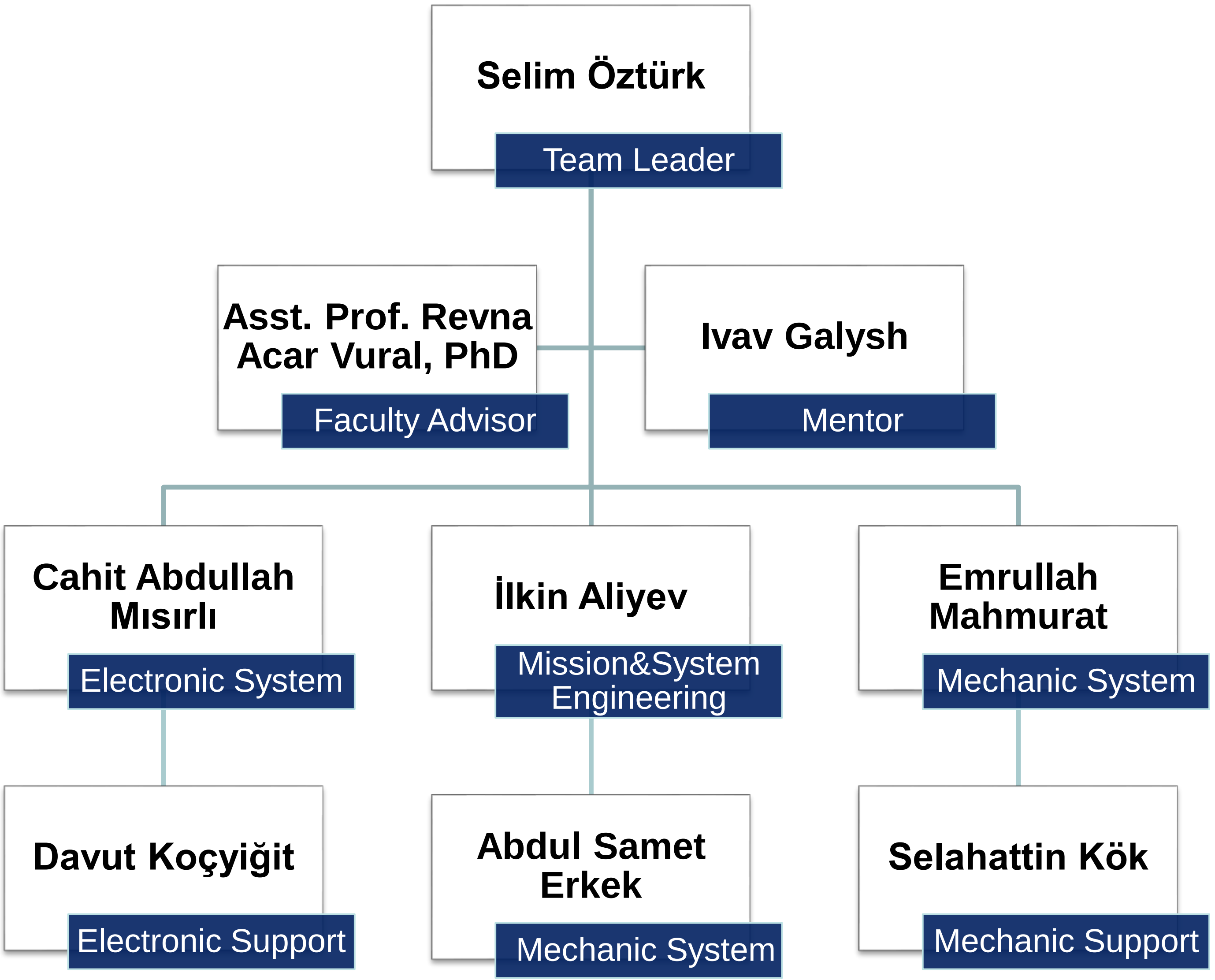
CanSat 2017
Critical Design Review (CDR)

Team 5851
IQRASAT
Yildiz Technical University

Presentation Outline

Section	Presenter(s)
Introduction	İlkin Aliyev
System Overview	İlkin Aliyev
Sensor Subsystem Design	Selim Öztürk
Descent Control Design	Abdul Samet Erkek & Selahattin Kök
Mechanical Subsystem Design	Abdul Samet Erkek & Emrullah Mahmurat
Communication & Data Handling	İlkin Aliyev
Electrical Power System	Cahit Abdullah Mısırlı
Flight Software Design	Cahit Abdullah Mısırlı
Ground Control System	İlkin Aliyev
CanSat Integration & Testing	Abdul Samet Erkek & İlkin Aliyev & Davut Koçyiğit
Mission Operations & Analysis	Selim Öztürk
Requirement Compliance	İlkin Aliyev
Management	Selim Öztürk & İlkin Aliyev

Team Organization

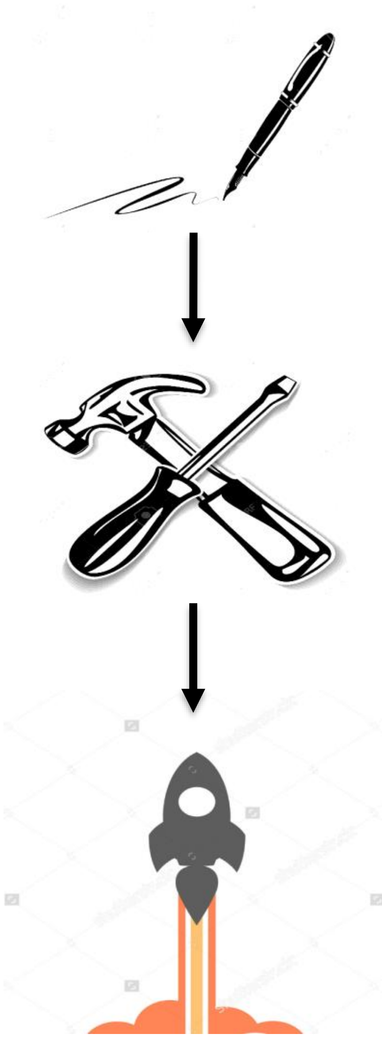


Acronyms

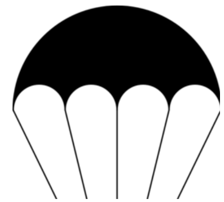
- ABS → Acrylonitrile –Butadiene -Styrene
- SR → System Requirement
- dBi → Decibel Isotropic
- SS → Sensor Subsystem
- RPS → Rocket Payload Section
- DCS → Descent Control System
- EPS → Electrical Power Subsystem
- CDH → Communication And Data Handling
- GCS → Ground Control System
- SV → Science Vehicle
- HD → High Definition
- RF → Radio Frequency
- RPS → Rocket Payload Section
- I^2C → Inter Integrated Circuit
- SPI → Serial Peripheral Interface
- UART → Universal Asynchronous Receive Transmitter
- ADC → Analog to Digital Converter
- PCB → Printed Circuit Board
- ABS → Acrylonitrile Butadiene Styrene
- MCU → Microcontroller
- LDR → Light Dependent Resistor
- RTC → Real Time Clock
- FSPL → Free Space Path Loss
- GS Ground Station

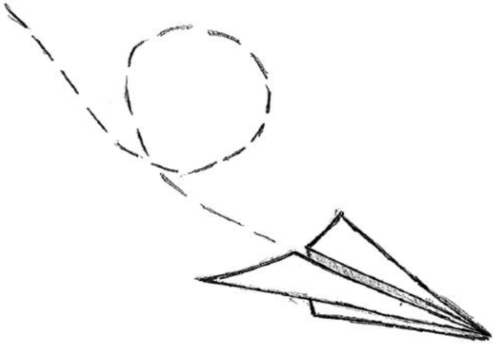
System Overview

İlkin Aliyev

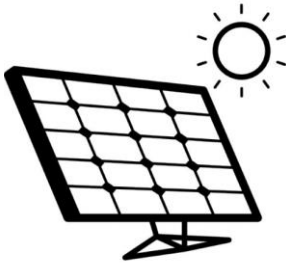


Design





Build



Launch

Mission Summary (2 of 2)

Mission

The 2017 mission simulates a solar powered sensor payload traveling through Venus atmosphere while sampling the atmospheric composition of the planet during flight.

Mission Objectives

- Design special elegant CanSat system and ensure system robustness.
- Payload will be protected in container during initial deployment from rocket.
- Container will use parachute for descent.
- Container will use mechanism for ejection of SV.
- Payload will glide in circular pattern.
- Payload will be fully powered by solar cells.
- Both container and glider will collect data from environment using sensors. (pressure, temperature, altitude etc.).
- Telemetry data will be transmitted to and monitored at a ground station in real time.

Bonus Objective

A color Camera located at the bottom of glider will be snapping HD pictures as fast as possible.

Summary of Changes Since PDR

Mechanical Changes

- Tail was added to increase stability of the glider.
- Wider angle increased the surface of glider thus center of gravity.
- As result of tests with dummy glider, it was seen that great lack of stability with aerodynamic shadow is the single point of failure. That is why a dedicated reflective gear mechanism to response to momentary aerodynamic influences was integrated into overall system. Despite the fact that this increased the complexity of manufacturability of glider structure, But, as key performance indicator, this made sure that the glider will start to slide in air as soon as it is ejected from container and keep stable descent.

Electrical & Software Changes

- Camera of glider is changed.
- Magnetometer of glider is changed.
- Interrupts now are used for Flight Software of both container and glider
- Flight Software of both container and glider is nearly finished (about %20 left)
- The XBee S2C modules were tested in API mode without external antenna.
- Solar panels and Supercapacitors are tested under different light intensities.
- GCS software is being developed.

System Requirement Summary (1 of 4)

ID	Requirement	Rationale	Priority	Children
SR-01	Total mass of the CanSat shall be 500 grams +/- 10 grams.	Competition Requirement	High	DC-01 MS-01
SR-02	Glider shall be secured in container. And no part can extend beyond container.	Competition Requirement	High	DC-02 MS-02
SR-03	Container shall fit in a cylindrical envelope of 125 mm diameter x 310 mm length including the container passive descent control system.	Competition Requirement	High	DC-03 MS-03
SR-04	The container shall use parachute as passive descent control system. Both container and parachute shall be orange colored. Container shall not have any sharp edge.	Orange color for tracking. No sharp edge for safe deployment	High	DC-04 MS-04 MS-06
SR-05	The rocket airframe shall not be used to restrain any deployable parts of the CanSat.	Competition Requirement	High	DC-05 MS-05 MS-07 MS-09
SR-06	The glider must include an easily accessible power switch which does not require removal from the container for access. Access hole or panel in the container is allowed.	The glider can be powered off immediately in emergency situation	High	EPS-03
SR-07	The glider shall be released at 400+/-m and then start to glide at circular pattern passively.	Competition Challenge	High	FSW-01
SR-08	CanSat mechanical elements shall survive 30Gs of shock and 15Gs of acceleration.	Competition Requirement	High	DC-07 DC-08 MS-11 MS-12

System Requirement Summary (2 of 4)

ANNUAL CANSAT COMPETITION

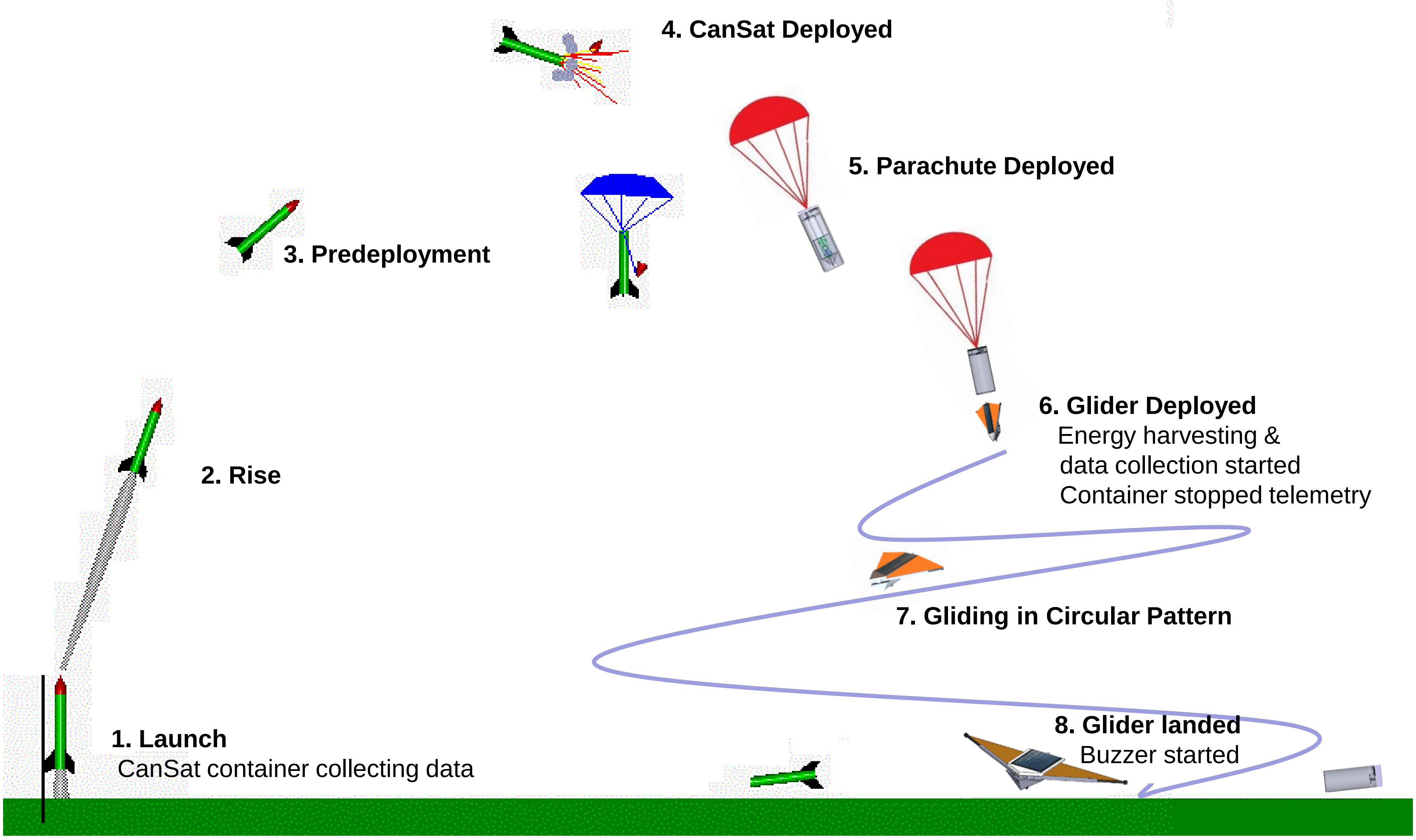
ID	Requirement	Rationale	Priority	Children
SR-09	Electronics section shall be enclosed and shielded from environment with exception of sensors	Competition Requirement	High	SS-01 MS-10
SR-10	Mechanisms shall use neither pyrotechnics nor heat.	Safe Operation	High	MS-15 MS-16
SR-11	During descent, the glider shall collect air pressure, outside air temperature, compass direction, air speed and solar power voltage once per second and time tag the data with mission time.	Competition Requirement	High	SS-04,05,06,07,08 FSW-02 CDH-01
SR-12	Telemetry shall include mission time with one second or better resolution, which begins when the container and glider is powered on. Mission time shall be maintained in the event of a processor reset during the launch and mission	Competition Requirement	High	FSW-04 CDH-03
SR-13	XBee Pro radios shall be used for communication with ground station. 2.4Ghz and 900Mhz frequencies are allowed.	Competition Requirement	High	CDH-04
SR-14	Glider electronics shall be fully solar powered with exception of time keeping device.	Competition Requirement	Very High	EPS-01
SR-15	Cost of CanSat shall not exceed $1000	Competition Challenge	High	EPS-02 CDH-07
SR-16	Each team shall build their ground station	Competition Requirement	High	GCS-01

System Requirement Summary (3 of 4)

ID	Requirement	Rationale	Priority	Children
SR-17	The ground station shall include one laptop computer with a minimum of two hours of battery operation, XBee radio and a hand held antenna.	This data enables to analyse glider flight characteristic.	High	GCS-06
SR-18	All telemetry shall be displayed at ground staion in real time with engineering units (meters, meters/sec, Celsius, etc.)	Time reference for every collected packet	High	GCS-03
SR-19	Teams shall plot each telemetry data field in real time during flight. In addition, the ground system shall display a two dimensional map of estimated glider position based on speed and heading telemetry data.	Seeing those data in time spectrum enables to catch change more easily	High	GCS-04 GCS-05
SR-20	The flight software shall maintain a count of packets transmitted, which shall increment with each packet transmission throughout the mission. The value shall be maintained through processor resets.	Radio interference prevention	High	FSW-07
SR-21	No lasers allowed.	Broadcast mode is slower	High	FSW-12
SR-22	The container shall contain electronics and mechanisms to release the glider at the required altitude. The electronics shall be powered by only alkaline batteries.	Competition Challenge	High	EPS-04 MS-18

System Requirement Summary (4 of 4)

ID	Requirement	Rationale	Priority	Children
SR-23	The glide duration shall be as close to 2 minutes as possible.	Competition Requirement	High	DC-09
SR-24	Glider shall be a fixed wing glider and glide duration shall be approximately 2 minutes.	Competition Requirement	High	CDH-08
SR-25	The glider shall use a time keeping device to maintain mission time. The time keeping device can use a small coin cell battery.	Time reference for every collected packet	High	EPS-05
SR-26	The container shall transmit telemetry once per second from the time being turned on until 2 seconds after releasing the glider.	Competition Requirement	High	FSW-09
SR-27 (Bonus)	A color camera be added to take picture of ground as often as possible	Competition Requirement	Medium	SS-09 SS-10 FSW-13



4. CanSat Deployed
5. Parachute Deployed
3. Predeployment
6. Glider Deployed
Energy harvesting &
data collection started
Container stopped telemetry
2. Rise
7. Gliding in Circular Pattern
8. Glider landed
Buzzer started
1. Launch
CanSat container collecting data

System Concept of Operations (2 of 2)

Pre-launch activities
CanSat Assembly • Integrate all CanSat Subsystems • Perform Final tests, Calibrations and power on CanSat
Ground Station Setup • Set up the ground station • Ensure communication between CanSat GCS
Loading CanSat into Rocket • Check-in with flight line judges • Place overall CanSat into rocket

Post-launch recovery and data reduction
Recovery • Track glider and container by utilizing container parachute & glider kite and buzzer. • Check CanSat for any damage. • Power off CanSat. • Remove SD card. • Return to ground station.
Data reduction • Extract data from SD card • Analyze flight data • Clean ground station • Prepare post flight review (PFR)

Team member roles on Launch Day

Abdul Samet Erkek
- Leading CanSat mechanical parts integrating.
- Participating CanSat recovery
- Assessing Post flight glider performance.

Selim Öztürk
- Calibration of CanSat sensors.
- İntegrating CanSat Electrical subsystem.
- Assessing Post Flight mission data

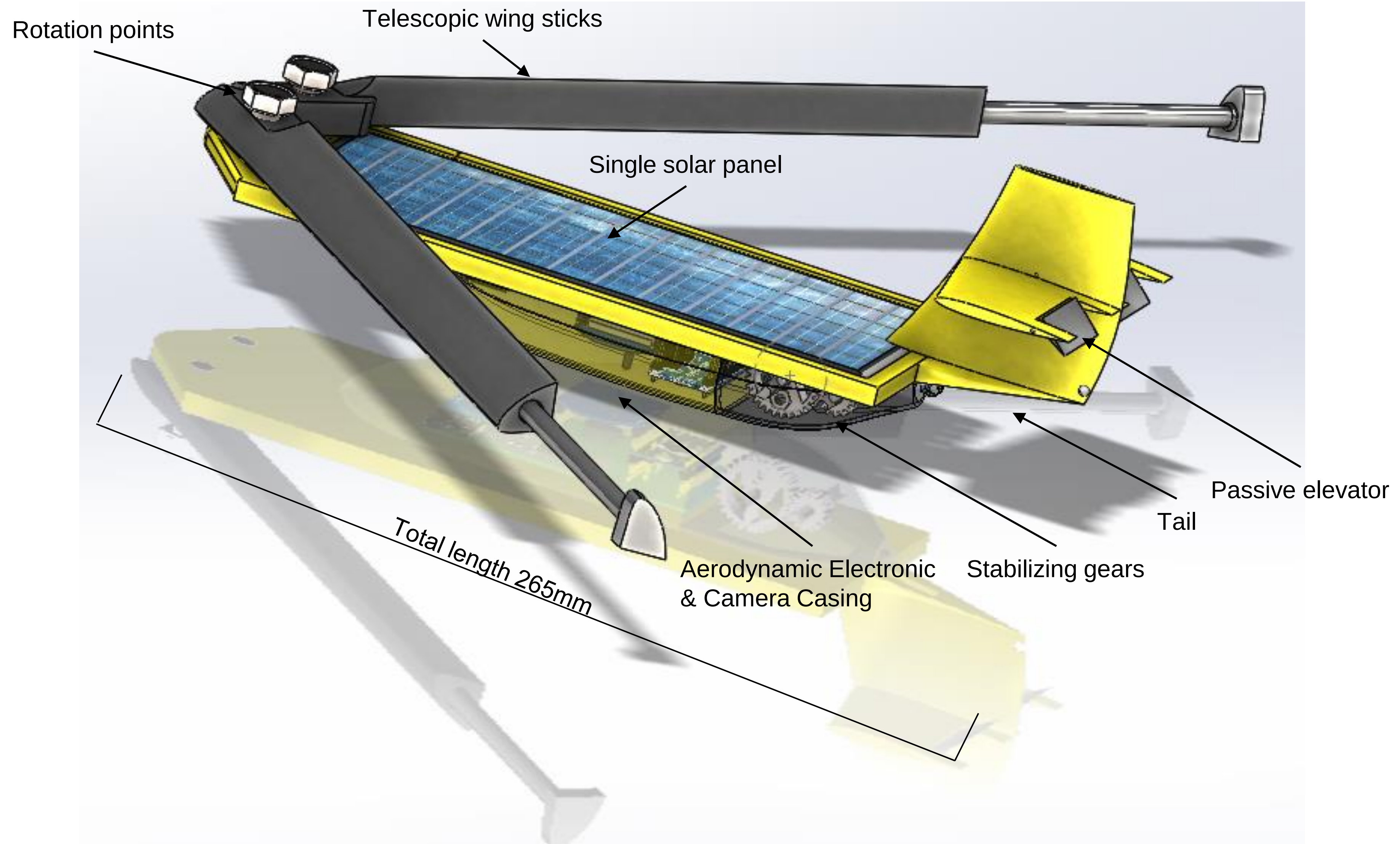
Cahit A. Mısırlı
- Testing CanSat electronic subsystem via external power
- Aid to setting up of Ground Station..
- Assessing Post Flight Mission Data

Ilkin Aliyev
- Setting up Ground Station.
- Ensure communication between CanSat and GCS
- Participating in CanSat assembly
- Assessing Post Flight Mission data

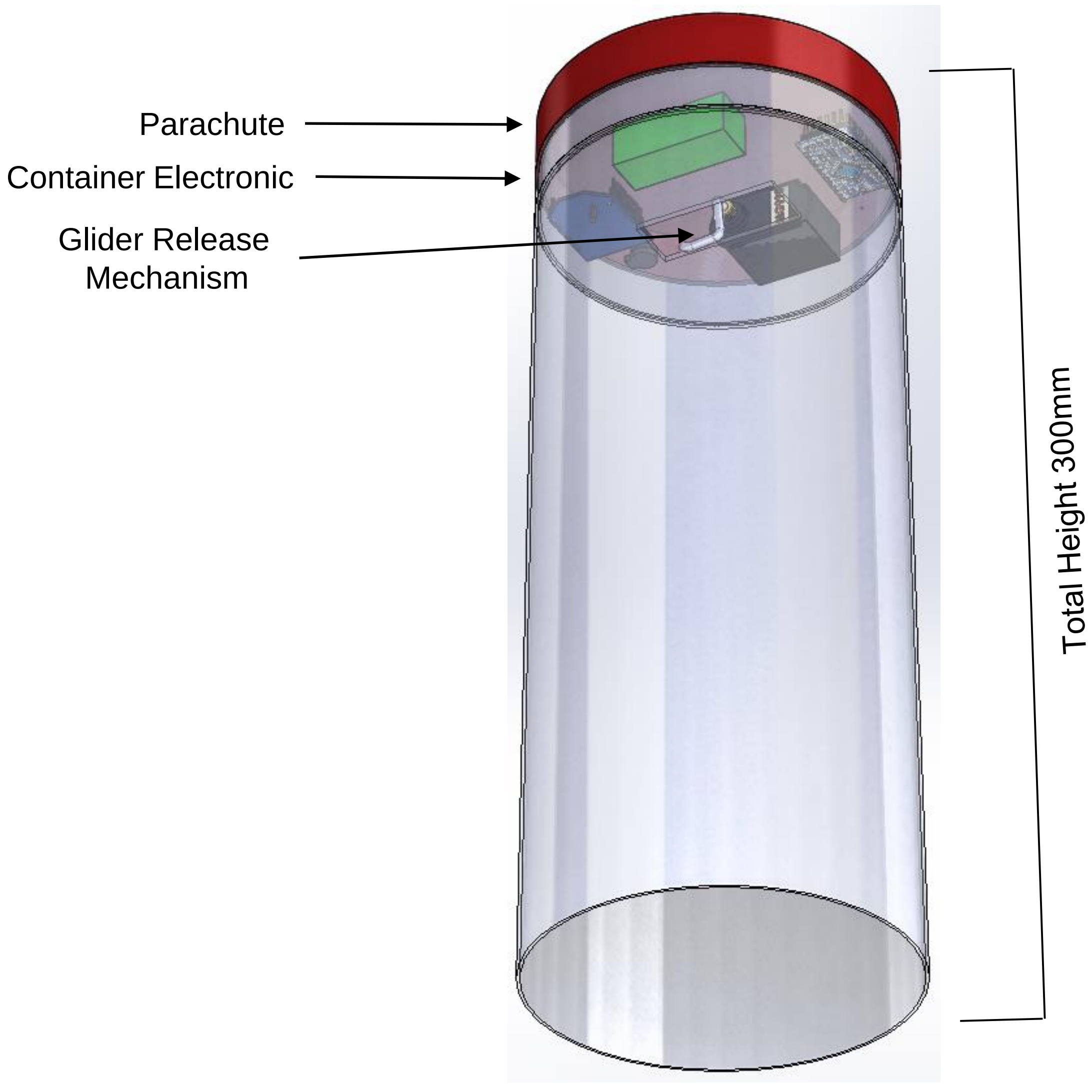
Emrullah Mahmurat
- Load CanSat into Rocket
- Participating CanSat assembly.
- Receiving CanSat
- Analyze post flight glider performance

Selahattin Kok
- Participating in CanSat assembly.
- Recovering CanSat

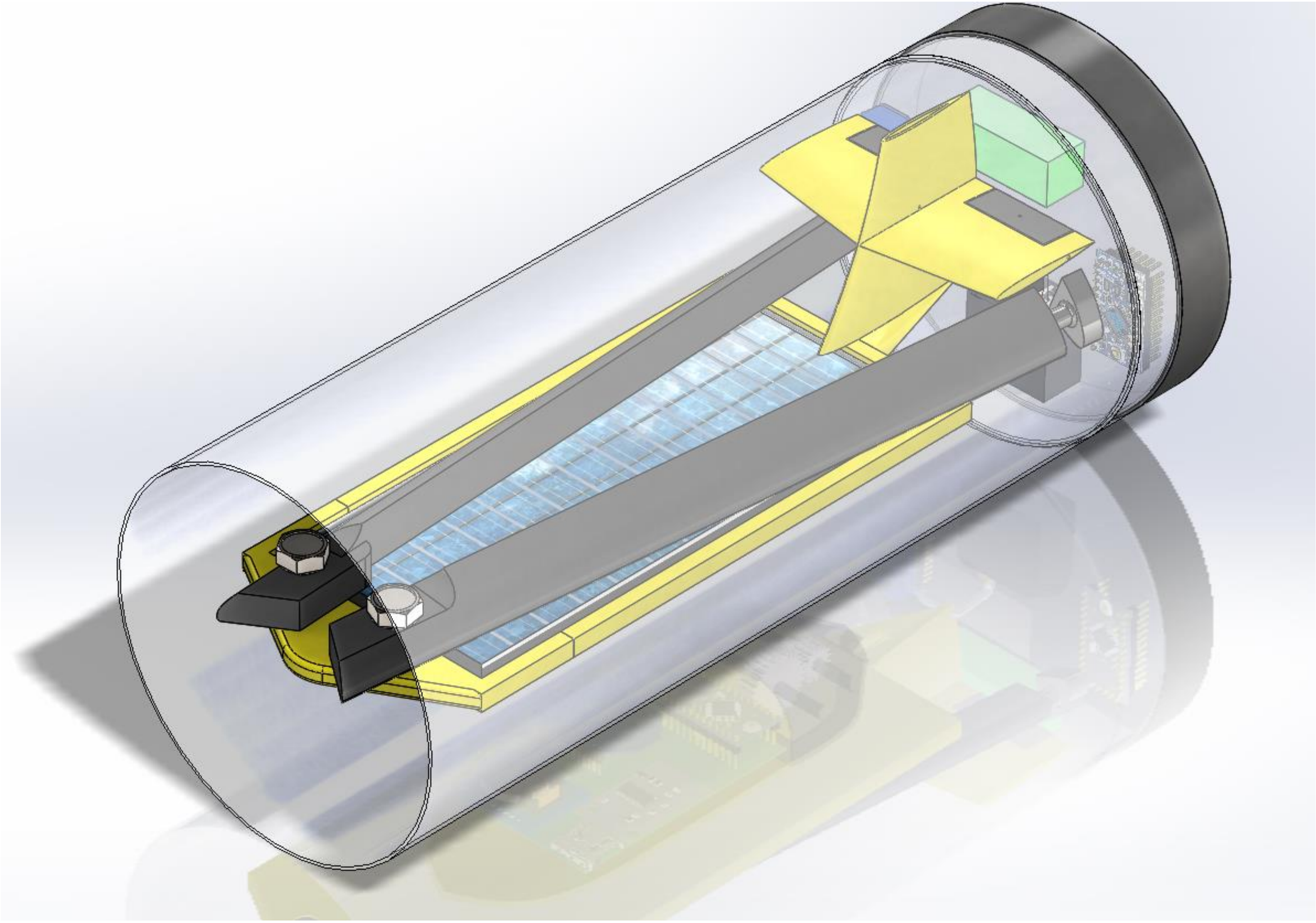
Payload Physical Layout



Container Physical Layout

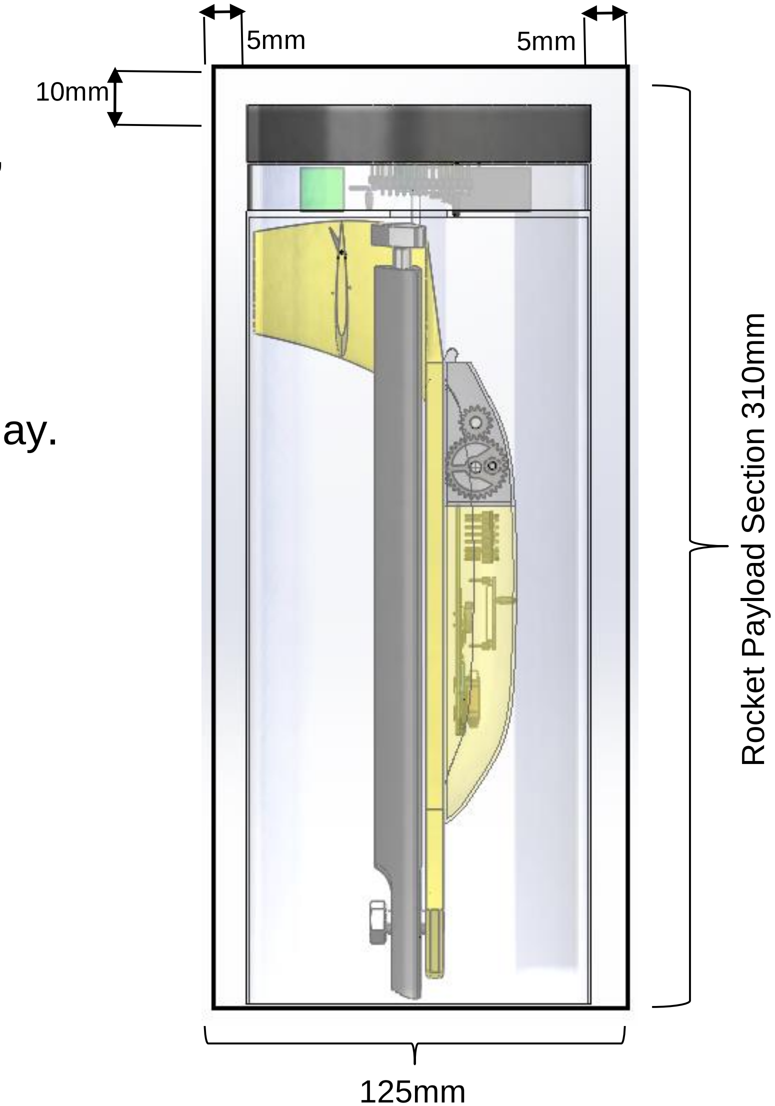


Overall CanSat



Launch Vehicle Compatibility

- CanSat will be placed in RPS upside down.
- Launch vehicle compatibility directly. impact mission success. If it does not fit inside RPS, no point at all.
- Keeping in mind dimension requirements, CanSat was designed to fit in RPS with safe tolerances.
- We will test proper sizing by a RPS prior to launch day.



- **Rocket Payload Section:** 310mm x 125mm
- **Container:** 300mm x 115mm
- **Glider:** 300mm x 100mm

Sensor Subsystem Design

SELİM ÖZTÜRK

Sensor Subsystem Overview

Sensor Type	Model	Used For	Location
Magnetometer	DSPC01	Calculating compass direction	Payload
Air Pressure	DSPC01	Calculating air pressure	Payload
	BMP280		Container
Pitot Tube	Homemade pitot tube	Calculating air speed	Payload
Air Temperature	BMP280	Calculating air temperature	Payload & Container
Solar Power Voltage	Voltage Divider	Calculating solar power voltage	Payload
Battery Voltage	Voltage Divider	Calculating battery voltage	Container
Camera	Y2000 Mini Camera	Taking images of the ground.	Payload

Sensor Changes Since PDR

Changes	Rationale
DSPC01 Digital Compass Pressure Sensor Module	Direction is measured by DSPC01 instead of MPU9250 since it has a MCU and calibrated sensor data itself. So this reduces the processing load of glider’s MCU. Speed also is calculated by this sensor’s static pressure values instead of BMP280 values.
Y2000 Mini Camera	The Y2000 mini camera is a separate subsystem so it takes a photo and saves it in micro sd card itself in 2 or 3 seconds. The glider's MCU only gives command which is take a photo. So the glider's MCU reduces the processing load.

Sensor Subsystem Requirements

ID	Requirement	Rationale	Priority	Parents
SS-01	All electronic components shall be enclosed and shielded from the environment with the exception of sensors.	Competition Requirements	High	SR-09
SS-02	All electronics shall be hard mounted using proper mounts such as standoffs, screws, or high performance adhesives.	Competition Requirements	High	None
SS-03	Operation voltage 3.3V or lower	Payload Requires Power	Medium	None
SS-04	Measurement of barometric altitude	Required For Telemetry	High	SR-11
SS-05	Measurement of air temperature	Required For Telemetry	High	SR-11
SS-06	Measurement of battery voltage	Competition Requirement	High	SR-11
SS-07	Measurement speed of air	Competition Requirement	High	SR-11
SS-08	Measurement of compass direction	Competition Requirement	High	SR-11
SS-09	Camera is needed for imaging	Competition Requirement	High	SR-27
SS-10	The resolution of the camera shall be a minimum of 640x480 pixels in color.	Competition Requirement	High	SR-27

DSPC01 Digital Compass Pressure Sensor Module

- DSPC01 is a type of digital sensor module which consists of a high resolution piezo-resistive pressure sensor, a compass sensor and a MCU. By one module DSPC01 can measure pressure, temperature and compass parameters. The output data are digitally calibrated and users can easily access related data through I2C interface, which shortens the development time and simplifies the work of designers greatly.

- DSPC01 modules work at 2.4~3.6V. It consumes about 2uA in standby mode and 1.5mA in normal work mode. Because of its compact size and extra low power consumption, it is very suitable for portable products.

Compass Mode:

- The host sends command (0xC0) to DSPC01 and the module will return two bytes of unsigned data (0~359). In order to get the accurate direction, the compass should be calibrated for the first use. After sending command (0Xe0) users should rotate the DSPC01 module horizontally for at least 2 times and each circle should last at least 3 seconds. The DSPC01 module will quit the calibration mode after 10 seconds.

- Compass resolution → 1°
- Compass accuracy → ±3°
- Compass range → 0°~359°

Command	Function	Returned Value	Explanation
C0	Read compass value	0x XX XX	Unsigned value, no fraction
E0	Calibration mode	---	Calibrating the compass

DSPC01 Digital Compass Pressure Sensor Module

Altitude Mode :

- The host sends command (0xA0) to DSPC01 and the module will return 3 bytes of Hex data representing altitude value. The MSB of first byte is symbol bit so the altitude might be a negative number. The remaining 23 bits will be divided by 10 and the result is the actual altitude in meters.

E.g. 0x80 00 10 = 1 00000000000000000010000B → -1.6m
0x00 07 D1 = 0 00000000000011111010001B → 200.1m

Pressure Mode;

- The host sends command (0xB0) to DSPC01 and the module will return 3 bytes of Hex data representing pressure value (300hpa ~1100hpa) which should be transferred to decimal value.

- Altitude resolution → 1m
- Altitude range → -689 ~ 8948m
- Pressure resolution → 0.01hpa
- Pressure accuracy → ±2hpa
- Pressure range → 300 ~ 1100hpa

Command	Function	Returned Value	Explanation
A0	Read altitude value	0x XX XX XX	Signed value; one decimal fraction
B0	Read pressure value	0x XX XX XX	No decimal fraction

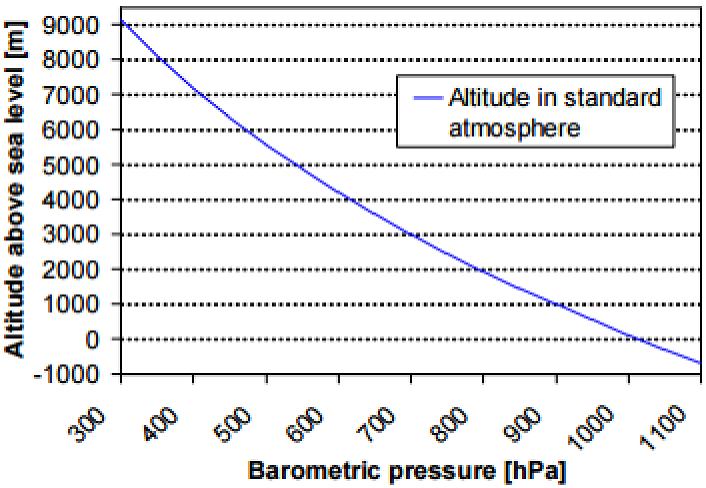
BMP280 Digital Pressure Sensor

- Pressure range — 300 … 1100 hPa (equiv. to +9000…-500 m above/below sea level)
- Relative accuracy (950 … 1050hPa @25°C) — ±0.12 hPa, equiv. to ±1 m
- Absolute accuracy (950 ...1050 hPa, 0 ...+40°C) — typ. ±1 hPa
- Temperature coefficient offset (25 ... 40°C @900hPa) — 1.5 Pa/K, equiv. to 12.6 cm/K
- Digital interfaces — I²C (up to 3.4 MHz) SPI (3 and 4 wire, up to 10 MHz)
- Current consumption — 2.7µA @ 1 Hz sampling rate

Calculation of pressure;

1. Read calibration data from the EEPROM of the BMP280
2. Read uncompensated pressure value
3. Calculate true pressure

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



Where po = pressure (hPa) at sea level, p = measured pressure (hPa)

Payload Pitot Tube Summary

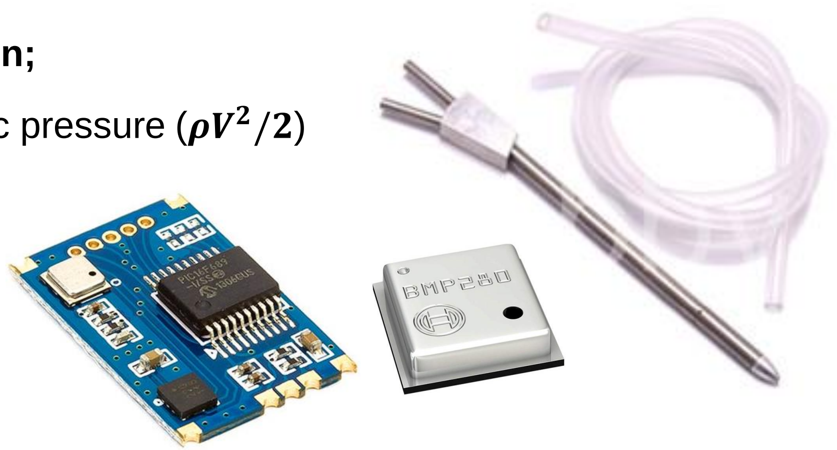
Homemade Pitot Tube

Static Pressure	Dynamic Pressure
Will be calculated with DSPC01	Will be calculated with BMP280
300 ~ 1100hpa pressure range	300 ~ 1100hpa pressure range
±2 hPa pressure accuracy	±1 hPa pressure accuracy
I²C digital interface	I²C or SPI digital interface

The speed will be calculated by the Bernoulli equation;

Stagnation pressure ($\boldsymbol{p_t}$) = static pressure ($\boldsymbol{p_s}$) + dynamic pressure ($\boldsymbol{\rho V^2/2}$)

$$p_t = p_s + \left(\frac{\rho V^2}{2}\right) \qquad V = \sqrt{\frac{2(p_t - p_s)}{\rho}}$$



Where $\boldsymbol{\rho}$ is air density in $\boldsymbol{kg/m^3}$

BMP280 Digital Pressure Sensor

• Temperature accuracy	±0.5 °C @ +25 °C ±1.0 °C @ 0 . . . +65 °C
• Temperature range	-40 … +85 °C
• Temperature coefficient offset (25 ... 40°C @900hPa)	1.5 Pa/K, equiv. to 12.6 cm/K
• Digital interfaces	I²C (up to 3.4 MHz) SPI (3 and 4 wire, up to 10 MHz)
• Current consumption	2.7µA @ 1 Hz sampling rate

Calculation of temperature ;

1. Read calibration data from the EEPROM of the BMP280
2. Read uncompensated temperature value
3. Calculate true temperature

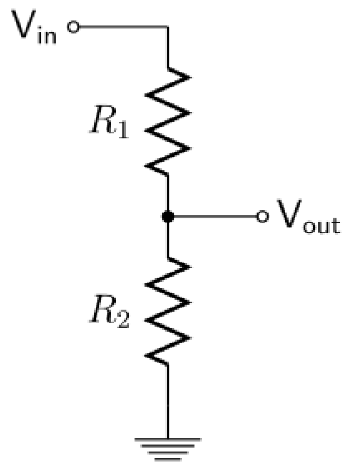
We will use BMP280 for Payload & Container air temperature sensor.

Voltage Divider

- Easy to use
- Inexpensive
- Sample
- 10-bit ADC resolution

<u>Voltage Measurement Method;</u>

1. Two resistors(10kΩ) connected in series to form
2. The power supply(solar panel or battery) will be connected to the resistor's two ends
3. The resistances of the junction will connect the microcontroller's ADC
4. Digital data will be held in mathematical calculations
5. Voltage to be calculated



We will use voltage divider for Payload & Container voltage sensor.

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

Y2000 Mini Camera

- We will use Y2000 mini camera(without battery).
- The camera has its own storage space.
- We will control the camera with transistors and digital pin of microcontroller.
- Firstly, the camera will be set picture mode, then it take pictures.

- Normally the camera has 100mAh lithium polymer battery.
- So 3.7v voltage is enough start it.

<u>The Camera Feature;</u>

- Small Size (L x W x H): 2.80 x 2.70 x 2.70 cm
- Weight: 0.011 kg
- Picture Resolution: 1600 x 1200
- Picture Mode: JPG
- Memory Card: TF, Micro SD, UP to 32GB

Descent Control Design

Abdul Samet Erkek

Selahattin Kök

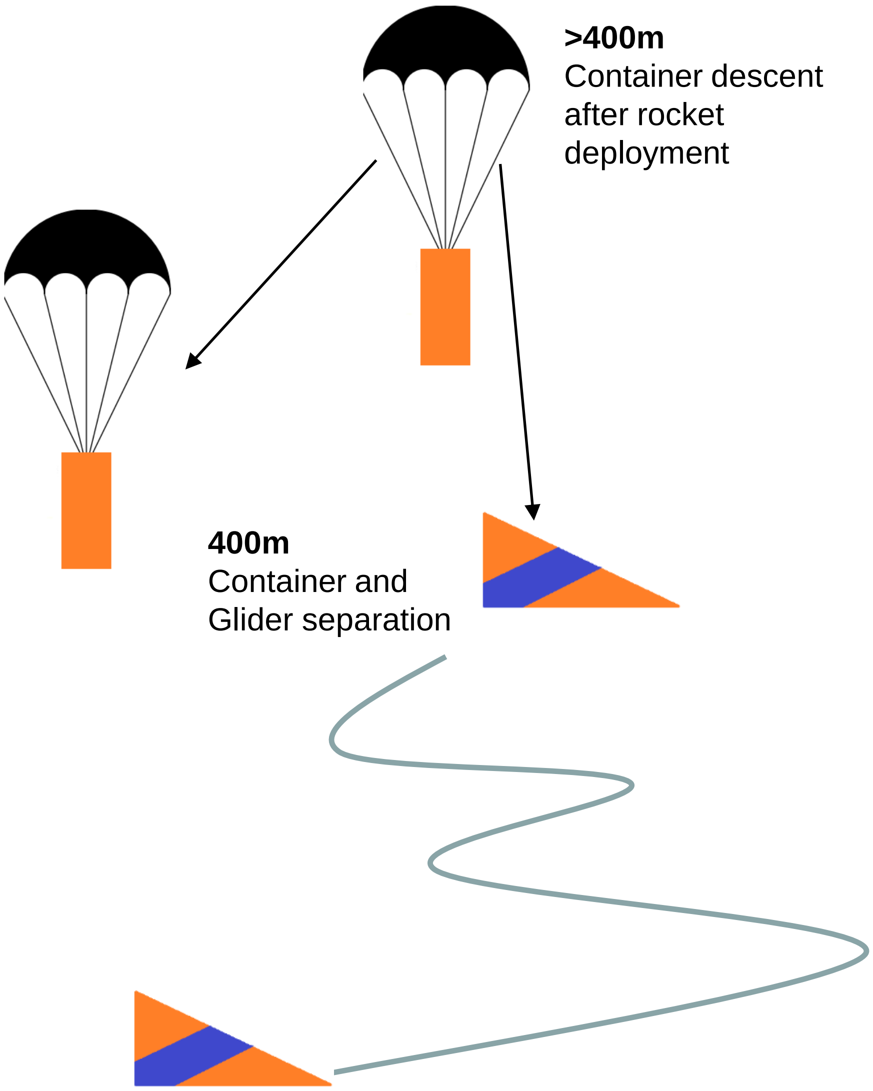
Descent Control Overview

Container DCS

- After the CanSat deployment at altitude of around 700m, parachute with diameter of 60 cm is deployed passively and it will keep CanSat's descent rate at 8,21 m/s
- A spill hole will be cut to stabilize the parachute
- Thanks to the swivel located between the parachute and the container, the parachute ropes will not circulate.
- Separation mechanism is triggered when the container drops below 430m. Container descent rate slowed down to 4.68 m/s due to the less weight of the container.

Glider DCS

- After the glider is separated from the container, the telescopic wings sticks will become delta.
- The mechanism on the tail will take a recovery action and glider start to gliding.



Descent Control Changes Since PDR

Container	
Changes	**Rationale**
Used area from container was optimized.	To gain larger volume for glider system
Glider release mechanism was changed.	Release mechanism is more reliable

Glider	
Changes	**Rationale**
Glider sweep angle increase 90° to 120°	To obtain wider surface in order to increase lift force.
Vertical stabilizer was added.	To avoid unwanted rolling motion.
Wing stick profile was changed	To obtain better lift force, airfoil profile given to wing stick.
Mechanical elevator system was added.	To make glider more stable especially when release happens.
Electronic's casing become more aerodynamic	To obtain better aerodynamic characteristic.

Descent Control Changes Since PDR

Observations

Prototype was tested to observe flight characteristic. Vehicle was thrown from approximately 50m. Flight was not satisfying our expectations. The time that glider becomes horizontal is too long and it was the major reason of failure. Secondly, wings did not produce enough lift force.

Deductions & Solutions

Horizontal stabilizer needs to have controllable. A system was developed that does not requires any servo motor or active elements.

Airfoil profile was given to the wing stick and wing sweep angle increased.

Descent Control Requirements (1 of 2)

ID	Requirement	Rationale	Priority	Parents
DC-01	Total mass of 500+/-10gr	Competition Requirement	High	SR-01
DC-02	No part of the glider may extend beyond the container.	Competition Requirement	High	SR-02
DC-03	Container shall fit in a cylindrical envelope of 125 mm diameter x 310 mm length including the container passive descent control system with safe tolerances	Competition Requirement	High	SR-03
DC-04	The container shall use a passive descent control system. It cannot free fall. Parachute is highly recommended	Competition Requirement	High	SR-04
DC-05	The CanSat shall deploy from the rocket payload section.	Competition Requirement	High	SR-05

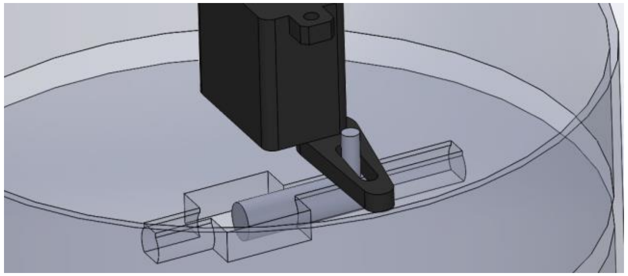
Descent Control Requirements (2 of 2)

ID	Requirement	Rationale	Priority	Parents
DC-06	The glider shall not be remotely steered or autonomously steered. It must be fixed to glide in a preset circular pattern of no greater than 1000 meters diameter. No active control surfaces are allowed.	Competition requirement CanSat should be easy to find	Medium	None
DC-07	All descent control device attachment components shall survive 30 Gs of shock.	CanSat must be enough durable to rocket launch and separation	High	SR-08
DC-08	All descent control devices shall survive 30 Gs of shock.	All descent control devices must be enough durable to rocket launch and separation.	High	SR-08
DC-09	The glide duration shall be as close to 2 minutes as possible.	Competition Requirement	High	SR-23
DC-10	Glider shall be a fixed wing glider. No parachutes, no parasails, no parafoils, no auto-gyro, no propellers. Hang glider design where the electronics section has a hard attachment point is allowed.	Competition Requirement	High	None

Container Descent Control Hardware Summary

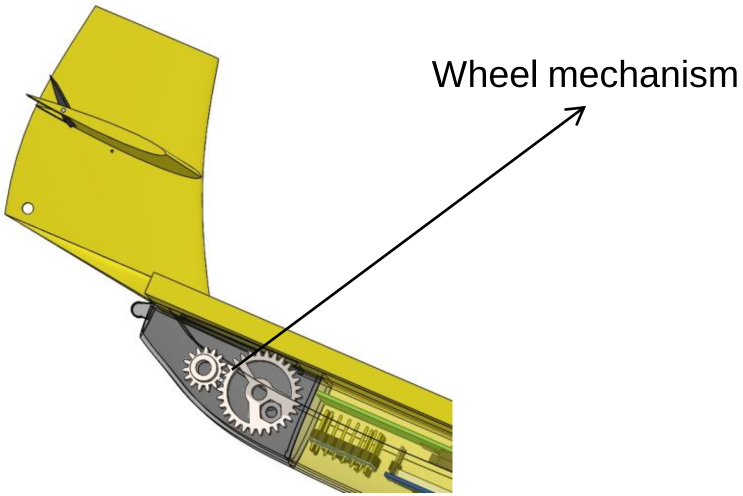
- Descent rate of container is controlled by the parachute
- The parachute will made from ripstop nylon with diameter of 60 cm, attached to the container via nylon cords and single swivel.
- Color of ripstop nylon is orange.
- There is a spill hole in the center of the parachute. It provides stability and prevents shock during parachute deployment.
- Parachute will be designed as modular as it can be tested before flight

- **Container design:**
- 30 cm length, 12cm diameter.
- Container will be fixed design, bottom of container is open for glider deployment.
- Color of container is transparent for charge the solar panel until release.
- The precision of the bmp included in the container is 1m. When CanSat reaches 430m, Arduino activates the servo motor.

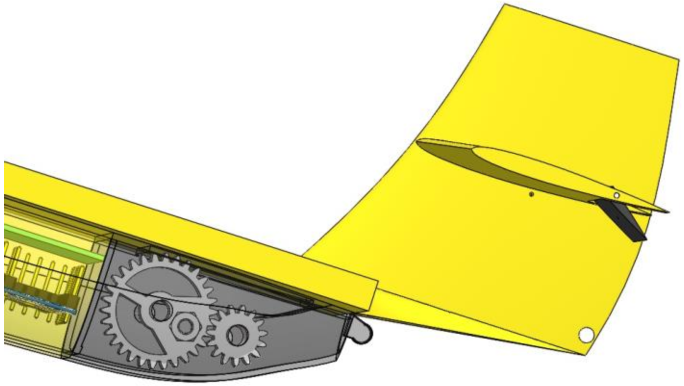


Payload Descent Control Hardware Summary (1 of 2)

- Glider will be triangular wing design, since it provides wider wing surface and less weight.
- The glider will be attached to the container by a hinge, as material for this hinge was chosen metal for being sturdy.
- The wing sticks opens by rotating around tis axis with force applied from the installable spring in the middle of the mechanism and fixes it with the magnet in front of wing sticks.
- The length of the wing sticks to 325 cm long with the extra stick .this provide wider wing surface which increases lift.
- Wing will made from rip-stop nylon and its color is orange.



Case 1



Case 2

When glider nose goes down, the elevator goes up thanks rope attached to the gears.

Same way as soon as the glider tend to tumble the elevator comes down.

By this way, stable flight of the glider is ensured.

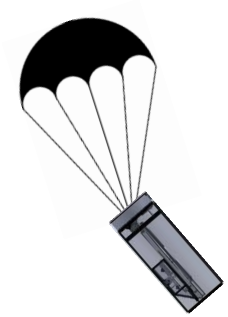
Descent Rate of Container

Descent rates calculated using terminal velocity equation

$$v = sqrt(\frac{2W}{C_d r A})$$

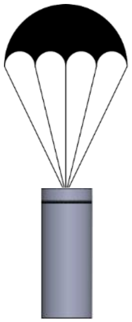
- C_d : Drag coefficient of Parachute
- C_d : 2.56(calculated with
- using flow simulation)

- r : Air density
- r :1.225 kg/m^3
- A : Parachute area



Container + Payload velocity;

11,52 m/s



Container velocity;

6.9m/s

- Area is calculated $S=\frac{\pi d^2}{4}$

- Mass of CanSat(Container + Glider) is 500g

- Mass of container is 200g

Descent Rate of Glider

Descent rate estimated using the following formula;

$$v = sqrt(\frac{2W}{C_d r A})$$

- w : Mass of glider (approximately 300g)
- C_d : Drag coefficient (0.8704 estimated)
- r : Air density
- A : Frontal area of glider

Estimated horizontal velocity : 9.79m/s

Estimated vertical velocity : 3.33 m/s

Payload velocity;

$10{,}34\, m/s$

Descent Rate Estimation

PART	MASS(g)	PAYLOAD VELOCİTY(m/s)
CONTAINER + PAYLOAD	500	11.52
ONLY CONTAINER	300	6.9
PAYLOAD	200	10,34

Mechanical Subsystem Design

Abdul Samet Erkek
Emrullah Mahmurat

Container

Container dimensions are 300mm height ,120 mm diameter and it made from fiber glass. Fiber glass has high **strength** that is why it is survival to 3Gs shock and fiber glass is suitable to **transparency.**

Location of Electronics

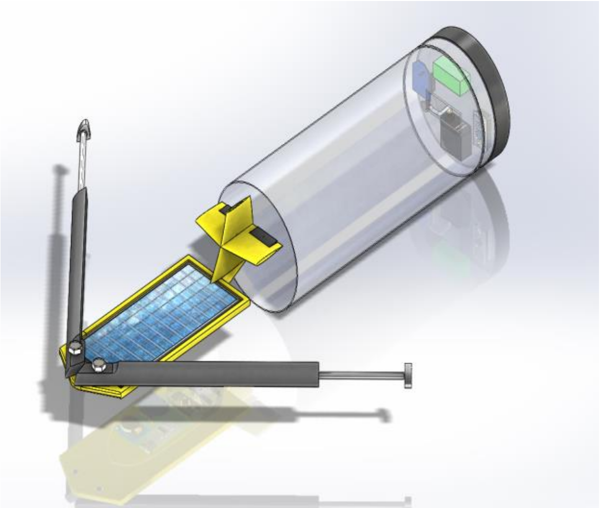
- Parachute is allocated the bottom of the container.
- Battery and electronic system are allocated under the parachute because of safe location and fixed structure in the container.
- Separation mechanism is hook system which is actuated by servo motor and it is same location with electronics.

Payload

Payload dimensions are 230 mm wing span and 460 mm wing cord and 30 degree sweep angle.

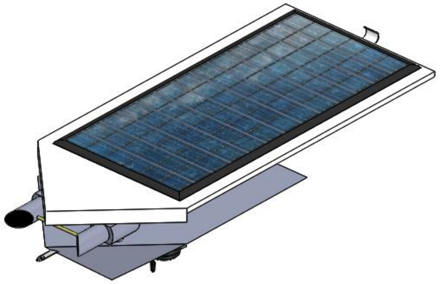
Location of components

- Payload wing sticks and payload body are made from **XPS** because of light. Extension sticks are made from aluminum.
- Using elevator for tail which triggered by wheel and elevator made from **XPS** and wheel made from **Plexiglas.**
- Wing kite is **ripstop nylon.**
- Fuselage is made from 3D printed because PCB is bolted the fuselage that is why the fuselage must be durable.
- And supported structure is aluminum for using **XPS.**



Payload Changes

- **Previous**

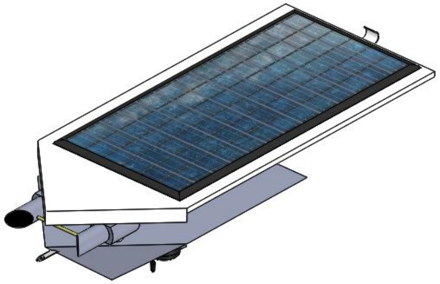


There was no tail in the previous configuration. İt has been chosen T formed tail for stabilizing flight of the glider. During tests, it was observed that lacking of tail is the indicator of serious unstable flight. Use elevator which triggered by wheel on the tail for last configuration.

- **Now**

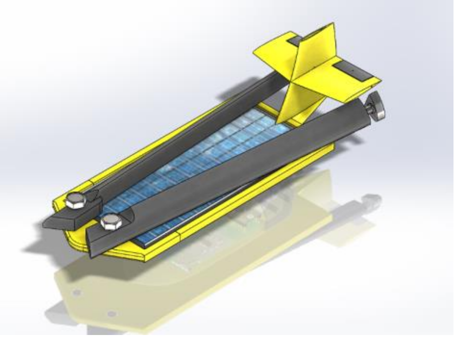
Exchanged Wing Location

- **Previous**



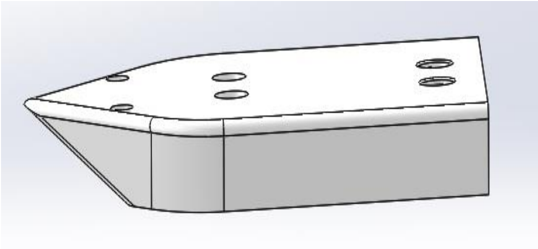
The wing sticks was below the previous confuguration.it has been located above the payload. During tests, it was observe that there was no enough angle of attack that is why lift force was not enough for sliding of glider in air

- **Now**



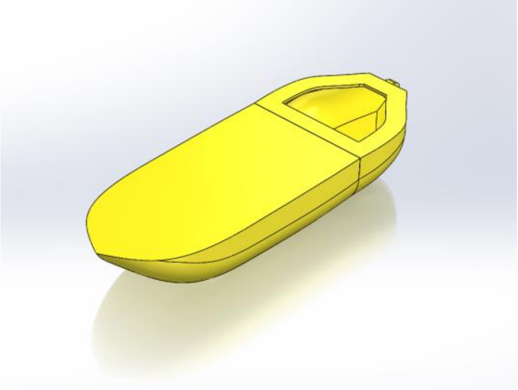
Mechanical Subsystem Changes Since PDR

- **Previous**

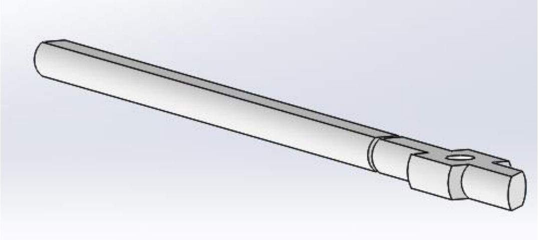


Modification of the casing
Fuselage has been changed. The previous fuselage was tested in flow simulation. Because of high drag coefficient, drag force was high and this caused aerodynamic inadequacy thus unstable flight.

- **Now**

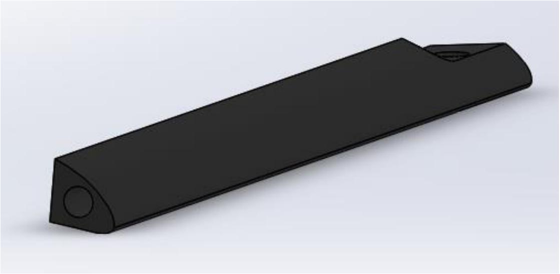


- **Previous**



Modification of the wing sticks
Wing sticks type has been changed. There was no airfoil profile on the wing sticks and it did not create lift force for efficient fly.

- **Now**



Mechanical Sub-System Requirements (1 of 3)

ID	Requirement	Rationale	Priority	Parents
MS-01	Total mass of 500+/-10gr	Competition Requirement	High	SR-01
MS-02	No part of the glider may extend beyond the container.	Competition Requirement	High	SR-02
MS-03	Container shall fit in a cylindrical envelope of 125 mm diameter x 310 mm length including the container passive descent control system with safe tolerances	Competition Requirement	High	SR-03
MS-04	The container shall use a passive descent control system. It cannot free fall. parachute is highly recommended	XBee modules are reliable RF modules as well as easy to use	Medium	SR-04
MS-05	The container shall not have any sharp edges to cause it to get stuck in the rocket payload section.	Smooth Deployment	High	SR-05
MS-06	The container shall be a florescent color, pink or orange	High Visibility	Medium	SR-04
MS-07	The rocket airframe shall not be used to restrain any deployable parts of the CanSat.	Competition Requirement	Medium	SR-05

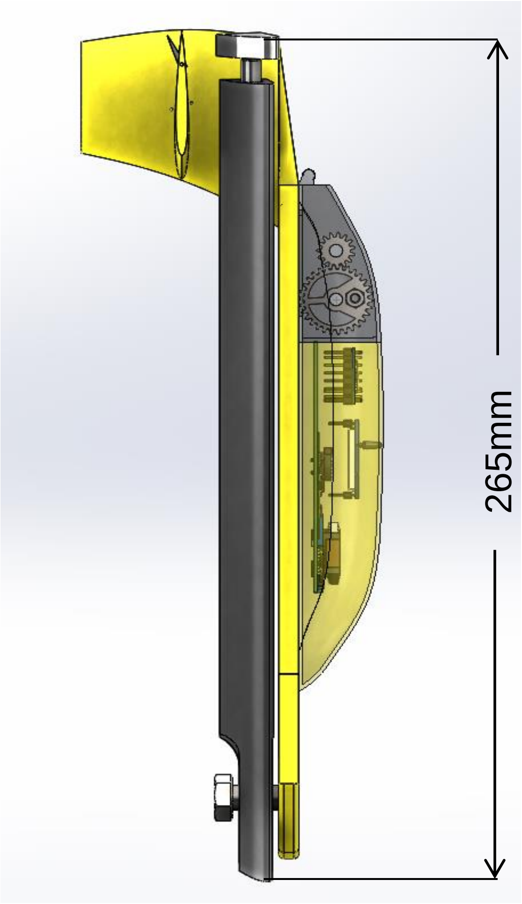
Mechanical Sub-System Requirements (2 of 3)

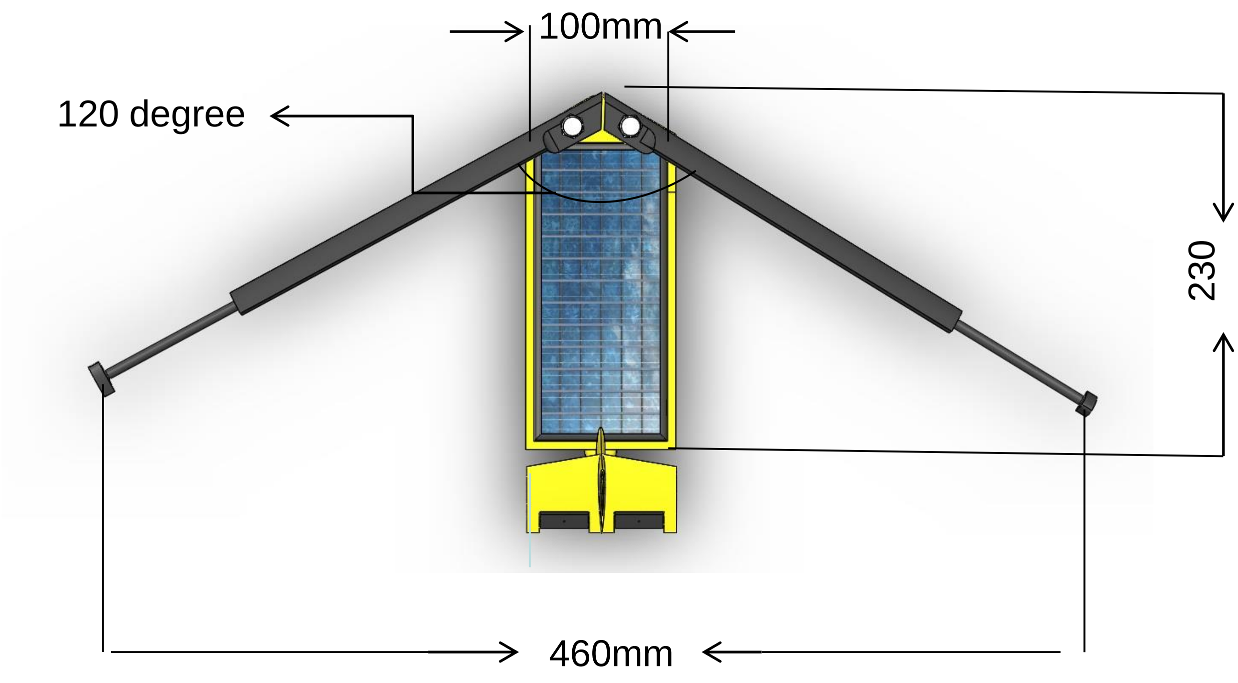
ID	Requirement	Rationale	Priority	Parents
MS-08	The rocket airframe shall not be used as part of the CanSat operations.	Competition Requirement	Medium	SR-
MS-09	The CanSat (container and glider) shall deploy from the rocket payload section.	Competition Requirement	High	SR-05
MS-10	All electronic components shall be enclosed and shielded from the environment with the exception of sensors.	Prevention from environmental affections	Medium	SR-09
MS-11	All structures shall be built to survive 15 Gs acceleration.	To survive during rocket deployment	High	SR-08
MS-12	All structures shall be built to survive 30 Gs of shock.	To survive during rocket launch	High	SR-08
MS-13	All electronics shall be hard mounted using proper mounts such as standoffs, screws, or high performance adhesives.	To survive during rocket deployment and launch	High	None

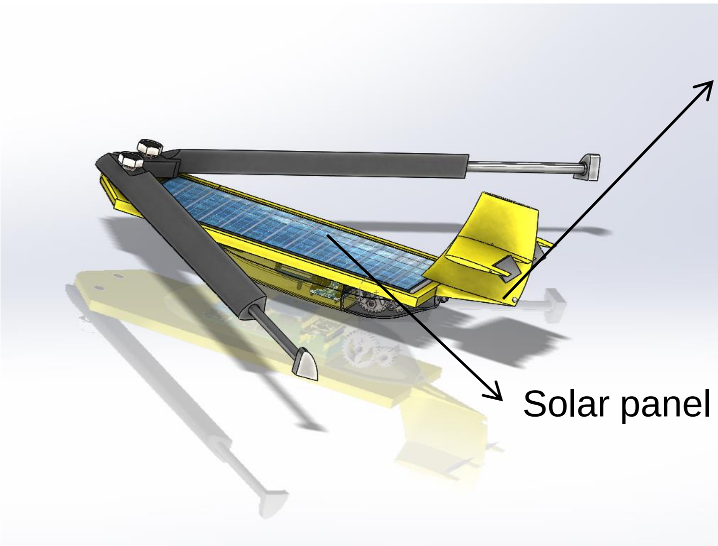
Mechanical Sub-System Requirements (3 of 3)

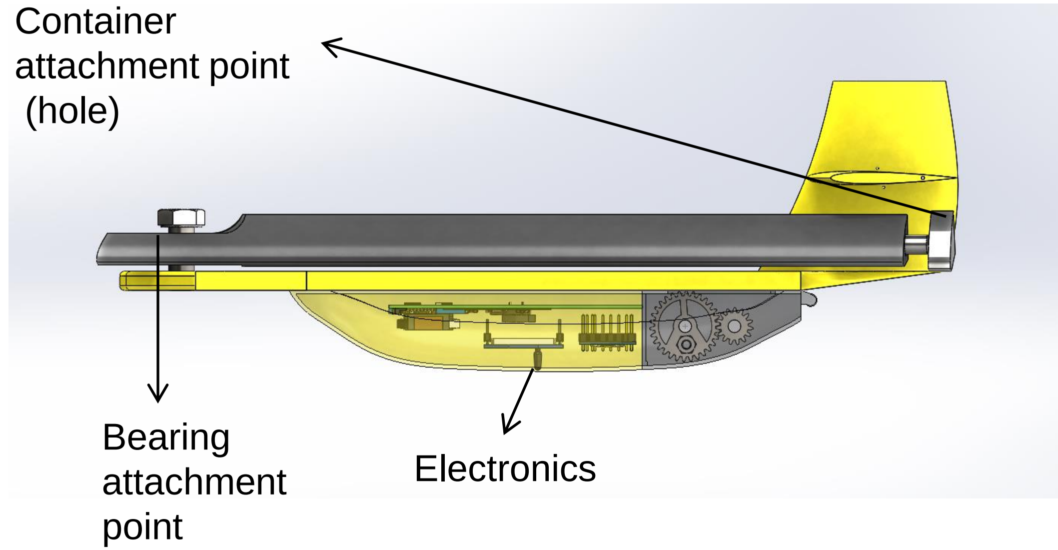
ID	Requirement	Rationale	Priority	Parents
MS-14	All mechanisms shall be capable of maintaining their configuration or states under all forces	All mechanisms must be prevented from environmental impact.	High	None
MS-15	Mechanisms shall not use pyrotechnics or chemicals	Chemicals or pyrotechnics may contanct with anything and can damage people or environment	High	SR-10
MS-16	Mechanisms that use heat (e.g., nichrome wire) shall not be exposed to the outside environment to reduce potential risk of setting vegetation on fire.	No heating mechanisms shall be used	Medium	SR-10
MS-17	Both the container and glider shall be labeled with team contact information including email address.	Loss Prevention	Medium	None
MS-18	The container shall contain electronics and mechanisms to release the glider at the required altitude.	Competition Requirement	High	SR-22

Payload Mechanical Layout of Components (1 of 1)



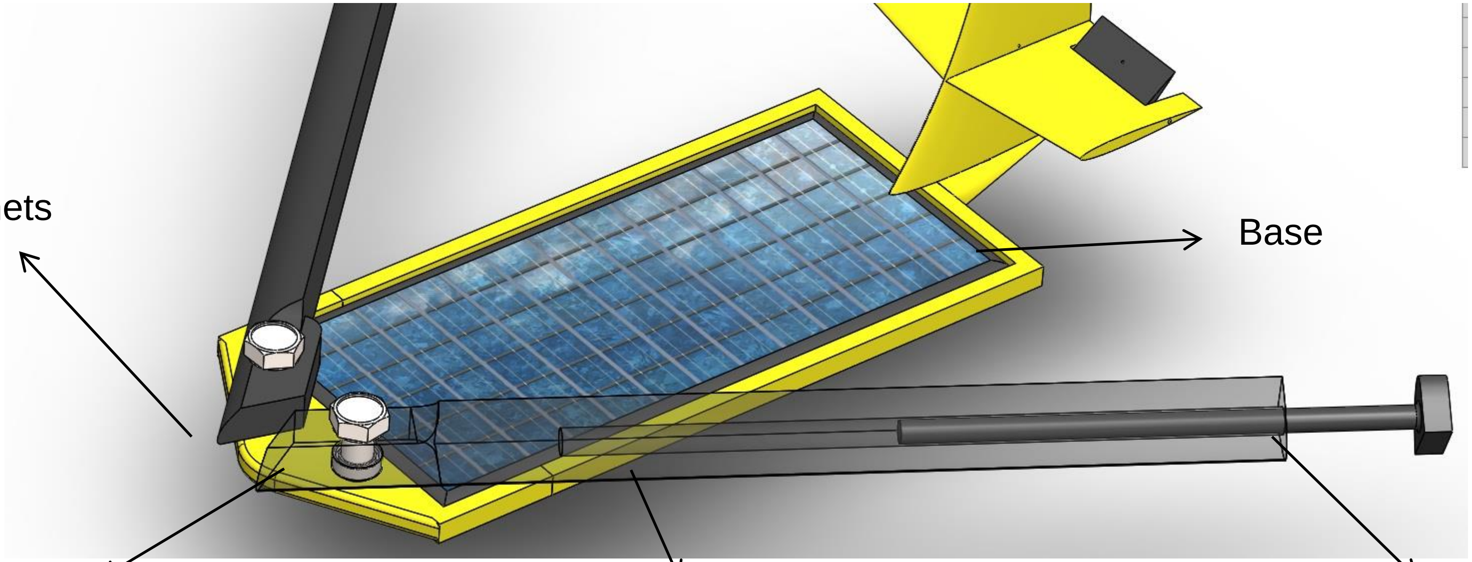






- All electronic components and PCB are located inside the fuselage. PCB and all electronics must be stable (not moving) and protected.
- Camera location is center of gravity as possible because camera must be stable and center of gravity is most stable location on the payload.
- Pitot tube is located outside and front of fuselage due to it measures air speed correctly.
- Container and glider attach together via hole and servo arm. The arm will be made from aluminum because it must survive during launch.

Payload Mechanical Layout of Components (3 of 4)



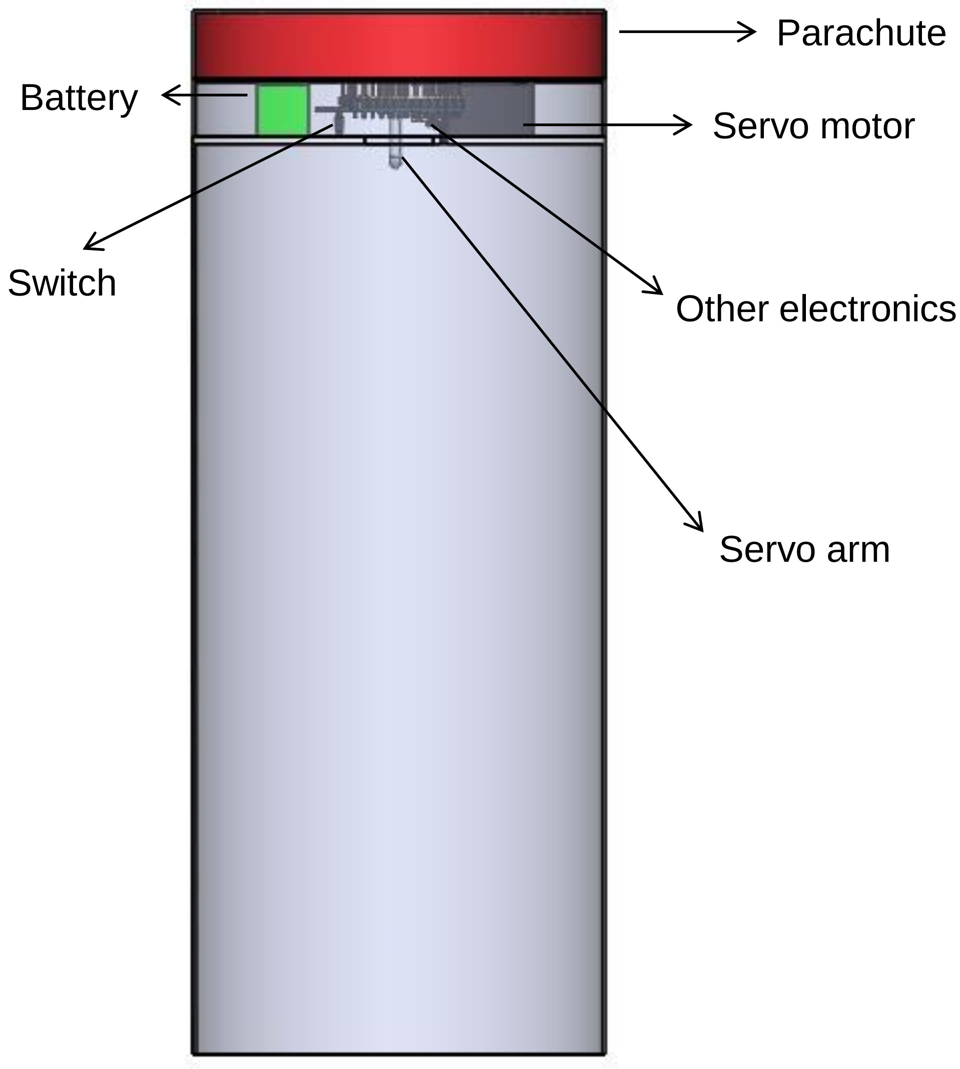
- Rotate mechanism is located between wing sticks and fuselage. Wing sticks rotate 60 degree around of mechanism
- Use ball bearing in the wing sticks which decrease to friction.
- Rubber band is located front of wing sticks. Rubber band must be strong because during the deployment it can approach the wing sticks.
- And use extra extendable wing sticks and it is pushed by spring.

Payload Mechanical Layout of Components (4 of 4)

Material	Mechanical Component	Strength [kN*m/kg]
Rib Stop Nylon	Wing Kit	1200 - 3100
XPS	Wing sticks and Base	30
3D – ABS	Fuselage	70
ALUMİNUM	Supported material	110-320

Glider fuselage is 3D printed from ABS due to its high strength. Wing sticks and base are made from XPS because of light. Aluminum is used for wing sticks and base as supported material. And use rib stop nylon for wing kit.

Container Mechanical Layout of Components (1 of 2)

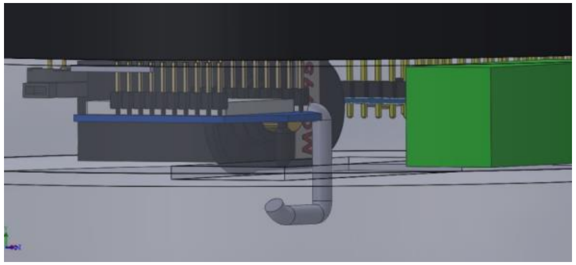


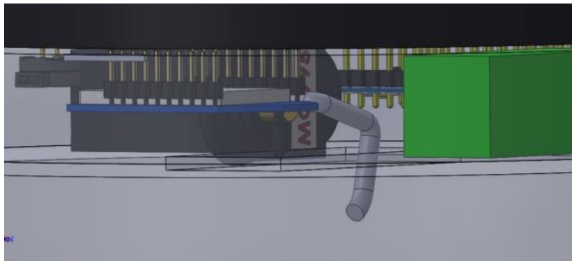
Container consists of three sections: parachute, electronics, glider sections. Glider section and electronics section is attached via hole – arm mechanism and there are plank and PCB between parachute part and electronics part. And container dimensions are 300mm height and 120mm diameter.

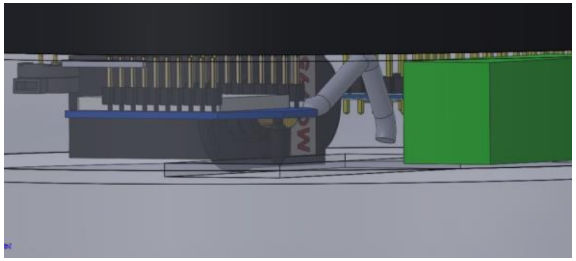
- PCB electronics is located top of the container
- The parachute is located above PCB electronics
- Servo and battery are located under PCB electronics
- Switch button is located under the parachute

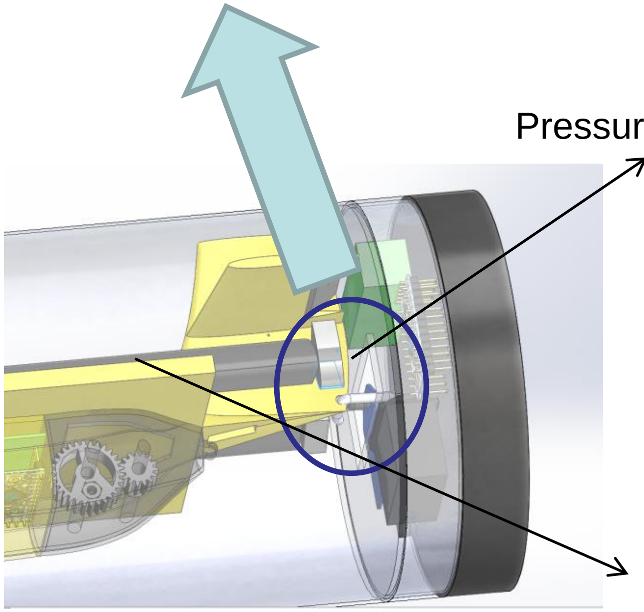
Container Mechanical Layout of Components (2 of 2)

Material	Mechanical Component	Tensile Strength(PSI)
Fiber Glass	Container	42,000 - 34,000
Ribstop Nylon	Parachute	1200 - 3100









- The glider is connected to a container via arm and arm attached with servo motor and hole-arm mechanism.
- We have got a servo motor and a spring for deploying configuration.
- Slide mechanism moved by servo motor when altitude drops 400 meters.
- The servo arm is released from the hole
- Glider release from container owing to spring thrust.
- Friction at the pressure point can be neglected by comparison to spring thrust.
- Magnets and tire supply to attach wing sticks.

Structure Survivability

Electronic component mounting methods

- Electronic components such as PCB and camera module will be attached to fuselage via bolts.
- The battery will be in keeping special holder. The holder will be glued to fuselage with high strength adhesive/epoxy/

Electronic component enclosures

- For container, all electronic components will be fixed under parachute.
- For a glider, all electronic components will be enclosed in the electronic casing made fromo alimininum reinforced XPS.
- Pitot tube, the camera lens and XBee antenna will stick out outside of the fuselage.

Securing electrical connections

- To minimize bunch of cabling issue, every single electronic component is soldered on the PCB. But to make sure we will use high adhesive/

Descent control attachments

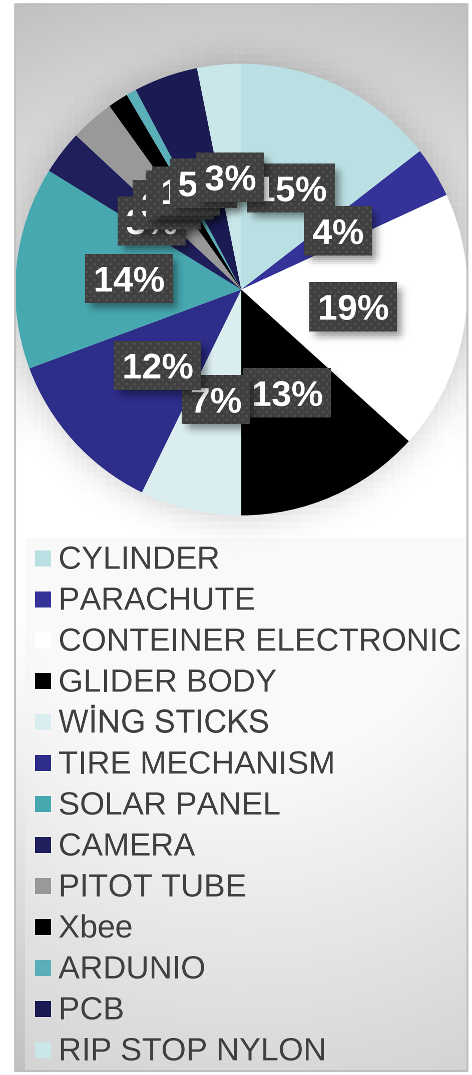
- For container, Parachute fabric is rigid material – ripstop nylon
- Parachute shroud line are attached to swivel. And swivel is attached to wire and finally wire is connected to container.
- As container absorbs most of the shock, it will be made from fiberglass.
- For glider, Rotation points of wing sticks are carbon fiber standoffs & bolts.
- Since glider shape is more complex rather than conventional gliders, it will be made from ABS.

Mass Budget

GLIDER		
COMPONENT	**MASS**	**SOURCE**
BODY	55g	Measured
SOLAR PANEL	60g	Datasheet
TİRE	50g	Estimated
WING STICKS	30g	Measured
CAMERA	13g	Datasheet
PITOT TUBE	7g	Datasheet
XBee	6g	Datasheet
ARDUINO	3g	Datasheet
PCB	19g	Estimated
RIP STOP NYLON	11g	Measured
TOTAL	262g	

CONTAINER		
COMPONENT	**MASS**	**SOURCE**
BODY	60g	Estimated
PARACHUTE	15g	Datasheet
SERVO MOTOR	9g	Datasheet
BATTERY	48g	Datasheet
ELECTRONICS	20g	Measured
TOTAL	152g	

CONTAINER	152g
GLIDER	262g
MARJIN	86g
TOTAL	500g



❖ If the mass of CanSat become <500g we will add weight in the container as using proper solid.

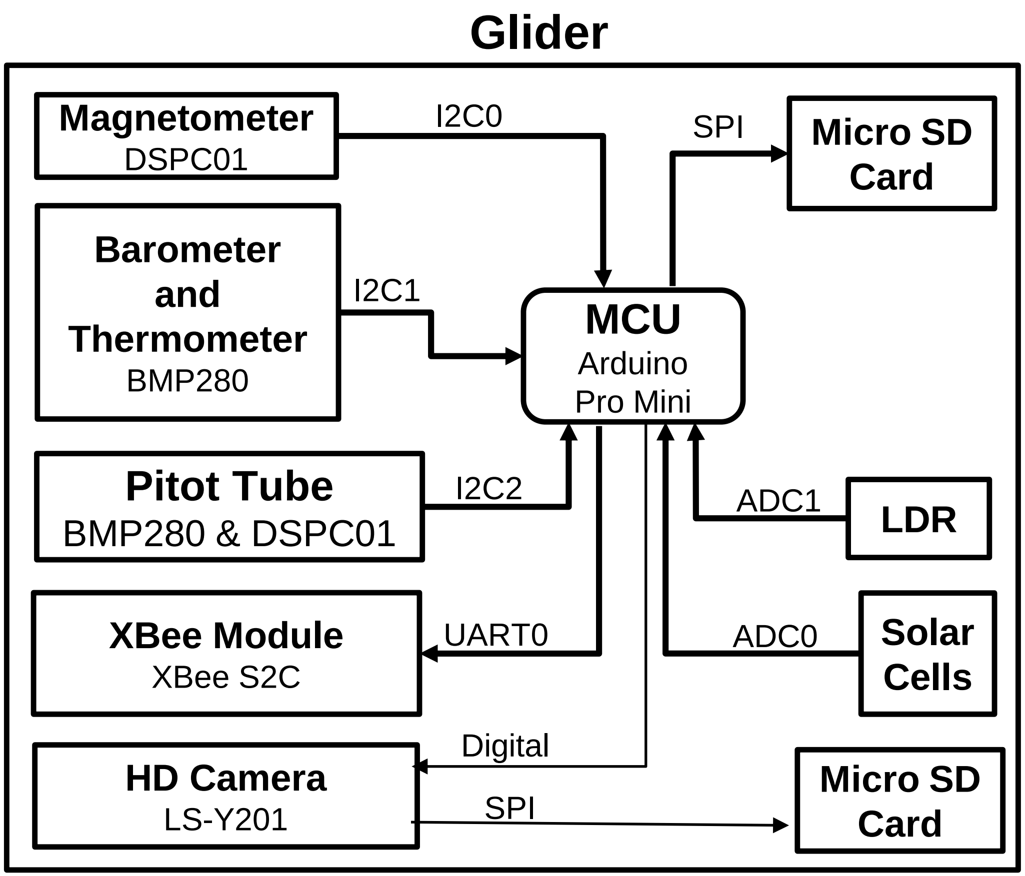
Communication and Data Handling Subsystem Design

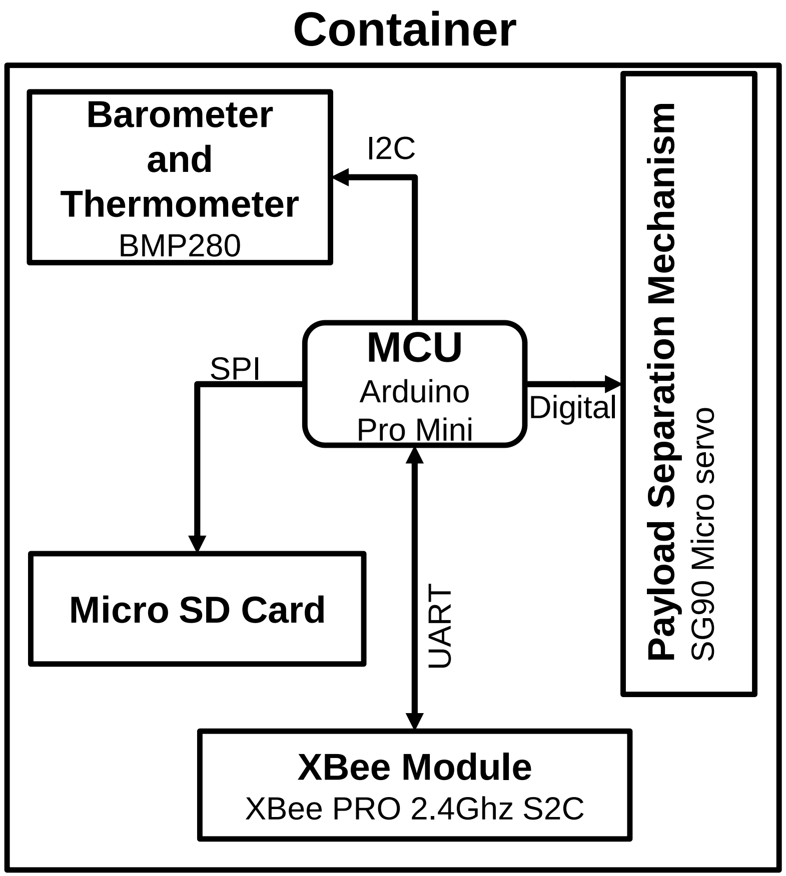
İlkin Aliyev

CDH Overview

General Description

- Communication & Data Handling (CDH) subsystem of CanSat is primarily responsible for communication with the ground station.





CDH Changes Since PDR

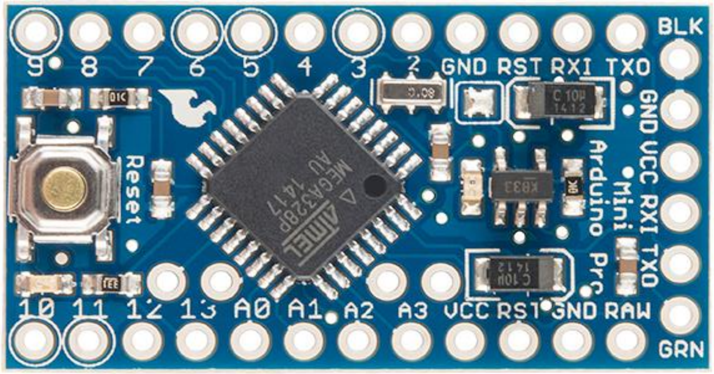
- **No Change was done.**

CDH Requirements

ID	Requirements	Comment	Priority	Parents
CDH-01	During descent, the glider shall collect air pressure, outside air temperature, compass direction, air speed and solar power voltage once per second and time tag the data with mission time	This data enables to analyze glider flight characteristic.	High	SR-11
CDH-02	During descent, both glider and container shall transmit telemetry at 1Hz Rate	Competition Requirement	Medium	None
CDH-03	Telemetry shall include mission time with one second or better resolution, which begins when the container and glider is powered on. Mission time shall be maintained in the event of a processor reset during the launch and mission	Time reference for every collected packet	High	SR-12
CDH-04	XBee radios shall be used for telemetry. 2.4 GHz Series 1 and 2 radios are allowed. 900 MHz XBee Pro radios are also allowed.	XBee modules are reliable RF modules as well as easy to use	High	SR-13
CDH-05	XBee radios shall have their NETID/PANID set to their team number.	Radio interference prevention	High	None
CDH-06	XBee radios shall not use broadcast mode.	Broadcast mode is slower	Medium	None
CDH-07	Cost of the CanSat shall be under $1000. Ground support and analysis tools are not included in the cost	Competition Challenge	Medium	SR-15
CDH-08	The container shall transmit telemetry from the time being turned on and placed on the launch pad until 2 seconds after releasing the glider.	Re-entry Container is responsible for releasing glider at stable conditions	Medium	SR-24
CDH-09	The container telemetry shall include team number, indication of container telemetry, altitude, temperature and software state.	This data enables to analyze container flight	High	None

Processor: Atmega328p based MCU was chosen for Container & Glider;

- Two Arduino Pro mini is used; one is placed in container other in glider.
- 8 MHz Clock speed is sufficient for all operation.
- 30 Kbyte programming memory is highly enough for whole flight software.
- 10mA instantaneous power consumption is good for energy management system.
- 1 UART interface for XBee, 1 SPI for SD card and 1 I2C for DSPC01 & BMP280
- LDR and solar & battery sources are measured using ADC pins of MCU.
- Camera is a separate subsystem, MCU only must send take picture command to camera via digital pin rest of the jobs is done by camera.
- There are 6 PWM interfaces, one used for servo motor in container.



Memory: SanDisk 8 GB Micro SD Card was chosen as Payload & Container Storage Unit;

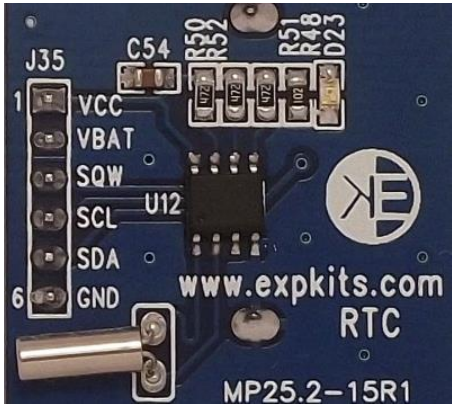
- 3 SD card will be used; one for picture storage, others for telemetry.
- Each of SD card is 8 GB which is sufficient for max 20 pictures and telemetry data.
- Writing to SD card consumes max 45mA which is good for energy management system.
- Writing speed to SD card is 24MB/S which is already meeting jpeg picture saving requirements.

Real-Time Clock

DS1338 was chosen as Payload & Container RTC;

- ✓ Resolution (1 second)
- ✓ I²C interface
- ✓ Low supply voltage (3.3V)
- ✓ Battery backup included
- ✓ Small size

- ❖ Pro mini has no internal RTC, so the hardware real-time clock will be used for both payload and container.
- ❖ Because, if the solar energy fails (or reset), software clock could not show the real-time correctly. So that a hardware real-time clock will be used.
- ❖ The device is powered by dedicated coin cell battery which enables it to run continuously. So it maintains mission time.
- ❖ Finally, the packet count is maintained by EEPROM memory of the processor. When the processor either resets or power fails the first thing the FSW is doing is to check out the packet count.



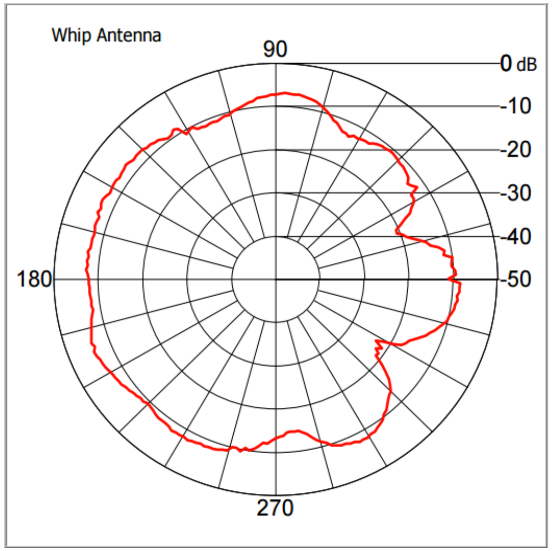
Payload Antenna Selection

As presented in PDR, we will use XBee model which comes with wire antenna for payload. The XBee will be placed at the bottom of the glider so it clearly communicates with ground station.

Features of Payload Antenna

- 1.5 -1.8 dBi antenna gain
- 18 dBm total output power
- 5 gram total transceiver weight

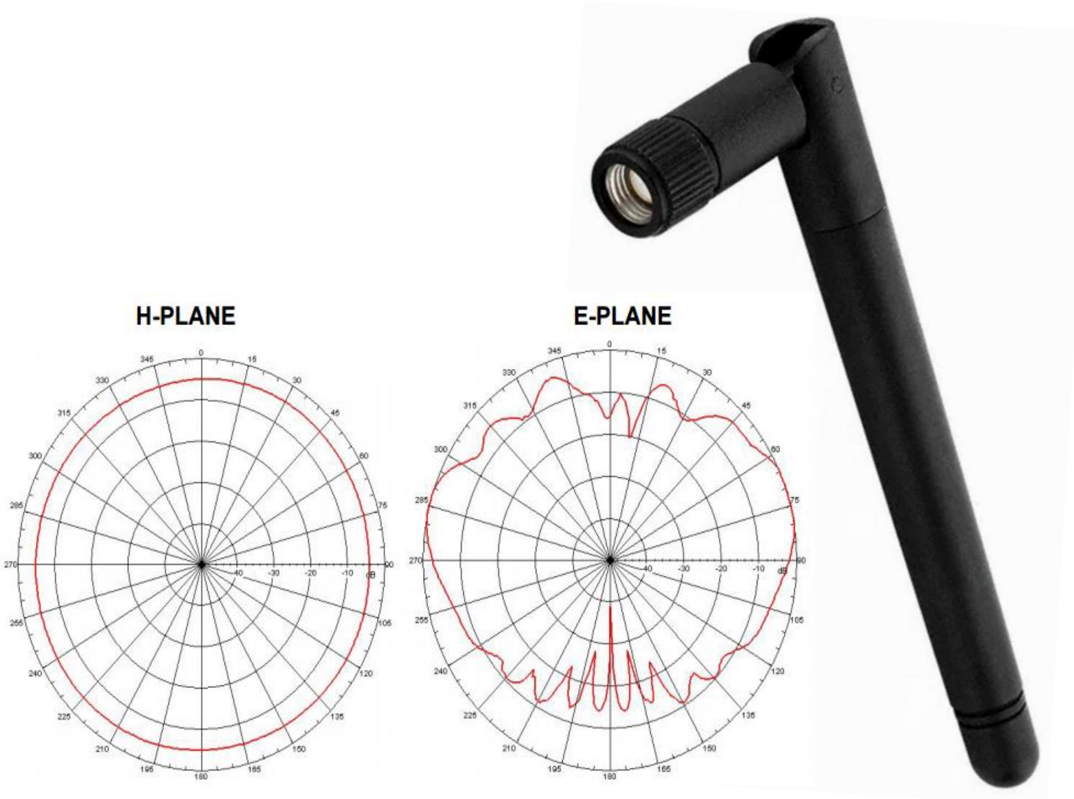
900Mhz frequency band is not permitted in Turkey so we use 2.4 GHz.



Container Antenna Selection

- The communication between Container and ground station is farther comparing to glider. That is why external antenna, with a better gain, must be used.

- **Duct antenna specifications:**
  - 2.1 dBm total
  - 2.4 GHz Frequency band
  - 13g weight
  - 105 x 10 mm size
  - Enables range up to 1 mile.
  - VSWR: <=2.5 : 1, maximum
  - RPSMA connector
  - Dipole antenna.



We plan to use aluminum foil to improve antenna performance.

Radio Configuration

- XBee 2.4GHz for glider and XBee Pro 2.4Ghz S2C RF module for container is used.

- Using XCTU utility 5851, team number, is set up as PANID.
- 3 XBee modules are operating in API mode; Payload and Container are end devices whereas the GCS is coordinator.
- Baud rate is set to 9600 kbps.

- In API mode, a response packet is sent to end device when telemetry packet is received by coordinator. This means that if communication is fail for a moment, the lost packet will be resend.
- API mode also enables sending remote commands to container in case of autonomous separation failure.

- Transmission is controlled by microcontroller. Cyclic interrupt with 1 second duty cycle is triggering data packet transmission. Every second one packet is sent.
- After glider separation, container will stop telemetry transmission.

Payload Telemetry Format

- Payload Telemetry is included;

i. <TEAM ID> is our team number is 5851.
ii. Insert the word GLIDER in this position.
iii. <MISSION TIME> is the time since power up in seconds.
iv. <PACKET COUNT> is the count of transmitted packets.
v. <ALT SENSOR> is the altitude with one meter resolution.
vi. <PRESSURE> is the measurement of atmospheric pressure.
vii. <SPEED> is the measurement from the pitot tube (meters/second).
viii. <TEMP> is the sensed temperature in degrees C with one degree resolution.
ix. <VOLTAGE> is the voltage of the CanSat power bus.
x. <HEADING> is the CanSat glider heading measured by magnetometer.
xi. <SOFTWARE STATE> is the operating state of the software.
xii. <PHOTO COUNT> is the count of saved picture.

- Data is transmitted at default Baud Rate of 9600 in continuous mode.
- Upon powering up, the CanSat glider shall collect the required telemetry at a 1 Hz sample rate. The telemetry data shall be transmitted with ASCII comma separated fields followed by a carriage return in the following format:

<TEAM ID>,GLIDER,<MISSION TIME>(<HOUR>,<MINUTE>,<SECOND>),<PACKET COUNT>,<ALT SENSOR>, <PRESSURE>,<SPEED>, <TEMP>,<VOLTAGE>,<HEADING>,<SOFTWARE STATE>,<PHOTO COUNT>

- Data frame example is ‘‘5851,GLIDER,12,00,00,1,400,10200.32,3.3,34.68,5.4,90,TOUCHDOWN,1’’.

Container Telemetry Format

- Container Telemetry is included;

i. <TEAM ID> is our team number is 5851.
ii. Insert the word GLIDER in this position.
iii. <MISSION TIME> is the time since power up in seconds.
iv. <PACKET COUNT> is the count of transmitted packets.
v. <ALTITUDE> is the altitude with one meter resolution.
vi. <TEMPERATURE> is the temperature of the container.
vii. <VOLTAGE> is the voltage of the CanSat container power bus.
viii. <SOFTWARE STATE> is the operating state of the software.

- Data is transmitted at default Baud Rate of 9600 in continuous mode.

- Upon power up, the CanSat container shall transmit telemetry at a 1 Hz rate until two seconds after deploying the glider. The telemetry data shall be transmitted with ASCII comma separated fields followed by a carriage return in the following format:

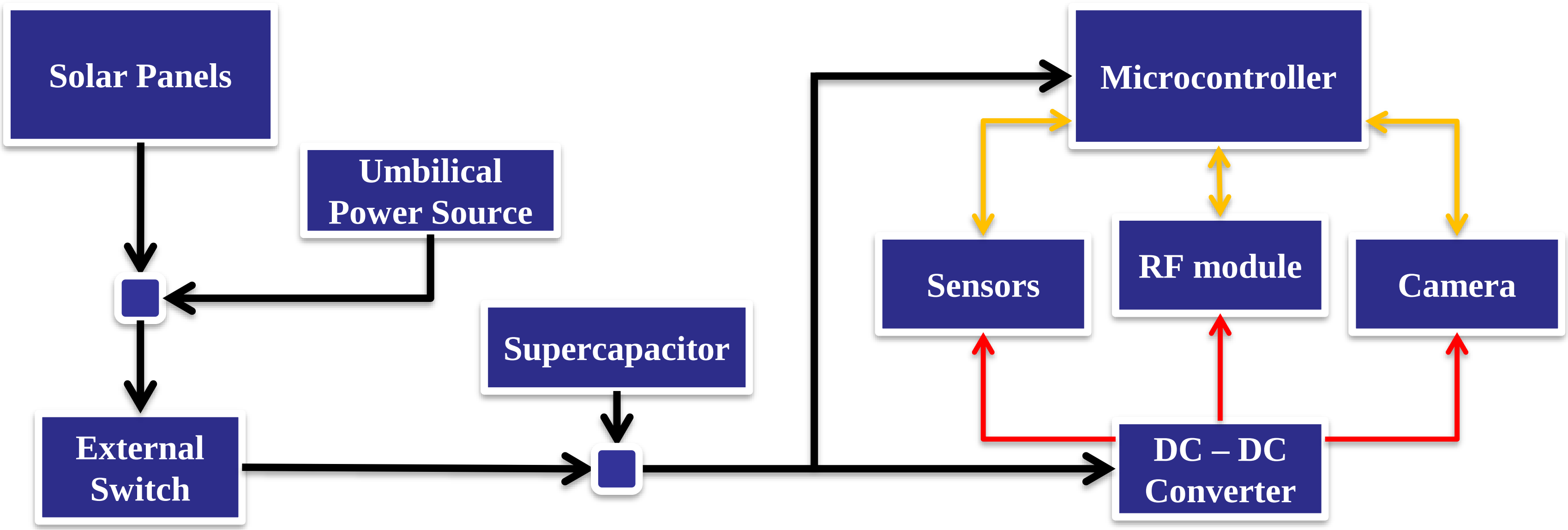
<TEAM ID> ,CONTAINER,<MISSION TIME>(<HOUR>,<MINUTE>,<SECOND>),<PACKET COUNT>, <ALTITUDE>,<TEMPERATURE>, <VOLTAGE>,<SOFTWARE STATE>

- Data frame example is ‘‘5851,CONTAINER,12,00,00,1,400,34.68,5.2,LAUNCH’’.

Electrical Power Subsystem Design

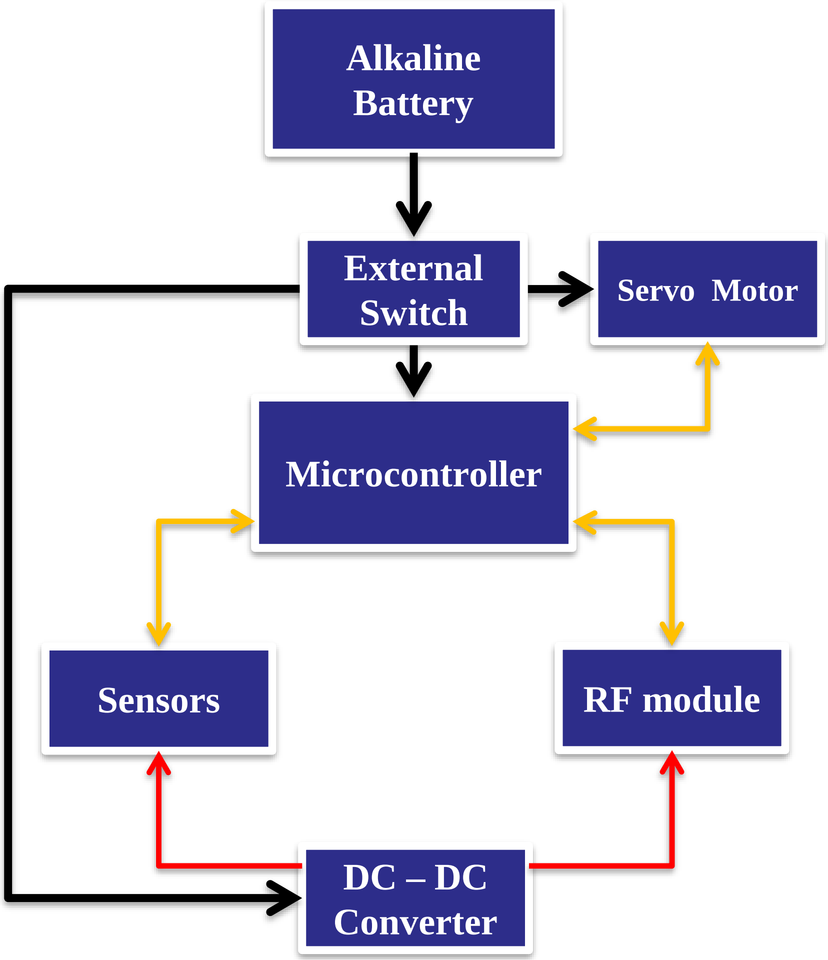
Cahit Abdullah Mısırlı

EPS Overview Payload



- **Solar Panels (5.5 V – 360 mA)**
  Harvest the energy from sunshine and then provide energy for our payload
- **Umbilical Power Source**
  Used to test the payload electronic system
- **Supercapacitor**
  Connected in parallel to keep voltage within the tolerance
- **DC – DC Converter (S7V8F3)**
  Efficiently regulate the voltage

EPS Overview Container



- **Alkaline Battery**
  Supply electrical energy for subsystem of container
- **RF module**
  Transmits telemetry data
- **Servo Motor**
  Actuates separation mechanism

EPS Changes Since PDR

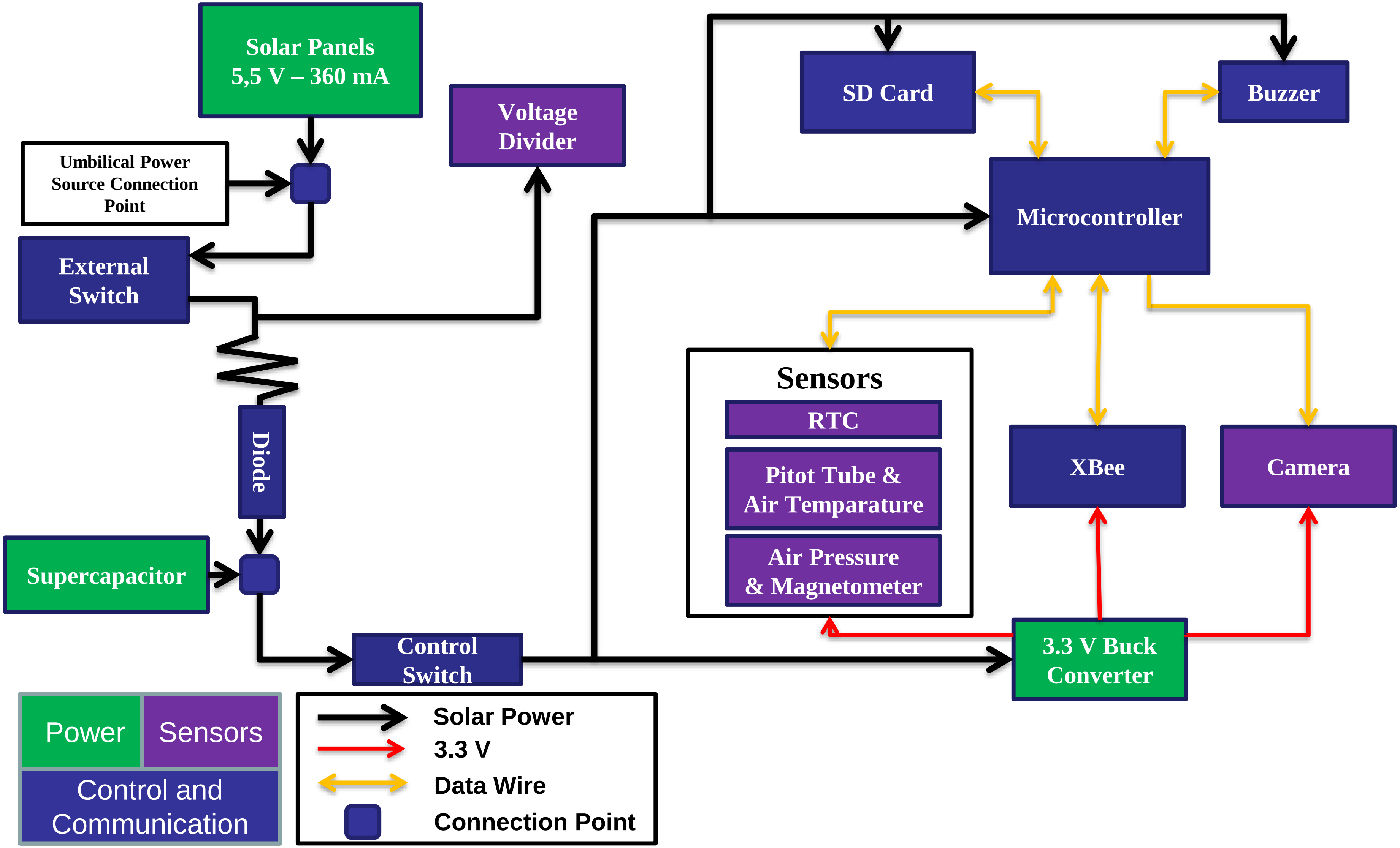
- **Payload**
  - Added details to the blok diagram
  - Power Budget was refreshed

- **Container**
  - Power Bugdet was refreshed

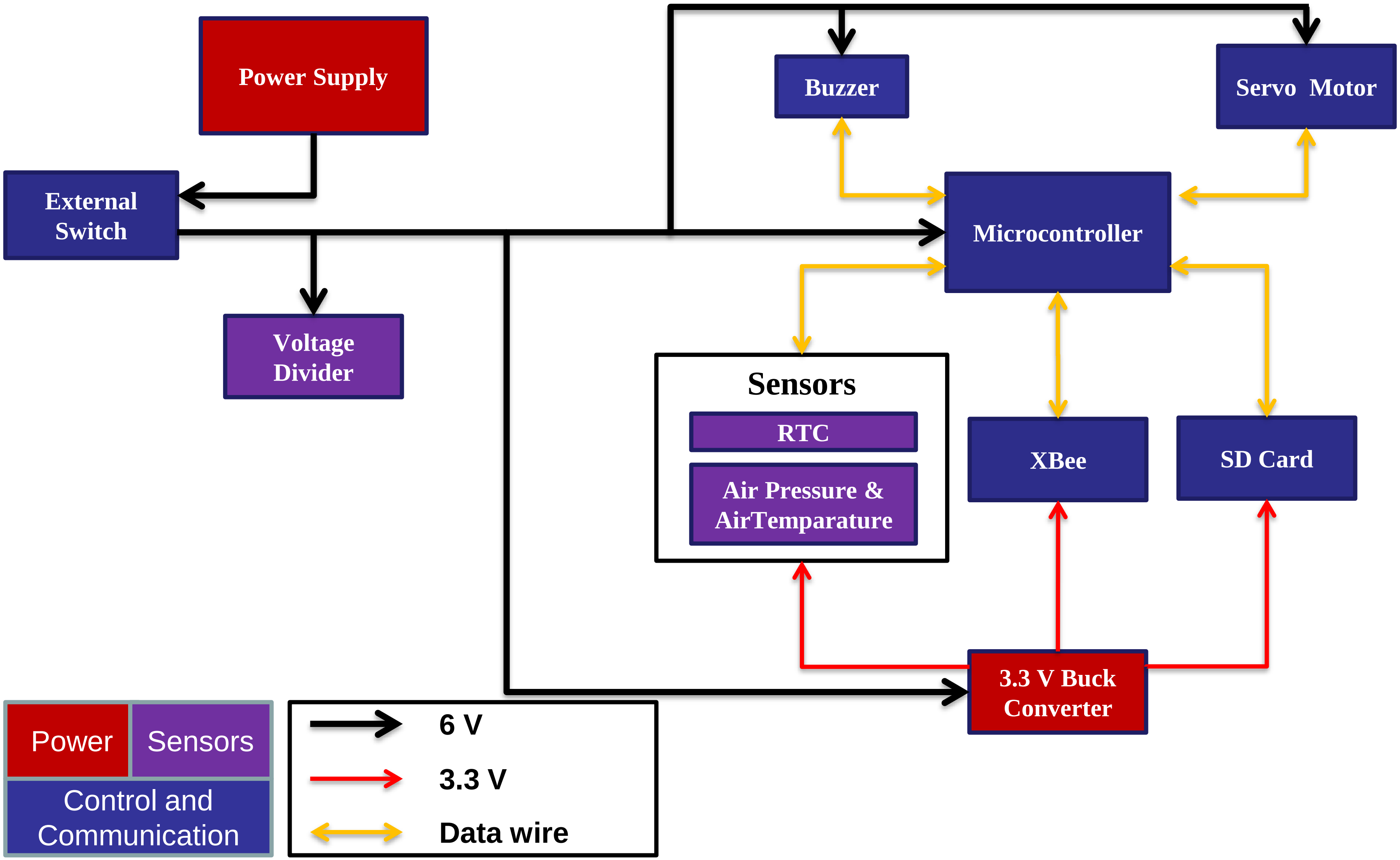
EPS Requirements

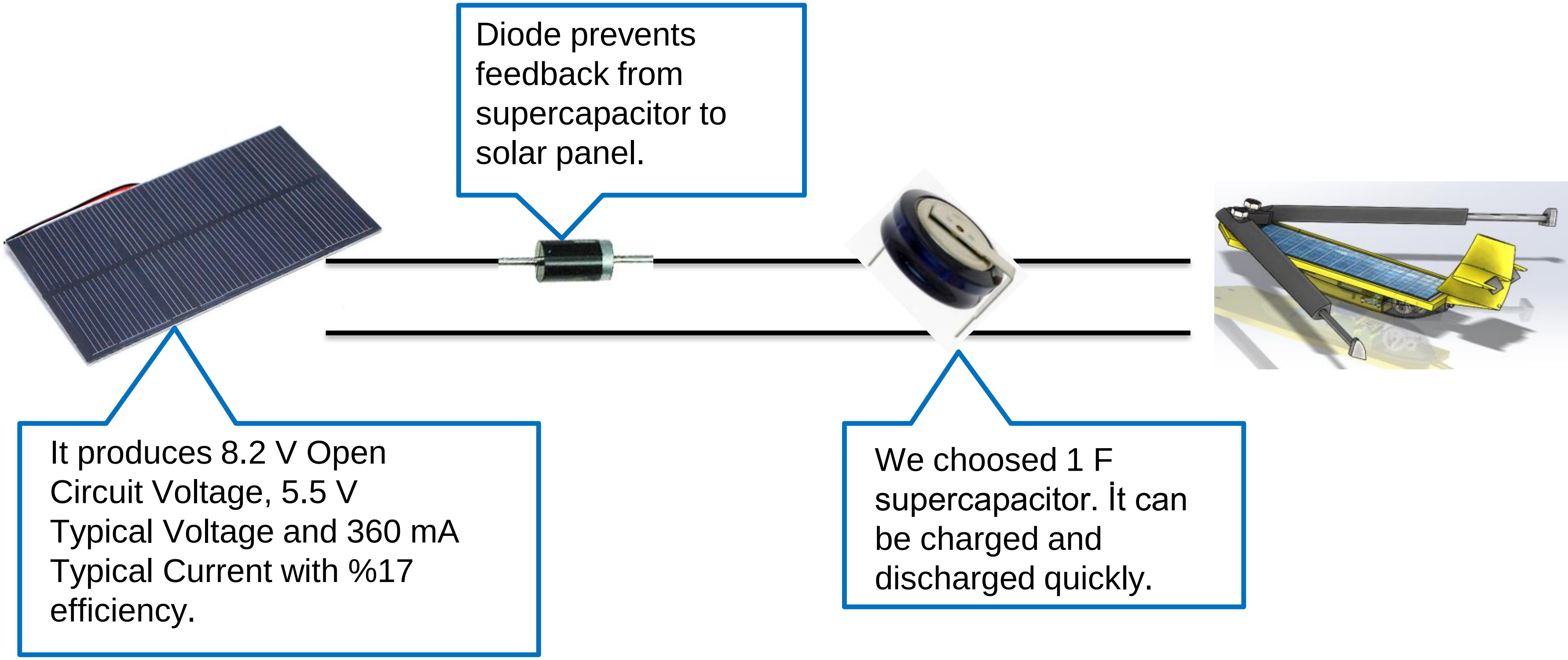
ID	Requirement	Rationale	Priority	Parents
EPS-01	The glider electronics must be all solar powered except for the time keeping device.	Competition Requirement	Very High	SR-14
EPS-02	Cost of the CanSat shall be under $1000.	Competition Challenge	Medium	SR-15
EPS-03	The glider must include an easily accessible power switch	The glider can be powered off immediately in emergency situation	High	SR-06
EPS-04	The container electronics shall be powered by only alkaline batteries.	Competition Challenge	Medium	SR-22
EPS-05	The glider shall use a time keeping device to maintain mission time. The time keeping device can use a small coin cell battery.	Time reference for every collected packet	Medium	SR-25
EPS-06	The time keeping device battery shall be a coin cell battery with a capacity limit of 240 mAh and with no more than a 1 ma discharge rate	1mA is enough for RTC module.	High	None
EPS-07	An audio beacon for the glider shall be included and powered off of the solar power.	To find glider after touchdown	High	None

Payload Electrical Block Diagram



Container Electrical Block Diagram





Diode prevents feedback from supercapacitor to solar panel.
It produces 8.2 V Open Circuit Voltage, 5.5 V Typical Voltage and 360 mA Typical Current with %17 efficiency.
We choosed 1 F supercapacitor. İt can be charged and discharged quickly.

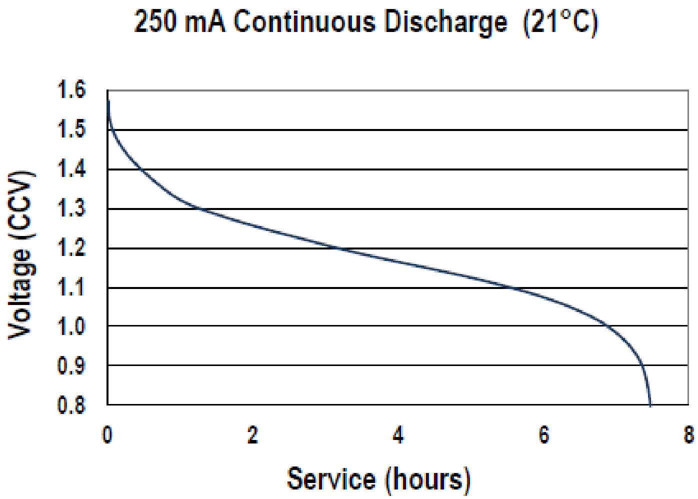
Container Battery Selection

Models	Type	Capacity (mAh)	Voltage	Weight (g)	Dimensions (mm)	($)Price
	Alkaline	900	1.5	11.9	10.5 x 44.5	5.49 (4 pieces)

- We chose **Energizer EcoAdvanced XR91 AAA Batteries** for our container.
- We used 4 pieces batteries in series. We have 6.0 V and 900 mAh capacity.

Rationales:

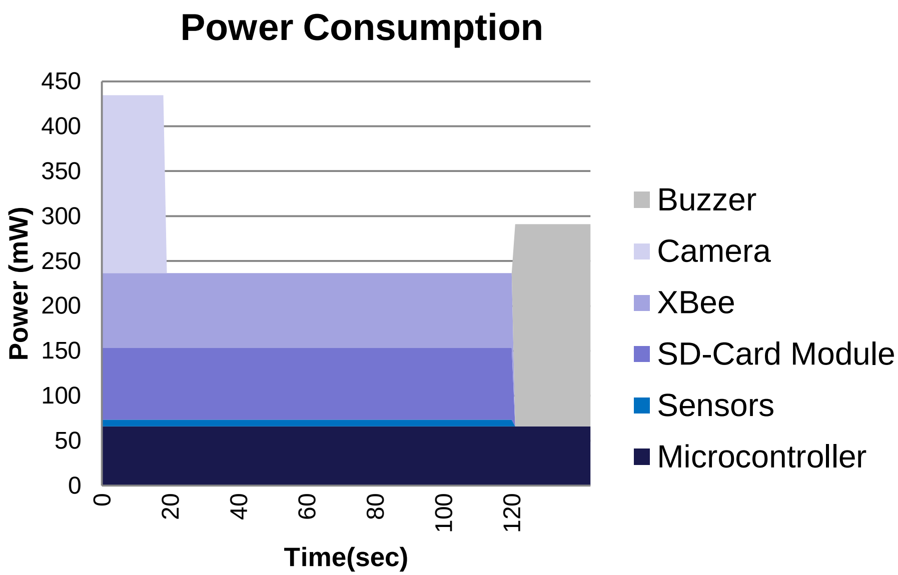
- ➢More Eco-friendly (Unlike the others, made of recycled batteries)
- ➢Higher capacity
- ➢Favorable size

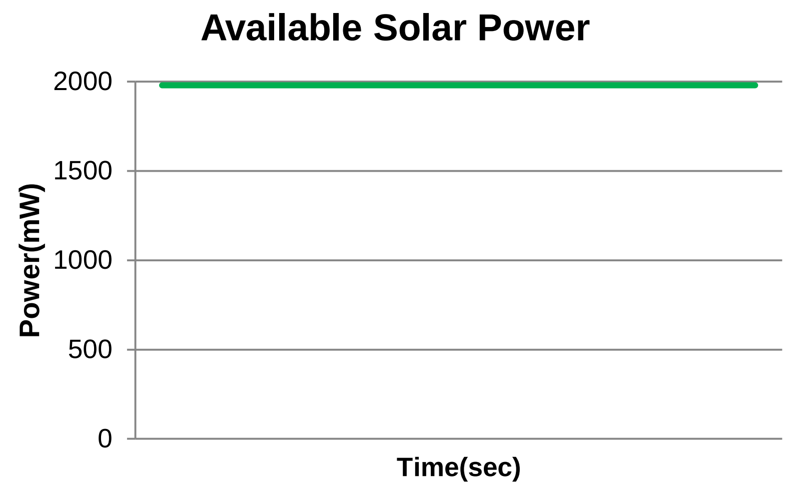


Payload Power Budget (1 of 2)

Components	Voltage (V)	Active Mode Current (mA)	Idle Mode Current (mA)	Duty Cycle(%)	Avarage Current (mA)	Avarage Power (mW)	Source
Microcontroller	3.3	20	10	100	20	66	Datasheet
Magnetometer& Air Pressure	3.3	1.5	0.002	100	1.5	4.95	Datasheet
Air Temperature & Pitot Tube	3.3	0.01	0.001	100	0.01	0.033	Datasheet
Camera	3.7	100	0	50	50	185	Datasheet
SD Card	3.3	40	12	50	26	85,8	Datasheet
XBee	3.3	45	20	20	25	82,5	Datasheet
Real Time Clock	3.3	0.2	0.1	100	0.2	0.66	Datasheet
Buzzer	5.5	20	0.1	100	20	110	Datasheet
Voltage Divider	5.5	0.2	0.2	100	0.2	1.1	Measurement

Payload Power Budget (2 of 2)





		Total Power Consumption (mW)	Total Power Available (mW)	Margins (mW)
During Flight	0-60 s	426	1980	1554
	60-120 s	241	1980	1739
During Recovery		176	1980	1804

Container Power Budget

Components	Voltage (V)	Active Mode Current (mA)	Idle Mode Current(mA)	Duty Cycle(%)	Avarage Current (mA)	Avarage Power (mW)	Mission Time (in a hour)	Total Energy Consumption (mWh)	Source
Microcontroller	3.3	20	10	100	20	66	3600 sec	66	Datasheet
Air Pressure & Air Temperature	3.3	0.01	0.001	100	0.01	0.033	3600 sec	0.033	Datasheet
SD Card	3.3	40	12	50	26	80	3600 sec	80	Datasheet
XBee(Transmit)	3.3	120	20	20	25	83	3600 sec	83	Datasheet
XBee(Receive)	3.3	31	10	20	14	46.2	0 sec	33	Datasheet
Real Time Clock	3.3	0.2	0.1	100	0.2	0.66	3600 sec	0.66	Datasheet
Servo Motor	4.8	100	5	50	52.5	252	1 sec	24.1	Datasheet
Buzzer	5.5	50	0.1	100	20	225	0 sec	0.55	Datasheet
Voltage Divider	5.5	0.2	0.2	100	0.2	1.1	3600 sec	1.1	Measurement

Total Budget	288.5	Estimated
Available Power (Alkaline Battery)	900	Datasheet
Margins	621.5	

Flight Software (FSW) Design

Cahit Abdullah Mısırlı

FSW Overview

Basic FSW Architecture

- FSW shall collect the required telemetry at a 1 Hz sample rate and send the telemetry through XBee. The FSW utilizes from interrupts for telemetry transmission and imaging.

Programming languages

- C/C++

Development Environment

- Arduino IDE

Brief summary Container FSW tasks

- Read sensors data at rate of 5Hz.
- Read battery voltage.
- Calculate the average value of sensor data
- Transmit collected sensor data packet ar rate of 1Hz
- Write packets to SD card
- Initiate glider separation mechanism
- Detect glider separation using cable cutting and LDR value.
- Activate buzzer when touchdown

Brief summary Glider FSW tasks

- Start telemetry transmission when altitude is less than 400m
- Read sensors data at rate of 5Hz
- Calculate the average value of sensor data
- Transmit collected sensor data packet
- Write packets to SD card
- Control camera image taking – send command every 3 second for picture taking. increment number of taken pictures for bonus field in telemetry
- Activate buzzer when touchdown.

FSW Changes Since PDR

- **DSPC01 senor library is added and MPU9250 is removed.**
- **Camera library is not used. Microcontroller will only send commands for picture taking and increment after each command is sent.**
- **Interrupts now are used as triggering source of telemetry transmission and picture taking command**
- **FSW State Diagrams are refreshed**

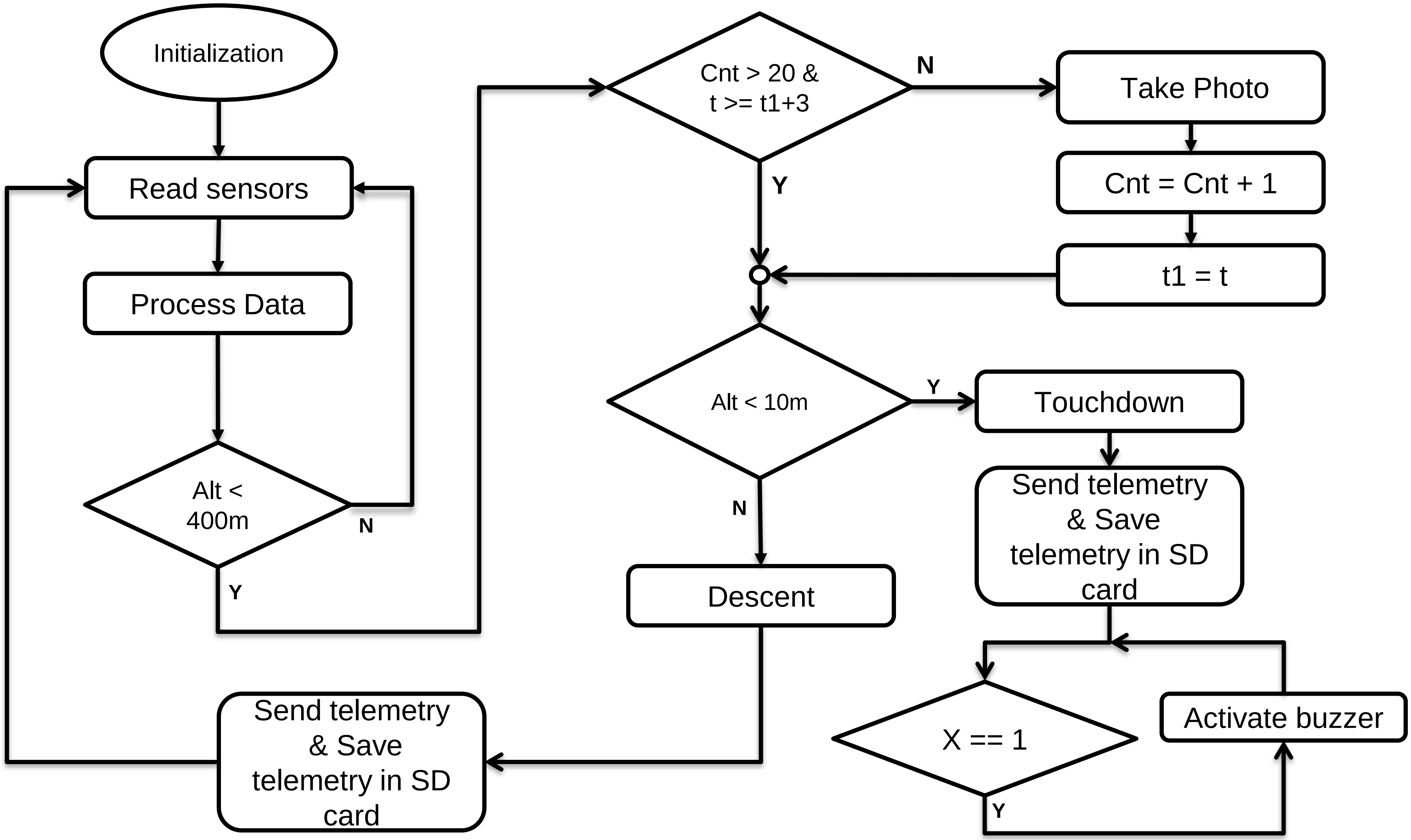
FSW Requirements (1 of 2)

ID	Requirement	Rationale	Priority	Parent
FSW-01	The glider must be released from the container at 400 meters +/- 10 m.	Competition Requirements	High	SR-07
FSW-02	During descent, the glider shall collect air pressure, outside air temperature, compass direction, air speed and solar power voltage once per second and time tag the data with mission time.	Competition Requirements	High	SR-11
FSW-03	During descent, the glider shall transmit all telemetry. Telemetry can be transmitted continuously or in bursts.	Competition Requirements	High	None
FSW-04	Telemetry shall include mission time with one second or better resolution, which begins when the container and glider is powered on. Mission time shall be maintained in the event of a processor reset during the launch and mission.	Competition Requirements	High	SR-12
FSW-05	All telemetry shall be displayed in real time during descent.	Competition Requirements	High	None
FSW-06	All telemetry shall be displayed in engineering units (meters, meters/sec, Celsius, etc.)	Competition Requirements	High	None
FSW-07	The flight software shall maintain a count of packets transmitted, which shall increment with each packet transmission throughout the mission.	Competition Requirements	High	SR-20

FSW Requirements (2 of 2)

ID	Requirement	Rationale	Priority	Parent
FSW-08	The CanSat container shall have a payload release override command to force the release of the payload in case the autonomous release fails.	Competition Requirements	High	None
FSW-09	The container shall transmit telemetry from the time being turned on and placed on the launch pad until 2 seconds after releasing the glider	Competition Requirements	High	SR-26
FSW-10	The container telemetry shall be transmitted once per second.	Competition Requirements	High	None
FSW-11	The container telemetry shall include team number, indication of container telemetry, altitude, temperature and software state.	Competition Requirements	High	None
FSW-12	No lasers allowed.	Broadcast mode is slower	Medium	SR-21
FSW-13	A color camera shall be added to take picture of ground as often as possible	Competition Requirement	Medium	SR-27

Payload FSW State Diagram (1 of 2)



Payload FSW State Diagram (2 of 2)

- **Data processing**
  1)Filter sensors data – Sensors are sampling data in 5Hz rate. The FSW is averaging the data and gives more accurate data.
  2)Calculate velocity – Glider velocity is obtained by applying Bernoulli equation. Dynamic pressure is measured via BMP280 whereas static pressure via DSPC01 pressure sensor.

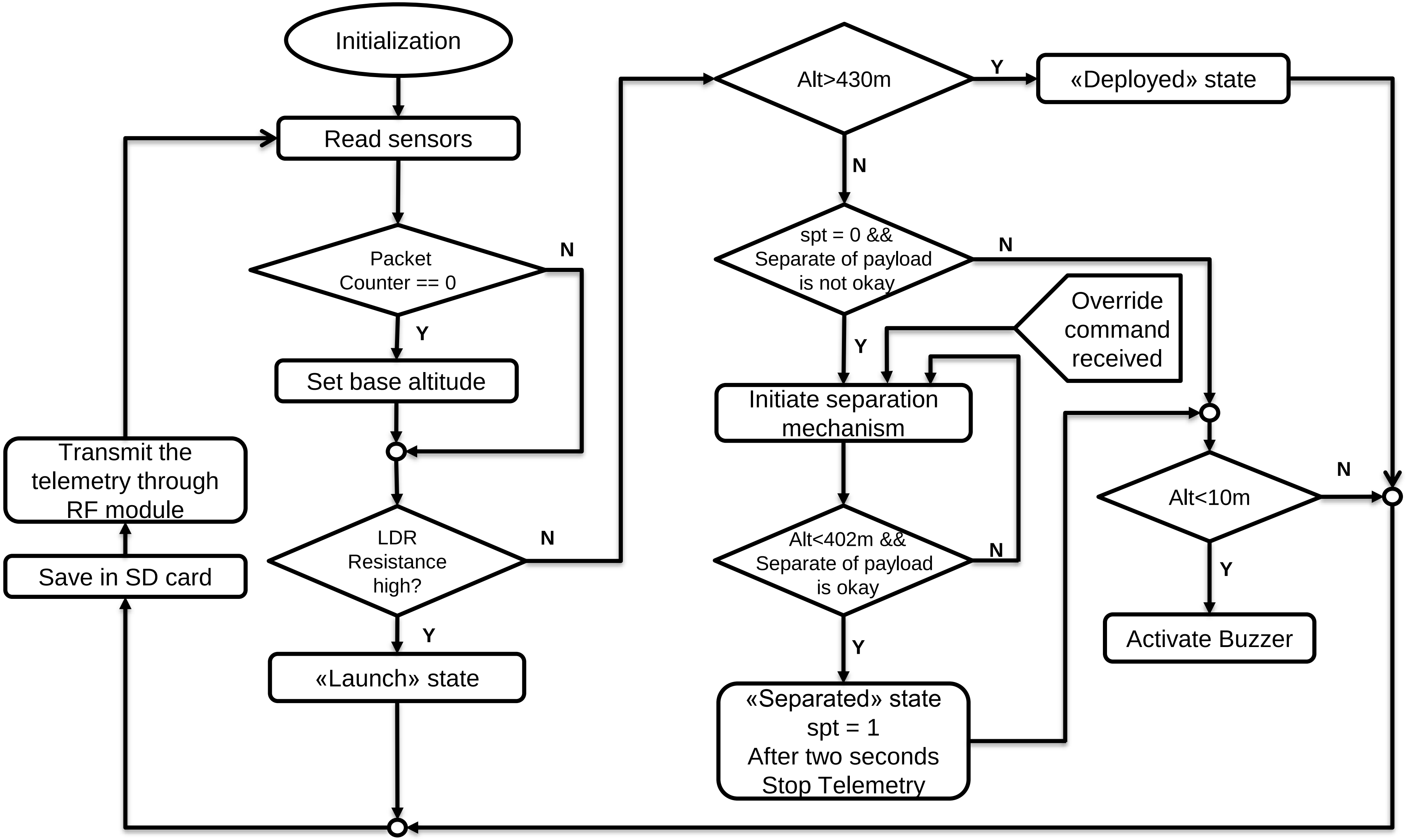
- **Altitude calibration**
  Real altitude shall be determined by subtracting sea level altitude from sensor reading. Sea level of launch area will be added to FSW before launch.

- **Picture counter**
  The microcontroller is triggering the camera every 3 second for taking picture. A variable called cnt keeps track of each picture taken. This variable is included in telemetry.

- The Flight Software is designed as electrical components use instantaneous solar energy in extreme efficient way. We divided high consumer components to 3 part; SD card, XBee and Camera picture taking & saving process. Since microcontroller runs continuously and also sensors & RTC consumptions are negligible they are not considered. The XBee and SD card are running sequentially while camera is running in parallel to these.

- The FSW will be optimized until competition to ensure no computation bug is left.

Container FSW State Diagram (1 of 2)



Container FSW State Diagram (2 of 2)

- Spt is an integer variable assigned for checking separation status Until glider separation in telemetry spt will be zero.
- Container shall be connected to glider via header cables and the cables will be connected to digital input of MCU.
- When the glider is separated from container, the header cables will be splitted and digital input will give 0 which indicates separation is executed successfully.

- The FSW will check reset status of microcontroller through every loop. This will be done comparing updated packet count values with prestored packet values.

- There are 3 FSW state; Launch, Deployed and separated. Identification of each state is described below;
- Launch state: If LDR resistance is high enough which means CanSat is inside of rocket.
- Deployed state: If relative altitude is more than 430 and LDR resistance is low.
- Separated state: If spt parameter is zero and altitude is less than 400meter.

- Separation mechanism is activated at 430 meter by checking spt variable value. Separation process is estimated to last 3 seconds.

Software Development Plan (1 of 2)

Prototyping And Prototyping Environments

- Arduino IDE is used as prototyping environment.
- Arduino Uno board and breadboard is used for prototyping basic CanSat hardware.

Test Methodology

- Laboratory tests
- Outdoor tests
- Wireless communication tests

Development Team

- İlkin Aliyev
- Selim Öztürk
- Cahit Abdullah Mısırlı

Software Subsystem Development Sequence

- To avoid late software development, tasks are slice into small chunks.
- So far sensors and SD card module are interfaced with MCU. In the next period, the camera will be interfaced as it is received.
- Finally first prototype of FSW will be integrated into hardware.

Analog to Digital Converter (ADC) → BMP280 MPU-9250 DS1338 (I2C) → XBee (USART) → SD Card Telemetry saving → Camera triggering and picture saving for every second → Tests & Final implementation

Software Development Plan (2 of 2)

Progress since PDR

- After PDR, we integrated and tested DSPC01 sensor, servo motor, SD card module and XBee. A sample of container telemetry was generated and transmitted every second.

Milestones after CDR

- Camera and RTC module are not received. After they are received we will integrate glider and container FSW prototype.
- Then we will perform these integrated system tests with the solar panels.
- According to results of those tests, the electronic system CanSat will be optimized & upgraded.

Ground Control System (GCS) Design

İlkin Aliyev

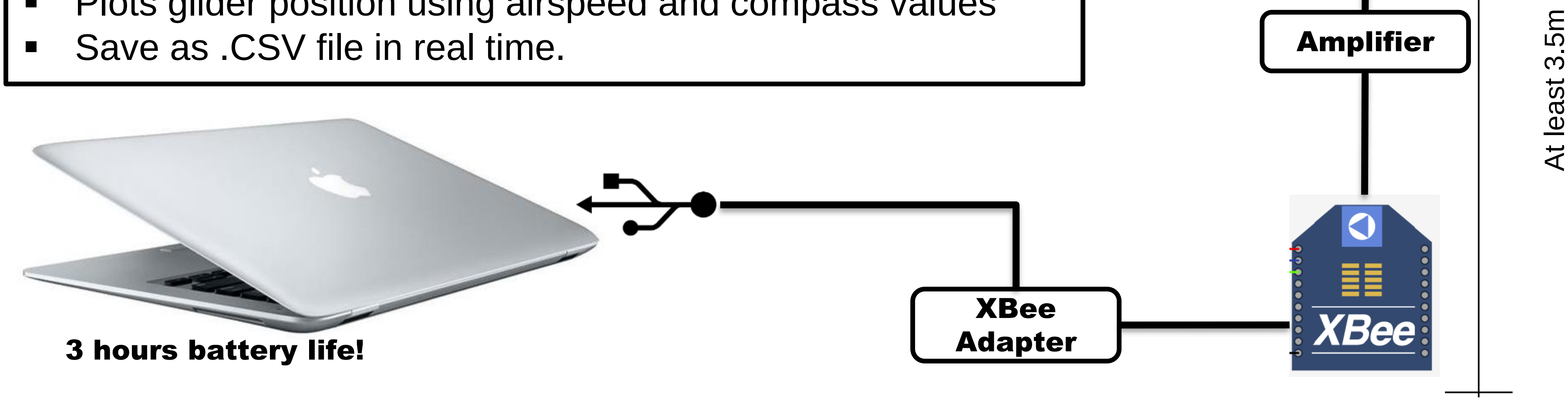
GCS Overview

There are 3 main components of at Ground Station.

Directional Panel Antenna boosts received signal.
Amplifier provides sufficient power for antenna boosting.
XBee Pro S2C receives incoming telemetry from CanSat and forwards the to Laptop simultaneously.

Software developed in Matlab receives data packets via serial port and then;

- Clearly displays the telemetry data
- Plots required parameters
- Plots glider position using airspeed and compass values
- Save as .CSV file in real time.



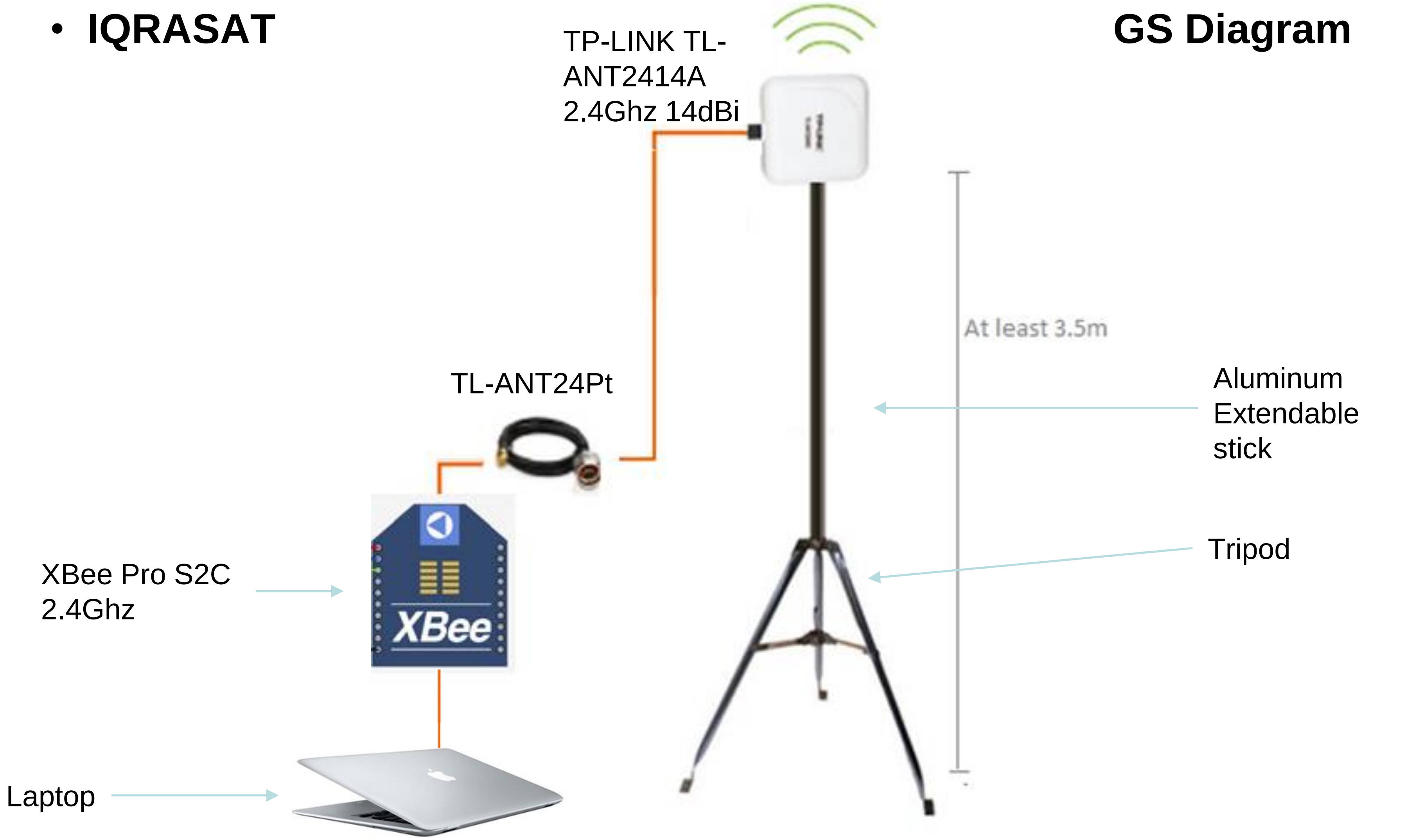
No change was done to GCS.

GCS Requirements

ID	Requirement	Rationale	Priority	Parent
GCS-01	Each team shall develop their own ground station.	Monitoring telemetry data	High	SR-16
GCS-02	All telemetry shall be displayed in real time during descent.	Competition Requirements	High	None
GCS-03	All telemetry shall be displayed in engineering units (meters, meters/sec, Celsius, etc.)	Data Standardization	High	SR-18
GCS-04	Plotting of pressure, outside temperature, altitude and glider speed changing	Seeing those data in time spectrum enables to catch change more easily	High	SR-19
GCS-05	The ground system shall display a two dimensional map of estimated glider position based on speed and heading telemetry data.	Observing glider trajectory gives us chance of refinement of glider flight characteristics	High	SR-19
GCS-06	The ground station shall include one laptop computer with a minimum of two hours of battery operation, XBee radio and a hand held antenna.	The GUI is running in Laptop that is why laptop is needed. Battery is need since no AC line is available in the competition area. XBee receives telemetry from CanSat and Antenna strengthens the signal	High	SR-17
GCS-07	The ground station must be portable so the team can be positioned at the ground station operation site along the flight line. AC power will not be available at the ground station operation site.	Competition Requirement	High	None

- **IQRASAT**

GS Diagram



GCS Design (2 of 2)

Specifications		
Battery Operating Time	**Overheating Mitigation**	**Auto Update Mitigation**
Our laptop battery is capable of operating more than whole mission, which is corresponds to 3 hours.	For preventing ultra sun effect from GS, we will use an umbrella. On the other hand the laptop fan is cooling the system sufficiently.	We have two options for auto update resolution. First, we will turn off updating and set it up as it will ask us when auto update needed. Secondly, we will scan the laptop before. We will remove any software that is found to have potential risk.

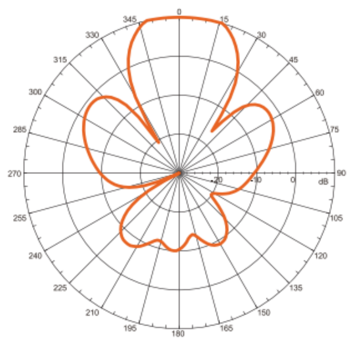
Chosen Antenna: TP-LINK TL-ANT2414A 2.4Ghz 14dBi

- CanSat payload is a spiral flight performing glider, that is why we have to chose directional or yagi type antenna.
- Selected antenna is a directional panel antenna.
- It has good gain and small size.
- To be compatible with XBee modules, only 2.4 GHz antenna models are considered.
- Antenna connector is Reverse Polarized SMA type.
- Antenna radiation pattern and setup is presented in the next slide.
- Link budget calculation is presented CDH antenna selection part.

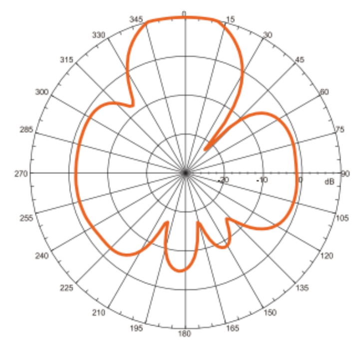
GCS Antenna (2 of 2)

- **Radiation Pattern**

V-Plane Co-Polarization Pattern



H-Plane Co-Polarization Pattern



- **Antenna mast height and mounting strategy**
  - The antenna will be set up by extendable tripod.
  - Antenna is directional so it will be able to be manipulated by GS Crew member.
  - Using tape measure, length of setup will be verified.
- **Things To Consider**
  - While designing Ground Station of CanSat, every single parameter of system was brainstormed.
  - Exceptional cases besides foreseen ones shall be detected while range test.

GCS Software (1 of 2)

- **GCS application was decided to be designed using Matlab as it offers more strong plot functions.**

- **It will read received telemetry data periodically. Recreation of packets in FSW will cause updating of the GUI.**

- **No Commercial off-the-shelf (COTS) software will be used.**

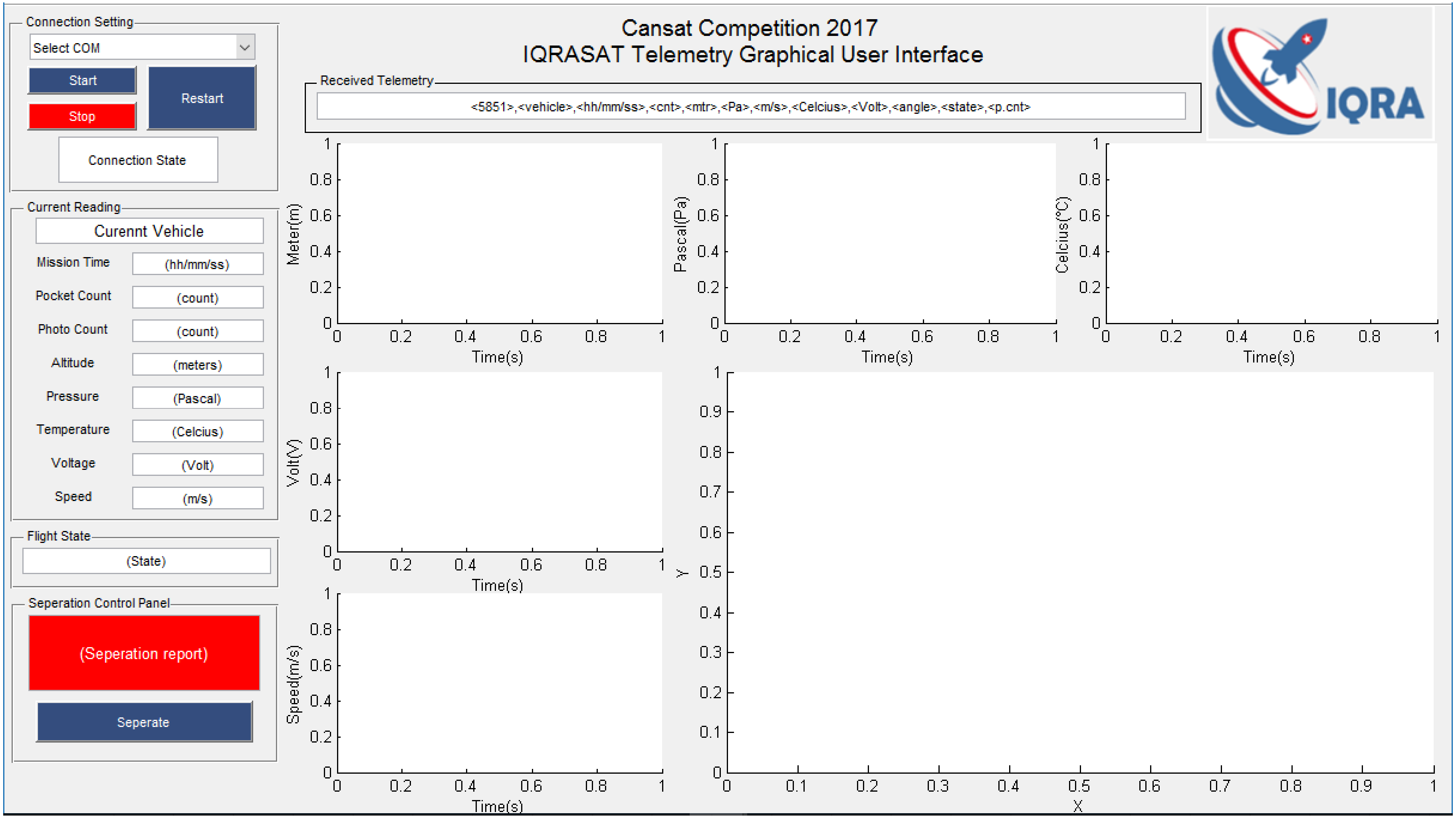
- **The Simple Matlab GUI shall have several capabilities.**
  - Display full telemetry
  - Plot some parameters.
  - Save in .CSV or Excel file
  - Special dedicated command panel

- **Only one interface/GUI panel will present either container or glider telemetry.**
  - First, the container will be launched this time until glider separation the GUI will display container telemetry
  - After glider get separated from the re-entry container the simple application will project the glider telemetry
  - Special indicators will report both vehicle states (flight state, separation situation)

- **The GUI will utilize from cyclic interrupt for telemetry reading.**
  - When new data is available in serial port, the GUI will instantly implement the events.
  - This will also enable sending command to CanSat when it is not separated

- **The GUI will plot 2 dimensional map/trajectory of a glider using speed and compass values.**
  - First, x and y axis will be determined. X is considered as the max diameter of the glider landing area, whereas Y is altitude.
  - After the formulas, X = 400 - v*sin(a).*t, Y = v*cos(a).*t + 500   which specify the axis coordinates plotting will update every second.
  - v refers to received speed and a to direction.

GCS Software (2 of 2)



CanSat Integration and Test

Abdul Samet Erkek

İlkin Aliyev

Davut Koçyiğit

CanSat Integration and Test Overview

CanSat Integration

Structure assembly → Electronic mounting → Glider DCS → Glider & Container → Parachute

1. Glider structure is 3D Printed. Solar panels will be placed on the fuselage.

2. First, electronic components will be mounted to the PCB. Then camera module and pitot tube will be mounted. The camera lens and pitot tube is stuck out. Also XBee wire antenna is stuck out.

3. Glider wing sticks will be integrated to fuselage. And kite will be mounted to wing sticks so that extendable wing sticks can harm the kite when they deploy. Magnets and rubber band will be mounted to wing sticks.

4. Glider wing will be folded and the kite will be folded safely so that it can deploy correctly. Ring behind the glider is attached to container rod. And the rod sifted to closed position. This part is extremely important thus right before launch container will be held by our hand the rod will be shifted to make sure that there is no mechanical problem in glider releasing.

5. Finally, the parachute will be attached to the container and folded in a container parachute section.

Test Proc.	Test Description	Rqmts	Pass Fail Criteria
	Subsystem level testing		
1	BMP280 – to check the accuracy of the static pressure measurement of the sensor. Altitude is calculated and we set the base altitude the ground we go up by elevator.	21, 48	Pass İf the altitude is incremented by lifting up
2	DSPC01 – To check accuracy of direction, temperature and dynamic pressure measurement of the sensor. We turn the senor direction where we know exactly and ensure its accuracy. Also we measure the speed by Bernoulli formula and we measure speed also with manometer. We measure the real temperature with thermometer and compare the values with the DSPC01's values.	21, 32	Pass compass test if direction is nearly 10 degree same. Pass if temperature measurement is same with thermometer values. Pas if calculated speed is same with manometer's value.
3	Camera – We ensure that the camera is taking the capturing command and accomplish the process less than 3 seconds.	Bonus	Pass if capturing and saving are finished in less than 3seconds.
4	FSW functionality– We make sure that the Arduino is carrying out the operations correctly and handle the reset situations. The power will be cut off for a moment and then again given. We make sure that there is no delay and bug in the software.	21, 36	Pass if packet count is still maintained. Pass if p.c incremented with each packet transmission.
5	RTC – the purpose of hardware RTC was to obtain more accurate mission time. So we reset the Arduino.	21	Pass if RTC is maintain the mission time.
6	XBee – we generated container data packet and tested inside the faculty (nearly 30m). We saw the packets are continuously sent and received correctly without any parameter loss.	24, 46	Pass if each packet and each parameter in the packet are received

Test Procedures Descriptions (2 of 4)

Test Proc.	Test Description	Rqmts	Pass Fail Criteria
7	Solar panel - we shake the panels and how much energy it harvests in different several angles.	27	Pass if panel is harvesting expected energy
8	Supercapacitor – supercaps ensure the constant voltage into the system. W observe supercapacitor charge/discharge rate. We learn how much time the supercaps can feed the system if glider took unwanted position.	27	Pass if superacapacitors feed the system for at least 7 seconds
9	Separation mechanism – we make sure that there is no bug in the software to cause separation triggering failure. Also we make sure that there is no mechanical problem that cause glider gets stuck inside container. For this we perform quadcopter test. As redundancy we can test by dropping from our faculty building (15m)	10, 39, 42	See whether separation is executed successfully.
10	Range - we ensure that we obtain the packets from 1000meter with XBee Pro S2Cfor container and obtained packets from 600 meter for the glider.	24, 25, 26	Pass if packets are received without any loss.
11	GCS Matlab Software – we make sure that the GCS software is receiving, displaying and saving the data packets continuously without any error. For this we send random numbers from serial terminal.	30, 31, 32	Pass if every packet is received saved and plotted correctly.

Test Procedures Descriptions (3 of 4)

Test Proc.	Test Description	Rqmts	Pass Fail Criteria
	Integrated Functional Level Testing		
1	Release glider from container - Separation mechanism testing will be done in such way. After CanSat wholly integrated. The ensure system will be held in one hand and fled with our hand to right and left to simulate the real parachute descent. Then Remote command will be sent from GS and see whether there is any issue of in glider separation.	10	Pass if the mechanism is triggered and realized.
2	Deployment after release – Deployment tests will be applied to wing opening parts. A rubber band of the glider must be renewed before the launch. And also the rubber band must be stretched a few times before the flight. The glider is kept with our hand and left down to see wether how effective unfolding is.	11	Pass if wing sticks unfold automatically, operatively wand kite fabric don't get stuck when telescopic wing sticks open.
3	Glider Functionality – The team owns a quadcopter which is capable of lifting the cansat to 250m nearly. We will left the glider down and see wether it start to stabilize and glide as required. We expect it to start gliding after approximately 10meter loss.	11, 41, 43	See whether separation is executed successfully.
4	GCS Matlab Software – we make sure that the GCS software is receiving, displaying and saving the data packets continously without any error. For this we send random numbers from serial terminal.	30, 31, 32	Pass if packets are received without any loss.
5	Communications - we ensure that we obtain the packets from 1000 meter with XBee Pro S2Cfor container and from 600 meter for the glider. Telemetry test was already done. Next step is to make sure the range with 14dBi antenna/	24, 25, 26	Pass if every packet is received saved and plotted corectly.

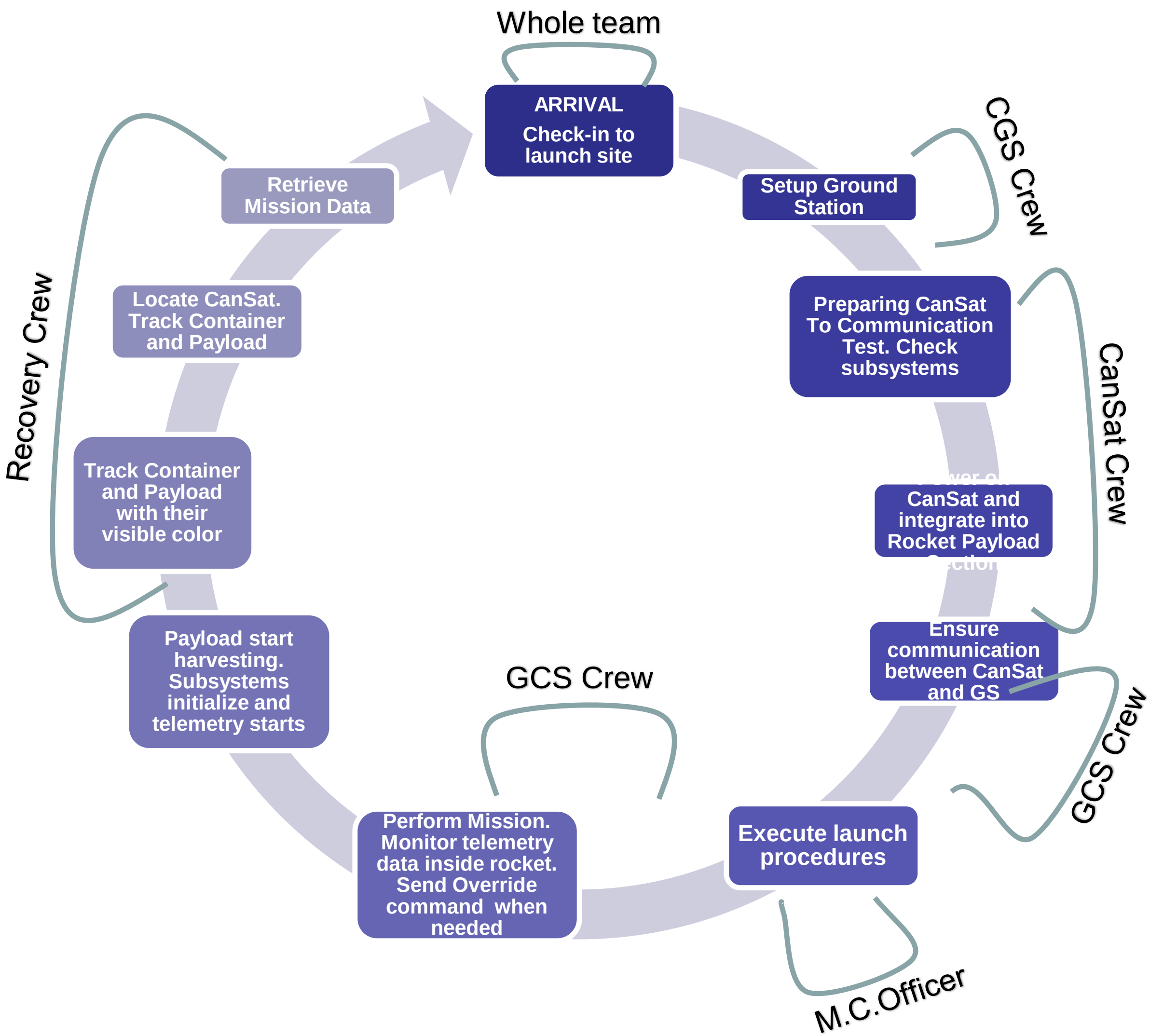
Test Procedures Descriptions (4 of 4)

Test Proc.	Test Description	Rqmts	Pass Fail Criteria
	Environmental Testing		
1	Drop I. Secure a 1 m rope to the ceiling 2m from ground. II. Secure the other end of rope to parachute attachment point of container. III. Raise CanSat up 80cm line with the rope. Release and let it drop.	12 18	Pass if 1)parachute attachments survive. 2)Container holds glider 3)Every single component mounts, especially battery, survive
2	Thermal I. Generate a foam insulation chamber and place CanSat into. II. Seal the thermal chamber and turn on the hair dryer. III. Circulate hair dryer and heat the air in the chamber. Up to 60 degree for two hours IV. Remove the CanSat and perform a visual inspection. Perform functional tests to verify CanSat can operate as expected.	18	Pass if CanSat still performs its functionality
3	Vibration I. Turn the sander upside down and secure it in a bench vise. II. Place CanSat on the sand paper part of the sander and secure with duct tape. III. Over one minute turn the sander on, wait two second to power up to full speed, turn off. As soon as sander stop moving repeat until one minute is complete. IV. Remove CanSat from test fixture and inspect it for any damage.	12 18	Pass if there is no loosed component.
4	Dimensions verification A self made RPS with real RPS dimensions will be used to continuously test proper sizing. Glider fitting inside container is tested, too.	2 3 5	Pass if 1)CanSat fits RPS with tolerances. 2)No part of glider extends beyond the container.

Mission Operations & Analysis

Selim Öztürk

Overview of Mission Sequence of Events



Team Members Assignment

CanSat Crew
- Selim Öztürk
- Abdul Samet Erkek
- Emrullah Mahmurat

GCS Crew
- Ilkin Aliyev
- Cahit A. Mısırlı

Recovery Crew
- Emrullah Mahmurat
- Selahattin Kök
- Abdul Samet Erkek.

Mission Control Officer
- Selim Öztürk

Field Safety Rules Compliance

- **Missions Operations Manual will be developed based the mission guide and real tests before competition.**
- **It will cover below topics;**
  - ✓ Setting up the GCS.
  - ✓ CanSat assembly.
  - ✓ Loading CanSat into RPS.
  - ✓ Launch procedures.
- **There will be 2 copies and assembled in three binders.**

CanSat Location and Recovery

- **Container and Payload Recovery**
  - Container and Payload will be recovered using buzzers.
  - Orange parachute of container will help tracking and increase tractability.
  - The payload orange kite also will help recovery crew tracking.
  - Recovery crew will be well-coordinated and extra accurately track both vehicles.
  - Both vehicles will be labeled with team contact information.

Mission Rehearsal Activities

Ground system radio link check procedures
- Check all components integrity.
- Power on the container or glider via external source.
- Establish GCS antenna and start GCS software
- Confirm data reception.

Loading the CanSat in the launch vehicle
- Put parachute wholly in the container.
- Ensure parachute will deploy after rocket deployment.
- Place the CanSat in the RPS.

Powering on/off the CanSat
- Check all components integrity.
- Press on the switch button on the glider/container.
- Glider is sending telemetry since it is lower than 400m
- Container is powered on.
- After recovery, inspect the CanSat.
- Press on the power buttons.
- CanSat is powered off.

Recovery
- 3 members especially will be assigned to track CanSat.
- Thanks to buzzer, location of CanSat is determined.
- Inspect for any damage.
- Take to GCS for data retrieval

Launch configuration preparations
- Fit check the container.
- Attach parachute line. Fold the parachute.
- Insert glider in the container.
- Attach the glider to container.
- Place CanSat into RPS

Telemetry processing, archiving, and analysis
- Open the serial port in the GCS software.
- Make sure that data is coming and plotted in real time.
- After recovery, retrieve the mission data from SD card.
- Compare logged data with transmitted data
- Mission assessment. PFR preparation

Requirements Compliance

İlkin Aliyev

Requirements Compliance Overview

Indicator Summary

- Currently most of the requirement are satisfied.

- Sensor Subsystem requirements are fulfilled (%90).
  All sensors are integrated and tested, only camera is left.
- CDH Subsystem requirements are completely fulfilled (%95).
  Each component is tested. But Range test still not performed.
- EPS requirements are met.
  Solar panel and supercapacitors are tested. But we must ensure that generated solar energy supplies the system with safe tolerances.

- FSW requirements are fully satisfied. The FSWs of container and glider are under development. About %10 is left.
- DCS requirements are partially complied.
  Glide duration of 2 minutes must be tested and verified
  Gliding in circular pattern must be tested and verified.
- Drop tests will be conducted to verify shock – force survival.

Requirements Compliance (1 of 6)

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 glider) shall be 500 grams +/- 10 grams.	Comply	58	Probably, we shall add modular weight to our Container
2	The glider shall be completely contained in the container. No part of the glider may extend beyond the container. One circular end of the cylindrical container may be open (no door enclosure is required); however, the glider may not extend outside the container.	Comply	17 19	Win sticks are completely fitting inside container. No part is extend
3	Container shall fit in a cylindrical envelope of 125 mm diameter x 310 mm length including the container passive descent control system. Tolerances are to be included to facilitate container deployment from the rocket fairing.	Comply	17 19	Constructional clearance is left
4	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.	Comply	30 33	Parachute controls container descent
5	The container shall not have any sharp edges to cause it to get stuck in the rocket payload section.	Comply	53 54	Cylindrical shape
6	The container shall be a florescent color, pink or orange.	Comply	54	Florescent color
7	The rocket airframe shall not be used to restrain any deployable parts of the CanSat.	Comply	54	
8	The rocket airframe shall not be used as part of the CanSat operations.	Comply	54	

Requirements Compliance (2 of 6)

Rqmt Num	Requirement	Comply No Comply Partial	X-Ref Slide(s) Demonstrating Compliance	Team Comments or Notes
9	The CanSat (container and glider) shall deploy from the rocket payload section.	Comply	18	
10	The glider must be released from the container at 400 meters +/- 10m.	Comply	90	Servo triggered shift-rod mechanism
11	The glider shall not be remotely steered or autonomously steered. It must be fixed to glide in a preset circular pattern of no greater than 1000 meter diameter. No active control surfaces are allowed.	Partial	37	Tests need to be done
12	All descent control device attachment components shall survive 30 Gs of shock.	Partial	33	Tests need to be done
13	All descent control devices shall survive 30 Gs of shock.	Partial	33, 55, 57	Tests need to be done
14	All electronic components shall be enclosed and shielded from the environment with the exception of sensors.	Comply	57	
15	All structures shall be built to survive 15 Gs acceleration.	Partial	57	Tests need to be done
16	All structures shall be built to survive 30 Gs of shock.	Partial	57	Tests need to be done
17	All electronics shall be hard mounted using proper mounts such as standoffs, screws, or high performance adhesives.	Comply	57	

Requirements Compliance (3 of 6)

Rqmt Num	Requirement	Comply No Comply Partial	X-Ref Slide(s) Demonstrating Compliance	Team Comments or Notes
18	All mechanisms shall be capable of maintaining their configuration or states under all forces.	Partial	57	To ensure this, we must freefall our CanSat from Faculty building
19	Mechanisms shall not use pyrotechnics or chemicals.	Comply	56	No pyro/chemical
20	Mechanisms that use heat (e.g., nichrome wire) shall not be exposed to the outside environment to reduce potential risk of setting vegetation on fire.	Comply	56	No mechanism use heat
21	During descent, the glider shall collect air pressure, outside air temperature, compass direction, air speed and solar power voltage once per second and time tag the data with mission time.	Comply	21=28 88	Glider equipped with proper sensors
22	During descent, the glider shall transmit all telemetry. Telemetry can be transmitted continuously or in bursts.	Comply	69, 88	Continuous mode
23	Telemetry shall include mission time with one second or better resolution, which begins when the container and glider is powered on. Mission time shall be maintained in the event of a processor reset during the launch and mission.	Comply	70,89	When processor reset RTC shall retrieve the time
24	XBee radios shall be used for telemetry. 2.4 GHz Series 1 and 2 radios are allowed. 900 MHz XBee Pro radios are also allowed.	Comply	66, 68	2.4Ghz radios are used
25	XBee radios shall have their NETID/PANID set to their team number.	Comply	68	TeamID to NETID
26	XBee radios shall not use broadcast mode.	Comply	68	Multicast mode

Requirements Compliance (4 of 6)

Rqmt Num	Requirement	Comply No Comply Partial	X-Ref Slide(s) Demonstrating Compliance	Team Comments or Notes
27	The glider electronics must be all solar powered except for the time keeping device may use a coin cell battery. No batteries are allowed. Super capacitors are allowed and must be fully discharged at launch.	Comply	82	Solar panels provide sufficient energy
28	Cost of the CanSat shall be under $1000. Ground support and analysis tools are not included in the cost.	Comply	119, 120	
29	Each team shall develop their own ground station.	Comply	93-100	
30	All telemetry shall be displayed in real time during descent.	Comply	99, 100	Our GUI catch up all incoming telemetry using events and brought shows
31	All telemetry shall be displayed in engineering units (meters, meters/sec,Celsius, etc.)	Comply	100	
32	Teams shall plot each telemetry data field in real time during flight. In addition, the ground system shall display a two dimensional map of estimated glider position based on speed and heading telemetry data.	Comply	100	Even under ultra sunlight, human eye can observe our GUI graphs change
33	The ground station shall include one laptop computer with a minimum of two hours of battery operation, XBee radio and a hand held antenna.	Comply	95, 96	
34	The ground station must be portable so the team can be positioned at the ground station operation site along the flight line. AC power will not be available at the ground station operation site.	Comply	95, 96	Lenovo Yoga laptop tripod antenna is whole thing
35	Both the container and glider shall be labeled with team contact information including email address.	Comply	109	It will be done

Requirements Compliance (5 of 6)

Rqmt Num	Requirement	Comply No Comply Partial	X-Ref Slide(s) Demonstrating Compliance	Team Comments or Notes
36	The flight software shall maintain a count of packets transmitted, which shall increment with each packet transmission throughout the mission. The value shall be maintained through processor resets.	Comply	70	The value shall be written to EEPROM and retrieved from there in case of reset
37	No lasers allowed.	Comply		We don't need laser
38	The glider must include an easily accessible power switch which does not require removal from the container for access. Access hole or panel in the container is allowed.	Comply	Payload trade selection	
39	The container shall contain electronics and mechanisms to release the glider at the required altitude.	Comply	56, 90	Shift-rod
40	The container electronics shall be powered by only alkaline batteries.	Comply	81	Glider and container power sources are ecofriend
41	The glide duration shall be as close to 2 minutes as possible.	Partial	41	Tests need to be done
42	The CanSat container shall have a payload release override command to force the release of the payload in case the autonomous release fails.	Comply	100	
43	Glider shall be a fixed wing glider. No parachutes, no parasails, no parafoils, no auto-gyro, no propellers. Hang glider design where the electronics section has a hard attachment point is allowed.	Comply	15, 37	Our spectacular delta wing glider
44	The glider shall use a time keeping device to maintain mission time. The time keeping device can use a small coin cell battery.	Comply	64	RTC has it

Rqmt Num	Requirement	Comply No Comply Partial	X-Ref Slide(s) Demonstrating Compliance	Team Comments or Notes
45	The time keeping device battery shall be a coin cell battery with a capacity limit of 240 mAh and with no more than a 1 ma discharge rate.	Comply	64	
46	The container shall transmit telemetry from the time being turned on and placed on the launch pad until 2 seconds after releasing the glider.	Comply	90	
47	The container telemetry shall be tramsmitted once per second.	Comply	90	
48	The container telemetry shall include team number, indication of container telemetry, altitude, temperature and software state.	Comply	71	
49	An audio beacon for the glider shall be included and powered off of the solar power.	Partial	82, 89	No sure how glider will land
50	An audio beacon is required for the container.	Comply	84, 90	

Management

Selim Öztürk
İlkin Aliyev

Status of Procurements

- **All sensors and electrical componenets are ordered. Just a few of electrical componenets are not received**
  - Camera is expected to be reeived middle of the april.
  - GCS antenna is expected to be received 10.April.
- **Mechanical materials are received. Some materials such as rip stop nylon, springs and screws are not ordered because they will be bought from local hardware stores.**

CanSat Budget – Hardware

Electrical Costs			
Descriptiona	**Quantity**	**Price[$]**	**Status**
Arduino Pro Mini (C&P)	2	5.15	Actual
XBee s2c (P)	2	38	Actual
XBee Pro s2c (C)	1	25	Actual
BMP280 – pressure sensor for pitot tube (P)	2	6	Actual
BMP280 – (pressure+ compass) (C&P)	1	32.07	Actual
Servo Motor (C)	1	3.28	Actual
RTC DS1338 (C&P)	1	2.85	Actual
LS-Y201 Camera mod. (P)	1	45	Actual
5.5V Solar panel(P)	1	7.95	Actual
Buzzer (C&P)	2	1.18	Actual
9V Battery (C)	1	4	Actual
SD card socket (C&P)	1	2.25	Actual
SD card (C&P)	1	6.50	Actual
Supercapacitor (P)	-	20	Estimated
Subtotal		**277.25**	Estimated

Mechanical Costs			
Description	**Quantity**	**Price[$]**	**Status**
Ripstop nylon (C&P)	4 merer	62.45	Actual
Rubber band (P)	N/A	8.16	Actual
Swivel (C)	1	12.05	Actual
ABS filament (P)	0.5 Kg	17.33	Actual
Screw, nuts etc. (C&P)	N/A	20	Estimated
Rocket Payload Section	1	25	Estimated
Spring (P)	1	4.15	Estimated
Neodymium magnets(P)	1	2.14	Actual
Other parts (C&P)	1	50	Estimated
Subtotal		**202.68**	Estimated

- No component is reused from previous years.
- C - Container
- P - Payload

Total CanSat Budget: 481.93

CanSat Budget – Other Costs

Ground Control System Costs			
Description	**Quantity**	**Price[$]**	**Status**
XBee Pro S2c	1	43	Actual
TP-LINK TL-ANT2414A panel antenna	1	75	Actual
Mounting hardware	N/A	25	Actual
Other Costs			
Self funded	N/A	500	Estimated
Visa	7 (person)	165	Actual
Travel	7 (person)	700	Estimated
Hotel	7 (days)	50	Estimated
Food	7(person)	250	Estimated
Car Rental	10 (days)	100	Estimated
	Subtotal	1438	

- Total funding from the university is 2000$. This funding includes components ordered, 3D & PCB printing and laboratory & test facilities.
- For travel and following costs, Turkish Airlines Technic is sponsored to the team. Total funding from the company is $10.000

Description	Cost[$]
CanSat Hardware	481.93
Ground Control System	143
Other Costs	9655
Total	10279.93

Program Schedule

ANNUAL CANSAT COMPETITION

Mission	Start	Finish	Comp
Start of CanSat	01.11.2016	01.11.20...	100
Competition Milestones	01.11.2016	11.06.20...	96
PDR	01.11.2016	01.02.20...	100
PDR Teleconference	24.02.2017	24.02.20...	100
CDR	02.02.2017	29.03.20...	100
CDR Teleconference	10.04.2017	10.04.20...	0
The Preflight Briefing	09.06.2017	09.06.20...	0
Launch	10.06.2017	10.06.20...	0
PFR	10.06.2017	11.06.20...	0
Academic Milestones and Holidays	07.11.2016	09.06.20...	79
1st Midterm Fall Semester	07.11.2016	11.11.20...	100
2nd Midterm Fall Semester	05.12.2016	09.12.20...	100
Final Exam Fall Semester	02.01.2017	14.01.20...	100
Semester Holiday	15.01.2017	19.02.20...	100
1st Midterm Spring Semester	10.04.2017	14.04.20...	0
2sd Midterm Spring Semester	08.05.2017	12.05.20...	0
Final Exam Spring Semester	05.06.2017	09.06.20...	0
Software Team Schehude	01.11.2016	25.05.20...	66
Reviewing Mission Guide	01.11.2016	10.11.20...	100
Design of FSW Algorithm	11.11.2016	26.11.20...	100
Design of GCS	28.11.2016	21.01.20...	80
XBEE Configuration Settings	31.12.2016	25.01.20...	100
Testing Communication XBEE	14.01.2017	13.02.20...	100
Reading Data from Sensors	24.01.2017	16.02.20...	100
Design of FSW	06.02.2017	10.04.20...	60
Improve FSW	29.03.2017	25.05.20...	0
Electrical Team Schedule	01.11.2016	10.04.20...	82
Reviewing Mission Guide	01.11.2016	10.11.20...	100
Reviewing Electronic Structure	11.11.2016	20.11.20...	100
Select of Sensors	19.11.2016	28.11.20...	100
Select of Solar Cell	19.11.2016	02.12.20...	100
Design of Pcb	06.12.2016	15.01.20...	100
Design Electrical System	05.01.2017	02.03.20...	100
Design Electronic System	16.01.2017	05.03.20...	100
Testing Electrical System	20.02.2017	03.04.20...	60
Testing Electronic System	28.02.2017	10.04.20...	50
Testing Pcb	29.03.2017	10.04.20...	0
Mechanical Team Schedule	01.11.2016	25.05.20...	66
Reviewing Mission Guide	01.11.2016	10.11.20...	100
Reviewing Mechanic structures of Syst...	11.11.2016	01.12.20...	100
Research Plane Construction Materials	25.11.2016	14.12.20...	100
Research Plane Construction Tools	27.11.2016	18.12.20...	100
Design Mechanic System	19.12.2016	07.01.20...	100
Testing Mechanic System	02.02.2017	29.03.20...	80
Improve Mechanic System	29.03.2017	25.05.20...	0

Shipping and Transportation

- Turkish Airlines was chosen for transporting to Texas (Houston).
- The team will rent a car for 10 days transportation in Texas

- CanSat will be transported in safe containers in the luggage of team members since it is not allowed to transport it in carry on from istanbul.
- The antenna mast (Tripod, telescopic tube and mounting hardware) will be transported in a compact bag.

- The CanSat componenets will be packed with bubble Wrap to prevent any damage during travel.
- Airline operator also will be contacted for getting opinion about how to transport the device in safest way

- The CanSat tools will be transported with luggage.

Conclusions

Major Accomplishments

- A practical engineering based approach was applied to achieve the goal.
- The final design was analyzed in ANSYS software to explore flight characteristic of glider.
- Energy harvesting and power management strategy were designed.
- All components were received except GCS antenna and rip stop nylon.

Major Unfinished Work

- Energy harvesting must be tested with integrated system.
- FSW is under development and exected to be finished by end of april.
- Sruvivability and glider gunctionality tests must be conducted
- More tests with quadcopter must be conducted continuously, over and over again to verify system integrity

The *IQRASAT* model satellite is designed for victory. This is achieved through development of robust system capable of flying all phases of mission. The team is ready for the next phase. We have strong belief that we will gain the title of the competition as representative of Turkel.

Thank You