 mm in length and 120 mm in diameter.	The size of the container was increased to make the payload more comfortable to stow.
We use plastic hinge for folding mechanism of the wing.	We will use the new hinges for the folding mechanism of the wing. The use of our 3D printers able us to produces the hinges.	We can produce in the sizes we want. Faster, easier and flexible production is possible.

- **We discussed the details of the changes in subsequent slides.**

Mechanical Sub-System Requirements (1 of 3)

Requirement Number	Requirement	Rationale	Priority	VM			
				A	I	T	D
RN#1	Total mass of the CanSat (science payload and container) shall be 600 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	HIGH		✓		
RN#5	The container shall be solid and fully enclose the science payload. Small holes to allow access to turn on the science payload is allowed. The end of the container where the payload deploys may be open.	Competition requirement	HIGH		✓	✓	
RN#6	The rocket airframe shall not be used to restrain any deployable parts of the CanSat.	Competition requirement	HIGH		✓		✓
RN#7	The CanSat shall deploy from the rocket payload section and immediately deploy the container parachute.	Competition requirement	HIGH		✓		✓

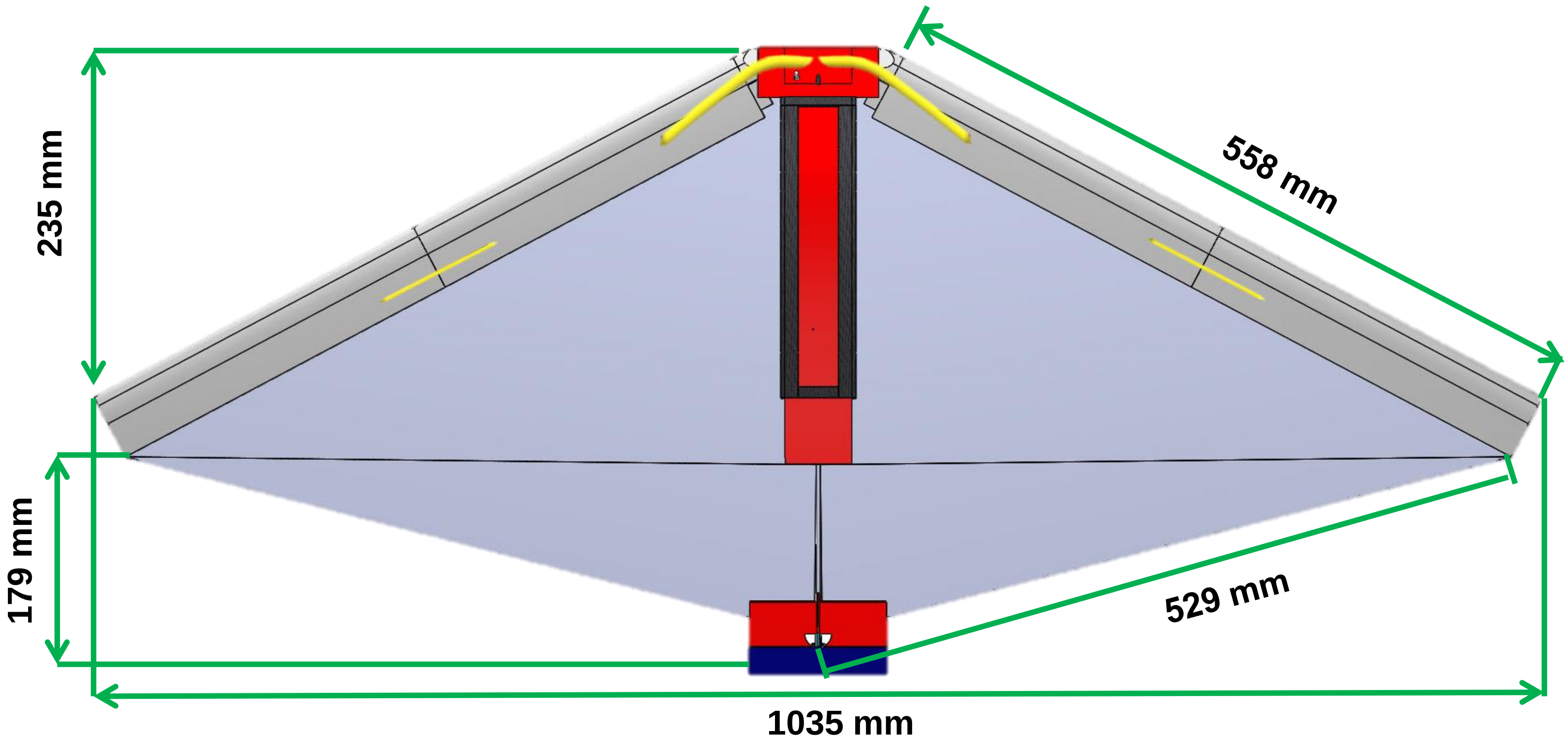
Mechanical Sub-System Requirements (2 of 3)

Requirement Number	Requirement	Rationale	Priority	VM			
				A	I	T	D
RN#8	The container parachute shall not be enclosed in the container structure. It shall be external and attached to the container so that it opens immediately when deployed from the rocket.	Competition requirement	HIGH		✓	✓	✓
RN#9	The descent rate of the CanSat (container and science payload) shall be 20 meters/second +/- 5m/s.	Competition requirement	HIGH		✓	✓	✓
RN#10	The container shall release the payload at 450 meters +/- 10 meters.	Competition requirement	HIGH		✓	✓	✓
RN#11	The science payload shall glide in a circular pattern with a 250 m radius for one minute and stay above 100 meters after release from the container.	Competition requirement	HIGH	✓	✓	✓	✓
RN#12	The science payload shall be a delta wing glider.	Competition requirement	HIGH	✓	✓		✓
RN#14	All descent control device attachment components shall survive 30 Gs of shock.	Competition requirement	HIGH	✓	✓	✓	
RN#15	All electronic components shall be enclosed and shielded from the environment with the exception of sensors.	Competition requirement	HIGH		✓	✓	✓
RN#16	All structures shall be built to survive 15 Gs of launch acceleration.	Competition requirement	HIGH	✓	✓	✓	

Mechanical Sub-System Requirements (3 of 3)

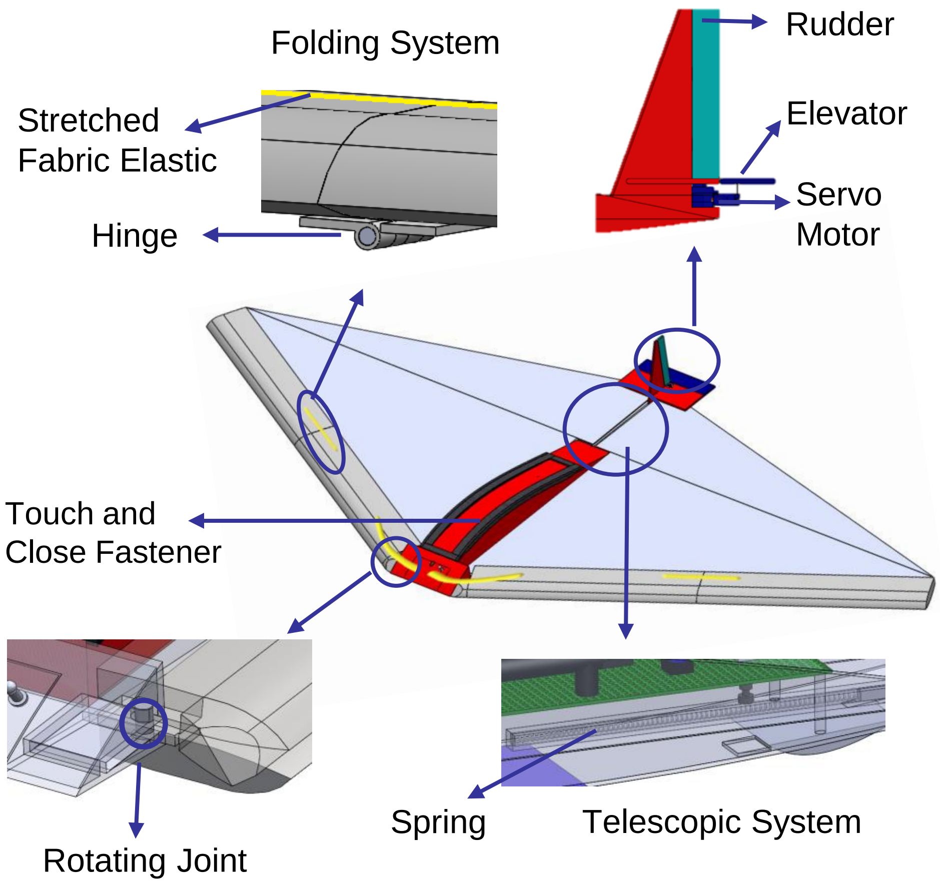
Requirement Number	Requirement	Rationale	Priority	VM			
				A	I	T	D
RN#17	All structures shall be built to survive 30 Gs of shock.	Competition requirement	HIGH	✓	✓	✓	
RN#18	All electronics shall be hard mounted using proper mounts such as standoffs, screws, or high-performance adhesives.	Competition requirement	HIGH	✓	✓		
RN#19	All mechanisms shall be capable of maintaining their configuration or states under all forces.	Competition requirement	HIGH	✓		✓	
RN#20	Mechanisms shall not use pyrotechnics or chemicals.	Competition requirement	HIGH	✓	✓		
RN#21	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#38	Cost of the CanSat shall be under $1000. Ground support and analysis tools are not included in the cost.	Competition requirement	MEDIUM	✓	✓		
RN#54	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#56	The CANSAT must operate during the environmental tests laid out in Section 3.5.	Competition requirement	HIGH	✓	✓	✓	✓
EXTRN#2	Active control must be provided by using rudder and elevatorin servo motor control.	To perform active control	HIGH	✓	✓	✓	

Payload CAD Model Dimensions

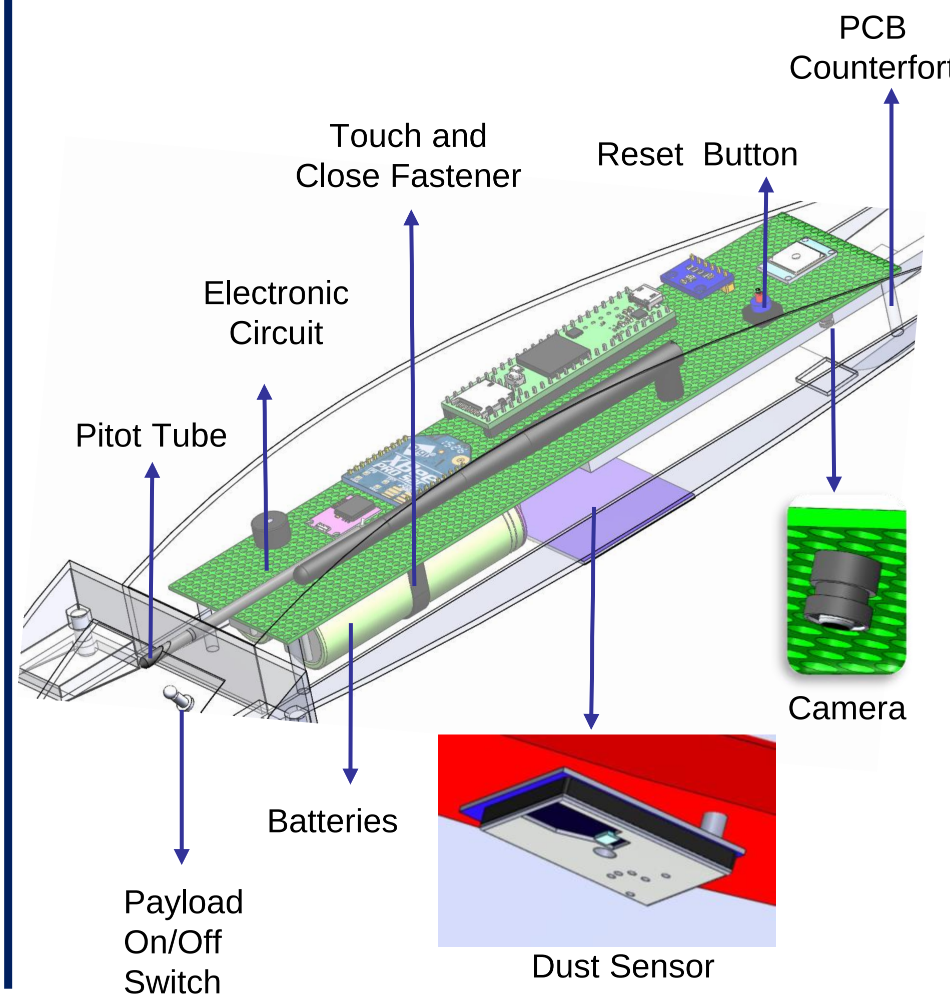


Payload Mechanical Layout of Components (2 of 4)

Major Mechanical Parts

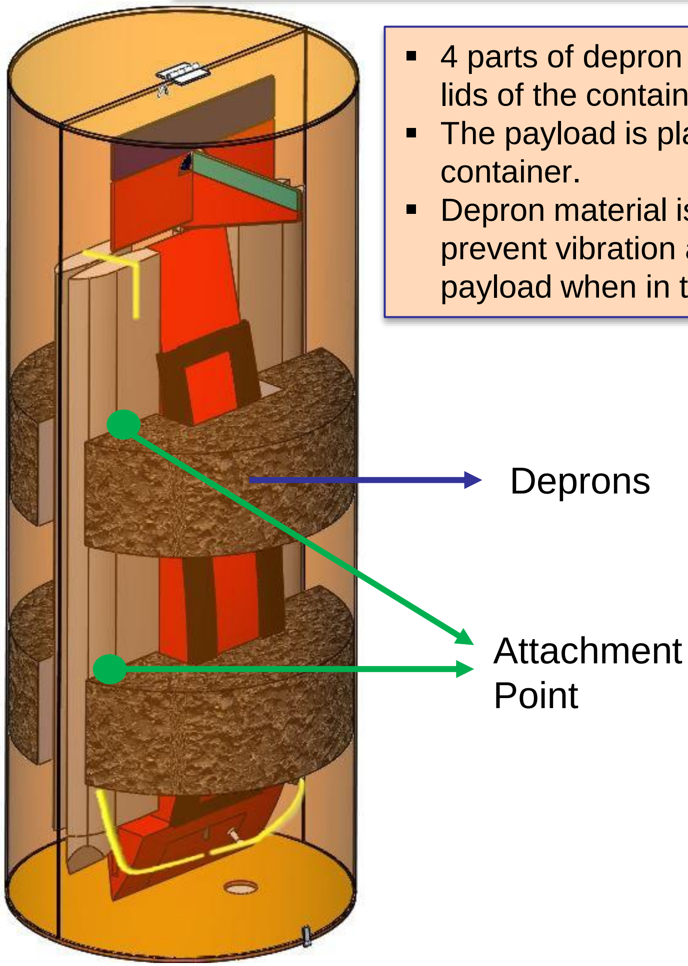


Location of Electronic Components



Payload Mechanical Layout of Components (3 of 4)

Payload Attachment Point

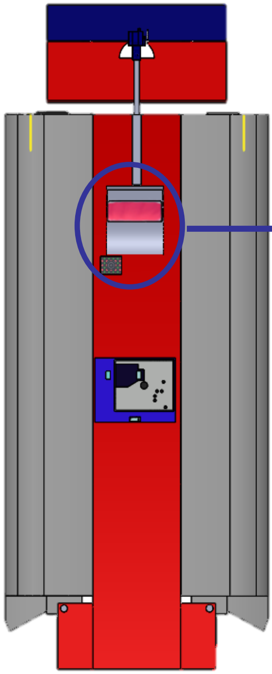


- 4 parts of depron were glued to the lids of the container with epoxy.
- The payload is placed in the container.
- Depron material is selected to prevent vibration and protect the payload when in the rocket.

Payload Structural Material Selections

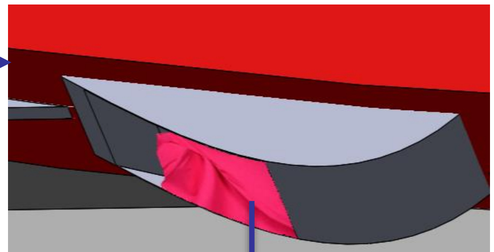
PART	MATERIAL	RATIONALE
Payload Body	Fiberglass	• Strong • Light
Payload's Wing and Parachute	Silnylon 30D Nylon 66	• Low air permeability • High tear strength
Payload's Wing Frame	Carbon Fiber Sticks	• Low density • Very durable
Plastic Hinge	ABS	• Fast production • Cheap
Stretched Fabric Elastic	Rubber	• Easy to supply • Useful
Rotating Joint	Steel	• Longer durability • Less friction force
Spring	Steel	• Durable

THE PAYLOAD'S PARACHUTE OPENING MECHANISM



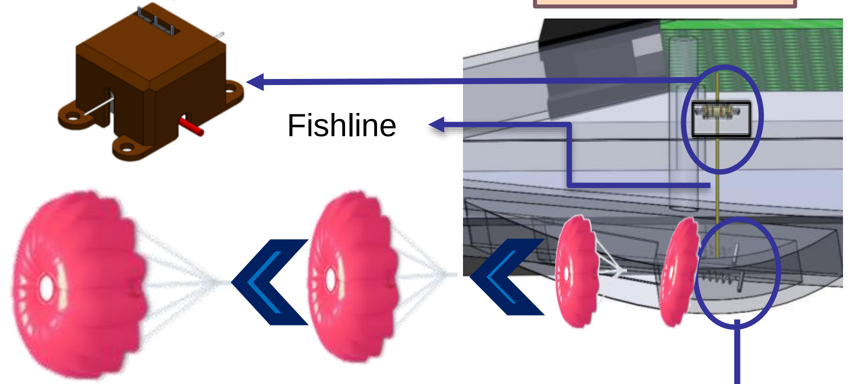
Payload's bottom view

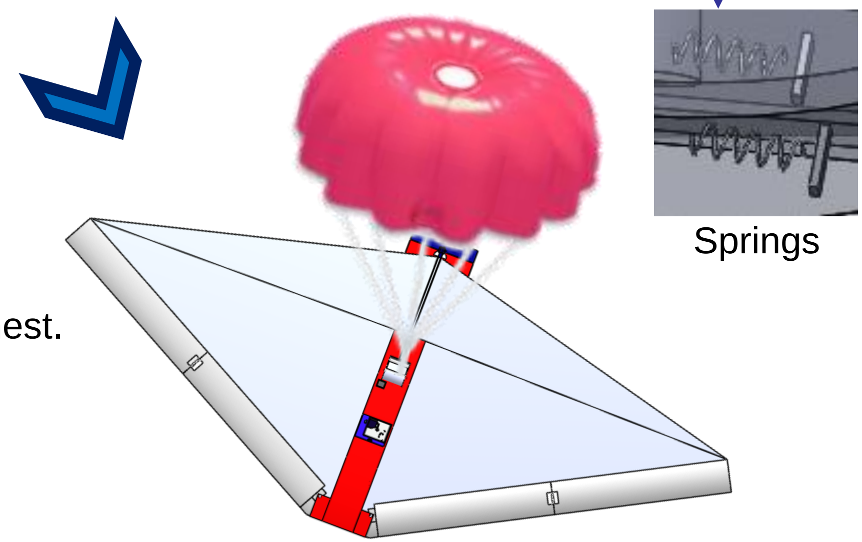
Folded parachute



Stowed Parachute Point

Springs open



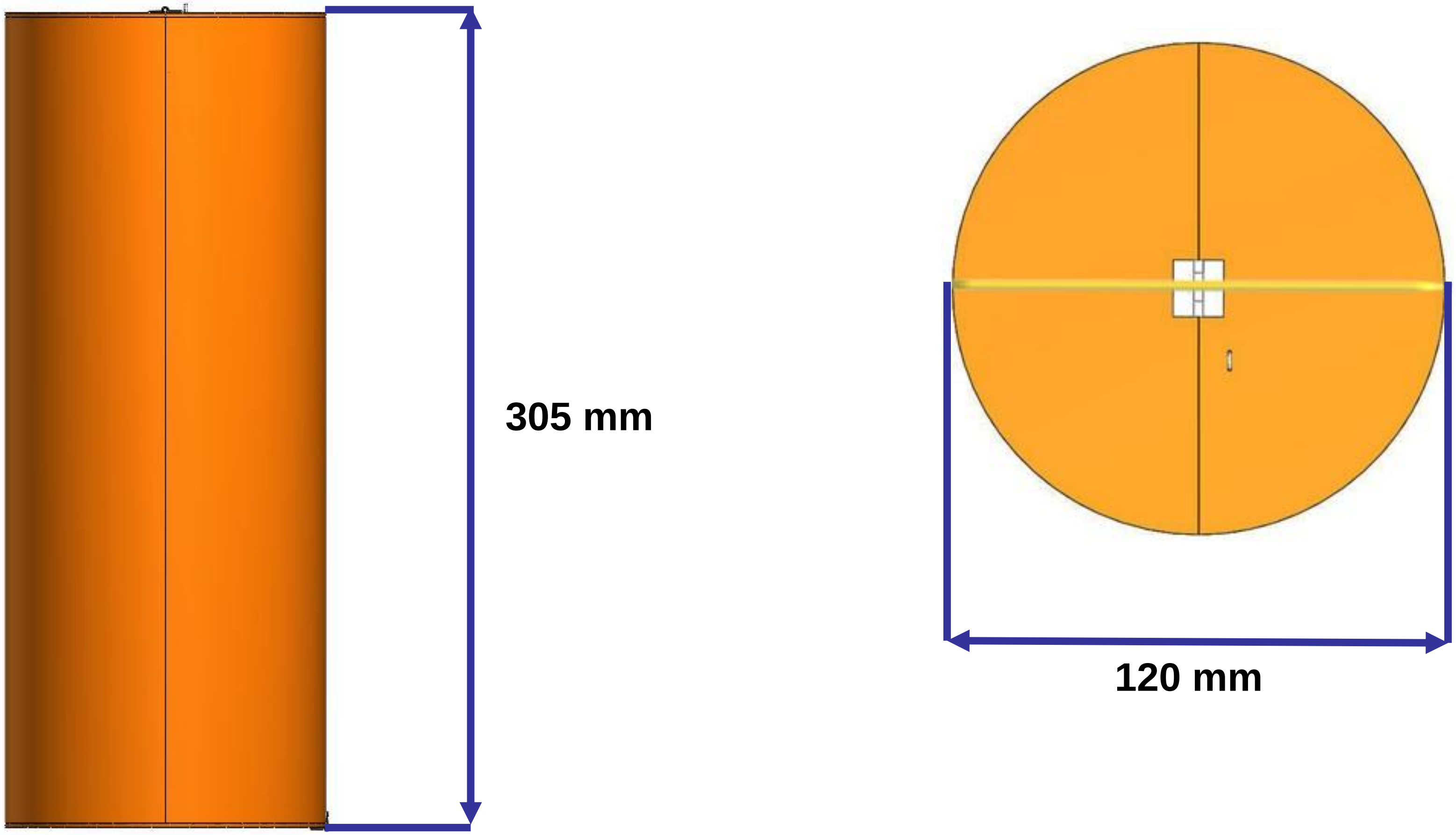


Springs

- The springs in the parachute nest will be compressed.
- The payload's parachute will be stowed in the parachute nest.
- The folded parachute will be fixed with fishline.
- The melt of fishline method will be realized and the fixed parachute will be opened with the thrust of the springs.

Container Mechanical Layout of Components (1 of 3)

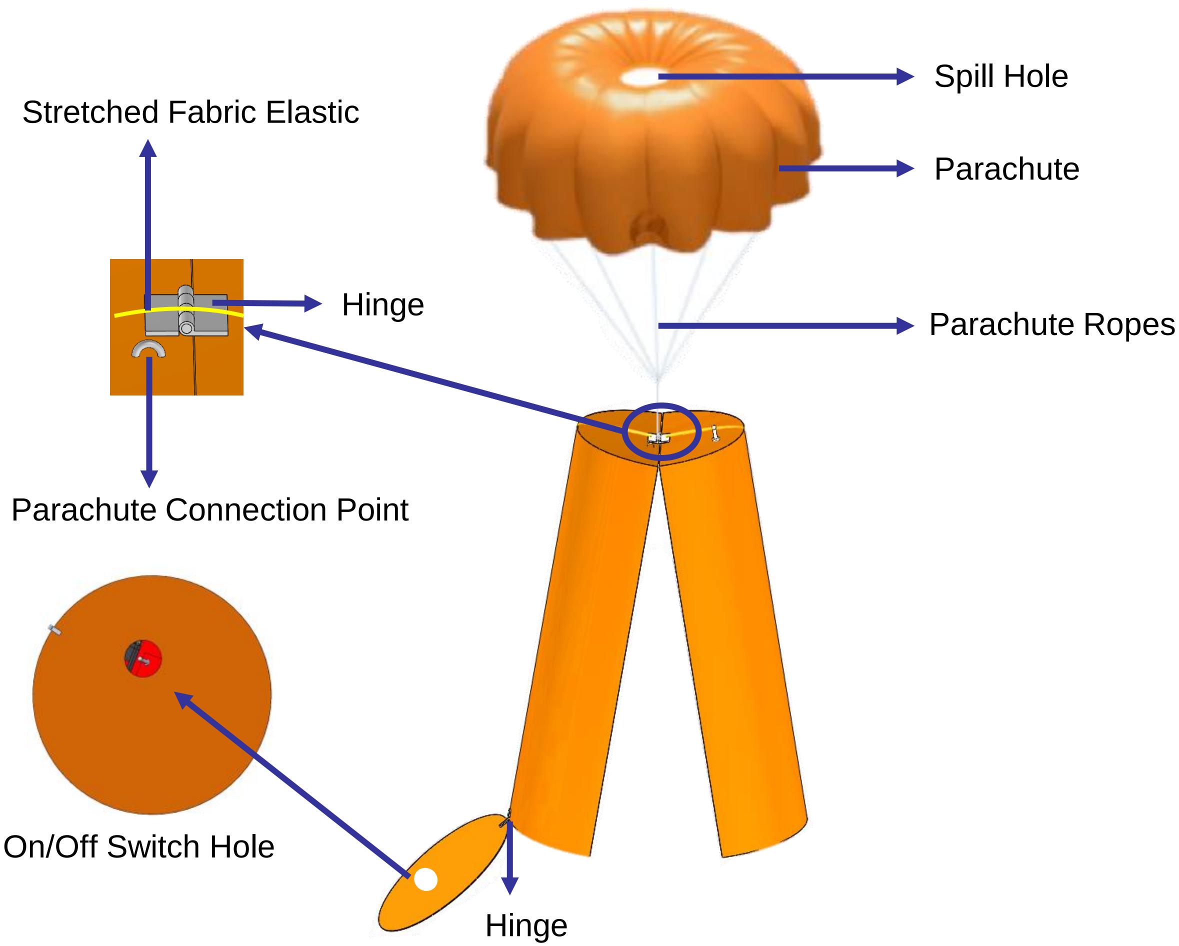
Container CAD Model Dimensions



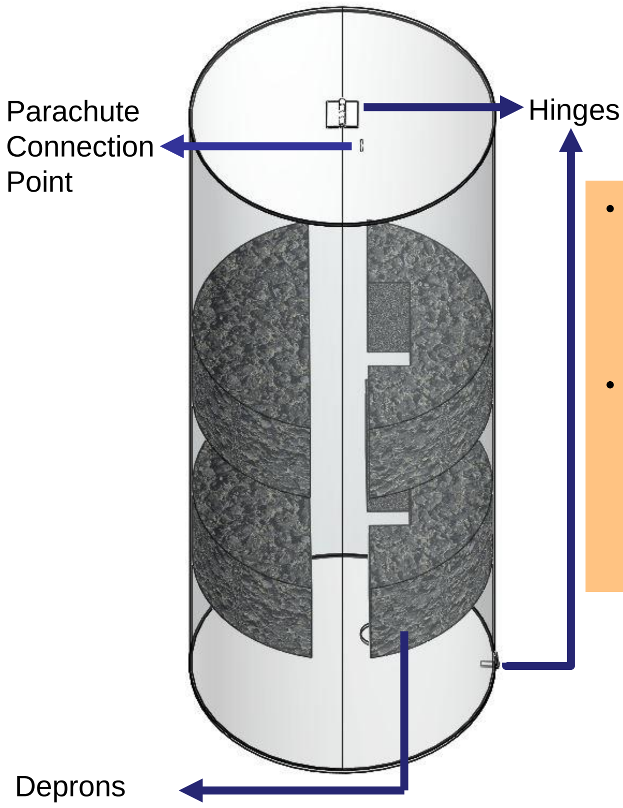
Location of Electrical Components

- **The container has no electronic components.**
- **We applied this method as there will be no electronic circuit in the container.**
- We found that the payload frame is nonpersistent during the prototype tests. Therefore, the wall thickness of the frame was increased.

Location of Major Mechanical Parts



Container Attachment Point

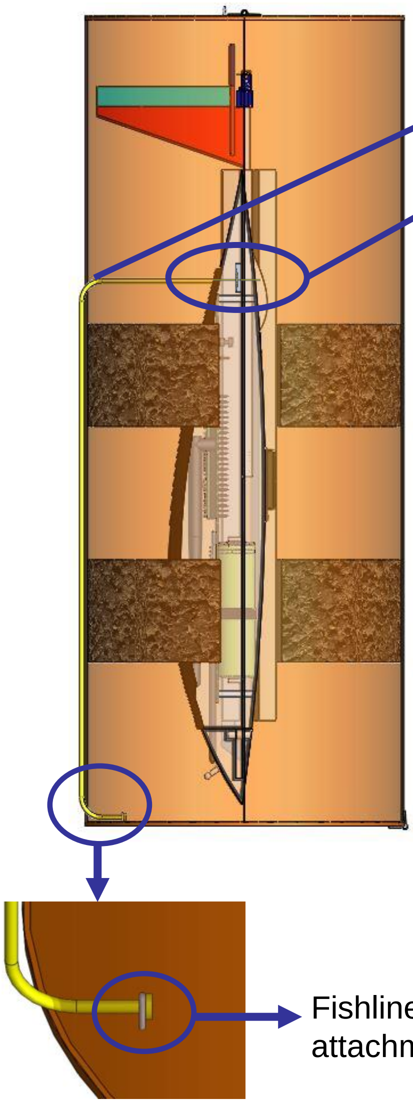


- The container consist of 3 parts and mounted with hinges and screws.
- The parachutes connection point and deprons are glued to the container with epoxy.

Container Structural Material Selection

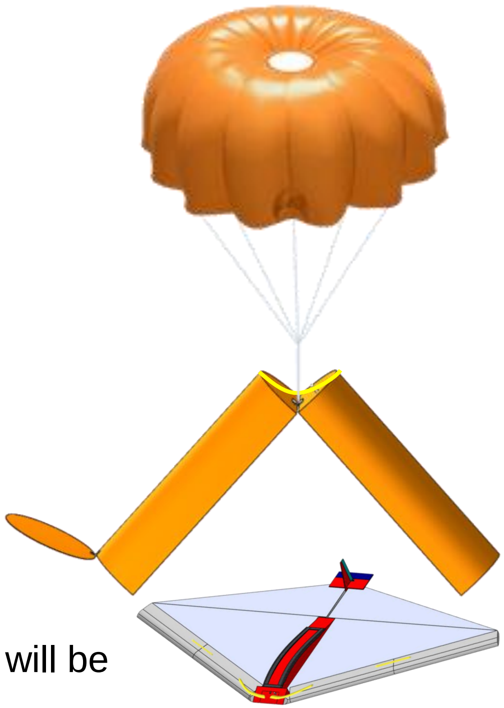
PART	MATERIAL	RATIONALE
Container	Body	• Strong • Light
Hinge	Steel	• Resistant • Long-term use
Parachute	Silnylon 30D Nylon 66	• Easy to supply • It has high air resistance • Strong, high abrasion resistant fabric
Payload Stabilizer	Depron	• Vibration isolator • Shock absorber

Payload Release Mechanism (1 of 2)



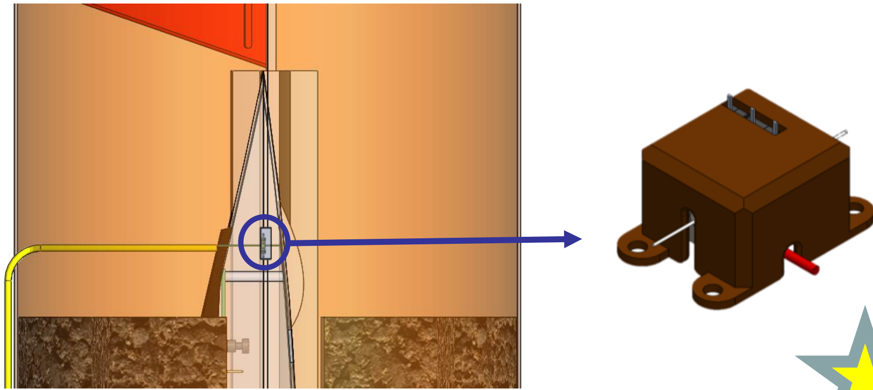
CONNECTION METHOD

- The container bottom cover will be opened.
- The wings of the payload will be folded and pushed into the container.
- The bottom cover of the container will be closed.



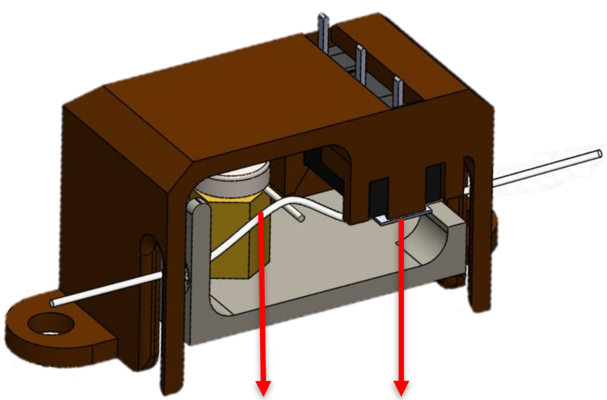
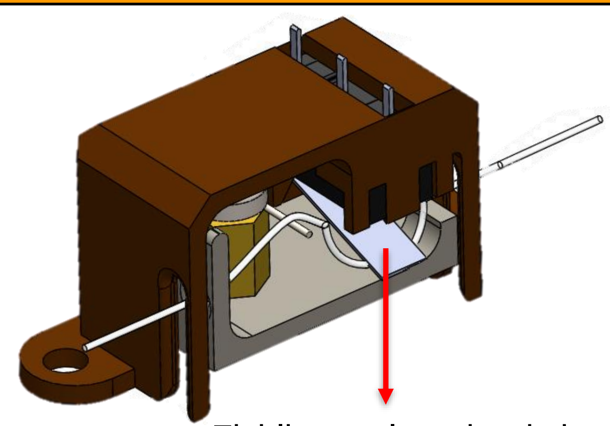
RELEASE METHOD

- When the CanSat reaches 450 meters the container will be opened using the melt of fishline method.
- The payload will be released with the effect of gravity. The wing will be opened due to the tension of the stretched fabric elastic.
- Melt of fishline method will be carried out in a box in order to protect the system from possible harmful effects.
- The melt of fishline method draws a current of 1.4 amperes.
- The melt of fishline takes less than 1 second.



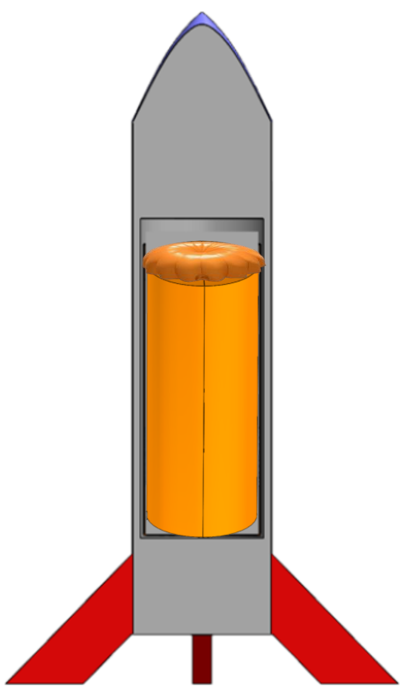
- **The melt stop box will be used for safety.**
- We will be used the melt of fishline method for reuse.
- After the fishline melt, the switch is activated and sends data to the microcontroller.
- Then the power to the fishline will be stopped.
- **We had no problems in our previous competition experiences.**

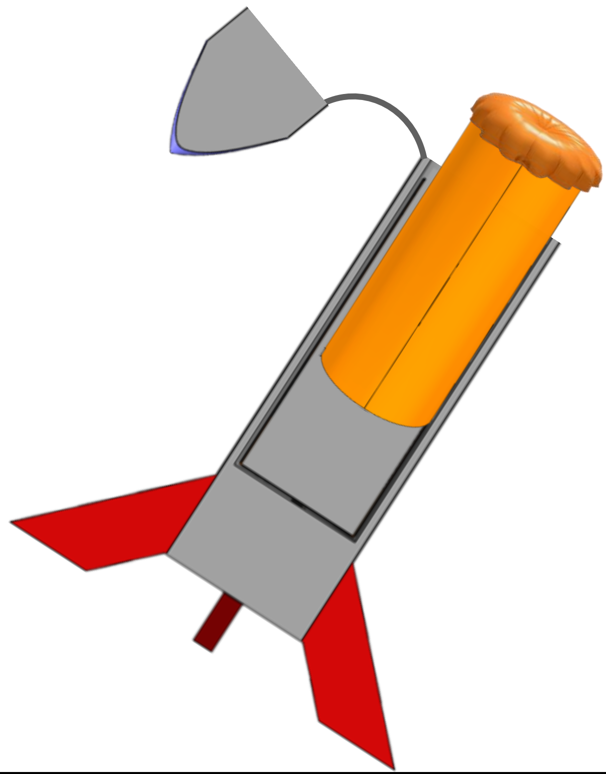
The opening of the parachute of the payload will also use the melt of fishline method in the melt stop box added to the payload.

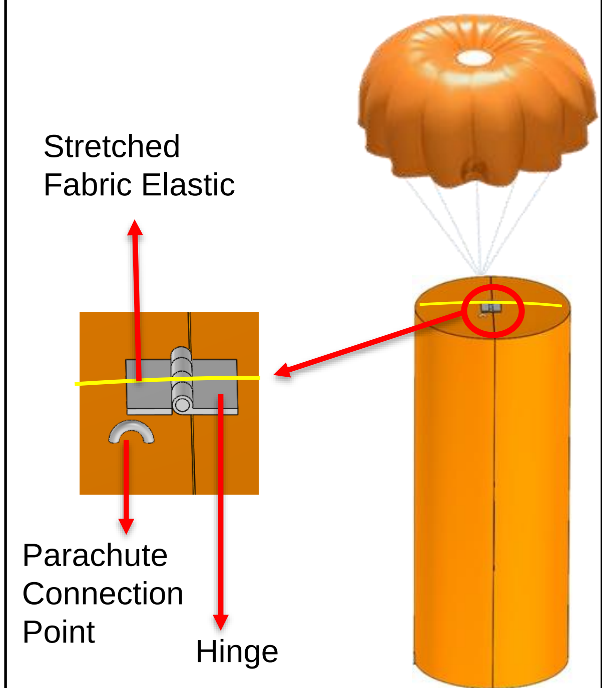
STEP 1	STEP 2
 Fishline Switch off	 Fishline melt and switch active (sending data to the microcontroller)

Container Parachute Attachment Mechanism

STEP 1 (at ground)	STEP 2 (at 670-725 meters)	STEP 3
1. The parachute will be folded and placed over the container and then attached to the container by the ropes. **2**. The CanSat will be placed in the rocket.	**1.** The rocket will be reached to (670-725 meters). **2.** The CanSat will be separated from the rocket (670-725 meters).	**1.** The parachute on the top of the container will be opened by air resistance. **2.** The CanSat will be descent at a speed of 20 m/s.

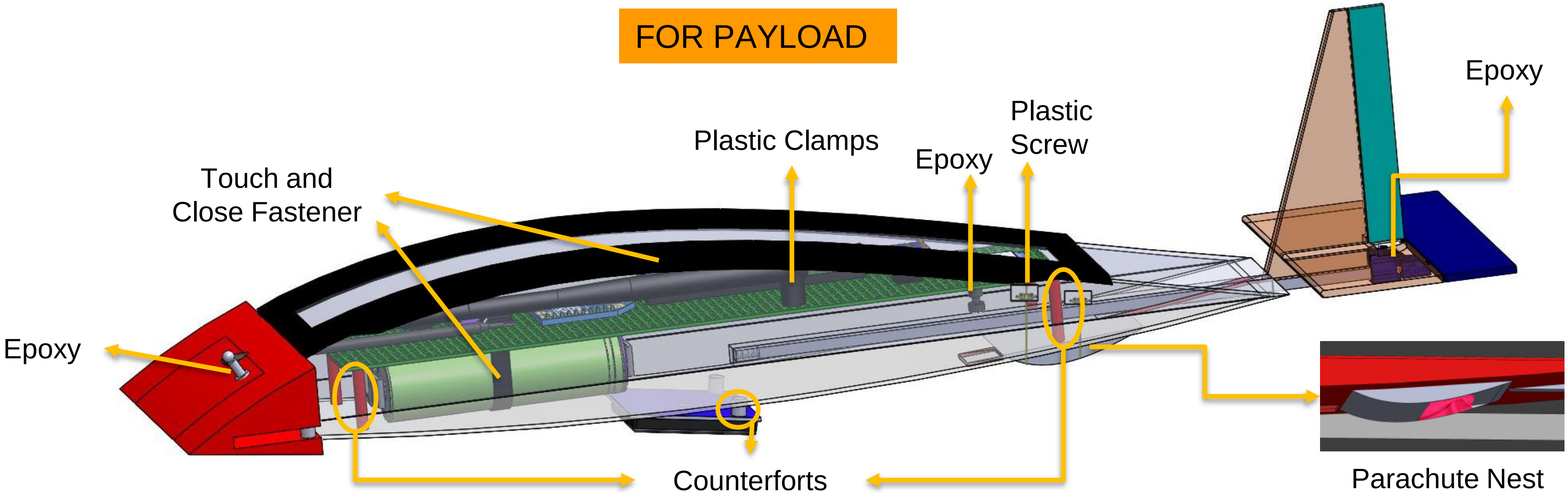






Structure Survivability (1 of 2)

FOR PAYLOAD

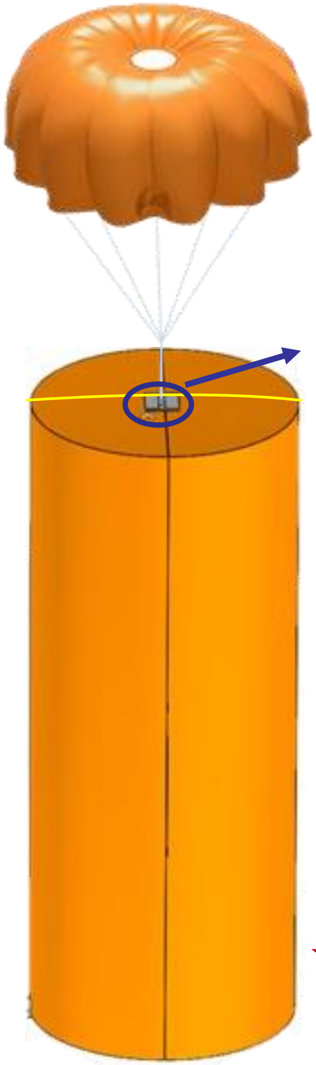


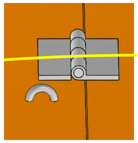
Connection	Enclosure	Mounting	Descent Control Attachments
• Connectors of electronic components will be soldered to the PCB.	• Batteries and electronic components are easily reached by touch and close fastener. • PCB will be fixed via using plastic screw with counterforts in the payload. • Batteries will be connected to the PCB with touch and close fastener.	• Pitot tube, servo motors and switch will be glued to payload with epoxy. • Dust sensor will be attached to the counterforts formed at an angle with epoxy. • Servo motors will be glued to each other with epoxy. • The camera will be glued to PCB with epoxy. • The antenna will be connected to the PCB by plastic clamps. • Melt stop box will be fixed to PCB with plastic screw.	• Descent will be provided by parachute fixed to the container. • Payload's parachute will be placed in the nest. • The parachute nest will be glued to payload with epoxy. • The payload frame will be constructed using carbon fiber sticks. The top surface of the payload will be covered with Silnylon 30D Nylon 66. • The rudder and elevator will be connected to the telescopic system.

Structure Survivability (2 of 2)

FOR CONTAINER

The container has no electronic components.

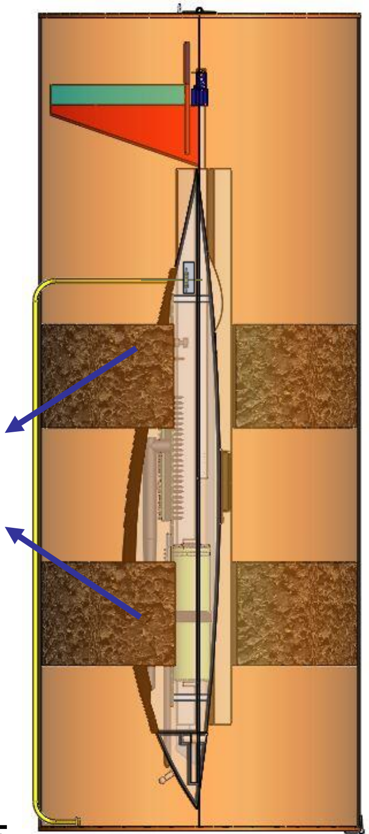




Parachute Connection Point

Descent Control Attachment

- We will use a parachute for container descent control.
- The bottom cover and container body will open simultaneously during the descent.
- 4 parts of depron were glued to the lids of the container with epoxy.
- The parachute connection point will be glued to the payload with epoxy.
- The parachute ropes will be attached to the parachute connection point.
- The container will be not blocked the payload during separation.



We are planning to do shock force and acceleration tests on 7-25 April. However, we could not perform this test because of Covid-19.

Mass Budget (1 of 3)

PAYLOAD	Electronic Components:	Quantity:	Unit Weight (g):	Weight (g):	Determination:	Margins (g):
	10-DOF IMU (MPU-9255+BMP280)	1	2	2	MS	-
	Air Speed Sensor Kit (APM 2.6 MPXV7002DP)	1	15	15	MS	-
	GPS Sensor (NEO-7M)	1	16	16	MS	-
	Microcontroller (Teensy 3.6)	1	4.9	4.9	MS	-
	Optical Dust Sensor (Sharp GP2Y10)	1	20	20	MS	-
	Camera (SQ11)	1	4	4	MS	-
	Battery (Sony VTC6)	2	48.5	97	MS	-
	Servo Motor (Feetech FS5106R)	2	39	78	MS	-
	Buzzer (KSTG951AP RS Pro)	1	1	1	DS	-
	XBee Radio (XBee Pro S2C)	1	11	11	MS	-
	On/Off Switch (KTS102)	1	2	2	DS	-
	Reset Button	1	1	1	DS	-
	Coin Cell (CR2032 3V)	1	1.2	1.2	DS	-
	SD Card (SanDisk Ultra)	2	1	2	DS	-
	DC-DC 5V Regulator (S7V7F5)	1	2	2	MS	-
	DC-DC 3.3V Regulator (AMS1117)	1	1	1	MS	-
	Antenna (TP-LINK TL-ANT2405CL)	1	19	19	MS	-
	PCB	1	30	30	E	1.5
	Structural Components:					
	Payload Body	1	40	40	MS	-
	Elevator	1	9	9	MS	-
	Rudder	1	9	9	MS	-
	Wing Frame	1	115	115	MS	-
	Hinge	2	2	4	MS	-
	Parachute	1	15	15	MS	-
	Melt Stop Box	2	6	12	MS	-

Acronyms:
MS: Measurement
DS: Datasheet
E: Estimate

Error margin for estimated data is selected as 5%.

Electronic Components	Structural Components	Total Mass
307.1 (±1.5) g	204 g	511.1 (±1.5) g

Mass Budget (2 of 3)

CONTAINER	Structural Components:	Quantity:	Unit Weight (g):	Weight (g):	Determination:	Margins:
	Container Body	1	55	55	MS	-
	Parachute	1	10	10	MS	-
	Depron	4	3	12	MS	-
	Hinge	2	2	4	MS	-

Acronyms:
MS: Measurement
DS: Datasheet
E: Estimate

Measurement (Electronic Balance)
Max Capacity: 1200 g
Readability: 0.01 g

Structural Components	Total Mass
81 g	81 g

Error margin for estimated data is selected as 5%.

Since we measured components that could not be measured at the time of PDR stage, our specified margin for components decreased.

Mass Budget (3 of 3)

CONTAINER	81 g
PAYLOAD	511.1 (±1.5) g
Total Mass of CanSat	592.1 g

Total Mass Margin of CanSat
∣ Mass Requirement - Total Mass ∣ = Margin
∣ 600 – 592.1 ∣ = **7.9** g

CORRECTION METHODS	
If weight of CanSat < 590 g	The container with thicker wall will be used (for example container weight 84 g).
If weight of CanSat > 610 g	The container with thinner wall will be used (for example container weight 79 g).

Communication and Data Handling (CDH) Subsystem Design

Sedef ÖZEL

CDH Overview (1 of 2)

MCU - Teensy 3.6
• This is the microcontroller that is used to control all other components.

XBee Radio - XBee Pro S2C
• The XBee radio is used for conducting communication between the payload and the ground station.

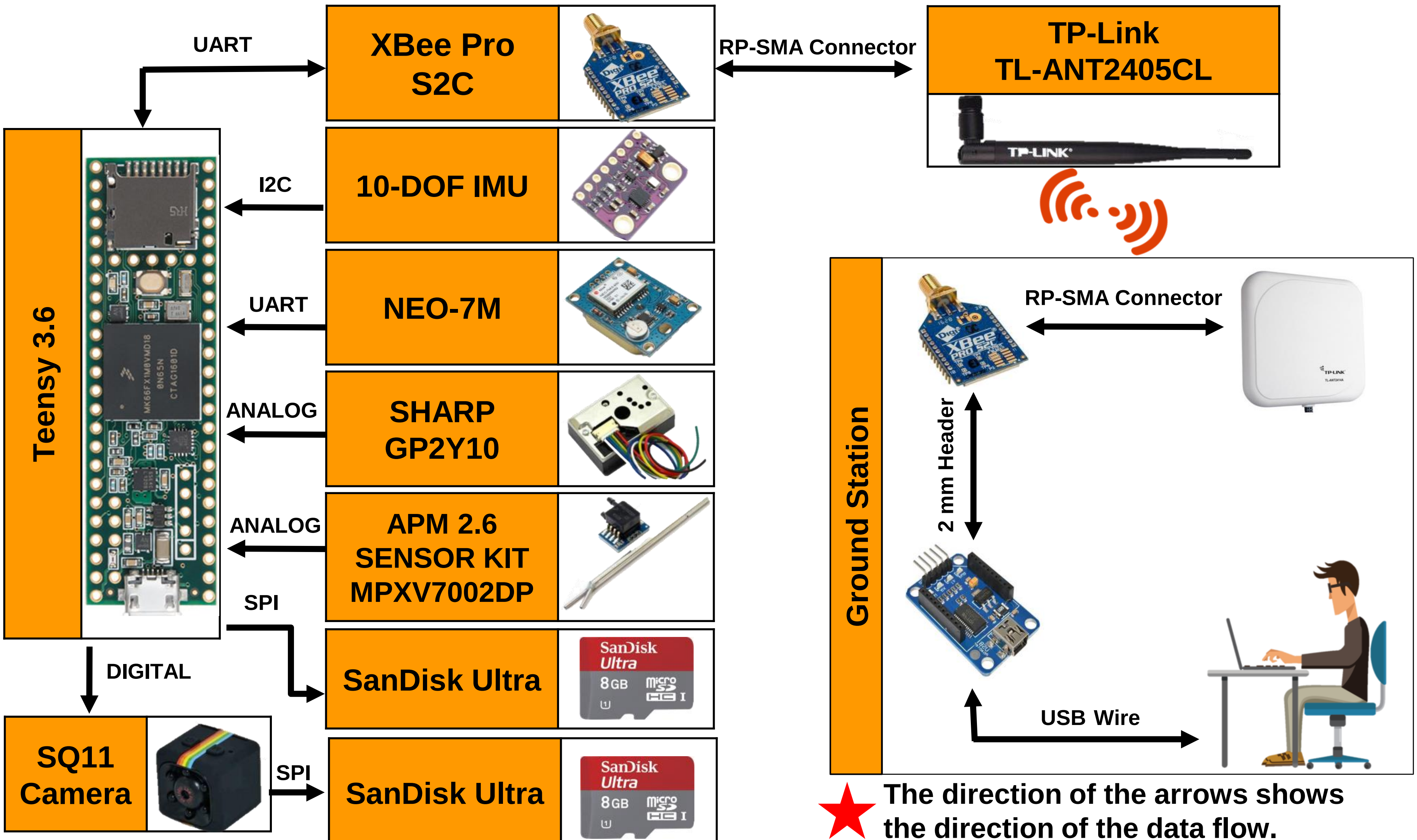
Antenna - TP-Link TL-ANT2405CL
• An external antenna is used to increase the gain of the XBee radio.

Data Storing - SanDisk Ultra
• This memory card is used to record telemetry data.

Sensors
• Particulate/dust sensor, air speed sensor, GPS, air temperature/air pressure sensor and gyroscope on the 10-DOF IMU.

Other
• The camera is used for bonus objective (camera has an internal SD card module). • The buzzer 92 dB loud audio beacon.

CDH Overview (2 of 2)



The direction of the arrows shows the direction of the data flow.

CDH Changes Since PDR

PDR	CDR	Rationale
• We will be used the electronic circuit for the container.	• The container will not have any electronics components.	• We decided not to use an electronic circuit in the container. We will perform the separation of the payload from the container with the additional melt stop box placed in the payload.
• The payload will be separated from the container with the melt stop box on the container.	• The separation of the payload from the container will be provided with the melt stop box **added** to the payload.	• The separation of the payload from the container and the opening of the payload's parachute will be performed by the use of **two different** melt stop box in the payload. Since no electronic components will be used in the container.

- **We discussed the details of the changes in subsequent slides.**

CDH Requirements (1 of 2)

Requirement Number	Requirement	Rationale	Priority	VM			
				A	I	T	D
RN#9	The descent rate of the CanSat (container and science payload) shall be 20 meters/second +/- 5m/s.	Competition Requirement	HIGH		✓	✓	✓
RN#10	The container shall release the payload at 450 meters +/10 meters.	Competition Requirement	HIGH		✓	✓	✓
RN#31	The ground system shall command the science vehicle to start transmitting telemetry prior to launch.	Competition Requirement	HIGH	✓	✓	✓	
RN#32	The ground station shall generate a csv file of all sensor data as specified in the telemetry section.	Competition Requirement	HIGH	✓	✓	✓	
RN#33	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#34	Configuration states such as if commanded to transmit telemetry shall be maintained in the event of a processor reset during launch and mission.	Competition Requirement	HIGH	✓	✓	✓	
RN#35	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#36	XBee radios shall have their NETID/PANID set to their team number.	Competition Requirement	MEDIUM	✓	✓		

CDH Requirements (2 of 2)

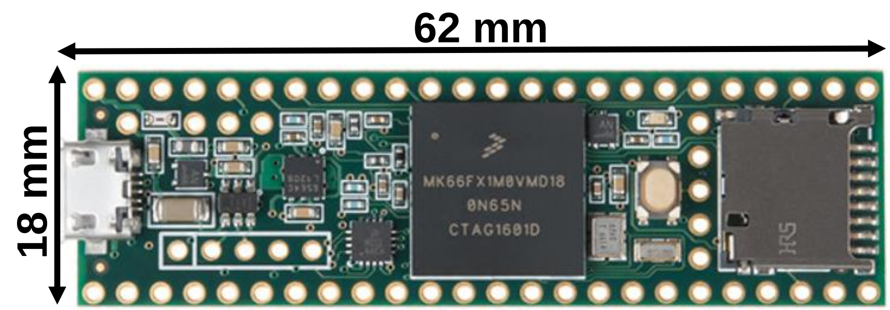
Requirement Number	Requirement	Rationale	Priority	VM			
				A	I	T	D
RN#37	XBee radios shall not use broadcast mode.	Competition Requirement	HIGH	✓	✓		
RN#40	All telemetry shall be displayed in real time during descent.	Competition Requirement	HIGH		✓	✓	
RN#41	All telemetry shall be displayed in engineering units (meters, meters/sec, Celsius, etc.).	Competition Requirement	MEDIUM	✓			✓
RN#42	Teams shall plot each telemetry data field in real time during flight.	Competition Requirement	HIGH	✓	✓	✓	✓
RN#44	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#51	An audio beacon is required for the probe. It may be powered after landing or operate continuously.	Competition Requirement	HIGH	✓		✓	
RN#52	The audio beacon must have a minimum sound pressure level of 92 dB, unobstructed.	Competition Requirement	HIGH	✓		✓	
RN#57	Payload/Container shall operate for a minimum of two hours when integrated into rocket.	Competition Requirement	HIGH	✓	✓		

Payload Processor & Memory Selection

Payload Processor	Boot Time (ms)	Processor Speed (MHz)	RAM (kB)	Flash Memory (kB)	Operating Voltage (V)	Data Interface (Number)		Data Bus Width (Bit)	Price ($)
Teensy 3.6	0.3	180	256	1024	3.3	Digital Pins (62) PWM Pins (22) UART Pins (6)	Serial Pins (6) SPI Pins (3) I2C Pins (4)	32	29.25

Properties of Teensy 3.6

- Low operating voltage.
- Suitable processor speed.
- Suitable flash memory.
- Includes RTC.
- Includes SD card slot.

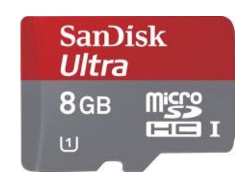


Memory Model	Memory (GB)	Interface	Speed (Mb/s)		Price ($)
			Write	Read	
SanDisk Ultra	8	SPI	75	80	4.56

Properties of SanDisk Ultra

- Suitable storage capacity.
- Fast and cheap.

- **The tests we have carried out, showed that the memory card has sufficient capacity.**



Payload Real-Time Clock

Payload RTC Model	Type	Size (mm)			Weight (g)	Operating Voltage (V)	Interface	Price ($)
		Length	Width	Heigth				
Teensy 3.6 RTC	Hardware	Included in the microcontroller				3	I2C	Free

Properties of Teensy 3.6 RTC

- It is free because included in the microcontroller.
- Small in size and weight.
- **The RTC will not reset if the power to the microcontroller is lost.**
- We use **hardware RTC,** therefore we can get the time value with more precision and minimal error.

HARDWARE

The RTC has a built-in power detection circuit that detects power failures and automatically switches to a back up source. **The RTC is 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.

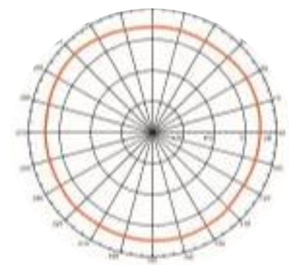
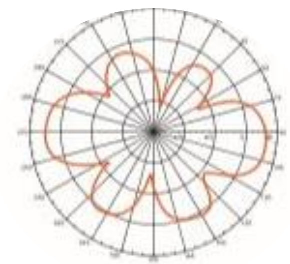
RESET TOLERANCE

The packet count, *referance altitude*, *reference coordinate, calibration state* and *counter data* **will be saved in the internal EEPROM of the Teensy 3.6 during the power failure**. In this way data loss will be prevented.

Payload Antenna Selection

Payload Antenna	Size (mm)		Range (km)	Frequency (GHz)	Gain (dBi)	Connector Type	Radiation Pattern	Price ($)
	Length	Diameter						
TP-Link TL-ANT2405CL	190	13	~1	2.4	5	RP-SMA	Omni-directional	5

Properties of TP-Link TL-ANT2405CL
• High gain. • Easily available. • Better price/performance ratio.

Horizontal	Vertical
	

Performance and Mass Discuss
• TP-Link TL-ANT2405CL antenna was used in the tests and the tests were successfully completed. • 19 grams of antenna mass isn't a problem for the CanSat system. • Range, frequency and gain values are as adequate for system performance.

Payload Radio Configuration

Radio Model	Sensitivity (dBm)	Range (km)	Transmit Current (mA)	Supply Voltage (V)	Transmit Power (mW)	Operating Frequency (GHz)
XBee Pro S2C	-101	3.2	120	2.7 – 3.6	63	2.4

Overview of Radio Configuration

- **XBee Radio Model:** XBee Pro S2C.
- XBee configuration will be accomplished with XCTU Software.
- XBees are operating in one network with the same PANID/NETID number. PANID/NETID will be set through to the team number **(*#7840*)**.
- The XBee communicates in **unicast** mode**.**

CanSat XBee Module	Ground Station XBee Module
• CanSat XBee is the **coordinator** in this network.	• Ground station XBee is an **enddevice**.

Transmission Control

- The communication will then established between the ground station and the payload when the CanSat is opened. Then the data will be sent **in bursts** with a frequency of **1 Hz**.
- Transmission control will be managed by the ground station while the payload stop off in the launch pad. Then transmission control will be managed by FSW during flight.
- **The buzzer will be activated via FSW and data transmission will be stopped at 5 meters altitude from the ground.**

We are continuing the communication tests that we have started at PDR stage. The tests will be presented in detail in section CanSat Integration and Test.

Payload Telemetry Format (1 of 3)

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 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 11 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.

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.
AIR SPEED		is the air speed relative to the payload in meters/second.
SOFTWARE STATE		is the operating state of the software (boot, idle, launch detect, deploy, etc.).
PARTICLE COUNT		is a decimal value representing the measured particle count in mg/m^3.
BONUS DATA	PITCH	is the tilt angle in the pitch axis in degrees.
	ROLL	is the tilt angle of the roll axis in degrees.
	YAW	İs the tilt angle of the yaw axis in degrees.

Data Format

<TEAM ID>,<MISSION TIME>,<PACKET COUNT>,<ALTITUDE>,<PRESSURE>, <TEMP>,<VOLTAGE>,<GPS TIME>,<GPS LATITUDE>,<GPS LONGITUDE>,<GPS ALTITUDE>,<GPS SATS>,<AIR SPEED>,<SOFTWARE STATE>,<PARTICLE COUNT>,<PITCH>,<ROLL>,<YAW>

Example Data Format

7840,00:20:30,60,550.6,1079.4,40,4.67,12:10:01,27.03406,45.64770,602.5,10,23.02, LAUNCH,0.31,75,82,70

- **The values shown in red are for the bonus data.**
- **Data will be transmitted at a rate of 1 Hz in bursts.**
- **The telemetry data file shall be named as follows: Flight_7840.csv**

The presented telemetry format match the competition guide requirements.

Payload Telemetry Format (3 of 3)

INCOMING DATA TO GROUND STATION

REAL-TIME PLOTTING	JUST SHOWN	OTHER
ALTITUDE	TEAM ID	GPS LATITUDE (SHOWN ON MAP)
TEMPERATURE	MISSION TIME	GPS ALTITUDE (SHOWN ON MAP)
PRESSURE	PACKET COUNT	GPS LONGITUDE (SHOWN ON MAP)
VOLTAGE	SOFTWARE STATE	PITCH (SHOWN ON 3D)
AIR SPEED	GPS TIME	ROLL (SHOWN ON 3D)
PARTICLE COUNT	GPS SATS	YAW (SHOWN ON 3D)

Container Processor & Memory Selection

Discussion of Change Detail
• The container will not have any electronics components. • The test we carried out on the breadboard showed that the payload circuit can also perform the separation task priorly performed by the container circuit.

Electrical Power Subsystem Design

Hüseyin SERTKAYA

PAYLOAD COMPONENTS

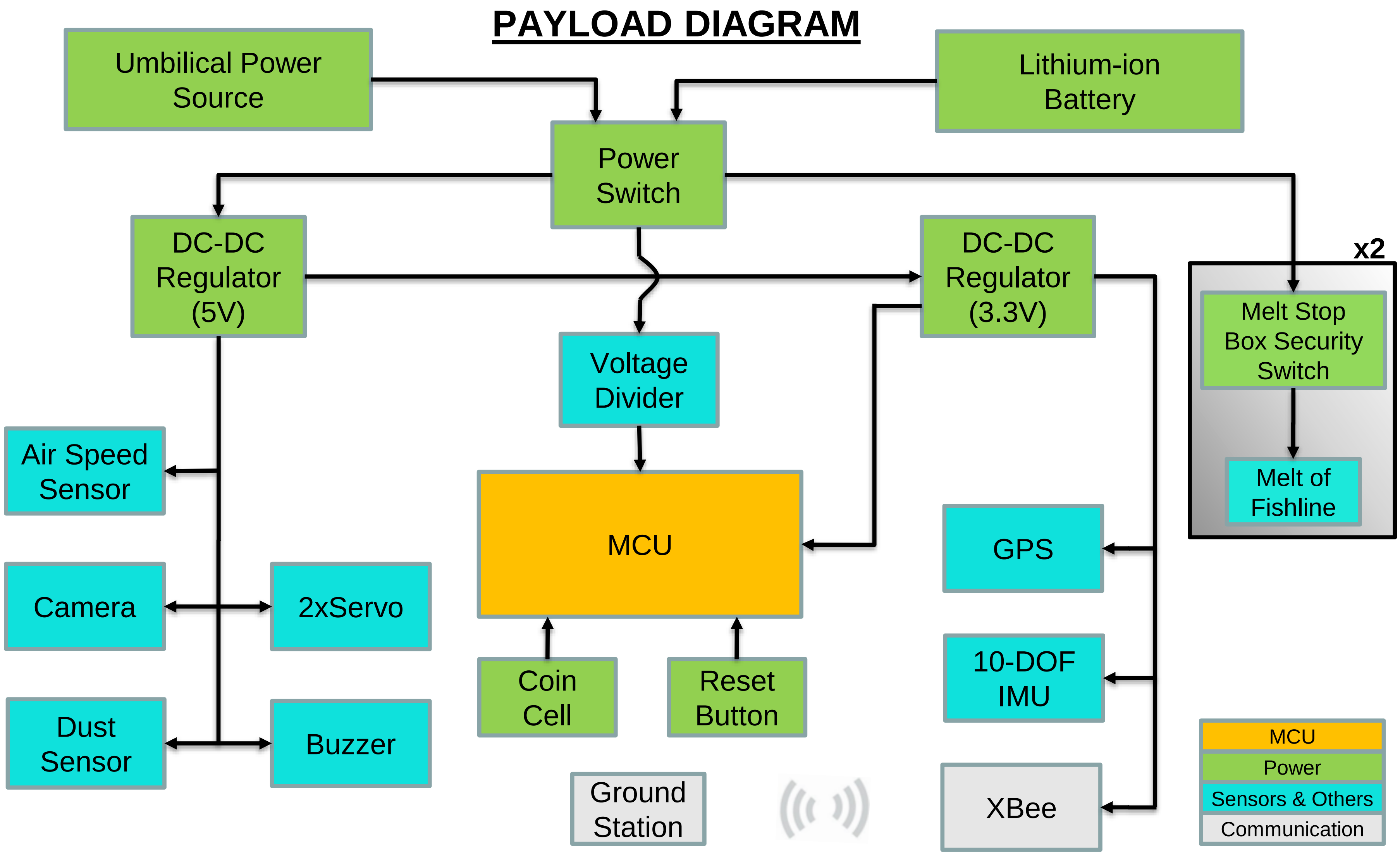
MCU
- All sensors in the payload will be connected to the MCU and powered by lithium-ion batteries.

Power
- The umbilical power supply is used for an external supply.
- A 3 V battery will also be used for the an internal RTC.
- We will be used the reset button to reset the payload.
- The voltage regulators will be used to arrange the required voltages.
- A power switch (external on/off switch) will be used to control the system power of the payload.

Sensors & Others
- 92 dB buzzer will be used for payload recovery.
- The camera will be powered by 5 V for the bonus mission.
- We will be used an air speed sensor powered by 5 V line.
- The battery voltage will be measured by the voltage divider method.
- We will be used GPS powered by 3.3 V line to find the location of the payload.
- We will be used 10-DOF IMU sensor and servo motors for active control and 3D simulation.
- Air temperature and air pressure data will be taken from the BMP280 sensor powered by 3.3 V line.
- We will be used a particulate/dust sensor powered by a 5 V line to measure dust particles.
- The payload's parachute opening system and the payload release mechanism from the container will be used melt of fishline method.

Communication
- We will be used XBee Pro S2C powered by 3.3 V line for telemetry transmission.

EPS Overview (2 of 2)



EPS Changes Since PDR

PDR	CDR	RATIONALE
• We will be used the electronic circuit for the container.	• The container will not have any electronic components.	• The test we carried out on the breadboard showed that the payload circuit can also perform the separation task priorly performed by the container circuit.
• Separation of the payload from the container will be ensured by the melt stop box in the container.	• The separation of the payload from the container will be provided by the additional melt stop box added to the payload.	• The separation of the payload from the container and the opening of the payload's parachute will be performed by the use of two different melt stop box in the payload. Since no electronic components will be used in the container.

- **We discussed the details of the changes in subsequent slides.**

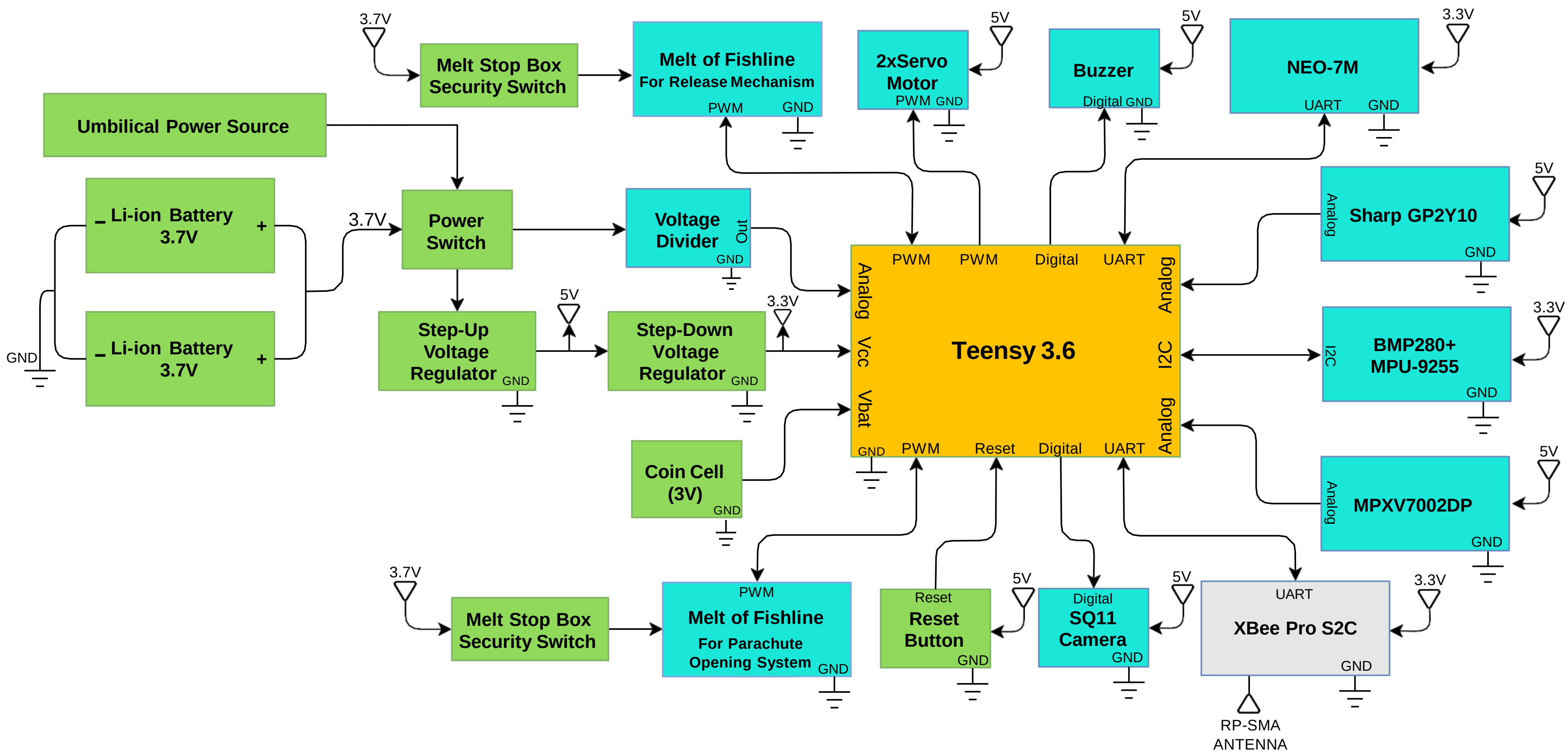
EPS Requirements (1 of 2)

Requirement Number	Requirement	Rationale	Priority	VM			
				A	I	T	D
RN#22	The science payload shall measure altitude using an air pressure sensor.	Competition Requirement	HIGH	✓		✓	✓
RN#23	The science payload shall provide position using GPS.	Competition Requirement	HIGH	✓		✓	✓
RN#24	The science payload shall measure its battery voltage.	Competition Requirement	HIGH	✓		✓	✓
RN#25	The science payload shall measure outside temperature.	Competition Requirement	HIGH	✓		✓	✓
RN#26	The science payload shall measure particulates in the air as it glides.	Competition Requirement	HIGH	✓		✓	✓
RN#27	The science payload shall measure air speed.	Competition Requirement	HIGH	✓		✓	✓
RN#28	The science payload shall transmit all sensor data in the telemetry.	Competition Requirement	HIGH	✓	✓	✓	✓
RN#29	Telemetry shall be updated once per second.	Competition Requirement	HIGH		✓	✓	
RN#49	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	✓	✓	✓	

EPS Requirements (2 of 2)

Requirement Number	Requirement	Rationale	Priority	VM			
				A	I	T	D
RN#50	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#51	An audio beacon is required for the probe. It may be powered after landing or operate continuously.	Competition Requirement	HIGH	√		√	
RN#52	The audio beacon must have a minimum sound pressure level of 92 dB, unobstructed.	Competition Requirement	HIGH	√		√	
RN#53	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#54	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#55	Spring contacts shall not be used for making electrical connections to batteries. Shock forces can cause momentary disconnects.	Competition Requirement	MEDIUM	√	√		
RN#57	Payload/Container shall operate for a minimum of two hours when integrated into rocket.	Competition Requirement	HIGH	√	√		
EXTRN#3	The selected battery should meet the current requirements drawn by the system.	To withstand high current	HIGH	√		√	√

Payload Electrical Block Diagram



- The electronic system will be easily accessible on/off by a switch.
- The led turn light and buzzer beeps when the system is powered on.

MCU
Power
Sensors & Others
Communication

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	Impedance 13 mΩ Typ.
Average Weight	48.5 g
Typical Volume	17.3 cm^3
Operating Temperature Range	−20°C to 60°C
Battery Chemistry	Lithium-ion
Current Capacity	3130 mAh
Generated Current	10 A

- A Sony VTC 6 battery supply 3.7 volts. **Two batteries** will be connected in parallel to get **3.7 V** and **6260 mAh**.
- Instantaneous high current is needed for the melt of the fishline method. Therefore, we chose Sony VTC 6.

Payload Power Budget (1 of 3)

Components	Voltage (V)	Current (mA)	Duty Cycles (h:min:s)	Power Consumption (Wh)	Source
Teensy 3.6	3.3	79.13	02:00:00	0.522	DS
Buzzer	5	80	02:00:00	0.8	DS
SQ11 - Camera	5	200	00:01:00	0.0167	MS
XBee Pro S2C	3.3	120	02:00:00	0.792	DS
NEO-7M GPS	3.3	35	02:00:00	0.231	DS
10-DOF IMU	3.3	4.42	02:00:00	0.03	DS
2xMelt Of Fishline	3.7	1400	00:00:01	2x0.001438	MS
2xServo Motor	5	2x500	00:01:00	2x0.0417	MS
Sharp GP2Y10	5	11	02:00:00	0.11	DS
MPXV7002DP	5	10	02:00:00	0.1	DS

Payload Power Budget (2 of 3)

Available Power (Max)	23.162 Wh
Total Power Consumption	2688 mWh
Margins	20.474 Wh

Available Power (Max) - Total Power Consumption = Margins

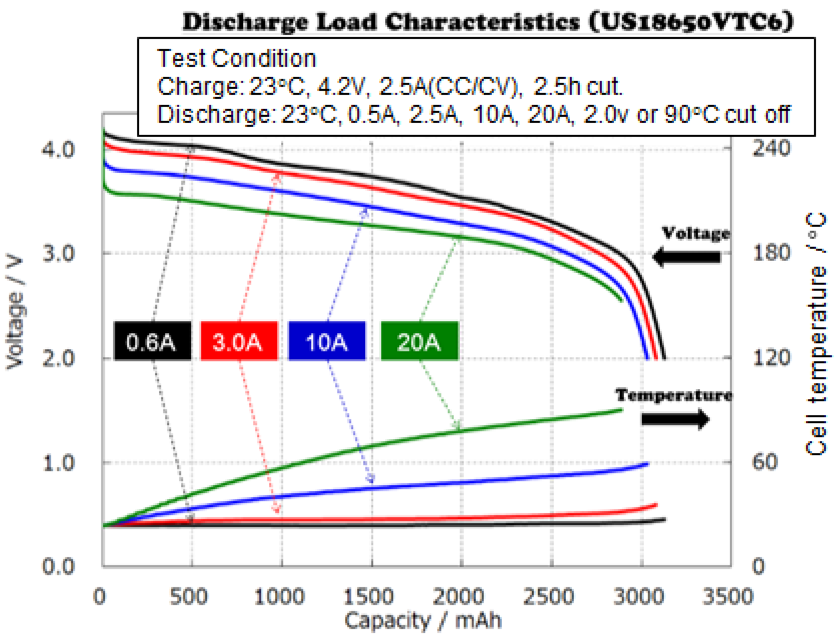
The margin is changing according to the current consumption by sensors at different working temperatures.

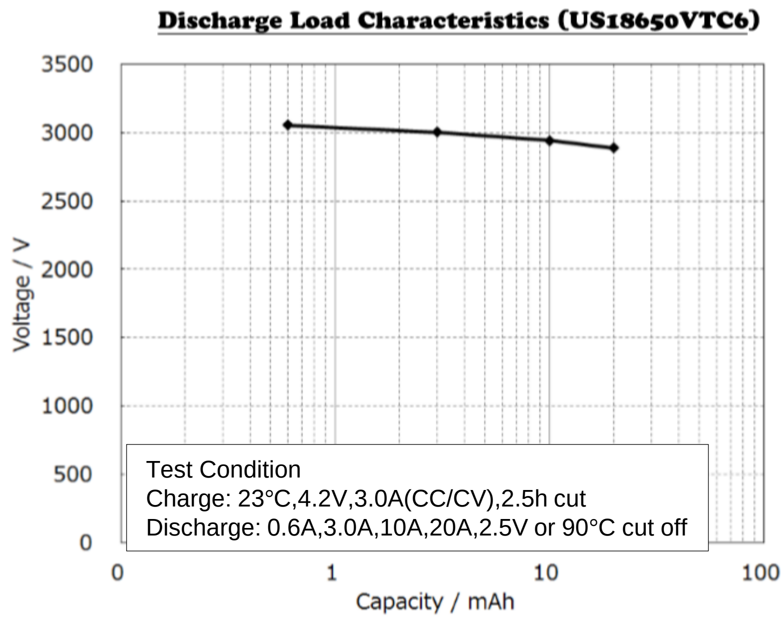
Payload Power Strategy:

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

((6260 mAh) / (1539.55 mA)) * 0.707 = 2.87 h

- **The system will be powered only with the battery.**
- **The system will be operated for more than two hours.**
- **The melt of fishline method draw current less than one second so this current is not included in the calculations.**





Source: Sony VTC 6 Datasheet

The required total power value of the payload circuit was calculated and then measured. It was concluded that the power value required to activate the separation mechanisms is sufficient for the system.

Container Power Source

The container will not have any electronic components so we will not use a power source.

Container Power Budget

The container will not have any electronic components.

Flight Software (FSW) Design

Osman SERİNKAN

Overview of The Cansat FSW Design

- The CanSat will be gathered data from sensors during the flight, data will be saved to SD card and transmitted to the ground station via XBee.
- Bonus mission include a camera and it will be recorded video during the flight.

Programming Language

- C/C++

Development Environments

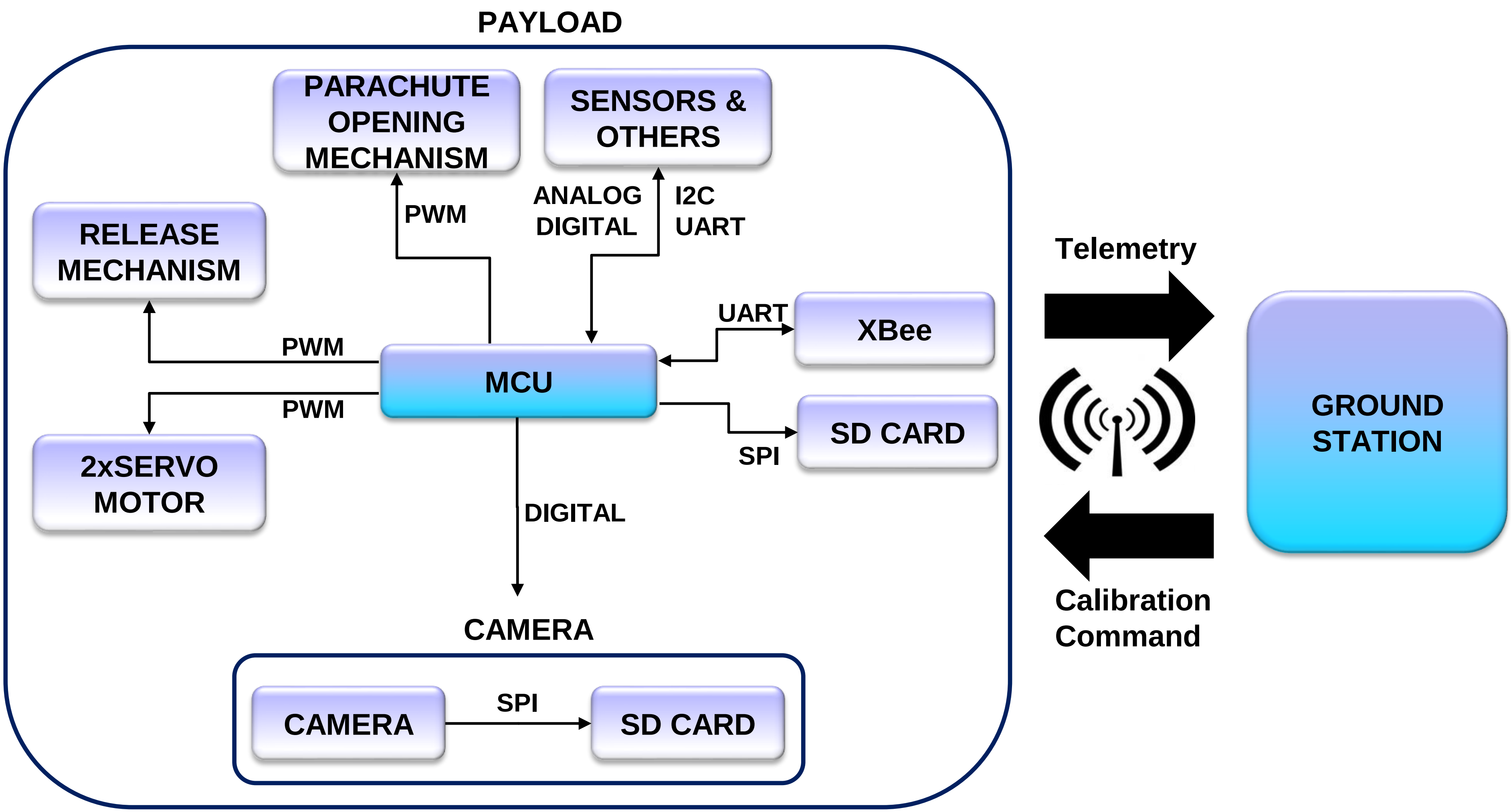
- Arduino IDE
- ClickCharts by NCH software
- Atom Text Editor

FSW Overview (2 of 3)

Brief Summary of the FSW Tasks

- The electronic system will be activated by the power (on/off) button.
- If "System calibrate" command will be received from ground station, EEPROM will be reset, the reference altitude, will be determined and system will be calibrated.
- The payload will be gathered data from the sensors and save to the SD card transmit it to the ground station via XBee at same time.
- CanSat will be launched with a rocket and will be released after completing the rocket rise and container's parachute will be opened by air resistance.
- Release mechanism and parachute opening mechanism will be activated by FSW.
- The payload will be released from container at 450 m (±10 m) via melt of fishline then camera will be started to record video according to the reference point.
- The payload glides with an active descent at above 100 m for one minute within a radius of 250 m. The payload’s parachute will be opened at above 100 m.
- The buzzer will be activated when the altitude drops below 5 m and data transmission will be stopped. The buzzer will continue to beep until the electronic system is turned off by the power (on/off) button.
- The mission will be completed.

FSW Design of Basic Flow Chart for the Payload



FSW Changes Since PDR

PDR	CDR	RATIONALE
The container algorithm was created.	The container algorithm removed.	A single microcontroller software will be prepared. This will save us time and we will have the opportunity to do more testing.
The release mechanism was controlled from the container’s algorithm.	The release mechanism controlled from the paylaod’s algorithm.	The test we carried out on the breadboard showed that the payload circuit can also perform the separation task priorly performed by the container circuit.

- **We discussed the details of the changes in subsequent slides.**

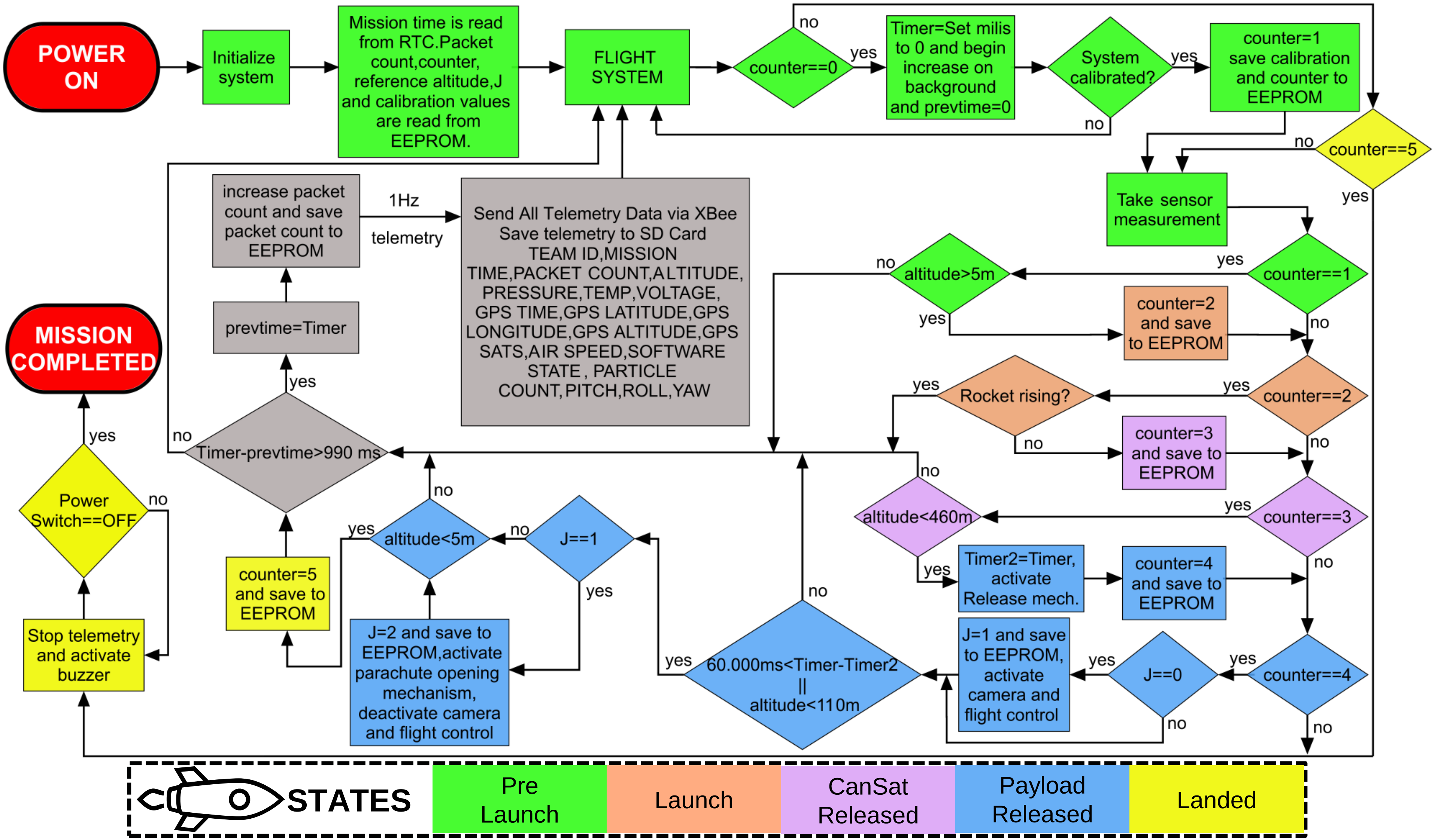
FSW Requirement (1 of 2)

Requirement Number	Requirement	Rationale	Priority	VM			
				A	I	T	D
RN#10	The container shall release the payload at 450 meters +/- 10 meters.	Competition Requirement	HIGH		✓	✓	✓
RN#11	The science payload shall glide in a circular pattern with a 250 m radius for one minute and stay above 100 meters after release from the container.	Competition Requirement	HIGH	✓	✓	✓	✓
RN#22	The science payload shall measure altitude using an air pressure sensor.	Competition Requirement	HIGH	✓		✓	✓
RN#23	The science payload shall provide position using GPS.	Competition Requirement	HIGH	✓		✓	✓
RN#24	The science payload shall measure its battery voltage.	Competition Requirement	HIGH	✓		✓	✓
RN#25	The science payload shall measure outside temperature.	Competition Requirement	HIGH	✓		✓	✓
RN#26	The science payload shall measure particulates in the air as it glides.	Competition Requirement	HIGH	✓		✓	✓
RN#27	The science payload shall measure air speed.	Competition Requirement	HIGH	✓		✓	✓
RN#28	The science payload shall transmit all sensor data in the telemetry.	Competition Requirement	HIGH	✓	✓	✓	✓
RN#29	Telemetry shall be updated once per second.	Competition Requirement	HIGH		✓	✓	

FSW Requirement (2 of 2)

Requirement Number	Requirement	Rationale	Priority	VM			
				A	I	T	D
RN#31	The ground system shall command the science vehicle to start transmitting telemetry prior to launch.	Competition Requirement	HIGH	✓	✓	✓	
RN#33	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#34	Configuration states such as if commanded to transmit telemetry shall be maintained in the event of a processor reset during launch and mission.	Competition Requirement	HIGH	✓	✓	✓	
RN#40	All telemetry shall be displayed in real time during descent.	Competition Requirement	HIGH		✓	✓	
RN#41	All telemetry shall be displayed in engineering units (meters, meters/sec, Celsius, etc.).	Competition Requirement	HIGH	✓			✓
RN#47	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#51	An audio beacon is required for the probe. It may be powered after landing or operate continuously.	Competition Requirement	HIGH	✓		✓	

Payload CanSat FSW State Diagram (1 of 2)



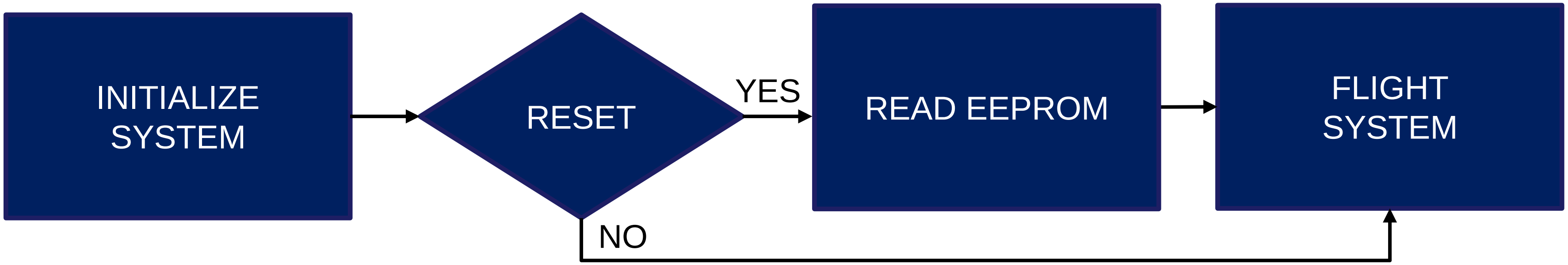
Payload CanSat FSW State Diagram (2 of 2)

Data Recovery for Payload

- Microcontroller will be reset when a temporary power failure occurs.

- **Mission time** will be saved in the internal EEPROM of the RTC module. In this way, data loss will be prevented if a momentary power failure occurs.

- **Packet count**, **referance altitude**, **reference coordinate**, **calibration state** and counter data will be saved in the internal EEPROM of the MCU. In this way data loss will be prevented if microcontroller reset occurs.



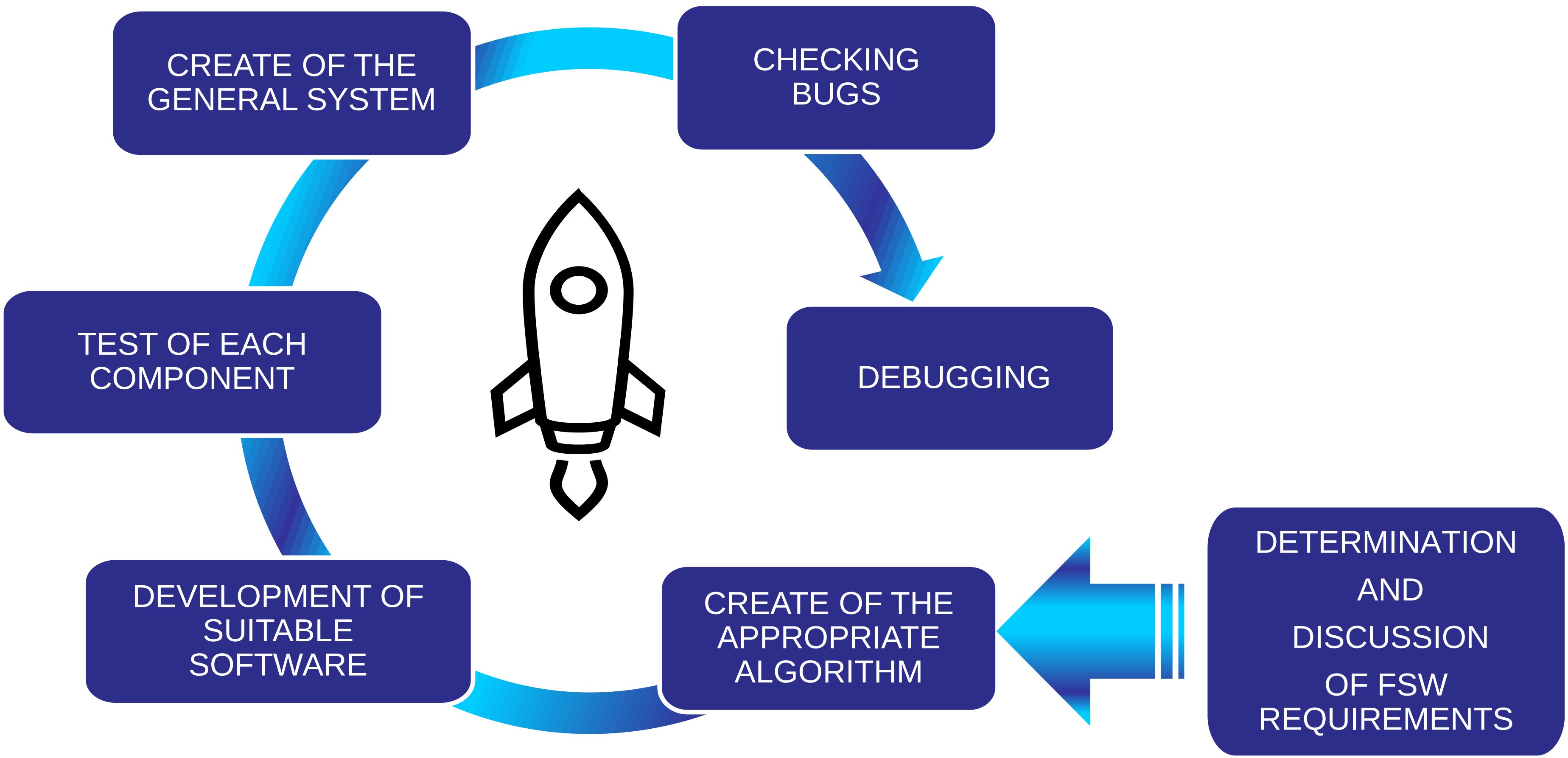
If the microcontroller will be reset, the necessary data will be received from the EEPROM.

Container CanSat FSW State Diagram

We have figured out that the container-related tasks (separation) can be handled by the microcontroller placed in the payload. Therefore, we have **not used any electronic circuits and related algorithms** for the container.

Software Development Plan (1 of 3)

Subsystem Software Development Sequence Plan



Prototype and Prototyping Environments

- The necessary software is installed on the microcontroller.
- Each component is tested separately on breadboard.
- The data stream is checked from the Arduino Serial monitor.

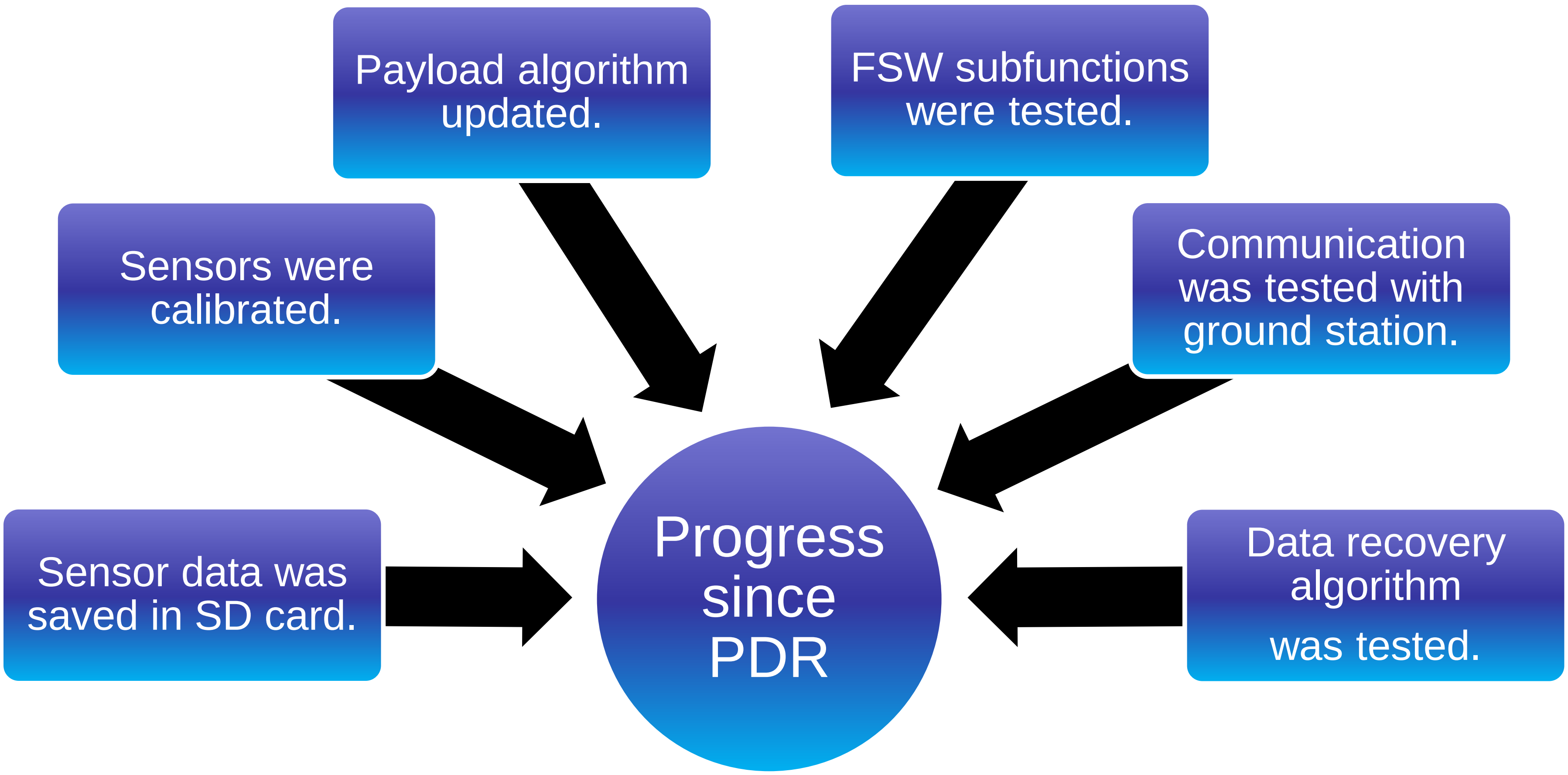
Test Methodology

- Appropriate software is installed in Arduino IDE.
- Sensors to be used in the system is tested.
- Release and parachute mechanism algorithms is tested.
- Data recovery algorithm is tested.
- Checking whether the FSW meets the CanSat competition requirements.
- FSW will be tested on the general CanSat system.

Development Team

- Osman SERİNKAN
- İpek GÜZEL

Software Development Plan (3 of 3)



Ground Control System (GCS) Design

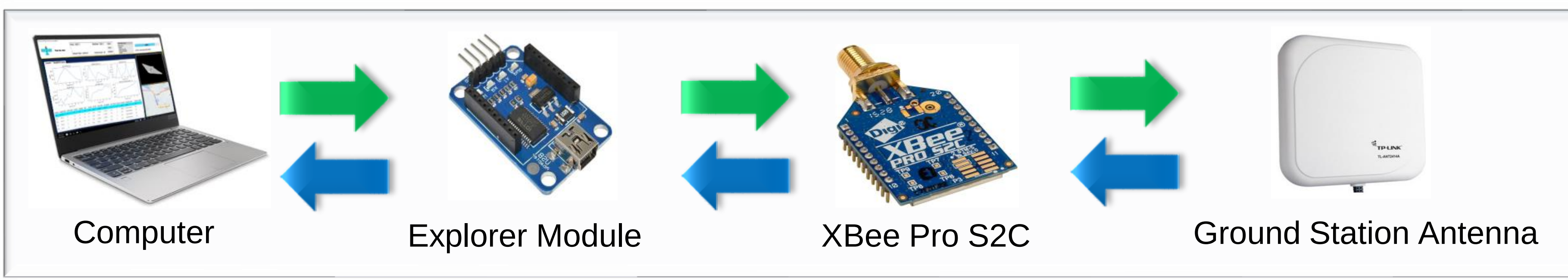
İpek GÜZEL

GCS Overview

PAYLOAD

The calibration command will be transmitted from the ground station to the payload.

Telemetry data will be transmitted from the payload to the ground station.



GROUND STATION

GCS Changes Since PDR

- **No changes have been made since PDR.**

GCS Requirements (1 of 2)

Requirement Number	Requirement	Rationale	Priority	VM			
				A	I	T	D
RN#29	Telemetry shall be updated once per second	Competition Requirement	HIGH		✓	✓	
RN#31	The ground system shall command the science vehicle to start transmitting telemetry prior to launch.	Competition Requirement	HIGH	✓	✓	✓	
RN#32	The ground station shall generate a csv file of all sensor data as specified in the telemetry section.	Competition Requirement	HIGH	✓	✓	✓	
RN#33	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#34	Configuration states such as if commanded to transmit telemetry shall be maintained in the event of a processor reset during launch and mission.	Competition Requirement	MEDIUM	✓	✓	✓	
RN#35	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#36	XBEE radios shall have their NETID/PANID set to their team number.	Competition Requirement	HIGH	✓	✓		
RN#37	XBEE radios shall not use broadcast mode.	Competition Requirement	HIGH	✓	✓		

GCS Requirements (2 of 2)

Requirement Number	Requirement	Rationale	Priority	VM			
				A	I	T	D
RN#39	Each team shall develop their own ground station.	Competition Requirement	HIGH	✓	✓	✓	
RN#40	All telemetry shall be displayed in real time during descent.	Competition Requirement	HIGH		✓	✓	
RN#41	All telemetry shall be displayed in engineering units (meters, meters/sec, Celsius, etc.)	Competition Requirement	HIGH	✓			✓
RN#42	Teams shall plot each telemetry data field in real time during flight.	Competition Requirement	HIGH	✓	✓	✓	✓
RN#44	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#45	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#47	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 Design

RP-SMA Connector

2 mm Header

Ground Station Antenna

XBee Pro S2C

Explorer Module

USB Wire

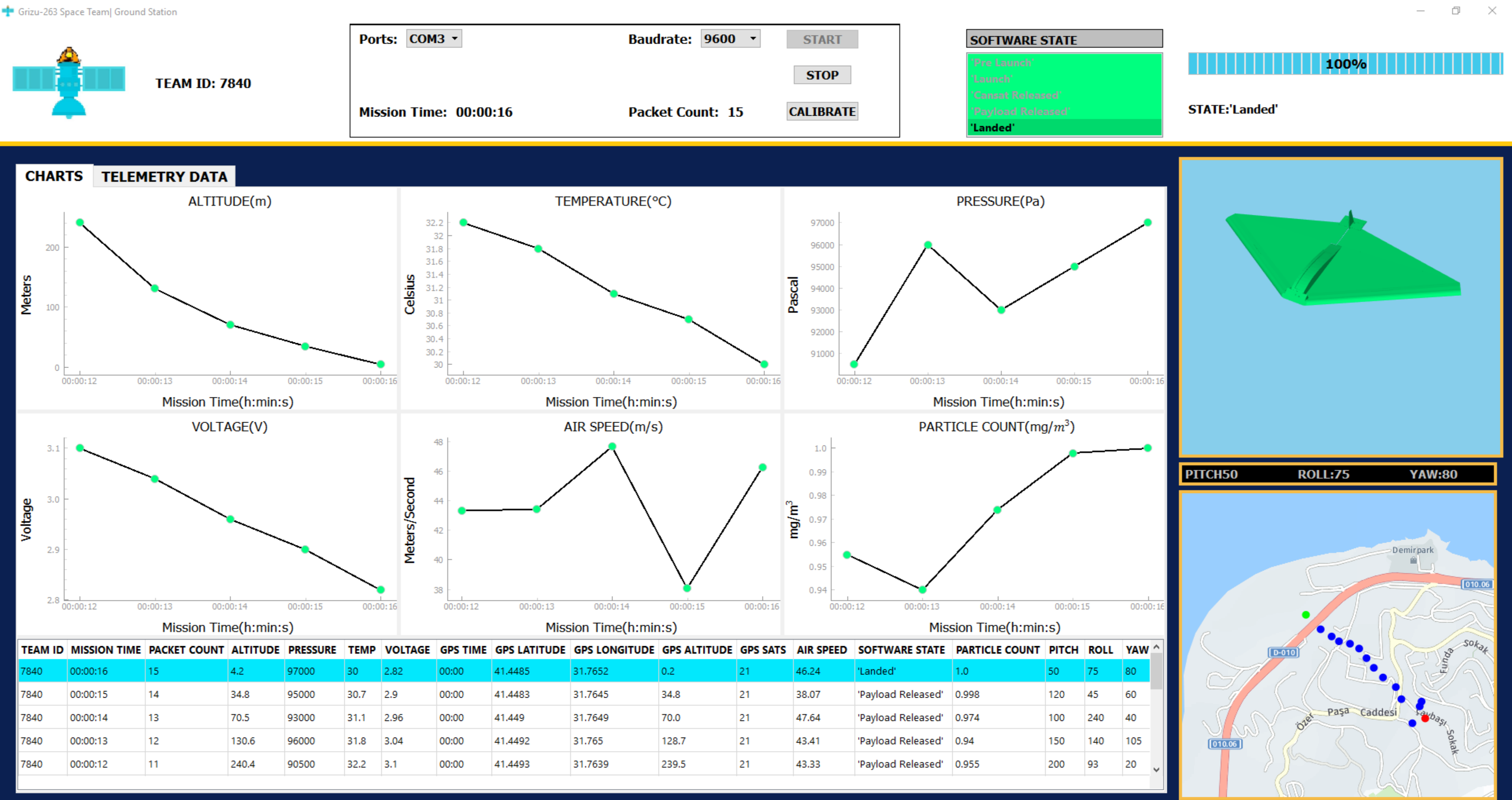
Computer

Specifications

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

- ✓ An umbrella will be used to protect the computer from sunlight.
- ✓ A fan will be used the cool the computer.
- ✓ **The power bank will be used for supplying the required energy to the fan for not consuming the computer battery.**
- ✓ The computer will be updated prior to the competition. Then the updates will be disabled. Finally, the computer will be disconnected from the internet.

Real time display of telemetry data



TEAM ID	MISSION TIME	PACKET COUNT	ALTITUDE	PRESSURE	TEMP	VOLTAGE	GPS TIME	GPS LATITUDE	GPS LONGITUDE	GPS ALTITUDE	GPS SATS	AIR SPEED	SOFTWARE STATE	PARTICLE COUNT	PITCH	ROLL	YAW
7840	00:00:16	15	4.2	97000	30	2.82	00:00	41.4485	31.7652	0.2	21	46.24	'Landed'	1.0	50	75	80
7840	00:00:15	14	34.8	95000	30.7	2.9	00:00	41.4483	31.7645	34.8	21	38.07	'Payload Released'	0.998	120	45	60
7840	00:00:14	13	70.5	93000	31.1	2.96	00:00	41.449	31.7649	70.0	21	47.64	'Payload Released'	0.974	100	240	40
7840	00:00:13	12	130.6	96000	31.8	3.04	00:00	41.4492	31.765	128.7	21	43.41	'Payload Released'	0.94	150	140	105
7840	00:00:12	11	240.4	90500	32.2	3.1	00:00	41.4493	31.7639	239.5	21	43.33	'Payload Released'	0.955	200	93	20

Real time display of telemetry data

Grizu-263 Space Team| Ground Station

TEAM ID: 7840

Ports: COM3 | Baudrate: 9600 | START | STOP | CALIBRATE

Mission Time: 00:00:16 | Packet Count: 15

SOFTWARE STATE

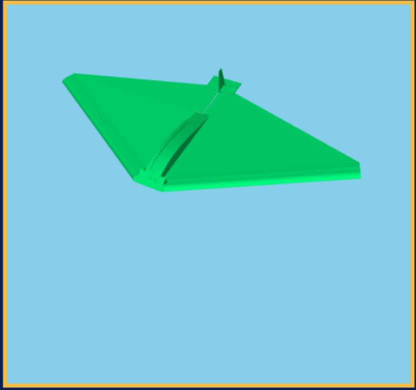
'Pre Launch'
'Launch'
'Cansat Released'
'Payload Released'
'Landed'

100%

STATE:'Landed'

CHARTS | TELEMETRY DATA

TEAM ID	MISSION TIME	PACKET COUNT	ALTITUDE	PRESSURE	TEMP	VOLTAGE	GPS TIME	GPS LATITUDE	GPS LONGITUDE	GPS ALTITUDE	GPS SATS	AIR SPEED	SOFTWARE STATE	PARTICLE COUNT	PITCH	ROLL	YAW
7840	00:00:16	15	4.2	97000	30	2.82	00:00	41.4485	31.7652	0.2	21	46.24	'Landed'	1.0	50	75	80
7840	00:00:15	14	34.8	95000	30.7	2.9	00:00	41.4483	31.7645	34.8	21	38.07	'Payload Released'	0.998	120	45	60
7840	00:00:14	13	70.5	93000	31.1	2.96	00:00	41.449	31.7649	70.0	21	47.64	'Payload Released'	0.974	100	240	40
7840	00:00:13	12	130.6	96000	31.8	3.04	00:00	41.4492	31.765	128.7	21	43.41	'Payload Released'	0.94	150	140	105
7840	00:00:12	11	240.4	90500	32.2	3.1	00:00	41.4493	31.7639	239.5	21	43.33	'Payload Released'	0.955	200	93	20
7840	00:00:11	10	325.0	89000	32.4	3.25	00:00	41.4498	31.7636	325.3	21	33.09	'Payload Released'	0.94	80	45	104
7840	00:00:10	9	487.3	88500	33.6	3.22	00:00	41.4502	31.7629	486.3	21	32.26	'Cansat Released'	0.933	55	30	55
7840	00:00:09	8	600.1	88500	33.6	3.22	00:00	41.4506	31.7624	604.2	21	32.75	'Cansat Released'	0.925	42	74	65
7840	00:00:08	7	700.5	90000	31.4	3.29	00:00	41.451	31.762	701.7	21	33.98	'Launch'	0.903	60	99	41
7840	00:00:07	6	670.7	94000	30.4	3.41	00:00	41.4516	31.7616	669.5	21	26.67	'Launch'	0.918	35	78	0
7840	00:00:06	5	510.2	96000	32.1	3.34	00:00	41.4516	31.7611	507.2	21	27.23	'Launch'	0.912	65	65	74
7840	00:00:05	4	430.4	98000	34.3	3.47	00:00	41.4517	31.7605	430.7	21	25.16	'Launch'	0.895	80	65	85
7840	00:00:04	3	280	98100	37.4	3.52	00:00	41.4519	31.7601	283	21	22.43	'Launch'	0.88	70	245	105
7840	00:00:03	2	70.9	98070	35.4	3.62	00:00	41.4522	31.7595	72.5	21	5.1	'Launch'	0.84	30	120	25
7840	00:00:02	1	0	98050	30.2	3.71	00:00	41.4528	31.7587	0.1	21	0	'Pre Launch'	0.8	0	90	0



PITCH50 ROLL:75 YAW:80

Real-time display

- Telemetry packets read from the USB port are displayed in terms of the real time in table, graph, 3D simulation and map. Telemetry shall be updated once per second.

.csv telemetry file creation for judges and Telemetry data recording

- A .csv file will be created when the start button is pressed on the ground station interface.
- Telemetry data transmitted to the ground station will be saved in csv file format by using ',' among the received telemetry data.

Commercial off the shelf (COTS) software packages used

- Anaconda [(Spyder)(Python distribution)]
- XCTU (XBee Program Software (Free))

Real-time plotting software design

- We plot the data read from the serial port in real-time with Python by using the Pyqtgraph and PyQt5 libraries. Then we show the charts in the ground station interface.

GCS Software (4 of 4)

Media presentation for judges

- Telemetry data in csv extension file format, the screenshot of the interface, the media data recorded by using the camera in the SD card will be transferred to the judge's USB memory at the end of the mission.

Command software and interface

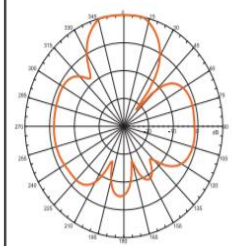
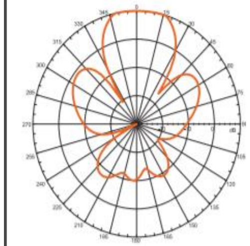
Calibration Command

- A calibration command button has been added to the GCS interface.
- The ground station will send the calibration command in prior to launch. Then the CanSat will start to transmit telemetry data.
- The calibration verification will be performed regarding the telemetry data sent from the barometric sensor and IMU. The roll/pitch angles of the payload will be verified from the ground station.

Progress since PDR

- The image part of the interface design had been created. Charts, tables, maps and 3D simulations were shown in real-time on the interface after the PDR.
- The data were tested and verified by communicating with XBee and the antenna from a distance.
- The transmission of the calibration command has been tested and verified.
- The accuracy of the data coming to the interface has been tested.
- Telemetry data acquired from the payload was recorded in the .csv file format.

GCS Antenna (1 of 2)

Model	Spread	Frequency (GHz)	Gain (dBi)	Dimensions(mm)			Range (km)	Beamwidth (Horizontal/ Vertical)	Antenna Patterns	
				Length	Width	Height			Horizontal	Vertical
TL-ANT 2414A	Directional	2.4~2.5	14	240	240	40	3.5	360°/12°		

We Selected Mounting Antenna Design: Hand-Held Antenna
The antenna must be hand-held for easy targeting and minimize data loss since the payload will glide in a circular pattern with a radius of 250 meters.

Selected Antenna: TL-ANT2414A

★ It is a directional antenna.

- Provide high gain during signal transmission for the targeted direction.
- Suitable sizes for hand-held orientation.
- Suitable beamwidth for targeting.

Simple Link Budget Calculation

P_{RX} (received power)	**− 73.9dBm**
P_{TX} (transmitter power output)	18dBm
G_{TX} (transmitter antenna gain)	5dBi
L_{TX} (transmitter losses (coax, connectors...))	0dB
L_{FS} (path loss,usually free space loss)	**110.9dB**
G_{RX} (receiver antenna gain)	14dBi
L_{M} (miscellaneous losses(fading margin,body loss etc.))	0dB
L_{RX} (receiver losses(coax,connectors…))	0dB
XBee transmit power	18dBm
XBee receiver sensitivity	−101dBm

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

d(distance)=3.5km **f(frequency)**=2400MHz

Losses other than L_{FS} are neglected because they are not calculated.

Distance value is an estimate.

L_{FS}=32.45dB + 20 x log(f) + 20 x log(d) = **110.9 dB**

P_{RX}=18 + 5 − 0 − 110.9 − 0 + 14 − 0 = − **73.9 dBm**

★ **Calculated P_{RX} is − 73.9 dBm > − 101 dBm , our margin is − 27.1 dBm approximately that provides a reliable operation within the margin.**

CanSat Integration and Test

Gizem Kübra YAMAN

CanSat Integration and Test Overview (1 of 3)

Cansat Integration and Test Overview

Subsystem Level Testing Plan

- Sensors
- CDH
- EPS
- Radio Communications
- FSW
- Mechanical
- Descent Control

Integrated Level Functional Test Plan

Release Payload From Container

- Release Trigger
- Mechanisms
- Payload Parachute Release

Communications

- Ground Station Software
- Telemetry
- Antennas

Environmental Test Plan

- Drop Test
- Thermal Test
- Vibration Test
- Fit Check

Subsystem Level Testing

- **Sensors:**Sensors were calibrated and sensor tests were performed using microcontroller.
- **CDH:** XBee communications were tested with the XCTU software as well as antenna range test.
- **EPS:** Power sufficiency calculations were made. Tests were carried out for the consumption of current and voltage values of electronic components.
- **FSW:** Data recovery algorithm, separation mechanism algorithm and accuracy of the data received from sensors were tested with FSW.
- **GCS:** The simulation of the data was tested for the ground station interface.
- **Mechanical:** Separation mechanisms were tested. Cansat mass, cansat size and active control of delta wing will be performed.
- **Descent Control:** Sufficiency and descent rate of the delta wing and parachute system were tested.

Integrated Functional Level Testing

Release Payload From Container

- **Release Trigger:** Payload release from container and payload parachute opening mechanism will be tested using the melt of fishline method.
- **Mechanisms:** Delta wing folding mechanism were tested. The durability of the hinges in the opening mechanism of the container was tested by opening and closing manually.
- **Payload Parachute Release:** Release of payload from the container will be tested via drone. The parachute of the payload will be checked for its durability.

CanSat Integration and Test Overview (3 of 3)

Integrated Functional Level Testing

Communications

- **Ground Station Interface:** It will be tested whether the data is transmitted in the correct order to the ground station with the use of ground station interface. Data processing speed will be tested . The telemetries in the interface are updated once per second.
- **Telemetry:** Telemetry data format accuracy checked, it will be tested whether the data is obtained correctly and transferred to the ground station in the correct order with the use of flight software.
- **Antennas:** Communication testing between the transmitter and receiver XBee, antenna distance and connectivity issues were tested using XCTU software.

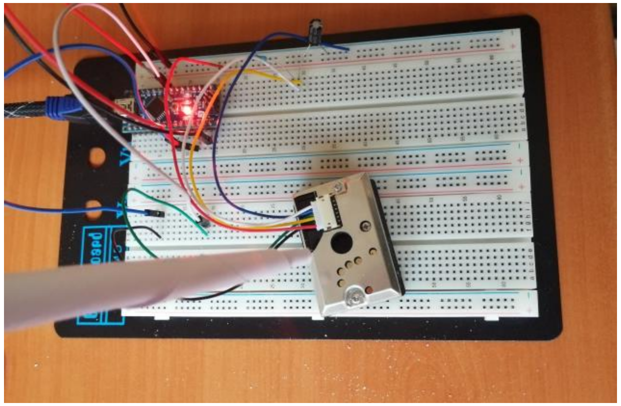
Environmental Testing

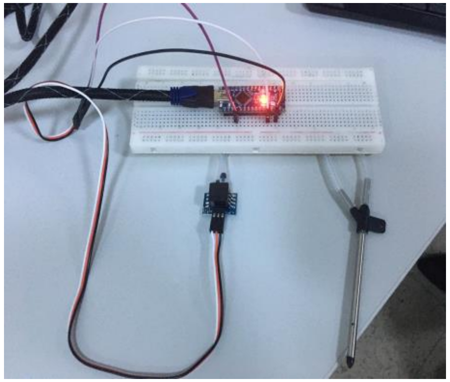
- **Drop Test:** The payload holding in the container, component and battery mounts, and 30 Gs shock durability of the system will be tested.
- **Thermal Test:** CanSat's temperature durability will be tested at 60°C for 2 hours.
- **Vibration Test:** The vibration test will be conducted to check the assembly integrity for all components.
- **Fit Check:** The CanSat dimensions for the requirements will be checked.

Educational activities in our country were decelerated due to the safety regulations to combat corona virus pandemic. We conducted our team work through the Microsoft Teams application, but we were unable to complete some of our tests. We have prepared a table in the test procedure descriptions pages for our tests that could not be done due to the unusual conditions.

SENSORS

- Each of the sensors was tested on the breadboard with the use of the required software and the microcontroller. The accuracy of the data obtained from each sensor was checked.
- Then the sensor tests were carried out in a combined manner.



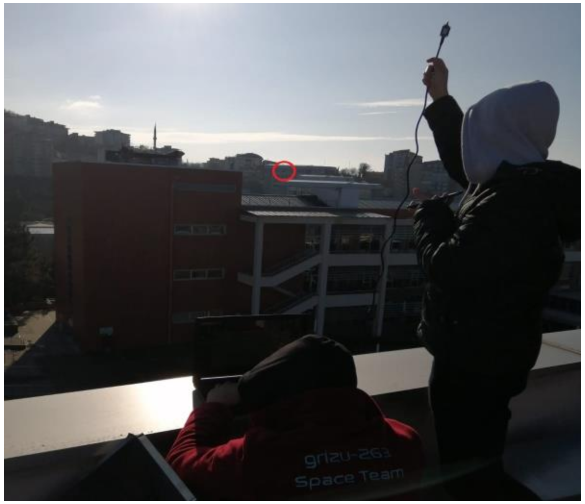


- Firstly, we connected the particulate/dust sensor to microcontroller. Then, we have tested the sensor by the use of baby powder.
- We checked the sensor that can sense the powder particles.

- We connected the air speed sensor to the microcontroller.
- We have obtained appropriate analog output when we exposed the pitot tube to air flow.

CDH

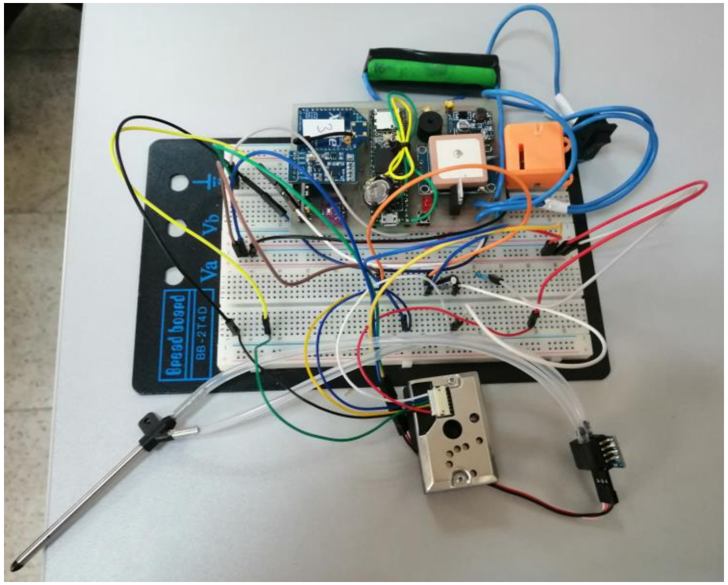
- The communication between the microcontroller and the sensors was tested.
- The communication between the receiver and transmitter XBee were tested using the XCTU Software for the competition distance requirements (600-800 meters).
- The gain test of the antenna was tested using the XCTU Software.
- The data transmission altitude requirement (750 meters) in competition will be tested via drone.
- Then, the data transmission speed and the accuracy of the data sent to the ground station will be checked.

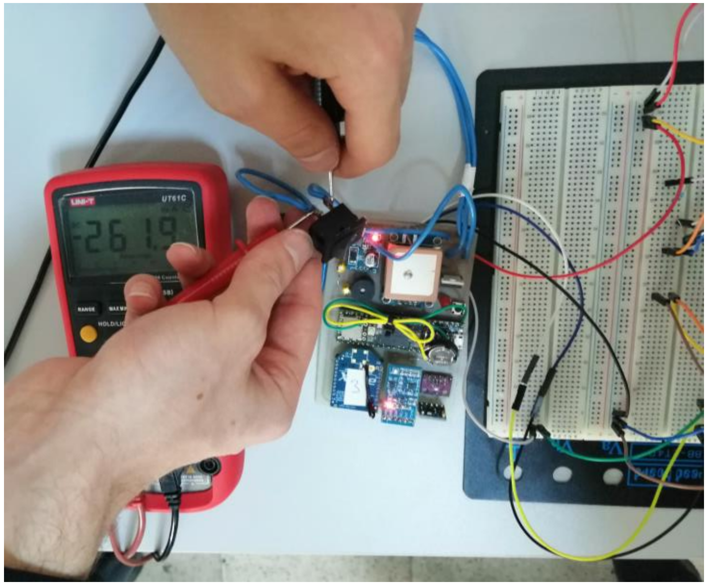


Ground Station

EPS

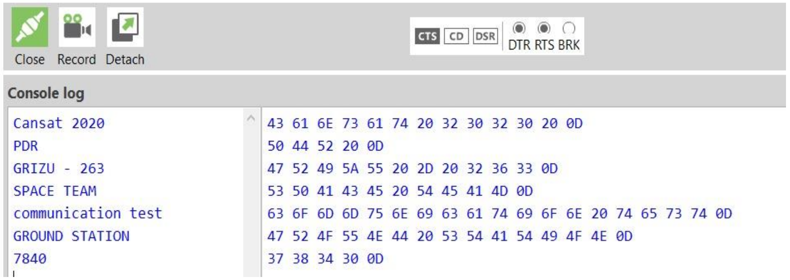
- Prototype circuit was installed on the perforated plate and breadboard. It was checked if it works with the required power supply.
- The total current of the system was measured. Calculated and measured values were compared.
- The melt of fishline circuit was installed and the break time of the melt was measured.
- The MOSFET used in circuit was triggered with 3.3V to check its operation.
- It will be checked whether there is a short circuit on the PCB.



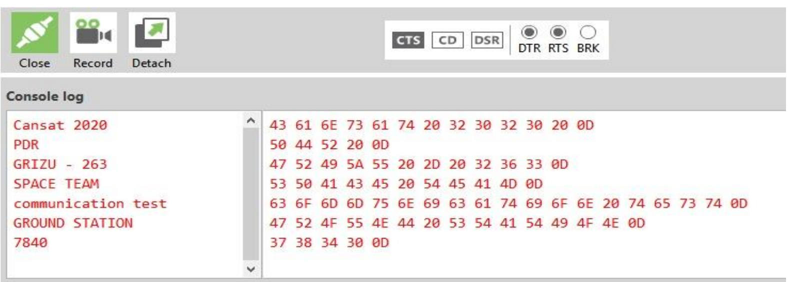


RADIO COMMUNICATION

Transmitter XBee



Receiver XBee



- The XBees setting was done over XCTU software. NETID/PANID and baud rate accuracy was checked.
- The XBee communicates in **unicast** mode**.** XBees do not broadcast, the XBees only communicate with each other.
- Data received from the sensors on the circuit will be transmitted to the ground station via XBee.
- The data will be checked from the ground station interface.
- The sufficiency of the computer battery was tested for 2 hours.
- We continue the tests as we have started at the PDR stage.

FSW


```
7840,10:47:47,325,1.53,96586.17,21.27,0.21,10:47:47,37.77,29.10,400.10,5,-9.53,3,0.00,-15104.00,-29952.00,-3073.00
7840,10:47:48,326,1.73,96583.89,21.26,0.15,10:47:48,37.77,29.10,400.40,5,-5.14,3,0.00,-11776.00,-29696.00,-2817.00
7840,10:47:49,327,1.66,96584.66,21.27,0.13,10:47:49,37.77,29.10,400.70,5,-17.19,3,0.00,-9728.00,-31744.00,-4353.00
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7840,10:48:0,338,1.94,96581.36,21.26,0.21,10:48:0,37.77,29.10,401.10,5,-6.66,3,0.00,-12032.00,-30976.00,-3073.00
```


The example data format

- The accuracy of the data get from the each sensors were checked (particulate/dust, air speed, GPS location, temperature, pressure, etc.).
- Sub-systems were tested (release mechanisms, parachute opening, communication, etc.).
- Data recovery algorithms were tested in case of microcontroller reset.
- The sequence of the data transmission to the ground station will be checked for consistency in the appropriate order.

Subsystem Level Testing Plan (5 of 6)

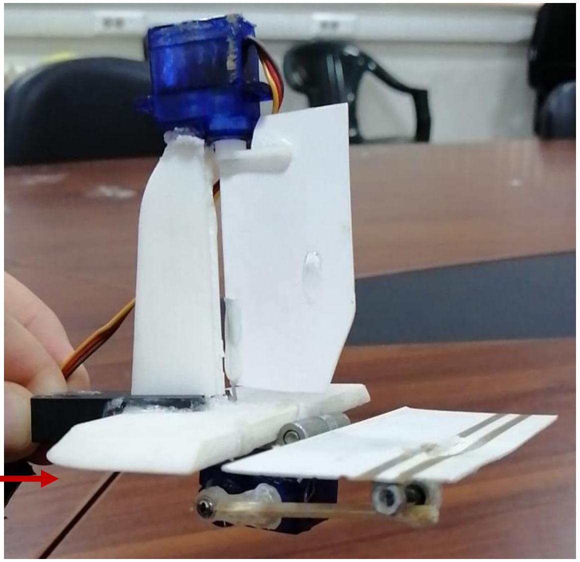
MECHANICAL




Folding mechanism of delta wings

- Delta wing folding mechanism was tested (hinge, rotating joint, stretched fabric elastic and telescopic system).
- The sufficiency of the delta wings for descenting was tested at different altitudes.
- The CanSat's mechanical tests will be checked (separation, drop and fit check etc.).
- The payload release mechanism will be tested with FSW.
- The CanSat's subsystems durability before and after the test flights will be checked.
- The CanSat will be checked for the given environmental test requirements.
- Thanks to the folding mechanism designers in our team. It fits well into the container.
- The camera stabilization will be achieved by actively controlling payload with rudder and elevator using servo motors.

DESCENT CONTROL



Rudder and elevator

- The installed electronic circuit will be placed in the payload and it will be tested at 450 meters via the drone.
- The payload's delta wings will be tested for gliding in a circular pattern with a radius of 250 meters from 450 meters to above 100 meters **(actively controlled for one minute)**. Its aerodynamic suitability will also be checked during the test.
- Active control of the payload will be provided with rudder and elevator using the servo motors.
- The opening of the payload's parachute will be tested at an altitude above 100 meters.

Integrated Level Functional Test Plan (1 of 4)

Release Payload From Container

Descent Testing

- Descent performance of delta wings was tested without electronic circuit. The payload kept its stability during the descent.
- The payload’s delta wings will be tested for gliding in a circular pattern with a radius of 250 meters from 450 meters to above 100 meters **(actively controlled for one minute)**. Its aerodynamic suitability will also be checked during the test.
- Container and payload parachutes were tested to provide the desired descent speeds. *(Shown on Deployment testing slide.)*

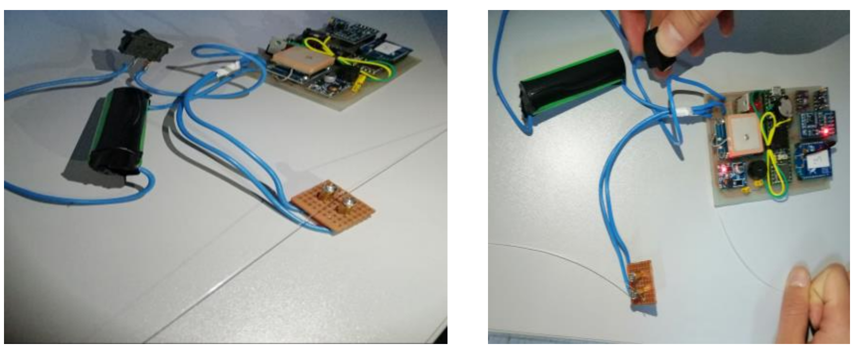
Sufficiency Test for Delta Wings

Integrated Level Functional Test Plan (2 of 4)

Release Payload From Container

Mechanisms

- The release trigger was tested on the breadboard using the melt of fishline method.
- Then, the release trigger will be tested with FSW at 450 meters via the drone.
- The altitude will be tested using the air pressure sensor and separation will be provided at the required altitude using the melt of fishline method.
- The folding mechanism of delta wing was tested.
- Opening and closing of all hinges and rotating joints in the system were tested.
- The durability of mechanical parts was tested in the drop tests.
- The camera stabilization will be achieved by actively controlling the payload with rudder and elevator by the use of servo motors.
- The whole system will be tested again via drone after the functional test plan is completed.



Melt of Fishline Method

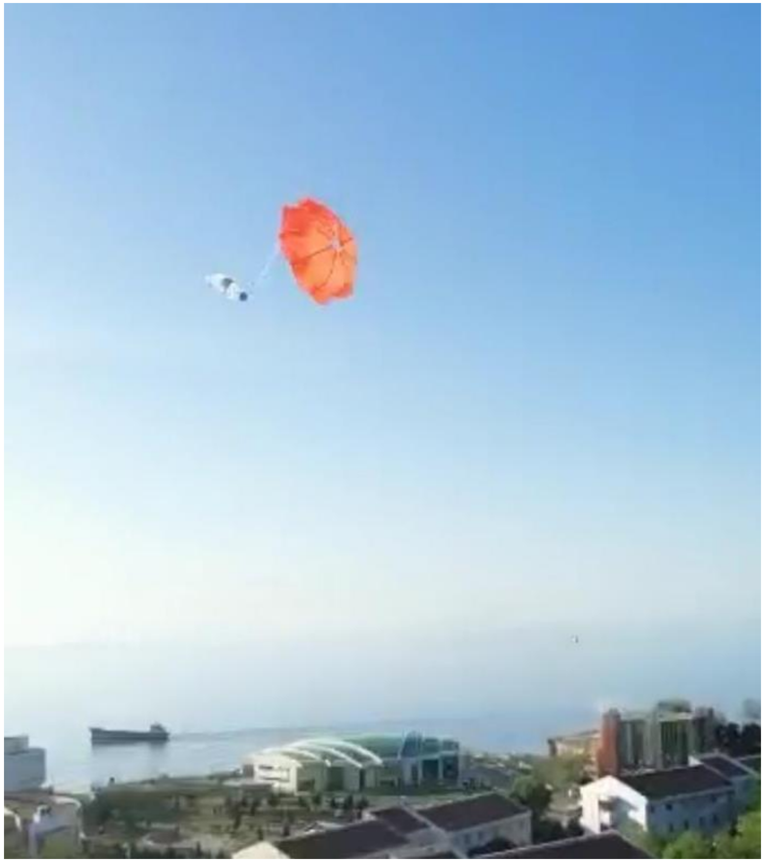
Folding Mechanism

Release Payload From Container

Deployment Testing

- Whether the CanSat parachute can carry the CanSat was tested.
- The CanSat parachute was tested to provide the required descent speed.
- The release mechanism will be tested at an altitude of 450 meters via the drone using the melt of fishline method as stated in the mechanisms.
- The payload release of the container at the required altitude and its ability to complete the task will be tested after finishing the whole system.
- The payload released from the container will be observed to perform a smooth flying during testing.
- The payload parachute will be observed to make a smooth landing after opening at an altitude of 100 meters.

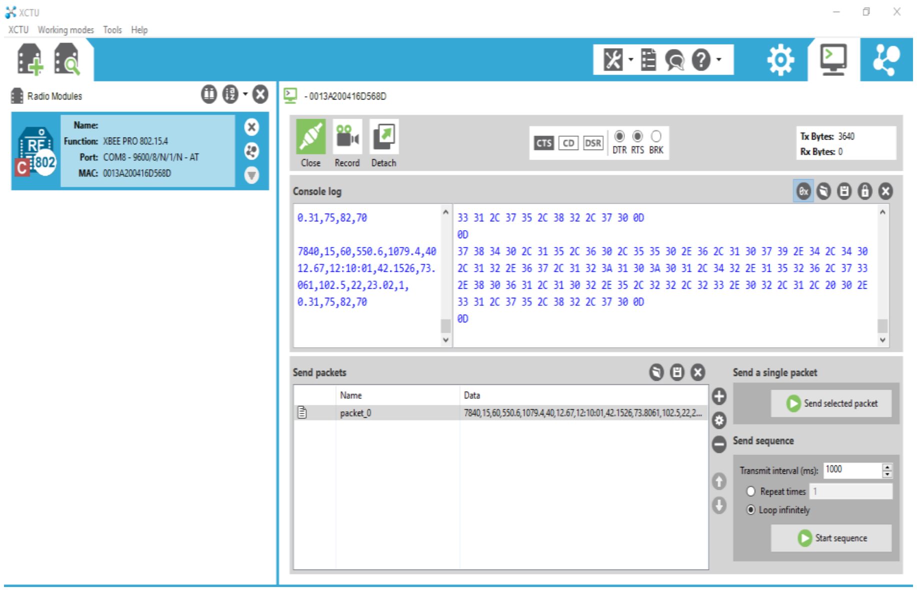
A pet bottle weighted at CanSat (600g) was used during the parachute endurance test.

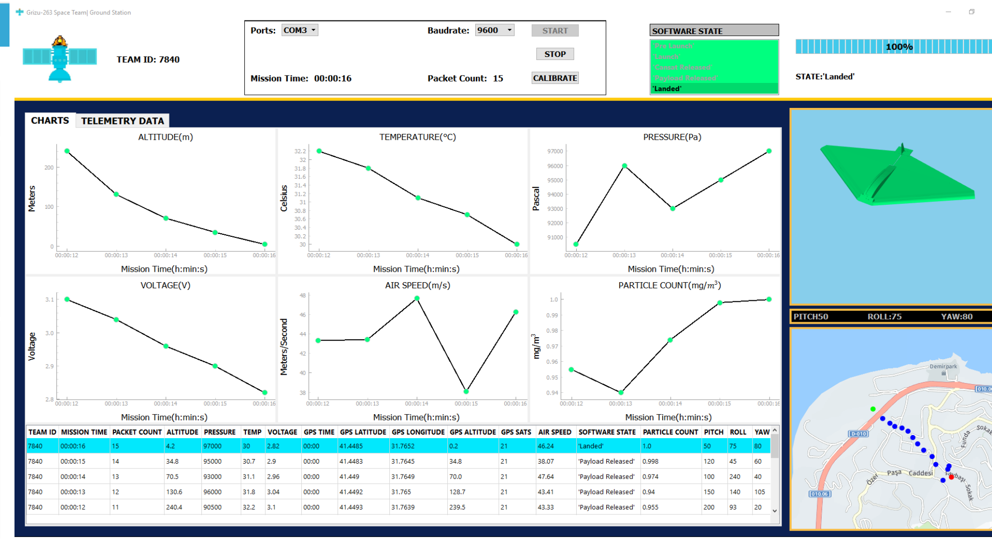


Sufficiency Test for the CanSat Parachute

Integrated Level Functional Test Plan (4 of 4)

COMMUNICATIONS





- The completed system will be taken to a required altitude via the drone and communication tests will be performed.
- The ground station interface was tested by real-time plotting by using the telemetry data acquired from the payload. Telemetry data are updated once per second.
- The integrity of the acquired data was tested. Data accuracy and data format were tested.
- The data saved in the SD card that is located in the payload will be compared to the data acquired by the ground station.
- The antennas were tested at different distances (600-1200 meters) to make sure the data transfer was correct.

Environmental Test Plan (1 of 2)

DROP TEST

- The CanSat will be released from a height of 2 meters after being tied up with 61 cm rope.
- The release mechanism will be tested to verify the durability of the container and the payload in it.
- It will be checked whether CanSat is still operational.
- CanSat will be checked for any mechanical damage.
- It will be confirmed that CanSat is still receiving telemetry.

Drop test image from last year

THERMAL TEST

- CanSat will be powered on and then placed in the thermal chamber.
- The temperature of the thermal chamber will be adjusted to 60°C.
- The thermal test duration will be 2 hours.
- The operational conditions of entire mechanisms and the communications at the end of the test will be checked.

Environmental Test Plan (2 of 2)

VIBRATION TEST

- The vibration test will be realized to verify the mounting integrity of all components, mounting connections, structural integrity and battery connections.
- The CanSat will be placed on the orbit sander and the vibration test will be conducted with a vibration ratio of 20-29 Gs for 5 minutes by exposing it to 0-233 Hz vibration.
- Any mechanical and electrical damage will be checked after the test.

Vibration test image from last year

FIT CHECK

- In order to control CanSat's dimensions, a 125 mm diameter hole is cut from a steel plate.
- The accuracy of the diameter of the generated circle will be controlled by a micrometer caliper.
- The accuracy of CanSat's diameter will be tested with the formed hole.

Steel plate and formed hole

Fit check image from last year

Test Procedures Descriptions (1 of 8)

SENSORS

Test Procedures	Test Description	Requirements	Pass/Fail Criteria	Pass/ Fail
Air Pressure Sensor Test	Altitude accuracy test according to the pressure	22	If the resulting value is equal to the actual altitude and pressure,	✓
Air Temperature Sensor Test	Accuracy test of temperature data	25	If the data confirms the actual air temperature and is stable,	✓
GPS Sensor Test	Accuracy test of location readings	23	If GPS data matches our actual location,	✓
Air Speed Sensor Test	Accuracy test of air speed sensor by exposure to different air speeds	27	If the sensor value and the value of the device that puts the air in a constant flow (blow dryer, etc.) match,	✓
Dust/Particulate Sensor Test	Accuracy test of measurement using particles of different sizes and concentrations	26	If it is observed that there is an accurate ratio between the data using water vapor and the various dust particles,	✓
Voltage Divider Test	Accuracy test of the battery's voltage	24	If the known value is equal to the measured value,	✓
Camera Test	Test of the camera's compliance with competition guide requirements	EXTRN#4	If the camera produces a 640x480 pixel image,	✓

Test Procedures Descriptions (2 of 8)

	Test Procedures	Test Description	Requirements	Pass/Fail Criteria	Pass/Fail
EPS	**Testing of Current Sufficiency**	Test and comparison of calculated and measured current values for electronic circuit	EXTRN#3	If the calculated and measured current values match,	✓
CDH	**Testing of XBee Communication**	Test whether communication is in unicast mode using XCTU at various distances	29,35,36,37	If the data communication is achieved at a distance of about 500 meters,	✓
CDH	**Testing of XBee's and Antenna's Range**	Test connections of XBee and antenna from different ranges	35,44	If the data receive to GCS from 450 m,	✓
FSW	**Testing of Release Mechanisms and Parachute Opening Mechanisms**	Test of separation in control of melt of fishline method through software using MCU	10,13,21	If the method melts the fishline when the power is applied,	✓
FSW	**Testing of Subfunction**	Accuracy test of payload data at GCS interface	22,23,24,25,26,27 ,28,29,28,33	If the communication is established between the payload and the interface,	✓

Test Procedures Descriptions (3 of 8)

	Test Procedures	Test Description	Requirements	Pass/Fail Criteria	Pass/Fail
FSW	**Testing of Data Transmission at 1 Hz**	Test of data transmission rate at GCS interface	29,33	If the data from the interface is transmitted in the correct order and at the correct speed,	✓
FSW	**Testing of Data Recovery Algorithm**	Test of whether data saved to EEPROM is preserved when the system is reset	33,47	If the packet count, referance altitude, calibration state, GPS coordinate and counter data are preserved,	✓
GCS	**Testing of the GCS Interface**	Testing of transmitting data to the GCS interface by creating data example and the adequacy of the computer battery for 2 hours	28,31,32,39,40,42, 44	If the telemetry data is shown in real time and the computer battery is sufficient during the mission,	✓
GCS	**Testing the Accuracy of XBee's Communication**	Accuracy test of communication between XBees (from about 600-800 m)	35,36,37	If the data received and transmitted in XCTU software is matched,	✓
GCS	**Testing of Compliance of Data with Competition Guide Requirements**	Accuracy testing according to the match of our own data format with the format presented in the competition guide requirements and recording in .csv format	22,23,24,25,26,27, 28,32,39,44	If the data received is in accordance with the requirements of the competition guide,	✓

Test Procedures Descriptions (4 of 8)

MECHANICAL

Test Procedures	Test Description	Requirements	Pass/Fail Criteria	Pass/ Fail
Release Mechanisms Level Testing	Test of the melt of fishline method was tested both software and electrically for separation	10	If the method melt the line when the power is applied,	✓
Testing of Payload Parachute Opening Mechanism and Speed	Test of the opening mechanism and descending speed of the parachute of the payload with the spring system we manufactured	13	If the compressed spring system opens our parachute and descends with the desired speed,	✓
Opened and Folded Test of Telescopic System	Test of the springs system of the telescopic system	2	If the telescopic system opens easily and folds easily,	✓
Testing of Payload Folding Mechanism	Test of the folding of the payload into the container using hinge, rotating joint and stretched fabric elastics	2	If the payload fits easily into container,	✓
Testing of Delta Wing	Stability test of delta wing	12	If the lifting force due to the surface area of the wing provides stable flight,	✓
Testing of Solidworks Simulation Stress	Test of the damage our system's frame can take at the desired rate of decline	19	If our system's frame is not damaged on descending,	✓
Testing of Circular Pattern	Testing of rotation of payload in 250 m radius with elevator, rudder and servo motors	11, EXTRN#2	If our system draws a circular pattern within the specified diameter for 1 minute,	✓

Test Procedures Descriptions (5 of 8)

MECHANICAL

Test Procedures	Test Description	Requirements	Pass/Fail Criteria	Pass/ Fail
Descent Test	Payload and CanSat testing to perform the desired task at the desired speed	9,11,13	If the time calculated for CanSat's descent from a specified height that matches the time we tested,	✓
Testing of Aerodynamic Suitability	Aerodynamic suitability testing using Solidworks Flow Simulation	-	If it is observed that the level of wind friction is less due to the airfoil structure of the payload,	✓

Test Procedures Descriptions (6 of 8)

Non-performing Tests

Education in our country has been interrupted due to COVID-19 pandemia. Therefore, we conducted our team work through Microsoft Teams. Unfortunately we were unable to perform some of our tests. In this section, we created a table for our tests that could not be done due to the pandemia.

The non-performing tests section includes tests that we plan to do when the entire system is complete and CanSat is running.

	Test Procedures	Test Description	Requirements	Pass/Fail Criteria	Pass/Fail
Environmental	**Drop Test**	Test of the durability of all CanSat's attachment points	16,17,18,19,55,56	If the CanSat is still running after falling from 2 meters distance,	✗
Environmental	**Vibration Test**	Test of the integrity of all components and battery connections	16,17,18,19,55, 56	If the CanSat is one piece, durable and still operational,	✗
Environmental	**Thermal Test**	Test of whether the payload and container can operate in a warm environment	18,56, 57	If the CanSat is still running after maximum temperature,	✗
Environmental	**Fit Check**	Test of the accuracy of whether the CanSat had the desired dimensions	2,56	If the CanSat has the desired dimensions values,	✗

Non-performing Tests

	Test Procedures	Test Description	Requirements	Pass/Fail Criteria	Pass/Fail
SENSORS	**MPU 9255 + Servo Motors**	Active control test by providing axis stabilization with MPU-9255 sensor	EXTRN#1, EXTRN#2	If the system is actively descending,	✗
SENSORS	**Camera Test**	Test of whether the camera's trigger is compatible with our system	EXTRN#4	If the video recording of the desired point is done with the camera,	✗
EPS	**Testing of Short Circuit**	Short circuit test performed to check incorrect connections on PCB after installation of all circuits	-	If there is no problem with the circuit connection,	✗
EPS	**Testing of Battery Power Sufficiency**	Sufficiency test of the power of the parallel connected batteries for 2 hours	53,57	If the batteries respond to CanSat's power requirement for 2 hours,	✗
GCS	**Testing of GCS Interface**	Test of accuracy and integrity of data received during payload flight	28,31,32,39,40,42, 44	If the data is shown correctly and without data loss in the GCS interface,	✗

Test Procedures Descriptions (8 of 8)

Non-performing Tests

Integrated Level Functional

Test Procedures	Test Description	Requirements	Pass/Fail Criteria	Pass/ Fail
Release Mechanisms Level Testing	Test of payload release mechanism by melt of fishline method	10,21	If the payload is correctly released at an altitude of 450 meters,	
Testing of Payload Parachute Speed and Opening	Test of payload parachute for opening at the desired altitude and descending at a certain speed	13	If the parachute opens above 100 meters according to sensors and descends at a speed of 10 m/s,	
Testing of Cansat Parachute Opening and Speed	Test of CanSat's parachute for descending at a certain speed and opening passively	8,9	If the parachute opens and descents at a speed of 20 m/s,	
Testing of CanSat Mass	Test of compliance with competition guideline requirements by measuring CanSat's mass	1	If the weight of CanSat is 600 grams,	
Testing of Actively Control	Test of the width of the elevator and rudder and the adequacy of the servo motor's rotation angles for active rotation at 100 meters radius	11, EXTRN#1, EXTRN#2	If our system glides in a circular pattern at a radius of 100 meters,	

Mission Operations & Analysis

Uğurcan SORUÇ

Overview of Mission Sequence of Events (1 of 5)

ARRIVAL

- Arrive to the launch location
- Set up ground system (GSC)
- Check the CanSat (Whole Team)

PRE-LAUNCH

- Software calibration command transmission to the payload from the ground station (GSC).
- Check the size and weight of the CanSat (MCO).
- Check communication (GSC)
- Check delta wing, rudder and elevator (CC)
- Check parachutes (CC)
- Check separation mechanisms (CC - GSC)
- Perform drop test (MCO - GSC - CC)
- Check safety requirements (MCO)

Ground System Setup (GSC)

- Test batteries for 2 hours
- Check power bank

Antenna Constructions (GSC)

- A single part antenna will be used. Check the antenna for consistency.
- The antenna will be directly connected to the XBee. Check communication.
- The XBee is connected to the ground station computer via serial port. Check data flow.

Assembly (CC)

- The delta wing will be stowed with the help of a folding mechanism.
- The payload will be stowed into the container.
- Then parachute will be folded and placed on the top of the container.

Overview of Mission Sequence of Events (2 of 5)

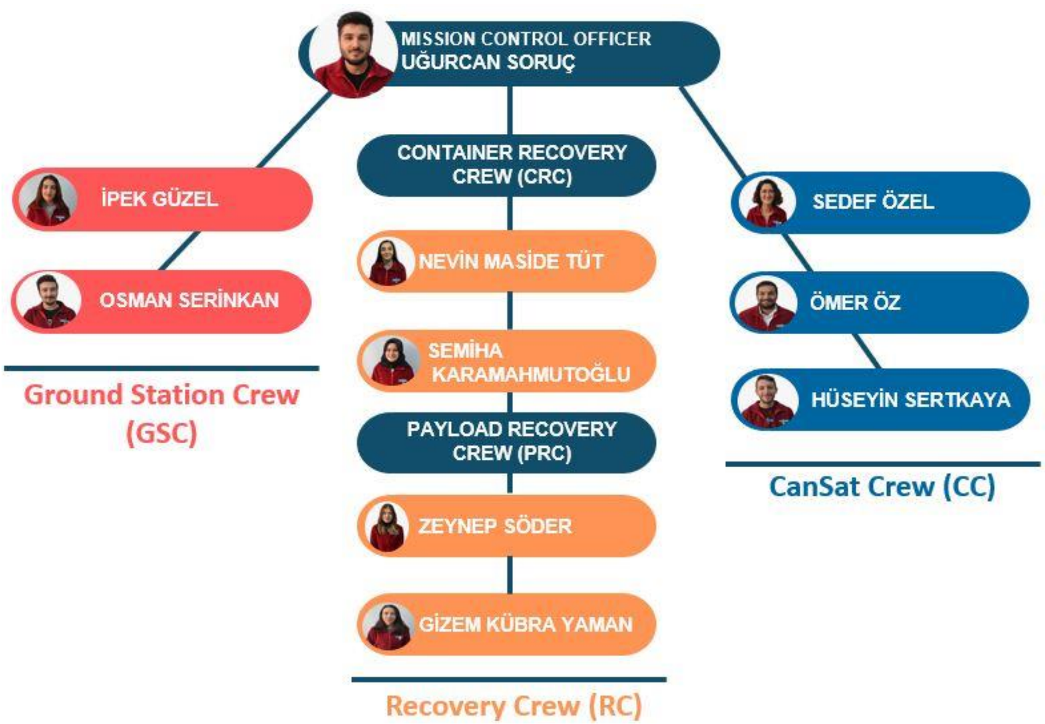
LAUNCH

- Placing the CanSat into the rocket
- Start of data transmission by electronic system
- Liftoff rocket
- Release of CanSat from rocket (between 670-725 meters)
- Opening of CanSat's parachute
- Descent of CanSat up to 450 meters with a speed of 20 m/s (±5 m/s)
- Separation of payload from container at 450 meters (±10 meters)
- Active control of payload with delta wing
- Glide of payload in a circular pattern with 250 meters radius for one minute
- Glide of payload above 100 meters
- Opening the parachute of the payload above last 100 meters
- Descent of payload with a speed of 10 m/s (±5 m/s)
- Activating the buzzer 5 meters before the end of the flight
- Stopping telemetry transmission when the buzzer is activated

FLIGHT RECOVERY

- The container will descent by parachute. Find the container using the fluorescent color of its parachute and the audio beacon (CRC).
- Find payload using GPS telemetry, audio beacon and with the fluorescent color of its parachute (PRC).
- Retrieve and back up telemetry data from payload‘s SD card (GSC).

DATA ANALYSIS
• Check camera data (GSC - MCO)
• Analyze telemetry data (GSC - MCO)
• Check real-time graphics (GSC – MCO)
POST FLIGHT REVIEW
• Prepare PFR file (Whole Team)



Overview of Mission Sequence of Events (4 of 5)

Set up Ground Station System and Antenna Construction (GSC)	Preparation and installation of equipment required for the ground station. A laptop battery will work for at least 2 hours (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 RP-SMA connector to XBee and XBee is connected to computer with USB.
	We will update Windows for latest version before establish ground station.
	The laptop will not have internet connection.

Overview of Mission Sequence of Events (5 of 5)

CanSat Assemble	Electronic circuits will be assembled (CC).
	Check mechanical systems (folding mechanism of delta wing) (CC).
	The 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 Tests	CanSat weight test (600 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)

Field Safety Rules Compliance

MISSION OPERATIONS MANUEL

- **Configure the Ground Station**
  - Communication test
  - Check antenna
- **Preparing the CanSat**
  - Assemble CanSat
  - Release mechanism control
  - Mass and size control
  - Drop test
  - Delta wing, rudder and elevator control
- **Integrating the CanSat Into the Rocket**
  - Fit check
  - Check stowed CanSat's parachute
- **The Launch Preparation Procedures**
  - Launch procedure
  - Removal procedure

MOM

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

DEVELOPMENT PLAN

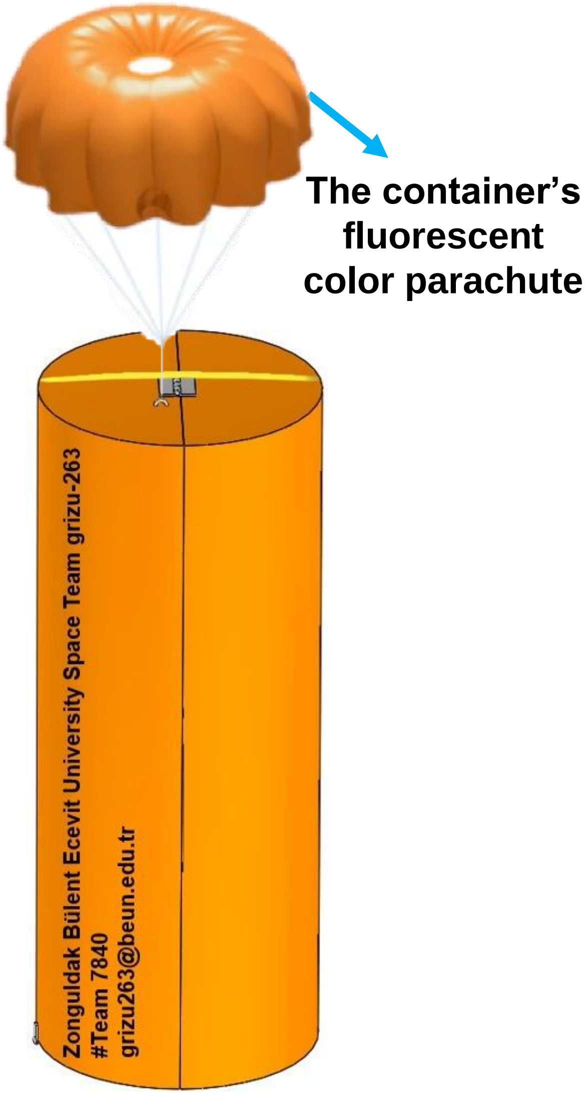
- The production of the final prototype has not been completed yet due to the corona virus-related unusual conditions.
- If the pandemic hadn't happened, May 15 would be the final date for completing the prototype. A test flight would be conducted on May 25.

CanSat Location and Recovery (1 of 2)

How can find the container?
• The container recovery crew will be found the container via it’s parachute fluorescent color.

Which color is the container and the parachute?
• The container color is fluorescent orange.
• The container’s parachute color is fluorescent orange.

The container return address
• The necessary contact information will be written on the container.
Zonguldak Bülent Ecevit University Space Team grizu-263 **#Team 7840** **grizu263@beun.edu.tr**



CanSat Location and Recovery (2 of 2)

How can find the payload?

- The payload recovery crew will be found the payload via buzzer, GPS telemetry and the payload's fluorescent pink color parachute.

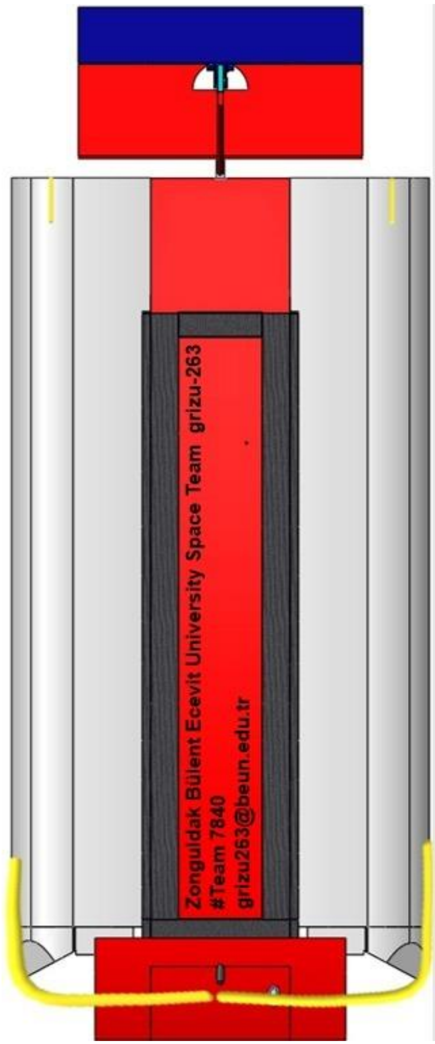
Which color is the payload and the parachute?

- The payload color is red and the delta wings colors are grey.
- The payload's parachute color is fluorescent pink.

The payload return address

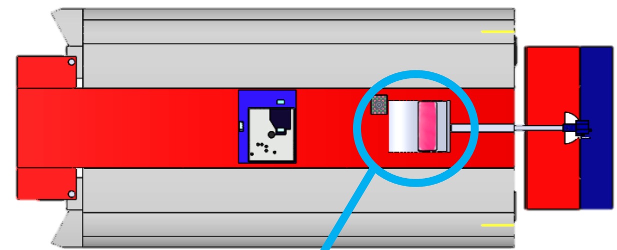
- The necessary contact information will be written on the payload.

Zonguldak Bülent Ecevit University
Space Team grizu-263
#Team 7840
grizu263@beun.edu.tr



Top view of the payload

Bottom view of the payload



The payload's fluorescent color parachute

View of the payload in the last 100 meters

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)	• The delta wings control • Separation mechanism control • Fit check • Check if CanSat is ready to receive data.
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:** We will use a buzzer on the payload and start to beep at 5 meters altitude. When the buzzer started, the data transfer will stop. We will use the Global Positioning System (GPS) to find the payload. **Container:** We will use fluorescent colors on the CanSat and the parachute to find the container easily.

Requirements Compliance

Uğurcan SORUÇ

Requirements Compliance Overview

- The design was prepared according to the CanSat 2020 mission.
- There is not any requirement that does not comply with our design.
- Environmental tests (drop, thermal, vibration, fit check) are planned in accordance with the requirements.

Mechanical Team

- Theoretically, the total mass was calculated to be 600 grams (± 10 g) according to requirements.
- The payload and container descent speeds were calculated according to requirements.
- The glide of the payload was calculated to be within a radius of about 250 meters for a minute at above 100 meters.
- Different types of delta wings were tested (simple delta, diamond delta etc.).

Electrical and Software Team

- The selected sensors and the required data was collected.
- Camera tests required for bonus mission were performed.
- Interface design was done by GCS.
- The antenna and XBee radio selection were completed.
- The communication test between the XBee's was performed.
- The algorithm for flight software that meets the requirements was completed by FSW team.

Requirements Compliance (1 of 7)

RN#	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 600 grams +/- 10 grams.	**Comply**	94,160,183	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**	26,27,37,38,163	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**	37,163	OK
4	The container shall be a fluorescent color; pink, red or orange.	**Comply**	26,66,75,179,181	OK
5	The container shall be solid and fully enclose the science payload. Small holes to allow access to turn on the science payload is allowed. The end of the container where the payload deploys may be open.	**Comply**	33,37,38,85,86,91	OK
6	The rocket airframe shall not be used to restrain any deployable parts of the CanSat.	**Comply**	37,38,163	OK
7	The rocket airframe shall not be used as part of the CanSat operations.	**Comply**	37	OK

Requirements Compliance (2 of 7)

RN#	Requirement	Comply / No Comply / Partial	X-Ref Slide(s) Demonstrating Compliance	Team Comments or Notes
8	The container parachute shall not be enclosed in the container structure. It shall be external and attached to the container so that it opens immediately when deployed from the rocket.	**Comply**	61,65,66,89	OK
9	The descent rate of the CanSat (container and science payload) shall be 20 meters/second +/- 5m/s.	**Comply**	14,35,36,54,55,65, 174	OK
10	The container shall release the payload at 450 meters +/- 10 meters.	**Comply**	14,32,35,36,54,61, 65,87,159,160,174	OK
11	The science payload shall glide in a circular pattern with a 250 m radius for one minute and stay above 100 meters after release from the container.	**Comply**	14,35,36,55,125, 146,157,174,183,	OK
12	The science payload shall be a delta wing glider.	**Comply**	28,29,31,32,54,58, 62,69,75,156,157, 159	OK
13	After one minute of gliding, the science payload shall release a parachute to drop the science payload to the ground at 10 meters/second, +/- 5 m/s.	**Comply**	14,35,36,54,61,72	OK
14	All descent control device attachment components shall survive 30 Gs of shock.	**Partial Comply**	**163**	Tested with prototypes. Need actual design test.
15	All electronic components shall be enclosed and shielded from the environment with the exception of sensors.	**Comply**	33,37,81,90	OK

Requirements Compliance (3 of 7)

RN#	Requirement	Comply / No Comply / Partial	X-Ref Slide(s) Demonstrating Compliance	Team Comments or Notes
16	All structures shall be built to survive 15 Gs of launch acceleration.	**Partial Comply**	**163**	Tested with prototypes. Need actual design test.
17	All structures shall be built to survive 30 Gs of shock.	**Partial Comply**	**163**	Tested with prototypes. Need actual design test.
18	All electronics shall be hard mounted using proper mounts such as standoffs, screws, or high performance adhesives.	**Comply**	90	OK
19	All mechanisms shall be capable of maintaining their configuration or states under all forces.	**Comply**	90,163	OK
20	Mechanisms shall not use pyrotechnics or chemicals.	**Comply**	75,92,93	OK
21	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**	83,88	OK
22	The science payload shall measure altitude using an air pressure sensor.	**Comply**	44	OK
23	The science payload shall provide position using GPS.	**Comply**	46	OK

Requirements Compliance (4 of 7)

RN#	Requirement	Comply / No Comply / Partial	X-Ref Slide(s) Demonstrating Compliance	Team Comments or Notes
24	The science payload shall measure its battery voltage.	**Comply**	47	OK
25	The science payload shall measure outside temperature.	**Comply**	45	OK
26	The science payload shall measure particulates in the air as it glides.	**Comply**	49	OK
27	The science payload shall measure air speed.	**Comply**	48	OK
28	The science payload shall transmit all sensor data in the telemetry.	**Comply**	36,105,106,126	OK
29	Telemetry shall be updated once per second.	**Comply**	144,151,161	OK
30	The Parachutes shall be fluorescent Pink or Orange.	**Comply**	54,57,62,179,180	OK
31	The ground system shall command the science vehicle to start transmitting telemetry prior to launch.	**Comply**	35,125,145	OK
32	The ground station shall generate a csv file of all sensor data as specified in the telemetry section.	**Comply**	106,145,146	OK
33	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**	125,130,131	OK

Requirements Compliance (5 of 7)

RN#	Requirement	Comply / No Comply / Partial	X-Ref Slide(s) Demonstrating Compliance	Team Comments or Notes
34	Configuration states such as if commanded to transmit telemetry shall be maintained in the event of a processor reset during launch and mission.	**Comply**	102,130,131	OK
35	XBEE radios shall be used for telemetry. 2.4 GHz Series radios are allowed. 900 MHz XBEE Pro radios are also allowed.	**Comply**	104	OK
36	XBEE radios shall have their NETID/PANID set to their team number.	**Comply**	104	OK
37	XBEE radios shall not use broadcast mode.	**Comply**	104	OK
38	Cost of the CanSat shall be under $1000. Ground support and analysis tools are not included in the cost.	**Comply**	195	OK
39	Each team shall develop their own ground station.	**Comply**	137,142,143,146, 173	OK
40	All telemetry shall be displayed in real time during descent.	**Comply**	125,142,143	OK
41	All telemetry shall be displayed in engineering units (meters, meters/sec, Celsius, etc.).	**Comply**	142	OK
42	Teams shall plot each telemetry data field in real time during flight.	**Comply**	142,143	OK

Requirements Compliance (6 of 7)

RN#	Requirement	Comply / No Comply / Partial	X-Ref Slide(s) Demonstrating Compliance	Team Comments or Notes
44	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**	137,141,146	OK
45	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**	35,141,146,173	OK
46	Both the container and probe shall be labeled with team contact information including email address.	**Comply**	179,180	OK
47	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**	131,133	OK
48	No lasers allowed.	**Comply**	37,81	OK
49	The probe must include an easily accessible power switch that can be accessed without disassembling the cansat and in the stowed configuration.	**Comply**	30,31,32,33	OK
50	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**	30,31	OK

Requirements Compliance (7 of 7)

RN#	Requirement	Comply / No Comply / Partial	X-Ref Slide(s) Demonstrating Compliance	Team Comments or Notes
51	An audio beacon is required for the probe. It may be powered after landing or operate continuously.	**Comply**	130,179,180	OK
52	The audio beacon must have a minimum sound pressure level of 92 dB, unobstructed.	**Comply**	96,110	OK
53	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**	110,116	OK
54	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**	90	OK
55	Spring contacts shall not be used for making electrical connections to batteries. Shock forces can cause momentary disconnects.	**Comply**	111,115,119	OK
56	The CANSAT must operate during the environmental tests laid out in Section 3.5.	**Comply**	162,163	OK
57	Payload/Container shall operate for a minimum of two hours when integrated into rocket.	**Comply**	117,118,119	OK

Management

Nevin Maside TÜT

Status of Procurements

Paylaod Electronic Components	Quantity	Order Date - Delivery Date	Status
Microcontroller (Teensy 3.6)	1	12.09.2019 - 12.22.2019	Purchased
10-DOF IMU (MPU-9255+BMP280)	1	12.09.2019 - 12.22.2019	Purchased
Optical Dust Sensor (SHARP GP2Y10)	1	12.09.2019 - 12.22.2019	Purchased
Air Speed Sensor Kit (APM 2.6 MPXV7002DP)	1	12.09.2019 - 12.22.2019	Purchased
Camera (SQ11)	1	12.09.2019 - 12.22.2019	Purchased
Servo Motor (Feetech FS5106R)	2	12.09.2019 - 12.22.2019	Purchased
GPS Sensor (NEO-7M)	1	12.09.2019 - 12.22.2019	Purchased
Buzzer (KSTG951AP RS PRO)	1	12.09.2019 - 12.22.2019	Purchased
Sony Battery (VTC6)	2	12.09.2019 - 12.22.2019	Purchased
Coin Cell (CR2032 3V)	1	12.09.2019 - 12.22.2019	Purchased
Switch (KTS102)	1	12.09.2019 - 12.22.2019	Purchased
DC-DC 5V Regulator (S7V7F5)	1	12.09.2019 - 12.22.2019	Purchased
DC-DC 3.3V Regulator (AMS-1117)	1	12.09.2019 - 12.22.2019	Purchased
SD Card (SanDisk Ultra 8 GB)	2	12.09.2019 - 12.22.2019	Purchased
Antenna (TP-link TL-ANT2405CL)	1	12.09.2019 - 12.22.2019	Purchased
IRF1404 N Channel Power MOSFET TO-220	3	12.09.2019 - 12.22.2019	Purchased
Capacitor	15	12.09.2019 - 12.22.2019	Purchased
Resistor	15	12.09.2019 - 12.22.2019	Purchased
XBee Radio (XBee Pro S2C)	1	12.09.2019 - 12.22.2019	Purchased
Container Mechanical Components	**Quantity**	**Order Date - Delivery Date**	**Status**
Fiberglass	1 m²	03.01.2020 - 03.08.2020	Purchased
Silnylon 30D Nylon 66	1 m²	03.01.2020 - 03.08.2020	Purchased
Steel Hinge	2	03.01.2020 - 03.08.2020	Purchased
Depron	1 m²	03.01.2020 - 03.08.2020	Purchased
Payload Mechanical Components	**Quantity**	**Order Date - Delivery Date**	**Status**
Carbon Fiber Stick	3 m	03.01.2020 - 03.08.2020	Purchased
ABS Filament	1 kg	02.28.2020 - 03.08.2020	Purchased
Fiberglass	1 m²	03.01.2020 - 03.08.2020	Purchased
Silnylon 30D Nylon 66	2 m²	02.28.2020 - 03.08.2020	Purchased
Spring	3	02.28.2020 - 03.08.2020	Purchased

Ground Station

- TL-ANT2414A for ground station.
Quantity: 1
Date:12.09.2019-12.22.2019
Status: Purchased
- XBee Pro S2C for ground station.
Quantity: 1
Date:12.09.2019 –12.22.2019
Status: Purchased
- We use our computer.
- We use the software that we have already develop.

- All the necessary electronics for the payload were ordered and delivered in a month.
- All the necessary raw materials for the mechanics were ordered and delivered in a week.
- We have no problem with maintaining the products and budgeting.

CanSat Budget – Hardware (1 of 3)

ELECTRONICS HARDWARE					
Components		Quantity	Unit Price ($)	Total Price ($)	Considerations
PAYLOAD	Microcontroller (TEENSY 3.6)	1	29.25	29.25	Actual
	10-DOF IMU (MPU-9255+BMP280)	1	10	10	Actual
	Optical Dust Sensor (SHARP GP2Y10)	1	7.01	7.01	Actual
	Air Speed Sensor Kit (APM 2.6 MPXV7002DP)	1	45.43	45.43	Actual
	Camera (SQ11)	1	12.05	12.05	Actual
	Servo Motor (Feetech FS5106R)	2	17.70	35.4	Actual
	GPS Sensor (NEO-7M)	1	17.4	17.4	Actual
	Buzzer (KSTG951AP RS PRO)	1	1.7	1.7	Actual
	XBee Radio (XBee Pro S2C)	1	57.3	57.3	Actual
	Battery (SONY VTC6)	2	5.5	11	Actual
	Coin Cell (CR2032 3V)	1	0.54	0.54	Actual
	Switch (KTS102)	1	0.48	0.48	Actual
	DC-DC 5V Regulator (S7V7F5)	1	1.9	1.9	Actual
	DC-DC 3.3V Regulator (AMS-1117)	1	0.5	0.5	Actual
	SD Card (SanDisk Ultra 8 GB)	2	4.56	9.12	Actual
	Antenna (TP-link TL-ANT2405CL)	1	5	5	Actual

TOTAL	**$244.08**

We bought again all components in this year.

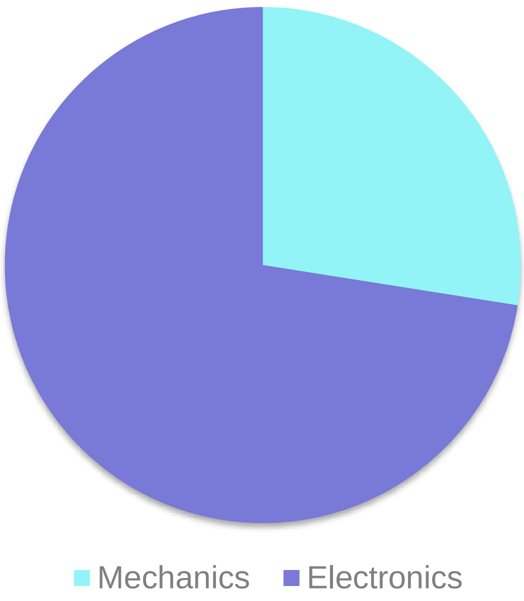
CanSat Budget – Hardware (2 of 3)

MECHANICS HARDWARE					
Components		**Quantity**	**Unit Price ($)**	**Total Price ($)**	**Considerations**
PAYLOAD	Carbon Fiber Stick	3 m	9	27	Actual
	ABS Filament	1 kg	15	15	Actual
	Fiberglass	1 m^2	3.53	3.53	Actual
	Silnylon 30D Nylon 66	2 m^2	12.5	25	Actual
	Spring	3	0.67	2	Actual
CONTAINER	Fiberglass	1 m^2	3.53	3.53	Actual
	Silnylon 30D Nylon 66	1 m^2	12.5	12.5	Actual
	Steel Hinge (30 mm*10 mm)	2	1	2	Actual
	Depron	1 m^2	2	2	Actual

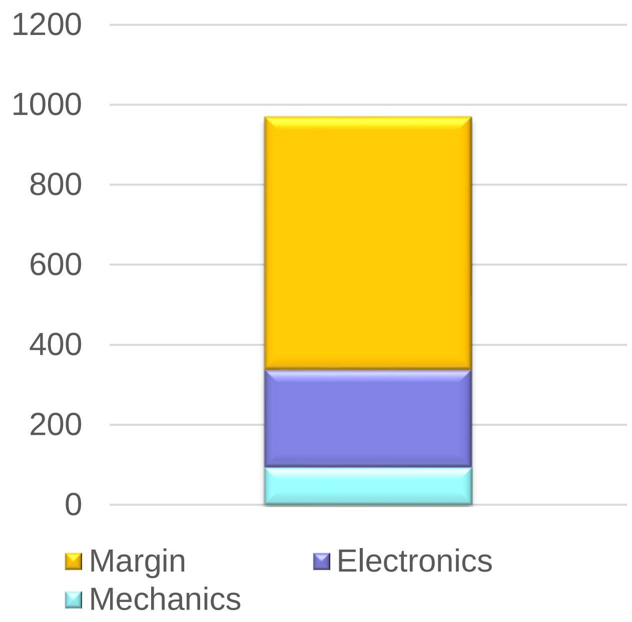
TOTAL	**$92.56**

We bought again all components in this year.

Electronics / Mechanics Components



ELECTRONICS	$244.08
MECHANICS	$92.56
EXACT TOTAL	$366.64
MARGIN	$633.36



CanSat Requirement Cost – Exact Total = Margin

$1000- $366.64 = $633.36

CanSat Budget – Other Costs (1 of 3)

GROUND STATION

Part	Model	Quantity	Price ($)	Total Price ($)	Considerations
Computer	-	1	Our Own Computer	-	Actual
XBee Radio	XBee Pro S2C	1	57.30	57.30	Actual
ANTENNA	TP-Link 2414A	1	64.05	64.05	Actual
Total				**121.35**	

OTHER

	Quantity	Total Price ($)	Considerations
Prototyping		150.00	Estimate
Test Facilities and Equipment		University Budget	
Rental	Car*2	800.00	Estimate
Computers		Our Own Computers	
Travel (Flight Ticket)	8 person	4,400.00	Estimate
VISA (USA)	8 person	1,280.00	Estimate
Hotel	8 person	2,250.00	Estimate
CanSat Competition Fee		200.00	Actual
Total		**9,080.00**	

INCOME

		Total Price ($)
Grants	ERDEMİR Company	7,500.00
	Zonguldak Bülent Ecevit University	3,800.00
Total		**11,300.00**

Planning Cost	
Categories	Cost ($)
Electrical and Mechanical	366.64
Ground Station	121.35
Other Cost	9,080.00
TOTAL	9,567.99

Income – Total = Margin

$11,300.000 - $9,567.99 = $1,732.01

- If the pandemic hadn't happened, our expenses would have been as seen on the table.

CanSat Budget – Other Costs (3 of 3)

Actual Cost	
Categories	Cost ($)
Electrical and Mechanical	366.64
Ground Station	121.35
CanSat Competition Fee	200.00
TOTAL	687.99

Income – Total = Margin

$11,300.000 - $687.99 = $10,612.01

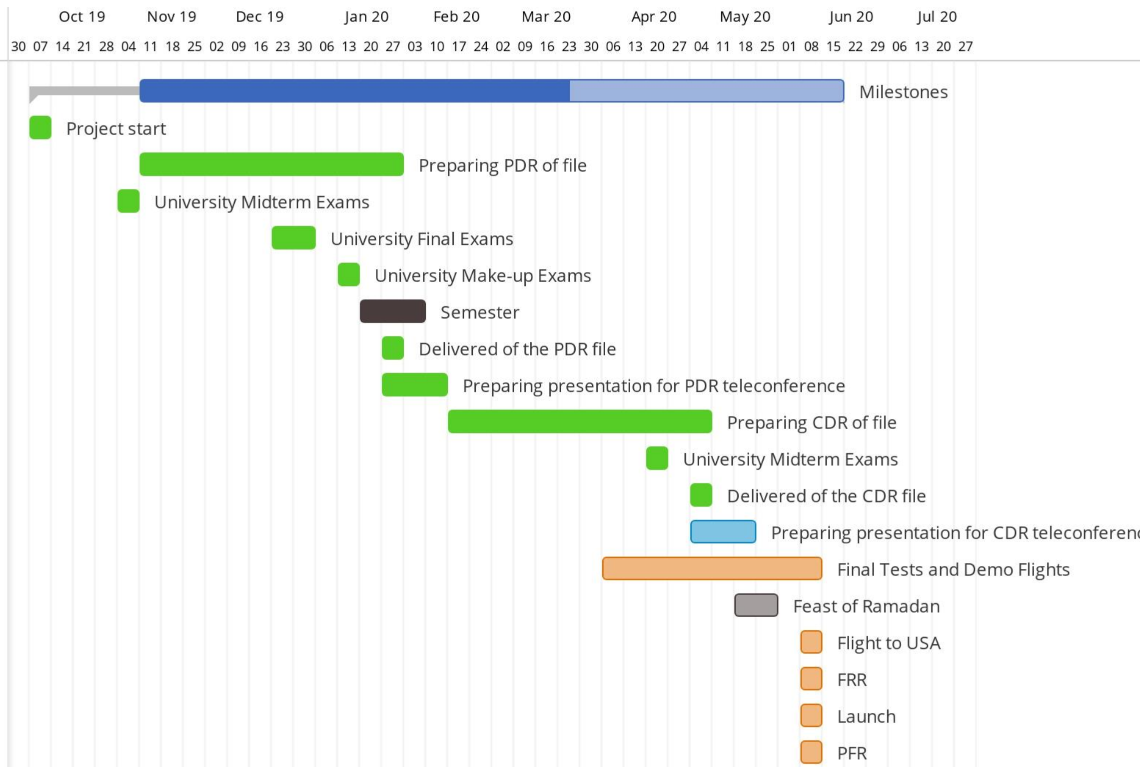
- Due to the pandemic, we did not include other costs (prototyping, rental, VISA, flight ticket, hotel).

- We're gonna use our margin for the CanSat Competition next year.

Program Schedule Overview

Milestones

ACTIVITIES	ASSIGNEE	EH	START	DUE	%
Milestones	All team	-	10/Oct	15/Jun	61%
Project start	All team	-	10/Oct	10/Oct	100%
Preparing PDR of file	All team	-	14/Nov	30/Jan	100%
University Midterm Exa...	All team	-	04/Nov	10/Nov	100%
University Final Exams	All team	-	23/Dec	03/Jan	100%
University Make-up Exa...	All team	-	13/Jan	19/Jan	100%
Semester	All team	-	20/Jan	03/Feb	100%
Delivered of the PDR file	All team	-	31/Jan	31/Jan	100%
Preparing presentation ...	All team	-	02/Feb	15/Feb	100%
Preparing CDR of file	All team	-	20/Feb	07/May	100%
University Midterm Exa...	All team	-	20/Apr	26/Apr	100%
Delivered of the CDR file	All team	-	07/May	07/May	100%
Preparing presentation ...	All team	-	08/May	22/May	0%
Final Tests and Demo Fl...	All team	-	12/Apr	08/Jun	0%
Feast of Ramadan	All team	-	24/May	26/May	0%
Flight to USA	All team	-	09/Jun	09/Jun	0%
FRR	All team	-	12/Jun	12/Jun	0%
Launch	All team	-	13/Jun	13/Jun	0%
PFR	All team	-	14/Jun	14/Jun	0%



Completed Tasks

Incompleted Tasks

Holiday

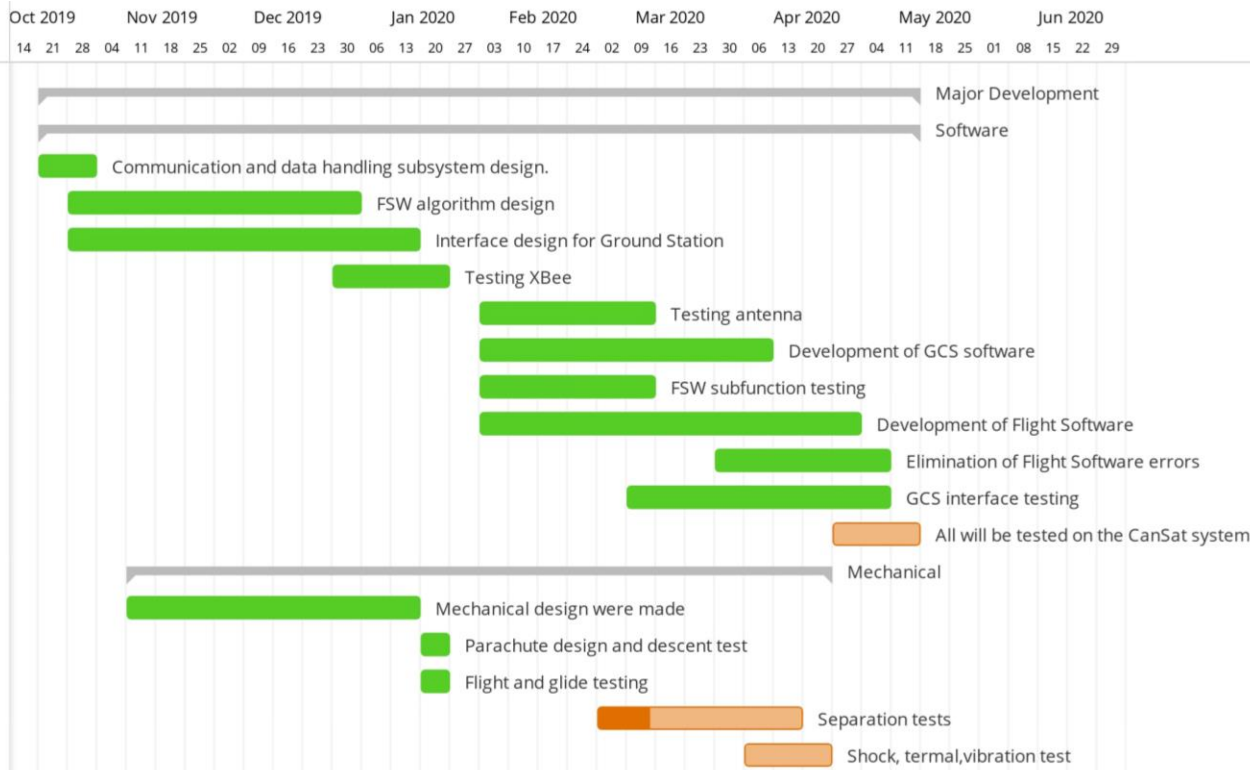
We planned but were unable to perform due to coronavirus

Due to coronavirus, face-to-face education during the spring semester has been canceled as of March 16, 2020. During this time, we continued to work on the internet using the "Microsoft Teams" application and will conduct our midterms exams through the online system.

Detailed Program Schedule (1 of 11)

Major Development (1 of 3)

ACTIVITIES	ASSIGNEE	START	DUE	%
Major Development	grizu-263	25/Oct	15/May	79%
Software	grizu-263	25/Oct	15/May	91%
Communication an...	ipek güzel	25/Oct	03/Nov	100%
FSW algorithm desi...	osman kemal se...	30/Oct	30/Dec	100%
Interface design for...	ipek güzel	01/Nov	16/Jan	100%
Testing XBee	software unit	03/Jan	22/Jan	100%
Testing antenna	software unit	05/Feb	14/Mar	100%
Development of GC...	ipek güzel	03/Feb	10/Apr	100%
FSW subfunction te...	osman serinkan	03/Feb	12/Mar	100%
Development of Fli...	osman serinkan	03/Feb	01/May	100%
Elimination of Flight...	ipek güzel	30/Mar	05/May	100%
GCS interface testing	software unit	13/Mar	06/May	100%
All will be tested on ...	software unit	01/May	15/May	0%
Mechanical	grizu-263	15/Nov	25/Apr	65%
Mechanical design ...	ömer öz	15/Nov	15/Jan	100%
Parachute design a...	semiha karama...	21/Jan	23/Jan	100%
Flight and glide test...	mechanical unit	22/Jan	26/Jan	100%
Separation tests	mechanical unit	03/Mar	15/Apr	25%
Shock, termal,vibra...	mechanical unit	07/Apr	25/Apr	0%



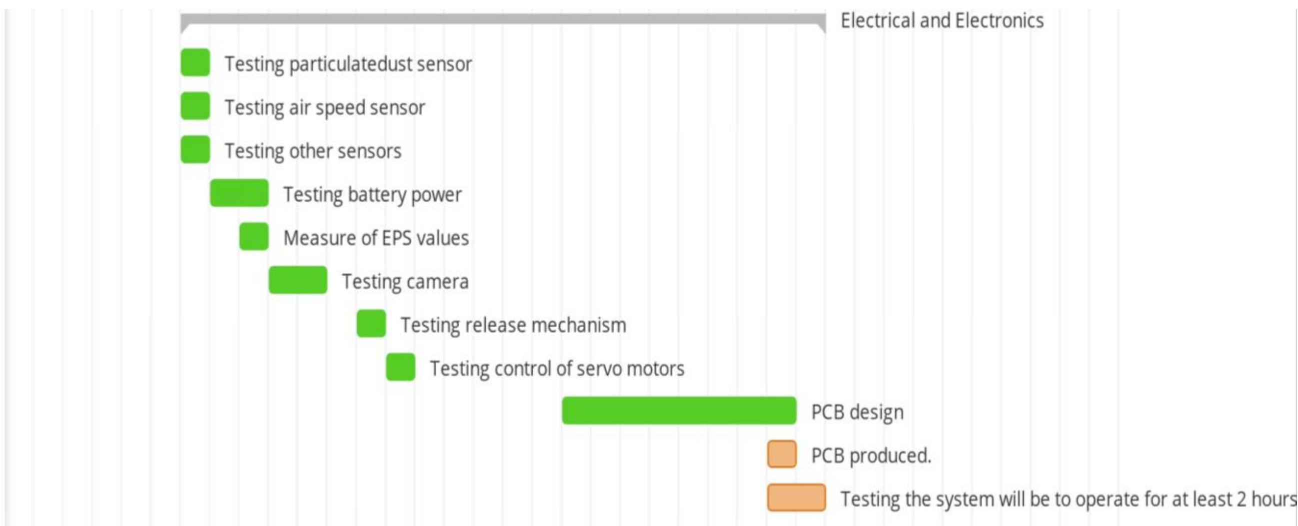
Completed Tasks

We planned but were unable to perform due to coronavirus

Assignee

Major Development (2 of 3)

Electrical and Electronics	grizu-263	25/Nov	20/Apr	82%
Testing particulate...	gizem kübra ya...	25/Nov	26/Nov	100%
Testing air speed s...	sedef özel	26/Nov	27/Nov	100%
Testing other senso...	zeynep söder	28/Nov	29/Nov	100%
Testing battery pow...	sedef özel	07/Dec	09/Dec	100%
Measure of EPS val...	hüseyin sertkaya	10/Dec	12/Dec	100%
Testing camera	hüseyin sertkaya	22/Dec	23/Dec	100%
Testing release me...	electrical and el...	06/Jan	07/Jan	100%
Testing control of s...	electrical and el...	13/Jan	15/Jan	100%
PCB design	hüseyin sertkaya	01/Mar	13/Apr	100%
PCB produced.	electrical and el...	14/Apr	17/Apr	0%
Testing the system ...	electrical and el...	18/Apr	20/Apr	0%



Completed Tasks

We planned but were unable to perform due to coronavirus

Assignee

85% of the total work is completed.

The tests that we can not perform due to coronavirus pandemic when the whole system was complete and CanSat.

Detailed Program Schedule (3 of 11)

Major Development (3 of 3)

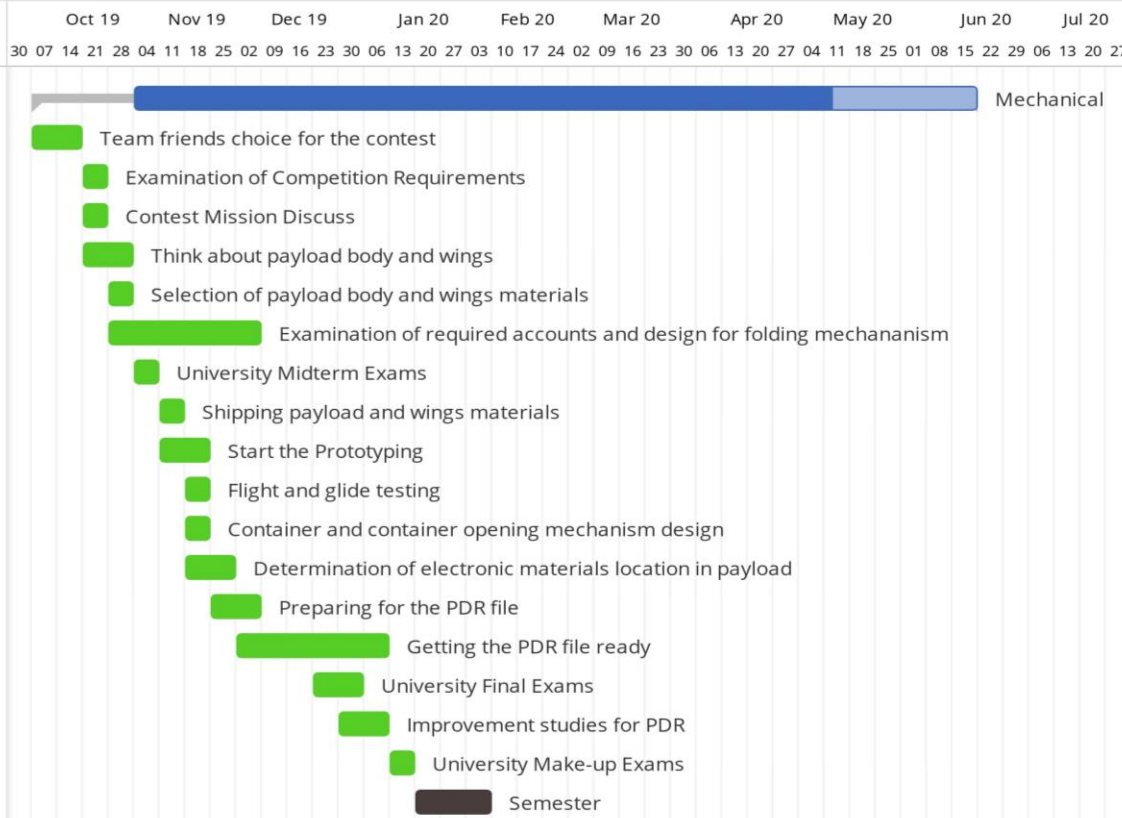
ASSIGNEE

- **SPONSORSHIP UNIT**
  - Nevin Maside TÜT – Mechanical Eng.
- **ELECTRONICS UNIT**
  - Sedef ÖZEL – Nanotechnology Eng.
  - Zeynep SÖDER – Electrical-Electronics Eng.
  - Gizem Kübra YAMAN – Electrical-Electronics Eng.
  - Hüseyin SERTKAYA – Electrical-Electronics Eng.
- **SOFTWARE UNIT**
  - Osman SERİNKAN – Electrical-Electronics Eng.
  - İpek GÜZEL – Computer Eng.
- **MECHANICS UNIT**
  - Ömer ÖZ – Mechanical Eng.
  - Semiha KARAMAHMUTOĞLU – Mechanical Eng.

The tasks is written under 'assignee' to obviously identify our team chart.

Mechanical (1 of 2)

ACTIVITIES	ASSIGNEE	START	DUE	%
Mechanical	mechanical unit	10/Oct	15/Jun	83%
Team friends choice for...	All team	10/Oct	14/Oct	100%
Examination of Competi...	All team	21/Oct	22/Oct	100%
Contest Mission Discuss	All team	23/Oct	24/Oct	100%
Think about payload bo...	mechanical unit	25/Oct	28/Oct	100%
Selection of payload bo...	ömer öz	29/Oct	29/Oct	100%
Examination of require...	mechanical unit	30/Oct	02/Dec	100%
University Midterm Exa...	All team	04/Nov	10/Nov	100%
Shipping payload and w...	semiha karama...	11/Nov	14/Nov	100%
Start the Prototyping	mechanical unit	15/Nov	18/Nov	100%
Flight and glide testing	mechanical unit	19/Nov	20/Nov	100%
Container and containe...	semiha karama...	21/Nov	23/Nov	100%
Determination of electr...	semiha karama...	24/Nov	26/Nov	100%
Preparing for the PDR file	All team	27/Nov	05/Dec	100%
Getting the PDR file rea...	All team	05/Dec	12/Jan	100%
University Final Exams	All team	23/Dec	03/Jan	100%
Improvement studies fo...	All team	03/Jan	12/Jan	100%
University Make-up Exa...	All team	13/Jan	19/Jan	100%
Semester	All team	20/Jan	03/Feb	100%



Completed Tasks

Holiday

Incompleted Tasks

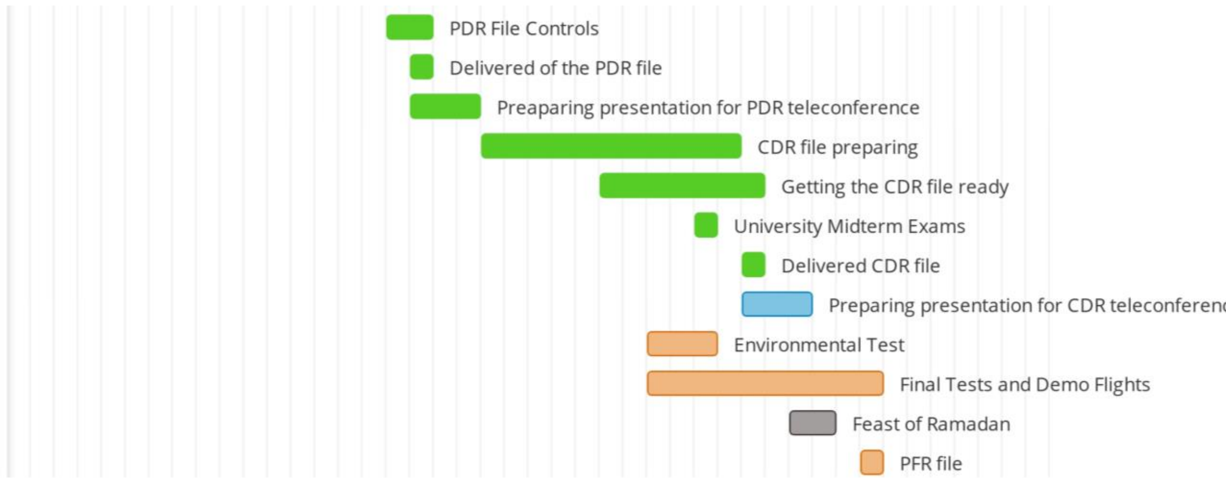
Assignee

We planned but were unable to perform due to coronavirus

Detailed Program Schedule (5 of 11)

Mechanical (2 of 2)

PDR File Controls	All team	23/Jan	29/Jan	100%
Delivered of the PDR file	All team	31/Jan	31/Jan	100%
Preaparing presentatio...	All team	02/Feb	15/Feb	100%
CDR file preparing	All team	20/Feb	01/May	100%
Getting the CDR file rea...	All team	25/Mar	06/May	100%
University Midterm Exa...	All team	20/Apr	26/Apr	100%
Delivered CDR file	All team	07/May	07/May	100%
Preparing presentation ...	All team	08/May	22/May	0%
Environmental Test	mechanical unit	07/Apr	25/Apr	0%
Final Tests and Demo Fl...	All team	12/Apr	08/Jun	0%
Feast of Ramadan	All team	24/May	26/May	0%
PFR file	All team	14/Jun	14/Jun	0%

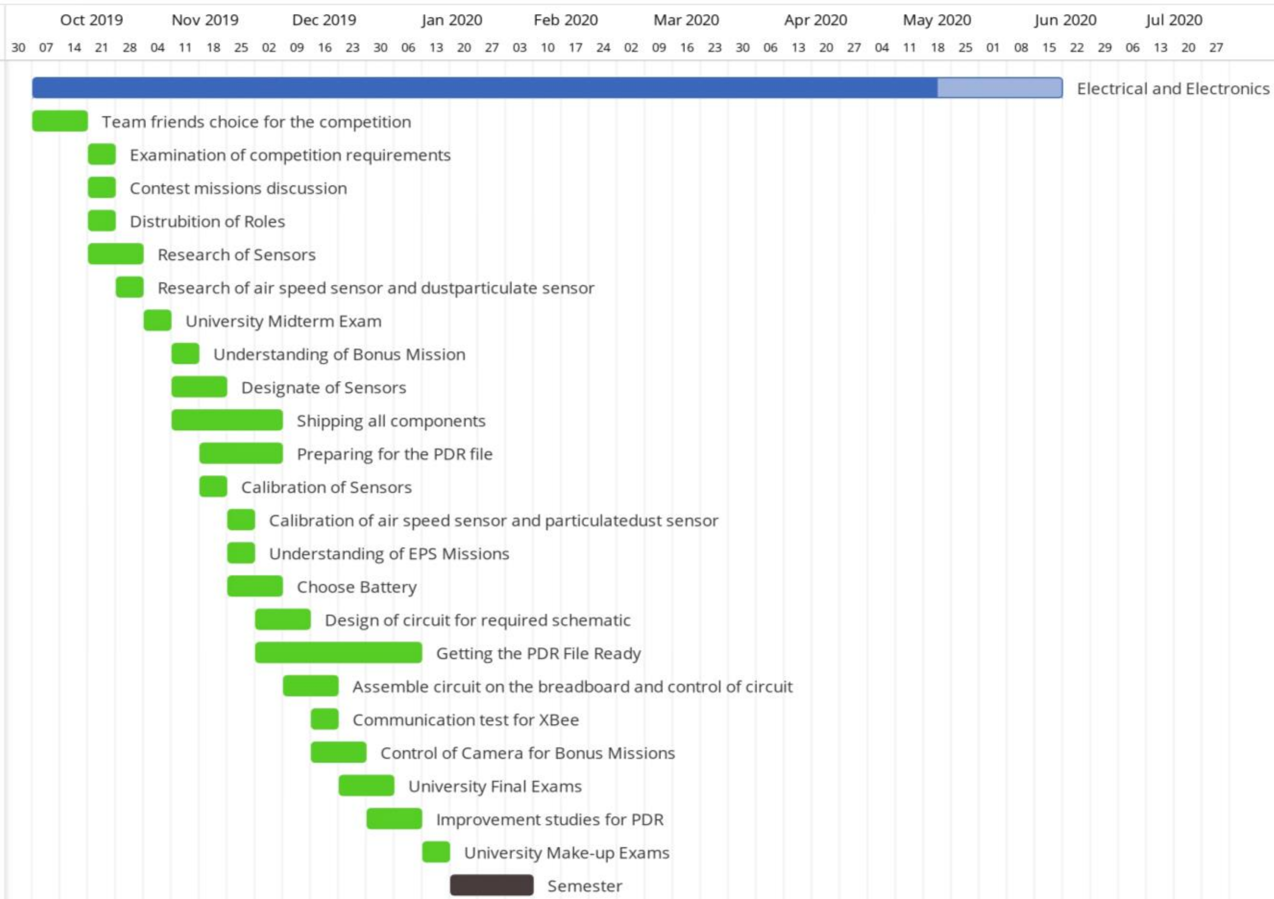


Completed Tasks | **Incompleted Tasks** | **Holiday** | **Assignee** | **We planned but were unable to perform due to coronavirus**

Detailed Program Schedule (6 of 11)

Electrical and Electronics (1 of 2)

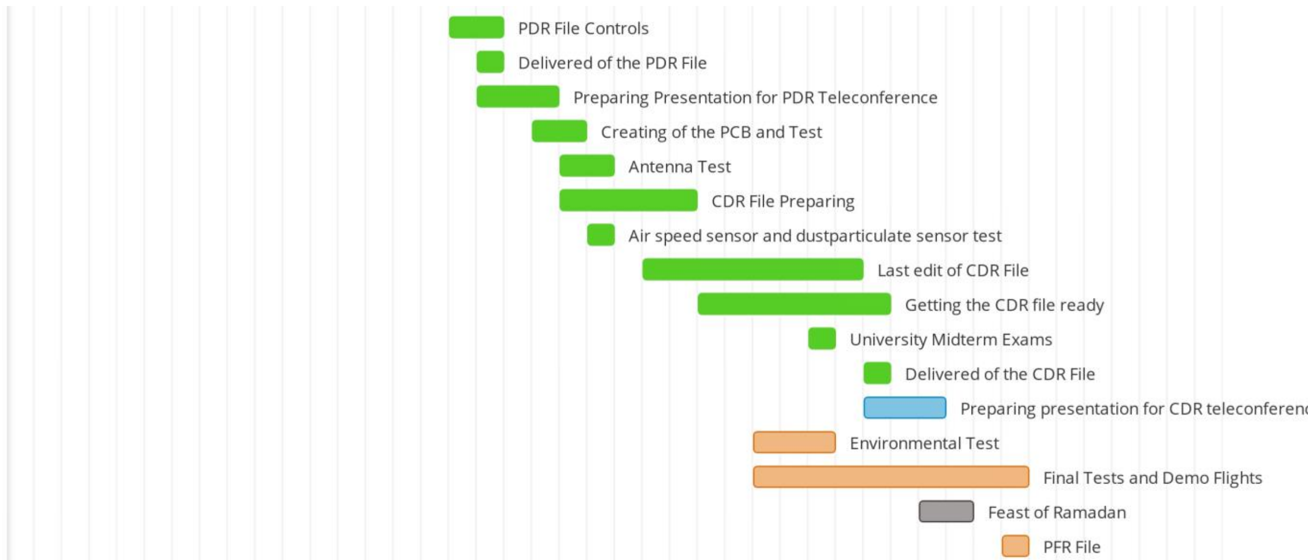
ACTIVITIES	ASSIGNEE	START	DUE	%
Electrical and Electronics	electrical and el...	10/Oct	15/Jun	88%
Team friends choice for...	All team	10/Oct	14/Oct	100%
Examination of competi...	All team	21/Oct	22/Oct	100%
Contest missions discus...	All team	23/Oct	24/Oct	100%
Distrubition of Roles	electrical and el...	24/Oct	25/Oct	100%
Research of Sensors	zeynep söder	26/Oct	29/Oct	100%
Research of air speed s...	zeynep söder	30/Oct	03/Nov	100%
University Midterm Exam	All team	04/Nov	10/Nov	100%
Understanding of Bonu...	electrical and el...	11/Nov	14/Nov	100%
Designate of Sensors	hüseyin sertkaya	15/Nov	20/Nov	100%
Shipping all components	zeynep söder	15/Nov	05/Dec	100%
Preparing for the PDR file	All team	20/Nov	05/Dec	100%
Calibration of Sensors	sedef özel	21/Nov	24/Nov	100%
Calibration of air speed ...	zeynep söder	25/Nov	27/Nov	100%
Understanding of EPS ...	electrical and el...	28/Nov	30/Nov	100%
Choose Battery	sedef özel	01/Dec	03/Dec	100%
Design of circuit for req...	hüseyin sertkaya	04/Dec	11/Dec	100%
Getting the PDR File Re...	All team	05/Dec	12/Jan	100%
Assemble circuit on the ...	electrical and el...	13/Dec	18/Dec	100%
Communication test for...	electrical and el...	17/Dec	22/Dec	100%
Control of Camera for B...	electrical and el...	22/Dec	23/Dec	100%
University Final Exams	All team	23/Dec	03/Jan	100%
Improvement studies fo...	All team	03/Jan	12/Jan	100%
University Make-up Exa...	All team	13/Jan	19/Jan	100%
Semester	All team	20/Jan	03/Feb	100%



Completed Tasks **Incompleted Tasks** **Holiday** **Assignee** **We planned but were unable to perform due to coronavirus**

Electrical and Electronics (2 of 2)

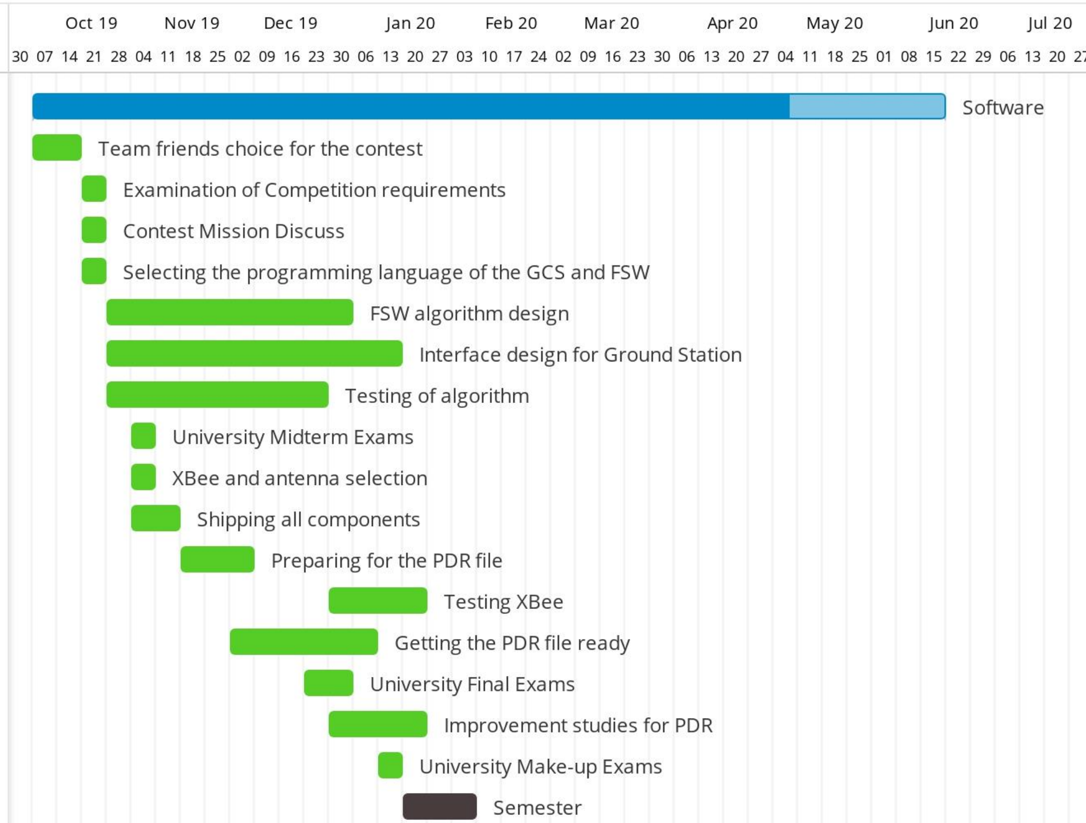
PDR File Controls	All team	21/Jan	29/Jan	100%
Delivered of the PDR File	All team	31/Jan	31/Jan	100%
Preparing Presentation ..	All team	02/Feb	15/Feb	100%
Creating of the PCB and..	electrical and el...	10/Feb	20/Feb	100%
Antenna Test	electrical and el...	21/Feb	24/Feb	100%
CDR File Preparing	All team	20/Feb	20/Mar	100%
Air speed sensor and d...	gizem kübra ya...	26/Feb	29/Feb	100%
Last edit of CDR File	All team	09/Mar	01/May	100%
Getting the CDR file rea...	All team	25/Mar	06/May	100%
University Midterm Exa...	All team	20/Apr	26/Apr	100%
Delivered of the CDR File	All team	07/May	07/May	100%
Preparing presentation ..	All team	08/May	22/May	0%
Environmental Test	electrical and el...	07/Apr	25/Apr	0%
Final Tests and Demo Fl...	All team	12/Apr	08/Jun	0%
Feast of Ramadan	All team	24/May	26/May	0%
PFR File	All team	14/Jun	14/Jun	0%



Completed Tasks **Incompleted Tasks** **Holiday** **Assignee** **We planned but were unable to perform due to coronavirus**

Software (1 of 2)

ACTIVITIES	ASSIGNEE	EH	START	DUE	%
Software	software unit	-	10/Oct	15/Jun	83%
Team friends choice for...	All team	-	10/Oct	14/Oct	100%
Examination of Competi...	All team	-	21/Oct	22/Oct	100%
Contest Mission Discuss	All team	-	23/Oct	24/Oct	100%
Selecting the program...	ipek güzel	-	25/Oct	27/Oct	100%
FSW algorithm design	osman serinkan	-	30/Oct	30/Dec	100%
Interface design for Gro...	ipek güzel	-	01/Nov	16/Jan	100%
Testing of algorithm	software unit	-	01/Nov	26/Dec	100%
University Midterm Exa...	All team	-	04/Nov	10/Nov	100%
XBee and antenna sele...	ipek güzel	-	05/Nov	10/Nov	100%
Shipping all components	osman serinkan	-	10/Nov	17/Nov	100%
Preparing for the PDR file	All team	-	20/Nov	05/Dec	100%
Testing XBee	osman serinkan	-	03/Jan	22/Jan	100%
Getting the PDR file rea...	All team	-	05/Dec	12/Jan	100%
University Final Exams	All team	-	23/Dec	03/Jan	100%
Improvement studies fo...	All team	-	03/Jan	22/Jan	100%
University Make-up Exa...	All team	-	17/Jan	17/Jan	100%
Semester	All team	-	20/Jan	03/Feb	100%

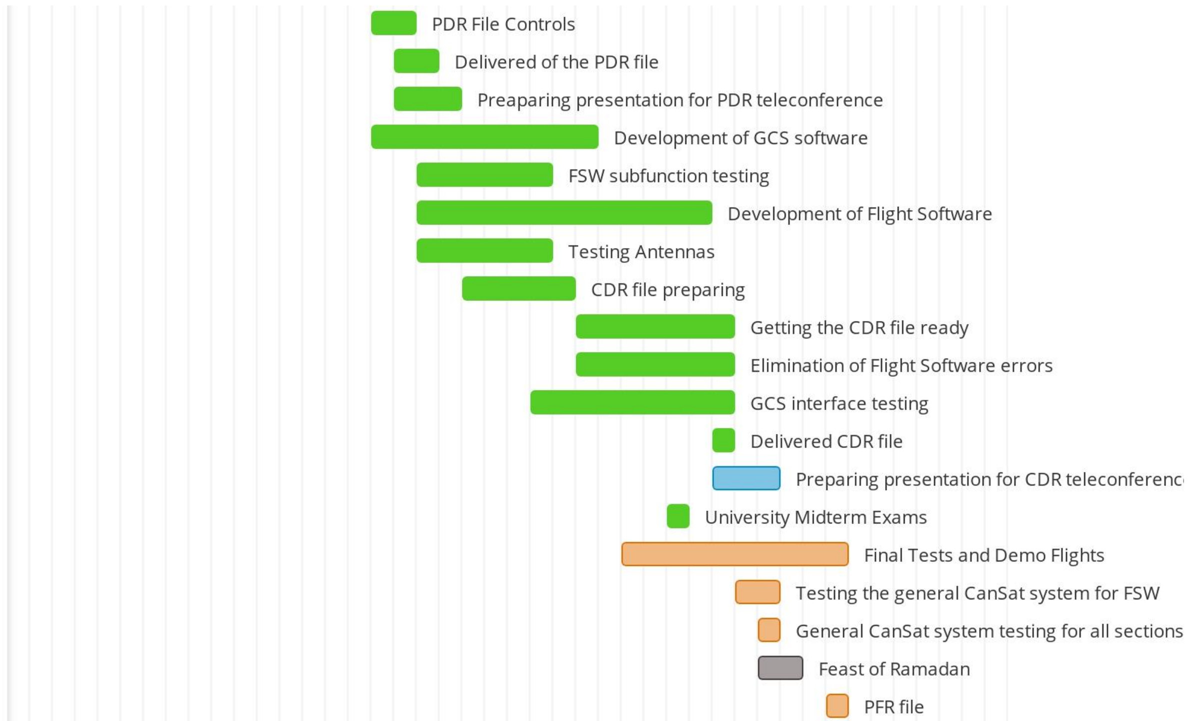


Completed Tasks **Incompleted Tasks** **Holiday** **Assignee** **We planned but were unable to perform due to coronavirus**

Detailed Program Schedule (9 of 11)

Software (2 of 2)

	Task	Assignee		Start	End	Progress
	PDR File Controls	All team	-	23/Jan	29/Jan	100%
	Delivered of the PDR file	All team	-	31/Jan	03/Feb	100%
	Preaparing presentatio...	All team	-	02/Feb	15/Feb	100%
	Development of GCS so...	sman serinkan	-	20/Jan	27/Mar	100%
	FSW subfunction testing	sman serinkan	-	03/Feb	12/Mar	100%
	Development of Flight S...	sman serinkan	-	03/Feb	01/May	100%
	Testing Antennas	software unit	-	05/Feb	14/Mar	100%
	CDR file preparing	All team	-	20/Feb	20/Mar	100%
	Getting the CDR file rea...	All team	-	25/Mar	04/May	100%
	Elimination of Flight Sof...	ipek güzel	-	23/Mar	05/May	100%
	GCS interface testing	software unit	-	13/Mar	06/May	100%
	Delivered CDR file	All team	-	07/May	07/May	100%
	Preparing presentation ...	All team	-	08/May	22/May	0%
	University Midterm Exa...	All team	-	20/Apr	26/Apr	100%
	Final Tests and Demo Fl...	All team	-	12/Apr	08/Jun	0%
	Testing the general Can...	software unit	-	14/May	20/May	0%
	General CanSat system...	software unit	-	22/May	24/May	0%
	Feast of Ramadan	All team	-	24/May	26/May	0%
	PFR file	All team	-	14/Jun	14/Jun	0%

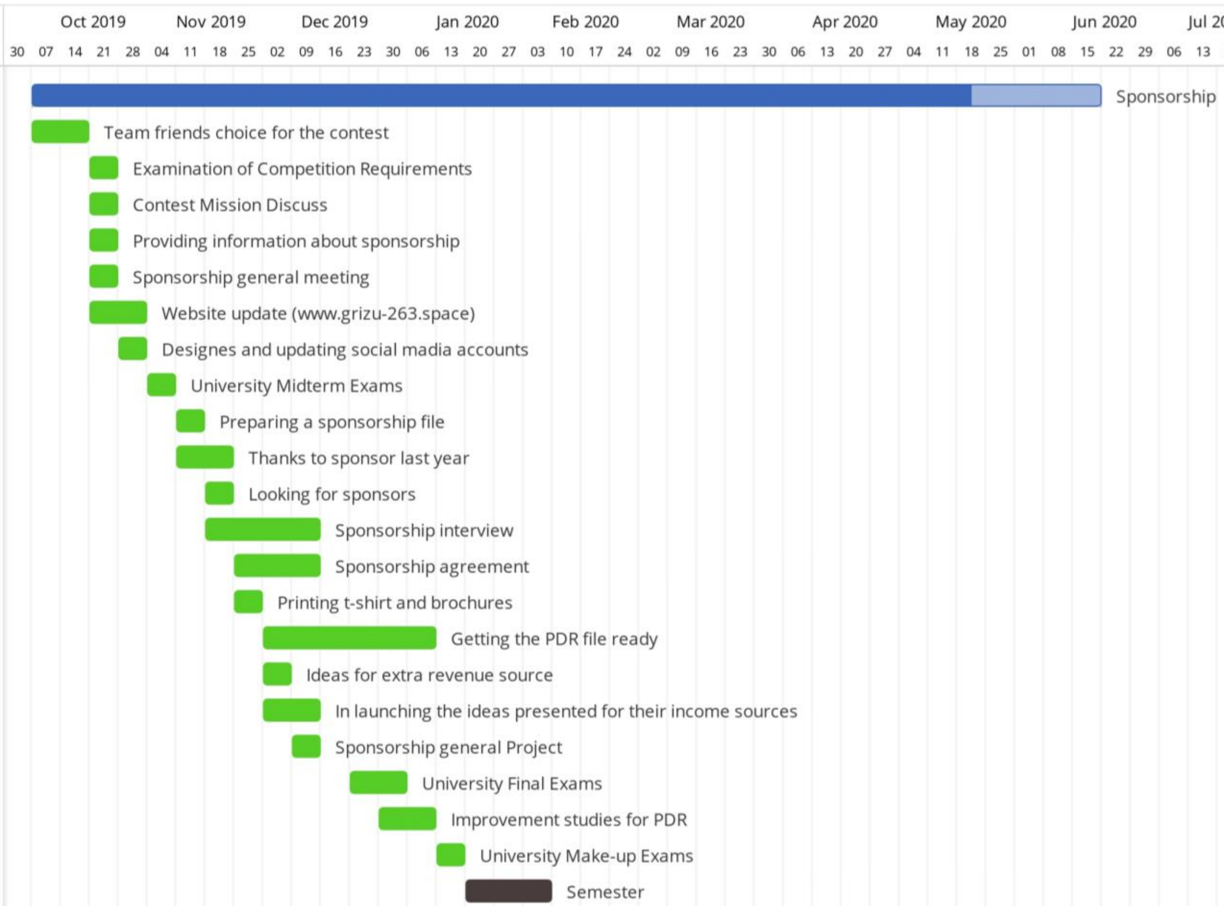


Completed Tasks **Incompleted Tasks** **Holiday** **Assignee** **We planned but were unable to perform due to coronavirus**

Detailed Program Schedule (10 of 11)

Sponsorship (1 of 2)

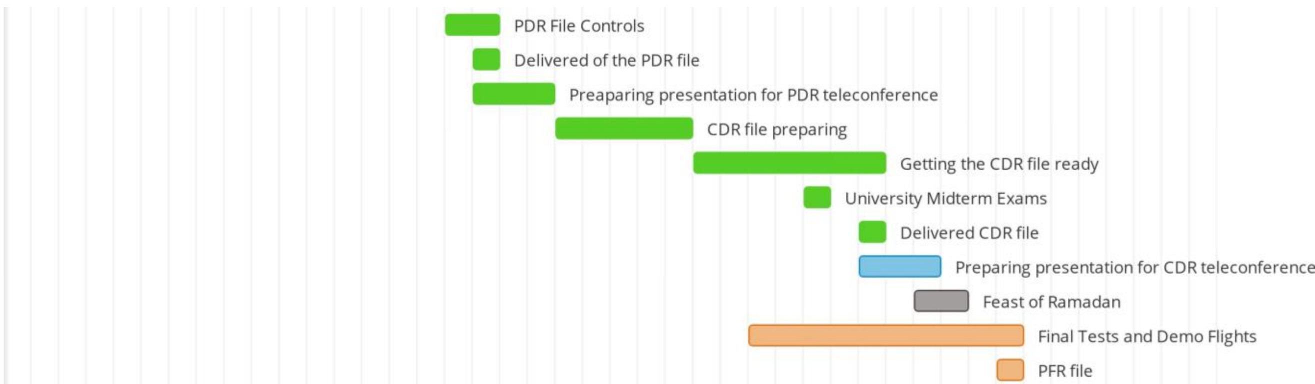
ACTIVITIES	ASSIGNEE	START	DUE	%
Sponsorship	sponsorship unit	10/Oct	15/Jun	88%
Team friends choice for...	All team	10/Oct	14/Oct	100%
Examination of Competi...	All team	21/Oct	22/Oct	100%
Contest Mission Discuss	All team	23/Oct	24/Oct	100%
Providing information a...	nevin maside tüt	25/Oct	26/Oct	100%
Sponsorship general m...	nevin maside tüt	26/Oct	26/Oct	100%
Website update (www.g...	nevin maside tüt	27/Oct	29/Oct	100%
Designes and updating ...	nevin maside tüt	30/Oct	02/Nov	100%
University Midterm Exa...	All team	04/Nov	10/Nov	100%
Preparing a sponsorshi...	nevin maside tüt	11/Nov	16/Nov	100%
Thanks to sponsor last ...	sponsorship unit	17/Nov	19/Nov	100%
Looking for sponsors	sponsorship unit	19/Nov	21/Nov	100%
Sponsorship interview	sponsorship unit	22/Nov	10/Dec	100%
Sponsorship agreement	sponsorship unit	25/Nov	10/Dec	100%
Printing t-shirt and broc...	sponsorship unit	26/Nov	28/Nov	100%
Getting the PDR file rea...	All team	05/Dec	12/Jan	100%
Ideas for extra revenue ...	sponsorship unit	06/Dec	07/Dec	100%
In launching the ideas p...	sponsorship unit	08/Dec	10/Dec	100%
Sponsorship general Pr...	sponsorship unit	11/Dec	11/Dec	100%
University Final Exams	All team	23/Dec	03/Jan	100%
Improvement studies fo...	All team	03/Jan	12/Jan	100%
University Make-up Exa...	All team	13/Jan	19/Jan	100%
Semester	All team	20/Jan	03/Feb	100%



Completed Tasks | **Incompleted Tasks** | **Holiday** | **Assignee** | **We planned but were unable to perform due to coronavirus**

Sponsorship (2 of 2)

PDR File Controls	All team	23/Jan	29/Jan	100%
Delivered of the PDR file	All team	31/Jan	31/Jan	100%
Preaparing presentatio...	All team	02/Feb	15/Feb	100%
CDR file preparing	All team	20/Feb	20/Mar	100%
Getting the CDR file rea...	All team	25/Mar	07/May	100%
University Midterm Exa...	All team	20/Apr	26/Apr	100%
Delivered CDR file	All team	07/May	07/May	100%
Preparing presentation ...	All team	08/May	22/May	0%
Feast of Ramadan	All team	24/May	26/May	0%
Final Tests and Demo Fl...	All team	12/Apr	08/Jun	0%
PFR file	All team	14/Jun	14/Jun	0%



Completed Tasks

Incompleted Tasks

Holiday

Assignee

We planned but were unable to perform due to coronavirus

Shipping and Transportation

If the pandemic hadn't happened**;**

- First of all, we will go to Istanbul which is our boarding place. We will go between Zonguldak and Istanbul with personal cars. We've scheduled our flight date for June 9.

- 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.

- 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 (1 of 2)

Accomplishments:

- All sensors determined, procured and tested.
- The PCB is designed according to the power budget.
- XBee and antenna communication was tested successfully.
- Receiving the telemetry data from the sensors have been completed.
- Mechanical design was made.
- All mechanical materials are defined, supplied.
- The melt of fishline method was tested in terms of software and hardware for safe separation.
- Payload flight and stabilization test was performed.

Unfinished Works:

- FSW and GCS software system will be tested on the CanSat system as a whole.
- The PCB isn't produced.
- Separation tests were not performed at 450 meters.
- Environmental tests not performed.
- CanSat mass test not performed.
- Active control test not performed.
- The parachute opening mechanism above 100 meters test not performed.

The tests on the final prototype have not been completed yet due to the corona virus-related unusual conditions.

Conclusions (2 of 2)

Testing to Complete:

- XBee’s communication tests completed successfully.
- The antenna range has been tested.
- Data transfer to the GCS interface, representation of the transferred data (3D, maps, charts, table) and accuracy have been tested.
- All sensors were tested on the breadboard.
- Payload folding mechanism and telescopic system testing were performed.
- The payload descent within 250 meters radius by the use of active control were tested.

Flight Software Status:

- Sensor libraries developed.
- FSW subsytems have been tested.
  - Payload algorithm updated.
  - Sensors were calibrated.
  - Sensor data was saved in SD card.
  - Data recovery algorithm was tested.
  - Communication with the ground station was tested.