CanSat 2015
Critical Design Review (CDR)

Team # 3891

METUSAT

Presentation Outline

- Team Overview
- Team Organization
- Acronyms
- Systems Overview (Omer Atas)
- Sensor Subsystem Design (Doga Yucalan)
- Descent Control Design (Efe Camci)
- Mechanical Subsystem Design (Munire Gulay Senol,Waheedullah Taj)
- Communication and Data Handling (CDH) Subsystem Design (Baran Bodur)
- Electrical Power Subsystem (EPS) Design (Barıs Duru)
- Flight Software (FSW) Design (Halil Ibrahim Ugurlu)
- Ground Control System (GCS) Design (Doga Veske)
- CanSat Integration and Test (Waheedullah Taj)
- Mission Operations & Analysis (Burak Yaglioglu)
- Requirements Compliance (Omer Atas)
- Management (Burak Yaglioglu)

Team Organization

Faculty Advisor
Prof. Dr. Ozan Tekinalp

Faculty Advisor
Prof. Dr. Sencer Koc

Faculty Advisor
Farid Gulmammadov

Team Leader
Omer Atas

Alternate Team Leader
Doga Yucalan

Mission and Systems Engineering
- Burak Yaglioglu

Communications and Ground Station
- Baran Bodur
- Doga Veske

Electronic System Design (Sensors, Data Handling & Power)
- Doga Yucalan
- Baris Duru
- Halil Ibrahim Ugurlu

Mechanical System
- Munire Gulay Senol
- Omer Atas
- Efe Camci
- Waheedullah Taj

Acronyms

A:	Analysis
ADC:	Analog Digital Converter
C:	Container
CDH:	Communication & Data Handling
CDR:	Critical Design Review
D:	Demonstration
DCR :	Descent Control Requirement
DCS:	Ground Control System
E.M. :	Electro Mechanical
EPS:	Electrical Power System
FCT	Far Communication Test
FSW:	Flight Software
FRR:	Flight Readinees Review
GCS:	Ground Control System
I:	Inspection
MR:	Mechanical Requirement
NCT	Near Communication Test
ORN	Original Requirement Number
P:	Payload
PDR:	Preliminary Design Review
PFR:	Preflight Review

Acronyms

RF:	Radio Frequency
RTC	Real Time Clock
SEN:	Sensor Subsystem Requirement
SR:	System Requirement
SV:	Science Vehicle
T:	Test
VM:	Verification Method
RW:	Reaction Wheel
GS:	Ground Station
PWM:	Pulse Width Modulation
GPS :	Global Positioning System

The purpose of this section is to introduce the reviewer to the overall requirements and configuration of the CanSat. This provides a basis for the details presented in the subsystem sections.

System Overview

Ömer Ataş

Mission Summary

Mission Objectives:

- General Objective: Simulate a Science Vehicle traveling through a planetary atmosphere sampling the atmospheric composition during descent.
- Protect the Science Vehicle in the Container during initial deployment from the rocket.
- Ensure safety of the fragile sample (*the egg*) at all phases of the mission.
- Ensure the descent of the Science Vehicle with auto-gyro method at the specified speed limit.
- Capture stable video of the ground during the descent.
- Collect and send telemetry data to a ground station at the required frequency.
- Process and represent the telemetry from CanSat in required format.
- Design, produce, integrate and test necessary mechanisms and electronics needed to accomplish mission objectives.
- Bonus Objective: Use a three-axis accelerometer to measure the stability and angle of descent of the payload during descent.

External Objectives:

- Establish a reusable and easily configurable CanSat construction framework for the present and future competitions.
- Establish a CanSat tradition in the university and regular attendance to the competitions.

Team Logo
Here
(If You Want)

Summary of Changes Since PDR

Impact level	Subject	Change	Previous Design	Rational
subsystem	Plate Material	Carbon fiber	Aluminum	Lower weight, higher strength
Subsystem	Number of Rods (science vehicle)	12 rod short	3 rod long	To disassemble and assemble part by part easily
Subsystem	Seperation Mechanism	Wire cutter + spring	Wire cutter	To guarantee separation if parachute fails
Subsystem	Parachute	1 Square shape with 4 hole	2 parachute	Lower weight, more stable, more drag
Subsystem	Acquiring data	Direct communicatio n via serial port	Read text file	Dual-directional,more reliable,
Subsystem	Some sensors	MPU-6050, DS18B20	TMP35, MPU-6000	Unavailability of the sensor in breakout board.

Team Logo Here (If You Want)

Summary of Changes Since PDR

ANNUAL CANSAT COMPETITION

Impact level	Subject	Change	Previous Design	Rational
Subsystem	Electrical Power	Power of system sensors are provided by battery through regulator not by microcontroller.	Microcontroller was chosen for this purpose.	Absolve microcontroller from more load
Subsystem	Power for sepatarion	Battery	Super capacitor	Avoid possible trouble

System Requirement Summary

ID	ORN	Requirement	Children	A	I	T	D
SR1	1	Total mass of the CanSat (Container and Science Vehicle) shall be 600 grams +/- 10 grams not including the egg.	MR1	X			X
SR2	2, 3	The Container shall fit in the envelope of 125 mm x 310 mm and completely contain the Science Vehicle. Tolerances are to be included.	MR2, MR3	X	X		X
SR3	4	The Container shall use a passive descent control system. A parachute is highly recommended.	DCR1		X		
SR4	5	The Container shall not be able to get stuck in the rocket.	MR4		X		
SR5	6	The Container shall be a florescent color, pink or orange.	MR5		X		
SR6	11	The Science Vehicle shall use a passive helicopter recovery system.	DCR2		X		
SR7	12,13, 15,16	The CanSat should be compliant with the environmental requirements (shock, acceleration and temperature).	DCR3, MR6			X	
SR8	19,20	The separation mechanism shall not use pyrotechnics or chemicals, and heating-based components shall not be exposed to outside environment.	MR8		X		
SR9	21, 22, 23	During the descent the Science Vehicle shall collect and transmit the required telemetries at 1Hz rate.	SEN1, CDH1, CDH2, CDH3, FSW2, FSW4, FSW6, GSC6, GSC7	X		X	
SR10	24	XBEE radios (at correct settings) shall be used for telemetry.	CDH4, CDH5, CDH6		X		

System Requirement Summary

ID	ORN	Requirement	Children	A	I	T	D
SR11	27, 28	The Science Vehicle shall have a video camera recording time-stamped video of the complete descent. 1 hour of recording shall be supported.	SEN2, CDH12, FSW5	X			X
SR12	29	The descent rate of the Science Vehicle shall be between 4 m/s and 10 m/s.	DCR4	X		X	
SR13	30	The image of the ground in the video shall be stable in 3 axes.	FSW8	X		X	X
SR14	31	The cost of the CanSat shall be under $1000.		X			X
SR15	33, 34, 35, 36	All the telemetry shall be displayed (in SI units) and plotted in real-time on the screen of the ground station’s laptop.	GCS1, GCS2, GCS3				X
SR16	38	The Science Vehicle shall hold one large raw hen’s egg which shall survive launch, deployment and landing.	MR7		X		
SR17	40	In the case of processor reset, the flight software shall re-initialize to the correct state.	CDH13, FSW3, FSW9	X		X	
SR18	42, 43, 44, 45,	The Science Vehicle must include a battery of allowed type and an easily accessible power switch.	EPS1, EPS3		X		
SR19		The Science Vehicle must produce an audible sound after the landing.	SEN9	X		X	
SR20	10	CanSat shall be able to determine the best separation conditions	FSW1, FSW7				

System Concept of Operations

Pre-Launch	Launch	Post Launch

• Preflight Briefing
• Last Checks
  • Mechanics
  • Electronics
• Arrive at the competition area
	• Preflight Operations
	• Set up the ground station
	• Place Egg into Payload
	• Integrate CanSat into rocket payload
	• Launch, Rise, Separation, Descent, Landing(*)
	• Locate and retrieve Container and Payload
		• Analyze Recieved Data
		• Prepare PFR
		• Presentation of PFR

System Concept of Operations
Launch Day Activities

- **Launch Campaign**
  - Setting up Ground Station
  - System Check (Mechanical and Electrical)
  - Launch of the CanSat
- **Rise**
  - Deploy from the Rocket
- **Separation**
  - Container: Parachute Deployment
  - Container: Passive attitude stabilization
  - Separation of Payload and Container (when oscilations are small enough)
- **Descent**
  - Container: Descent with a parachute
  - Payload: Auto-gyro Descent, Passive tilt damping, Active spin damping
  - Payload: Transmit Telemetries, Record Video
- **Landing**
  - Stop Data Transmission, Stop Video Recording, Activate sound
  - Post launch recovery
  - Mission Data Analysis

All Phases — Payload: Contain and Protect the Egg — Ground Station: Real Time Telemetry Collection and Monitoring

System Concept of Operations

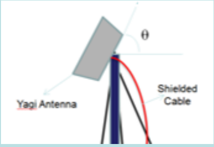
Team member roles and responsibilities on launch day

Hotel

Hotel to launch site
Prepare required equipments
(All team)

Launch site

Setup ground antenna (Baran, Doga V.)



Check&prepare for launch

Structural integrity(Omer)
Rotor system (Efe)
Parachute(Waheedullah)
Egg container (Gulay)
Container(Omer)
Separation sys.(Omer,Burak)

Electronic integrity(Burak)
Camera(Doga Y.)
Communication (Doga V.)
Flight software(Halil)
Power (Baris)

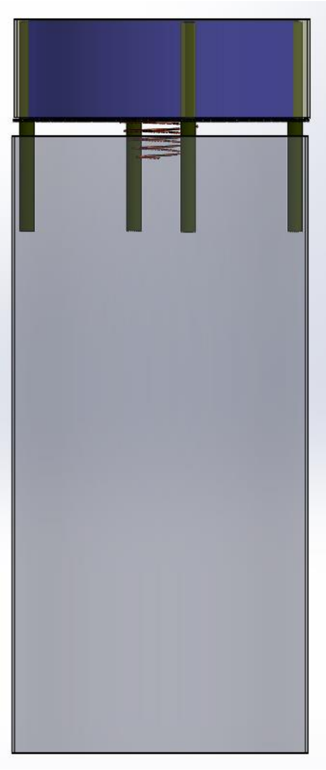
Place CanSat inside Rocket (Burak,Omer)

Real Time Telemetry Collection and Monitoring (Doga V. Halil)

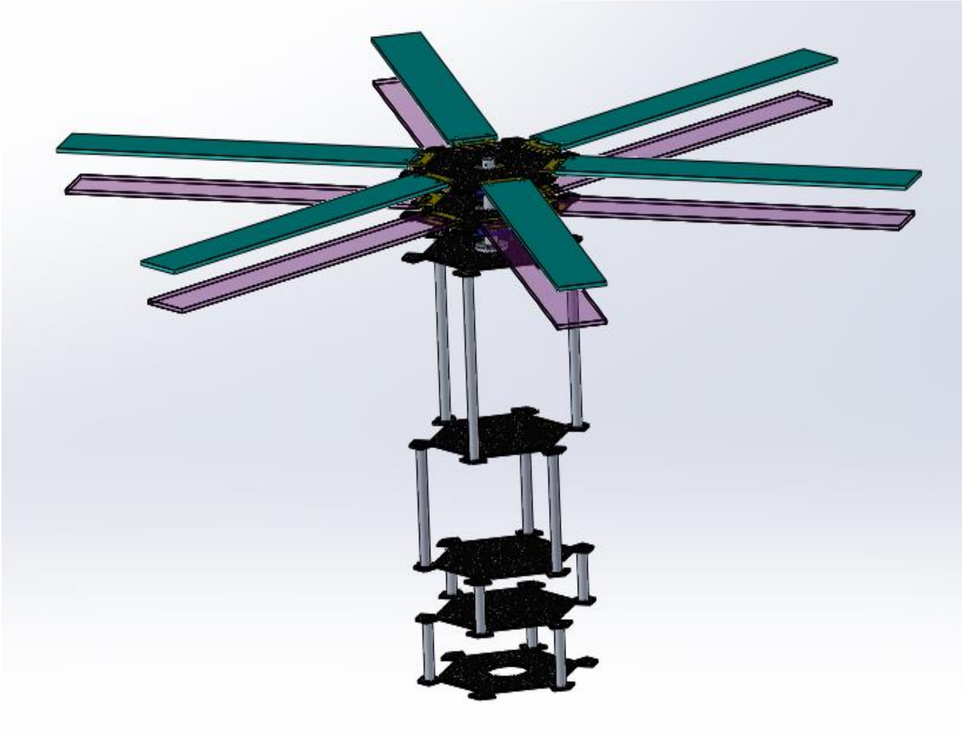
After landing

Find SV (All team)
Take egg (Omer)
Take SD card (Doga Y)

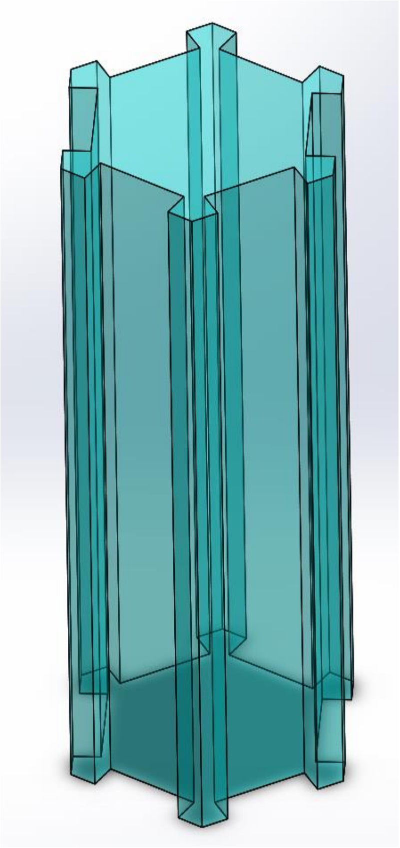
Physical Layout



Container



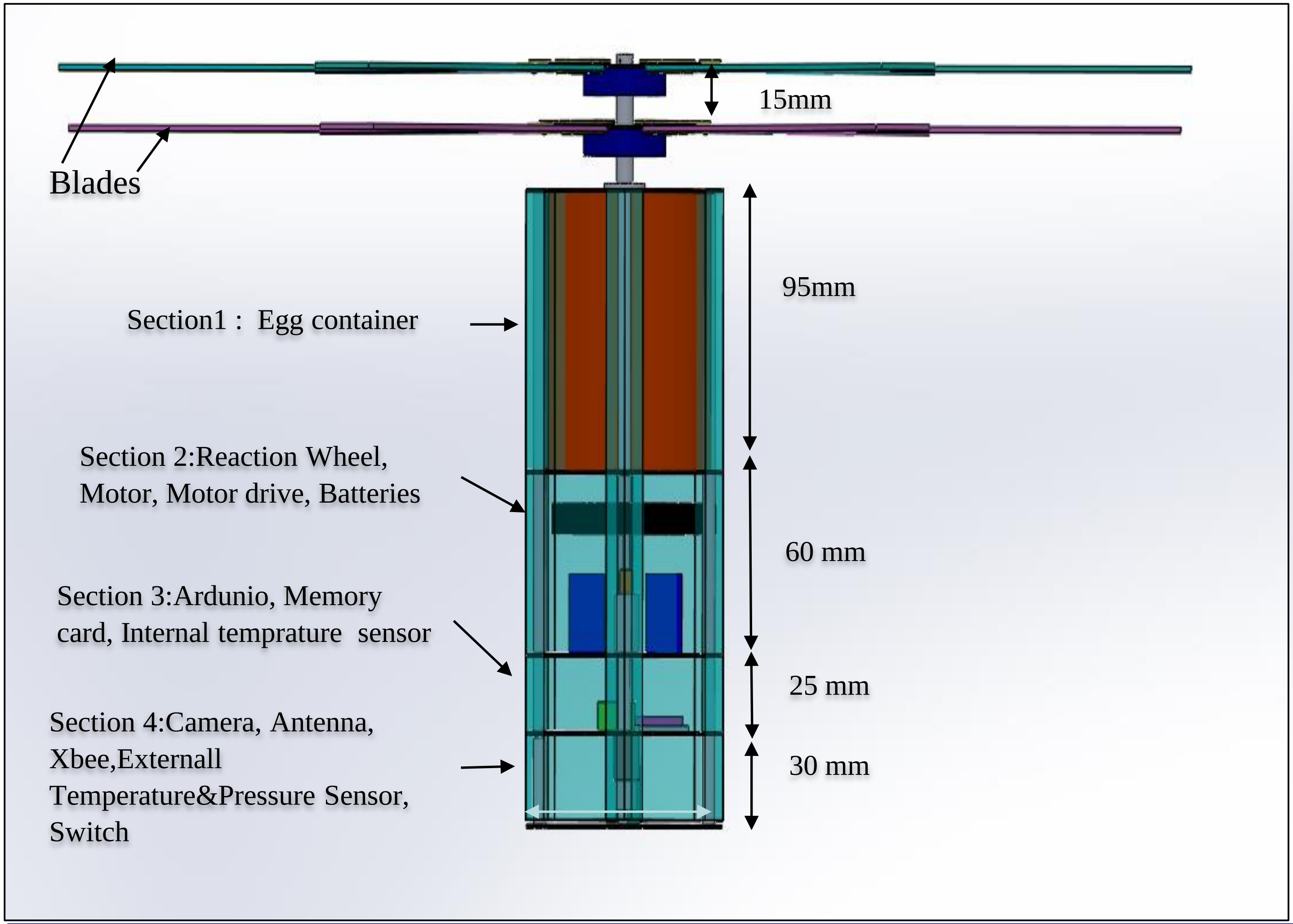
Science vehicle

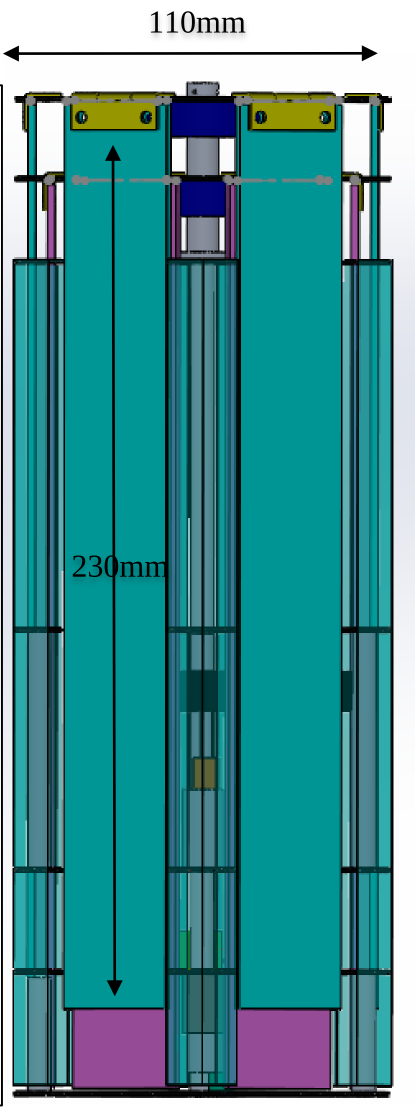


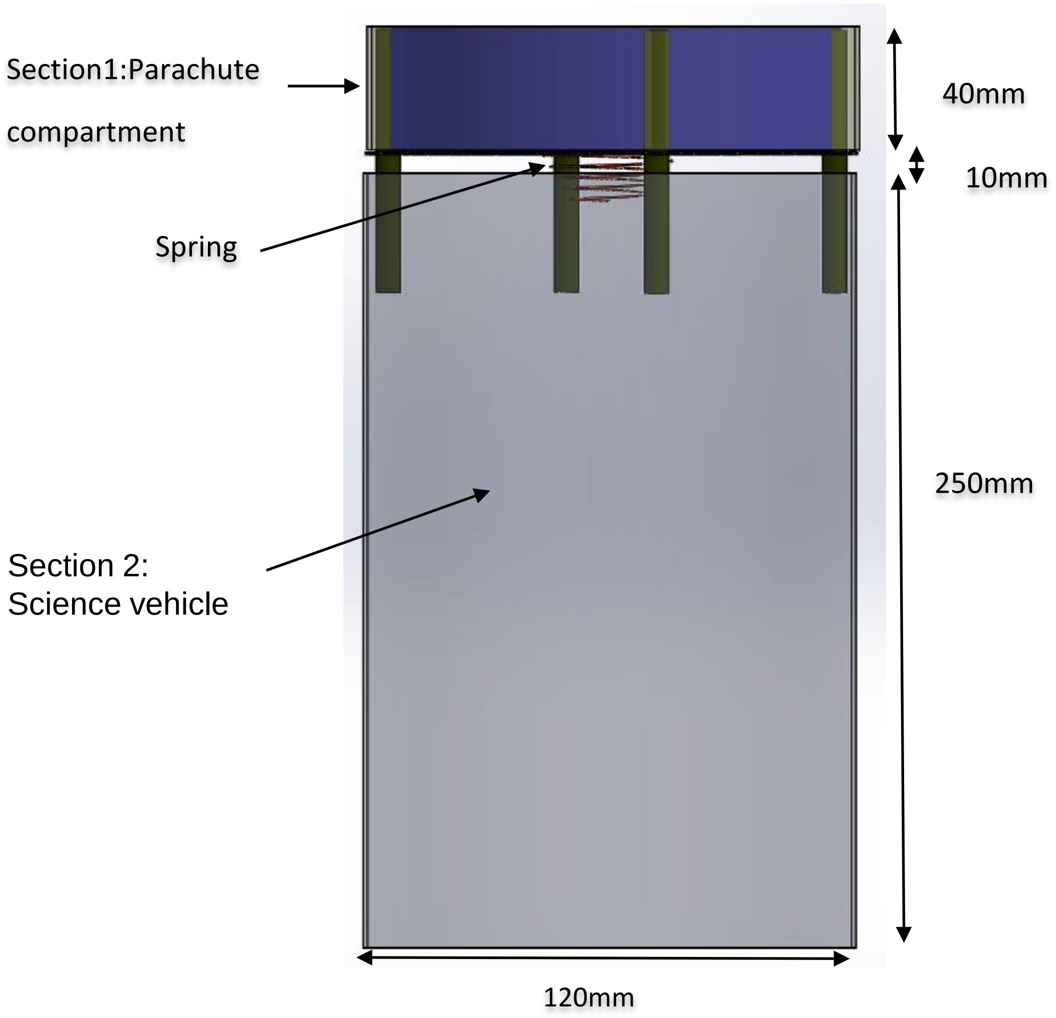
Science vehicle covering shell

Physical Layout

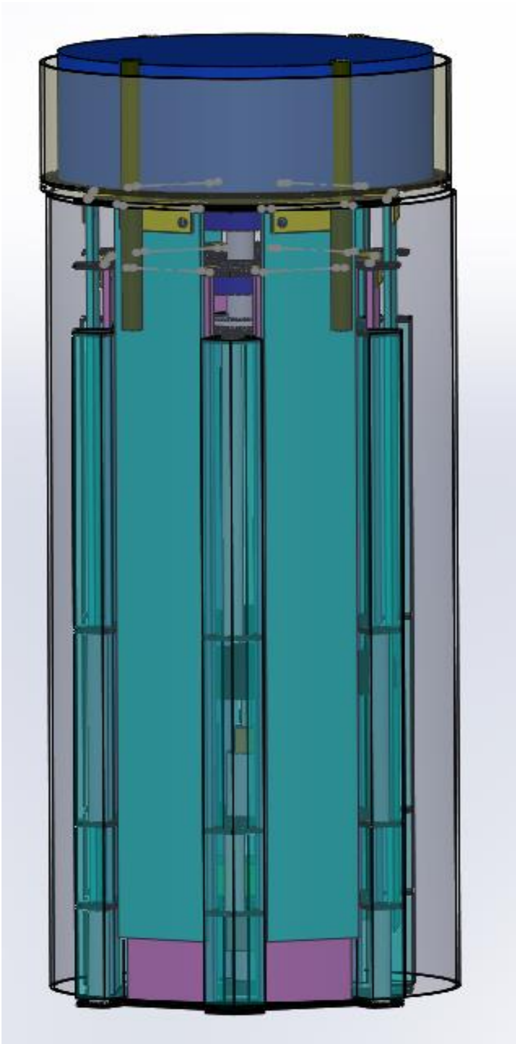
Science Vehicle







Section1:Parachute
compartment
Spring
Section 2:
Science vehicle
40mm
10mm
250mm
120mm



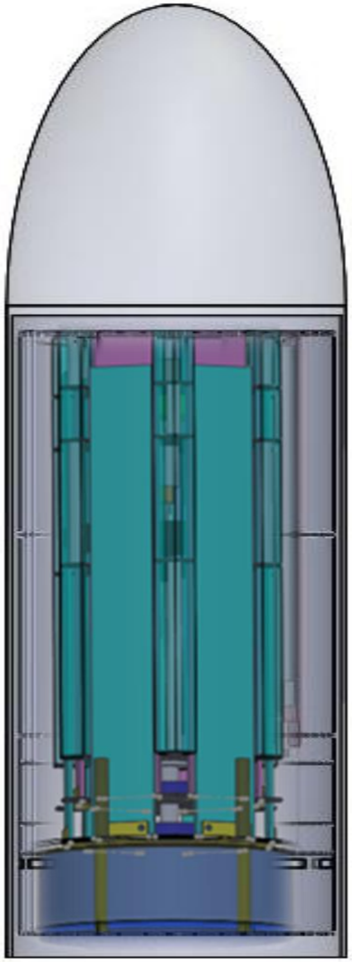
Launch Vehicle Compatibility

Diameter of CanSat: **120 mm**
Height of CanSat: **300 mm**

As seen from the dimensions and the scaled placement, the CanSat will easily fit into rocket payload according to given envelope dimensions (System Requirement 3, **125mmx310mm**)

There is also an offset left for easy deployment.

Descent control mechanisms are included in CanSat dimensions. With no change in design, it is compatible with the rocket payload section. A cardboard tube (same diameter and thickness with the rocket) can be used for testing prior to launch day.



Scaled placement in the rocket payload section

Sensor Subsystem Design

Doga Yucalan

Sensor Subsystem Overview

Telemetry Type	Parent System	Selected Component	Description
ALT	Science Vehicle	**Bosch** Digital Pressure Sensor – BMP183	For altitude calculation
TEMP	Science Vehicle	**Bosch** Digital Pressure Sensor – BMP183	For outside air temperature measurement
TEMP	Science Vehicle	**Maxim Integrated** Digital Thermometer – DS18B20	For inside air temperature measurement
CAM	Science Vehicle	**Omnivision** CMOS VGA CameraChip Sensor – OV7670	For ground imaging
GYR	Science Vehicle	**InvenSense** Motion Processing Unit – MPU-6050	For measuring 3-axial gyroscopic information
ACL	Science Vehicle	**InvenSense** Motion Processing Unit – MPU-6050	For measuring 3-axial acceleration
BUZZ	Science Vehicle	**Adafruit** 5V Buzzer – #1536	For recovery purposes

Sensor Changes Since PDR

Subject	Change	Previous Design	Rationale
Accelerometer	Accelerometer was changed to MPU-6050.	MPU-6000 was chosen for this purpose.	Unavailability of the sensor in breakout board.
Gyroscope	Gyroscope was changed to MPU-6050.	MPU-6000 was chosen for this purpose.	Unavailability of the sensor in breakout board.
Temperature Sensor	Outside air temperature sensor was changed to BMP183.	TMP35 was chosen for this purpose.	Due to the necessity of air contact, since BMP183 is together on the same board with the altitude sensor.
Temperature Sensor	Inside air temperature sensor was changed to DS18B20.	BMP183 was chosen for this purpose.	Availability of an appropriate sensor in hand.

Team Logo Here (If You Want)

Sensor Subsystem Requirements

ID	Requirement	Rationale	Parent	A	I	T	D
SEN1	During descent, the Science Vehicle shall collect air pressure (for altitude determination), outside and inside air temperature, and accelerometer (bonus) data.	Competition requirement	SR9	X		X	
SEN2	The Science Vehicle shall have a video camera recording time-stamped video of the complete descent. 1 hour of recording shall be supported.	Competition requirement	SR11	X			X
SEN3	Operating voltage range for all sensors must be between 2.5 – 5 V.	Due to power subsystem decisions	-	X	X		
SEN4	Temperature sensors must have a range of at least 0 – 50 °C.	Due to air conditions of launch location	-		X		
SEN5	Altitude measurement sensor (pressure sensor) must have a range of at least 80 – 110 kPa.	Due to maximum height the rocket reaches	-		X		
SEN6	Camera must have a resolution of at least 640 x 460 pixels.	Required for better view of the ground	-		X		
SEN7	3-axis gyroscope must have a range of at least ±360 dps.	Due to deployment and wind effects	-		X		
SEN8	3-axis accelerometer must have a range of at least ±1g.	Due to descent andwind effects	-		X		
SEN9	The Science Vehicle shall have an audio beacon. Its volume should be heard from --- meters.	For recovery purposes	SR19		X	X	

Altitude Sensor Summary

- Our final selection is **BMP183**.
- It is located on the Science Vehicle and known to use the pressure data to find the altitude.
- Its resolution is **1 Pa** and range is **30 – 110 kPa**.
- Its maximum conversion time of pressure is typically **3 ms** (maximum 4.5 ms) and rms noise is typically **6 Pa** in ultra low power mode which we will use.
- It uses **Serial Peripheral Interface** (i.e. SPI, four-wire interface). It will provide some **16 to 19 bit** pressure data.
- It includes a piezo-resistive sensor, an analog to digital converter and an EEPROM which gets the uncompensated data from the ADC and compensates the offset, temperature dependence and other parameters of the sensor using the stored 176 bit (11 x 16 bit) individual calibration data.
- The algorithm follows such a way: after the uncompensated temperature and pressure data is measured, the true temperature is calculated in EEPROM, since it is needed to find the true pressure. After finding the true pressure in EEPROM, the absolute altitude will be found in meters using the international barometric formula:

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

where p is the true pressure in hPa and $p_0 = 1013.25\,hPa$ is the pressure at sea level.

Outside Air Temperature Sensor Summary

- Our final selection is **<u>BMP183</u>**.
- It is located on the Science Vehicle.
- Its resolution is **0.1 °C** and range is **-40 – 85 °C**.
- Its maximum conversion time of temperature is typically **3 ms** (maximum 4.5 ms) and in standard mode which we will use.
- It uses **Serial Peripheral Interface** (i.e. SPI, four-wire interface). It will provide some **16 bit** temperature data.
- It includes a piezo-resistive sensor, an analog to digital converter and an EEPROM which gets the uncompensated data from the ADC and compensates the offset, temperature dependence and other parameters of the sensor using the stored 176 bit (11 x 16 bit) individual calibration data.
- After the uncompensated temperature and pressure data is measured, the true temperature is calculated in EEPROM using the following formula (taken from the datasheet of the sensor):

calculate true temperature

$$X1 = (UT - AC6) * AC5 / 2^{15}$$
$$X2 = MC * 2^{11} / (X1 + MD)$$
$$B5 = X1 + X2$$
$$T = (B5 + 8) / 2^{4}$$

- Please note that UT corresponds to the uncompensated temperature and AC5, AC6, MC, MD correspond to some of the calibration data stored in EEPROM. Here, we see T as the true temperature.

Inside Air Temperature Sensor Summary

- Our final selection is **DS18B20.**
- It is located on the Science Vehicle.
- Its resolution is **±0.5 °C** (corresponds to 9-bit resolution) and range is **-55 – 125 °C**.
- Its maximum conversion time of temperature is **93.75 ms**, when 9-bit resolution is selected.
- It communicates over a unique **1-Wire bus** and can provide 9-bit to 12-bit temperature measurements.
- It includes a temperature sensor, an 64-bit ROM, an EEPROM, a scratchpad memory to access to the (optional) alarm trigger system and the EEPROM, and a cyclic reduncancy check generator which checks if the data received is error free.
- The sensor can derive its power directly from the data line, hence, it needs no external power supply/cable to operate
- The output data of the sensor is calibrated in degrees Celsius and stored as a 16-bit sign-extended 2's complement binary number. Within the 16 bits, 5 most significant bits are sign bits. For 9-bit resolution, following 8 bits will be used and 3 least significant bits (2, 1 and 0) will be undefined. The algorithm for converting the output can be seen below. Note that T represents the temperature value; S represents the sign, 0 if positive and 1 if negative; and Bxx represent the bits (most significant is 15).

$$T = 2^6 B10 + 2^5 B09 + 2^4 B08 + 2^3 B07 + 2^2 B06 + 2^1 B05 + 2^0 B04 + 2^{-1} B03$$

$$S = \begin{cases} 0 \; if \; B15 + B14 + B13 + B12 + B11 < 3 \\ 1 \; else \end{cases}$$

Camera Summary

- Our final selection is <u>**OV7670**</u>.
- It is located on the Science Vehicle.
- Its active array size is **640 x 480**.
- It allows a maximum of 30 frames per second for VGA, we will use at least **7 frames per second**, which meets the requirement of minimum 7 frames per second.
- It uses **Serial Camera Control Bus** (SCCB) interface, which is known to be compatible with I2C interface.
- It includes an image sensor array, a timing generator, an analog signal processor, A/D converters, a test pattern generator, a digital signal processor, an image scaler and a digital video port.

3-Axis Gyroscope Sensor Trade & Selection

Module	Dimensions	Weight	Nominal Operating Voltage	Scale	Resolution	Data Interface	Cost
InvenSense MPU-6000	18 x 22 mm	1.4 g	2.375 – 3.46 V	± 500 dps	131 LSB/°/sec	I2C, SPI	$6.50
InvenSense MPU-6050	18 x 22 mm	1.4 g	2.375 – 3.46 V	± 500 dps	131 LSB/°/sec	I2C	$6.50
STMicroelectronics L3GD20H	30.65 x 19.11 mm	2.02 g	2.2 – 3.6 V	± 500 dps	17.50 mdps/digit	I2C, SPI	$12.50

Final selection: Invensense – MPU-6050 Motion Processing Unit

Reasons:

- Good accuracy
- Resistance to shock
- Availability

3-Axis Accelerometer Sensor Trade & Selection

Module	Dimensions	Weight	Nominal Operating Voltage	Scale	Resolutio n	Data Interface	Cost
InvenSense MPU-6000	18 x 22 mm	1.4 g	2.375 – 3.46 V	± 2 g	16384 LSB/g	I2C, SPI	$6.50
InvenSense MPU-6050	18 x 22 mm	1.4 g	2.375 – 3.46 V	± 2 g	16384 LSB/g	I2C	$6.50
Analog Devices ADXL345	25 x 19 mm	1.27 g	2.4 – 3.6 V	± 1.5 g	21.33 count/g	I2C	$16.95

Final selection: <u>InvenSense – MPU-6050 Motion Processing Unit</u>

Reasons:

- Good accuracy
- Resistance to shock
- Availability

Descent Control Design

Efe Camci

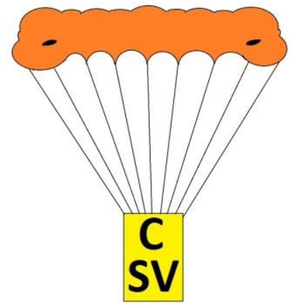
Descent Control Overview

- After the **separation from the rocket** at an altitude of around 700m, a **parachute** is deployed automatically (passively).
- The **separation** of the Science Vehicle **from the Container** is expected to occur at an altitude around 600m. The exact separation moment will be determined during flight, according to the pre-determined attitude stability criteria.
- After the separation, **the Container** will continue to descent with the very same **parachute**. The Science Vehicle will descent using an **auto-gyro** mechanism.
- The **auto-gyro** mechanism consists of 2 completely independent passive rotors, one below another. Each rotor has 6 blades. The rotors turn in opposite directions.
- The terminal velocities were estimated to be **6.5 - 7m/s** for the **Science Vehicle** and **4m/s** for the **Container**.

Descent Control Overview

Deployment from the rocket

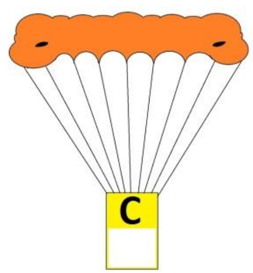
Altitude = 700 m

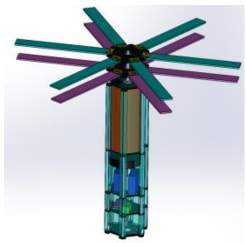


Container + Science Vehicle	Parachute

Altitude ≅ 600 m

Separation of Container & Science Vehicle





Container	Parachute

Science Vehicle	Autogyro and reaction wheel

Altitude = 0 m

Descent Control Changes Since PDR

Subject	Change	Previous Design	Rationale
Container Descent Strategy	Descent with 1 parachute	Descent with 2 parachutes with different diameters	To gain lighter, simpler and compact design
Parachute Type	Square shaped parachute with 4 holes at corners	Circular parachute with 1 hole at center	To achieve more stable descent

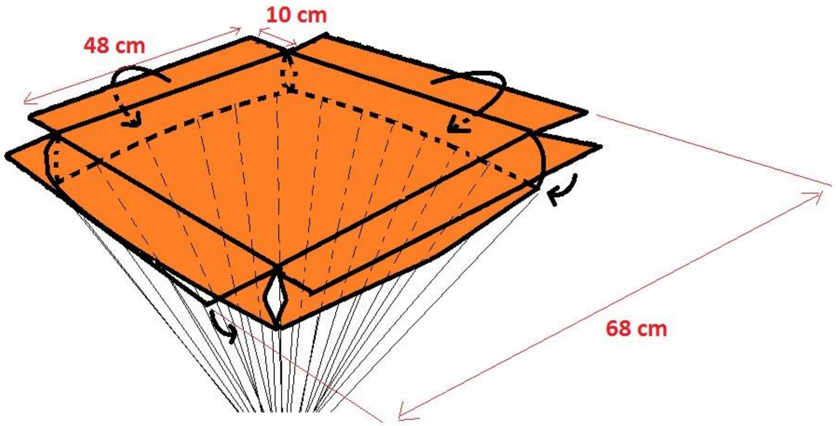
Descent Control Requirements

ID	Requirements	Rationale	Parent	A	I	T	D
DCR1	The Container shall use a passive descent control system. It cannot free fall. A parachute is allowed and highly recommended. Include a spill hole to reduce swaying.	Competition requirement	SR4		X		
DCR2	The Container or Science Vehicle shall include electronics and mechanisms to determine the best conditions to release the Science Vehicle based on stability and pointing. It is up to the team to determine appropriate conditions for releasing the Science Vehicle.	Competition requirement	SR10		X		
DCR3	The Science Vehicle shall use a helicopter recovery system. The blades must rotate. No fabric or other materials are allowed between the blades.	Competition requirement	SR11	X		X	
DCR4	All descent control devices & attachment components shall survive 50 Gs of shock.	Competition requirement	SR12 & SR13	X		X	
DCR5	The descent rate of the Science Vehicle shall be less than 10 meters/second and greater than 4 meters/second.	Competition requirement	SR29	X		X	

Parachute

- Square shaped with 4 holes
- Florescent orange coloured
- Made from parachute fabric
- The ropes are selected and stiched according to the shock constraints
- The deployment and the desired force was tested by releasing the container prototype from a certain altitude.
- **No active components in container DCS**

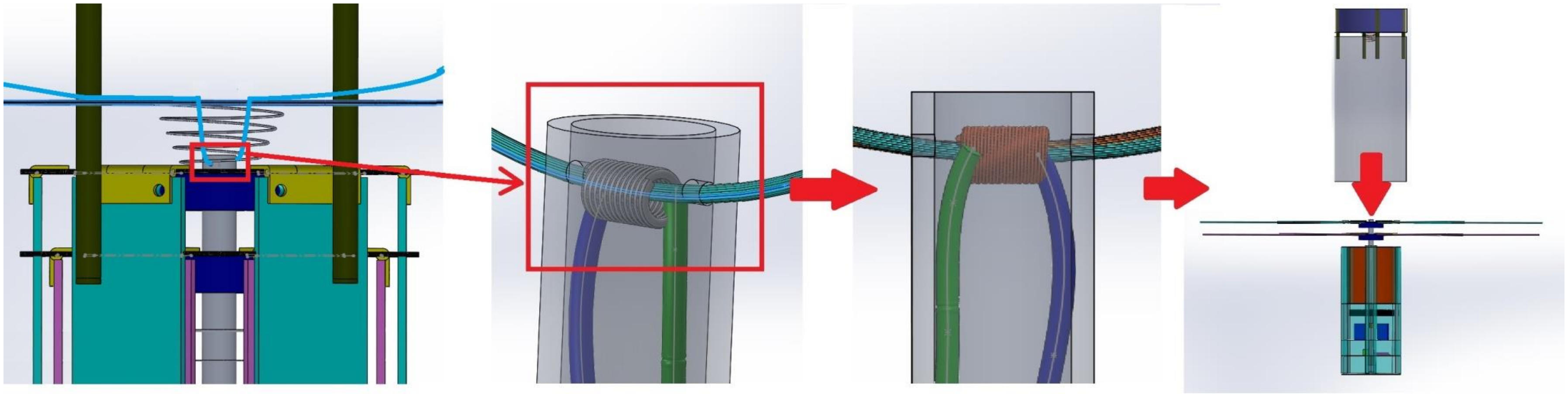
*Square shaped parachute with 4 holes



**Test pictures

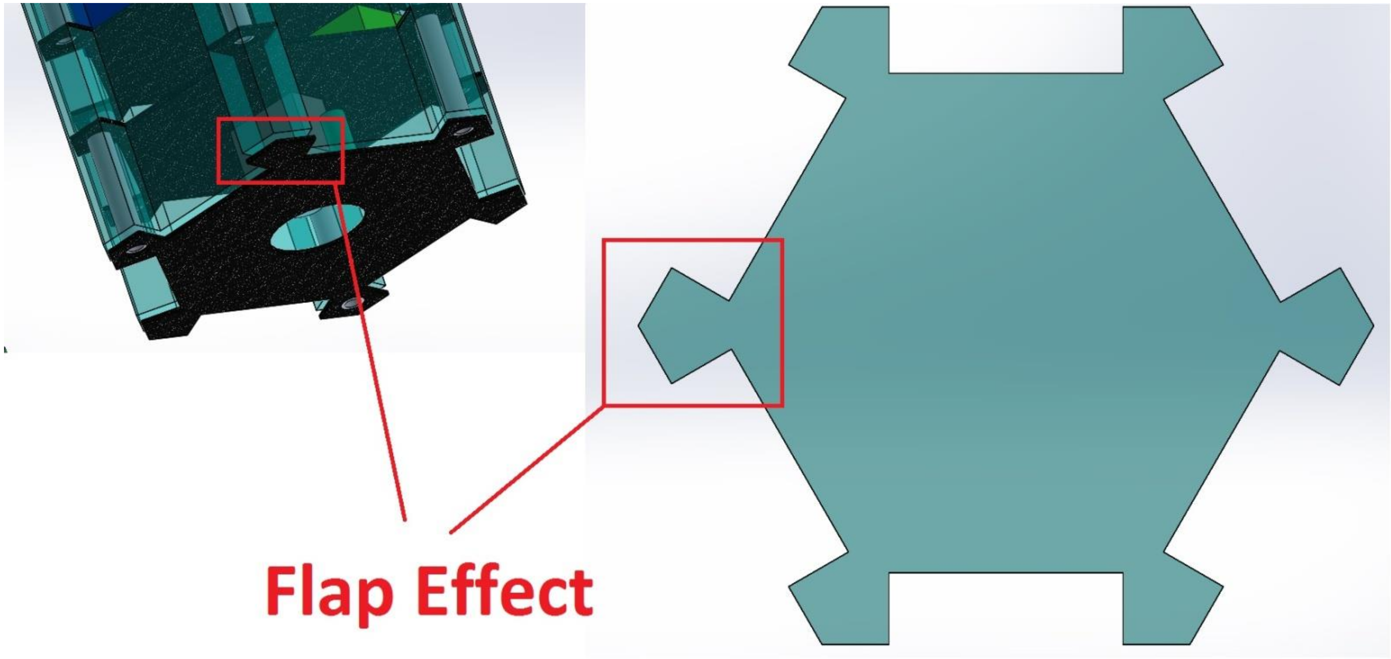
Wire Cutter and Separation Mechanism

- A thermo-resistive wire will be used to cut the rope for the deployment of the payload.
- The wire is enclosed within the shaft and is not exposed to the outside environment.
- The separation mechanism is activated according to the attitude stability and altitude.
- According to the conducted tests, the rope is cut within two seconds after the trigger.



Flap-like Structure

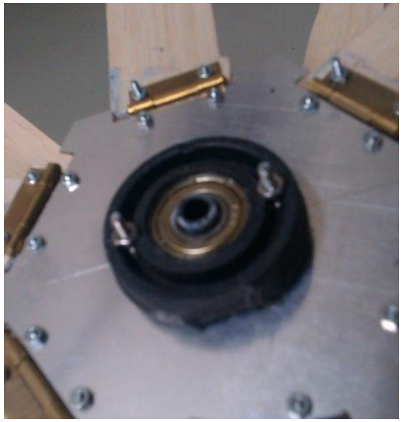
- Although there are no deployable flaps, the support rods covered with the shell create a flap-like effect naturally.
- These parts increase the air drag, thus, decrease the tilt and spin motion of the Science Vehicle.



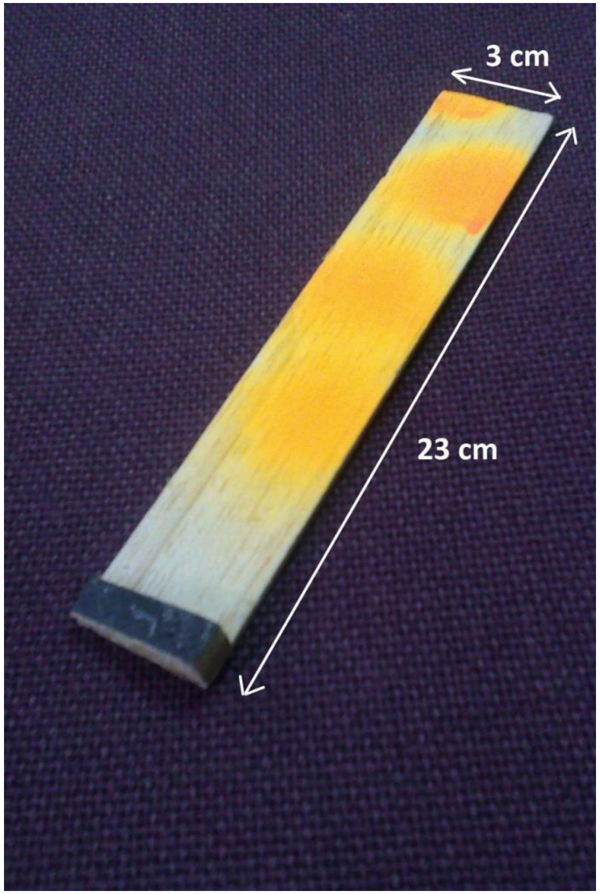
Rotors

- Rotor blades with span 23 cm and chord 3 cm
- Folded blades which open with spring hinges
- Made from balsa
- Florescent orange coloured
- 2 rotors turning independently and attached to the main shaft with roll bearings

*Spring hinge



**Roll bearing



***Rotor blade

Accelerometer and Gyroscope

- The accelerometer output provides the tilt measurement to trigger the separation.
- The gyroscope output provides the measurement to the reaction wheel which damps the spin during the descent.
- The range and accuracy of both sensors are given in the Sensor Subsystem trade and selection slides.
- The chip containing both sensors (MPU-6050) communicate over I2C interface and provides 16-bit measurements.
- Raw output data will be stabilized on-chip, using Digital Motion Processor (DMP) of the sensor.

$$\theta = \cos^{-1}\left(-\frac{X_{ac}}{\sqrt{X_{ac}^2 + Y_{ac}^2 + Z_{ac}^2}}\right)$$

*tilt formula

Reaction Wheel

- A 6V 1500 rpm DC motor is selected to turn the reaction wheel.
- The motor is driven by H-bridge (L293D chip). A PWM with frequency of 1 kHz and 8-bit duty cycle resolution is used to command the chip.
- Inertia of the wheel is estimated to be 0.000032 $kg \cdot m^2$.
- The angular momentum capacity of the wheel is more than enough to damp a spin of 60 rpm of the Science Vehicle with inertia 0.0004 $kg \cdot m^2$.
- The wheel is controlled by a PID controller implemented on the microcontroller, using the gyroscope for feedback.

Descent Rate Estimates

Container + Science Vehicle post separation

It is determined that the velocity should be 8 m/s above an altitude 600 m.

$$a = (2.W / C_d.\rho.V^2)^{0.5}$$

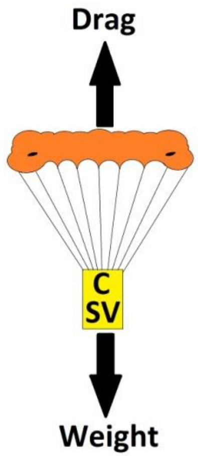
Total mass (with an egg) = 0.67 kg

It is assumed that air density (ρ) is 1.165 kg/m^3 at an altitude 600 m.

Cd = 1.0 for square shaped parachute

For the terminal velocity to be 8 m/s, the side length is calculated as:

a (side of the parachute) = 0.48 m



Container after deployment of the Science Vehicle

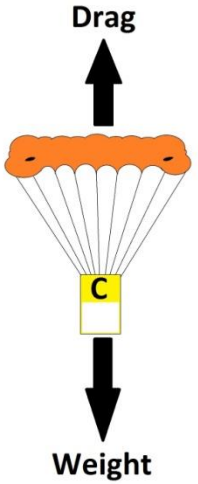
Container will descend with the same parachute.

$$V_c = (2.W / C_d.\rho.a^2)^{0.5}$$

Mass of the container = 0.095 kg

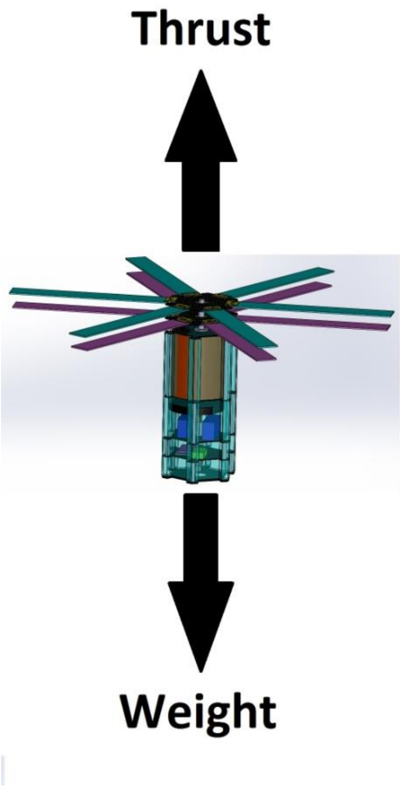
The terminal velocity for the container is calculated as:

$$V_c = 4 \text{ m/s}$$



Science Vehicle after separation from the Container

- Science vehicle starts its descent with 8 - 9 m/s velocity.
- Blades are opened, thrust force acts in the opposite direction of descent.
- Thrust includes lift & drag components in itself.
- Science vehicle decelerates until thrust and weight are balanced.
- After that time, science vehicle will continue its descent with approximately 6.5 - 7 m/s terminal velocity.
- Approach is based on changing rpm with constant pitch angle.
- Rpm firstly increases from 0, then decreases to a terminal value.
- Thrust created increases with speed until it is equal to weight.
- For 0,57 kg mass to be balanced, 5,5 N thrust is needed.

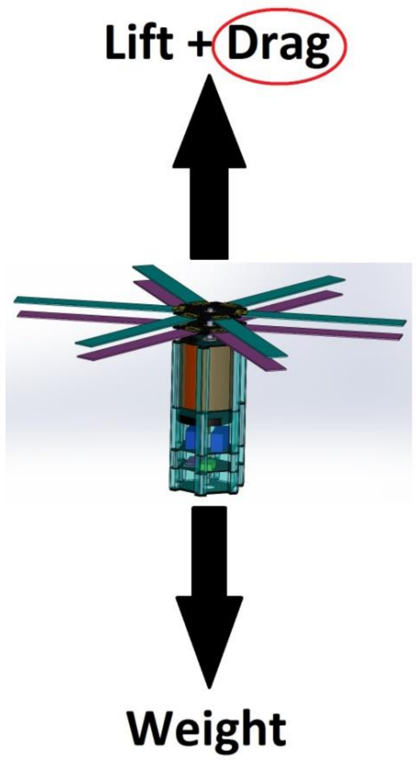


Science Vehicle after separation from the Container

- Firstly, drag component of the thrust is calculated.
- Cd = 1.28 for flat plate
- Results yield as:

Velocity (m/s)	Drag (N)
10	**6,05**
9	**4,90**
8	**3,87**
7	**2,97**
6	**2,18**
5	**1,51**

*These values are obtained by Excel sheet we created.



ANNUAL CANSAT COMPETITION

Science Vehicle after separation from the Container

- An Excel spreadsheet which can read airfoils as input is created for calculations.
- The sheet calculates rotor behaviour (i.e. thrust, power, rpm, induced velocity).
- The sheet uses Blade Element Theory.
- Many airfoils (S809, Boeing VR-7, NACA 0012, flat plate A/F etc.) with different pitch angles were analyzed.
- Since the span value is not large, the airfoil effect is dispensable.
- Considering ease of manufacturing, **flat plate A/F** was chosen and related rotor behaviour is given as:

Velocity (m/s)	rpm	Thrust (N)
10	≅ 3500	**23,72**
9	≅ 2800	**14,36**
8	≅ 2400	**9,01**
7	≅ 2100	**6,91**
6	≅ 1900	**5,93**
5	≅ 1800	**5,24**

*These values are obtained by Excel sheet we created.
**Rpm values are the lowest required values in order not to stall the blades.

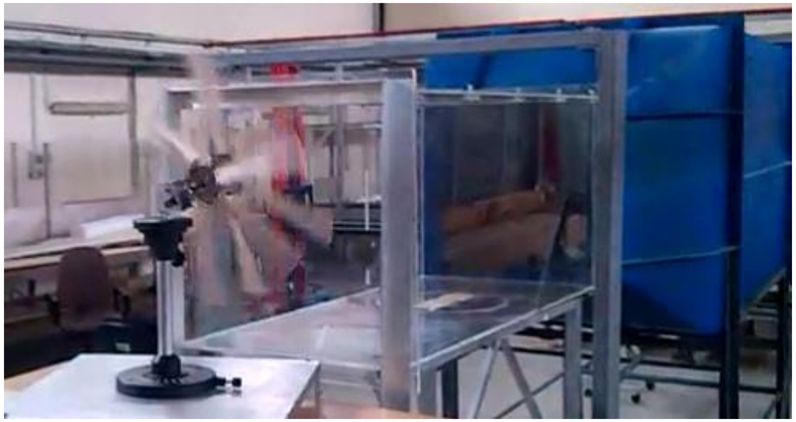
Science Vehicle after separation from the Container

- In order to validate our calculations, wind tunnel test was done.
- With a pitch angle about 10°-12°, results are obtained as:

Velocity (m/s)	Thrust (N)
10	**7,76**
9	**8,22**
8	**8,35**
7	**6,93**
6	**5,61**
5	**4,52**
4	**3,47**

*These values are obtained by wind tunnel tests.

- For 0,57 kg weight to be balanced, approximately 5,5 N thrust is needed.
- Wind tunnel results differ from calculations (desired rpm may not be reached or tip losses etc.)

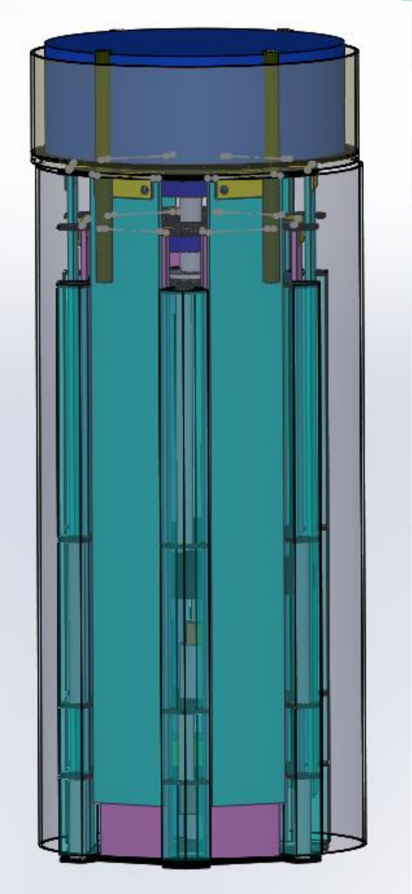


Mechanical Subsystem Design

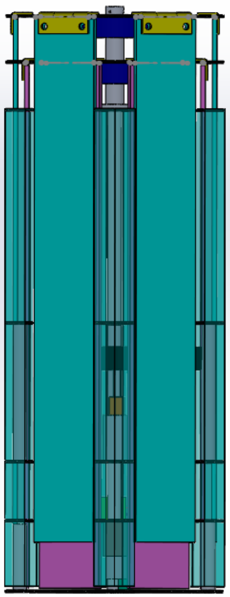
Munire Gulay Senol

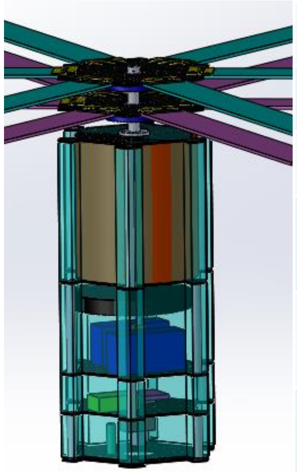
Waheedullah Taj

Mechanical Subsystem Overview



Container	
Structural Elements	
Element	**Material**
Bar	Aluminum
Plate	Carbon Fiber
Cover Shell	Plastic
Parachute	Fabric
Interface Elements	
Element	**Material**
SV+Container	Rope





Science vehicle	
Structural Elements	
Element	**Material**
Bar	Aluminum
Plate	Carbon Fiber
Cover Shell	One sheet fiber glass composite
Blade	Balsa
Egg Container	Sponge + Plastic Cover
Interface Elements	
Element	**Material**
Hinge	Metal
Rotor+Shaft	Superior glue adhesive
Hinge+Blade interface	Screw
Shaft+structure interface	Screw

Mechanical Subsystem Changes Since PDR

Subject	Change	Previous Design	Rational
Plate Material	Carbon fiber	Aluminum	Lower weight, higher strength
Number of Rods (container)	4 rod	3 rod	To tie equidistantly for 4 rope
Number of Rods (science vehicle)	12 rod short	3 rod long	To disassemble and assemble part by part easily
Covering shell	Carbon and glass fiber composite	Plastic	Easy shaping and light weight
Seperation Mechanism	Wire cutter + spring	Wire cutter	To guarantee separation if parachute fails

Mechanical Sub-System Requirements

ID	Requirement	Rationale	Parent	A	I	T	D
MR 1	Total mass of the CanSat (Container and Science Vehicle) shall be 600 grams +/- 10 grams not including the egg.	Competition Requirement	SR1	X		X	X
MR 2	The Science Vehicle shall be completely contained in the Container.	Competition Requirement	SR2	X		X	X
MR 3	The Container shall fit in the envelope of 125 mm x 310 mm. Tolerances are to be included.	Competition Requirement	SR2	X		X	X
MR 4	The Container shall not be able to get stuck in the rocket.	Competition Requirement	SR4				X
MR 5	The Container shall be a florescent color, pink or orange.	Competition Requirement	SR5				X
MR 6	The CanSat should be compliant with the environmental requirements (shock, acceleration and temperature).	Competition Requirement	SR7	X			X
MR 7	The Science Vehicle shall hold one large raw hen's egg which shall survive launch, deployment and landing.	Competition Requirement	SR16		X	X	X
MR 8	The heating based components shall not be exposed to the outside environment.	Competition Requirement	SR8	X	X		

Egg Protection Overview

The selected egg protection system consists of a visco-elastic sponge and container.

Egg container is made of plastic cover filled with visco-elastic sponge.

- ➢ Visco-elastic material resists shear flow and strain linearly with time when a stress is applied.
  1. To decrease the stress transformed to egg.
  2. To prevent vibration inside egg container.
  3. To absorb the force.
- ➢ Container is made from rigid plastic. Shape is cylindrical.
  1. The stress is transferred through the cover.
  2. The rigid plastic ensures to stand still.

Advantages:

- Low complexity.
- Low weight.
- Inexpensive.
- Readily available

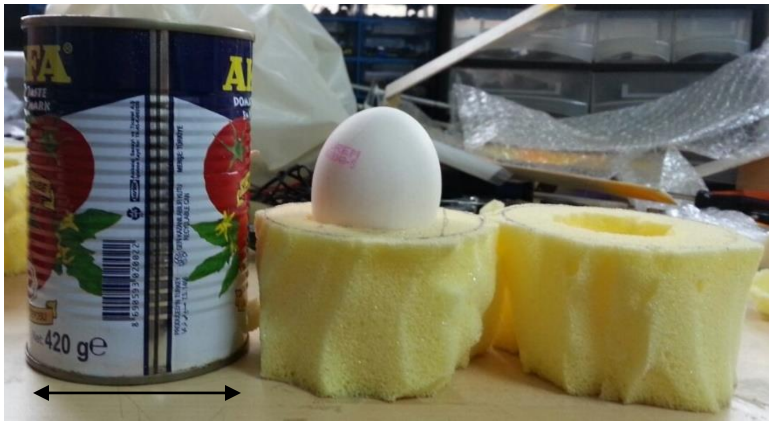
✓ The egg will be placed upside down, the pointy side down.

In this way, the pressure on the egg is less, and the layout increases the robustness against breaking.

✓ Egg protection section is placed between rotor section and reaction wheel compartment. Thanks to egg protection location, egg will not be exposed to shock too much.

Egg Protection Overview

95 mm

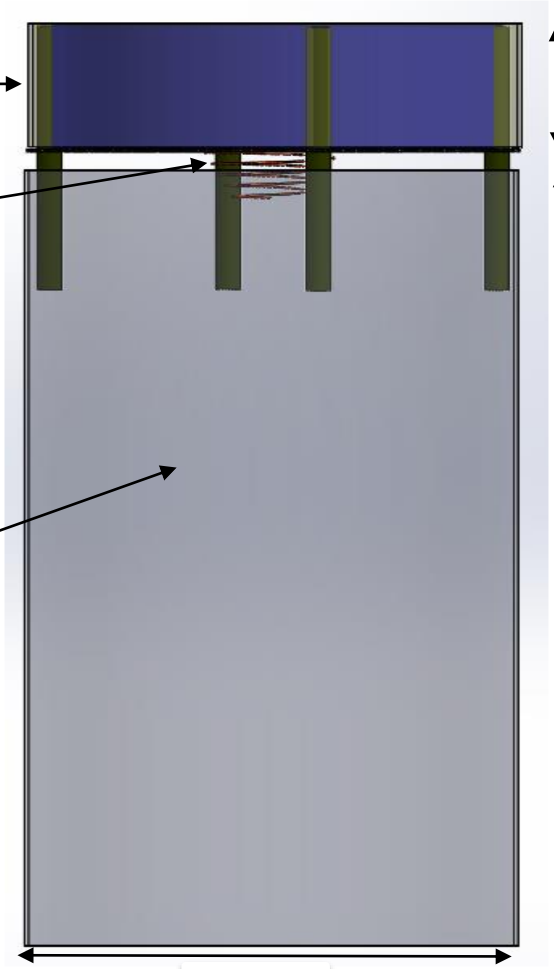


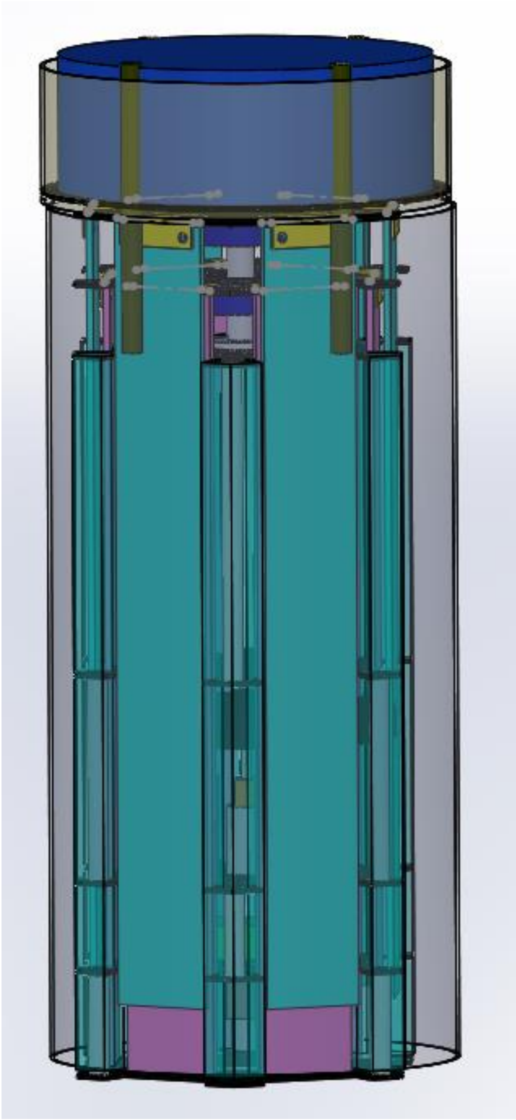
70 mm

- ✓ The egg protection system was tested by being dropped on solid surfaces from different heights and calculating impact velocities and accelerations.
- ✓ The results of the test can be seen in the table below.

Test number	Height (m)	Impact velocity (m/s)	Stopping time (s)	Acceleration	Result
1	1	4.4	0.05	8.98 g	No crack
2	2	6.26	0.05	12.76 g	No crack
3	3.2	8	0.05	16.3 g	No crack
4	5	10	0.05	20.36 g	Cracked

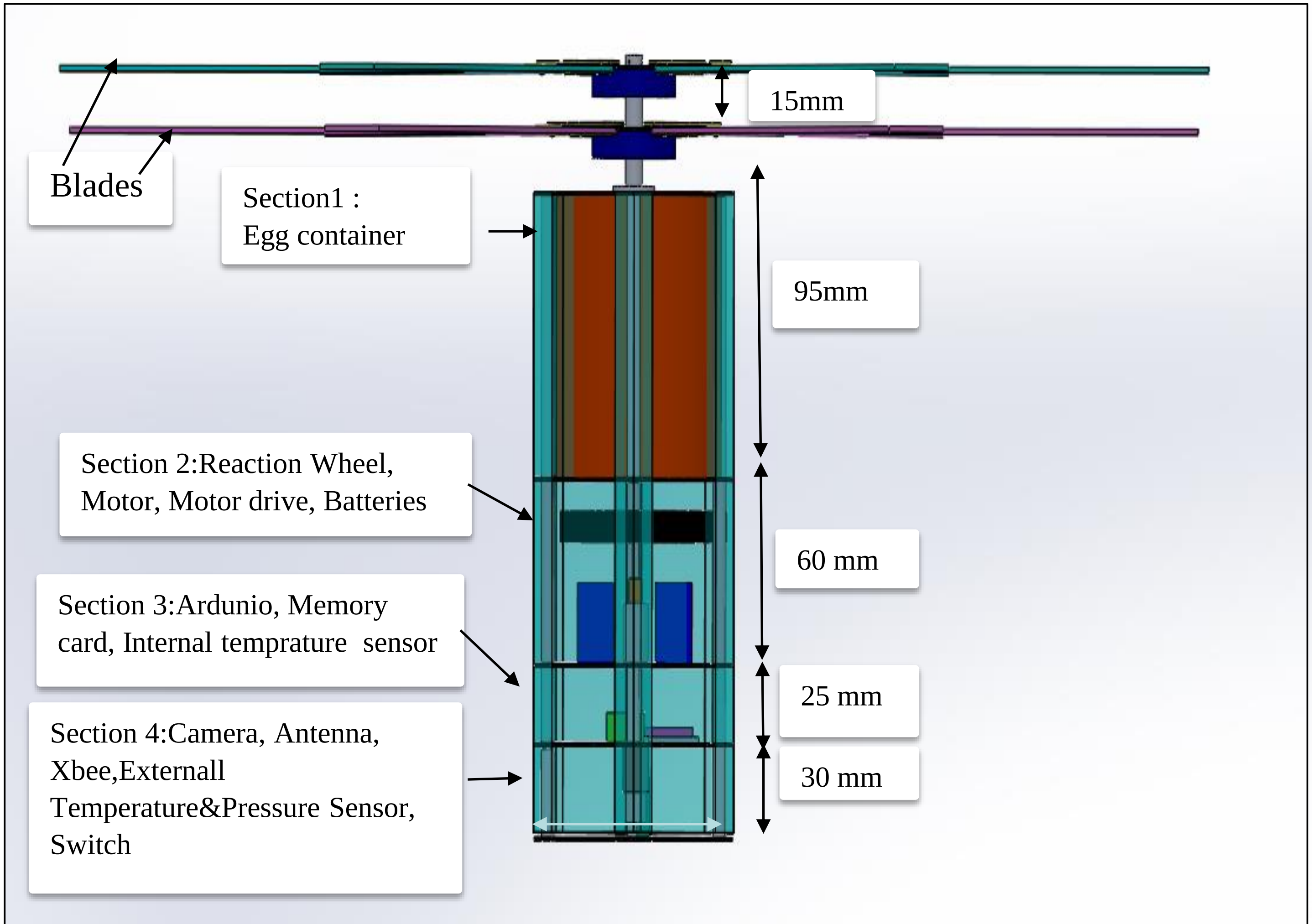
Container

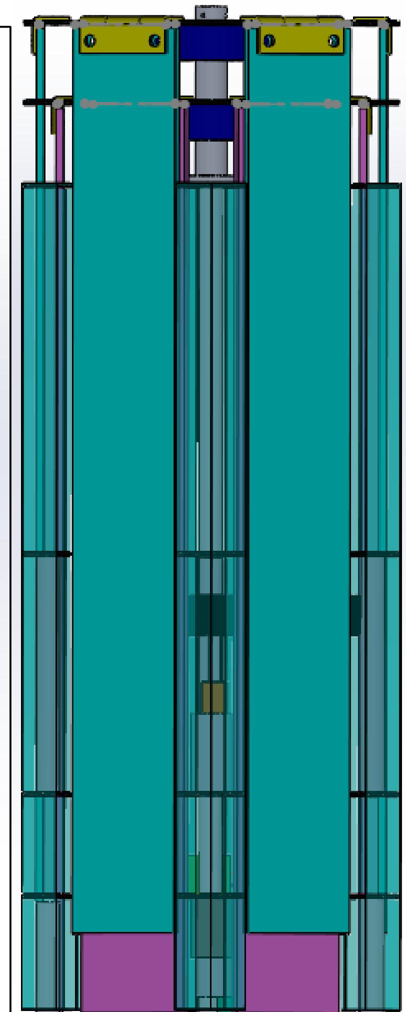

Section1:Parachute compartment
Spring
Section 2:
Science vehicle
40mm
10mm
250mm
120mm



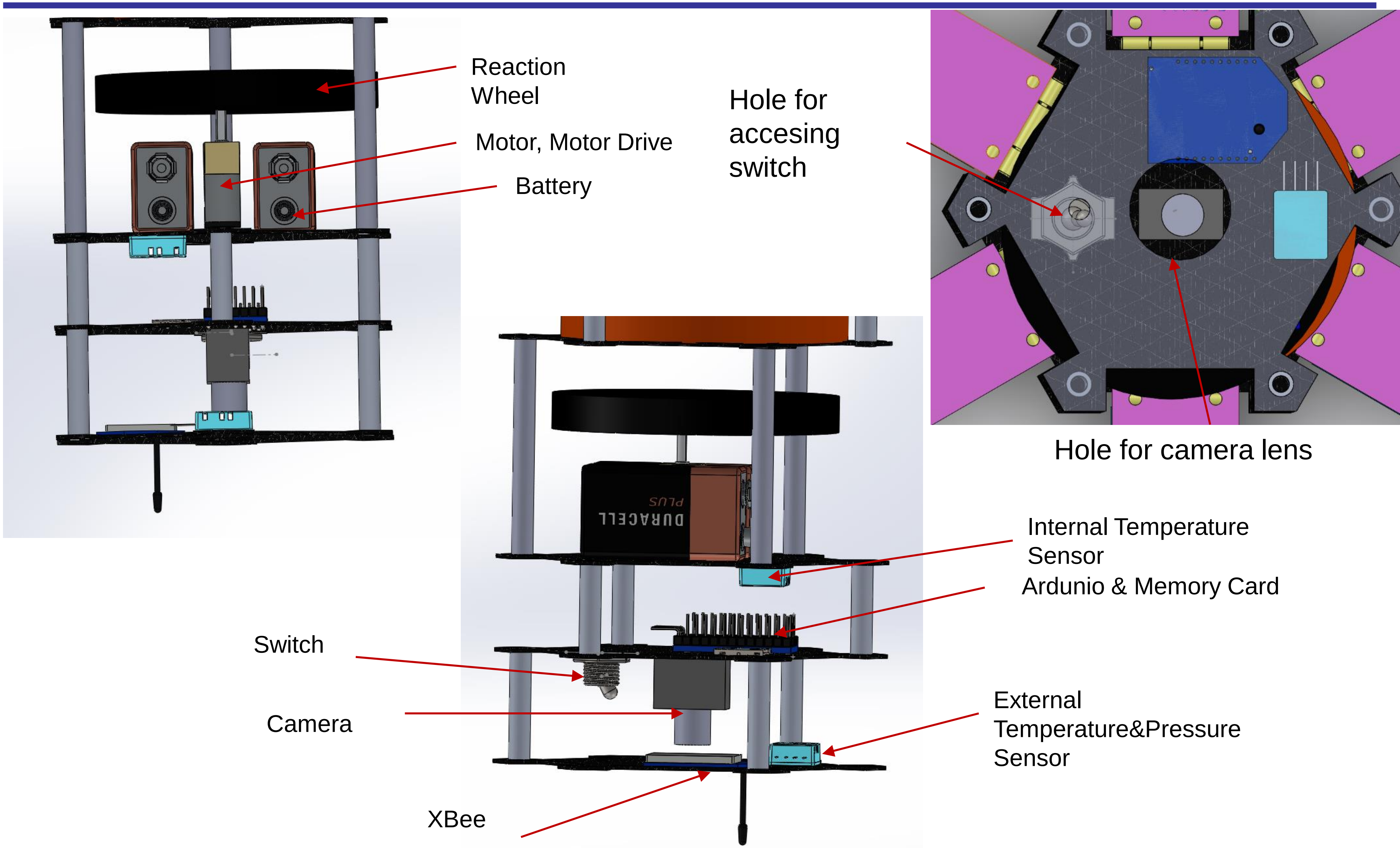
Mechanical Layout of Components

Science Vehicle





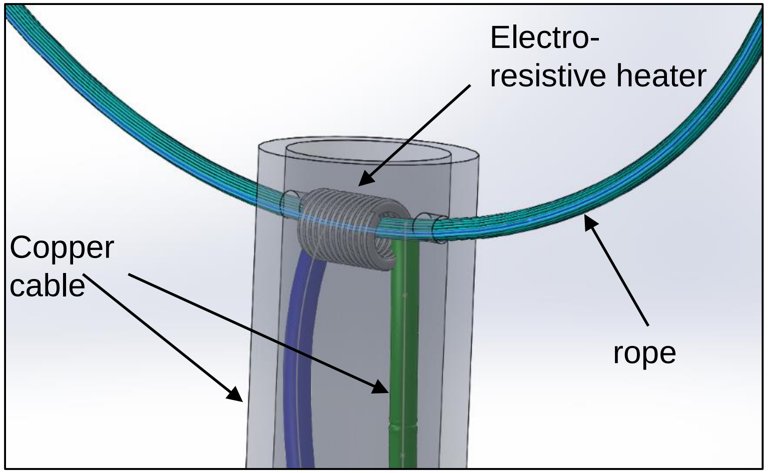
Mechanical Layout of Components



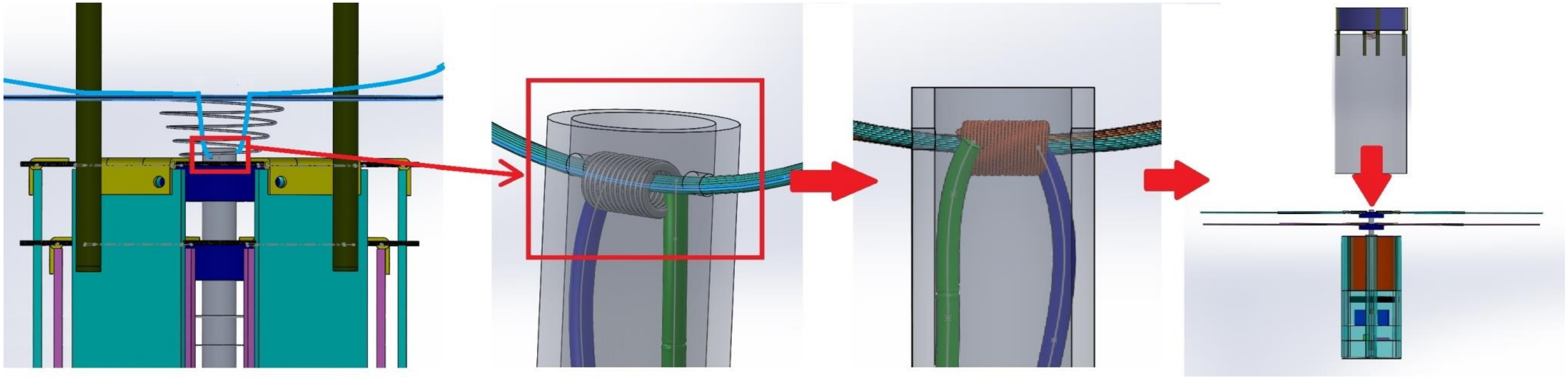
Material Selections

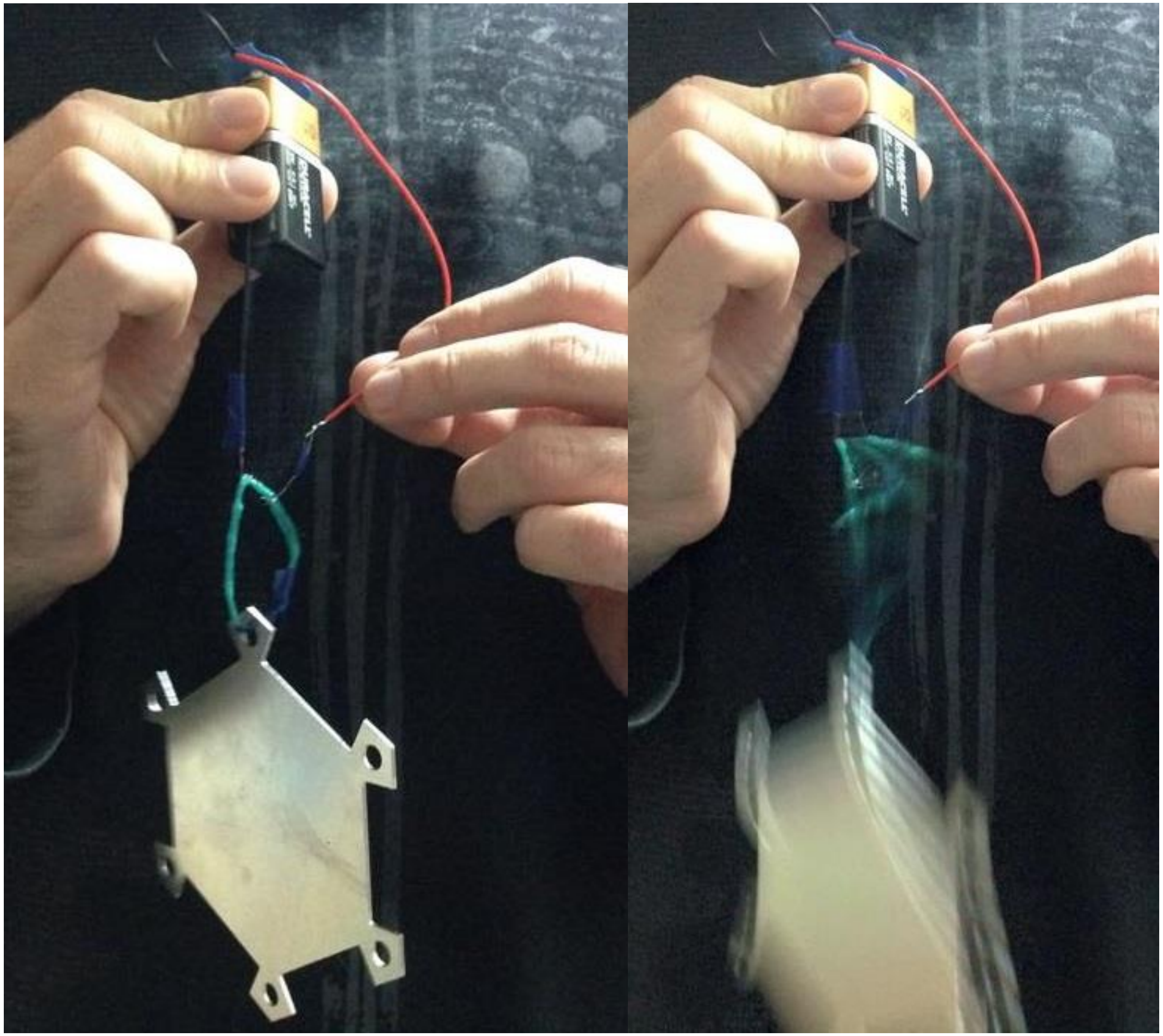
Component	Material	Reason
Covering shell of container	Carbon fiber composite	- Lightweight - Resistance to fragility - Simple, cheap - Feasible structural integrity
Covering shell of science vehicle	Fiber glass composite	-Easy shaping,light weight
Plates	Carbon Fiber Plate	-Very low weight and high strength
Bars	Aluminum	- Density near 2.70 $g \cdot cm^{-3}$ - Aluminum alloys commonly have tensile strengths of between 70 and 700 MPa. The range for alloys used in extrusion is 150 – 300 MPa. - Lightweight - Strong
Blades	Fiber glass reinforced balsa	- High strength / weight ratio - Strength : 11.6 Mpa - Density: 150 kg/m^3 - Lightweight
Egg container	Plastic	-Low weight
Egg protection (inside egg container)	Visco elastic sponge	- Absorbs the induced vibration, stress and shock effectively - Low weight

Container - Payload Interface



- Wire cutter is be placed inside the main rotor shaft
- Shaft will isolate the electro-resistive heater from SV
- 2 rope will hold the SV inside the container
- Heater will be wraped around the ropes
- Ropes will pass through the conic spring and will be linked to the container rodes





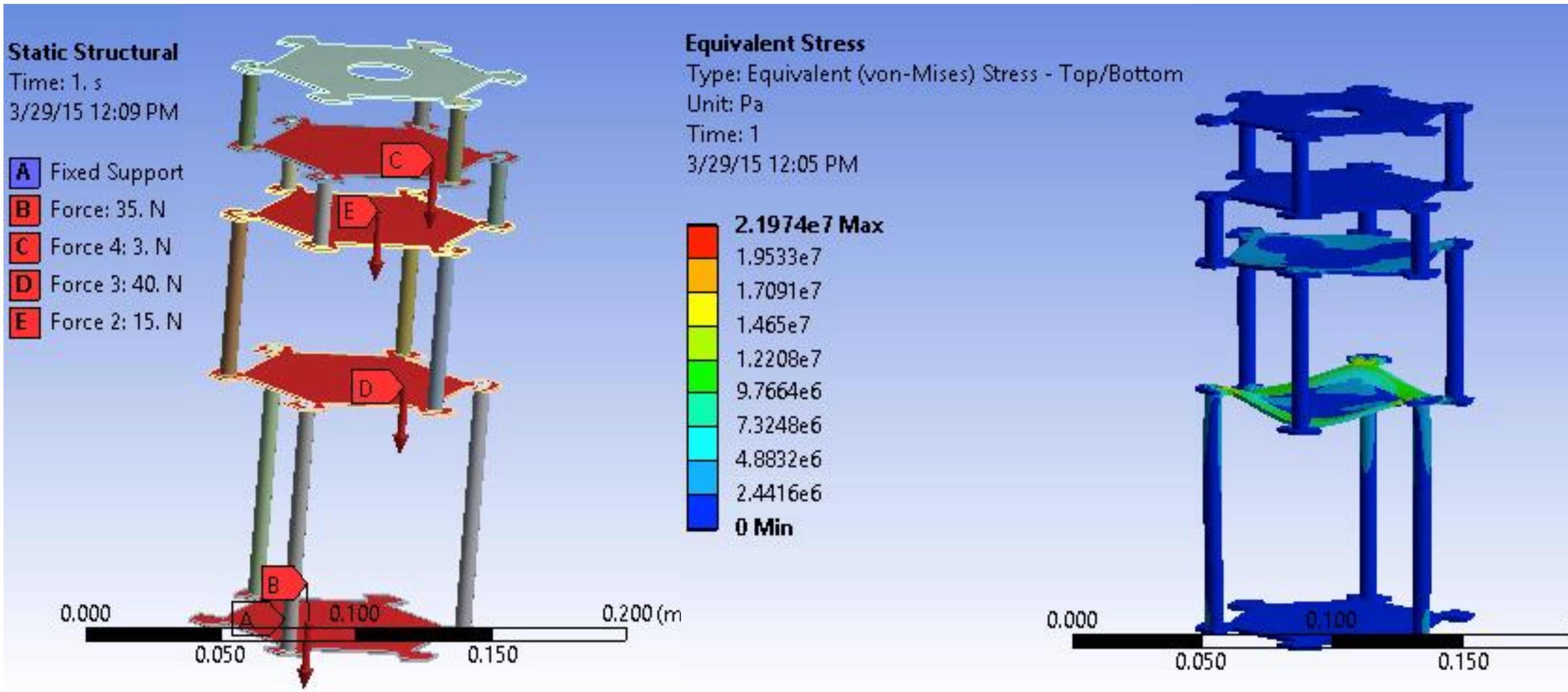
- By using a 9V battery wire cutter was tested and the rope(nylon rope with diameter about 1mm) was cutted in less than 1 second

Structure Survivability

- **For both Container and Science vehicle**:
  - Electronic components will be soldered on a PCB which will be bolted to the structure (plate) for robust mountings.
  - Electronic connections will be isolated if a short circuit risk is identified.
  - For electronic card, screws and nuts will be hot glued to prevent to get harm due to vibration.
  - Electronic components will be enclosed within the science vehicle by a covering shell and there will be no direct exposure to environment.
  - Covering shells are designed such that the shell is easily removable in order to allow preflight inspection.
  - Parachute and payload blades are tested in wind tunnel and design optimization is carried out to ensure the desired descent rate is acieved and the structure can survive any perturbation or abnormal situation during flight.

Structure Survivability

- All structural components are designed to survive accelerations of 15g and shocks of 30g magnitude. Results of finite element analysis in Ansys can be seen below:



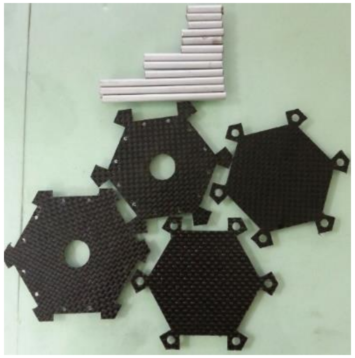
As can be seen from the figures, the maximum equivalent stress in the structure is around 22 Mpa for carbon fiber reinforced material and 15 Mpa for aluminum. These values are below yield strength of the respective materials (20 MPa for Aluminum and 110 Mpa), thus the structure is safe.

Mass Budget

Container		
Elements	**Weight (g)**	**Source**
Carbon-fiber plate	15 g	Measured
Alumium bars	17 g (total)	Measured
Parachute	30 g	Measured
Estimated total mass off container	62 g	Sum
Science vehicle		
Elements	**Weight (g)**	**Source**
Carbon-fiber plates	41 g (total)	Measured
Aluminum bars	32 g (total)	Measured
Rotor (Blades&Shaft&Bearings+Hinges)	120 g (total)	Measured
Egg protection	40 g	Measured
Battery	90 g (45x2)	Product catalog
Reaction Wheel	50 g	Estimated
Motor	10 g	Product catalog
Covering shell	65 g	Estimated
Electronics (Ardunio, Xbee, Sensors etc.)	40 g	Product catalog
Estimated total mass of science vehicle	488 g	Sum

Container + SV = 550 g
Interface Elements is assumed to be 20g
Container + SV+ Interface Elements= 570g
Mass margin=30±10g

Here the mass of Interface Elements (screws, nuts, ropes, wires, cables, glue, silicon etc.) is not included. After the integration of CanSat, we will measure the final mass and include or exclude extra items if the total mass is not 600 +/- 10 gr without the egg

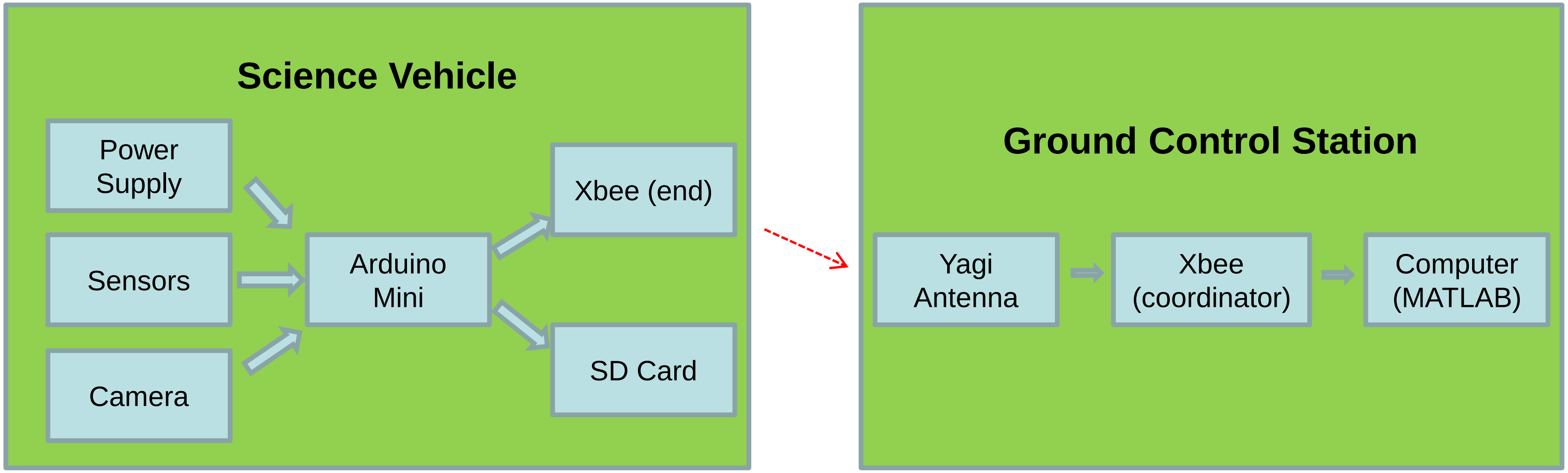


Communication and Data Handling Subsystem Design

Baran Bodur

CDH Overview

Container	Science Vehicle	Ground Station
Passive	Arduino Mini for controlling the Science Vehicle	External antenna for additional gain
	Sensors to measure data and send it to Arduino	An Xbee to receive data
	SD Card for storing camera image and sensor data	GCS Software to interpret and graph data
	Xbee for sending required telemetry	



CDH Changes Since PDR

Subject	Change	Previous Design	Rationale
Memory	Micro SD card	SD Card XL	Compatibility with Arduino SD card shield
Processor Interface Number and Types	12 Digital, 7 Analog Pins (Arduino mini)	7 Digital, 6 Analog Pins (Arduino mini)	Change in used sensors and added utilities

CDH Requirements

ID	Requirement	Rationale	Parent	A	I	T	D
CDH1	During descent, the Science Vehicle shall collect and telemeter necessary data.	Competition Requirement	SR9				X
CDH2	The Science Vehicle shall transmit telemetry at a 1 Hz rate.	Competition Requirement	SR9			X	X
CDH3	Telemetry shall include mission time with one second or better resolution, which begins when the Science Vehicle is powered on.	Competition Requirement	SR9			X	X
CDH4	XBEE radios shall be used for telemetry.	Competition Requirement	SR10		X		X
CDH5	XBEE radios shall have their NETID/PANID set to their team number.	Competition Requirement	SR10				X
CDH6	XBEE radios shall not use broadcast mode.	Competition Requirement	SR10		X		X

CDH Requirements

ID	Requirement	Rationale	Parent	A	I	T	D
CDH7	Telemetry Format should be satisfied.	Competition Requirement	-		X		X
CDH8	Total information in one package should be less than 100 bytes.	Due to maximum package size	-	X			
CDH9	Link budget should be satisfied with at least 15 dBm margin for a 1.5 km range.	For maintaining communication	-	X			
CDH10	Microprocessor should have necessary amount of interfaces.	For controlling the Science Vehicle	-		X		
CDH11	Mission time shall be kept by an external RTC or by the software.	Competition Requirement	-		X	X	X
CDH12	There should be enough memory to save camera footage.	Competition Requirement	SR11	X		X	
CDH13	There should be enough memory to save sensor data.	In case of system reset or communication failure	SR17	X		X	

Processor & Memory Selection

- **We will stick to our plan so, we will use Arduino Mini 05 as a microprocessor, its properties can be seen below**

Weight and Size	Power	Interfaces	Speed	Price
2g 18 x 30 mm	5-9V, 250 mA max 1.25 W	14 Digital I/O (with 6 PWM) 8 Analog In (2 I2C)	16MHz	$12.95

- **The type and amount of interfaces can be seen in the following slide**

Processor Trade and Selection

Microprocessor Interface Budget

- 2 Digital Pins (1 PWM) output for controlling the motor of the reaction wheel
- RX, TX and 1 Digital Pin to communicate with XBee
- 1 Digital Pin to activate wire cutter (for separation)
- 1 Digital Input for DS18B20 Temperature Sensor
- 1 Analog Input to measure battery voltage via voltage division
- 1 Analog Input to measure back emf of the motor
- 2 Analog (I2C)and 1 digital pins for OV7670
- 4 Digital Pins (1 PWM) for SD Card
- (4) Digital Pins for BMP183 pressure and temperature sensor (same pins above)
- (4) Digital Pins for MPU6050 accelerometer and gyroscope (same pins above)
- 2 Analog Inputs for DS1307 RTC
- 1 Digital Pin for Buzzer

A total of

- 12 Digital(2 PWM, RX, TX) and 7 Analog(2 I2C) pins are necessary for our purposes.

Memory

- Memory required for all telemetry is 69 byte/s. This corresponds 245 KB for one hour of operation.
- Camera is 8 bits, 25 frame/s, and has a resolution of 640 x 480 , this corresponds to 25 GB memory requirement for one hour of recording.
- We will use an 32 GB micro SD card for memory.
- Its trade off was shown in PDR, only type of SD card was changed due to compatibility with Arduino.

Memory Type	Voltage	Power	Memory	Price
Micro SD card	2.7-3.6 V Will be operated at 3.3 V	200 mA write current so, 0.66 W	32 GB	15 $

Real-Time Clock

- Container will be passive so, no real-time clock there.

- DS1307 hardware real-time clock will be used for the Science Vehicle.

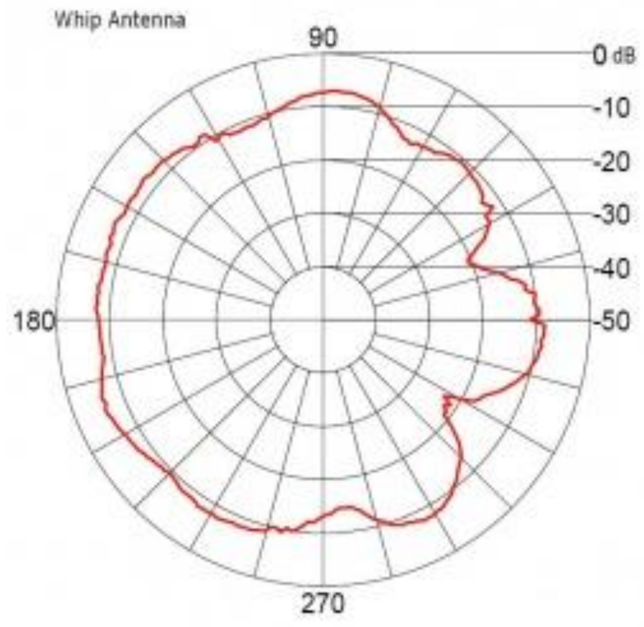
RTC	Mass and Size	Power Consumption	Price	Accuracy	In System Reset
Hardware DS1307	1g 10.16 x 6.60 x 3.56 mm	3V 800 nA (in battery mode)	$13.4	±20 ppm	Reading continues through external hardware

- Using software timekeeping will cause low accuracy and less reset tolerance. In a reset, the error in new time cannot be known.

- By using a hardware real time clock, the mission time will continue normally even the microprocessor resets.

Antenna Selection

- There is not a change in our antenna selection since the PDR, we will use XBee Model coming with a wire antenna for the science vehicle since its cheap, light, small and have a good gain.
- XBee in Science Vehicle will be at the bottom and wire antenna will be just out of the edge.



- **Antenna and XBee Properties:**
- 1.5 - 1.8 dBi antenna gain
- +18 dBm total output power
- 0.5 gr antenna weight
- 5 gr total transceiver weight

Antenna Trade & Selection

- **Link Budget**
  - FSPL (dBm) =20 log(d)+20 log(f)-147.55 (where d is in meters and f is in hertz)
  - Using 2.4 GHz XBee radios, at a max distance of 1 km in horizontal gives a 1.5 km maximum total distance
    - FSPL= 103.6 dBm
    - The cable losses will be maximum 3 dBm.
    - XBee transmit power = +17 dBm
    - XBee wire antenna gain=+1.5 dBi
    - XBee receiver sensitivity = -100 dBm
    - Ground station antenna gain = 9 dBi
  - Transmit Power – Losses + Antenna Gain > Receiver Power
    - 17 - (103.6 + 3) + (9 +1.5) > -100 dBm
  - Which gives a very good link margin of **20.9 dBm**
  - Also at 3 km distance between cansat and ground station, there will still be a **15 dBm** link margin which is still usable

Radio Configuration

- XBee Series 1 Pro, 2.4 GHz radios will be used.
- All transceivers will be used in API mode.
- Baud Rates will be the same (~9600)
- NETID/PANID number will be set as our team number “3891” for both XBee.
- In API mode one of the XBees will be the coordinator, so Xbee at ground station will be set as coordinator.
- When data transmitted successfully, a response packet will be received in API mode
- Usage of API mode enables us to send commands from coordinator(ground station) to end device (science vehicle) . These commands may provide us options about releasing mechanism.
- Microprocessor will control 1Hz transmission rate to satisfy the requirement. Every second, we will send only one packet of data via XBee.
- Microprocessor will transmit the packaged data obtained from sensors at every second to XBee end device. Coordinator device will receive it at ground via an external antenna.
- Camera image will not be included and will be acquired after recovery.
- A computer running MATLAB software will use serial port to communicate with XBee at the ground station, in order to obtain incoming data.
- A MATLAB GUI will graph and display the data in real time.

- **API Configuration Transmit-Receive Format**

Start Delimiter	Length Bytes	API Identifier	API from ID	Destination Address	Option Byte	Data Packet	Checksum

- For Example:
- **7E 00 0C 01 01 56 98 00 4D 45 54 55 53 41 54 EC**

- 7E : Start Delimiter : ~ (in ASCII)
- 00 0C : Length bytes : 12 (in ASCII)
- 01 : API Identifier
- 01 : API from ID
- 5698 : Destination Adress
- 00 : Option Byte
- 4D 45 54 55 53 41 54 : Data Packet : METUSAT (in ASCII)
- EC: Checksum

Telemetry Format

- **Included Data**
  - All data obtained from sensors (Inside and outside temperature, altitude, battery voltage, accelerometer data and calculated angle of descent as bonus objective and angular velocity (from a gyroscope) data for our purposes)
  - Flight Software State
  - Time
  - Team ID

- **Data rate of packets**
  - Burst transmission with one packet of data each second
  - Enough space for all data in one packet
  - Saves energy (XBee is idle most of the time)

- **Data Formatting**
  - Data will be read by MATLAB using serial communication and plotted in real time. After landing, MATLAB will print all data to a .csv file, with headers as required.
- **Data Format**

  <TEAM ID(3891)>,<MISSION_TIME>,<ALT_SENSOR>,<OUTSIDE_TEMP>,<INSIDE_TEMP>, <VOLTAGE>,<FSW_STATE>,<ANGLEofDESCENT>,<ACCELEROMETER_x>,<ACCELEROMETER_y>, <ACCELEROMETER_z>,<GYROSCOPE_x>,<GYROSCOPE_y>,<GYROSCOPE_z>

Telemetry Format

- **An example telemetry packet, excluding the bits required for communication protocol is given below:**
- Packet: 3891, 184, 355, 21.2, 24.3, 7.8, 5, 4.32, 433, -527, 2304 , 12, 23, 67

3891 : Team ID

184 : Mission Time in seconds

355 : Altitude

21.2 : Outside Temperature

24.3 : Inside Temperature

7.8 : Battery Voltage

5 : FSW State (corresponds to Descent)

4.32 : Angle of Descent

433 : Accelerometer x axis

-527 : Accelerometer y axis

2304 : Accelerometer z axis

12 : Angular Velocity x axis

23 : Angular Velocity y axis

67 : Angular Velocity z axis

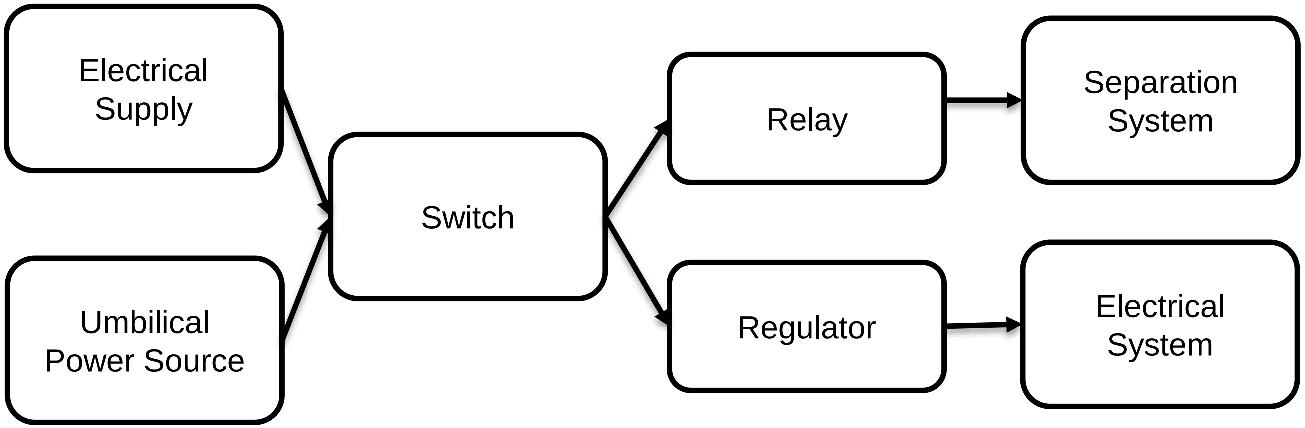
Electrical Power Subsystem Design

Baris Duru

EPS Overview

Only the Science Vehicle will possess electronic components.
The Container will consist of only passive mechanic components.

Component	Functionality
Battery	Supplies power to the electrical system
Switch	Controls power flow from electrical supply to the system
Relay	Routes power to nichrome wire in the separation mechanism
Regulator	Maintains constant voltage or current flow through the electrical system
Voltage Divider	Adjusts the right voltage for the electrical system (resistor circuit)



EPS Changes Since PDR

Subject	Change	Previous Design	Rationale
Separation Power Supply	Battery will be used for seperation.	Super-capacitor was chosen for this purpose.	• Better realibility • Test results
Sensors Power Supply	Power of system sensors are provided by battery through regulator not by microcontroller.	Microcontroller was chosen for this purpose.	• Absolve microcontroller from more load

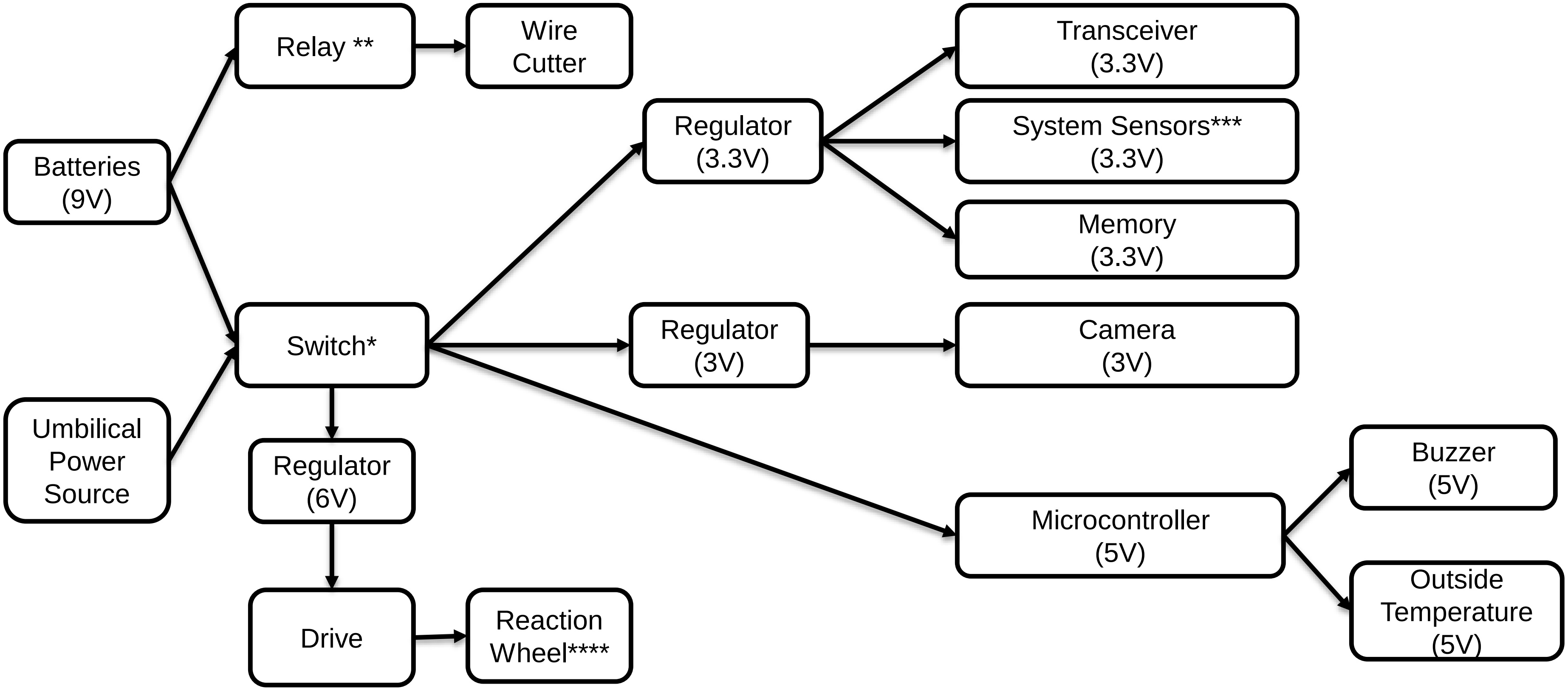
EPS Changes Since PDR

Subject	Change	Previous Design	Rationale
Motor Power Supply	Power of the dc motor is provided by battery through 6 V regulator.	9 V battery was chosen for this purpose.	• Motor was changed to a 6 V type.
SD Card Power Supply	3.3 V regulator will be used instead of 3.6 V.	3.6 V regulator was chosen for this purpose.	• Changing SD Card Shield.

EPS Requirements

ID	Requirement	Rationale	Parent	A	I	T	D
EPS1	The Science Vehicle must include a battery of an allowed type.	Competition requirement	SR18		X		
EPS2	The Science Vehicle must be connectable to an external power source via umbilical.	Competition requirement	-		X		X
EPS3	The Science Vehicle must include a power switch that has “Battery”, “Umbilical” and “OFF” settings.	Extended competition requirement	SR18		X		X
EPS4	The EPS must be able to provide power to CanSat’s all electrical devices whenever required.	Basic function of a power system	-	X		X	X
EPS5	During the separation voltage drop on the supply of the electronics should not occur.	Reliability of electrical system	-	X		X	

Electrical Block Diagram



*	Switched manually
**	Switched by microcontroller
***	It includes Pressure, Inside Temperature, Accelerometer and Gyroscope.
****	Reaction wheel includes 6V DC motor and H-bridge drive chip.

Payload Power Source Selection and Design:Battery Types

Alternatives	Concept	Pros	Cons
Lithium–Ion	Electrodes are made of lightweight lithium and carbon.	• Enviromentally friendly • Recharged • No memory effect • High energy density	• Expensive • High internal resistance • Poor performance with high current
Nickel–Cadmium (Ni–Cad)	Using nickel oxide hydroxide and metallic cadmium as electrodes.	• Economically priced • Reliable • High discharge	• Heavy • Die rapidly • Long discharging time • Memory effect • Toxic
Nickel Metal Hydride(Ni–MH)	Positive electrode of nickel oxyhydroxide and negative electrode of hydrogen are used.	• High energy density • Recycling profitable	• Heavy • Low cycle life • Memory effect • Heat
Alkaline	Reaction between zinc and manganese dioxide.	• Longer life • Low cost • High energy density • Widely available	• High internal resistance • Bulkier

Payload Power Source Selection and Design: Batteries

Payload:

Component	Physical Characteristics		Electrical Characteristics		Price ($)
	Size*(mm)	Weight (gr)	Nominal Capacity (mAh)	Voltage (V)	
VARTA High Energy (Alkaline)	50.1 x 14.4	25	2700	1.5	1.1
VARTA High Energy (Alkaline)	62.0 x 22.0 x 67.0	160	6100	4.5	7.40
VARTA High Energy (Alkaline)	47.5 x 17.5 x 26.5	50	550	9	1.68
Energizer (Alkaline)	48.5 x 17.5 x 26.5	46	625	9	3.25
Duracell (Alkaline)	48.5 x 17.5 x 26.5	45	550	9	2.35

- Two batteries (each 9V) will be connected in parellel to obtain required current.

- Chosen Battery: Duracell 6LR61 (Alkaline)
  - Desired nominal capacity
  - Reasonable price
  - Low weight
  - Meets required energy
  - Construction Guide advice

* Sizes are in Height x Diameter or Height x Width x Depth

Power Budget

Payload:

Component	Current (mA)	Voltage (V)	Power (mW)	Expected Duty Cycle (%)	Duration(sec)	Source / Uncertainity
Microcontroller (Arduino Mini)	250(max)	5	1250	100	100+	Datasheet
Camera (OV7670)	20	3 Analog: 2.45-3	60	100	85	Datasheet
Transceiver (XBEE Pro 2.4GHz)	215	3.3	709.5	100	100	Datasheet
Pressure & Outside Temperature Sensor (BMP183)	0.3	3.3	0.99	100	100+	Datasheet
Inside Temperature Sensor (DS18B20)	1	5	5	100	100+	Datasheet
Memory (SD Card)	200	3.3	660	100	100+	Datasheet
InvenSense MPU-6050 (Accelerometer & Gyroscope)	3.9	3.3	12.87	100	100+	Datasheet

Power Budget

Payload:

Component	Current (mA)	Voltage (V)	Power (mW)	Expected Duty Cycle (%)	Duration(sec)	Source / Uncertainity
6V DC Motor	500	6	3000	25	85	Datasheet
Adafruit#1536 Buzzer	20	5	100	100		Datasheet
Voltage Divider	_	_	negligible	100	-	Estimation

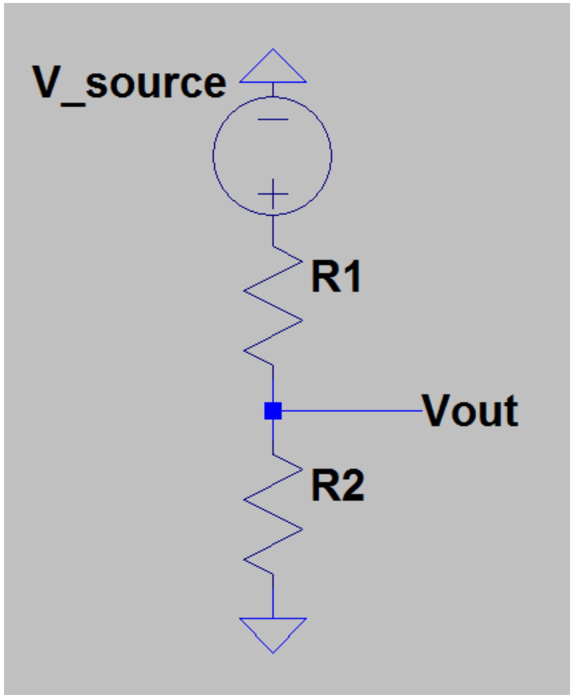
Mission	İnitial Time	Final Time
Camera (Active)	Science Vehicle Seperation	Landing
XBee	Launch	Landing
Arduino	Power ON	Power OFF
Sensors+ Camera SB	Power ON	Landing
Wire Cutter	Science Vehicle Seperation	Science Vehicle Seperation
Motor	Science Vehicle Seperation	Landing
Buzzer	Landing	Power OFF

Total Power Consumed	644 mAh
Available Power	1100 mAh
Margin	456 mAh

Needed Voltage	3 - 9 V
Battery Supply	9 V

Power Bus Voltage Measurement

- Power source voltage of the payload will be measured from microcontroller’s ADC (analog-to-digital converter) channel.
- Maximum input voltage is expected to be 9V. Therefore, input voltage is scaled down through the voltage divider.
- Voltage divider is;
  - Simple, cheap and reasonably efficient.
  - Power loss is negligible. When high valued resistors are chosen, negligible current will flow through the resistors.

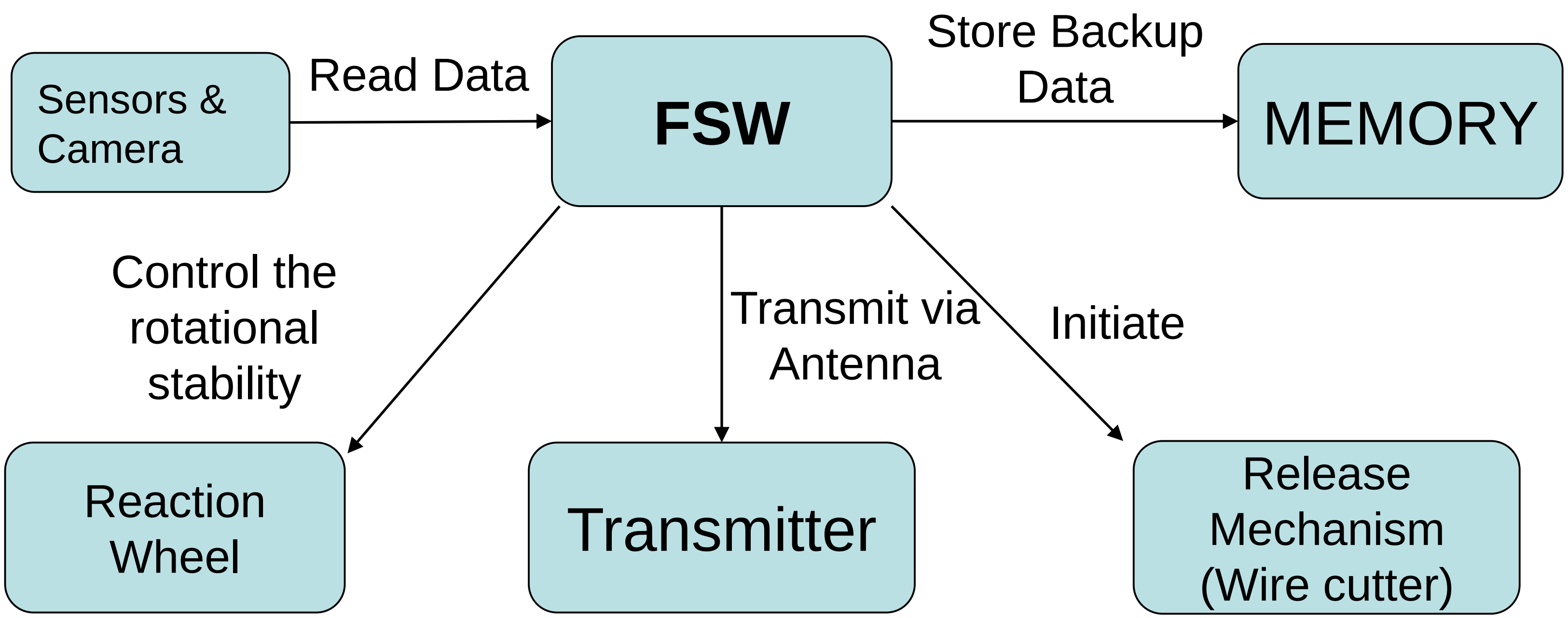


Flight Software (FSW) Design

Halil İbrahim Uğurlu

FSW Overview

- **There will be a FSW design for the Payload. Its basic structure will be shown as;**



FSW Overview

- We will use C/C++ with Arduino IDE for Payload & Container.
- The FSW will work in a ATMega328 (on Arduino Mini 5V Card).
- While Flight Software running;
  - Payload will read Pressure,Temperature and 3-axis acceleration values from the sensors and Voltage value from the ADC Channel (by voltage dividing). Then, it will prepare the data packet for RF Transmission.
  - Payload will control the camera to start and stop the recording.
  - Payload will store all data and detailed flight log on Memory.
  - After preparing a packet, payload will communicate with Ground Station for transmitting data via antenna.
  - Payload should be aware when to start sending telemetry.
  - Payload shall release itself from container at the right time (at right altitude).
  - Payload should start to read data when it is powered on.
  - Payload should be aware when it is landed and it must stop sending telemetry.

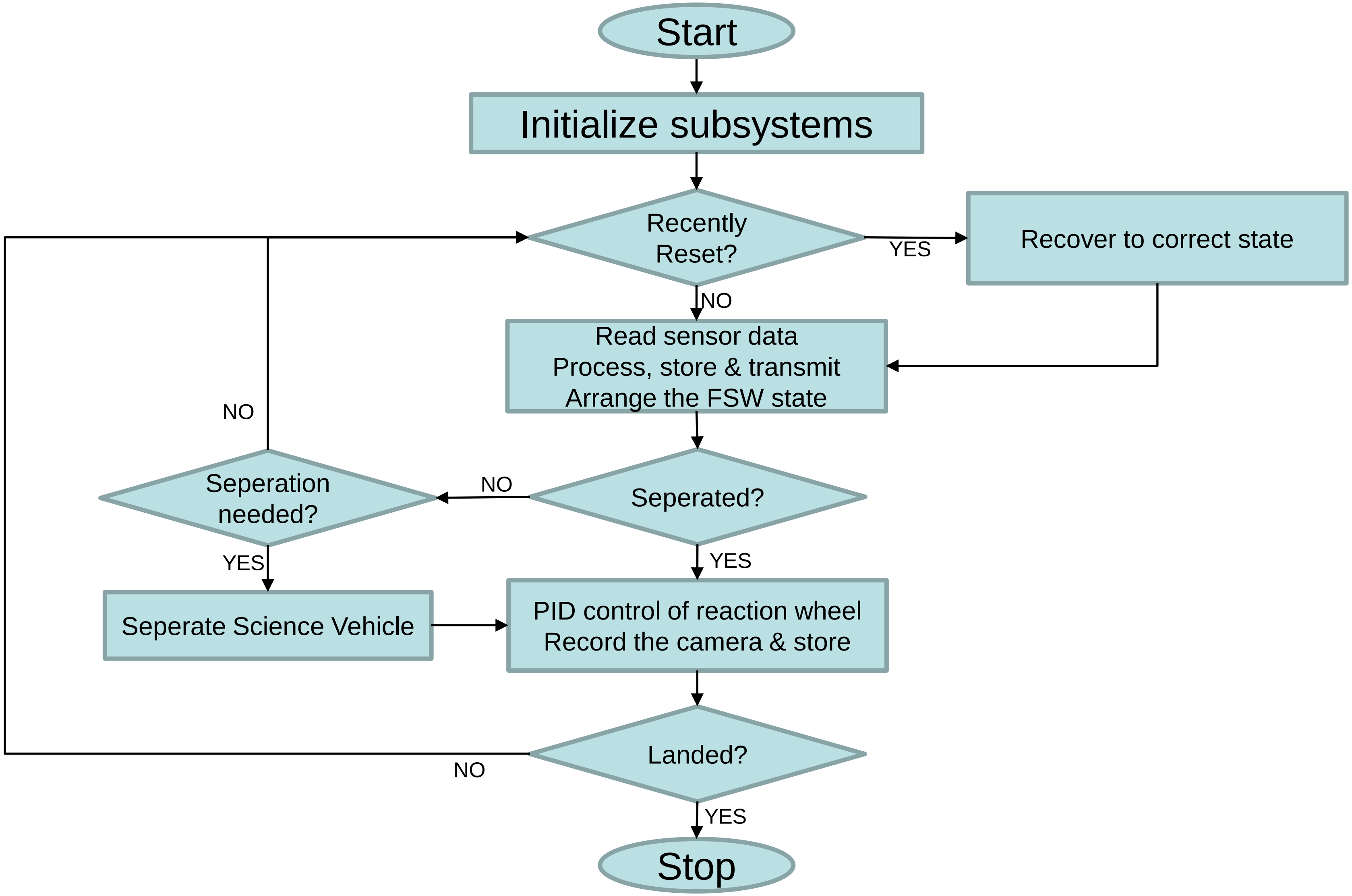
FSW Changes Since PDR

- **There is no major change in the planned software.**

FSW Requirements

ID	Requirement	Rationale	Parent	A	I	T	D
FSW1	FSW shall determine the best condition to release the payload.	Competition requirement	SR20	X		X	X
FSW2	FSW shall collect sensor data and prepare data packet by combining with FSW state, battery voltage and acceleration values.	Competition requirement	SR9				X
FSW3	FSW shall store all gathered data on Memory	Required for analysis, tests and reinitialization	SR17				X
FSW4	FSW shall transmit data packets at a rate of at least 1 Hz	Competition requirement	SR9				X
FSW5	FSW shall record a video of descent with the camera and store it on memory	Competition Requirement	SR11				X
FSW6	FSW shall count time with one second or better resolution	Competition requirement	SR9			X	X
FSW7	FSW shall activate the release mechanism on time (when the conditions are met)	Required to correctly release the Science Vehicle	SR20			X	X
FSW8	FSW shall control the reaction wheel for rotational stability	The video must be stable	SR13				X
FSW9	FSW shall maintain the operating state, also could re-initialize the state in the case of any reset	Competition Requirement	SR17			X	X
FSW10	FSW shall activate the buzzer after landing	Competition requirement	SR19			X	X

CanSat FSW State Diagram



CanSat FSW State Diagram

- **The states of FSW are described below;**
  - PreFlightTest <0>: Device check, pre-flight functionality tests.
  - LaunchWait <1>: FSW checks the altitude data while waiting launch.
  - Ascent <2> : Start telemetry sending, and storing the log information. FSW checks the altitude whether the rise stops in order to go through the next state
  - RocketDeployment <3>: Check telemetry to ensure that CanSat is deployed from Rocket,
  - Stabilization & Separation <4> : Check the stabilization criteria to separate Science Vehicle and activate the separation mechanism when the criteria is met.
  - Descent <5> : Camera recording is started. Reaction wheel control is started. The video recording is stored in the memory. Check the altitude in order to understand whether the CanSat is landed or not.
  - Landed <6> : Stop camera recording, sensor reading, telemetry sending, also data storage. Start the buzzer to locate CanSat easily.

CanSat FSW State Diagram

- **Voltage measurement:**
  - We will use a voltage divider and the measurement is done by reading ADC Channel of microcontroller.
  - Data rate of ADC channel of microcontroller is 10 kHz
- **BMP183 (to measure pressure and outside temperature values)**
  - Communication between microcontroller is via SPI interface.
  - Data output refresh rate is 128Hz at maximum speed.
- **MPU6050 (to measure 3-axis acceleration value)**
  - Communication between microcontroller is via I2C interface.
  - Output data rate is 1000Hz.
- **DS18B20 (to measure inside temperature)**
  - The measurement is done by reading ADC channel of microcontroller.
  - Data rate of ADC channel of microcontroller is 10 kHz
- **OV7670 (camera for descent video record)**
  - Communication between microcontroller is via I2C interface.
  - Output data rate is 30Hz

NOTE: The slowest data sources are pressure sensors, however, these sampling rates of sensors are enough for telemetry at 1Hz. We will decide telemetry rate that will be transmitted within critical design phase.

CanSat FSW State Diagram

- **For Reaction Wheel (RW) driving:**
  - The RW is controlled by pulse width modulation (PWM) output.
  - If the reaction wheel goes into saturation, FSW will cut the motor current considering the power consumption and it will reset the integral of control error.
- **For Wire Cutter (release mechanism);**
  - A digital output will be used as activation signal of release mechanism.
  - Since the wire cutter works with high currents, FSW supplies it from a super capacitor and at the same time disconnects the super capacitor from battery. By this way, FSW makes provision against instanteneous voltage drops causing microcontroller reset.
- **For Data Storage:**
  - Communication between SD card memory and microcontroller is via I2C (more than one device can use same digital interface of the Arduino).
  - Its operating frequency is in the range of MHz.
- **For Telemetry:**
  - Communication between transceiver and microcontroller is via serial interface USART.
  - XBEE will be used as a transceiver. Its operating voltage is 3.3V and current draw from the power system is ~68mA.

CanSat FSW State Diagram

- **The following solutions are derived for recovery to correct state when processor resets:**
  - A hardware real-time clock could be used and the time may be maintained in this way.
  - Memory could be used for learning the last packet count and mission time, and after the comparison between these values and variables representing count and time on the software, the processor reset could be identified. If the processor reset,one more than these values can be equalised in the memory to count and time variables.
  - When processor reset, this situation can be understood at Ground Station by checking the received signals from the payload. If any reset is identified the last telemetry packet can be sent from the ground to payload. In the payload side the microcontroller could understand its reset if there is any data packet coming from ground, and reset the time and packet count values with respect to the received packet form the ground.

Software Development Plan

- **The FSW development plan will be chronogically;**
  - ❑ **Up to PDR:**
  - – Understanding the working principles of Arduino with the other components (sensors, motor driver and memory card).
  - – Definition of FSW requirements, functions and states
  - ❑ **Up to CDR:**
  - – Working on the functionalities of the subparts of FSW eventually verifying the data transfer between the sensors & actuators and the microcontroller.
  - – In parallel to the breadboard model integration, a FSW prototype will developed and the required functionalities will be verified with this prototype.
  - ❑ **Up to FRR:**
  - – The testing of all FSW functions will be done with realistic test cases, such as:
    - Camera recording and image monitoring.
    - By applying artificial temperature and pressure, the sensor data processing and the FSW state transitions would be tested.
    - By hanging the CanSat with a rope, and giving an initial rotational speed, the PID conrol of reaction wheel wolud be tested for stabilized camera recording.
  - – FSW bugs will be fixed and the final software will be integrated and tested.
- Our FSW development team is led by Halil İbrahim Uğurlu and consists Baran Bodur and Doğa Yücelan also.

Software Development Plan

- **Since PDR we tested sensors, RTC, votlage measurements, XBEE communication, Memory storage by Arduino. Check their functionalities.**
- **The test are described below;**

Software Development Plan

1) Initially, we controlled analog and digital pins of Arduino. We digital pins by turning an led on and off.

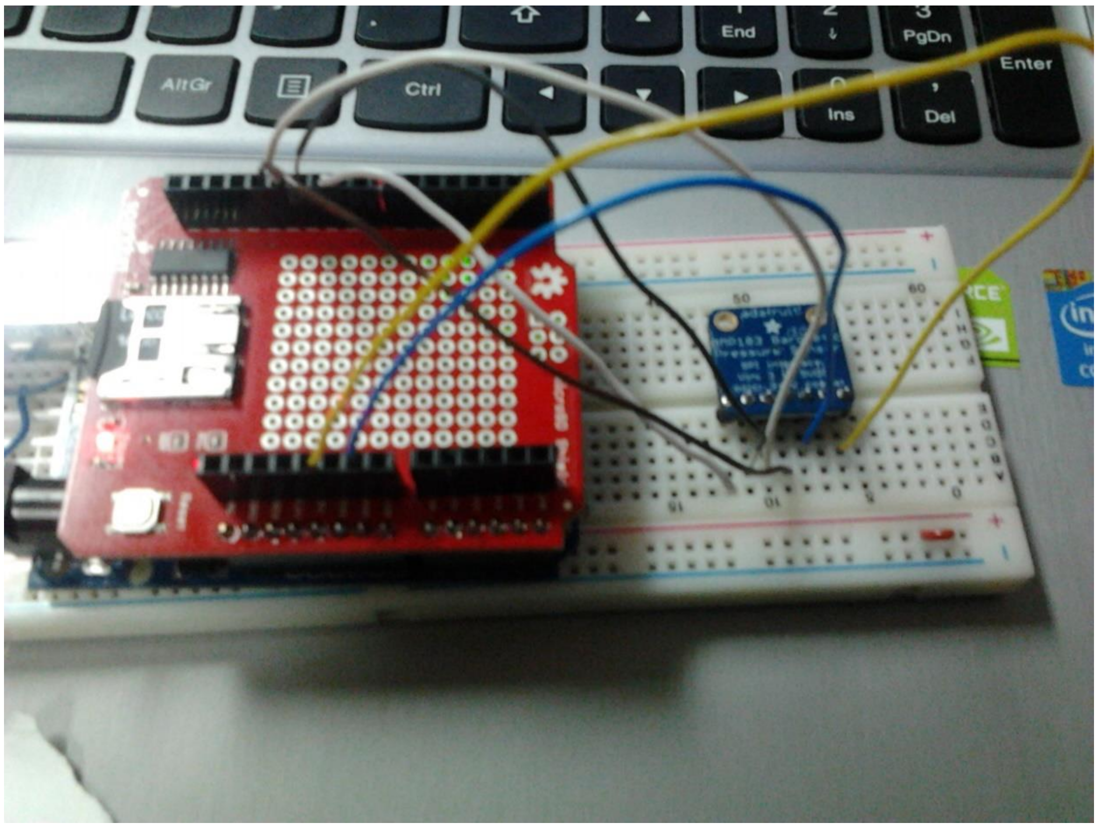
2) We measure a voltage value from analog input, by using a potentionmeter. We get a stable reading.

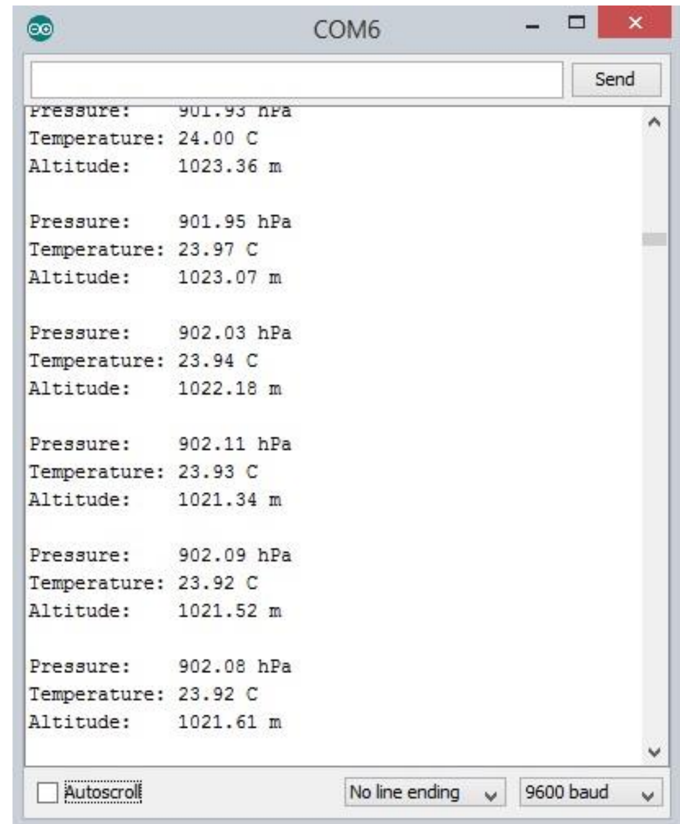
3) We tested the buzzer by connecting a digital output. We listen a high sound level, which can help us to locate CanSat after landing.

4) By using a L293D motor driver bridge, we can turn the motor both sides. The control resolution has 200 states before maximum speed is achieved in both sides. This is acceptable to use with a reaction wheel with the specified moment of inertia.

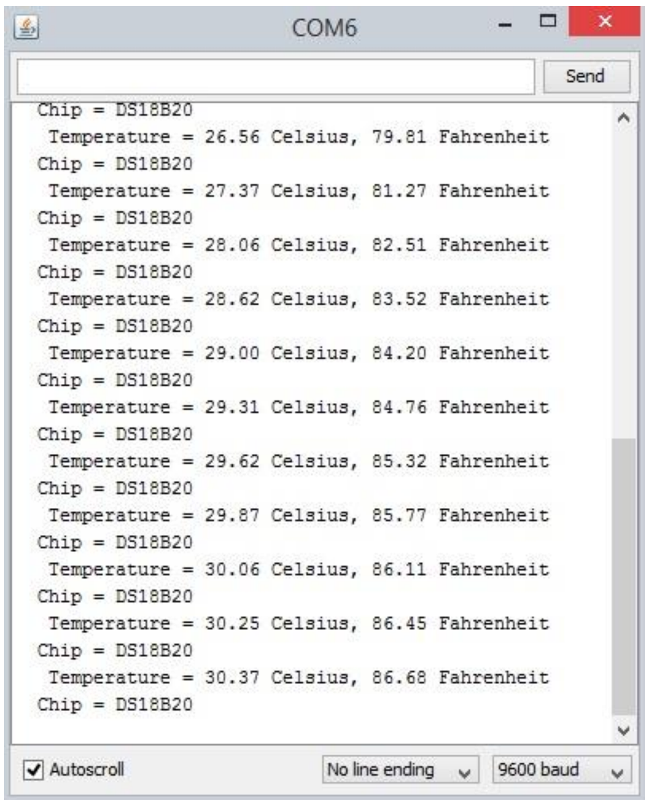
5) MPU6050 acceleration sensor was tested. By moving and rotating the sensor, the measurements are monitored and verified.

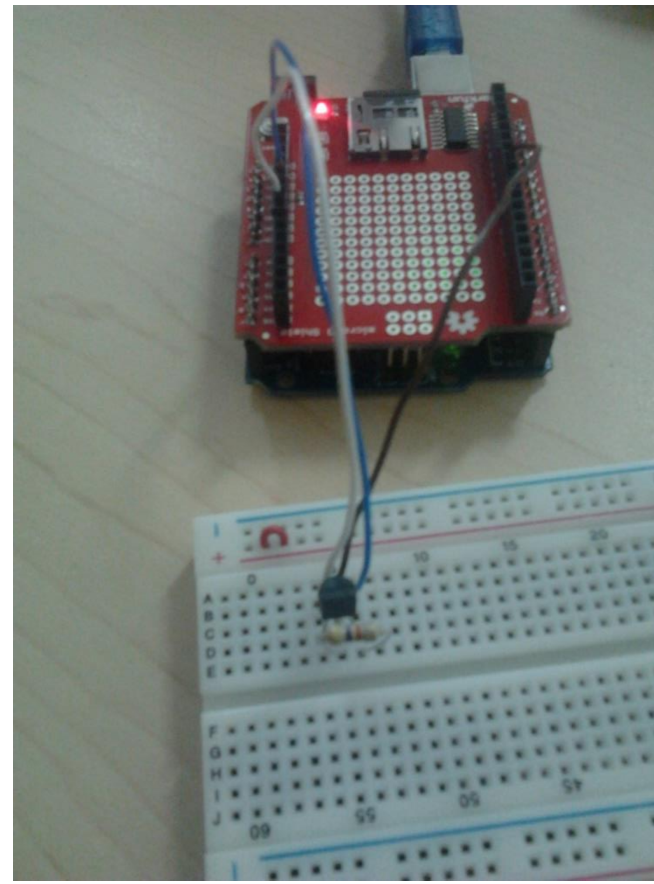
6) We tested our BMP183 sensor by collecting temperature, pressure and calculated altitude data. The measurements were coherent with the map values and the resolution was also confirmed with small altitude changes.



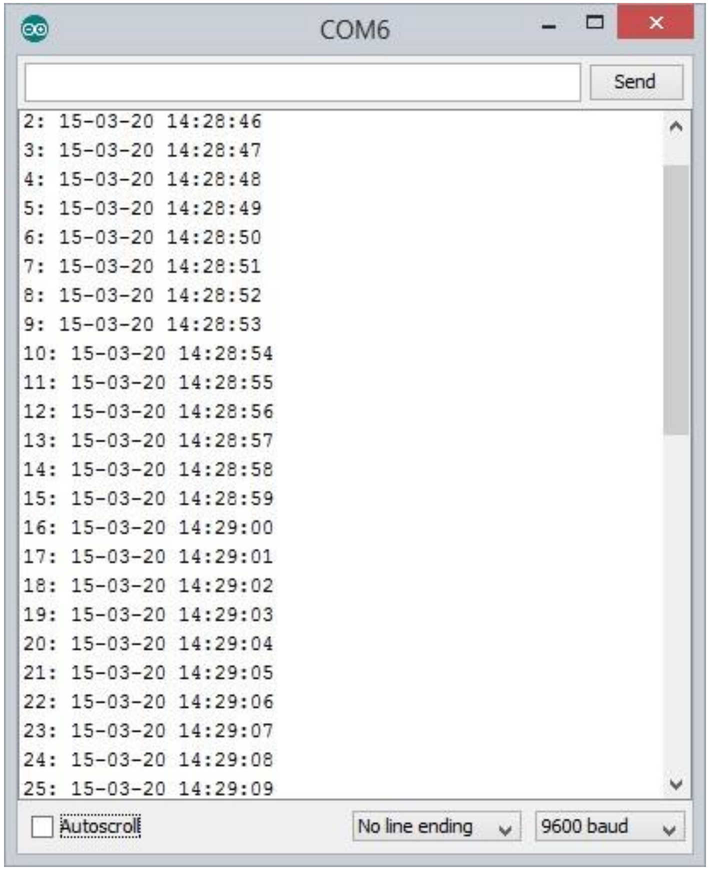


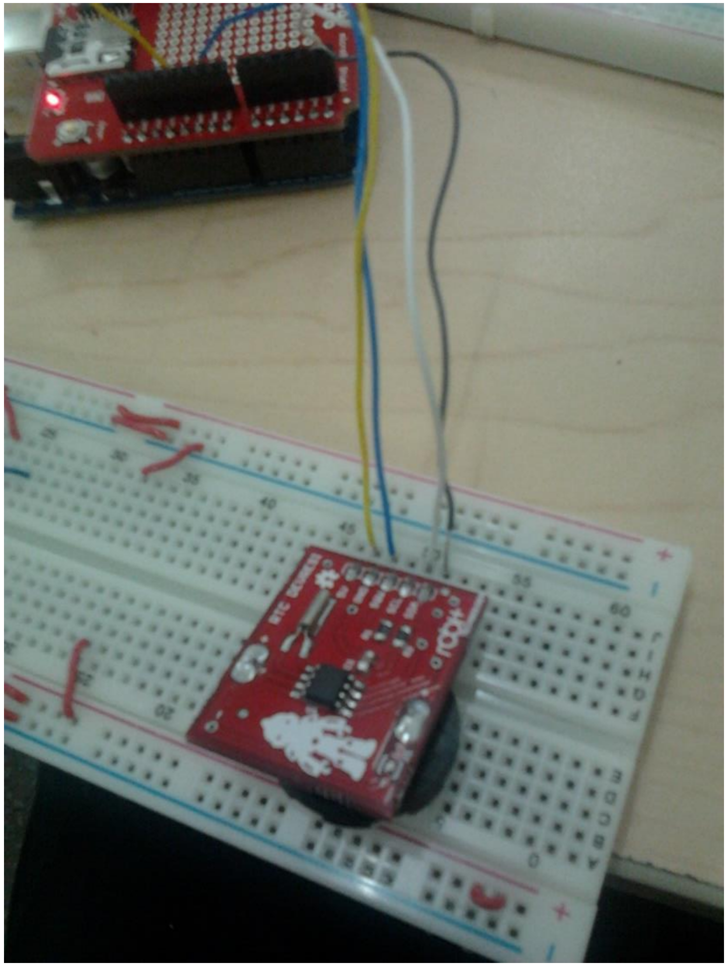
7) We tested our DS18B20 temperature sensor. The measurements are matching with real values. Also, when heated by my finger, the measurement value increases, as shown in figure below.



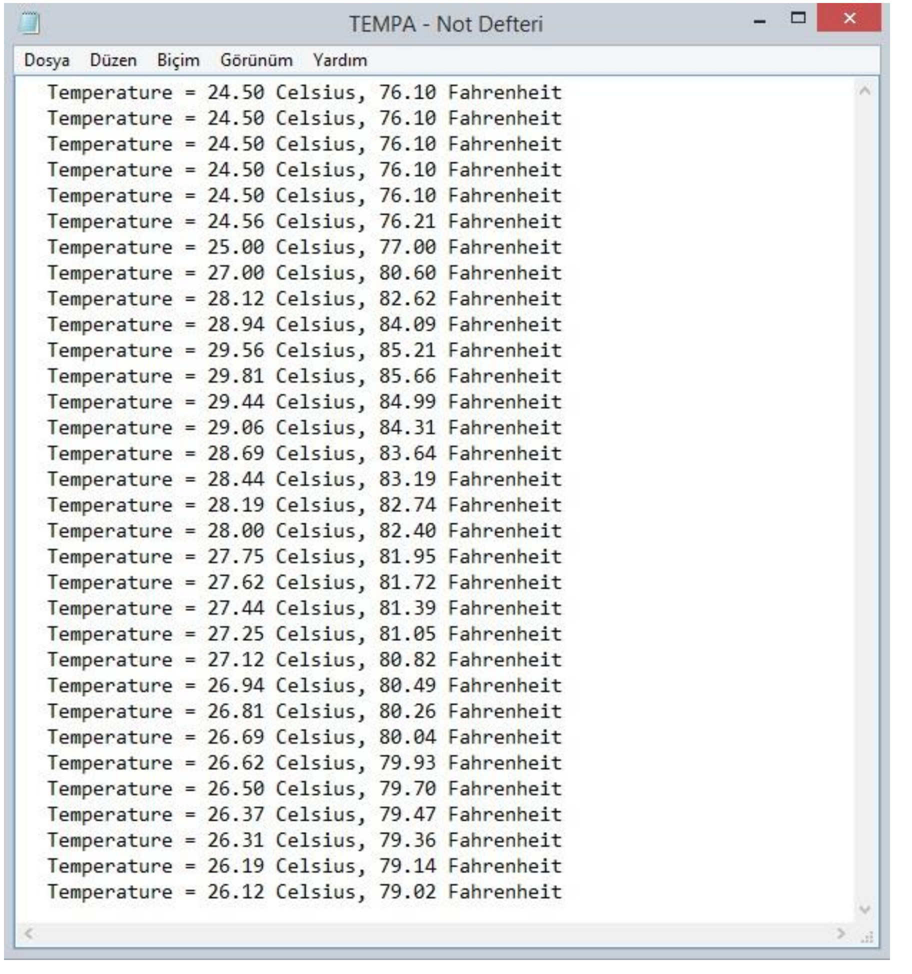


8) The real time clock was also tested. Firstly,we synchronized the real time clock and collected the date and time values. Successful operation was observed.





9) The SD card memory was also controlled. We write and read a text file in SD memory. Then, we write DS18B20 sensor values to a text file. The file opened on local computer is shown in the figure.

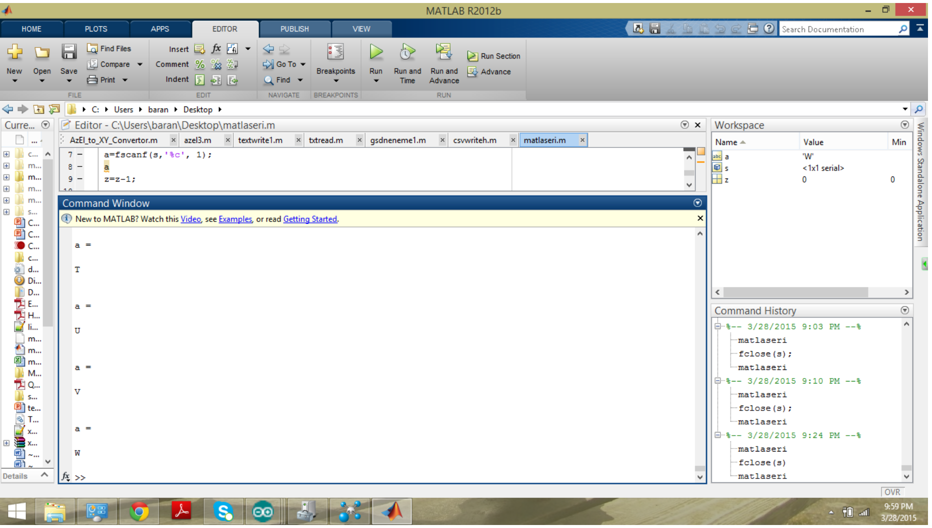

TEMPA - Not Defteri

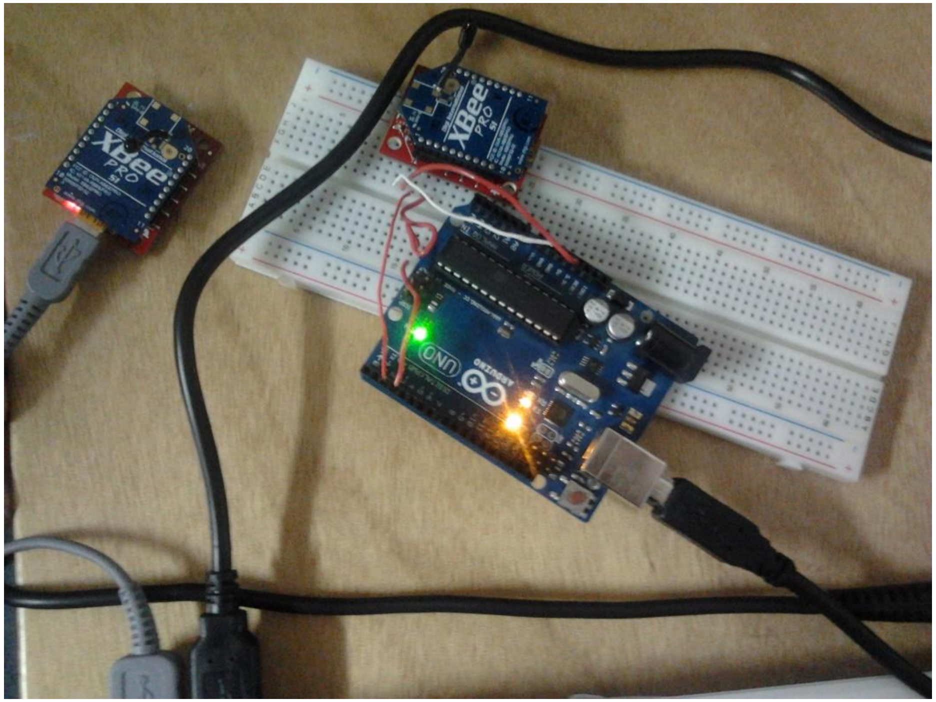
Dosya Düzen Biçim Görünüm Yardım

```
Temperature = 24.50 Celsius, 76.10 Fahrenheit
Temperature = 24.50 Celsius, 76.10 Fahrenheit
Temperature = 24.50 Celsius, 76.10 Fahrenheit
Temperature = 24.50 Celsius, 76.10 Fahrenheit
Temperature = 24.50 Celsius, 76.10 Fahrenheit
Temperature = 24.56 Celsius, 76.21 Fahrenheit
Temperature = 25.00 Celsius, 77.00 Fahrenheit
Temperature = 27.00 Celsius, 80.60 Fahrenheit
Temperature = 28.12 Celsius, 82.62 Fahrenheit
Temperature = 28.94 Celsius, 84.09 Fahrenheit
Temperature = 29.56 Celsius, 85.21 Fahrenheit
Temperature = 29.81 Celsius, 85.66 Fahrenheit
Temperature = 29.44 Celsius, 84.99 Fahrenheit
Temperature = 29.06 Celsius, 84.31 Fahrenheit
Temperature = 28.69 Celsius, 83.64 Fahrenheit
Temperature = 28.44 Celsius, 83.19 Fahrenheit
Temperature = 28.19 Celsius, 82.74 Fahrenheit
Temperature = 28.00 Celsius, 82.40 Fahrenheit
Temperature = 27.75 Celsius, 81.95 Fahrenheit
Temperature = 27.62 Celsius, 81.72 Fahrenheit
Temperature = 27.44 Celsius, 81.39 Fahrenheit
Temperature = 27.25 Celsius, 81.05 Fahrenheit
Temperature = 27.12 Celsius, 80.82 Fahrenheit
Temperature = 26.94 Celsius, 80.49 Fahrenheit
Temperature = 26.81 Celsius, 80.26 Fahrenheit
Temperature = 26.69 Celsius, 80.04 Fahrenheit
Temperature = 26.62 Celsius, 79.93 Fahrenheit
Temperature = 26.50 Celsius, 79.70 Fahrenheit
Temperature = 26.37 Celsius, 79.47 Fahrenheit
Temperature = 26.31 Celsius, 79.36 Fahrenheit
Temperature = 26.19 Celsius, 79.14 Fahrenheit
Temperature = 26.12 Celsius, 79.02 Fahrenheit
```

Software Development Plan

10) Our transcievers(XBEE) was tested. Initially, we send the basic data types such as char, integer, float and strings, then print these on the screen via XCTU and then with MATLAB.





Software Development Plan

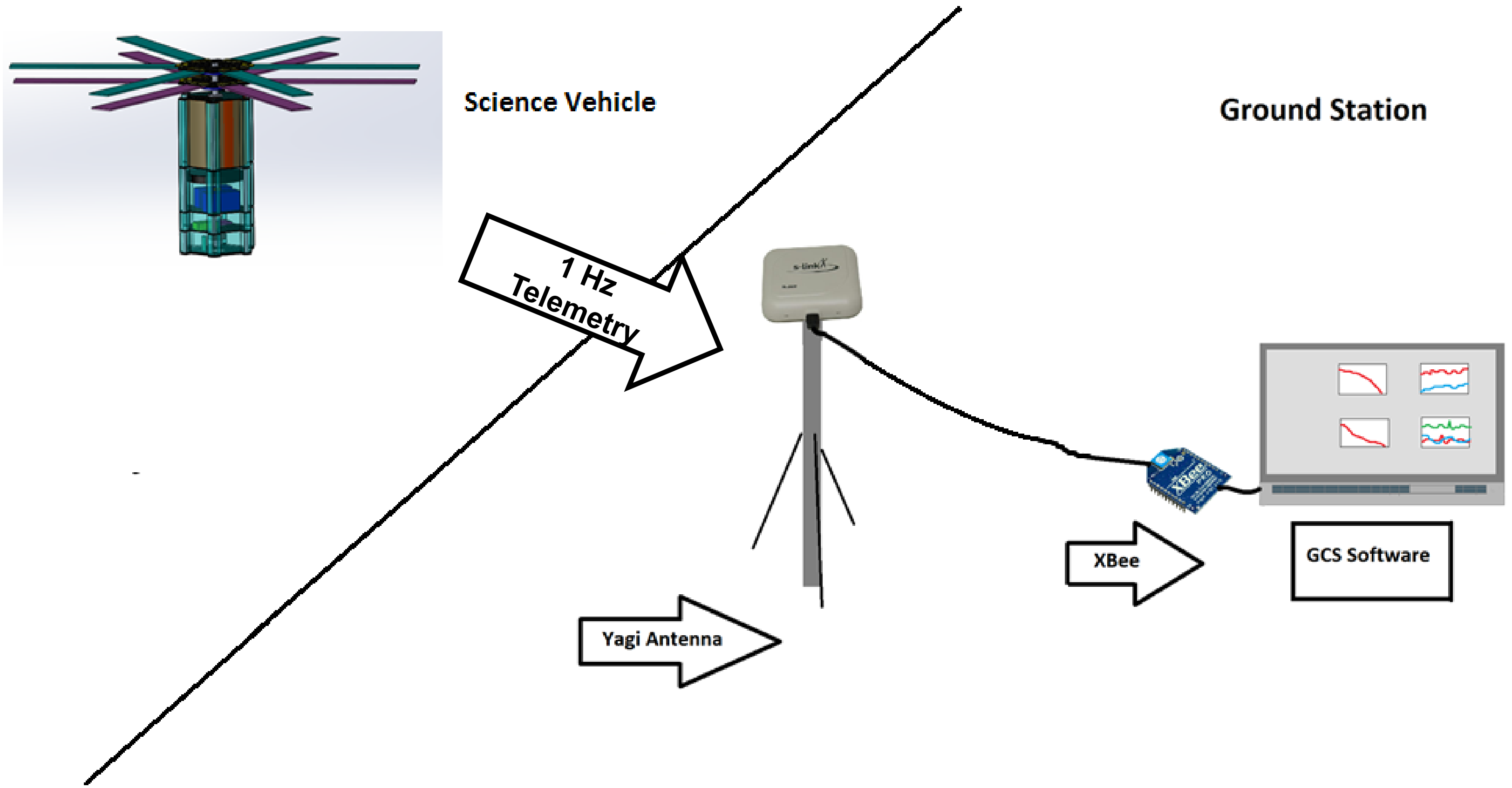
11) The camera OV7670 was acquired recently therefore the planned software development have not been finished yet. Here we are going to follow the steps below:

- Set the connections between Arduino, Camera and SD memory.
- Take an individual photo.
- Take video.
- Add time stamp from RTC.

Ground Control System (GCS) Design

Doga Veske

GCS Overview



GCS Changes Since PDR

- **Instead of using XCTU software for acquiring data from XBEE, MATLAB will be used. Because XCTU cannot write or store data to a file. Data will be taken from serial connection via MATLAB.**

GCS Requirements

ID	Requirement	Rationale	Parent	A	I	T	D
GCS1	All telemetry shall be displayed in real time during descent.	Competition Requirement	SR15	X		X	X
GCS2	All telemetry shall be displayed in engineering units.	Competition Requirement	SR15				X
GCS3	Teams shall plot data in real time during flight on the ground station computer.	Competition Requirement	SR15			X	X
GCS4	The ground station shall include one laptop computer with a minimum of two hours of battery operation, Xbee radio and a hand held or table top antenna.	Competition Requirement	-		X		X
GCS5	The ground station shall be portable.	Competition Requirement	-		X		X
GSC6	Antenna should be 3.5 m high from ground to have a RF LOS with Cansat.	To maintain successful communication	SR9		X		
GSC7	Link budget should be satisfied with at least 15 dBm margin for a 1.5 km range.	For successful communication	SR9	X			
GSC8	The data shall be presented in a CSV file with headers.	Competition Requirement	-				X

Antenna Trade & Selection

Antenna	Gain	Size (Portability)	Price	Directionality	Connector
TL-ANT2424B Grid Parabolic	14 dBi	Larger	$54.99	Directional	RP-SMA (compatible with XBee)
S-Link SL-2409 Yagi Antenna	9 dBi	Medium	$11.45	Directional	RP-SMA (compatible with XBee)
WRL-00558 External Duck Antenna	5 dBi	Relatively Small	$9.95	Omni-direcitonal	RP-SMA (compatible with XBee)

The Yagi Antenna was selected due to its;

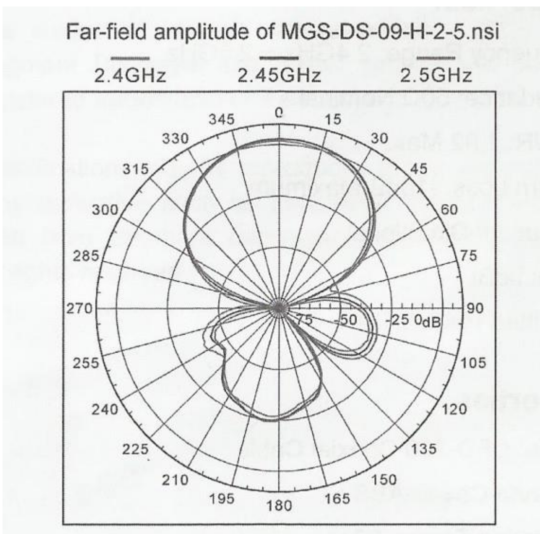
- Very good gain to price ratio
- Availability from last year

Antenna Properties

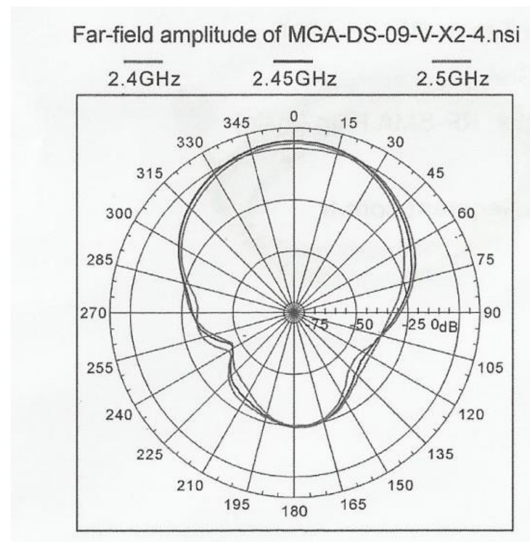
Gain: 9dBi

VSWR: 1.92 max

SL-2409 Antenna Patterns



Horizontal



Vertical

GCS Antenna Placement

Antenna Placement

- Antenna will be placed 3.5 m high to have a clear line of sight for high quality communication
- This requires a 4 m shielded cable for carrying the signal
- Antenna should be attached to a 3.5 m antenna mast
- A 3.5 m long rope will be hanged from the top of the mast,

when it barely touches to ground, the height will be 3.5 m.

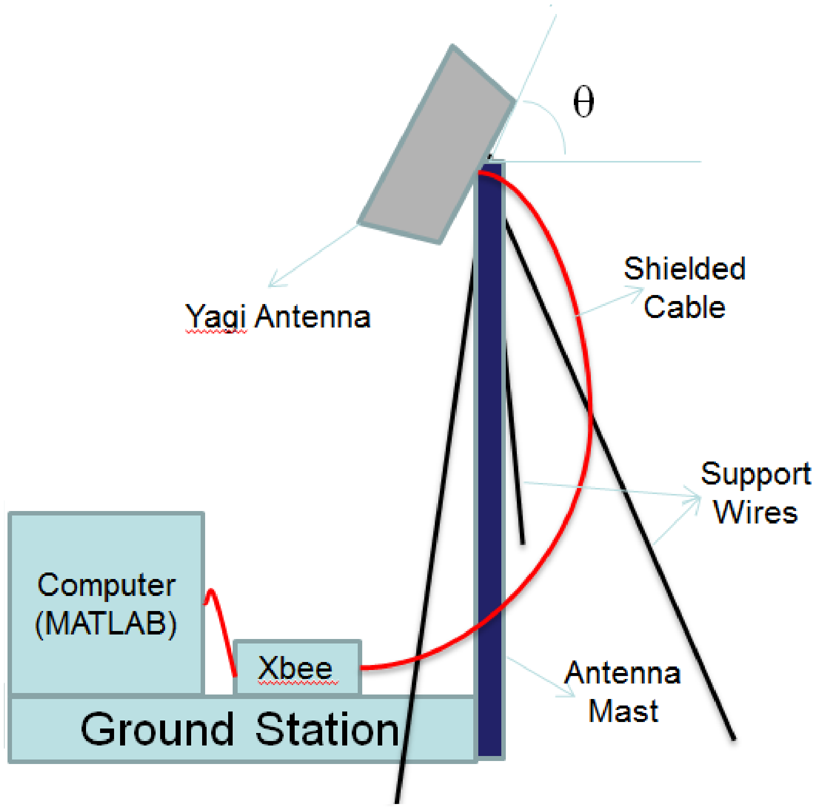
- The mast will be fixed with help of three visible wires
- The antenna is directional, so the angle should be

selected according to the horizontal distance between cansat and the ground station.

- $\frac{\theta}{2} = \arctan\left(\frac{d_{vertical}}{d_{horizontal}}\right),\ d_{vertical} = 700m$

- For example, if the vertical distance is 700 m, theta

should be selected as 22.5 degrees so communication will continue from 0 to 45 degrees. (From antenna pattern, it will have reasonable gain under ± 30 degrees)



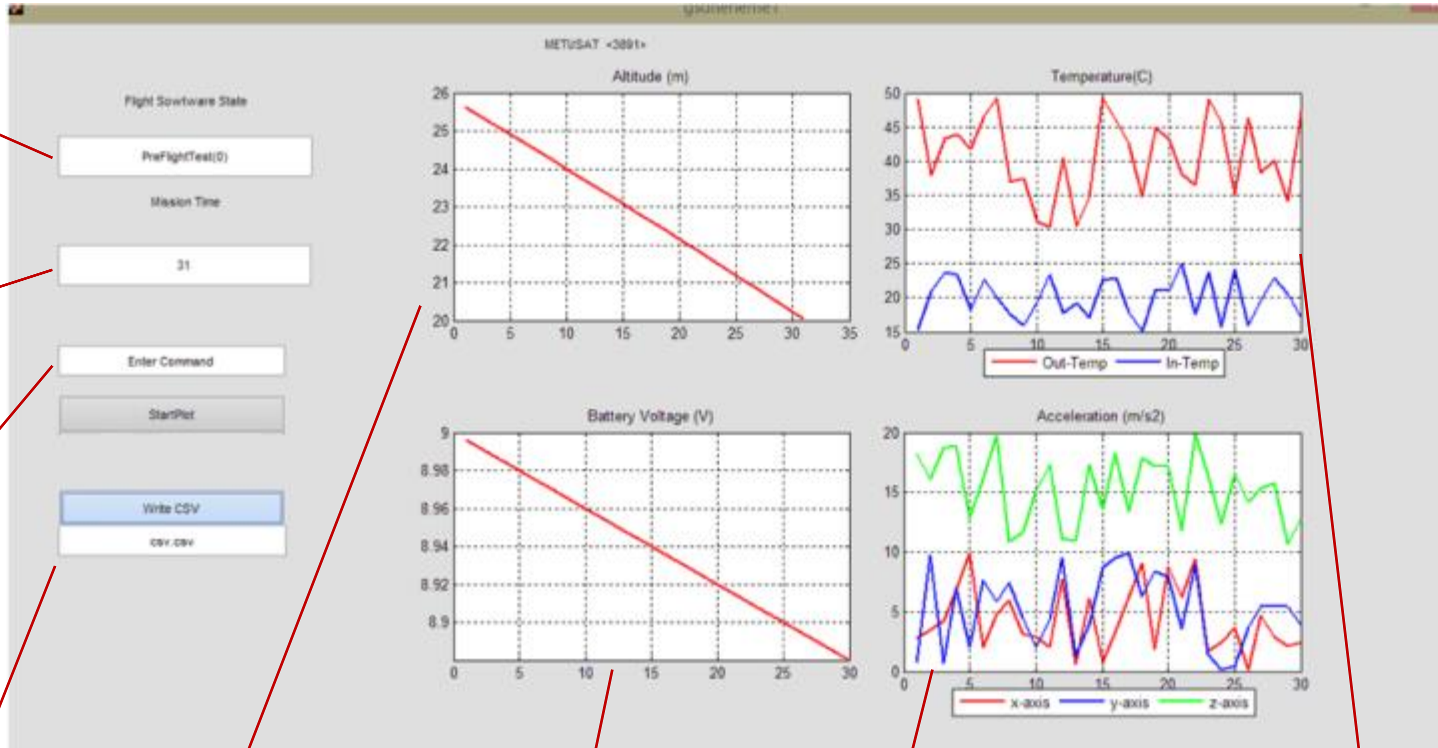
Link Budget

- FSPL (dBm) =20 log(d)+20 log(f)-147.55 (where d is in meters and f is in hertz)
- Using 2.4 GHz XBee radios, at a max distance of 1 km in horizontal gives a 1.5 km maximum total distance
  - FSPL= 103.6 dBm
  - The cable losses will be maximum 3 dBm.
  - XBee transmit power = +17 dBm
  - XBee wire antenna gain=+1.5 dBi
  - XBee receiver sensitivity = -100 dBm
  - Ground station antenna gain = 9 dBi
- Transmit Power – Losses + Antenna Gain > Receiver Power
  - 17 - (103.6 + 3) + (9 +1.5) > -100 dBm
- Which gives a very good link margin of **20.9 dBm**
- Also at 3 km distance between cansat and ground station, there will still be a **15 dBm** link margin which is still reasonable.

GCS Software

- GCS Software with GUI will be designed using MATLAB.
- It will continuously read data from the serial port. (The read frequency will be at least 10 Hz >> 1Hz –the data receive rate)
- It will display mission time, FSW status and Team ID.
- It will plot altitude, temperature, battery voltage and angle of descent (from accelerometer data).
- It will store all data in arrays and will be able to write all data to a selected .csv file with headers.
- Baud rate and other serial connection parameters can be arranged.
- Display of current temperature, altitude and voltage data will be added.
- A prototype of ground station software with GUI can be seen on the next slide.

GCS Software Example



Shows FSW state

Shows mission time in seconds

Commands can be entered

Writes data to a .csv file

Plots altitude data

Plots battery voltage

Plots angle of descent (from accelerometer data as bonus)

Plots outside and inside temperatures

GCS Testing Overview

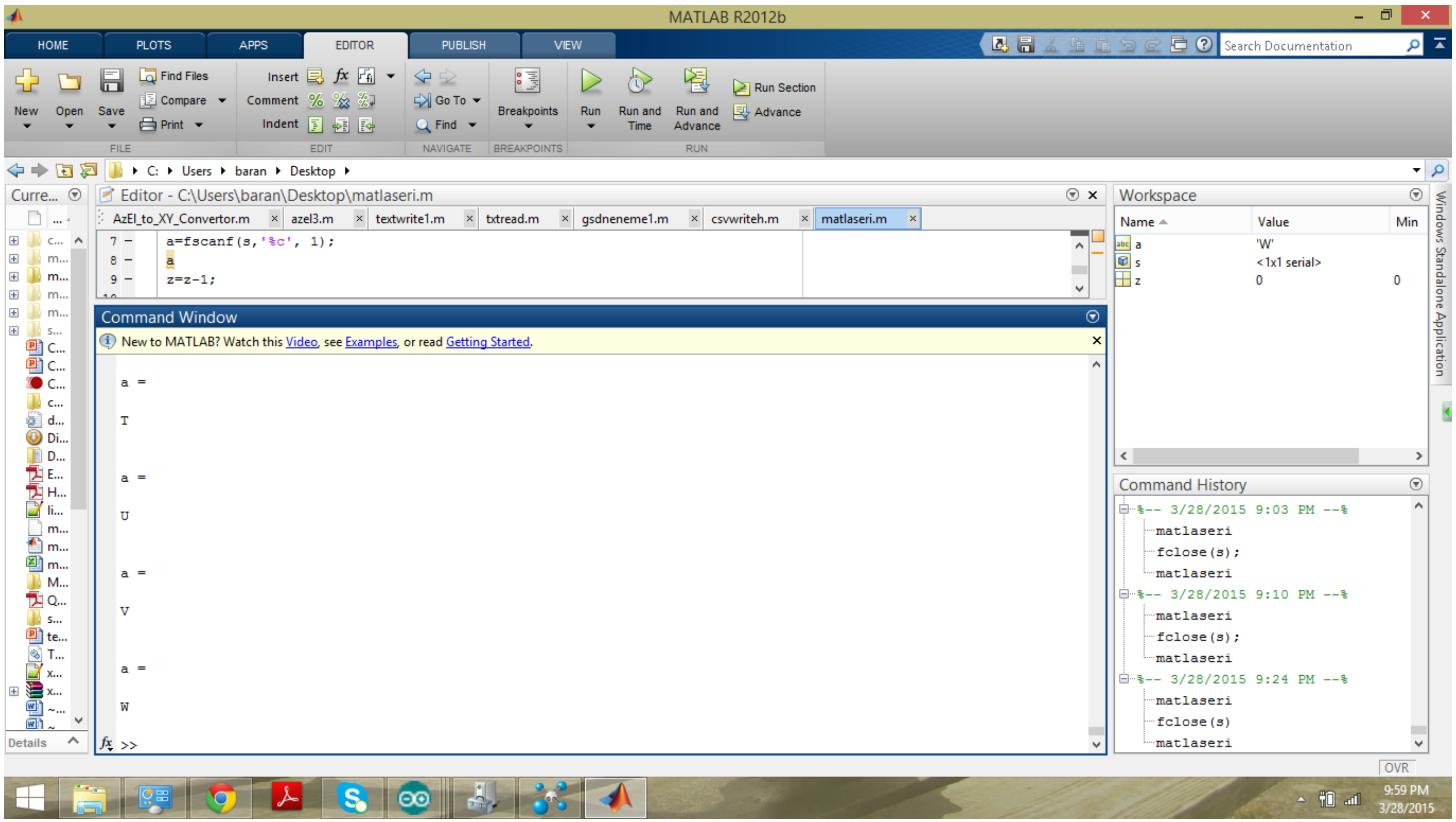
Test Id	Verified Requirements	Necessary Equipments	Test Description	Pass/Fail Criteria
Software Test *(DONE)*	GCS can plot the graphs correctly from the received data.	GCS software	1) Random data generator was written. 2) Graphs were obtained from the data.	**Pass** (Graphs were obtained correctly.)
Near Distance Communication Test (NCT) *(NOT COMPLETED)*	Communication can be done in the required packet format	Arduino, XBees, GCS software	1) Random data will be sent in the required packet format. 2) Graphs will be obtained from the data.	Successful reception of data in correct format and correct plots in GCS Software
Far Distance Communication Test (FCT) *(NOT STARTED)*	Link budget is enough.	Arduino, XBees, GCS software, Antenna	Same as NCT except it is done from a mission like distance with various angles.	Successful reception of data and correct plots in GCS Software from 1.5km distance and ±22.5°.

GCS Near Communication Test

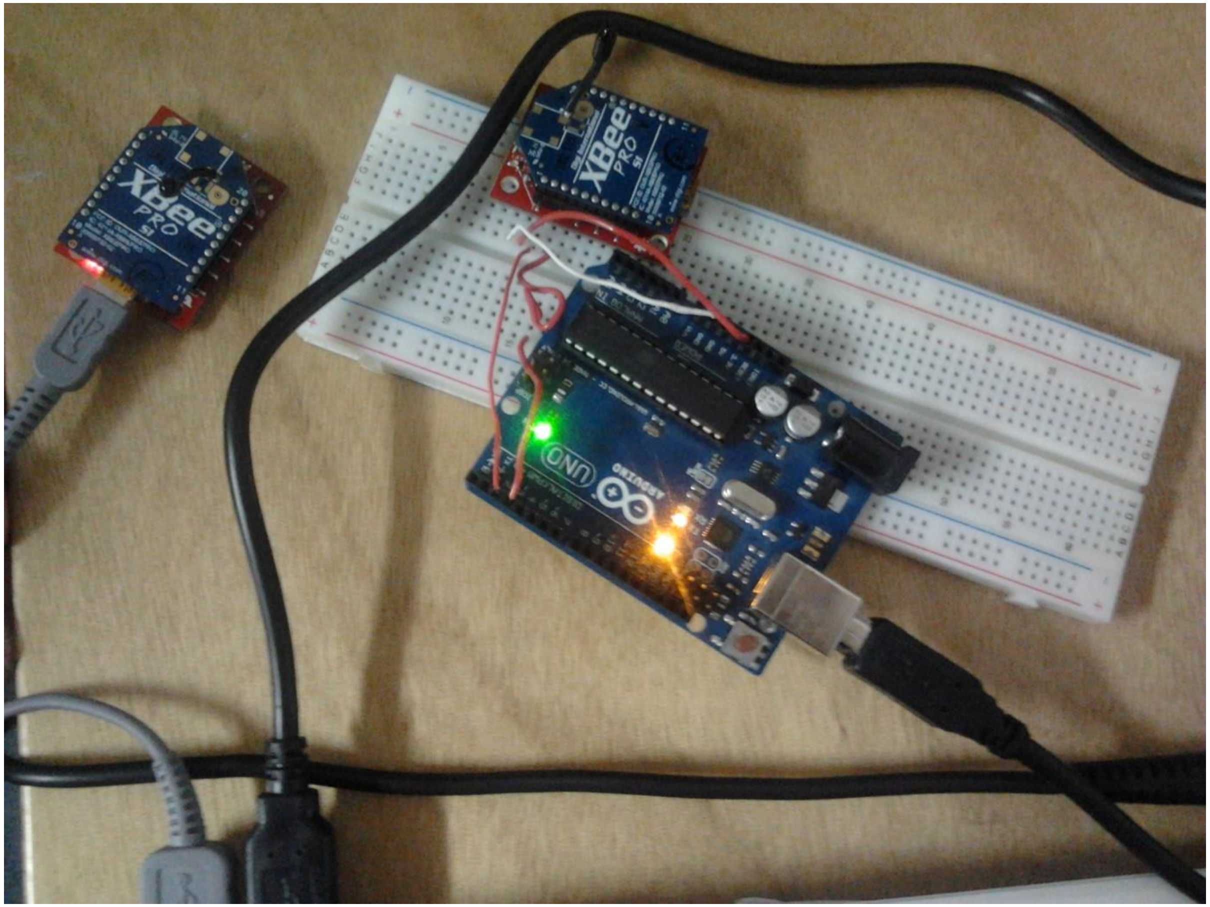
- **Letters were sent in alphabetical order from the Xbee connected to Arduino to the Xbee connected to PC.**
- **Letters arrived correctly.**

GCS Near Communication Test

- **Arrived letters at MATLAB interface**



- **Near communication test setup**



CanSat Integration and Test

Waheedullah Taj

CanSat Integration and Test Overview

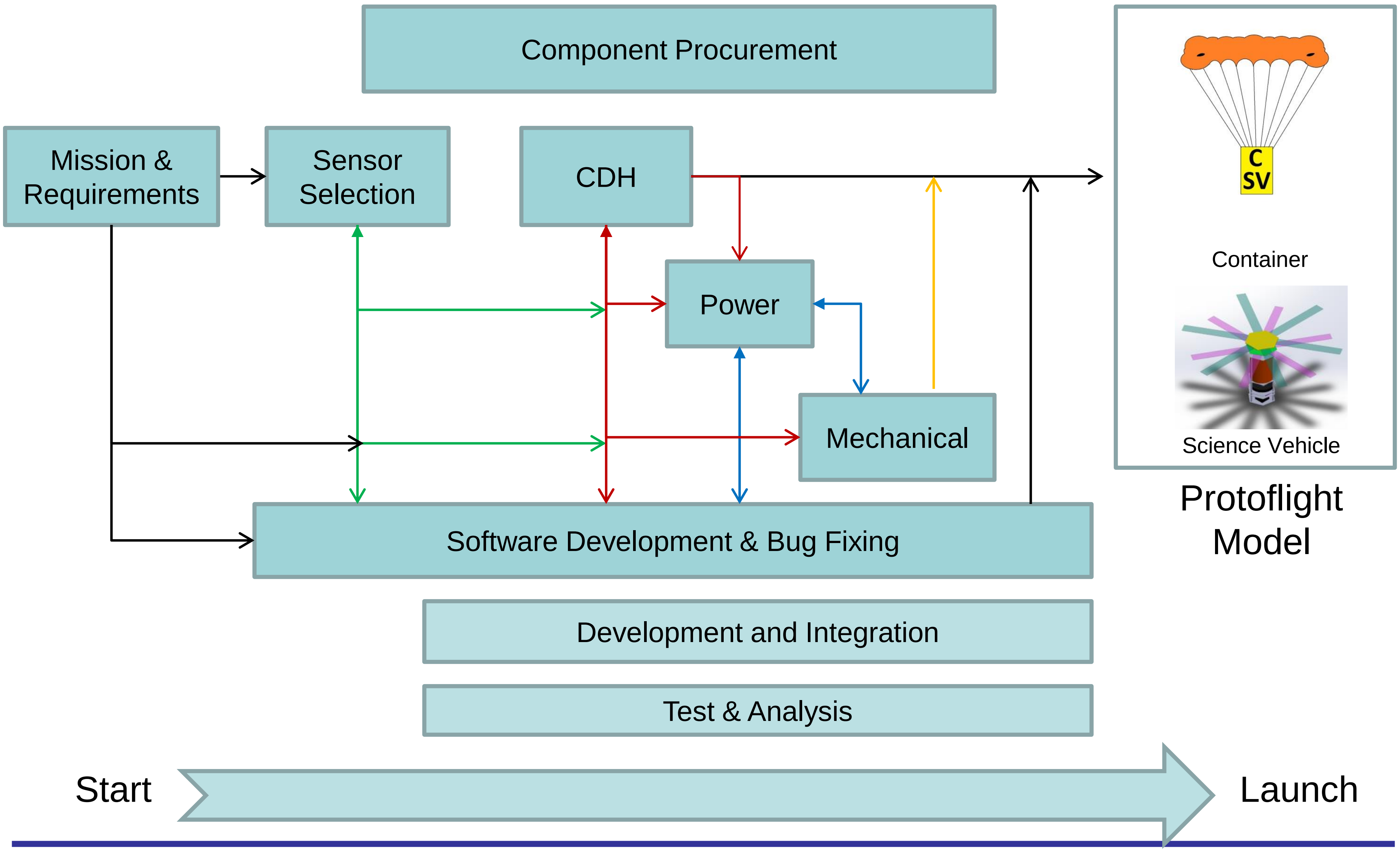
- **Subsystem integration**
  - Electronic components are attached to carbon fiber composite base plates using pin bolts, special adhesive and silicon.
  - The CanSat is integrated bottom to top by attaching the plates to each other via aluminum rods.
- **Cansat integration and tests are performed using three models**
  - <u>Structural Model</u> to perform mechanical and structural tests.
  - <u>BreadBoard Model</u> to perform CDH tests.
  - <u>Protoflight Model</u> to perform system level tests after system integration to verify functionality.
- **Content of the structural and breadboard models and performed subsystem tests are summarized in the next slide.**

CanSat Integration and Test Overview

Model	Content	Performed Subsystem Tests
Structural	Prototypes of container and payload compartments, rotors, egg container	Rotor functionality, parachute deployment, impact tests, egg container drop tests
Breadboard	Processors, sensors, tranceivers, power supply	Flight software, data handling, actuator and communication functionality, power regulation

- **Protoflight model will be integrated after the CDR based on the following sequence of subsystems:**
  - **Communication and Data Handling:** Sensors, Processors, Actuator, Transceivers, Flight Software
  - **Power:** Battery, Electronic Circuit Boards, Harness
  - **Mechanical:** Structural components, Interfaces, Parachute, Rotors, Egg Container, Reaction wheel

CanSat Integration and Test Overview



CanSat Integration and Test Overview

	Tests	Equipment/ Environment
Mechanical and Structural	Parachute Deployment	1. By deploying the CanSat from a known altitude (e.g. Roof of a building) 2. By performing wind tunnel tests to measure drag force.
	Payload Deployment Mechanism	1. By deploying the CanSat from a known altitude (e.g. Roof of a building)
	Descent Control Mechanism	1. By deploying a Payload prototype from a known altitude (e.g. Roof of a building) 2. Rotor blades were tested in the wind tunnel
	Shock Force and Acceleration Survival	1. By dropping /throwing the CanSat from a known altitude (e.g. Roof of a building) 2. By performing structural analysis

Sensor Subsystem Testing Overview

Test ID	Verified Requirements	Necessary Equipments	Test Description	Pass/Fail Criteria
SEN – T1	SEN1	Altitude (Pressure) Sensor, Arduino Mini	• **Stability**: The altitude is measured for some time on a stationary table. • **Accuracy**: The altitudes of several places is measured and compared with the official data. • **Ability to Sense**: The responsiveness of the sensor to sudden changes is observed by moving it up and down rapidly.	• The altitude measurements are stable. • The sensor has an accuracy as promised in the datasheet. • The sensor is responsive to sudden changes.
SEN – T2	SEN1	Outside Air Temperature Sensor, Arduino Mini	• **Stability**: The temperature is measured for some time in a room with no significant disturbances. • **Accuracy**: The temperatures of several rooms are measured and the measurements are compared with the readings of an ordinary thermometer. • **Ability to Sense**: The responsiveness of the sensor to sudden changes (radiator and fridge effects) is observed.	• The temperature measurements are stable. • The sensor has an accuracy as promised in the datasheet. • The sensor is responsive to sudden changes.
SEN – T3	SEN9	Buzzer, Arduino Mini	• **Stability**: The stability of the volume was observed for some time. • **Loudness**: The loudness is observed.	• The volume of the sensor is constant. • The sensor can be heard from 20m.

Sensor Subsystem Testing Overview

Test ID	Verified Requirements	Necessary Equipments	Test Description	Pass/Fail Criteria
SEN – T4	SEN1	Inside Air Temperature Sensor, Arduino Mini	• **Stability**: The temperature is measured for some time in a room with no significant disturbances. • **Accuracy**: The temperatures of several rooms are measured and the measurements are compared with the readings of an ordinary thermometer. • **Ability to Sense**: The responsiveness of the sensor to sudden changes (radiator and fridge effects) is observed.	• The temperature measurements are stable. • The sensor has an accuracy as promised in the datasheet. • The sensor is responsive to sudden changes.
SEN – T5	SEN2	Camera, SD Card Shield, Arduino Mini	• **Stability**: The camera will record a stationary scene for some time. • **Pixels**: Pure white, black, red, green and blue images were recorded with the camera to see active pixel area.	• We expect the video to be stable. • All pixels were found to be healty.
SEN – T6	DCR2	Gyroscope, Arduino Mini	• **Stability**: The angular velocity of the sensor is measured while it is kept stationary. • **Sensibility**: The responsiveness of the sensor to sudden changes in angular velocity is observed by giving it impulsive rotations.	• The angular velocity is measurements have no steady state error. • The sensor is responsive to sudden changes.

3-Axis Accelerometer Testing

Test ID	Verified Requirement	Necessary Equipments	Test Description	Pass/Fail Criteria
SEN – T7	SEN1	Accelerometer, Arduino Mini	• **Stability**: The acceleration data is measured while the sensor is kept stationary. • **Sensibility**: The responsiveness of the sensor to sudden changes in acceleration is observed.	• The acceleration measurements have no steady state error. • The sensor is responsive to sudden changes.

DATA STORAGE SIZING AND FORMAT

- The sensor chip communicates over the I2C interface and will provide 16-bit acceleration data.
- The frequency of the measurements will be 1 Hz and this corresponds to 120 bytes/min.

Mechanical Subsystem Testing Overview

Test	Constraints	Equipment	Procedure	Pass/Fail Criteria	Results
Impact Test	Survivability of the overall payload structure under shock	Prototype of the payload	The prototype is released from a calculated height (10 m) to ensure resistance to descent velocity.	Passed	Overall structure survived several repeated tests. No material crack or failure is observed.
Egg container drop tests	Survivability of the container and the egg in it.	•Viscoelastic sponge covered with metal can •Prototype of the container •Egg	The container with the egg inside it is released from different heights to achieve different velocities.	Passed	The egg and container displayed no permanent deformations or cracks when dropped from 3.2 m (8 m/s impact velocity).
Blade survivability in wind tunnel tests	Structural integrity of the blades and hinges.	Prototype of the blades, hinges and the uppermost plate.	A one-to-one prototype of the blades placed in wind tunnel and observed under different velocities.	Passed	Blade structures endured twice the magnitude of the expected aerodynamic loads in flight conditions.

CDH Subsystem Testing Overview

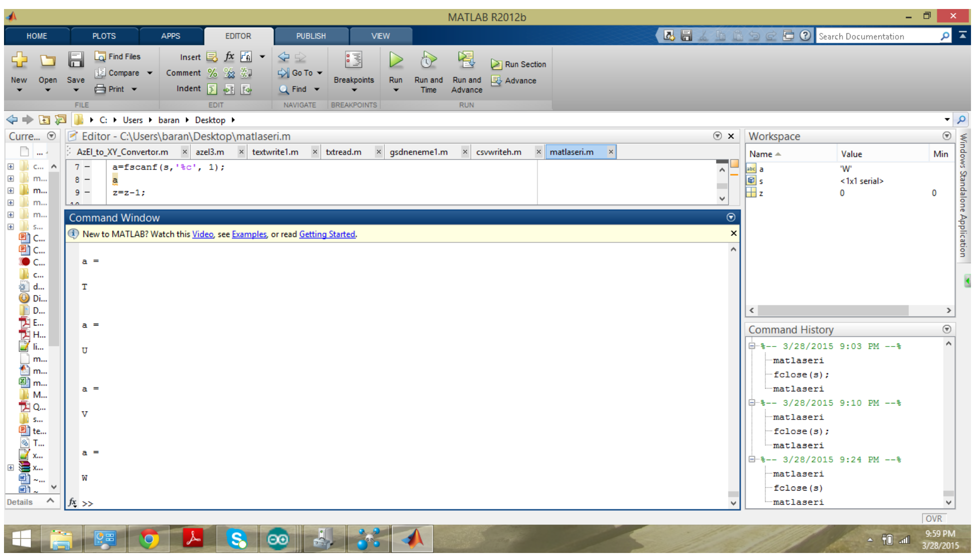
Test ID	Verified Requirements	Necessary Equipments	Test Description	Pass/Fail Criteria
CDH-T1 XBee Communication Range Test (NOT COMPLETED)	(CDH 2,4,5,6,9)	XBee Modules Arduino External Antenna Subsystems: GCS and CDH	1) One XBee will be connected to external antenna, and computer 2) The other will be connected to Arduino 3) The one with Arduino connection moves away	Successful communication without lost packets until 1.5 km distance
CDH-T2 RTC (Reset tolerance) (DONE)	(CDH 3,11)	Arduino DS1307 Subsystems: FSW and CDH	1) Real Time Clock is started with Arduino 2) Arduino will be reseted and error in time will be checked	Timekeeping continues with less than a second of error in reset
CDH-T3 SD Card (NOT COMPLETED)	Read Data from SD Card (CDH 12,13)	Arduino SD Card SD Card Shield Subsystems: FSW and CDH	1) Video recording and data generation by Arduino 2) Video and data will be saved to the SD card	Whether all data, including the video can be recovered from SD card or not

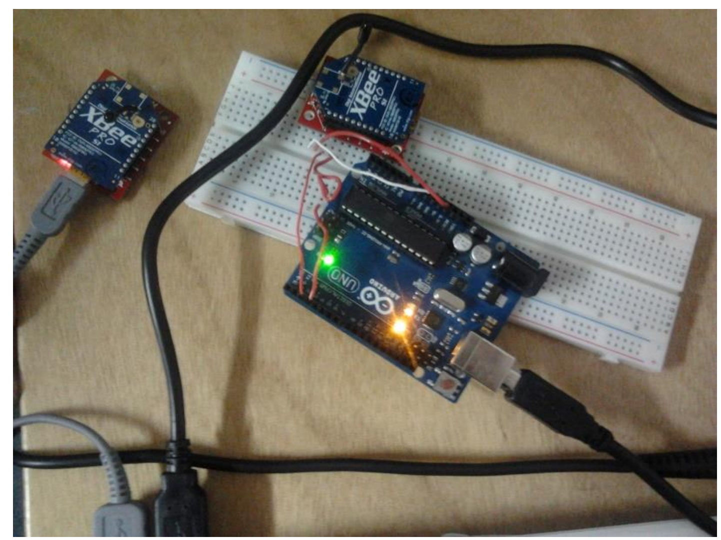
CDH Subsystem Testing Overview

Test ID	Verified Requirements	Necessary Equipments	Test Description	Pass/Fail Criteria
CDH-T4 Near Communication Test (NOT COMPLETED)	Communication can be done in the required packet format (CDH 2,5,6,)	Arduino, XBees, GCS software Subsystems: CDH, GCS	1) Random data will be sent in the required packet format. 2) Graphs will be obtained from the data.	Successful sending and receiving of data
CDH-T5 Sensors Test (DONE)	Sensors can send data to Arduino in required format (CDH 1,2,13)	Sensors, Arduino Subsystems: CDH, FSW and Sensor	1) Each sensor will be connected to Arduino 2) Necessary data is requested by an Arduino code	Arduino successfully obtains sensor data

Radio Testing

- Initial tests for radio communication was done. The test included two wire antenna XBees, one of them connected to Arduino, the other to the computer.
- At a range of 200m, successful communication without any lost packet is achieved, with 20 % of output power and without using the external antenna.
- The test will be repeated with full power and external antenna as stated in the CDH tests part.





EPS Testing Overview

Test Id	Verified Requirements	Necessary Equipments	Test Description	Pass/Fail Criteria
EPS-T1	EPS2, EPS3	Multimeter	Supply power through umbilical instead of batteries	Pass if all components (except nichrome) operate properly with the umbilical.
EPS-T2	EPS4	Multimeter	Check if all the desired voltage levels are provided	10% deivation is acceptable under full load
EPS-T3	EPS5	Multimeter	Pass current through the thermo-resistive wire using the relay	Pass if the rope is cut and all other electronics continue to function properly.

FSW Testing Overview

Test ID	Verified Requirements	Necessary Equipments	Test Description	Pass/Fail Criteria and Results
FSW–T1	SR9	BMP183, DS18B20, MPU6050 sensors Arduino Mini	Test the communication between the sensors and the microcontroller. The sensors are excited to provide varying measurements.	Pass if • Communication is done succesfully. • Expected variations in the sensor readings are observed.
FSW–T2	SR9	XBEE, Arduino Mini	Test telemetry sending from Arduino, and recieving from another XBEE	Pass if the sent data read with no loss.
FSW-T3	SR9	RTC(DS1307) Arduino Mini	Test the bidirectional communication between RTC and Arduino. Check the reliability of measurements That is very important for providing recovery state when processor reset occurs.	Pass if the clock counts very succesfully and coherently with our watches.

FSW Testing Overview

Test ID	Verified Requirements	Necessary Equipments	Test Description	Pass/Fail Criteria and Results
FSW–T4	SR17	MicroSD memory card, Arduino Mini	Reading and writing MicroSD memory card. It is important for camera recording and keeping flight log information. These data also would be very useful in a reset case.	Data write to and read from MicroSD card succesfully.
FSW–T5	SR13	DC motor, Motor driver bridge, Arduino Mini	Driving motor by applying PWM. This is important to provide rotational stability to camera by reaction whell.	Pass if motor can be rotated in both sides(CCW and CW) at desired speeds.
FSW-T6	SR19	Buzzer, Arduino Mini	Test the buzzer. It helps us to locate the CanSat after landing.	Pass if a high level sound heard from buzzer.
FSW-T7	SR11	Camera, MicroSD memory, RTC, Arduino Mini	Test the camera recording, and time stamp usage.	Pass if the video taken by camera is playable and the time stamp is visible.

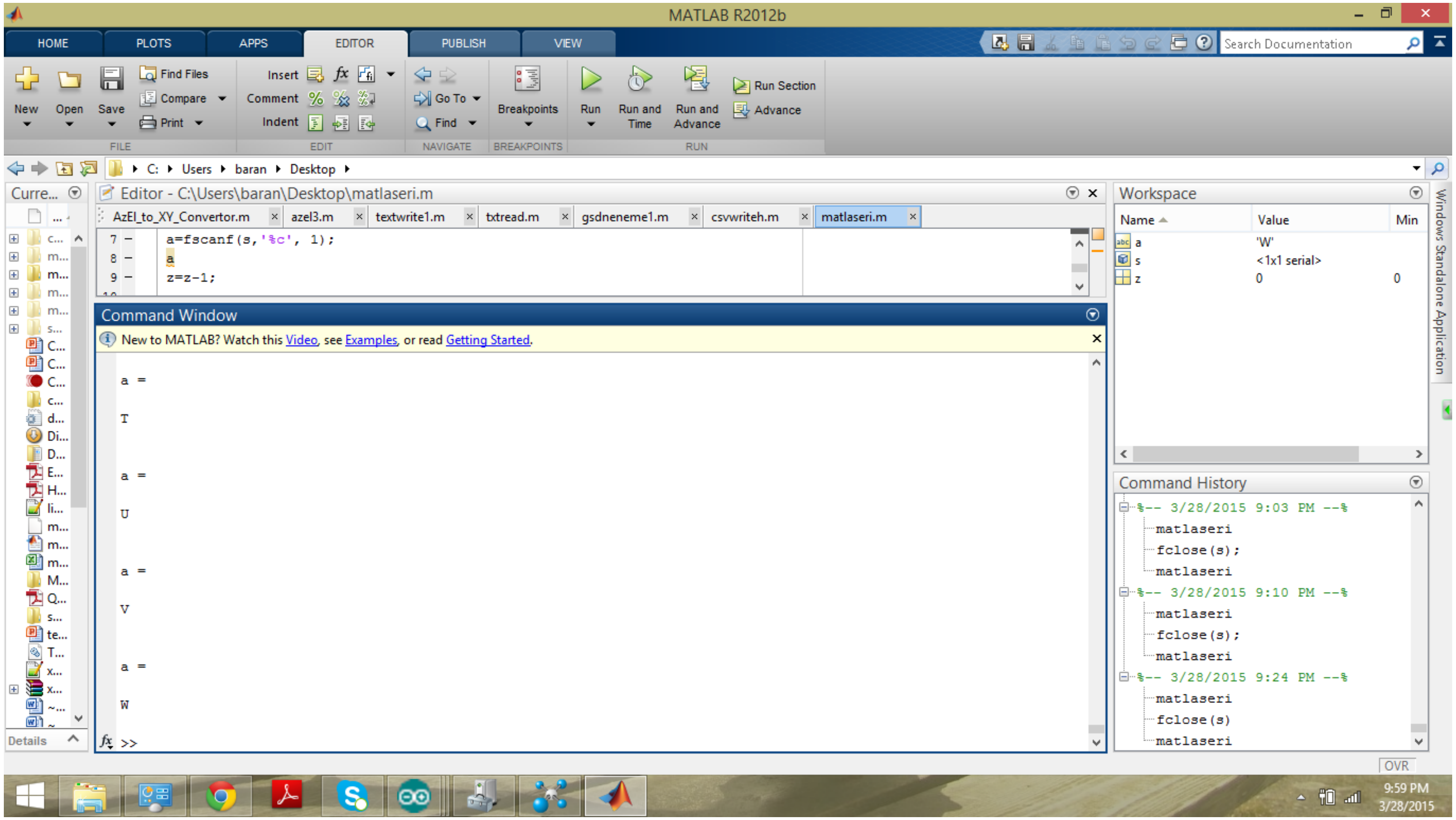
GCS Testing Overview

Test Id	Verified Requirements	Necessary Equipments	Test Description	Pass/Fail Criteria
Software Test *(DONE)*	GCS can plot the graphs correctly from the received data.	GCS software	1) Random data generator was written. 2) Graphs were obtained from the data.	**Pass** (Graphs were obtained correctly.)
Near Communication Test (NCT) *(NOT COMPLETED)*	Communication can be done in the required packet format	Arduino, XBees, GCS software	1) Random data will be sent in the required packet format. 2) Graphs will be obtained from the data.	Correct Graphs
Far Communication Test (FCT) *(NOT STARTED)*	Link budget is enough.	Arduino, XBees, GCS software, Antenna	Same as NCT except it is done from a distance away with various angles.	Correct graphs from 1.5km distance and ±22.5°.

GCS Near Communication Test

- **Letters were sent in alphabetical order from the Xbee connected to Arduino to the Xbee connected to PC.**
- **Letters arrived correctly.**
- **However the required packet format has not been formed.**

- **Arrived letters at MATLAB interface**



Mission Operations & Analysis

Burak Yaglioglu

Overview of Mission Sequence of Events

Ground Support Equipment Preparation
- Prepare electrical ground support equipment (check antennas, etc.)
- Connect electrical ground support equipment to the ground station computer
- Start up ground station software and wait for listening mode

CanSat Preparation
- Assemble final CanSat configuration
- Check structural integrity
- Check electrical connections
- Check software version and install software
- Power ON and check telemetry collection
- Confirm that the checklist is complete (connections, tests, etc.)

CanSat Integration to the Launcher
- Place CanSat in the payload section
- Check allowance and structural integrity
- Rocket Launch

Rise Phase
- Ground Station: Receive and monitor telemetry
- Container: Store & Transmit Altitude and Mission Time Data
- Release from Rocket (670-700m)

Separation Phase
- Container Parachute Deployment
- Ground Station: Receive and monitor telemetry
- Container: Store & Transmit Altitude and Mission Time Data
- Separation of Payload and Container (500m)

Descent Phase
- Payload: Passive Descent Control Mechanism
- Container: Store & Transmit Altitude and Mission Time Data
- Payload: Store & Transmit Data (Pressure, Temp, Voltage, Mission Time, +Bonus)
- Touchdown

Landing
- Stop Data Transmission
- Save mission data
- Locate CanSat
- Recover Container and Science Vehicle
- Analyse Data
- Check for egg

Overview of Mission Sequence of Events

Mission and Systems Engineering
- Coordination of Launch Campaign and Mission Operations

Electronic Systems Group
- Electronic System Inspection and Check
- Software and Electrical Ground Support Equipment Preparation
- CanSat Preparation
- CanSat Operations & Recovery

Communication and Ground Station Group
- Software and Electrical Ground Support Equipment Preparation
- Communication System Inspection and Check
- CanSat Preparation
- CanSat Operations

Mechanical Systems Group
- Mechanical Ground Support Equipment Preparation
- Structural Inspection and Equipment Check
- CanSat Preparation
- CanSat Recovery

Field Safety Rules Compliance

- **The Mission Operations Manual will include**
  - A set of checklist for the Ground Station and CanSat (Container + Science Vehicle) assembly and pre-flight functional tests
  - A set of checklist for the attachment of CanSat to the rocket.
  - A set of checklist for compliance with field safety regulations
  - Timelines of events, parameters to be monitored and commands (if necessary) throughout all mission phases from launch till landing.
  - Troubleshooting procedures based on the final electrical configuration and software functionalities.

- **Outline of the Mission Operations Manual has been prepared and it will be finalized after system level tests based on the final system configuration.**
- **Two copies of the Mission Operations Manual will be ready at the Flight Readiness Review by the day before launch.**

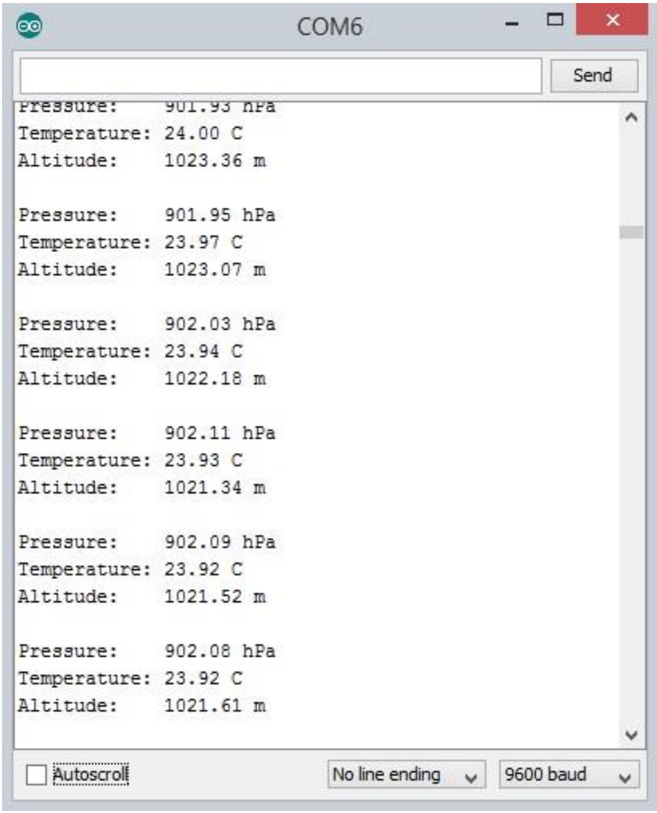
- **Container and Payload Recovery**
  - An analysis procedure and necessary software utilizing the mission and weather data (time, altitude, gyro, accelerometer, wind speed if possible) will be prepared and location of the container and science vehicle will be estimated.
  - The buzzer will start beeping as soon as it touches the ground and this will help to recover our CanSat
  - Visible colours for the parachute will be selected in order to aid team for locating the container. Similarly, identification of payload will be based on its colors.
  - A label with contact information will also be placed on both container and science vehicle.

Mission Rehearsal Activities

- **Ground system radio link check procedures**

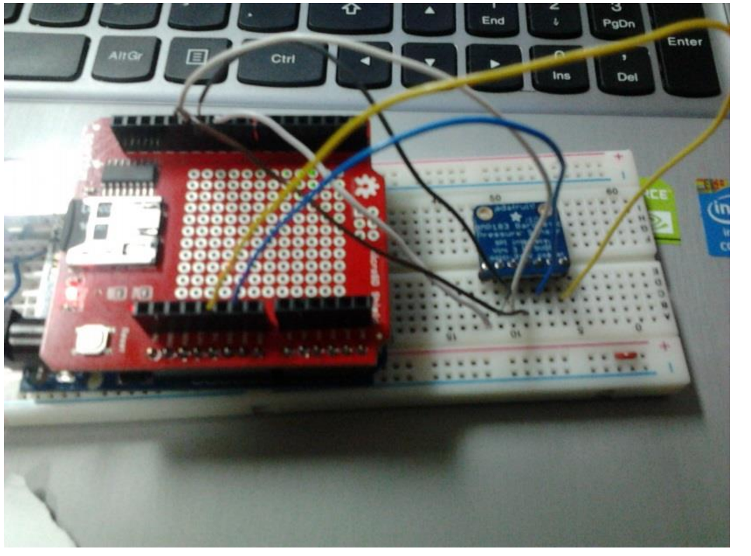
  (performed with the breadboard model)
  - Prepare electrical ground support equipment (ground station computer, etc.) and connect antennas
  - Configure the communication link
  - Check the telemetry
- **Loading the egg payload**

  (performed with a prototype)
  - Place the egg in viscoelastic material and then integrate into the egg protection prototype
  - Test it by releasing from several altitudes (1, 2, 3, 5 meters)

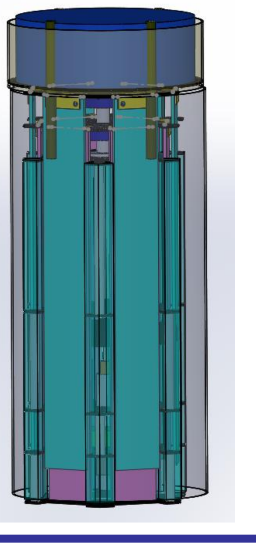


Mission Rehearsal Activities

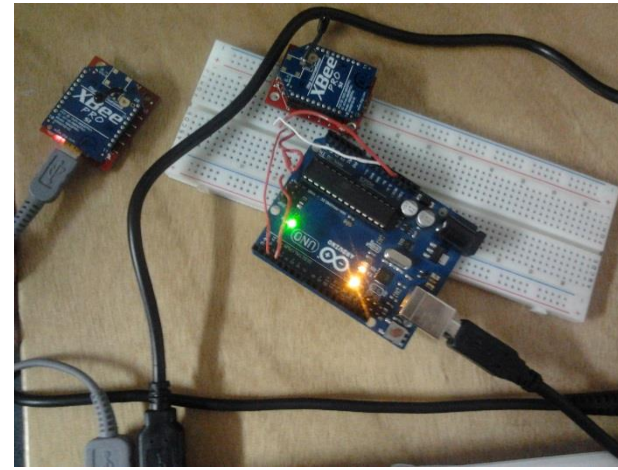
- **Powering on/off the CanSat (performed with breadboard model)**
  - Check for the electrical connections
  - Power the Science Vehicle via umbilical power source
  - Check for the electrical power availability / connection stability



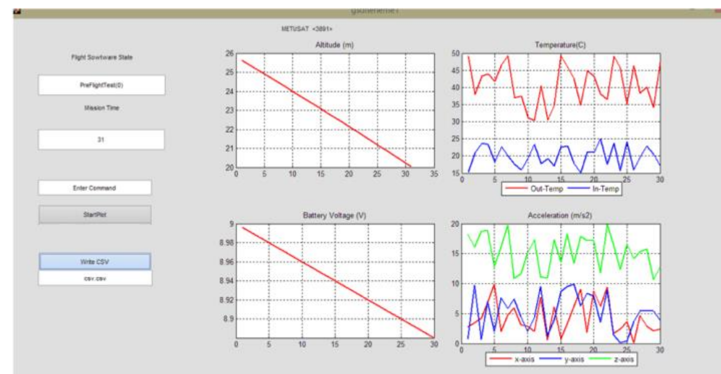
- **Launch configuration preparations (performed with structural model)**
  - Assemble CanSat configuration
  - Check for the structural integrity
  - Check for final mass and dimensions



Mission Rehearsal Activities



- **Telemetry processing, archiving, and analysis (performed with breadboard model)**
  - Install the final version of the software
  - Check for the telemetry collection, storage and monitoring in the ground station



- **Loading the CanSat in the launch vehicle (performed with structural model)**
  - Check for the final dimensions and rocket compatibility

- **Recovery (performed with breadboard model)**
  - Check for Buzzer functionality
  - Locate CanSat using observations, Buzzer noise and received data

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

Requirements Compliance

Omer Atas

Requirements Compliance Overview

- The detailed design is completed.
- Design complies to the requirements, based on analysis performed up to so far.
- All requirements are complied and verified by analysis. Several tests are done, which are explained in Integration and Tests section. Further integration tests will be done.
- Ground station is not built yet. It will be ready before the flight.

Requirements Compliance

Rqmt Num	Requirement	Comply / No Comply / Partial	X-Ref Slide(s) Demonstrating Compliance	Team Comments or Notes
1	Total mass of the CanSat (Container and Science Vehicle) shall be 600 grams +/- 10 grams not including the egg.	Comply	59	Mass margin=30g
2, 3	The Container shall fit in the envelope of 125 mm x 310 mm and completely contain the Science Vehicle. Tolerances are to be included.	Comply	18,51	1cm clearence
4	The Container shall use a passive descent control system. A parachute is highly recommended.	Comply	34	
5	The Container shall not be able to get stuck in the rocket.	Comply	18	
6	The Container shall be a florescent color, pink or orange.	Comply	37,34	Orange
11	The Science Vehicle shall use a passive helicopter recovery system.	Comply	37	2 rotor system
12,13, 15,16	The CanSat should be compliant with the environmental requirements (shock, acceleration and temperature).	Comply	134,50,56,58	Some tests need to be done
19,20	The separation mechanism shall not use pyrotechnics or chemicals, and heating-based components shall not be exposed to outside environment.	Comply	55,56	Electro-resistive heater is isolated from environment by clindrical aluminum shaft

Requirements Compliance

Rqmt Num	Requirement	Comply / No Comply / Partial	X-Ref Slide(s) Demonstrating Compliance	Team Comments or Notes
21, 22, 23	During the descent the Science Vehicle shall collect and transmit the required telemetries at 1Hz rate.	Comply	**71,132**	Tested
24	XBEE radios (at correct settings) shall be used for telemetry.	Comply	**131,132,71**	Tested
27, 28	The Science Vehicle shall have a video camera recording time-stamped video of the complete descent. 1 hour of recording shall be supported.	Comply	67,86,87	
29	The descent rate of the Science Vehicle shall be between 4 m/s and 10 m/s.	Comply	41,42,43,44	Tested
30	The image of the ground in the video shall be stable in 3 axes.	Partially Comply	27,28	Controller needs to be tested
31	The cost of the CanSat shall be under $1000.	Comply	156	
33, 34, 35, 36	All the telemetry shall be displayed (in SI units) and plotted in real-time on the screen of the ground station's laptop.	Comply	116,117,118	Tested
38	The Science Vehicle shall hold one large raw hen's egg which shall survive launch, deployment and landing.	Comply	50,130	Tested
40	In the case of processor reset, the flight software shall re-initialize to the correct state.	Comply	68,131	Tested
42, 43, 44, 45,	The Science Vehicle must include a battery of allowed type and an easily accessible power switch.	Comply	84,85	Tested

Management

Burak Yaglioglu

Status of Procurements

Component	Quantity	Status	Arrival Date (for orders not received yet)
Real Time Clock Module	1	Received	-
Arduino Mini 328-5V/16MHz	1	Received	-
Triple Axis Accelerometer Breakout-MPU6050	1	Received	-
Barometric Pressure Sensor-BMP183 Breakout	1	Received	-
Breakout Board for XBEE Modules	2	Received	-
Micro SD Card -32 GB	1	Received	-
Voltage Regulators (3, 3.3, 6)	3	Received	-

Status of Procurements

Component	Quantity	Status	Arrival Date (for orders not received yet)
2.4 GHz Yagi Antenna RP-SMA	1	Received	-
XBEE Explorer Dongle	1	Received	-
XBEE Pro 2.4GHz 60mW RPSMA	1	Received	-
XBEE Pro 60mW Wire Antenna	1	Received	-
Motor DriverL293D	1	Received	-
DC Motor (6V, 1500 rpm)	1	Received	-
OV7670 Camera	1	Received	-

Status of Procurements

Component	Quantity	Status	Arrival Date (for orders not received yet)
5V Buzzer	1	Received	-
DS18B20 Temperature Sensor	1	Received	-
SD Card Shield	1	Received	-
9V Battery	2	Received	-
Nickel-Chrome Wire	1m	Received	-
Relays, switches, resistors and other electrical equipment	-	Received	-

Status of Procurements

Component	Quantity	Status	Arrival Date (for orders not received yet)
Carbon Fiber Composite Sheet	1 (50x50x0.1cm)	Manufactured	-
Viscoelastic Sponge	1+1 (30x35x8.5cm) (48.5x50.5x5cm)	Received	-
Aluminum bars	6 (0.5x17cm)	Received	-
One layer carbon fiber composite (covering shell)	1(50x 50x0.03cm)	Manufactured	-
Parachute fabric	(1m x 3m)	Received	-
Balsa (for composite)	-	Obtained from university's workshop	-
One layer fiber glass composite material (for SV)	1 (30x40x0.03cm)	Manufactured	-
Bearing	2 (d=8mm, D=30mm)	Received	-

CanSat Budget – Hardware

Component	Quantity / Subsystem	Cost
Real Time Clock	1 / CDH	$13.4 (Actual)
Arduino Mini 05	1 / CDH	$12.95 (Actual)
3-Axis Accelerometer MPU-6000	1 / SEN	$6.5 (Actual)
Barometric Pressure Sensor-BMP183	1 / SEN	$9.95 (Actual)
Breakout Board for XBEE Module	2 / CDH	$2 (Actual)
SD Card	1 / CDH	$10 (Actual)

Component	Quantity / Subsystem	Cost
Voltage Regulator (3,3.3,6 V)	3/ EPS	$1.5 (Actual)
Temperature Sensor DS18B20	1 / SEN	$0.75 (Actual)
XBEE Explorer Dongle	1 / GCS	$24.95 (Actual)
XBEE Pro 2.4GHz 60mW RPSMA	1 / CDH	$50 (Actual)
XBEE Pro 60mW Wire Antenna	1 / CDH	$37.95 (Actual)
Camera Omnivision OV7670	1 / SEN	$6.5 (Actual)
Buzzer (5V)	1 / SEN	$1
S-Link SL-2409 Yagi Antenna	1 / GCS	$13 (from last year)

CanSat Budget – Hardware

Component	Quantity / Subsystem	Cost
Motor Driver L293D	1 / EPS	$0.50 (Actual)
DC Motor (6V, 1500 rpm)	1 / EPS	$16 (Actual)
SD Card Shield	1/ CDH	$15 (Actual)
9V Battery	2/ EPS	$4.7 (Actual)
Nickel-chrome wire, Relays, Swit-tches, Resistors etc.	-/EPS	$10 (Estimated)

Component	Quantity / Subsystem	Cost
Carbon Fiber Sheet (Covering Shell)	- / MS	$90 (to cut) (Actual)
Aluminum bars	- / MS	$5 (Actual)
Balsa	- / DCS	-
Fiber Glass composite	- / MS	-
Viscoelastic Material (Sponge)	- /MS	$5 (Actual)
Bearing	- / MS	$13 (Actual)
Hinge	-/MS	$20 (Actual)
Spring	-/MS	$2 (Actual)
Parachute Fabric	-/DCS	$20 (Actual)

CanSat Budget – Hardware Total

Category	Subtotal
Electronic Components	$240
Mechanical Components	$135
Shipping Costs	$200
Total Hardware Costs	**$575**

The CanSat Hardware budget is below $1000. The requirement is complied.

CanSat Budget – Other Costs

Component	Quantity / Subsystem	Cost
Antenna Mast	3m / GCS	$20 (Estimate)
Shielded Cable + USB Cable	1m + 2m / GCS	$10 (Estimate)
Aluminum plate	1 (50cmx50cmx0.1cm) / PROTOTIPING	$12.5 (Budgeted)
Viscoelastic Sponge	1+1 (30cmx35cmx8.5cm) (48.5cmx50.5cmx5cm) /PROTOTIPING	$10 (Actual)

Component	Quantity / Subsystem	Cost
Parachute Fabric	1m x 3m / PROTOTIPING	$20 (Budgeted)
Balsa	- / MS	-
Aluminum bars	12 (d:0,6cm, h:31cm) / PROTOTIPING	$5 (Actual)

CanSat Budget – Other Costs

Component	Quantity / Subsystem	Cost
Travel (Flight)	10	$10000 (10x$1000) (Estimate)
Hotel	10	$2500 (5x$500)
Test Facilities and Equipment	-	-
Train/Bus Travel	10	$1000 (10 x $100)
Food	10	$350 (10 x $35)

Category (Costs)	Subtotal
Electronic Components	$240
Mechanical Components	$135
Shipping Costs	$200
Other Costs	$14000
Unexpected Costs	$1000
Total Costs(+/-500)	**$15575**

CanSat Budget – Income

Source	Income
METU Engineering Faculty	$2600
National Aerospace Industry	$11000
Total Income	**$13600**

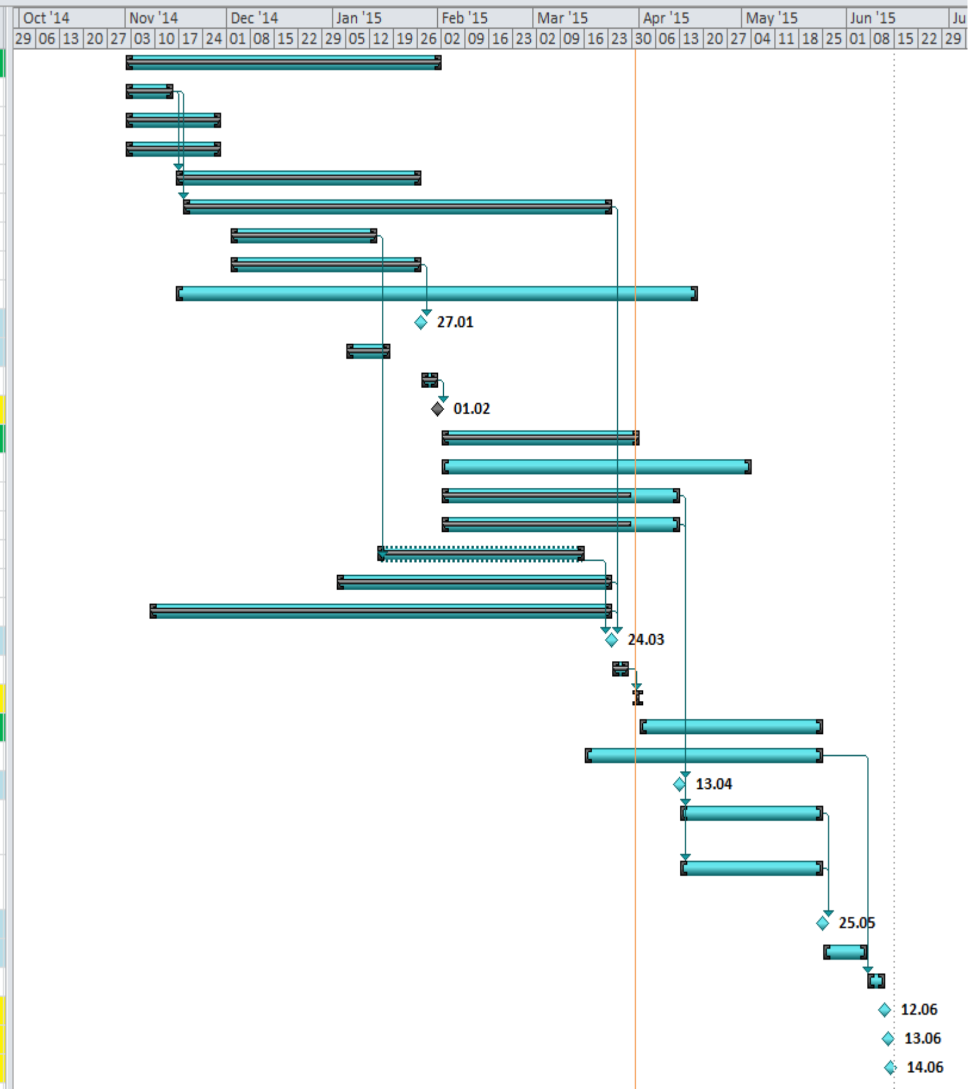
- **All income is currently expected.**
- **Hardware procurements will be funded by the METU Engineering Faculty**
- **National Aerospace Industry and Airline Operators will be contacted for sponsorships to cover the travel and other expenses.**

Program Schedule

Date	Development	Logistics	Academic and Other	Achievements
1 November 2014 - 1 February 2015	- Team Formation - Mission Definition - Literature Survey - Preliminary Design - Functionality Definition - Requirements Definition	- Hardware Literature Search - Hardware Procurement - Sponsorship Search	- National Holidays (2 weeks) - Quizzes, Homeworks, Midterms and Finals (~6 weeks)	- Preliminary Design Review and Reports
1 February 2015 - 15 March 2015	- Mission Interfaces and Requirements - Subsystem Design, Analysis and Interfaces - Software, Autonomy and Operational Modes	- Hardware Procurement -Test Environment Identification - Sponsorship Search	- Quizes, Homeworks, and Midterms (~1 week)	- CanSat Prototype - Software Prototype - Preliminary Test Reports
15 March 2015 - 31 March 2015	- Mission and Design Verification Plan - Documentation	- Hardware Procurement -Travel Organizations (tickets, hotels, etc.)	- Quizes, Homeworks, and Midterms (~1 week)	- Critical Design Review and Reports -CanSat Engineering Model
31 March 2015 - 24 May 2015	- System integration, tests and design verifiications - Software bug fixes - System checks and corrections	- Hardware Procurement - Accomodation and Flight Reservation - Visa Application	- National Holidays (2 days) - Quizes, Homeworks, and Midterms (~2 weeks)	- Team FRR - Final Software - CanSat Flight Model - Fixed Budget
24 May 2015 - 14 June 2015	- System checks - Launch Campaign	- Competition Preparation	- Finals (2 weeks)	- Flight Readiness Review - Launch - Post Flight Review Report

Program Schedule

		Task Name	Start	Finish	Predecessors	Duration
1	✓	**Preliminary Design Phase**	**Sat 01.11.14**	**Sun 01.02.15**		**67 days**
2	✓	Mission Definition	Sat 01.11.14	Fri 14.11.14		11 days
3	✓	Literature Survey	Sat 01.11.14	Fri 28.11.14		21 days
4	✓	Hardware Survey	Sat 01.11.14	Fri 28.11.14		21 days
5	✓	Conceptual Design	Sun 16.11.14	Mon 26.01.15	2	52 days
6	✓	Subsystem Design and Interfaces Definition	Tue 18.11.14	Mon 23.03.15	2	90 days
7	✓	Functionality and Operations Concept Definition	Tue 02.12.14	Tue 13.01.15		31 days
8	✓	Requirements Definition	Tue 02.12.14	Mon 26.01.15		40 days
9		Sponsorship Search	Sun 16.11.14	Sat 18.04.15		112 days
10	✓	**METUSAT Preliminary Design Review (M-PDR)**	**Tue 27.01.15**	**Tue 27.01.15**	**8**	**0 days**
11	✓	**METU Fall Finals**	**Mon 05.01.15**	**Sat 17.01.15**		**11 days**
12	✓	Competition PDR Documentation	Tue 27.01.15	Sat 31.01.15		5 days
13	✓	**Competition Preliminary Design Review (C-PDR)**	**Sun 01.02.15**	**Sun 01.02.15**	**12**	**0 days**
14	✓	**Critical Design Phase**	**Mon 02.02.15**	**Tue 31.03.15**		**43 days**
15		Hardware Procurement	Mon 02.02.15	Sun 03.05.15		67 days
16		Breadboard Model Development and Tests	Mon 02.02.15	Sun 12.04.15		52 days
17		Structural Model Development and Tests	Mon 02.02.15	Sun 12.04.15		52 days
18	✓	Software, Autonomy and Operations Definition	Wed 14.01.15	Sun 15.03.15	7	44 days
19	✓	Mission and System Verification Plan Definition	Fri 02.01.15	Mon 23.03.15		57 days
20	✓	CanSat System and Operations Definition	Sat 08.11.14	Mon 23.03.15		97 days
21	✓	**METUSAT Critical Design Review (M-CDR)**	**Tue 24.03.15**	**Tue 24.03.15**	**20;6;18;19**	**0 days**
22	✓	Competition CDR Documentation	Tue 24.03.15	Sat 28.03.15		5 days
23	✓	**Competition Critical Design Review (C-CDR)**	**Tue 31.03.15**	**Tue 31.03.15**	**22**	**1 day**
24		**Integration Test and Verification Phase**	**Wed 01.04.15**	**Sun 24.05.15**		**39 days**
25		Travel Organizations (Visa, Hotel, Flight, etc.)	Mon 16.03.15	Sun 24.05.15		52 days
26		**CanSat Engineering Model Test Results**	**Mon 13.04.15**	**Mon 13.04.15**	**16;17**	**0 days**
27		Protoflight Model Integration, Tests, Corrections and Verification	Mon 13.04.15	Sun 24.05.15	16;17	31 days
28		Flight and Ground Software Integration, Tests, Corrections and Verification	Mon 13.04.15	Sun 24.05.15	16	31 days
29		**Team Flight Readiness Review (T-FRR)**	**Mon 25.05.15**	**Mon 25.05.15**	**28;27**	**0 days**
30		**METU Spring Finals**	**Mon 25.05.15**	**Sat 06.06.15**		**11 days**
31		Travel to Texas and Launch Preparations	Sun 07.06.15	Thu 11.06.15	25	5 days
32		**Competition Flight Readiness Review (C-FRR)**	**Fri 12.06.15**	**Fri 12.06.15**		**0 days**
33		**Launch**	**Sat 13.06.15**	**Sat 13.06.15**		**0 days**
34		**Competition Post Flight Review (C-PFR)**	**Sun 14.06.15**	**Sun 14.06.15**		**0 days**



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34		**Competition Post Flight Review (C-PFR)**	**Sun 14.06.15**	**Sun 14.06.15**		**0 days**

Shipping and Transportation

- The CanSat hardware will be transported inside safe containers.
- To prevent losses due to airlines, the critical components and electronics will be carried inside hand baggages (necessary permissions from the airport security and the airline operator will be secured in advance).
- The antenna mast components will be constructed with components that can be acquired from US in case they are lost. Antenna mast will be constructed by smaller parts that can be combined, for mobility.

Conclusions

- **We have finished the critical design phase**
  - CanSat detail design and prototype development
  - Major design analysis on subsystems
  - Prototype software development (Tests ongoing)
- **Future work**
  - Breadboard and structural models are almost finished (few component tests left)
  - CanSat System Integration, Tests and Verification
  - Budget and travel organizations will be fixed
- **Things to be improved**
  - Sufficient income must be secured
- **Team is ready to proceed towards next phase.**