ISTANBUL TECNICAL UNIVERSITY

CANSAT 2011

TEAM HEZARFEN

258

PRELIMINARY DESIGN REPORT

FEB 2, 2011

Presentation Outline

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TEAM HEZARFEN

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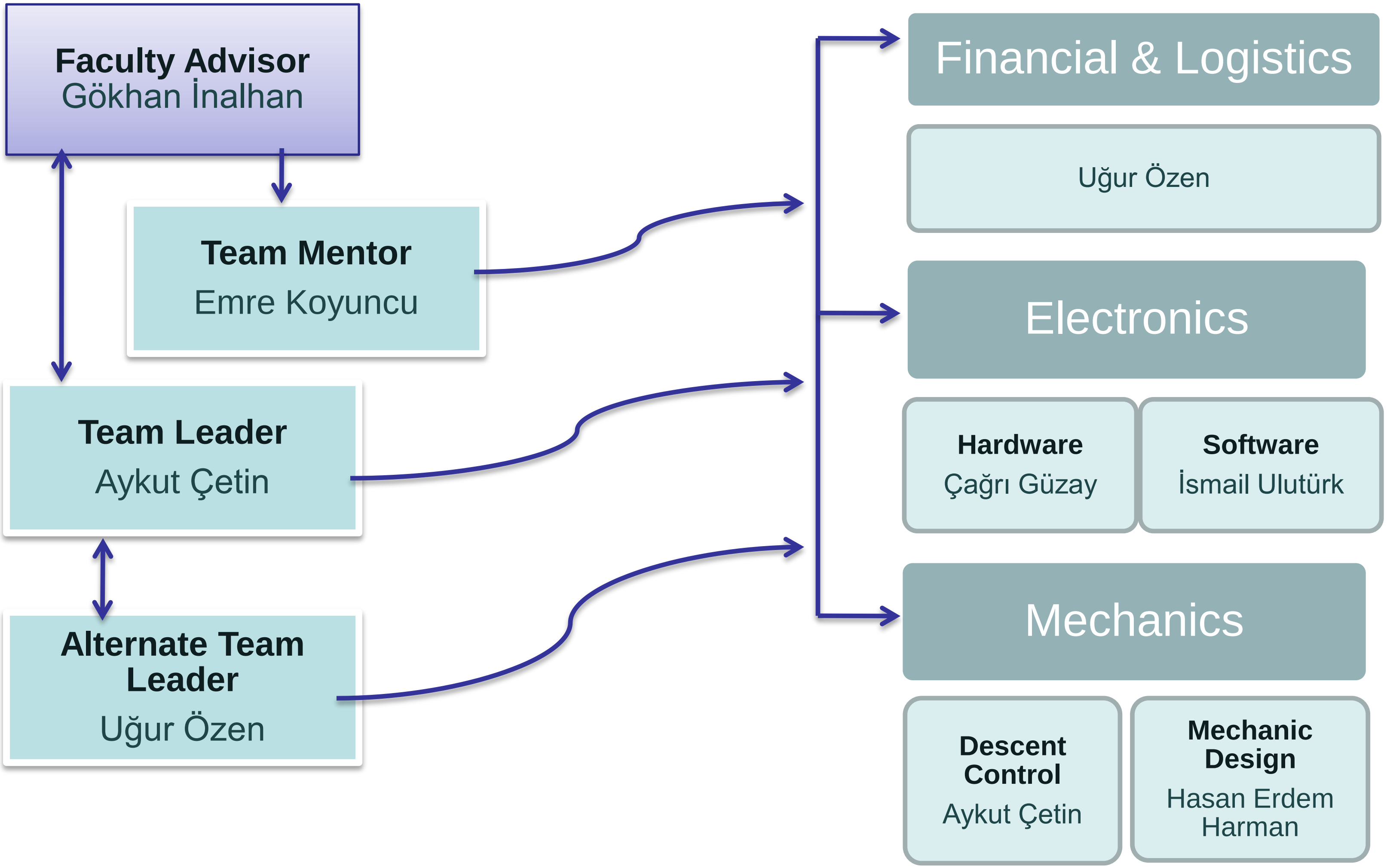
Team Organization



Acronyms

A	→ Analysis
ACL	→ Acceleration
ADC	→ Analog digital converter
ALT	→ Altitude
API	→ Application programming interface
CAM	→ Camera
CDH	→ Communication and Data Handling
D	→ Demonstration
DCS	→ Descent Control System Requirements
EEPROM	→ Electrically Erasable Programmable Read-Only Memory
EPS	→ Electric Power System
FSW	→ Flight Software
GPS	→ Global Positioning System
I	→Inspection
MSR	→ Mechanical System Requirements
RF	→ Radio Frequency
SEN	→ Sensor Subsystem Requirement
SPI	→ Serial Peripheral Interface
SR	→ System Requirements
T	→ Test
TTL	→ Transistor - Transistor Logic
TEM	→ Temperature
UART	→Universal synchronous asynchronous receiver/transmitter
VM	→ Verification Method

Systems Overview

Uğur Özen

Mission Summary

The Main Obective:

→The main purpose of Cansat is that provide egg safety from launch to landing

Other Objectives:

→Launch Cansat

→Separate Cansat two parts; lander and carrier

→Control descent of lander speed of 3-5m/s

→Control descent of carrier speed of 4,5-6,5m/s

→Collect data using sensors to send ground station

Bonus Objectives:

→Take a nadir position picture

→Calculate lander collision force

System Requirements

ID	Reqirements	Rationale	Priority	Parent	Children	VM			
						A	I	T	D
SR-01	Total mass of cansat shall not be more than 500gr. (exculuding egg)	competition requirement	High		MSR-01		X	X	
SR-02	The cansat shall fit inside the cylindirical of 72mm diameters 279mm in length.	competition requirement	High		MSR-02		X		
SR-03	Cansat egg placed inside shpuld be recovered safely	competition requirement	High		MSR-03			X	X
SR-04	The cansat shall deploy from the launch vehicle payload section and no protrusions	To be easy leaving from rocket	High		MSR-04			X	
SR-05	The descent control system shall not use any flommable or pyrotechnic devices	competition requirement	High				X		
SR-06	The average descent rate of cansat carrier after deployment of the lander shall be 4m/s	competition requirement	High		DCS-01	X		X	X
SR-07	The average descent rate of cansat lander after deployment of the lander shall be 5,5m/s	competition requirement	High		DCS-02	X		X	X
SR-08	The lander and the carrier need to be seperated at 500 meters altitude and the paracute need to be opened when it reaced	competition requirement	High		DCS-03	X		X	X

System Requirements

ID	Requirements	Rationale	Priority	Parent	Children	VM			
						A	I	T	D
SR-09	The cansat communication radio shall be the Laird AC4790-200	competition requirement	High		CDH-08 FS-01			X	X
SR-10	The cansat communications shall use the api packet format	competition requirement	High		CDH-08			X	
SR-11	The cansat shall autonomously terminate telemetry transmissions within 5 minutes of landing. This shall be verified via ground control station activities	competition requirement	High		CDH-09			X	X
SR-12	All telemetry shall be displayed in real –time during launch and descent in engineering unit.	competition requirement	High		GCS-05 GCS-06 GCS-07			X	
SR-13	During descent the carrier shall transmit following telemetry data once every two second.	competition requirement	High		CDH-01 FSW-04			X	
SR-14	Lander descent telemetry shall be stored on –board for post processing following retrieval of the lander.	competition requirement	High		CDH-03 FSW-05			X	
SR-15	The cost of cansat flight hardware shall be under 1000$ (ground tools are excluded)	competition requirement	Medium				X		
SR-16	The cansat and asociated operations shall comply with all field safety regulations.	competition requirement	Medium				X		

Concepts of Operations

Pre-Launch

1. Preflight briefing
2. Last Mechanic Controls
3. Last Electronics Control
4. Coming Competition Area

Launch Cansat

1. Preflight Operations
2. Launch Flight
3. Open Umbrella on Cansat
4. Sending and Collectng Data
5. Locate Cansat

Post-Launch

1. Saving Data
2. Analyzing Data
3. Prepare PFR
4. Presentation PFR

Concepts of Operations

Details of Launch Cansat

First step

On cansat → Put cansat into rocket → Launch rocket → Leaving cansat from rocket

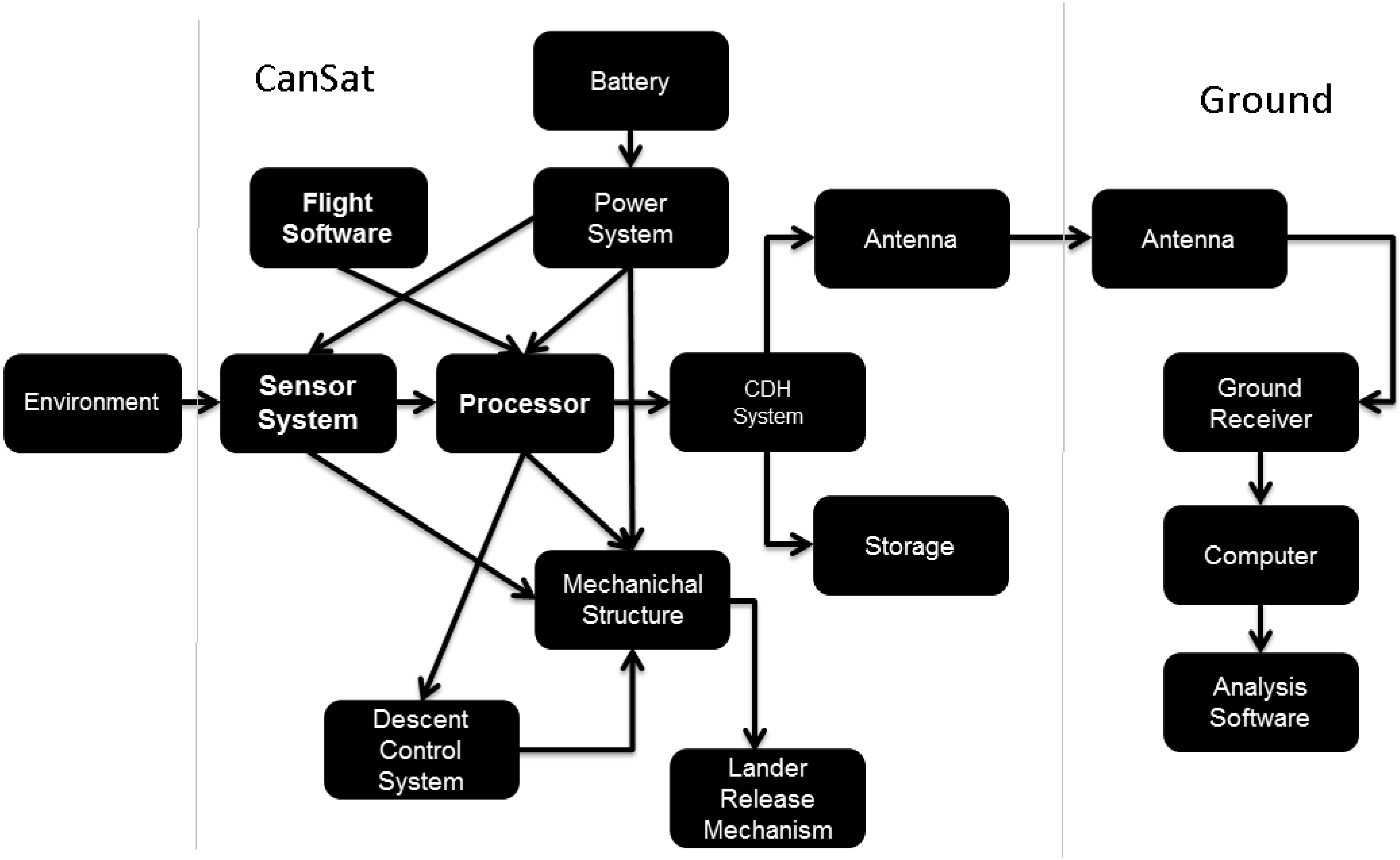
Second step

Measuring height of cansat → Seperate cansat on 500meters → Control of descent speed → Collecting data by ground station

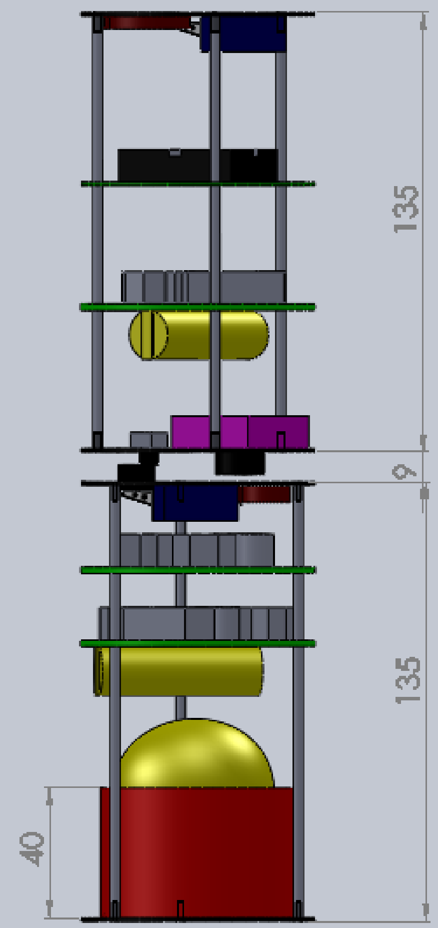
Third step

Calculate collusion force → Locate Cansat → Off cansat

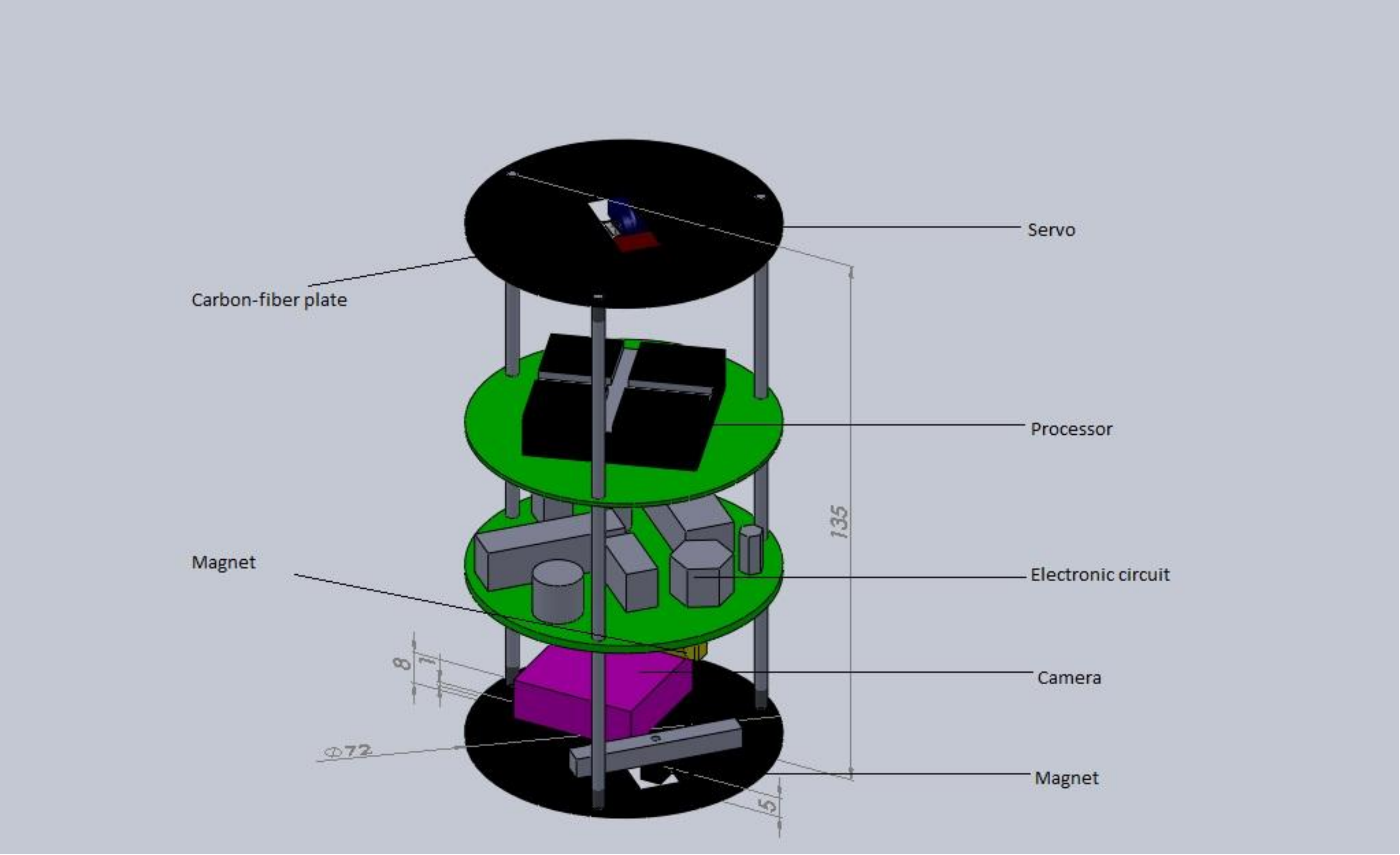
Context Diagram of Cansat



Phsical Layout

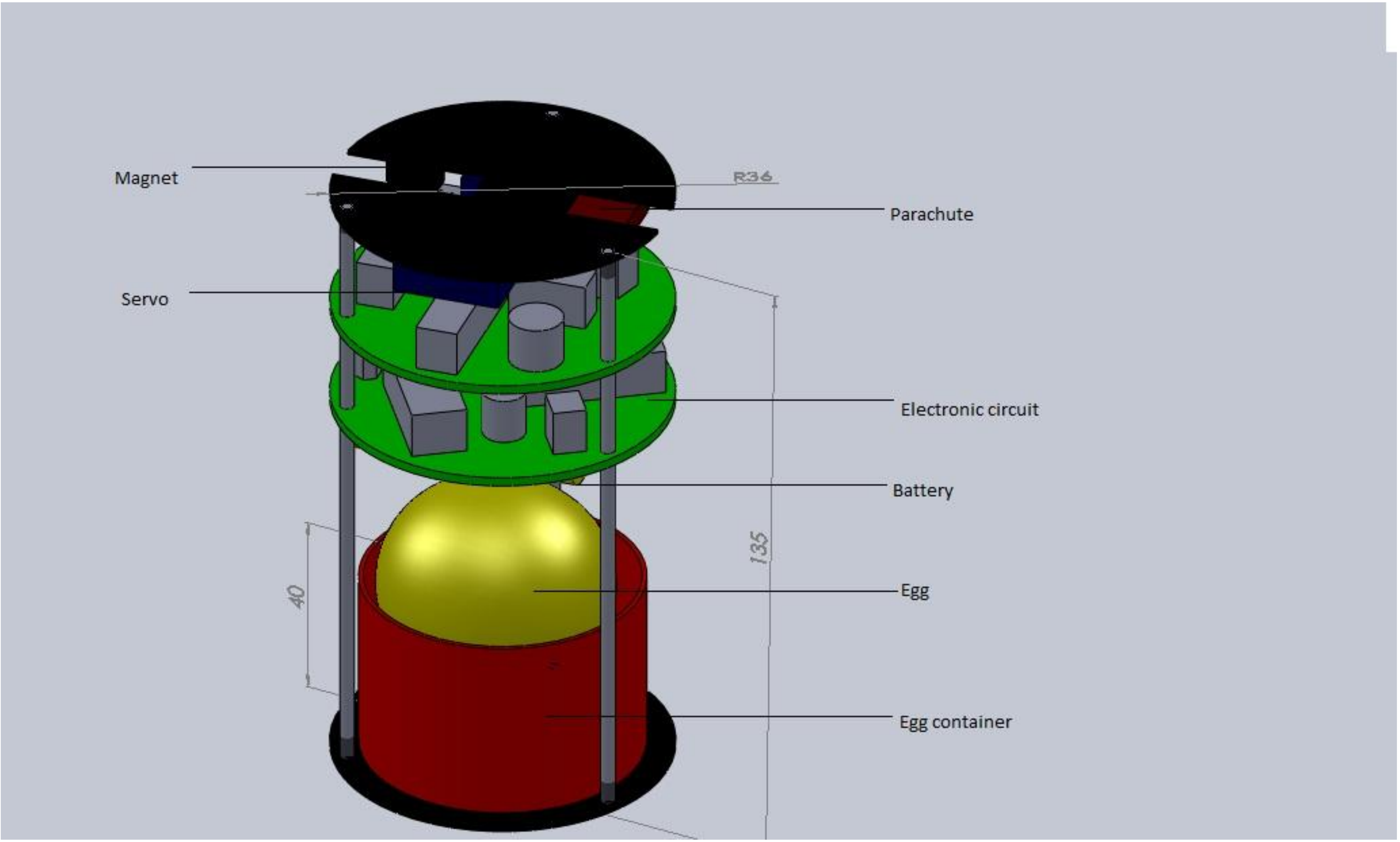


Carrier



Servo
Carbon-fiber plate
Processor
135
Magnet
Electronic circuit
8
1
Camera
Φ72
Magnet
5

Lander


Magnet
Servo
R36
Parachute
Electronic circuit
Battery
135
40
Egg
Egg container

Sensor Subsystem Design

Çağrı Güzay

Sensor Subsystem Overview

Subsystem	Parent System	Selected Component	Description
GPS	Carrier	20 Channel LS20126 GPS Receiver	UTC time, position, other tacking data
ACL	Carrier	20 Channel LS20126 GPS Receiver	Measuring 3-axial acceleration
ACL	Lander	Freescale – MMA7260Q	Measuring 3-axial acceleration
ALT	Lander	Barometric Pressure Sensor - BMP085	For altitude calculation
ALT	Carrier	MEMs Barometric Pressure Sensor - SCP1000	For altitude calculation
TEM	Carrier	MEMs Barometric Pressure Sensor - SCP1000	Air temperature measurement
CAM	Carrier	LinkSprite JPEG Color Camera TTL Interface	Obtain an image from nadir direction including Lander

Sensor Subsystem Requirements

ID	Requirement	Rationale	Priority	Parent	Children	VM			
						A	I	T	D
SEN-01	Operating voltage range for all sensor must be between 3.3V and 6V (Carrier & Lander)	Battery and regulator are selected by these values.	High	EPS-03		X	X		
SEN-02	More than two of Carrier’s sensors should not have UART data interface.	Microcontroller has only 3 UART interfaces. One of them is used for AC4790.	High	CDH-10		X			
SEN-03	More than two of Carrier’s sensors should not have SPI.	Microcontroller has limited SPI.	High	CDH-10		X			
SEN-04	One of the Lander sensors must have ADC data interface.	Microcontroller has limited SPI (Lander).	High	CDH-11		X			
SEN-05	Other sensors of the Lander should have SPI.	Microcontroller has another interface as SPI (Lander).	High	CDH-11		X			
SEN-06	Temperature sensor must have a range of at least 0ºC-50ºC (Carrier).	Air conditins of launch location.	Medium			X		X	

Sensor Subsystem Requirements

ID	Requirement	Rationale	Priority	Parent	Children	VM			
						A	I	T	D
SEN-07	Temperature sensor should have high resoluiton (Carrier)	The higher resolution, the more accurate measurement	Medium			X			
SEN-08	Non-GPS altitude measurement sensor (pressure sensor) should have wide range (Carrier)	Pressure measurement is done altitudes between 0m and 1000m.	High					X	
SEN-09	Non-GPS altitude measurement sensor (pressure sensor) should have high resoultion (Carrier)	The higher resolution, the more accurate measurement	High			X			
SEN-10	Accuracy and measurement range of the GPS should be at high level (Carrier)	To obtain the closest position	Medium				X	X	
SEN-11	Resolution of the camera must have at least VGA resolution (Carrier)	To be seen clearly of Lander from taken picture	Medium			X			

Sensor Subsystem Requirements

ID	Requirement	Rationale	Priority	Parent	Children	VM			
						A	I	T	D
SEN-12	Pressure sensor of the Lander should have high resolution and range	To obtain more accurate measurements	High			X			
SEN-13	Acceleration sensor of the Lander should have high resolution and range	To obtain more accurate measurements	High			X			

Carrier GPS Trade & Selection

Module	Physical Characteristics		Electrical Characteristics				Cost
	Dimensions	Weight	Nominal operating	Accuracy	Update Rate	Data Interface	
Locosys - LS20126 GPS Receiver	29x12 mm	10 gr	31mA @ 3.3V	<5 meters	1 Hz	UART	$59.95
Micro Modular - MN5010HS	40x15 mm	-	3.25-5.5V , 26.5mA	<2.5 meters	1 Hz	3.3VDC TTL serial interface	$89.95

Final selection: Locosys - LS20126 GPS Receiver

Reasons:

•Lower cost

•Lower size

•Integrated acceleration sensor

Carrier Non-GPS Altitude Sensor Trade & Selection

Module	Physical Characteristics		Electrical Characteristics				Cost
	Dimensions	Weight	Nominal operating	Resolution	Range	Data Interface	
Freescale – MPL115A1	19x12 mm	-	2.4-5.5V	1kPa	50-115 kPa	SPI	$24.95
VTI Tech. – SCP1000	20x19 mm	-	2.4-3.3V	2Pa	30-120 kPa	SPI	$34.95

Final selection: VTI Technologies- SCP1000 Barometric Pressure Sensor
Reasons:
•Higher resolution
•Higher range
•Integrated temperature sensor

Carrier Air Temperature Trade & Selection

Module	Physical Characteristics		Electrical Characteristics				Cost
	Dimensions	Weight	Nominal operating	Resolution	Range	Data Interface	
DS18B20	-	-	3.0-5.5V	9 to 12 bits	-55 to 125 ºC	SPI	$4.25
VTI Tech. – SCP1000	20x19 mm	-	2.4-3.3V	14 bits	-20 to 70 ºC	SPI	$34.95
LM335A	-	-	5.0V	10mV/ºK analog data	-40 to 100 ºC	ADC	$1.50

Final selection: VTI Technologies- SCP1000 Sensor
Reasons:
- Higher resolution
- Integrated pressure sensor

Lander Pressure Sensor Trade & Selection

Module	Physical Characteristics		Electrical Characteristics				Cost
	Dimensions	Weight	Nominal operating	Accuracy	Range	Data Interface	
Freescale – MPL115A1	19x12 mm	-	2.4-5.5V	1kPa	50-115 kPa	SPI	$24.95
VTI Tech. – SCP1000	20x19 mm	-	2.4-3.3V	2Pa	30-120 kPa	SPI	$34.95
Bosch – BMP085	16x16 mm	-	1.8-3.6V	3Pa	30-110 kPa	I^2C	$19.95

Final selection: Bosch – BMP085 Pressure Sensor

Reasons:

•Lower cost

•High accuracy

•Temperature sensor is not needed for Lander.SCP1000 has both pressure sensor and temperature sensor, having higher cost. So it is elected for this reason. Remaining choice is BMP085.

Lander Impact Force Sensor Trade & Selection

Module	Physical Characteristics		Electrical Characteristics				Cost
	Dimensions	Weight	Nominal operating	Sensitivity	Range	Data Interface	
Freescale – MMA7260Q	25x25 mm	-	3.3V	800mV/g	±6g	ADC	$19.95
Analog Devices – ADXL345	14x25 mm	-	2.0-3.6V	360mV/g	±16g	SPI and I^2C	$27.95
Analog Devices – ADXL335	18x18 mm	-	1.8-3.6V	330mv/g	±3g	SPI and I^2C	$24.95

Final selection: Freescale – MMA7260Q

Reasons:

- Lower cost
- Output is analog. Microcontroller card of the Lander has only one SPI port. It is planned that this port will be used to process SD-card. Thus, accelerometer can use ADC port of the microcontroller.

Carrier Camera Trade & Selection

Module	Physical Characteristics		Electrical Characteristics				Cost
	Dimensions	Weight	Nominal operating	Resolution	Set-up	Data Interface	
LinkSprite JPEG Color Camera	32x32 mm	-	3.3-5.0V 80-100mA	VGA/QVGA/ 160x120	Plug & play	TTL	$49.95
Toshiba – TCM8240	24x22 mm	-	2.8V	1300x1040	Not plug & play	SPI	$31.95

Final selection: LinkSprite JPEG Color Camera
Reasons:
•Ease of use, plug & play design
•Data interface is TTL

Descent Control Design

AYKUT ÇETİN

Descent Control Overview

The descent system includes a parachute to keep the descent velocity as constant.

The system also includes 3 micro servos (9gr.)

One servo is to seperate the lander and carrier. (number 1)

Two are to open the lander's (number2) and carrier's (number 3) parachute.

When the cansat falls and reaches at 500 meters altitute, number one servo will separate lander and carrier. Then number 2 servo will open the lander's and number 3 servo will open carrier's parachute. So that the the controlled descent starts with them and continues to the ground .

We chose the parachute:

- Low weight
- No need to motor control system
- Minimum energy (to open the servo 50 mAh energy needed and motor control system needs about 1500 mAh energy. So that low battery weight)
- Parachute system weight is about 50 gr, motor system is weight 250 gr.

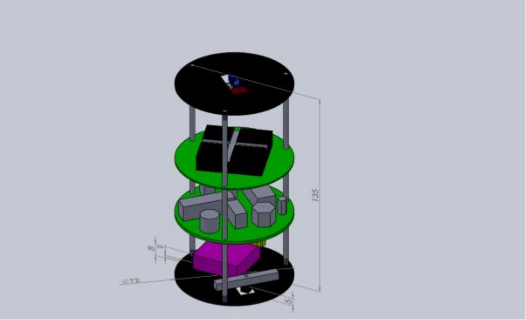
Descent Control Requirements

ID	REQUIREMENT	Rationale	Priority	Parent	A	I	T	D
DCS-01	PARACHUTE(The descent should be at a constant velocity which is 4 m/s for carrier	To make a system which has a constant descent rate	High	SR-06	×		×	×
DCS-02	PARACHUTE(The descent should be at a constant velocity which is and 5.5 m/s for lander.	To make a system which has a constant descent rate and to protect the egg from the crash	High	SR-07	×		×	×
DCS-03	MICROSERVOS (the lander and carrier need to be separated at 500m altitude and the parachutes need to be opened when reaced to 500 meters	To create a basic and a useful system using microservos and magnet.	High	SR-08	×		×	×

Volume calculations: for each servo 5,56 cm^3
for each parachute 12,5 cm^3 closed and 16746 cm^3 open condition
Mass: 30 gr for each parachute
6,3 gr for each servo
Carrier total mass of requirement:36,3 gr
Lander total mass of requirements: 42,4 gr
4 m/s descent rate for carrier
5.5 m/s descent rate for lander

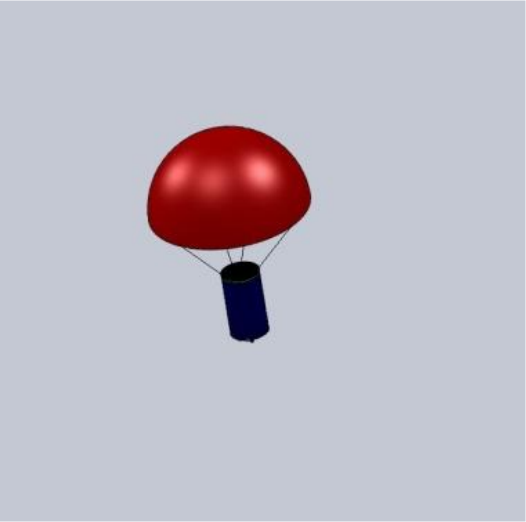
Carrier Descent Control Strategy Selection and Trade

The cansat will be separeted from rocket at about 1000 meters. The because of the gravity it will have a free fall to 500 metres.



When it reaches at 500 m, servo number 1 will separate the lander and carrier. After seperation number 2 servo will open the parachute. The reasons why we chose the parachute instead of motor control system are:

1. **Low weigth**
2. **Low volume**
3. **Low energy**
4. **No need to motor control system.**
5. **Basic and a useful system causes easy fly**

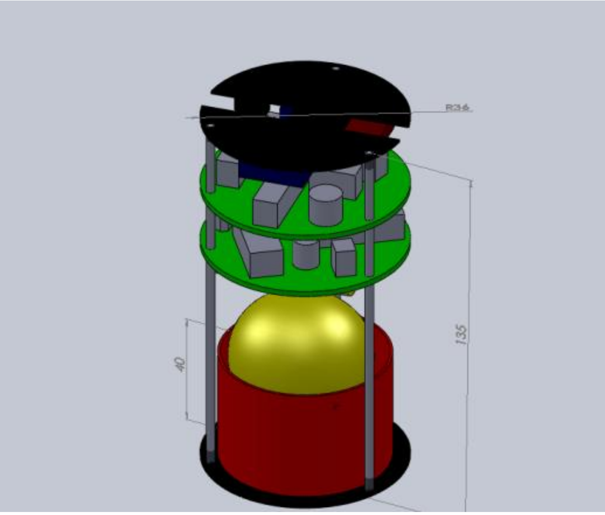


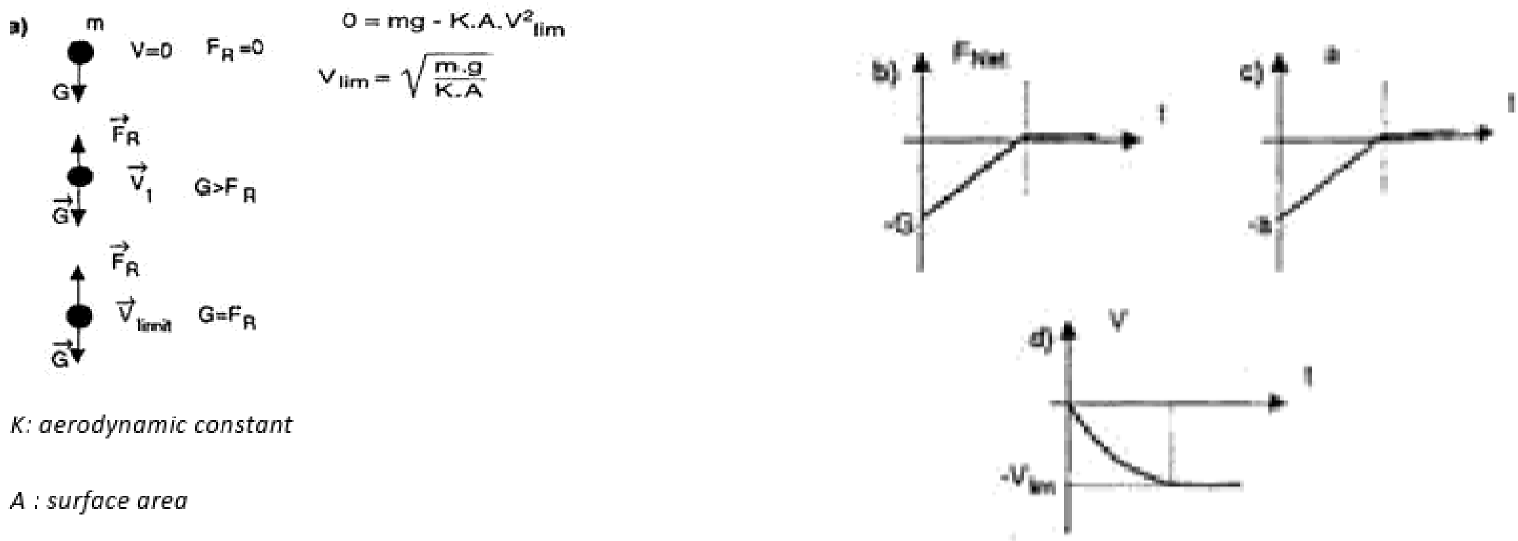
Lander Descent Control Strategy Selection and Trade

At 500 meters number 3 servo will open the parachute of lander.

The reasons why we chose the parachute instead of motor control system are:

1. **Low weigth**
2. **Low volume**
3. **Low energy**
4. **No need to motor control system.**
5. **Basic and a useful system causes easy fly**





Şekil 5-4

K: aerodynamic constant

A : surface area

V : relative velocity

$g=9.81m/s^2$

$0=m.g-K.A.V^2$

Parts of parachutes

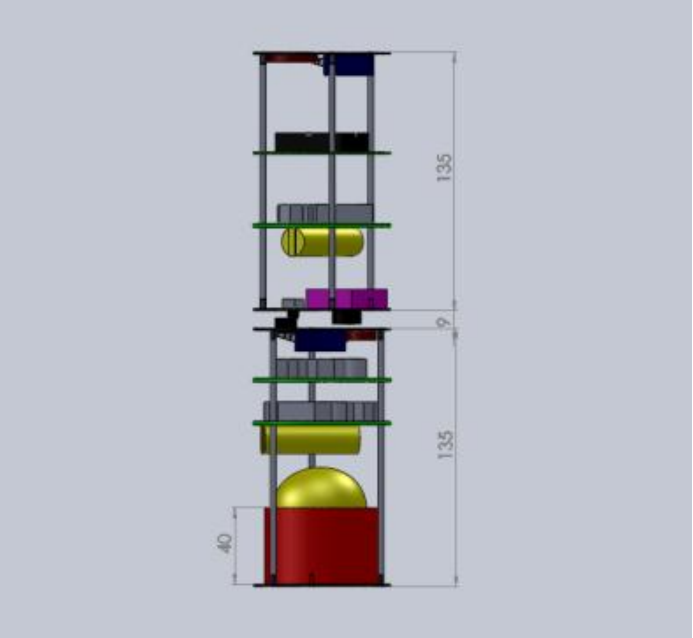
1. opening system mechanism
   - a)Otonom
   - b)Manuel
2. canopy
3. Harnes

Mechanical Subsystem Design

HASAN ERDEM HARMAN

Mechanical Subsystem Overview

MAJOR STRUCTURE ELEMENTS



Lander

The structure

Silver steel (building the body)

Carbon fiber plates (building the body

Epoxy

Glue and pin bolt, silicon tube and special dough

Control card, battery, sensors, memory card into the lander, egg, egg protection system.

Carrier

The structure

Silver steel (building the body)

Carbon fiber plates (building the body

Epoxy

Glue and pin bolt, silicon tube

Camera, control card, sensors, memory card, communication module, battery, power circuit.

The cards which includes electronic elements which are connected to bars. Silicon tubes are used to hold them stable in their location. The tube has a friction between the bars . It keeps the cards hold their location.

The lander and carrier are connected to each other with an powerful magnets. One magnet is stable on the lander's bottom however the other magnet is connected to a servo. When it is time to separating, the connection will break with servo's power.

Material selection

<u>Silver steel:</u>

1. its yield strenght is high

2. cheap

3. easy to machinability

4. low density

<u>Carbon fiber and Epoksi</u>

1. high strength

2. high flexibility

3. hard to machinability for carbon fiber but asy to machinability for epoksi

4. very low weight

5. we already have in our laboratory

<u>Glue and pin bolt for assemble the parts</u>

<u>Silicon tube</u>

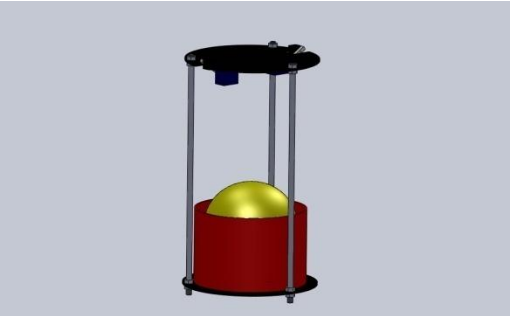
To fix the PCB to the body easily

Mechanical System Requirements

ID	REQUIREMENT	RATIONALE	PRIORITY	PARENTS	A	I	T	D
MSR-01	Total mass of the cansat will not be more than 500 gr excluding egg.	The rules says total mass should be under 500 gr.	High	SR-01		×	×	
MSR-02	Cansat will fit in a cylindrical diameter and 279 mm in length	The rules says the lenght of cansat should be 279mm	High	SR-02		×		
MSR-03	Cansat egg placed inside should be recovered safely	There will be no damage on the egg when the lander landed on the ground	High	SR-03			×	×
MSR-04	There will be no protrusions until cansat deployment from rocket payload	The rules says there will be no protrusions	High	SR-04			×	
MSR-05	Placement of gps antenna, transceiver antenna and camera module	The antenna and camera should be placed on a suitable place on the carrier	Medium				×	×

Egg Protection Trade & Selection

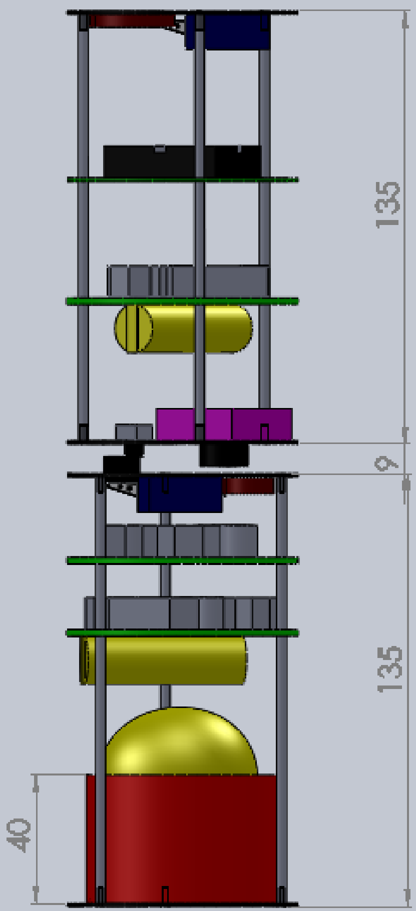
We think using a speacial organic dough for egg protection that it will damp the force while the lander crashing onto the earth. The dough damps the force using pnomatical systems on air bubbles. So that the egg is exposed low momentum forces.
The egg is generally breaks because of a very big force applies on a small area of the egg's surface and it causes sudden temperature changes.
The prepared dough provides explore the stress on the half of the egg's surface and explore the heat.

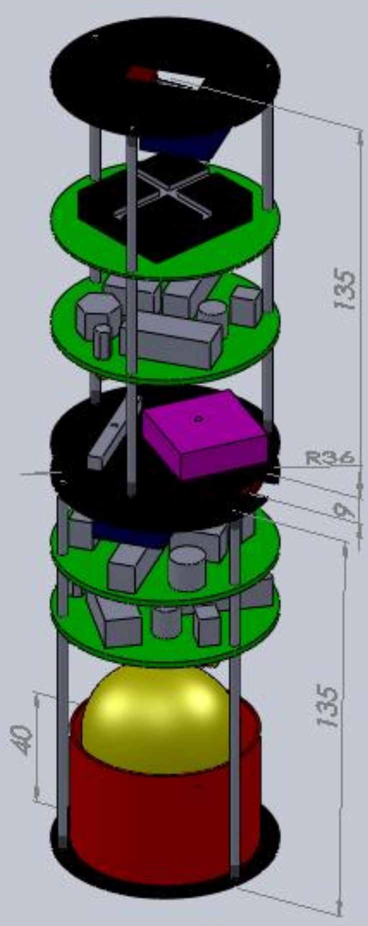


TRADE AND SELECTION

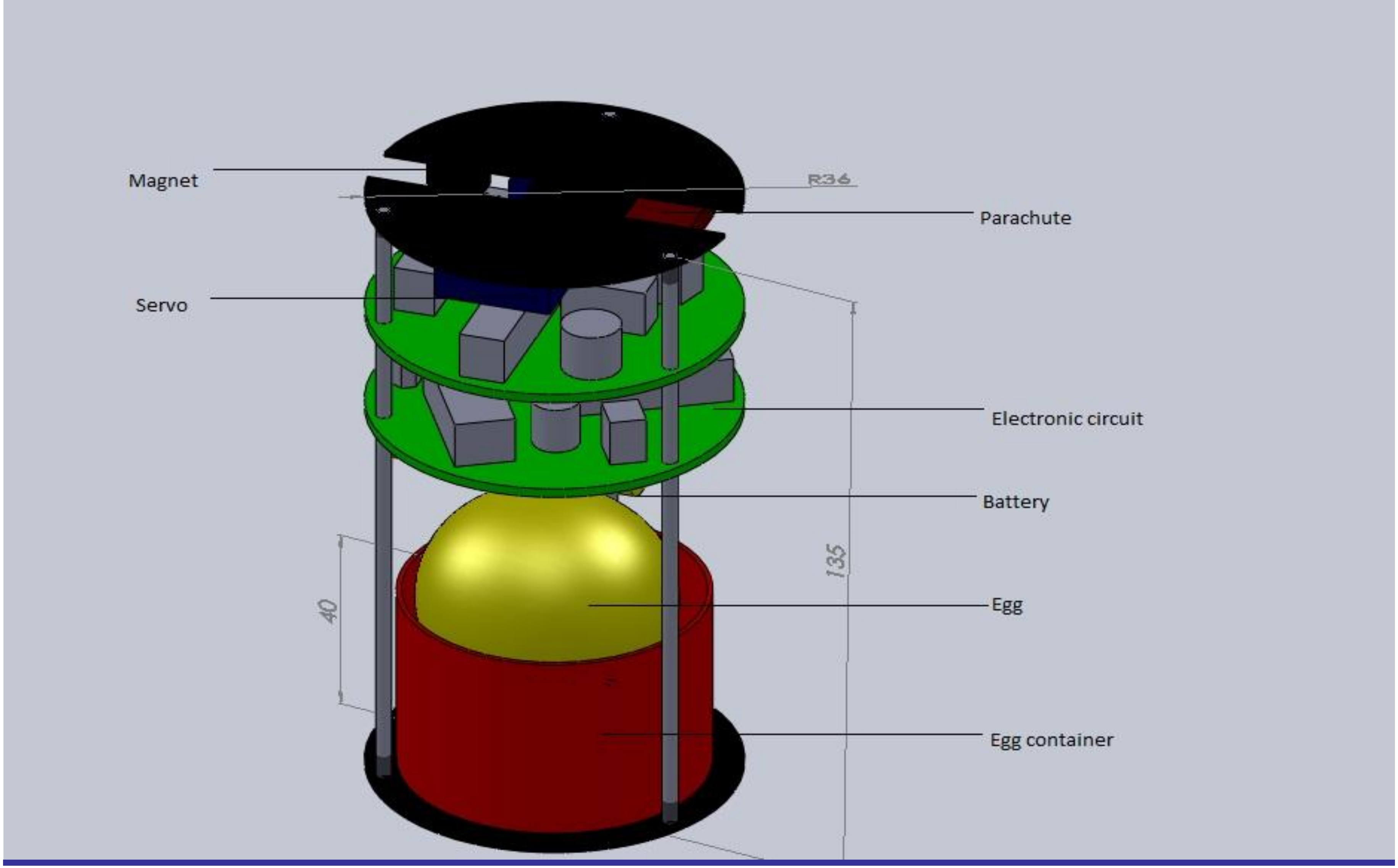
<u>The reasons using dough instead of spring</u>
Force cannot be explored on the half of the surface of the egg when using spring
The dough is cheaper from spring and if spring is chosen, the spring would have to assembled and more application for the assembly would needed.
<u>The reason using dough instead of sponge</u>
The coefficient of damping force of sponge is not enough to protect the egg from breaking.
If sponge is chosen we would use more volume to damp equivalent force

Mechanical Layout of Components Trade & Selection

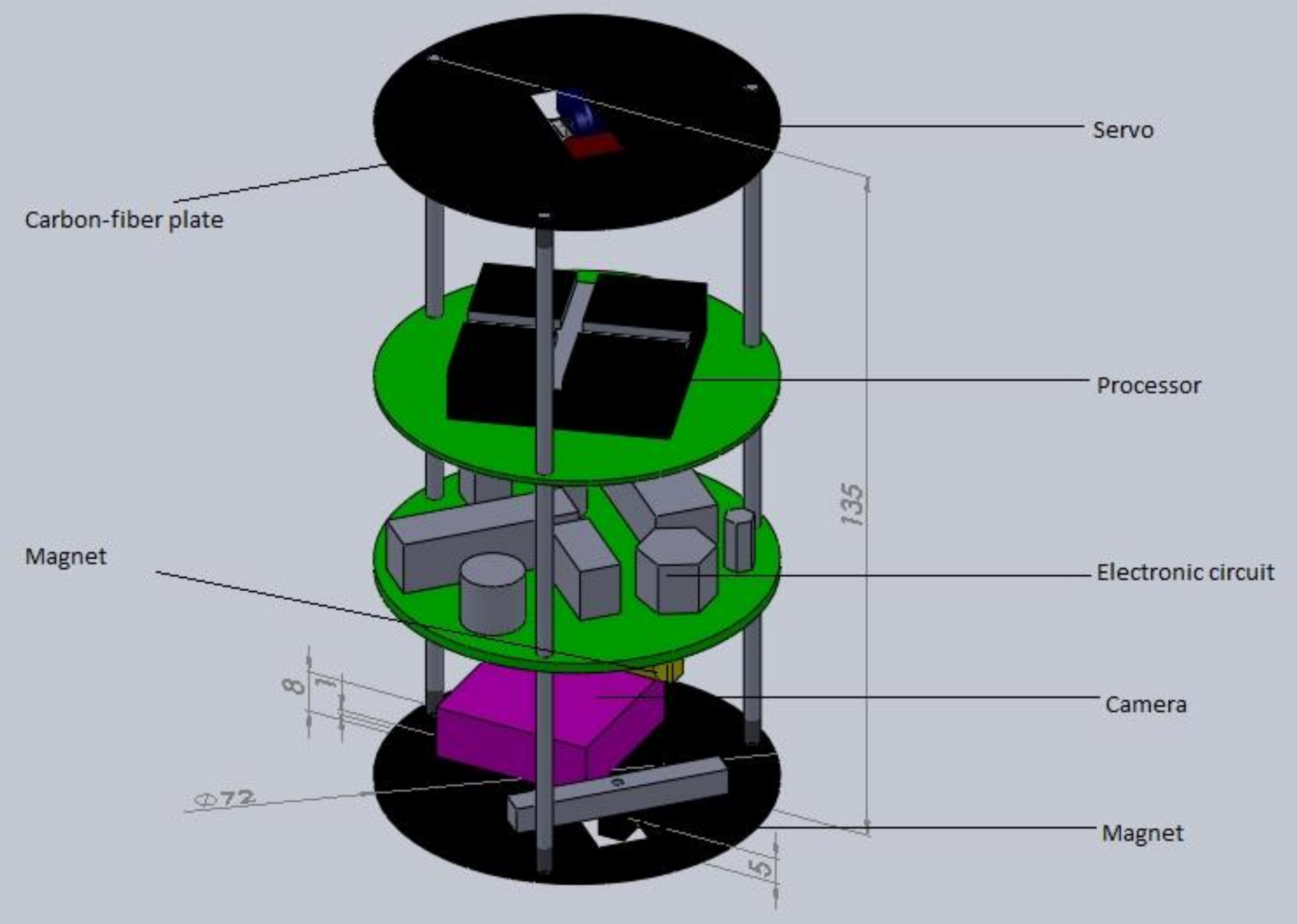




Lander layout of components

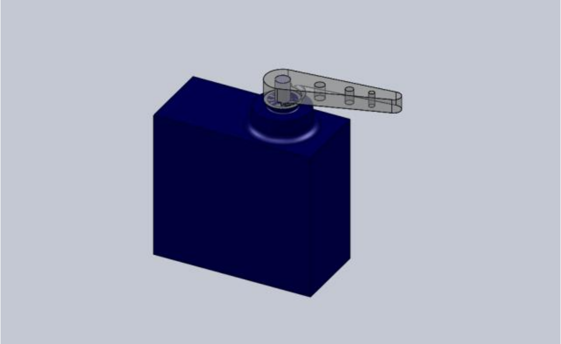


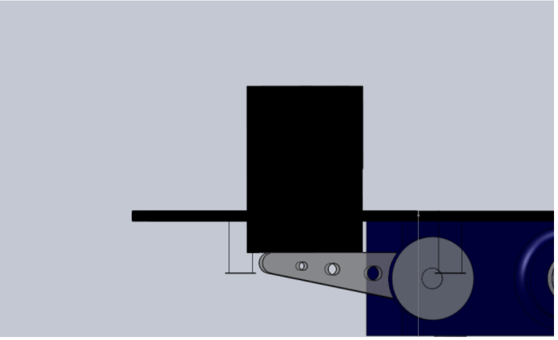
Carrier layout of components

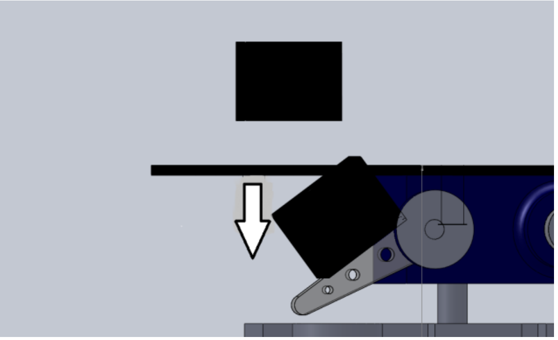


Carrier-Lander Interface

The lander and the carrier is connected from each part's bottom with magnets before separating. The magnets are controlled by servo number 1. When it is time to separating (at 500 meters from the ground) the servo 1 is pull of the magnets so that the connection of magnets is breaking down. The lander and the carrier is now separated from each other using a useful, light and a simple system.







The parachutes are located opposite site of the magnets. After sperating the parachutes will open so that, parachutes should be located top of the lander and carrier. This is provided by adjusting the center of gravity both in lander and carrier.

Mass of Components:

Carbon-fiber plate: 6,7 gr
M3 bold: 0,3 gr
Silver-Steel String: 8,1 gr
Silicon tube: 0,15 gr
Servo: 6,3 gr
Battery: 40 gr
Dough: 50 gr (changeable)
Magnet: 11,8gr
Egg: 60 gr
Egg container: 5 gr
Parachute: 30 gr
Total mass of prototype which has just
structural elements such as string, plates, bolts: 41,4 gr

Estimated total mass of lander : 200 gr
Estimated total mass of carrier : 150 gr

Allocated mass for egg payload: 80 gr

Communication and Data Handling Subsystem Design

İsmail Ulutürk

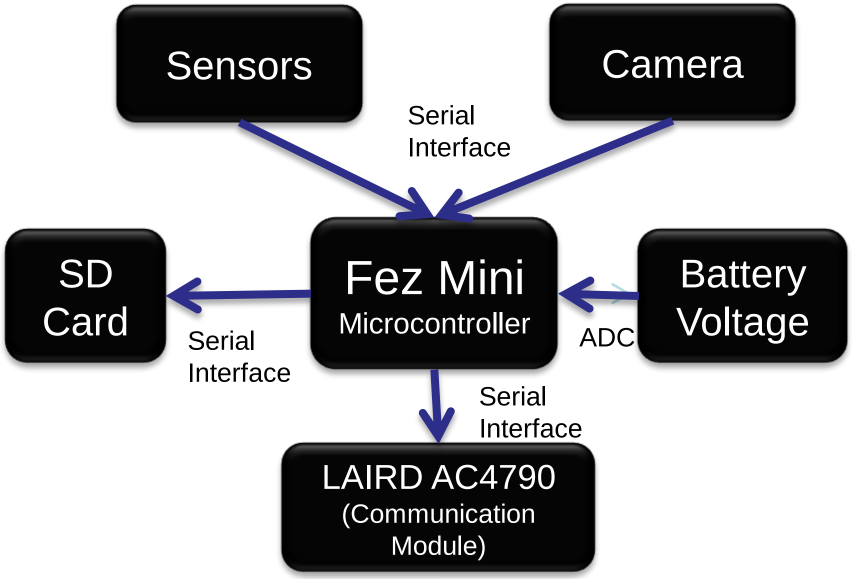
CDH Overview

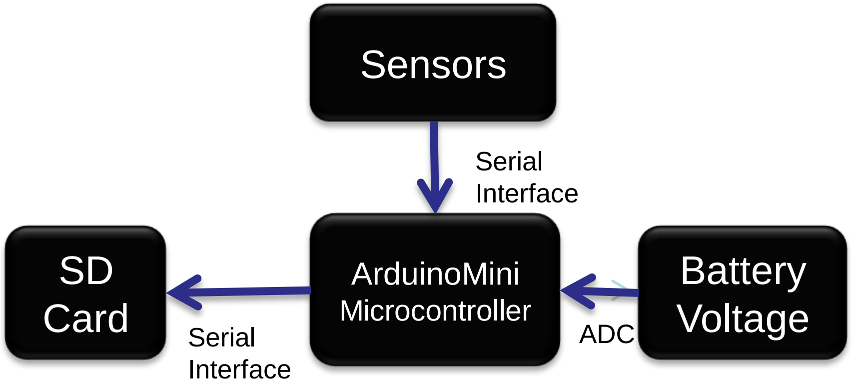
Carrier:

- A microcontroller will handle all comunication(Fez Mini).
- Data will be read from sensors via serial interface.
- Battery voltage will be measured via analog digital conversion.
- Read data will be packaged and sent to the ground using LAIRD AC4790 via serial interface.
- All data will also be stored to a SD-Card for back-up via a serial interface.

Lander:

- A microcontroller will handle all comunication(Arduino Mini).
- Data will be read from sensors via serial interface.
- Battery voltage will be measured via analog digital conversion.
- All data will also be stored to a SD-Card via a serial interface.





CDH Requirements

ID	Requirement	Rationale	Priority	Parents	Children	VM			
						A	I	T	D
CDH-01	Transmission of Telemetry Packets at 0.5Hz	Air to ground telemetry transmission is required by the competition	High	SR-13				X	X
CDH-02	Handling all sensor data	Sensor data should be converted to a format ready to transmit.	High					X	X
CDH-03	Storing lander sensor data on SD-CARD at 0.5Hz	Lander sensor data should be retreived later.	High	SR-14				X	X
CDH-04	Handling and storing of Image data	Captured Image should be stored for later retrival.	Medium					X	X
CDH-05	Capturing impact accelometer data	Required to calculate the impact force.	Medium				X	X	X
CDH-06	Data Back-up	Will be used in case of a communication failure	Low					X	X
CDH-07	Detailed flight log ,stored on board for later retrival.	Will help debuging and provide extra information about the flight	Low					X	X

CDH Requirements

ID	Requirement	Rationale	Priority	Parents	Children	VM			
						A	I	T	D
CDH-08	Communications shall use Laird AC4790-200 radio with API packet format.	Competition Requirement.	High	SR-09 SR-10				X	X
CDH-09	Communications shall be teriminated after landing detected	No need to transmit data after landing.	High	SR-11				X	X
CDH-10	Carrier's controller board shall have enough interfaces for sensors.	Controller needs to read data from all sensors.	High		SEN-02 SEN-03	X			
CDH-11	Lander's controller board shall have enough interfaces for sensors.	Controller needs to read data from all sensors.	High		SEN-04 SEN-05	X			

Processor & Memory Trade & Selection

	Arduino Pro Mini	Fez Mini	Custom board with PIC 18F2550
Processor Speed	8Mhz	72Mhz	20Mhz
Memory	1Kb Ram	62KB Usable Ram	2Kb Ram
Size	**1.8cm x 3.3cm**	4.8cm x 2.8cm	4 cm x 6 cm
Price	$19.95	$49.95	~$30
Development Environment	Processing IDE or any text editor + avr-gcc	**Microsoft Visual Studio with .NET Framework SDK**	Various IDE and Compiler Options
Debug Options	Limited	**Very Good**	Very Limited
Software Reusability	Little	**High**	Little
Communication Interfaces	1xUART,1xSPI,1xTWI	**3xTTL +1xRS232 UART, 2xSPI, I²C Support**	1xUART,1xSPI
Operating Voltage	**3.3V**	**3.3V**	5V

Carrier: We **choose Fez Mini for carrier** because:

- Excellent development environment and debug support
- Ability to write high level code using .NET Microframework will allow us to try different approaches with minimum effort
- Has enough communication interfaces for all sensors
- We will be able to add extra functionality to with very little effor if needed.
- It seems like an overkill, but there is virtually no advantage to us to use a more simple platform, and the time it will save us justifies its usage.

Lander: We choose **Arduino Pro Mini for lander** because:

- Small size
- 3.3V Operating Voltage
- Excellent community support
- Cheap and easily sourcable.

Processor & Memory Trade & Selection

- We will use **SD-Cards with FAT-32 filesystem** for all storing requirements,because:
  - If we wanted to use a dedicated memory chip, we would need to order it and wait for its arrival, but we can buy SD-Cards anywhere, and for very cheap.
  - It is an developed standard, which assures to work without any problems when interfaced correctly.
  - When we wanted to read its contents, it will be enough to take the card out from the device and plug it to a SD-Card reader, which is already present in most of modern computers.
  - Since SD-Cards have very high capacity, we will be able to keep extremely detailed log files for each flight, which will aid us greatly in all sorts of testing and provide us extra data on the flight day.
  - SD-Cards are non-volatile and ~~resistant so we will be less likely to lose our data in case of any failure.

Carrier Antenna Trade & Selection

- **Our first priority in the antenna selection is compatibility, so made our selection from the Approved Antenna List section of the AC4790 Users Manual.**

- **We choose between the ones that we can easily buy, and they all have same characteristics so we choose according to mechanical properties.**

- **We choose Lairdtech 0600-00019, because it can tilt and has an included cable so it fits better with our mechanichal design.Antennas other properties:**
  - Frequency 902MHz ~ 928MHz
  - VSWR 2
  - Gain 2dBi
  - Price 14$

Communications Configuration

- We will use API Packet format in the adressed mode, as specified in the mission guide.
  - We will also use API Send Data Complete feature to ensure that all of our data reaches its destination.
- We will rely on RF Packet Size for transmission since our packets will always be same size. We will set Interface Timeout to a big value we choose by tests, unless a failure occurs, transmission will be made by RF Packet Size.
- We will set System ID and RF Channel Number same with the module in the CanSat and the module at the ground station to be able to initiate sessions and communicate.
- We will write the configuration on the EEPROM of the module, so we won't need to configure the module On-The-Fly everytime we boot it.
- Since the API Send Data Complete function ensures successful transmission, we won't need to take many precautions, a simple checksum will be enough in our application side.

Communications Configuration

Prelaunch	• Establish communication link by sending out start communication packet and recieving acknowledgement packet.
Ascension	• Send data packets to the ground station. Communication is one way.
Descension	• Send data packets to the ground station. Communication is one way.
Ground	• Stop transmiting data packets after landing detected, send terimination packet to ground station untill recieving acknowledgement packet.

- During all phases, all sensor readings and other crucial data about the operation of CanSat and objectives are stored in a log on SD-Cards, at both Carrier and Lander.

Carrier Telemetry Format

Payload Data format:

Start Byte | Seconds since launch | Sensor Data | GPS Data | Checksum | End Byte

- Sensor Data will include:
  - Air temperature
  - Air pressure
  - Accelometer data
  - Battery voltage
- All data will be sent in ASCII character format, because it is a developed standard.
- Different data will be seperated by comma(‘,’) characters.
- Checksum is included to check the integrity of the recieved package.
- Start Byte and End Byte will be selected as characters that will never occur in the data nomally(0xF1,0xF2)
- The item with the slowest refresh rate in the list is GPS data, and it has a refresh rate of 1Hz, so we are planning to send data at 0.67Hz(once every 1.5 seconds)

Autonomous Termination of Transmissions

- **We have more than one idea to use, and we will decide which to choose after we completed our tests.**
  - We can terminate transmissions after pressure data is stable for 10 seconds.
  - We can terminate transmissions after we see a spike in the accelometer data.

- **We will verify that transmissions are terminated by the carrier by sending a pre-defined end-of-transmission package to the ground station**

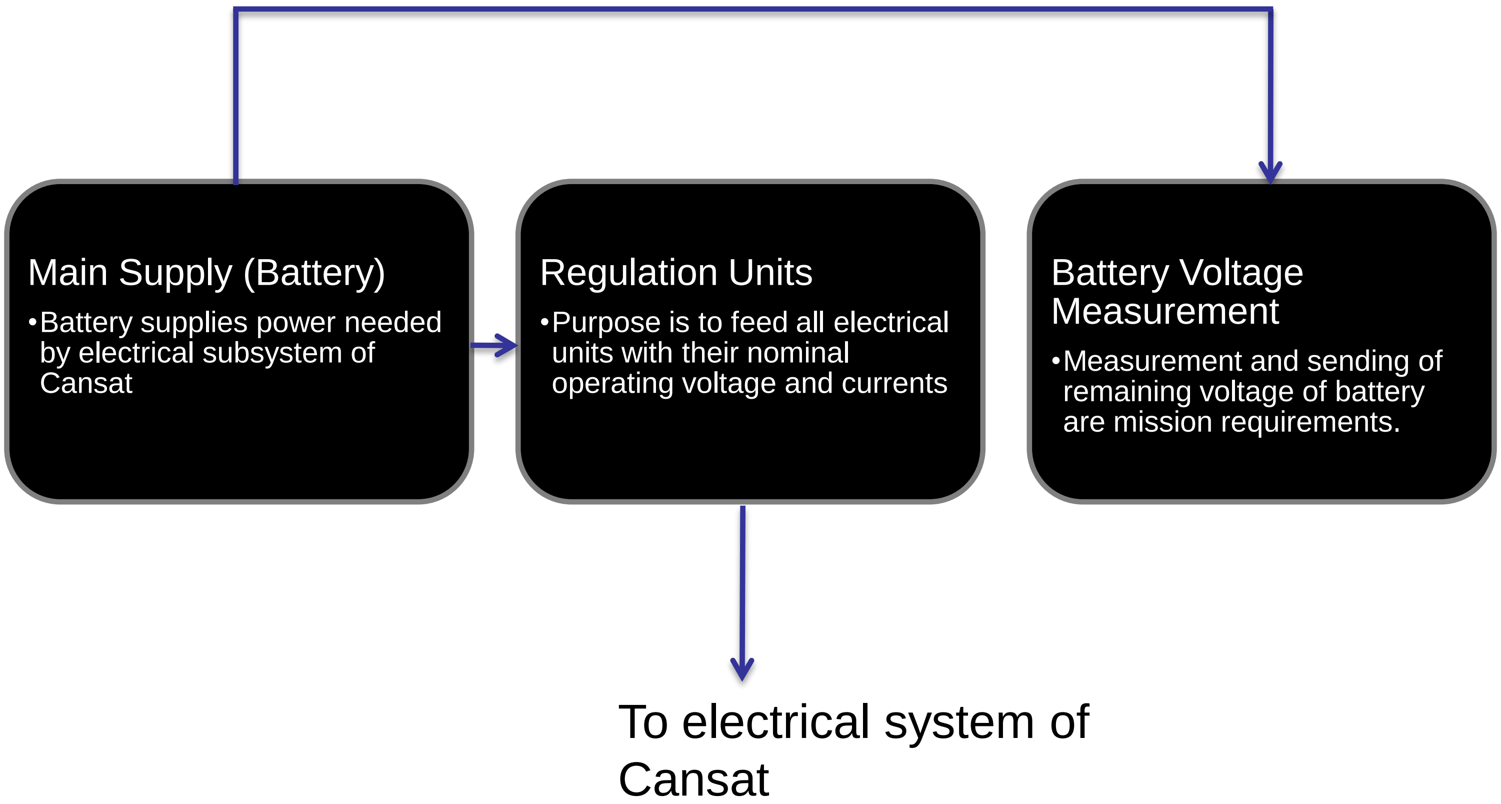
Locator Device Trade & Selection

- **Visual indicators might be hard to notice on some conditions, so both carrier and lander will activate a buzzer after landing.**
- **Locator devices will activate after carrier or lander detects that they have landed on the ground.**
- **Landing detection will be made by using methods discussed at the last slide, for terminating of the transmission.**
- **Locater devices will be shut down by a push-button on CanSat.**

Electrical Power Subsystem Design

Çağrı Güzay

EPS Overview



Note: Illustrated EPS overview will be used in both Carrier and Lander.

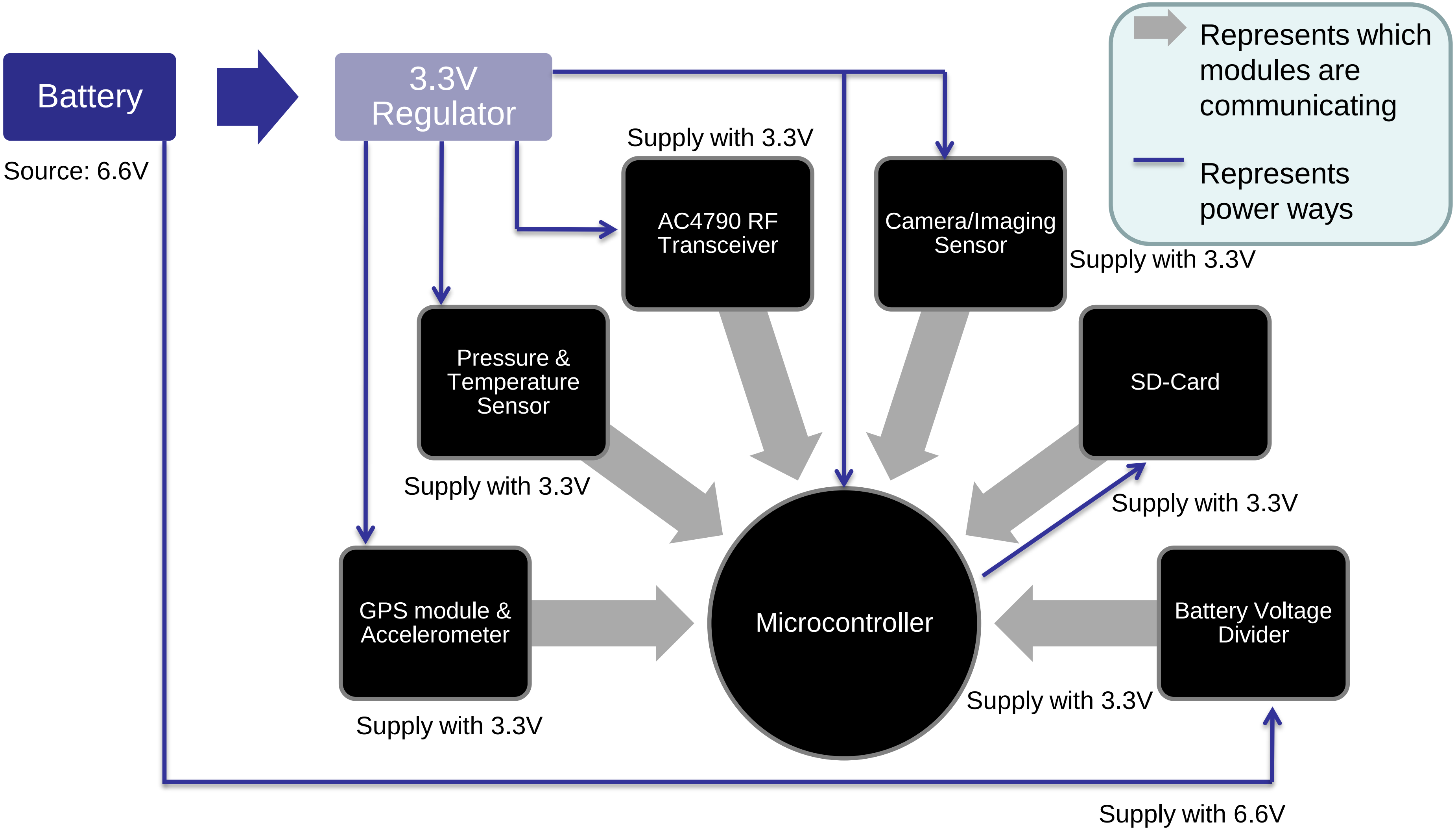
EPS Requirements

ID	Requirement	Rationale	Priority	Parent	Children	VM			
						A	I	T	D
EPS-01	All components should be supplied with an unique battery (Carrier).	There is only one voltage supply, battery.	High		EPS-05	X			
EPS-02	All components should be supplied with an unique battery (Lander).	There is only one voltage supply, battery.	High		EPS-04 EPS-05	X			
EPS-03	A 3.3V regulator must be used in Carrier.	All components use 3.3V.	High		SEN-01			X	
EPS-04	The battery of Lander should have between 3.3V and 12V.	It is planned to be used no regulator in Lander. Internal 3.3V regulator of microcontroller card will supply all components.	High	EPS-02			X		
EPS-05	The battery voltage must be higher than 3.3V both Carrier and Lander.	Voltage level of the battery decreases, using of it.	High	EPS-01 EPS-02				X	X
EPS-06	Voltage measurement circuit should draw negligible current	Drawing current effects battery	Medium			X		X	

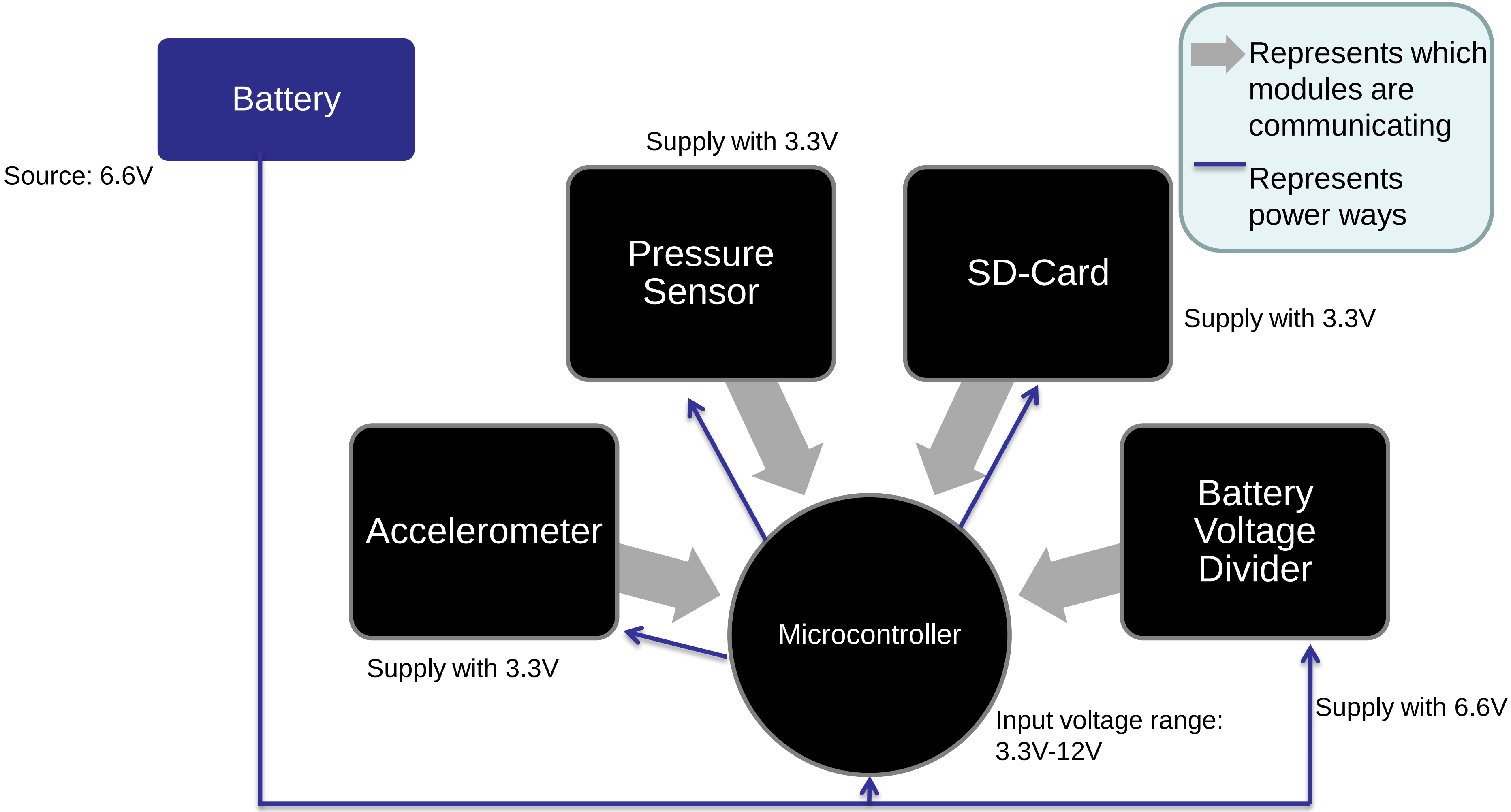
EPS Requirements

ID	Requirement	Rationale	Priority	Parent	Children	VM			
						A	I	T	D
EPS-07	Voltage measurement circuit should draw negligible current	Drawing current effects battery	Medium			X		X	
EPS-08	The battery should supply more than all needed power (Carrier)	Power insufficiency makes system unstable.	High			X	X		
EPS-09	The battery should supply more than all needed power (Lander)	Power insufficiency makes system unstable.	High			X	X		

Carrier Electrical Block Diagram



Lander Electrical Block Diagram



Microcontroller is selected as Arduino Mini Pro 3.3V. It has own regulator. Also, it can supply up to 150milliAmps.

Carrier Power Budget

Module	Power characteristics				Usage ratio
	Voltage	Current	Power	Source	
Microcontroller	3.3V	103mA	340mW	Datasheet	100%
GPS module & Accelerometer	3.3V	35.2mA	105.6mW	Datasheet	100%
Pressure & Temperature Sensor	3.3V	25µA	.0825mW	Datasheet	100%
AC4790 RF Transceiver	3.3V	68mA	200mW	Datasheet	100%
Camera / Imaging Sensor	3.3V	100mA	330mW	Datasheet	30%
Battery Voltage Divider	-	-	negligible	Estimation	100%

Total power consumption	**~240mAh**
Power Available	1100mAh
Margins	860mAh

Needed voltage	**3.3V-5V**
Battery supply	6.6V

Lander Power Budget

Module	Power characteristics				Usage ratio
	Voltage	Current	Value	Source	
Microcontroller	3.3V-12V	30mA	100mW	Estimation & Datasheet	100%
Accelerometer	3.3V	500µA	1.32mW	Datasheet	100%
Pressure Sensor	1.8V-3.6V	1mA	3.3mW	Datasheet	100%
Battery Voltage Divider	-	-	negligible	Estimation	100%

Total power consumption	**~32mAh**
Power Available	1100mAh
Margins	1068mAh

Needed voltage	**3.3V-5V**
Battery supply	6.6V

Power Source Trade & Selection

Module	Physical Characteristics		Electrical Characteristics		Cost
	Length & Diameter	Weight	Nominal capacity	Voltage	
A123 (LiFePO4)	40x10mm	39gr	1100mAh	3.3V	$8.06
Elite (NiMh)	42x10.5mm	13gr	1000mAh	1.2V	$8.06
Sanyo (NiCad)	43x17mm	28gr	1100mAh	1.2V	$8.06

Power budgets are obtained in previous slides for both Carrier and Lander. It is planned to be used the same battery for these two. Budget tables show total power consumption for an hour. Selected batteries satisfy these results. Moreover, there are very much margins for Carrier and Lander.

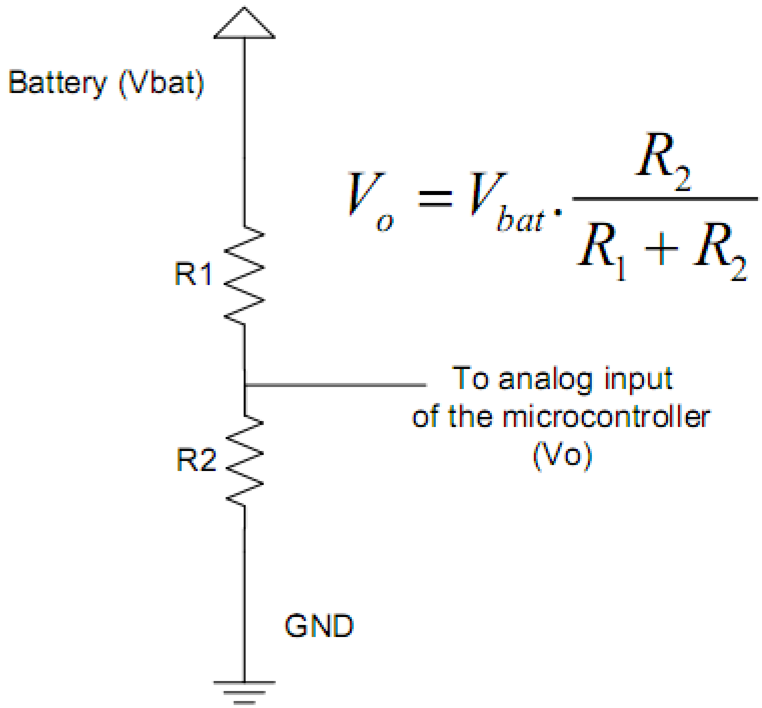
Power Source Trade & Selection

We choose A123 ($LiFePO_4$) for carrier and lander.
Because of,

- Excellent light mass
- Optimum mini size
- Cheap and easy charge
- Confident. It’s made of fireproof material

Battery Voltage Measurement Trade & Selection

Battery voltage measurement is done by reading microcontroller’s ADC (analog-digital converter) channel. Microcontrollers can take maximum 5Volts as ADC input. Therefore, battery voltage divider is used to read voltage measurement. Figure shown below represents how to be done this operation.



$$V_o = V_{bat} \cdot \frac{R_2}{R_1 + R_2}$$

We choose this way, because:

- Simple way to divide the voltage
- If resistors are selected as high valued, the current drawn by these resistors is negligible
- Weight and coverage area are negligible

Flight Software Design

İsmail Ulutürk

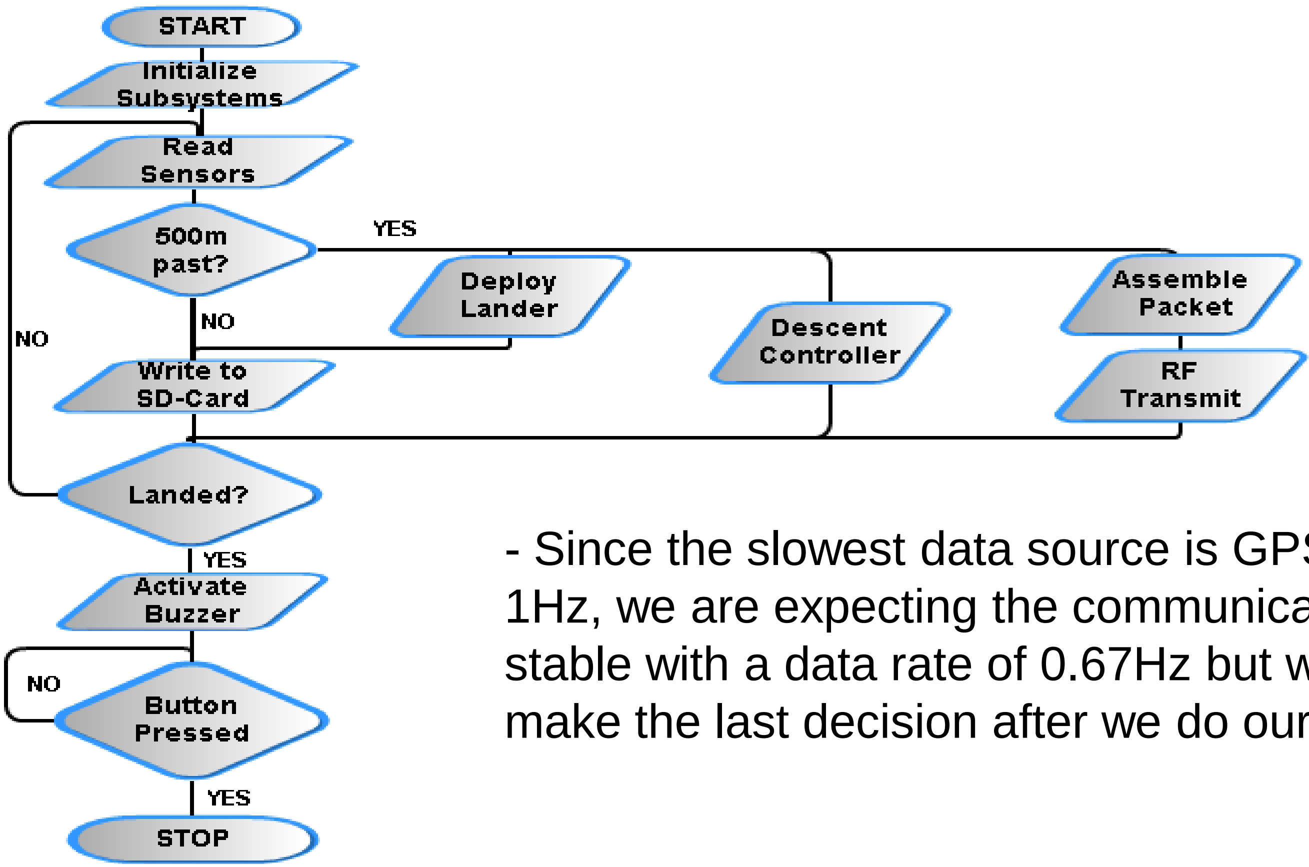
FSW Overview

- We will use C# with Microsoft Visual Studio Microframework SDK for carrier.
- We will use C with Arduino IDE for lander.
- Flight software:
  - Carrier shall release the lander at the right time.
  - Lander should be aware when its released.
  - Read all sensors and GPS data and prepare the data packet for RF Transmission.
  - Store all read data and detailed flight log on SD-Card.
  - Communicate with ground station.
  - Control speed of descension.

FSW Requirements

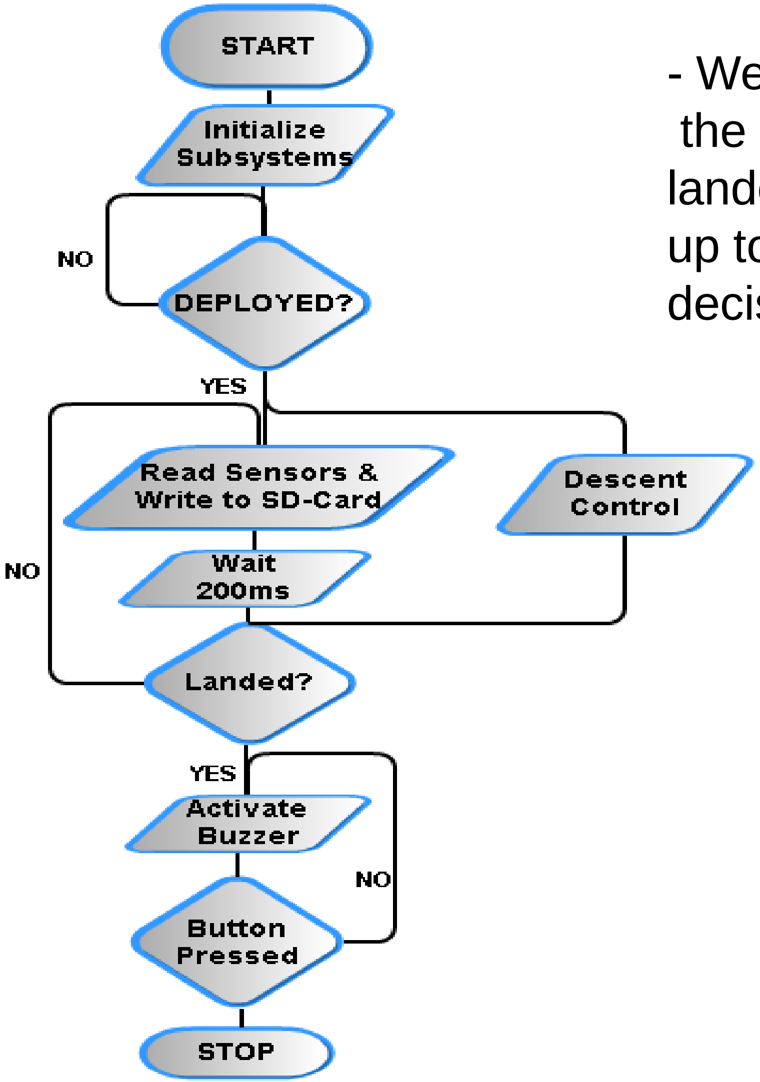
ID	Requirement	Rationale	Priority	Parent(s)	Children	VM			
						A	I	T	D
FS-01	FSW shall control transceiver via serial interface (CARRIER)	Required for air/ground communications	High	SR-09				X	
FS-02	FSW shall control DCS to ensure 4m/s avarage descend rate. .(CARRIER)	4m/s avarage descend rate is a competition requirement	High	SR-06		X		X	X
FS-03	FSW shall control DCS to ensure 5.5m/s avarage descend rate. (LANDER)	5.5m/s avarage descend rate is a competition requirement.	High	SR-07		X		X	X
FS-04	FSW shall transmit data packets at a rate of 0.5Hz at least (CARRIER)	0.50Hz Telemetry and GPS data transmission is a competition requirement.	High	SR-13				X	X
FS-05	FSW shall store all data read on a SD-CARD. (BOTH)	Required for Lander and back-up for Carrier.	High	SR-14				X	
FS-06	FSW shall keep a log of important flight events and subsystems(BOTH)	Will be used at tests to spot errors and also it will aid us in interpretetion of sensor data.	Low					X	X
FS-07	Shall capture a picture of Landers deployment (CARRIER)	Bonus Objective	Medium					X	X
FS-08	Shall capture Lander's impact force(LANDER)	Bonus Objective	Medium					X	X

Carrier Cansat FSW Overview



- Since the slowest data source is GPS with 1Hz, we are expecting the communication to be stable with a data rate of 0.67Hz but we will make the last decision after we do our tests.

Lander Cansat FSW Overview

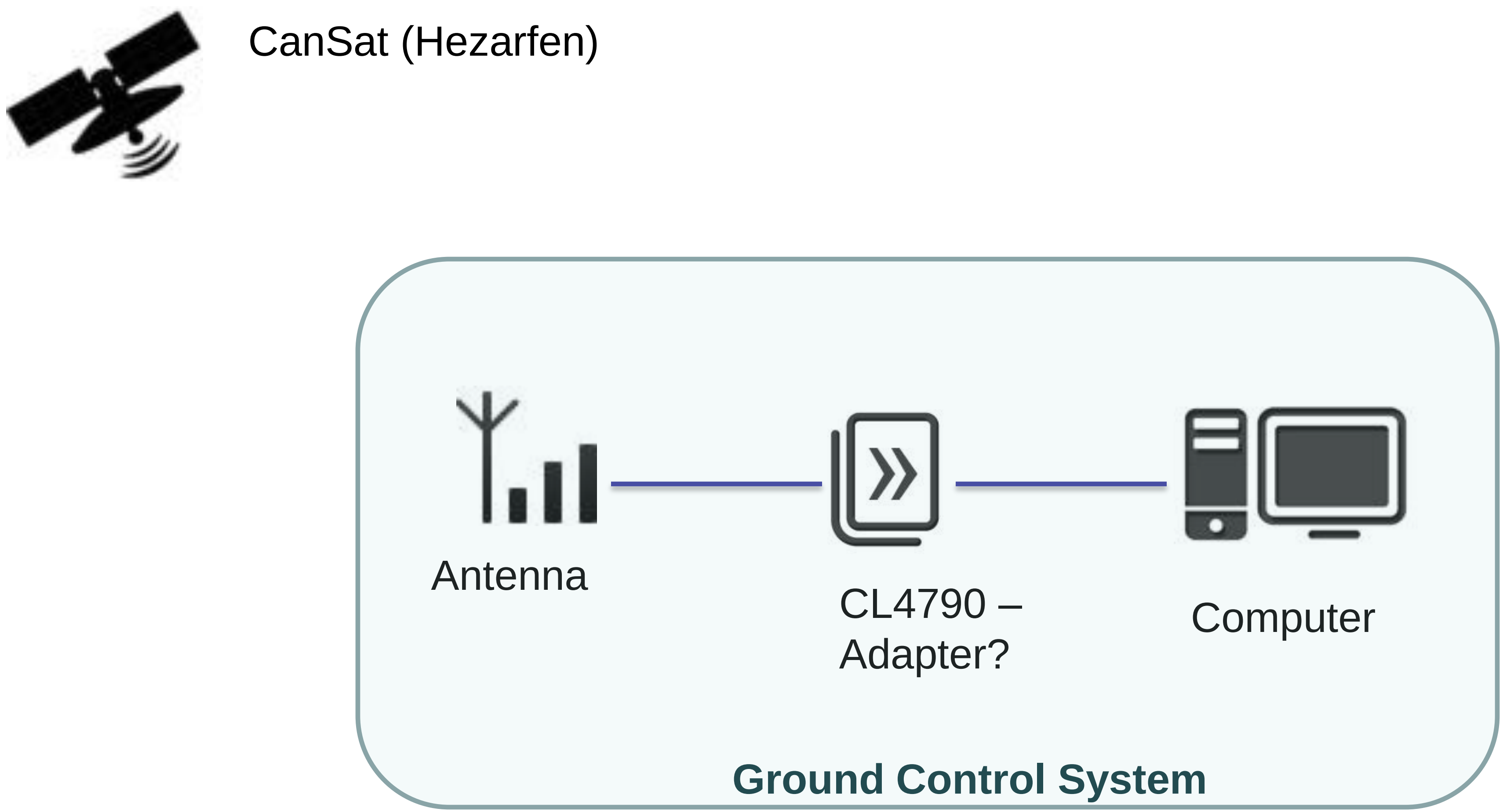


- We are planing a data rate roughly at 5Hz for the lander, since the slowest data source of lander is the pressure sensor which supports up to 9Hz data rate, but we will make our last decision after the tests.

Ground Control System Design

İsmail Ulutürk

GCS Overview

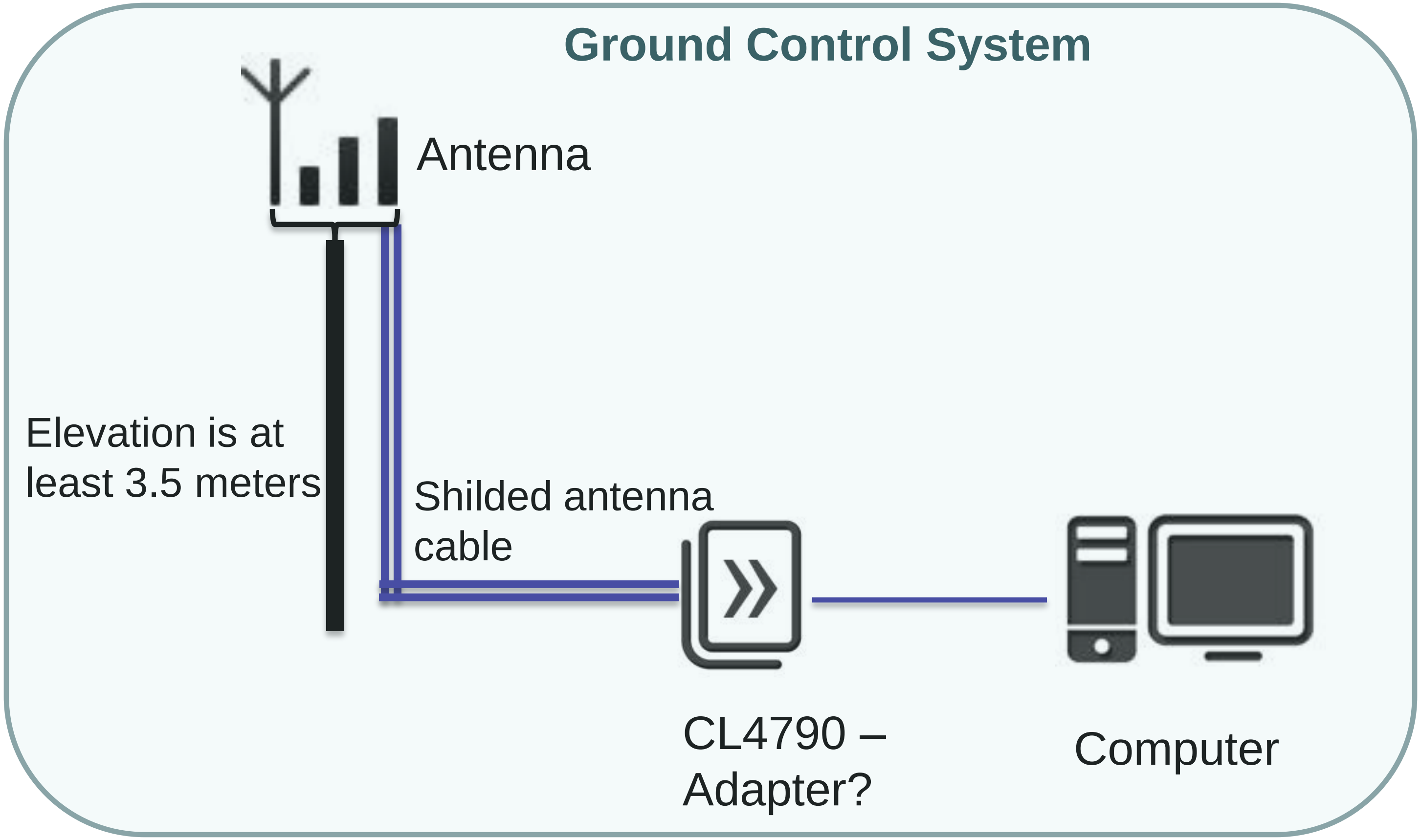


GCS Requirements

ID	Requirement	Rationale	Priority	Parents	Children	VM			
						A	I	T	D
GCS -01	Antenna should be placed at least 3.5 meters above the ground	Clear position of the antenna prevents disconnecting of communication	High				X		
GCS-02	Antenna should stand in facing point to Cansat	Clear position of the antenna prevents disconnecting of communication	High				X		
GCS-03	The cable conecting antenna and adapter must be shielded	Using an ordinary cable results in bad communication	High			X	X		
GCS-04	Adapter range must be higher than 1.5kilometers.	Vertical and horizontal distances (1km) give about 1.5 km (Triangular approximation).	High			X			
GCS-05	Analysis software must be fast enough and be useful	Miscalculation gives wrong results.	High	SR-12		X		X	
GCS-06	Data should be received properly from Carrier	To do accurate analysis	Medium	SR-12		X	X		

GCS Requirements

ID	Requirement	Rationale	Priority	Parent	Children	VM			
						A	I	T	D
GCS -07	It is needed to be drawn graphics for some measurements	To obtain time related variations	Medium	SR-12			X		X
GCS-08	Some measurements should be processed	Altitude, descent rate etc. are not measured directly. These are observed from some measurements by some calculations	High			X	X		
GCS-09	Some measurements should be compared with calculations	To be sure measurements are correct	Low			X		X	



The antenna coming with CL4790 will be used in GCS. It has enough specifications to communicate with cansat. Antenna expansion cable will be bought to supply at least 3.5 meters of elevation.

GCS Antenna Trade & Selection

Antenna of ground station must be placed properly. Placement instructions are in GCS requirements table. Also, both of AC4790 and CL4790 have 200mW maximum output power. This means maximum range of these equipments is about 6.5 kilometers.

At first steps -in air- of cansat, it will be about 1 kilometers. Assuming ground control system placed in distance of 1 kilometers from descend point of Cansat, maximum distance from ground station to cansat will be about 1.5 kilometers.

Movement limits of cansat (Carrier & Lander) are under the ranges of communication equipments.

CanSat Integration and Test

İsmail Ulutürk

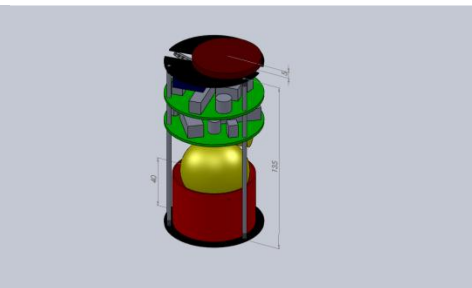
Cansat Integration

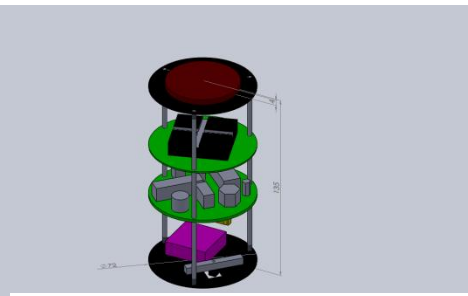
Cansat subsystems are all located to lander and carrier body.

The two bodies are also connected to theirselves with powerful magnets.

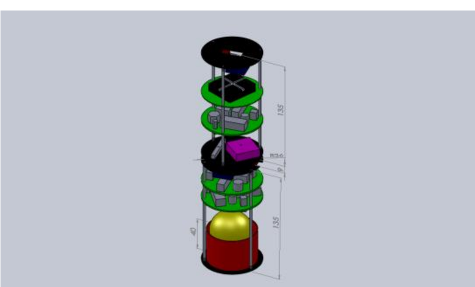
The magnets are connected to a servo.

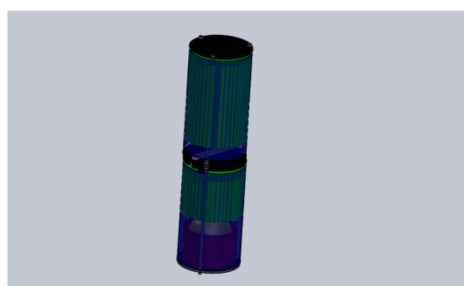
The bodies are made assembling steel bars and carbon-fiber plates for protecting the electronic circuits, sensors, processor and egg for creating a robust structure





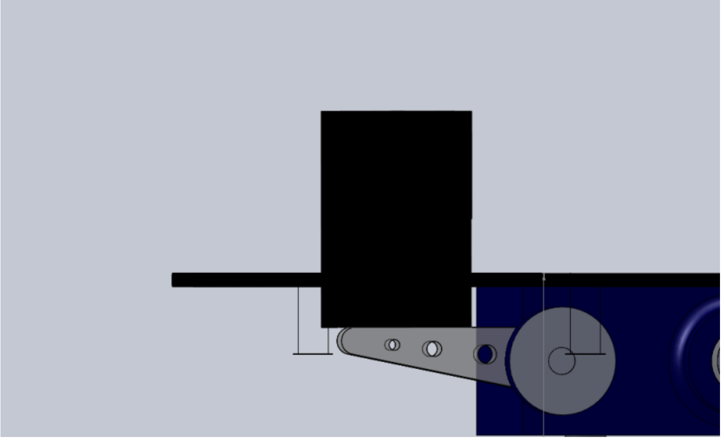
Processor, sensors and electronics are located inside the lander and carrier and they are connected to steel bars by the silicon tubes.

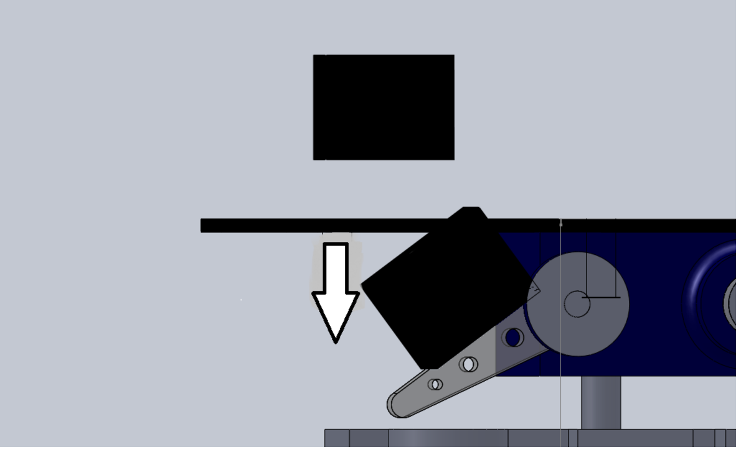


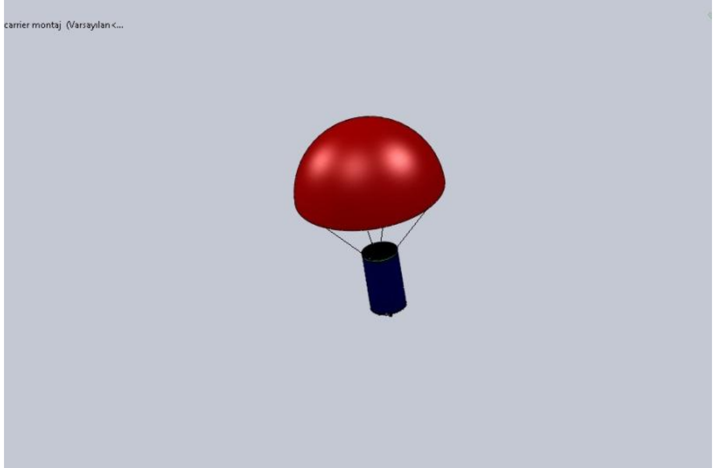


Cansat Integration

When its time to separating servo breaks the connection of magnets so lander and carrier fall by theirselves.







Cansat MechanicTest

The first system test is for body if it is a robust structure.
It should perform a good strength for damping the momentum force while crashing the ground. The body is exposed some forces by throwing it to the ground.
The second test is for parachutes for providing the 4 m/s and 5.5m/s
The third test is for egg protection system if it is enough for protecting the egg. The body with egg and egg protection system is thrown to the ground at certain velocity for several times.

The last test is for ensuring to be created whole robust structure. The body is thrown down to the ground.

Cansat ElectronicTest

The electronic tests are:

- → **Radar control test,**
- → **Power supply test,**
- → **Processor test,**
- → **Memory card test,**
- → **Software test,**
- → **Circuit test**

Mission Operations & Analysis

Hasan Erdem Harman

Overview of Mission Sequence of Events

1. On cansat
2. Put cansat into rocket
3. Launch rocket
4. Leaving cansat from rocket
5. Measuring height of cansat
6. Seperate cansat on 500meters
7. Take departure picture
8. Control of descent speeds
9. Collect data using sensors
10. Calculate collusion force
11. Saving data on ground station
12. Locate Cansat
13. Off cansat

Lander Landing Coordinate Prediction

- **We will use the sensor values transmitted between the launch and the deployment of the lander to estimate the horizontal speed of the CanSat with respect to the ground at the moment of release.**

- **Lander will most likely have a horizontal speed with almost similar direction, but the amplitude might vary.**

- **We will write our own analysis software for this but after tests, we might opt to go for a more advanced algorithm. Then we will need MATLAB and/or Mathematica.**

Cansat Location and Recover

- **We will make predictions about the location of Lander with the method explained in the previous slide.**
- **We will make predictions about the location of Carrier using the transmitted GPS data, the direction of its horizontal speed calculated using transmitted data, we will also keep the wind speed in mind.**
- **Both Carrier and Lander will have loud buzzers activated after landing, so finding them should not be so hard after we have their locations roughly.**

Management

UĞUR ÖZEN

Cansat Budget

Hardware Costs

	Category	Model	Quantity	Unit Cost	Determination
ELECTRONiC	Controller Board (Lander)	Arduino Pro Mini 328-3.3V/8MHz	1	19$	Actual
	Controller Board (Carrier)	Fez Mini	1	50$	Actual
	GPS Receiver (Carrier)	20Channel LS20126 GPS Receiver	1	60$	Actual
	Temperature + Pressure Sensor	SCP1000 with Breakout Board	1	35$	Actual
	Camera	LinkSprite JPEG Color Camera	1	50$	Actual
	Accelometer (Lander)	MMA7260Q	1	20$	Actual
	RF Transciever (Carrier)	AC4790-200M	1	51$	Actual
	RF Antenna (Carrier)	Laird 0600-00019	1	12$	Actual
	Pressure Sensor (Lander)	BMP085 with Breakout Board	1	20$	Actual
MECHANiC	Structure Materals	Silver steel	1	40$	Actual
	Parachute		2	10$	Actual
	Servo	Hitec HS-65HB Micro Carbonite	3	12$	Actual
	Egg protective mix	Dough	1	7$	Estimate
	SUBTOTAL			**400$**	

Cansat Budget

Ground System Costs

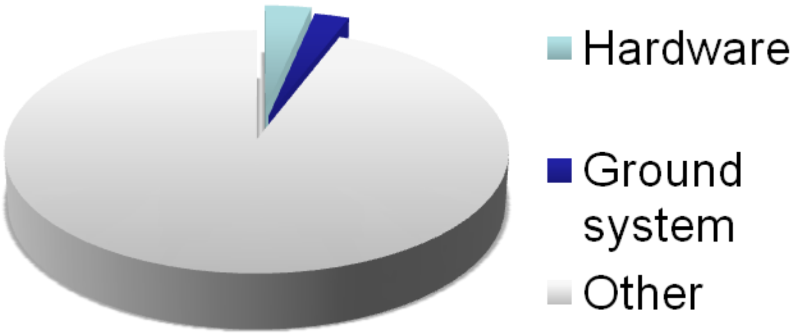
Category	Model	Quantity	Unit Costs	Determination
Antenna Cable	RG195 ANT Cable RPSMA Jack/Plug	1	56$	Actual
Wireless Adapter	Laird Tech. – CL4790	1	170$	Actual
Computer	Asus F3Sv	1	-	Actual
Miscallenous	Wires, expansion equipment		74$	Estimate
SUBTOTAL			**300$**	

Other Costs

Category	Quantity	Unit Costs	Determination
Travel	6	1000$	Actual
Hotel	3	700$	Estimate
Van Rental	1	1000$	Estimate
Food	6	350$	Estimate
SUBTOTAL		**11200$**	

Income-Cost Equilibirium

Category	Cost
Hardware	400$
Ground System	300$
Others	11200$
Suprise Costs	2100$
Total Cost	14000$
Income	14000$



→Source of project income is Rectorship of İstanbul Technical University

→The project can be fit with income and cost equilibirium

Program Schedule

<table>
<tr><th colspan="2"></th><th colspan="5">Categories</th></tr>
<tr><th colspan="2">Date</th><th>Mechanics</th><th>Electronics</th><th>Fin. & Log.</th><th>Academic Schedule</th><th>High Level Task</th></tr>
<tr><td rowspan="4">November</td><td>1.week</td><td rowspan="2">-</td><td rowspan="2">-</td><td rowspan="2">Team come together</td><td rowspan="8">School first term
Quizes Homeworks</td><td rowspan="4">Getting information about competition</td></tr>
<tr><td>2.week</td></tr>
<tr><td>3.week</td><td rowspan="2">Recognation of competition task</td><td rowspan="2">Recognation of competition tasks</td><td rowspan="2">Recognation of competition tasks</td></tr>
<tr><td>4.week</td></tr>
<tr><td rowspan="4">December</td><td>1.week</td><td rowspan="2">Design mechanic systems</td><td rowspan="2">Design electronic systems</td><td rowspan="5">Searching for Sponsorship</td><td rowspan="4">Doing subsystems design</td></tr>
<tr><td>2.week</td></tr>
<tr><td>3.week</td><td rowspan="2">Determining of using materials</td><td rowspan="2">Determining of using materials</td></tr>
<tr><td>4.week</td></tr>
<tr><td rowspan="4">January</td><td>1.week</td><td>Buying materials</td><td>Buying materials</td><td rowspan="3">Midterm Final Exams</td><td rowspan="4">Assign final materials which are used on competition</td></tr>
<tr><td>2.week</td><td rowspan="3">Testing mechanical materials</td><td rowspan="3">Testing electronical materials</td><td rowspan="3">Prepare PDR</td></tr>
<tr><td>3.week</td></tr>
<tr><td>4.week</td><td rowspan="2">Midterm Holiday</td></tr>
<tr><td rowspan="4">February</td><td>1.week</td><td rowspan="4">Break</td><td rowspan="4">Break</td><td rowspan="4">Break</td><td rowspan="4">Break</td></tr>
<tr><td>2.week</td><td rowspan="3">Starting second term</td></tr>
<tr><td>3.week</td></tr>
<tr><td>4.week</td></tr>
</table>

Program Schedule

Date		Categories				
Date		Mechanics	Electronics	Fin. & Log.	Academic Schedule	High Level Task
March	1.week	Put together subsystems	Put together subsystems	Searching for testing area	School second term Quizes Homeworks	Production of cansat prototype
	2.week					
	3.week	-	Creating ground system & software	Prepare CDR		
	4.week					
April	1.week	Testing cansat	Testing cansat	Buying fly tickets		Testing Cansat
	2.week					
	3.week			-		
	4.week					
May	1.week	Last controls and evaluating of cansat mechanic systems	Last controls and evaluating of cansat electronic systems	Hotel reservations & Taking visa		Full control of cansat and evaluating
	2.week					
	3.week					
	4.week				End year Final Exams	
June	1.week	-	-	Preparing cansat competition		Participating to cansat competition
	2.week			Cansat competition		

Conclusions

Major accomplishments

→ The team is come together

→ Subsystems are designed

→ Materials are selected

→ Cost and income are balanced

Major unfinishes work

→ We will produce cansat protype

→ We will write software

→ We will test cansat

We were succesfull all duties until now.

We will go on according to schudle until competition.