Cansat 2011 PDR Outline

Team # : 852

Team Gaganyaan

Presentation Outline

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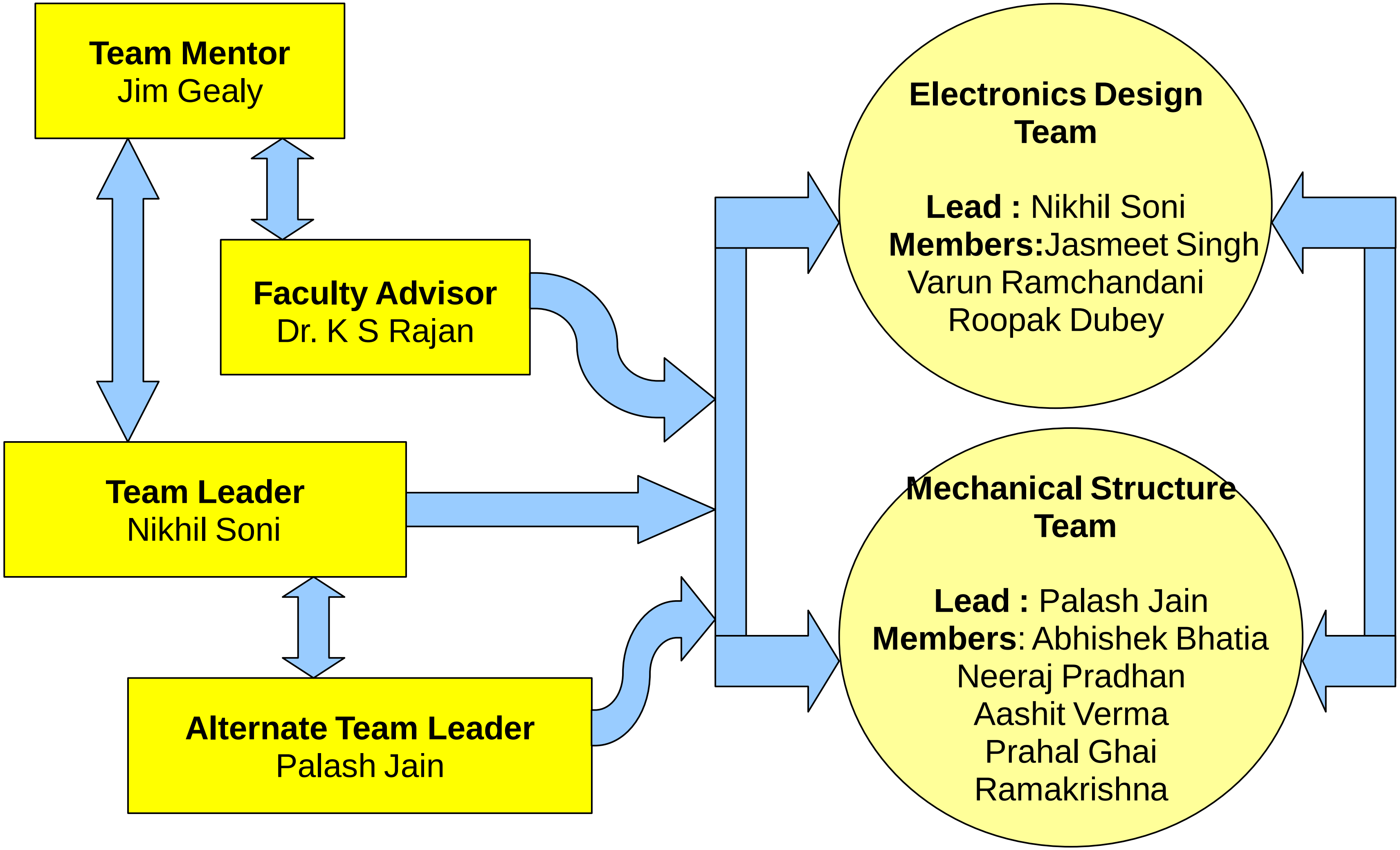
Team Organization

No.	Name	Year of study	Position	Contact details
1	Nikhil Soni	3rd yr	Team Leader Electronics Team lead	nikhil.soniug08@students.iiit.ac.in
2	Palash Jain	3rd yr	Alternate Team Leader Mechanical Team Lead	palash.jainug08@students.iiit.ac.in
3	Abhishek Bhatia	3rd yr	Member, Mechanical Team	abhishek.bhatiaug08@students.iiit.ac.in
4	Varun Ramchandani	3rd yr	Member, Electronics Team	varun.ramchandani@students.iiit.ac.in
5	Roopak Dubey	3rd yr	Member, Electronics Team	roopak.dubeyug08@students.iiit.ac.in
6	Neeraj Pradhan	3rd yr	Member, Mechanical Structure Team	neeraj.pradhanug08@students.iiit.ac.in
7	Jasmeet Singh	3rd yr	Member, Electronics Team	jasmeet.singhug08@students.iiit.ac.in
8	Aashit Verma	2nd yr	Member, Mechanical Structure Team	aashit.verma@students.iiit.ac.in
9	Prahal Ghai	2nd yr	Member, Mechanical Structure Team	prahal.ghai@students.iiit.ac.in
10	Ramakrishna Vedantam	2nd yr	Member, Mechanical Structure Team	ramakrishna.vedantam@students.iiit.ac.in

Internal Organization



Acronyms

- **M** Mission
- **S** Sensor
- **MS** Mechanical System
- **DCS** Descent Control System
- **CDH** Command and Data Handling
- **EPS** Electrical and Power system
- **FSW** Flight Software
- GCS Ground control station

❖A/D	Analog or Digital
❖ADC	Analog digital converter
❖CLK	Clock
❖CPU	Central processing unit
❖EEPROM	Electrically Erasable Programmable Read-Only Memory
❖FCC	Federal communications commission
❖g	Acceleration due to gravity
❖GHz	Giga hertz
❖GPS	Global positioning system
❖Hz	Hertz
❖ISM	Industrial, scientific and medical
❖Kbps	Kilobytes per second
❖Km	Kilometer
❖MHz	Mega hertz
❖NiMH	Nickel metal hydride
❖RF	Radio frequency
❖SPI	Serial peripheral interface
❖SRAM	Static random access memory
❖USART	Universal synchronous asynchronous receiver/transmitter
❖USD	US Dollar
❖INR	Indian Rupees

Systems Overview

Presenter : Abhishek Bhatia

Mission Summary

Mission:

- The mission of 2011 Cansat competition is Egg Lander.

Objectives:

- To carry the hen's egg intact for the entire duration from launch to landing.
- To control the descent of the cansat carrier and maintaining the descend speed of 3-5 m/s.
- The Carrier should hold the Lander till deployment and after the carrier reaches 500 m after deployment, it should deploy the lander containing the egg.
- To control the descent of the lander after its deployment from the carrier at the descend speed of 4-7 m/s.
- To determine the descent rate of the payload before the separation and of both carrier and Lander after the separation using pressure sensor and record the data on-board.
- To predict the landing position of the Lander based on the GPS data.
- To send the telemetry data to a central ground station.

Optional Objective:

- To measure the force of impact of the Lander with the ground and store the data on-board.

System Requirements

ID	Requirement	Rationale	Priority	Parent(s)	Children	VM			
						A	I	T	D
SYS-01	Total mass of the Cansat will not be more than 500gms excluding egg	There is always a finite limit of the mass that can be put into space	HIGH		MS01 DCS02		X	X	
SYS-02	Cansat will fit in a cylindrical envelope of 72mm diameter and 279 mm in length	Payload structure dimensions are influenced by launch vehicle characteristics	HIGH		MS02,03 DCS 04		X		
SYS-03	There will be no protrusions until Cansat deployment from rocket payload	Payload structure dimensions are influenced by launch vehicle characteristics	HIGH		DCS-01,02,03		X		
SYS-04	Cansat Carrier will descent with minimum rate of 3m/s and Lander at minimum rate of 4.5m/s	So that does not get drifted away by wind safe landing speed	MEDIUM		DCS-01,02,03,04	X		X	X

System Requirements

ID	Requirement	Rationale	Priority	Parent(s)	Children	VM			
						A	I	T	D
SYS-05	Cansat Carrier will descent with maximum rate of 5m/s and Cansat Lander at maximum rate of 6.5m/s	To know the Cansat state for taking appropriate decisions and to protect the Egg from a sudden jerk at the time of impact	MEDIUM		DCS-01,02,03,04	X		X	X
SYS-06	GCS will have external power control with confirmation from Cansat power state	To demonstrate external control capability	LOW				X		X
SYS-07	Total cost of the Cansat will not exceed $1000	Every well managed systems has constraint, to have uniformity	MEDIUM				X		
SYS-08	During descent Cansat Carrier will send its position along with house keeping telemetry	To track the health of the Cansat	HIGH		S01 MS05 CDH 01,02			X	X

System Requirements

ID	Requirement	Rationale	Priority	Parent(s)	Children	VM			
						A	I	T	D
SYS-09	Cansat Carrier will stop transmitting telemeter upon landing and Cansat Lander will calculate the impact force with the ground as requirement of bonus objective.	To measure the impact force on the Lander so as to estimate the amount of maximum force that the Lander can sustain in order to save the egg.	LOW		S01 MS05 CDH05			X	X
SYS-10	Cansat Carrier as well as the Lander should be recovered safely	To avoid damage to cansat structure and components so that it telemeters properly and can be reused	HIGH						X
SYS-11	Team will provide all saved telemetered data from both carrier as well as the lander	As a part of Post Flight Review so as to analyze the telemetered data	MEDIUM		CDH06,07,08				X

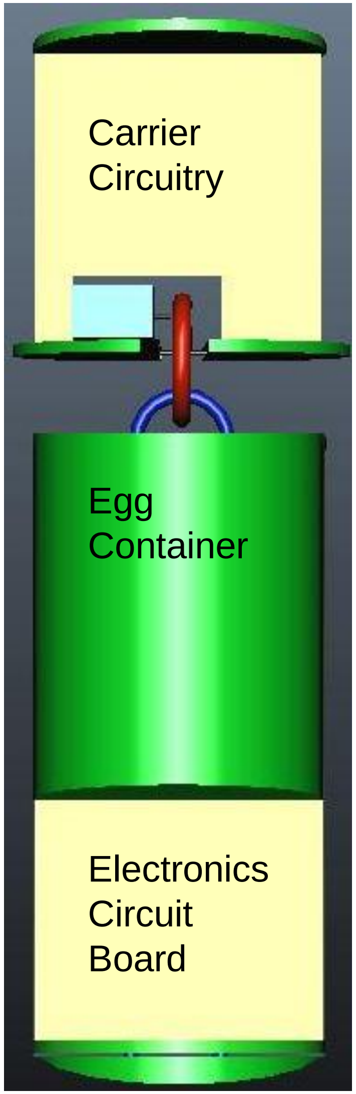
System Level Cansat Configuration Trade & Selection

1. **Choice of aluminum over steel:** aluminum was chosen over steel keeping in mind the mass constraints.
2. **Lander parachute does not inflate until the lander is released from the carrier:** as during testing we found out if both the parachutes inflate simultaneously than both the parachutes were getting entangled. So now the lander parachute is kept in an enclosed container and it inflates as soon as it is released from the carrier at a height of 500m above the ground.
3. Earlier **the container containing the egg was kept at top of the lander** and the electronics was at the bottom as we felt that the impulse of the ground will be more on the egg if the container containing the egg was at the bottom of the lander, but then this idea was rejected due to antenna constraints.

System Level Cansat Configuration Trade & Selection

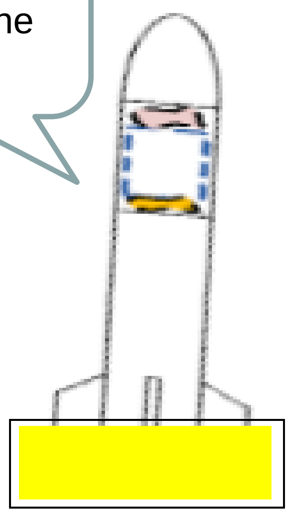
The other cansat system which we considered but was rejected due to the below mentioned reason:

The height of carrier frame is 8 cm, but the length of antenna that we are using for the communication purpose in carrier section is 17.5 cm. The given picture shows the physical layout that we wanted to use earlier, i.e. egg container at the top of lander . But to use this structure we would have had to penetrate the egg container to accommodate the antenna, which is not preferable because then the protection of egg would be under risk. So we inverted the lander configuration as the electronics section is moved at the top and the egg container at the bottom to accommodate the carrier antenna.



System Concept of Operations

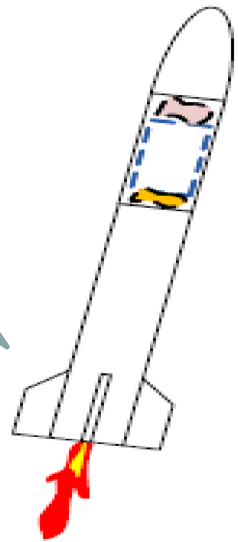
Cansat rests in the payload section of the rocket



Team developed Ground Control Station

System Concept of Operations

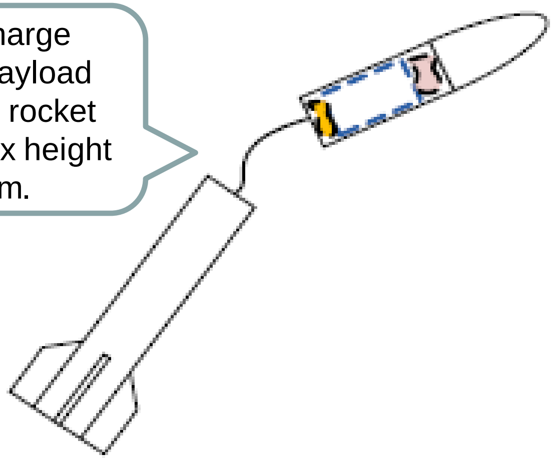
Cansat rests on its parachute still inside the parachute. The nose cone parachute rests at the bottom of the Cansat.



Ground Control Station

System Concept of Operations

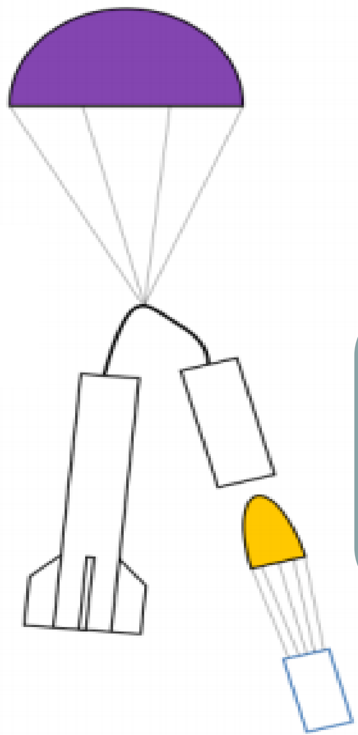
Ejection charge separates payload section from rocket around approx height of 1100m.



Ground Control Station

System Concept of Operations

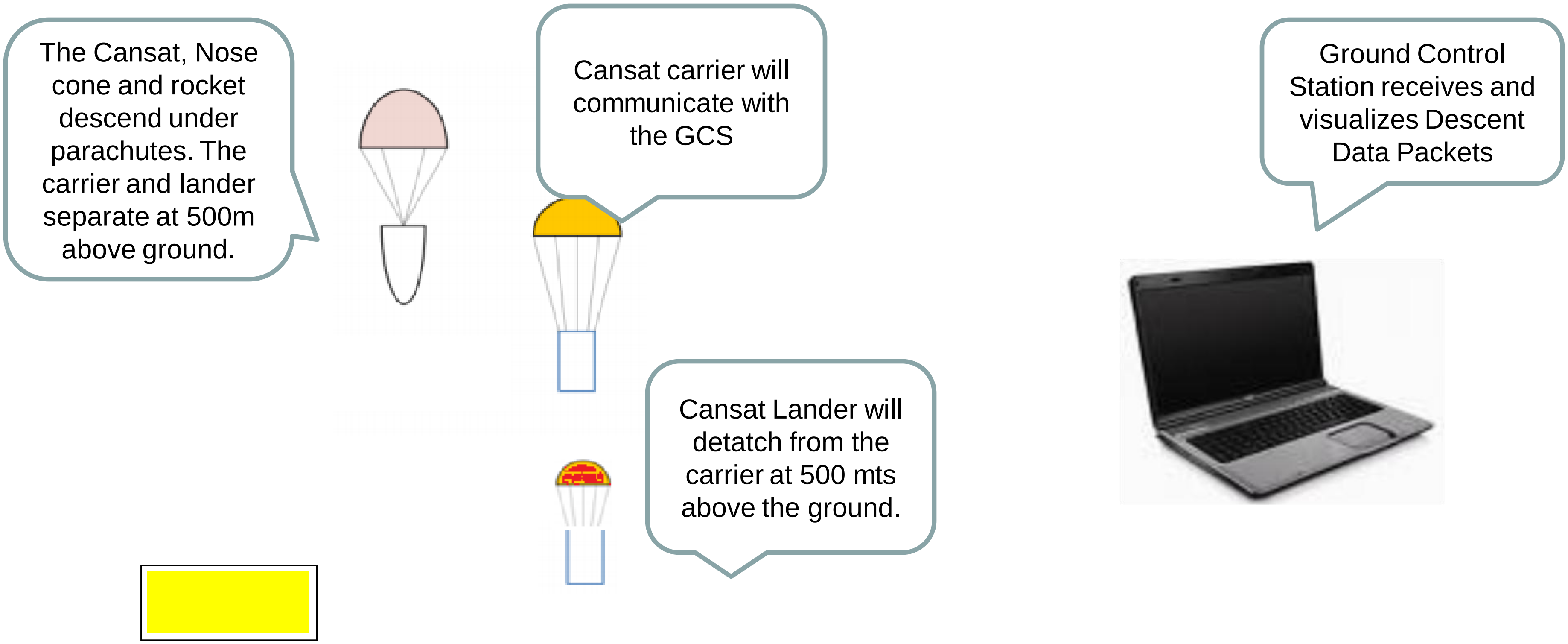
Front section tips over and the cansat falls out of the payload section. The Cansat Carrier parachute inflates over the cansat. This cansat consists of both Carrier and the Lander right now.



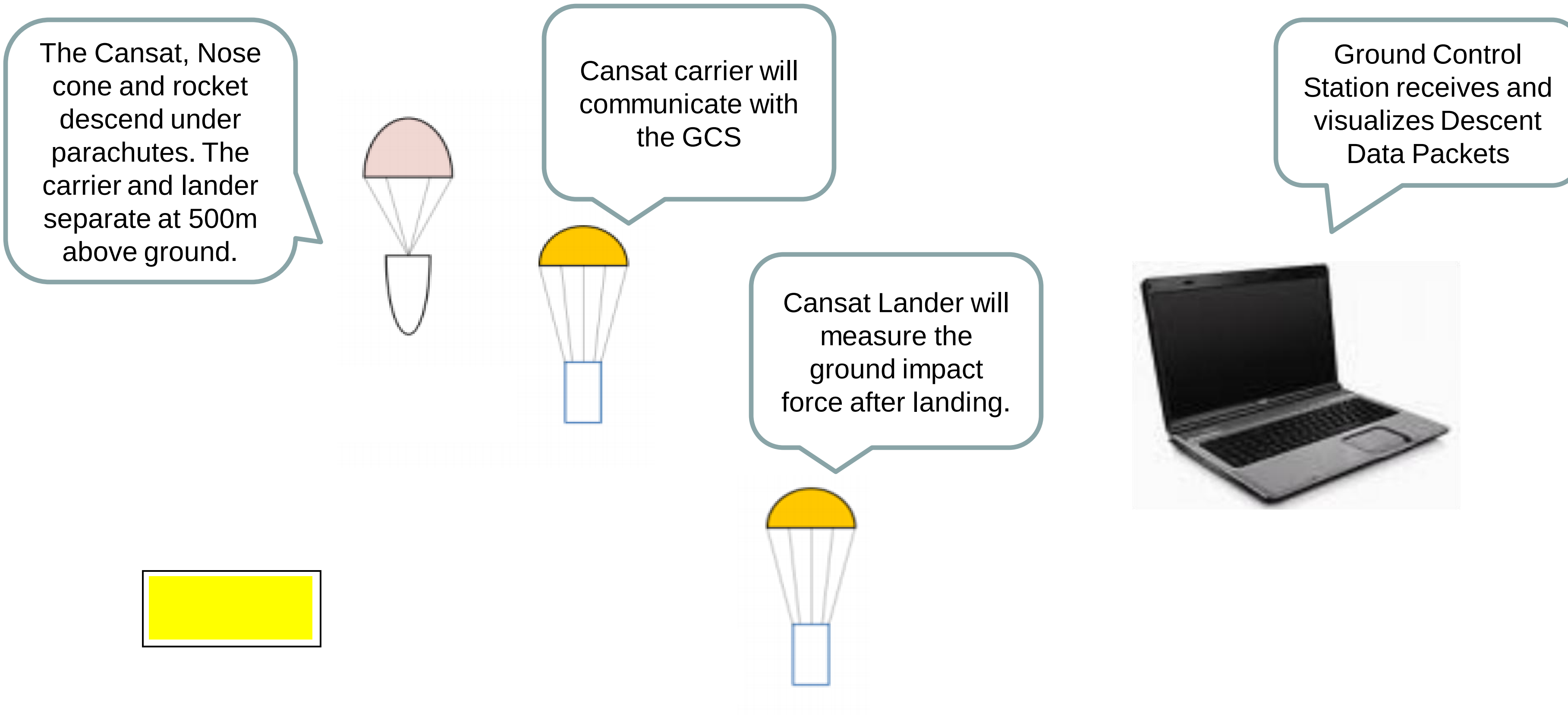
Cansat starts sending Descent Data Packets as soon as the parachute inflates.

Ground Control Station receives and visualizes Descent Data Packets

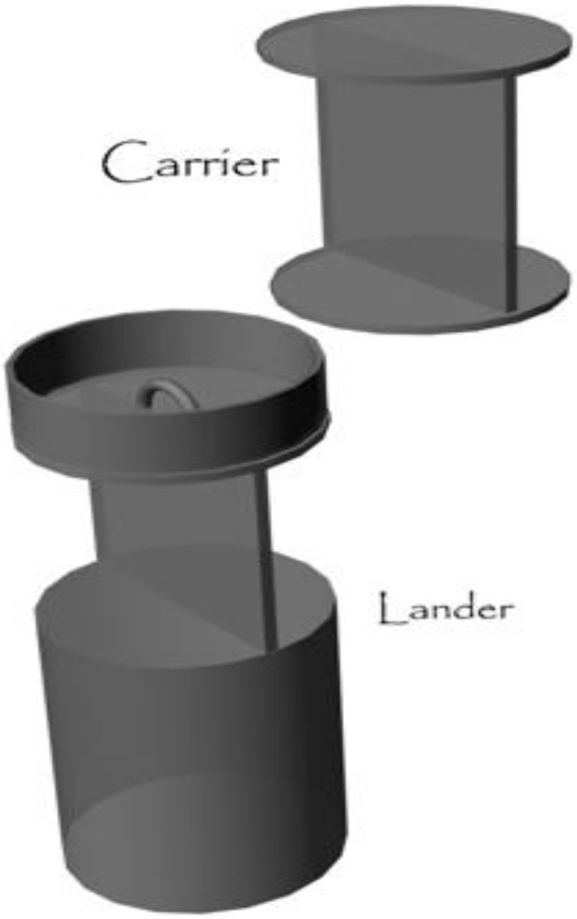
System Concept of Operations



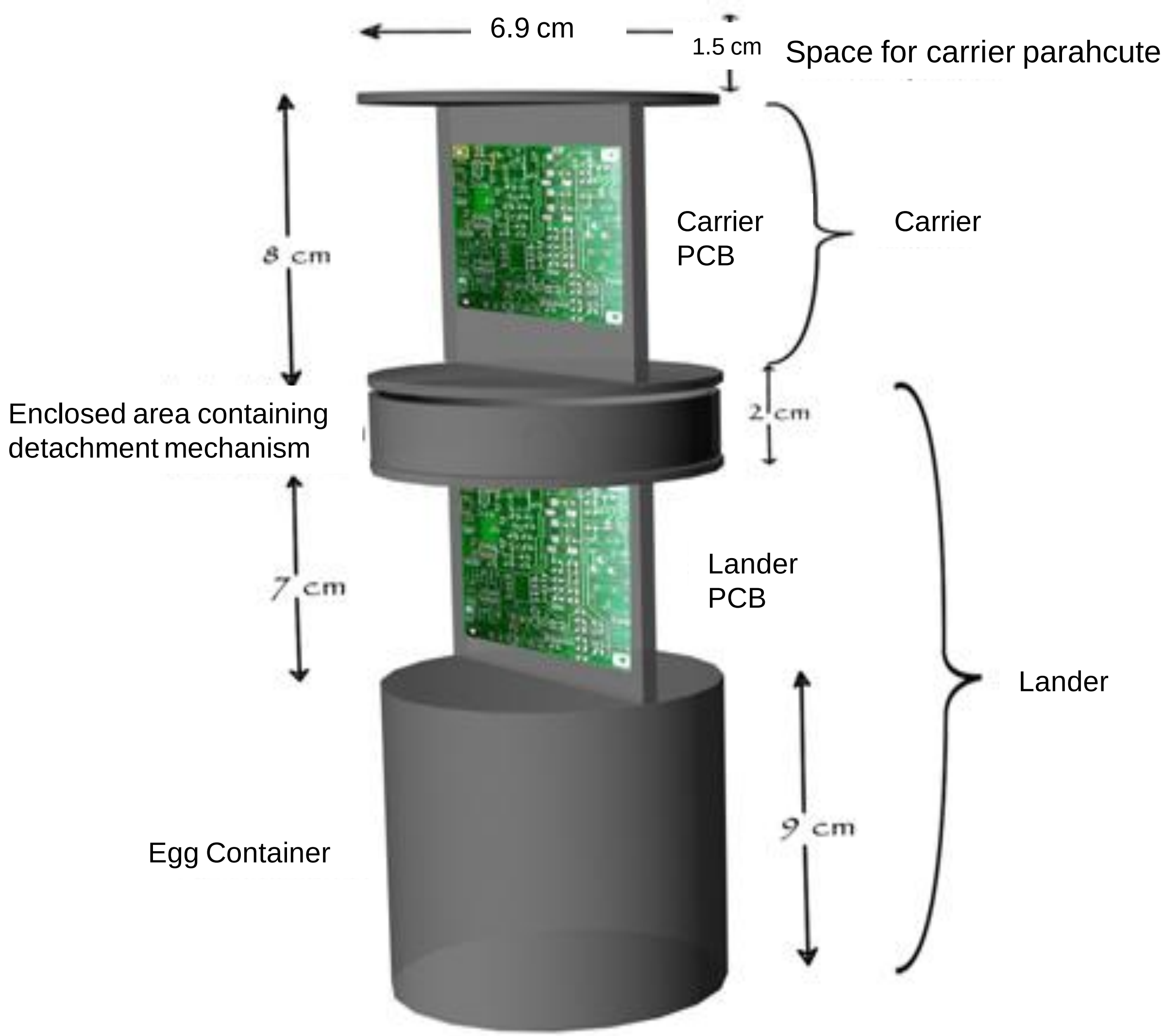
System Concept of Operations



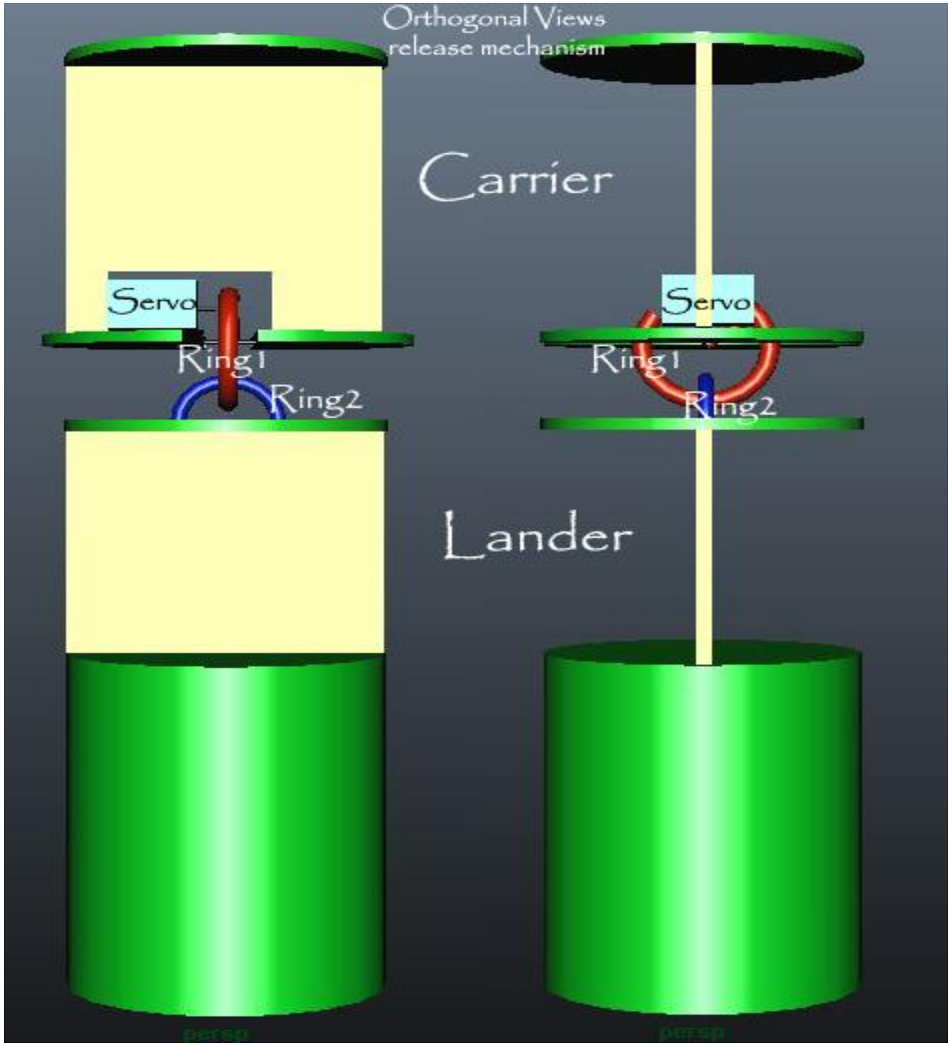
Physical Layout



Physical Layout



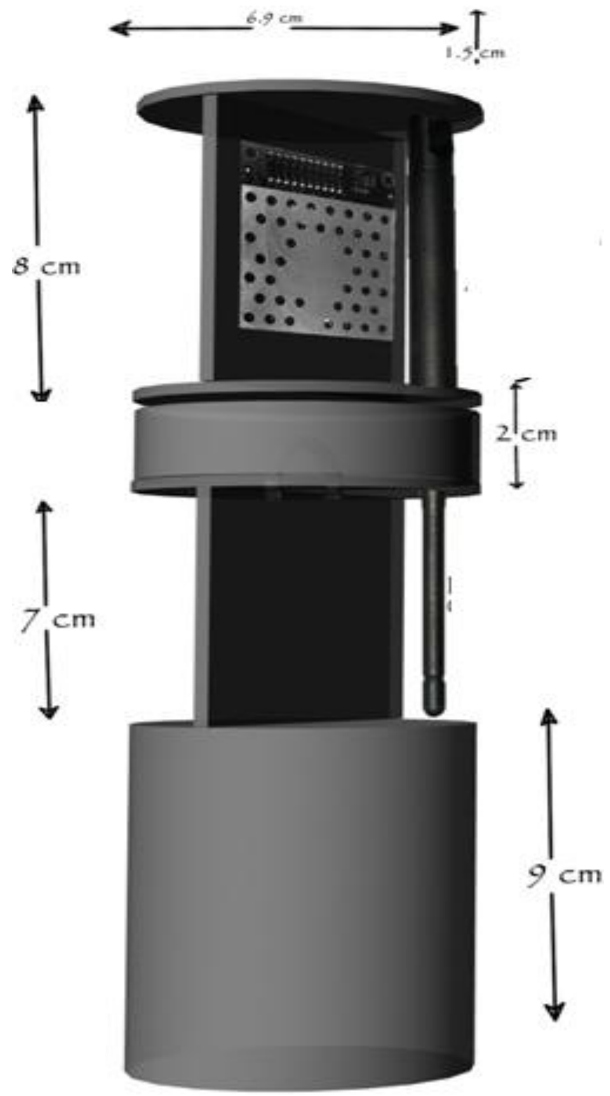
Physical Layout



A small Servo Motor controls the detachment of lander from carrier. Motor is controlled by the microcontroller, which uses GPS and pressure sensor data to decide when to detach the lander.

Launch Vehicle Compatibility

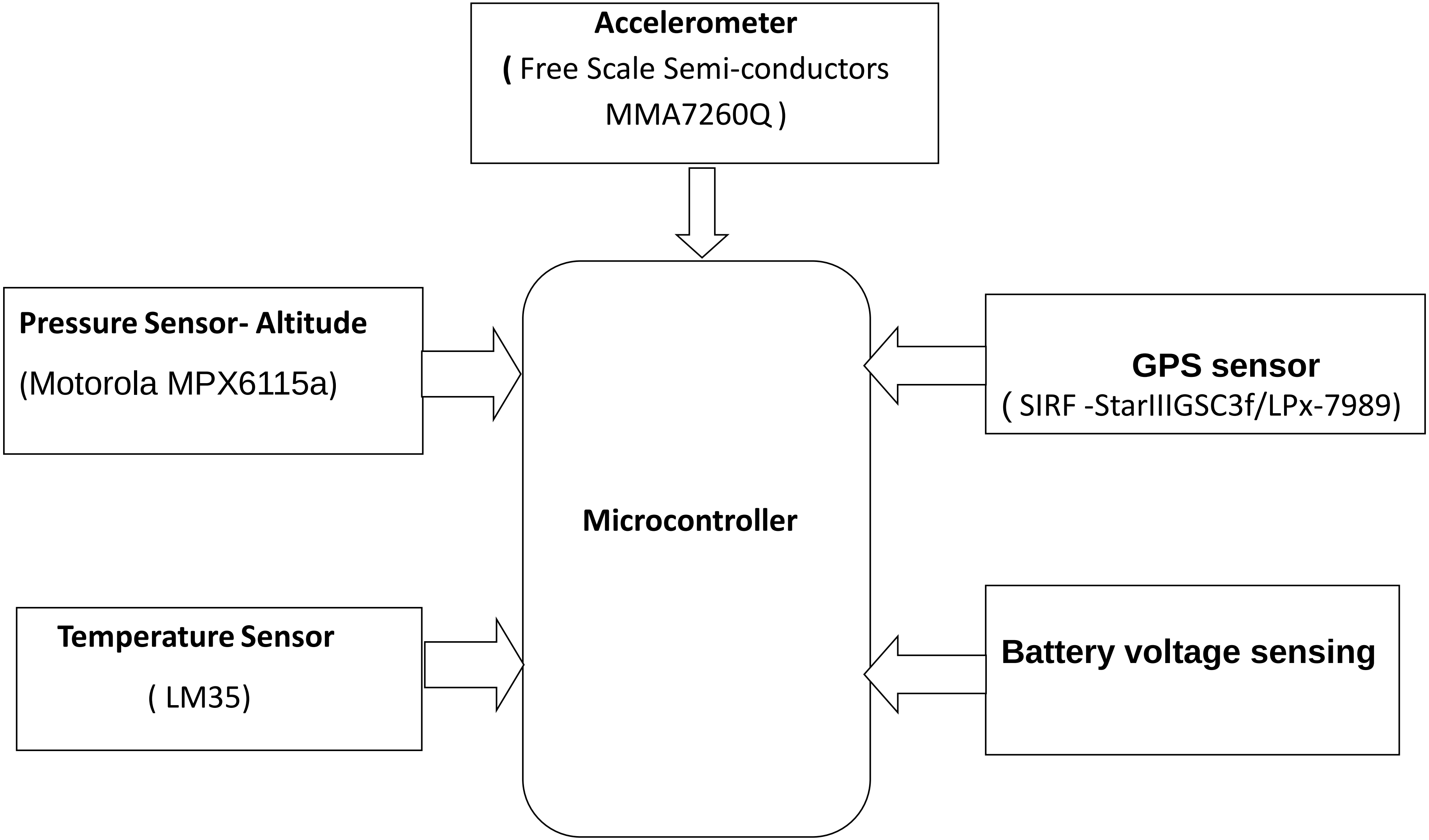
- Cansat structure is designed strictly keeping in mind the size and weight restrictions.
- maximum diameter of the cansat is 6.9 cm which is 0.3 cm less than the payload section diameter, hence facilitates smooth deployment.
- Height of the cansat is 1.5+8+2+7+9=27.5 cm. Thus is well under the given limit of 27.9 cm, ensuring that cansat will not protrude out of the payload section.
- No electronic/mechanical control is employed to push the cansat out of payload and is assumed that once the rocket dismantles it will automatically slip out of the payload bay.



Sensor Subsystem Design

Presenter : Varun Ramchandani

Sensor Subsystem Overview



Sensor Subsystem Requirements

ID	Requirement	Rationale	Parent	Children	Priority	VM			
						A	I	T	D
S01	Measurement of barometric altitude	It is a requirement for descent telemetry	SYS - 08,09		HIGH	x		x	x
S02	Measurement of air temperature.	It is a requirement for descent telemetry	SYS - 08,09	-	HIGH			x	x
S03	Measurement of Battery Voltage.	Requirement for Descent Telemetry and Housekeeping Data	SYS- 08,09	-	HIGH			x	
S04	GPS Location data	Descent Telemetry and determination of Landing	SYS- 08,09	-	HIGH	x		x	x
S05	Acceleration Sensor	Various events such as ejecting, mapping of motion and operational objective of landing data.	SYS – 08,09	-	MEDIUM	x		x	x
S06	Audio Beacon	It is required to retrieve the Cansat after it has landed.		-	MEDIUM				

Carrier GPS Trade & Selection

Manufacturer	Model	Dimensions	Accuracy	Mass	Power/voltage
SiRF	**StarIII GSC3f/LPx-7989**	**Length:27mm, Width: 23mm**	**5m**	**10g**	**75mw/3.3v**
Garmin	OEM GPS 15H-W	Length:30mm, Width: 30mm	4m	15g	85mw/8-40v
Global Sat	EM-406	Length:30mm, Width: 30mm	3m	23g	70mw/4.5v

SiRF GSC3f GPS Sensor

GS3f GPS sensor is selected because it has much more accuracy than other sensors, also it weighs less and uses less power which are other critical parameters for the selection of GPS sensor.

Carrier Non-GPS Altitude Sensor Trade & Selection

Manufacturer	Model	Accuracy	Mass	Power/voltage	Dimensions	A/D
Motorola	**MPX6115a**	**+-1.5%**	**25g**	**0.5ma/5v**	**16.6 * 7.2mm**	**A**
Omega	PX302	0.3%	131g	97ma/10v	28.6 * 81.7mm	A
Vaisala	PTB210	+-0.25hpa	110g	55ma/6v	120mm * 30mm	D

MPX6115a Non-GPS Altitude Sensor

MPX6115a Non-GPS Altitude Sensor is selected because it weighs less, consumes less power and is smaller than other two sensors in race.

Carrier Air Temperature Trade & Selection

Product	Type	Operates in region	Accuracy
FM 75	Digital	0 – 100 degrees	+-1degree Celsius
LM 35	**Analog**	**0 – 100 degrees**	**+- 0.5 degree Celsius**

LM 35

• This temperature sensor is selected to fulfill the need of our mission because of it's more accuracy than FM75, low cost and easy availability.

• Other fact about using this sensor is that it is very simple to use it rather than using a digital temperature sensor which on other hand is expensive and not easily available.

Lander Pressure Sensor Trade & Selection

MPX6115a will act as lander pressure sensor.

Barometric pressure changes with respect to altitude and temperature

The relation between analog pressure and voltage in analog sensors is almost linear and is most of the times provided by the manufacturer

Pressure from Voltage :

P = 22.222 * V + 10.556 – (22.222*EF)

MPX6115a Pressure Sensor

Height from Pressure :

$$h(feet) = 1.4544 \times 10^{5} \times \left(1 - \left(\frac{P(\text{kPa})}{101.325\text{kPa}}\right)^{0.1902}\right)$$

Lander Impact Force Sensor Trade & Selection

Model	Dimensions	Voltage/current Normal mode	Current Power saving mode	Range	Accuracy	Sensitivity Due to temp	A/D
Analog devices ADXL345	15mm*25mm	3.3V/145uA	0.1uA	±16g	±1%	±0.01%/° C	D
Free Scale Semi-conductors MMA7260Q	**25mm*25mm**	**3.3V/500uA**	**3uA**	**± 6g**	**±5%**	**±0.03%/° C**	**A**

- The MMA7260Q was selected because it is analog and also is very much comparable to the other in all aspects.

- The ADXL345 is digital and needs to be interfaced using SPI/I2C which will are already used up by other sensors and is thus not selected.

Descent Control Design

Presenter : Prahal Ghai

Descent Control Overview

- The Descent control system will be achieved through the use of parachutes of appropriate size 20cm for carrier and 25 cm for lander and design keeping in mind the aerodynamics of the fall.
- Proper design and right choice of materials will be the backbone of the Descent Control System, as it is not an electronically controlled one extreme care and precision needs to be involved in design taking care of all possibilities.
- Both Carrier and Lander sections will have separate parachute structures of appropriate sizes to achieve the required constant descent speeds of ~ 4m/s and 5.5m/s respectively.
- While the Cansat is in the payload section , the parachutes will be closed such as to occupy an allotted space.
- After deployment from the rocket airflow will cause the parachute of the carrier to inflate and the rate of descent will be controlled by the parachute.
- At the time of separation, air flow will cause the parachutes of the lander to open but their positioning will ensure a tangle free separation.
- The spill hole at the top(3cm radius) will ensure continuous air flow through the parachute, thereby stabilizing it and ensuring descent at required speeds.

❖ All calculations have been shown in the descent rate estimation slide.

Descent Control Requirements

ID	Requirement	Rationale	Parent	Children	Priority	VM			
						A	I	T	D
DCS01	carrier and lander chutes occupy their allotted space, whatever be the orientation of the payload.	to ensure a tangle free separation, and proper fitting while in payload.	SYS – 04		HIGH				
DCS02	carrier chute size such that descent rate ~4m/s	Competition requirement	SYS- 01,04		HIGH				
DCS03	Lander chute size such that descent rate ~5.5m/s	Competition requirement	SYS- 04		HIGH			X	
DCS04	Materials used to be light and flexible.	To minimize mass and volume requirements.	SYS- 02		MEDIUM				
DCS05	The descent control system shall not use any flammable or pyrotechnic device.	Safety.			MEDIUM				

Carrier Descent Control Strategy Trade and Selection

Strategy selection

Strategy	Pros	Cons
Use of streamers	Used by us the last time, complete knowledge of the mechanics and aerodynamics involved, reliable.	Achievement of speeds as low as 4m\s difficult
Use of parachute	**Easy to design and attain required speed, low space requirement.**	**Drift(can be countered by a spill hole, affects area)**

Material selection for parachute design

1. Silk- thin, light and easy to fold but expensive and not as elastic as nylon
2. **Rip stop Nylon cloth - Due to property to block air , easy availability and good elasticity.**

Strings to control shape : **Nylon strings – High strength , easy to use and light.**

Lander Descent Control Strategy Trade and Selection

Strategy selection

Strategy	Pros	Cons
Use of streamers	Used by us the last time, complete knowledge of the mechanics and aerodynamics involved, reliable.	Achievement of speeds as low as 5.5m\s difficult
Use of parachute	**Easy to design and attain required speed, low space requirement.**	**Drift(can be countered by a spill hole, affects area)**

Material selection for parachute design

1. Silk- thin, light and easy to fold but expensive and not as elastic as nylon
2. **Rip stop Nylon cloth - Due to property to block air , easy availability and good elasticity.**

Strings to control shape : Nylon strings – High strength , easy to use and light weight.

Descent Rate Estimates

As both our carrier and lander are working on a parachute based descent mechanism, the size of the parachutes is fixed by calculation from the following relation.

$$r = \text{sqrt}(\ (2\ m\ g)\ /\ (\boldsymbol{\pi}\ p\ \ C_d\ v^2)\ )$$

where,

π = 3.14159265359

ρ = 1.146 kg/m^3 (density of air at 35 °C)

C_d =1.5 (drag coefficient of the chute for a hemisphere chute)

v =terminal velocity achieved (from mission required)

r = radius of the chute

g = acceleration due to gravity

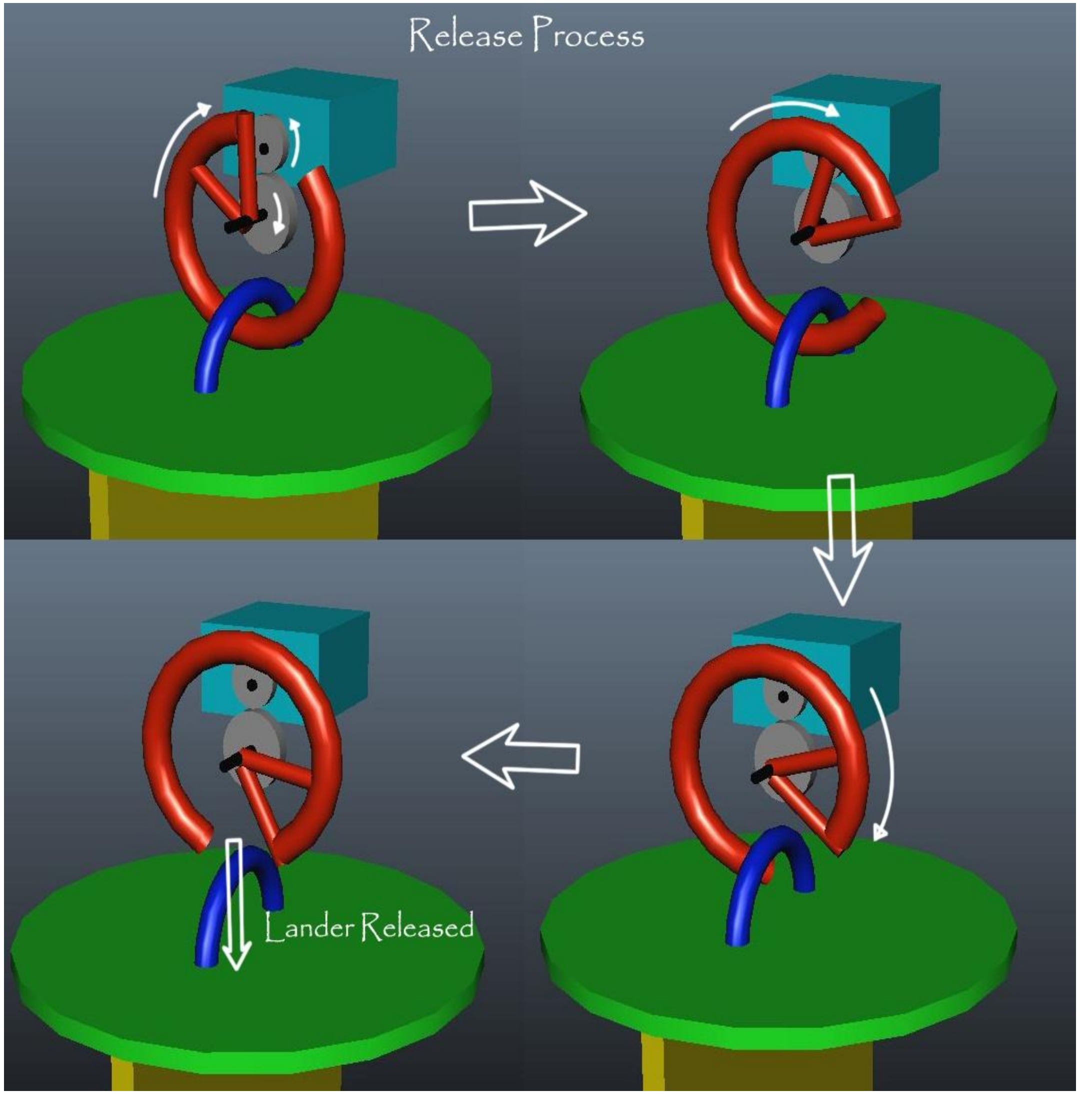
Descent Rate Estimates

RESULTS

Component	Mass	Velocity	Radius(before spill hole consideration)	Final radius(after spill hole, C_d consideration)
Carrier	212gm	3 to 5 m/s	17 to 28cm	28 cm
Lander	273gm	4.5 to 6.5m/s	15 to 23cm	25cm

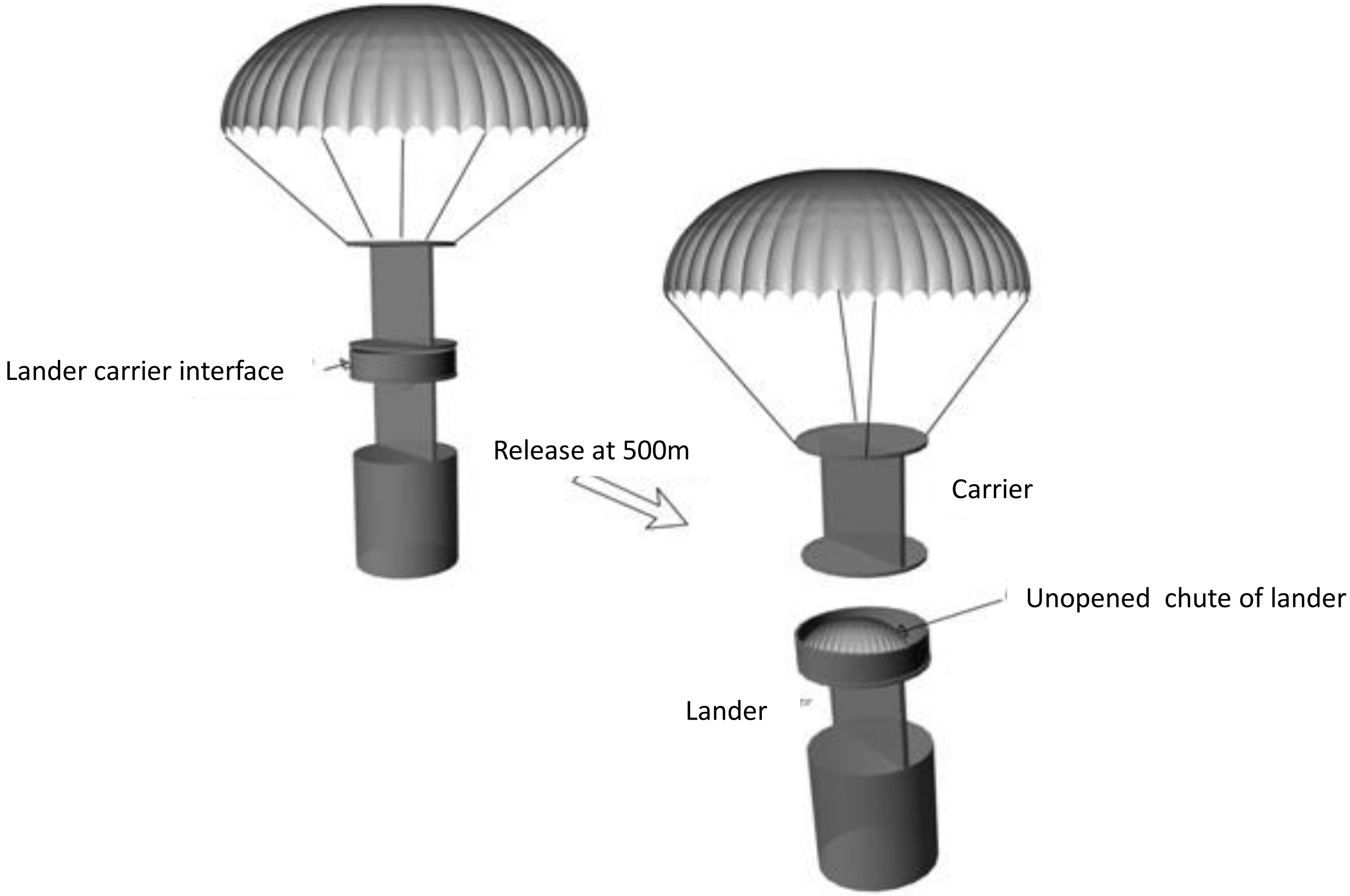
- C_d will not be 1.5 as parachute will not be completely hemispherical.
- Introduction of spill hole stabilizes the cansat by allowing air to flow but increases the rate of descent hence, maximum radius of parachutes is being preferred
- The radius of the spill hole(3cm) has been finalized by some tests performed from a height of ~50m and some extrapolation such that it will work well at a height of ~1500m as well.
- Before separation both the carrier and lander will be supported by the carrier parachute, mass m will be(212+323) is 535gm the descent velocity will be 6.5 m/s

Lander detachment strategy



Lander detachment strategy

The image below shows position of the parachutes at different times during the flight.



Mechanical Subsystem Design

Ramakrishna Vedantam S

Mechanical Subsystem Overview

- The major components of the cansat are the egg carrier or container, the carrier circuit , the lander circuit and the sensor arrangement.
- The egg container has the lander circuit placed on it. This is covered by folded lander parachute. A hook holds the carrier and the lander together. The release mechanism and the carrier circuitry complete the arrangement.
- The entire body skeleton is made of **aluminium**.
- Sensors are placed appropriately so as to achieve optimum space and functional efficiency.
- Carrier and lander are interfaced using a motor-hook system.

Mechanical System Requirements

ID	Requirement	Rationale	Parent	Priority	VM			
					A	I	T	D
MS01	Total mass of the Cansat will not be more than 500gms excluding egg	There is always a finite limit of the mass that can be put into space	SYS -01	HIGH		x	x	
MS02	Cansat will fit in a cylindrical envelope of 72mm diameter and 279 mm in length	Payload structure dimensions are influenced by launch vehicle characteristics	SYS -02	HIGH		x		
MS03	There will be no protrusions until Cansat deployment from rocket payload	Payload structure dimensions are influenced by launch vehicle characteristics	SYS -02	HIGH		x		
MS04	Cansat and egg placed inside should be recovered safely.	Structure should be able to withstand vibration shocks and protect the egg from breaking.		HIGH			x	x
MS05	Placement of GPS Antenna , Transceiver Antenna	Placement of Sensors and Antennas have to be appropriate for proper Transmission and Reception	SYS-08,09	MEDIUM			x	x
MS06	Ensure smooth detachment of the lander and the carrier at a height of 500m.							

Egg Protection Trade and Selection

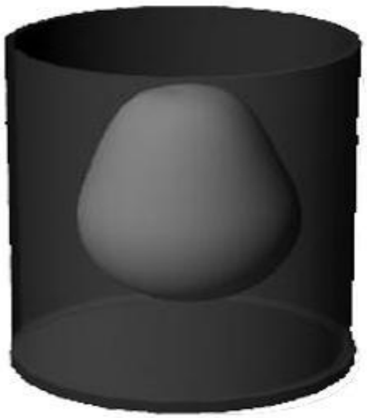
Egg is best protected in the following conditions -

•An ***Aluminum container*** is used for carrying the egg. The rationale of using aluminum is as follows:

Material	Density (gms/cc)	Tensile strength (GPa)	Cost per square meter	Availability
Aluminum	**2.7**	**90**	**59.74 $**	**Easily available**
Carbon Fiber	1.75	3.5	651 $	Facility not yet identified
Steel	7.9	1.3	52.31 $	Difficult

•The container is stuffed with ***polystyrene balls*** with egg in the middle.
• Sponge and paper cushions were also considered but rejected based on test observations (Refer : Egg drop test In Integrated test section).
•Polystyrene balls provide the required cushioning to protect the egg. Polystyrene balls are inexpensive, light weight and easily available

Egg Protection Trade and selection



Images showing the egg container region of the structure

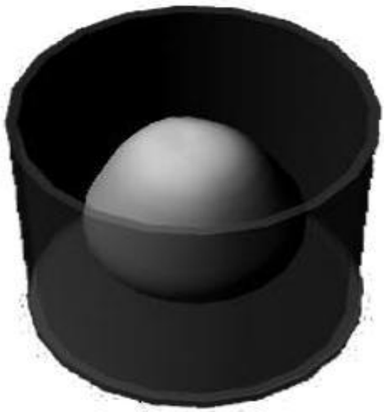
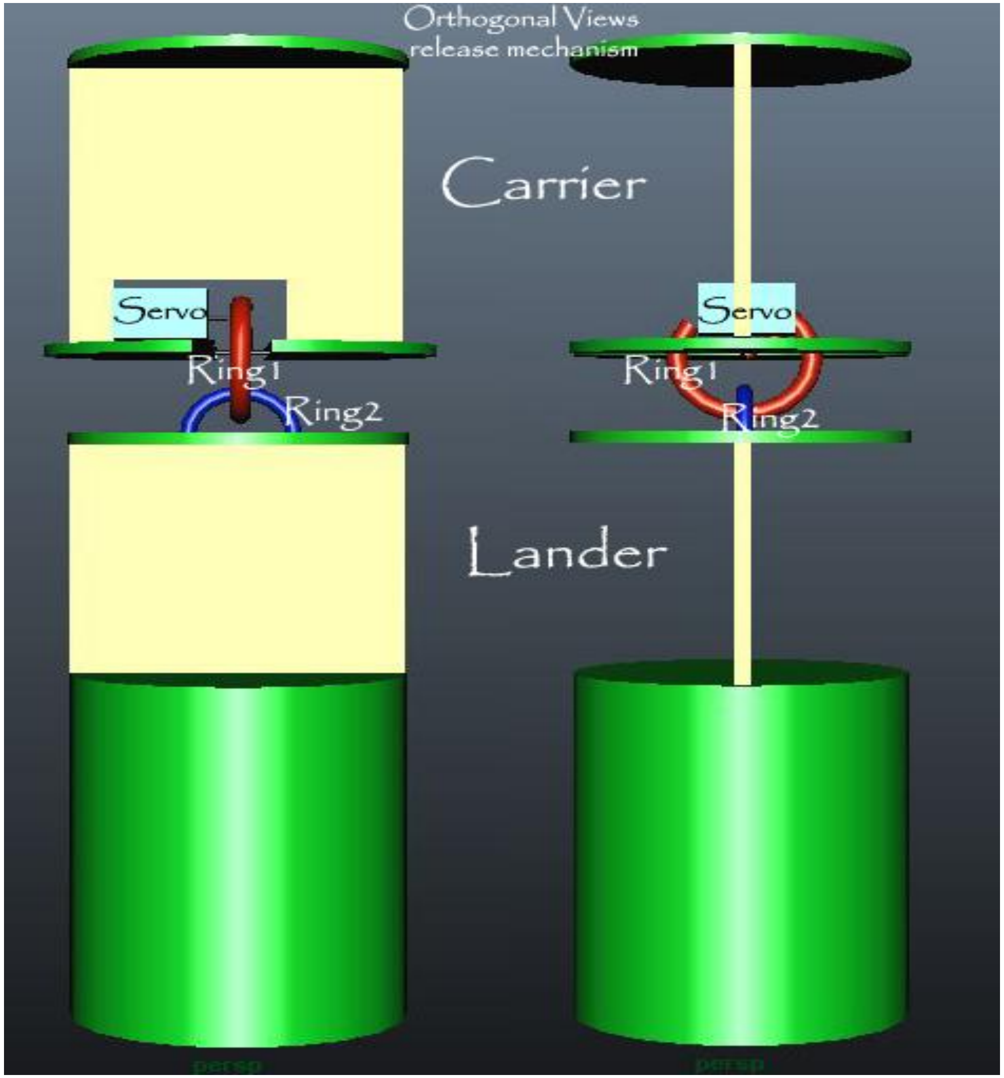


Image shows the egg surrounded by Polystyrene balls

Carrier-Lander Interface

- The lander will be connected to the carrier via a hook oriented horizontally. The hook will be moved using the servo when the release sequence is to be performed.

- The release of the hook results in the opening of lander parachute.



Mechanical Layout of Components Trade & Selection

- The Battery and the rest of the electronics have been placed on opposite sides in both carrier and lander to ensure that center of mass remains near the center of the structure for proper balance.
- The motor-hook arrangement is placed at the center of the CanSat cross-section for smooth release.
- The egg container is placed at the bottom , on top of it is the lander electronic section and above it, interfaced using motor – hook mechanism is carrier.

Estimated Mass Budget

Carrier	Weight (gm)
mass of skeleton (carrier)	52
mass of pcb(including microcontroller, temp.sensor)	23
total mass of electronics	84
battery	53
parachute	20
total carrier mass	232

Lander	Weight(gm)
mass of lander skeleton	140
mass of electronics	25
Parachute	30
Egg and cushioning	55
Battery	53
Total Lander mass	303

Total Mass	535
Total mass (excluding egg)	485

Communication and Data Handling Subsystem Design

Presenter : Jasmeet Singh

CDH Overview-1

- **Carrier**
  - Processor: AtMega 128 (As Central Processing Unit of the Carrier; sensing, processing, transmitting, storing telemetry data)
  - Memory: Atmel0736 (For storing telemetry data onboard for backup in case of communication failure)
  - Radio Transceiver: Laird AC4790 Transceiver (For transmitting data to ground station once every 2 seconds)
  - Antennae: S467XX-915S (2.0dBI)

CDH Overview-2

- **Lander**
  - Processor: AtMega 128 (As Central Processing Unit of the Lander; sensing, processing, storing sensor data;
  - Memory: Atmel0736 (For storing telemetry data onboard the lander for post processing)
- **Ground Station**
  - Processor: AtMega 128 (For receiving and decoding received telemetry data from carrier)
  - Radio Transceiver: Laird AC4790 Transceiver (For receiving data from the carrier once every 2 seconds)
  - Antennae: S467XX-915S (2.0dBI)

CDH Requirements-1 (CARRIER)

ID	Requirement	Rationale	Parent	Priority	VM			
					A	I	T	D
CDH01	Transmit GPS Data Stream	Descent Telemetry packet (transmitted every 2 seconds)	SYS -08 CD-01	HIGH			x	x
CDH02	Transmit Altitude in meters	Descent Telemetry packet (transmitted every 2 seconds)	SYS-08 CD-01	HIGH			x	x
CDH03	Transmit Air Temperature in Celsius	Descent Telemetry packet (transmitted every 2 seconds)	SYS-08 CD-01	HIGH			x	X
CDH04	Transmit Battery Voltage in Volts	Descent Telemetry packet (transmitted every 2 seconds)	SYS-08 CD-01	HIGH	x		x	x
CDH05	Terminate Telemetry	Terminate Telemetry within 5 minutes of landing.	SYS-08,09 CD-01	HIGH	x		x	x
CDH06	Store Telemetry Data	For Post Processing in case of Communication Failure	SYS-11	LOW				

CDH Requirements-2 (LANDER)

ID	Requirement	Rationale	Parent	Priority	VM			
					A	I	T	D
CDH06	Store Lander Altitude Measured	Descent Telemetry packet (stored every 2 seconds)	SYS-11	HIGH			x	x
CDH07	Store Lander Battery Voltage	Descent Telemetry packet (stored every 2 seconds)	SYS-11	HIGH			x	x
CDH08	Storing the Impact Force	Impact Force (Stored when lander hits the ground)	BONUS	HIGH				
CDH09	Send stored descent telemetry to Ground Control	For post-processing following retrieval of Lander	SYS-11	HIGH			x	X

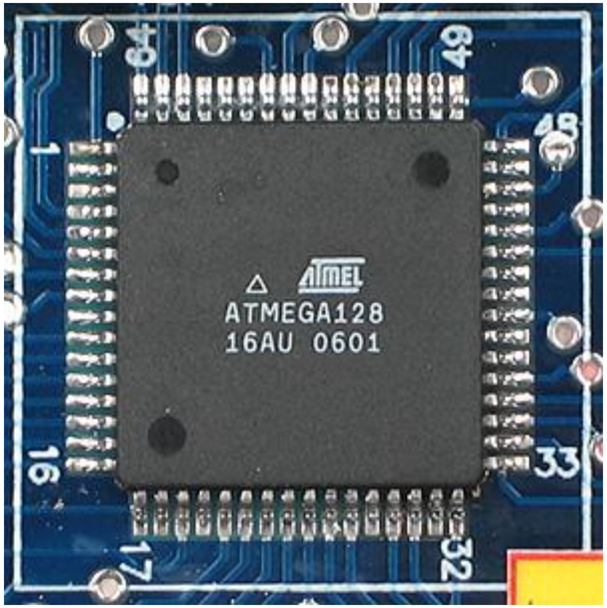
CDH Requirements-3 (GROUND STATION)

ID	Requirement	Rationale	Parent	Priority	VM			
					A	I	T	D
CDH09	Receive GPS Data Stream	Descent Telemetry packet Receive every 2S	CD01	HIGH			x	x
CDH10	Receive Altitude in meters	Descent Telemetry packet (received every 2 seconds)	CD01	HIGH			x	x
CDH11	Receive Air Temperature in Celsius	Descent Telemetry packet (received every 2 seconds)	CD01	HIGH			x	X
CDH12	Receive Battery Voltage in Volts	Descent Telemetry packet (received every 2 seconds)	CD01	HIGH	x		x	x
CDH13	Terminate Telemetry	Terminate Telemetry within 5 minutes of landing.	CD01	HIGH	x		x	x

Processor : Trade & Selection-1

Carrier: AtMega 128

- **Maximum Clock Frequency 16 MHz (external)**
- **Data Interfaces:**
  - USART: 2 (One for Transceiver and one for GPS)
  - SPI: 1(For memory)
  - ADC PORTS: 8 channels(one each for battery voltage, temperature sensor and pressure Sensor)



- **On chip Flash Memory: 128 Kb**
- **SRAM / EEPROM: 4 Kb**
- **Supply Voltage: 4.5V – 5V**

Processor : Trade & Selection-2

Lander: AtMega 128 (Will save design time to design another PCB, so carrier PCB will work for lander too, Other controllers were considered but not much different in cost and other factors was observed so this was selected due to its high functionality**)**

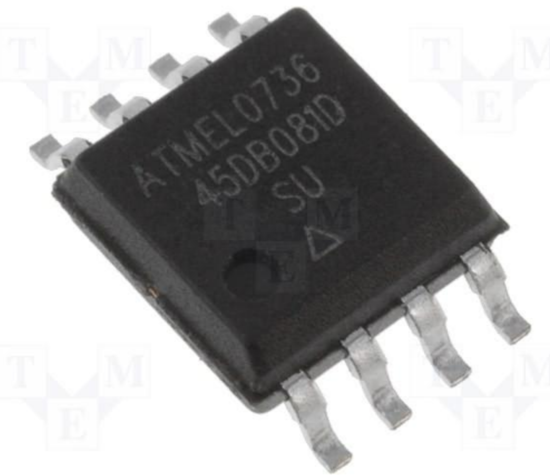
- **Maximum Clock Frequency 16 MHz (external)**
- **Data Interfaces:**
  - SPI: For memory
  - PORTS: 8 channels(one each for Battery voltage, accelerometer and pressure sensor)
- **On chip Flash Memory: 128 Kb**
- **SRAM / EEPROM: 4 Kb**
- **Supply Voltage: 4.5V – 5V**

Memory : Trade & Selection

- **If 5 minutes of Descent Telemetry(carrier) sampled at 2 seconds**
  5* 60 * (50 bytes) / 2 ~= 7.5 Kb
- **For lander, 5 minutes of height and battery voltage data sampled at 2 seconds:**
  5* 60 * (10 bytes) / 2 ~= 7.5 Kb
- **If Acceleration Data is calculated with 100 samples per second :**
  5 * 60 *100 ~= 30 Kb
- **Totally it adds up to at least 7.5 Kb for carrier and 31.5 kb for lander.**

The same memory chip is used for both Lander and carrier.

- **Atmel Memory chip**
  - 8 MB, SPI Mode, Chip Select Available



Carrier Antenna Trade & Selection

- **The Antenna had to be matching for the range of 900 – 928 MHz (900 MHz ISM)**
- **Have preferably an MMCX connector against SMA,BNC or TNC .**
- **High Decibel Gain**
- **VWSR less than 2.0 : 1**
- **Half Wave Dipole and Omni Directional**

- **Antenna Chosen: S467XX-915S (2.0dBI)**

Communications Configuration

Transceiver programmed for API control Mode

Fixed baud rate of 57600 bps , channel 0 in Receive mode for query wait

Transmit when asked for a query, through UDR buffer

The system in API mode set at fixed baud rate and channel transmits and receives through a 3 byte MAC address which can either be hard coded on the EEPROM or sent dynamically.

Carrier Telemetry Format

Characters	Definition
hhmmss	Data time tag in hours , minutes and seconds
AA.aaaa	Cansat latitude
N	Start of latitude data
BB.bbbb	Cansat Longitude
W	Start of longitude data
hh.hh..	Cansat GPS altitude
Ab	Number of satellites tracked in decimal
hh.hh..	Altitude via non GPS sensor(meters)
tt	Air temperature (1 degree resolution)
vv.vv..	Battery voltage

- **Data sent every 2 seconds with baud rate of 57600 bps.**
- **Data Format: Data Format will be finalized in CDR**

Autonomous Termination of Transmissions

- **To terminate telemetry:**
  - This will be done via a check in the loop which compares the altitude from GPS data to altitude from several previous data packets. If the altitude remains same for a certain amount of time, we conclude that the carrier has landed and that its time to stop sending the telemetry.
  - The GCS will recognize the end of telemetry by the special custom occurrence of 99 satellites tracked in the last incoming data packet.

Locator Device Trade & Selection

- We are not yet decided on the exact locator device which we will be using, but a list of locator devices considered so far is –

Name	Size	Power consumption	Cost	Availability
CMS0341KLX	3.4cm x3.4cmx1.5cm	20 W	7 $	Easily available
JS-666	0.8cm*3cm*3.8 cm	0.5W	10$	Facility not yet identified

- The problem with both of them is that one high power consuming and the other is not available easily. We are searching for other options.
- Locator device will be controlled using microcontroller, but will aslo have an external switch, thus will enable us to switch it off upon recovery.
- Both carrier and lander shall have same locator device.

Electrical Power Subsystem Design

Presenter : Neeraj Pradhan

EPS Overview

Design Considerations	• All the power and electrical requirements are met.
Voltage Regulation	• Level-shifting and voltage regulations for using two different voltage regulators each corresponding to 5v and 3.3v.
Power Monitoring	• Done by additional hardware

EPS Requirements For Cansat System

ID	Requirement	Rationale	Parent	Priority	VM			
					A	I	T	D
EP01	Voltage Requirement (5V, 3.3V)	• 5V required for MicroController and Pressure, Temperature Sensor, Servo. • 3.3V for Memory, GPS and Transceiver.		MEDIUM			x	x
EP02	Battery Requirement (9V)	To be able to provide adequate power for the whole period of flight.	EP01	MEDIUM		x		
EP03	Measurement Accuracy and Resolution (0.008V)	Voltage has to be measured and stored.		MEDIUM		x		

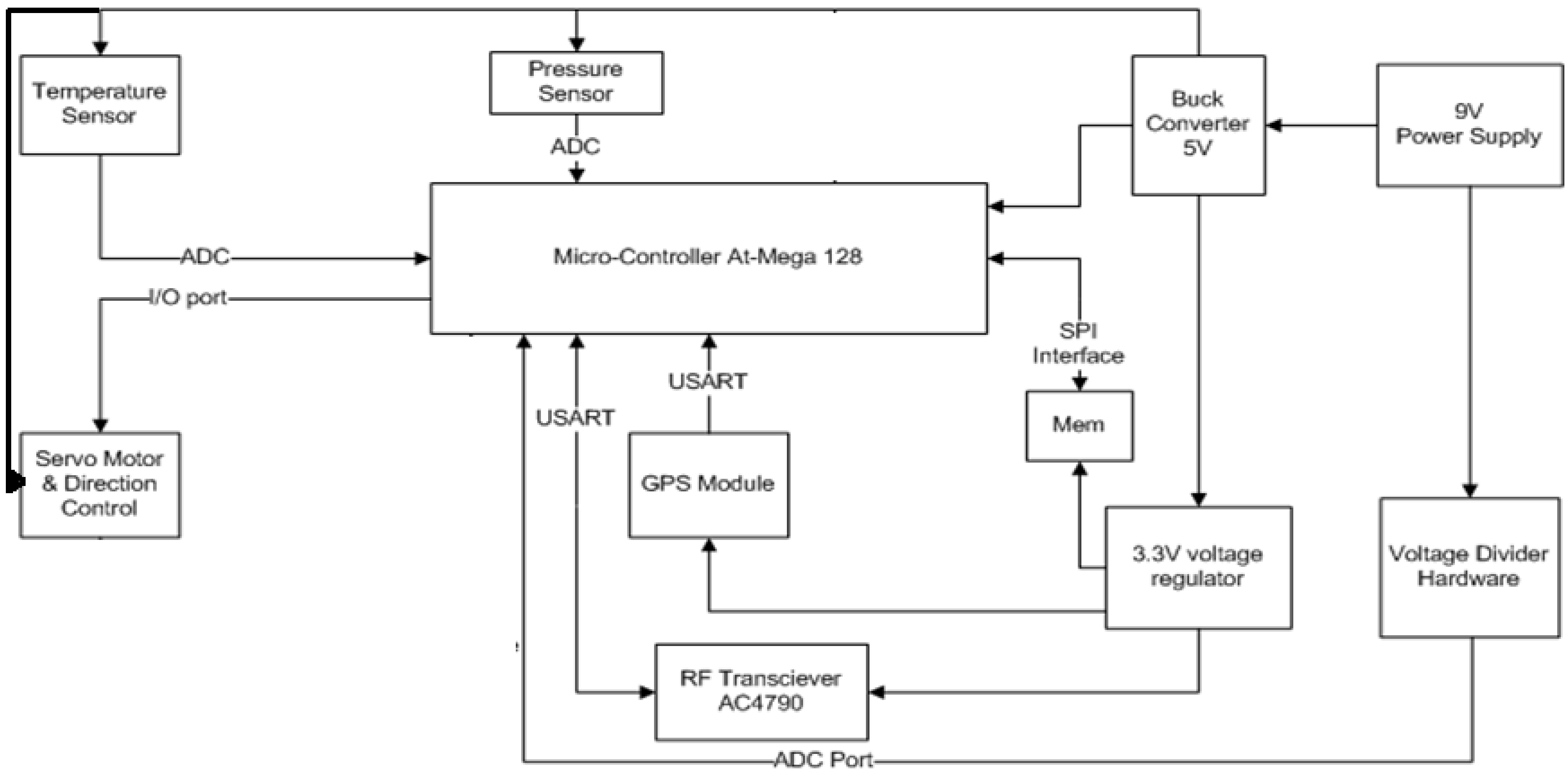
EPS Requirements For Carrier

ID	Requirement	Rationale	Parent	Priority	VM			
					A	I	T	D
EP01	Voltage Requirement (5V, 3.3V)	• 5V required for MicroController and Pressure, Temperature Sensor, Servo. • 3.3V for Memory, GPS and Transceiver.	-----	MEDIUM			x	x
EP02	Battery Requirement (9V)	To be able to provide adequate power for the whole period of flight.	EP01	MEDIUM		x		
EP03	Measurement Accuracy and Resolution (0.008V)	Voltage has to be measured and stored.	-----	MEDIUM		x		

EPS Requirements For Lander

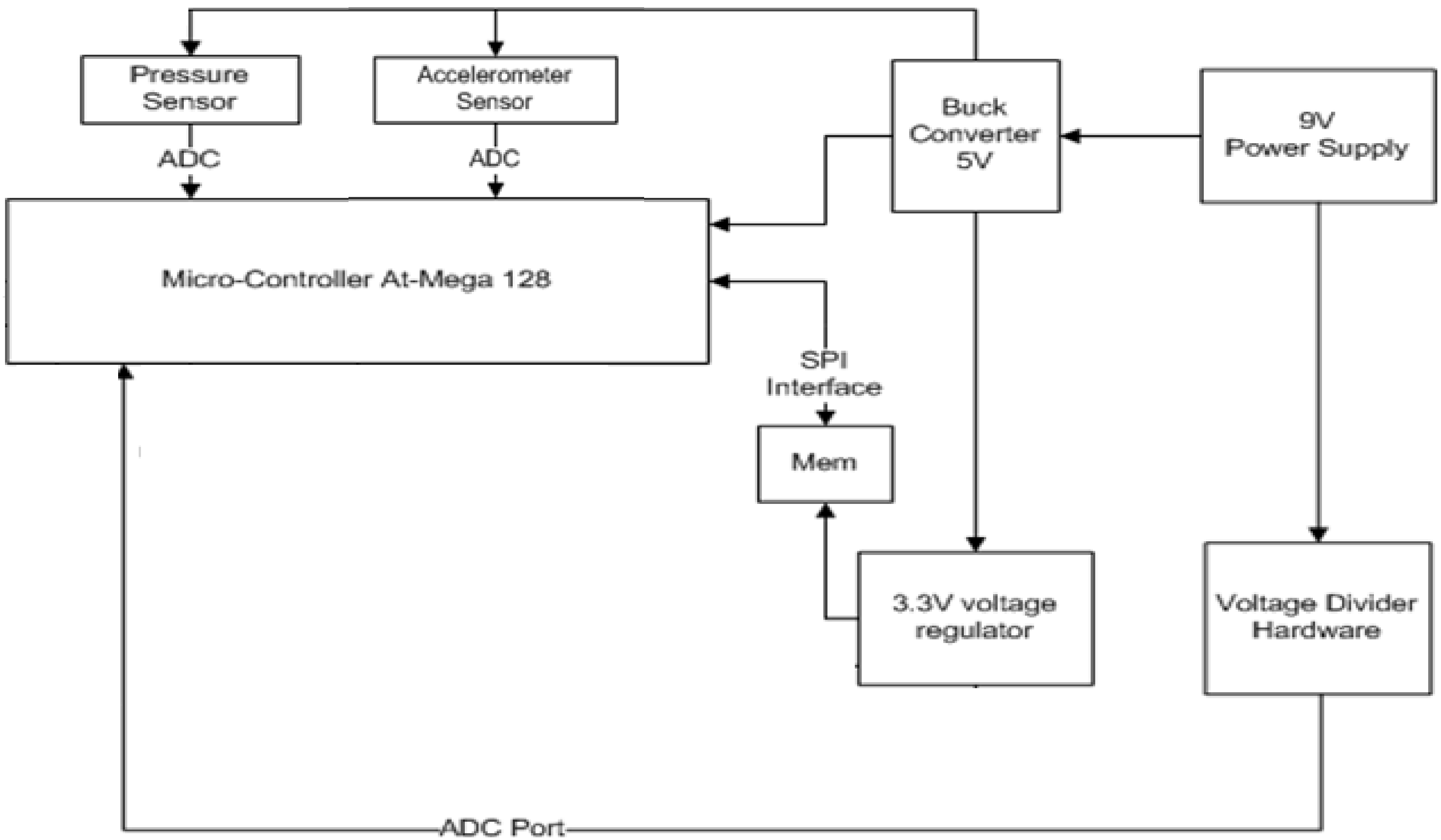
ID	Requirement	Rationale	Parent	Priority	VM			
					A	I	T	D
EP01	Voltage Requirement (5V, 3.3V)	• 5V required for MicroController and Pressure, Temperature Sensor. • 3.3V for Memory.	-----	MEDIUM			x	x
EP02	Battery Requirement (9V)	To be able to provide adequate power for the whole period of flight.	EP01	MEDIUM		x		
EP03	Measurement Accuracy and Resolution (0.008V)	Voltage has to be measured and stored.	-----	MEDIUM		x		

Carrier Electrical Block Diagram



External Power Switch will be present to control the power flow in the system. Battery Voltage will be read using microcontroller.

Lander Electrical Block Diagram



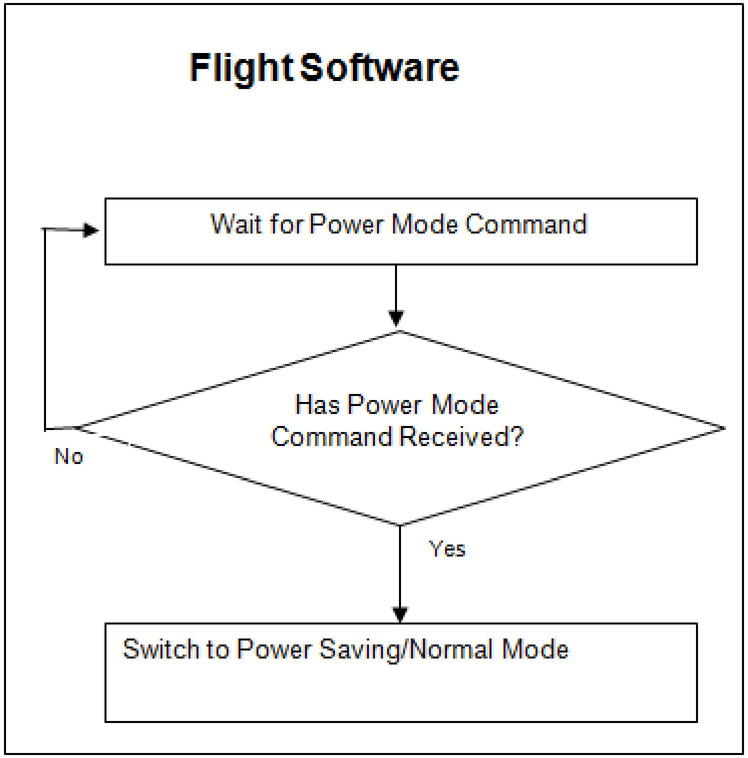
External Power Switch will be present to control the power flow in the system. Battery Voltage will be read using microcontroller.

External Power Control without disassembling CANSAT

- Idle Mode: In this mode of the processor would disable the CPU and the MEMORY by switching off the clk_cpu and clk_flash but the USART, ADC and SPI keep working which would save power.

- Power down Mode: In this mode we can switch off the ADC clock and the USART locks to save power.

- Simple LED indication of power on/off status with an external push button may be added



Carrier Power Budget

Device	Average Power consumption (Watts)	Voltage	Average Current	Usage in 3.5hrs
GPS	72.64mW	3.3v	22.7 ma	100%
Pressure Sensor	2.5mW	5v	0.5ma	100%
Temperature Sensor	5mW	5v	1ma	100%
Transceiver RF	0.214 W	3.3v	65ma	100%
Microcontroller	0.11 W	5v	28ma	100%
Flash memory	71.5mW	5v	14.3ma	100%
Buck Convertor 5v			**92% eff**	
Buck converter 3.3v			**90% eff**	
Voltage divider H			**Negligible**	
Servo Motor		5v		One Time

Lander Power Budget

Device	Average Power consumption (Watts)	Voltage	Average Current	Usage in 3.5hrs
Pressure Sensor	2.5mW	5v	0.5ma	100%
Microcontroller	0.11 W	5v	28ma	100%
Flash memory	71.5mW	5v	14.3ma	100%
Buck Convertor 5v			**92% eff**	
Buck converter 3.3v			**90% eff**	
Voltage divider H			**Negligible**	

Total Power Budget

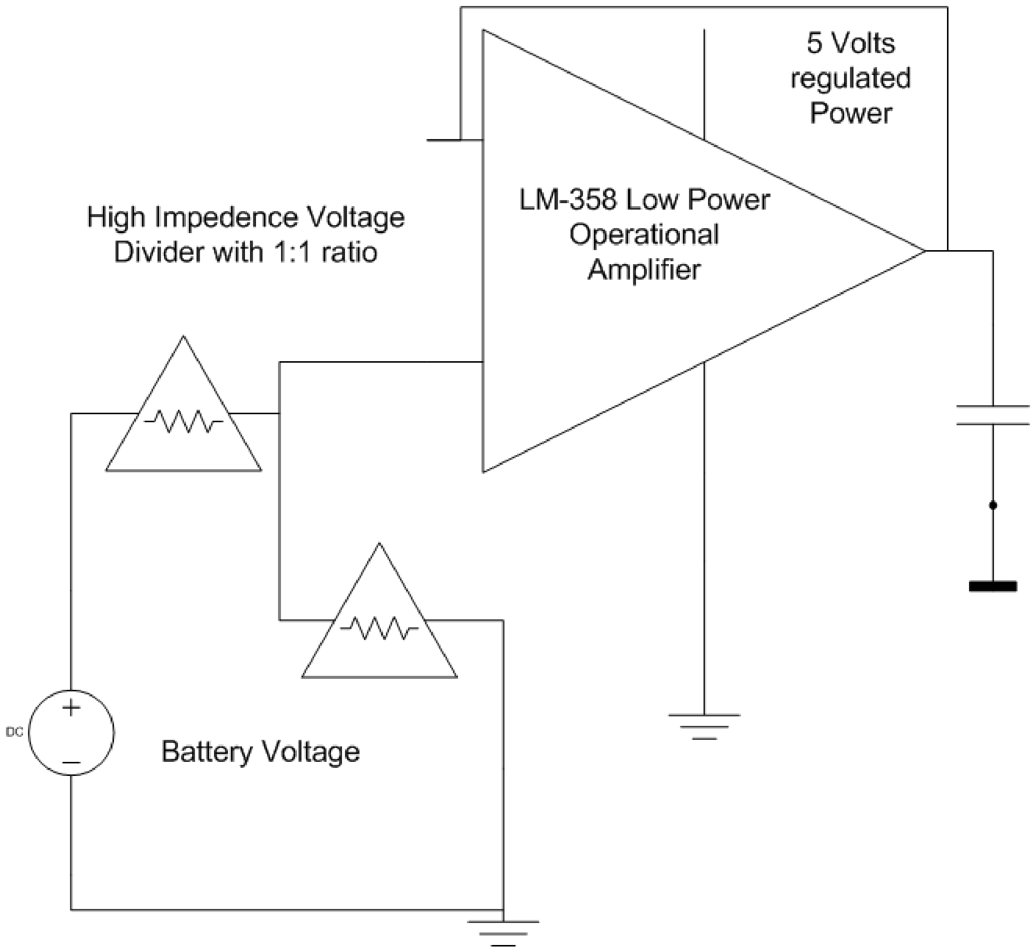
- **Total Power used by main components is 475.64mWh(Carrier) and 184mWh(Lander).**
- **Voltage loss of 90% efficiency in 3.3v and 92% in 5v for Buck Convertors**
- **Battery life: 3.85 hours (approx)**

Power Source Trade & Selection

Name	Voltage/Power	Type	Mass
6F22 Heavy duty	9v / 500mah	Alkaline	45g
UBP 001	3.7v/1800mah	Lithium Ion	41g
Dura Cell	**9.6v/ 230mah**	**Ni Mh**	**47g**

We are using Dura Cell for both Carrier and Lander as it is most easily available and Highly efficient for the purposes required.
Although we are thinking of switching to CR2430 Lithium Button Rechargeable Cells for Lander.

Battery Voltage Measurement Trade & Selection



- Battery Voltage is measured by giving a high impedance voltage divider with outsourcing and then interfaced to the ADC port.
- We use the same circuit for both Lander and Carrier.

EPS Testing Overviews

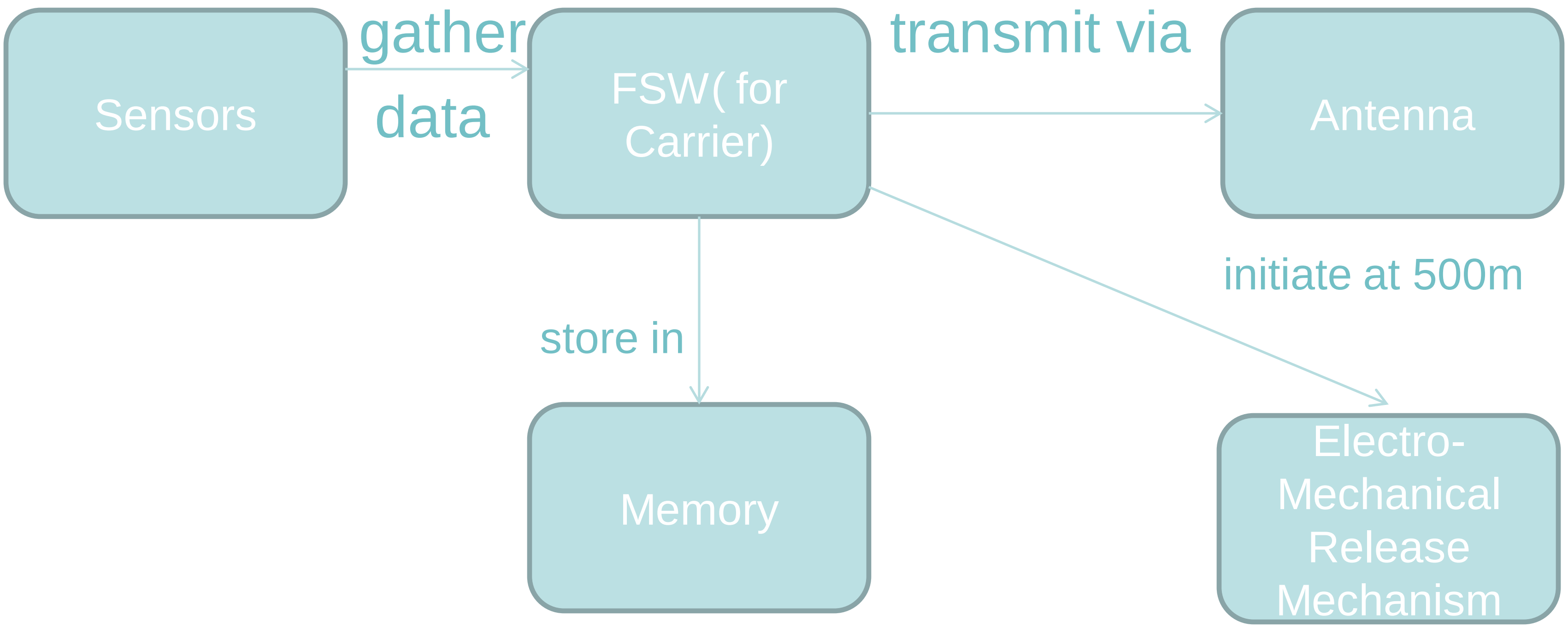
Power Regulation	• Testing of Buck Converter based Regulators 1 week post PDR
Lab Power Testing	• 1 week prior to CDR
On Field Power Testing	• Post CDR

Flight Software Design

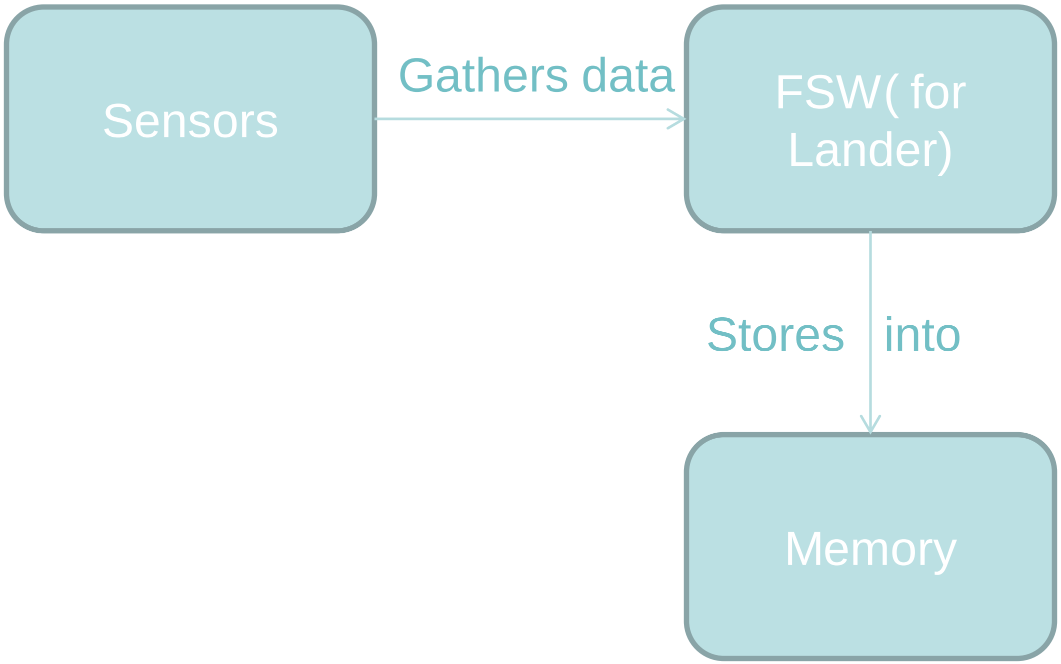
Nikhil Soni

FSW Overview

- The FSW will work in a Microcontroller(Atmega128). There will be separate FSW's for the lander and the carrier. Its basic structure will be as follows:



Basic Structure: FSW for Lander



FSW Overview

- The FSW for the carrier will collect data from all the sensors and store it onto the onboard memory. It will also transmit the collected data via the Antenna.
- It will also initialize the Electromechanical Mechanism used to release the lander from the carrier at the height of 500 meters.
- The FSW for the lander will collect data from the altitude sensor and the impact sensor and store it onto the onboard memory so as to be analyzed later.
- Complete FSW will be developed in C with an AVR GCC environment. All C programs are compiled and dumped as HEX codes in ATMEL microcontrollers which forms the embedded platform of our CANSAT. We have chosen this platform because we are familiar with it as it is a part of our curriculum.

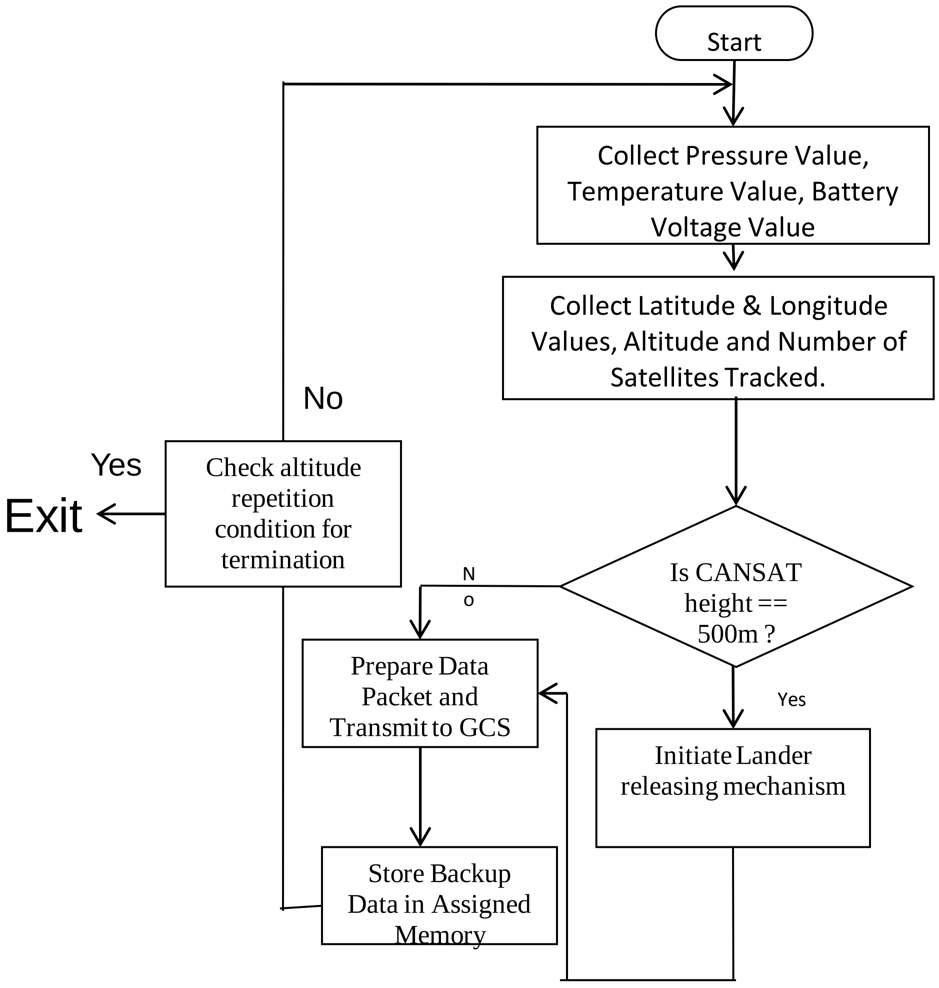
FSW (Carrier) Requirements

ID	Requirement	Rationale	Parent	Priority	VM			
					A	I	T	D
FSC01	Collection of Sensor data in processor and formation of packet	Reception of data values from sensors and analysis in firmware to produce data packets	CD01	HIGH	x		x	x
FSC02	Data packet to be sent to RF Transceiver via USART.	Packet sent for Transmission to Relay	CD01	HIGH			x	x
FSC03	Packets sent also stored as Data backup.	Packet also sent to memory for Data-packet backup.	CD01 CD04 CD06	LOW				x
FSC04	Control the Release mechanism of the lander	So that the lander can be released at height of 500 meters	CD03	LOW	x		x	x

FSW (Lander) Requirements

ID	Requirement	Rationale	Parent	Priority	VM			
					A	I	T	D
FSL01	Collection of Sensor data in processor and formation of packet	Reception of data values from sensors and analysis in firmware to store heights and impact force	CD01	HIGH	x		x	x
FSL02	Packets stored as onboard memory.	Data can be retrieved from memory for later analysis.	CD01 CD04 CD06	LOW				x

Software (Carrier) flow diagram(High Level)



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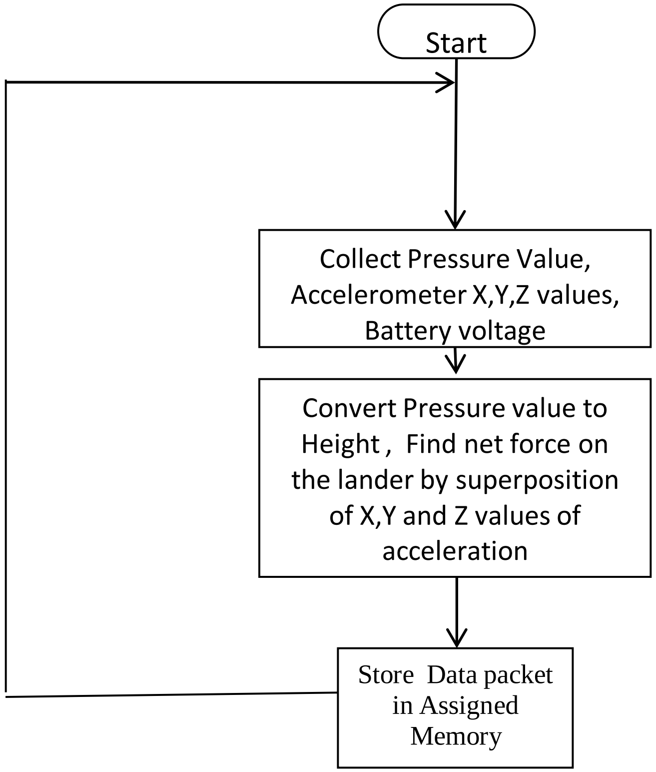
Sensors

- **Pressure Sensor:**
  - » Interfaced via ADC
  - » sampled at 50kHz
- **Temperature Sensor:**
  - » Interfaced via ADC
  - » sampled at 50kHz.
- **Battery Voltage Sensor:**
  - » Interfaced via ADC
  - » sampled at 50kHz.
- **GPS:**
  - » Interfaced via USART at 4800bps
  - » sampled at 1Hz.
- **Memory : Memory chip is interfaced via SPI**

A total of 7.5 KB of data is stored for a flight time of 5 minutes.(Calculation of memory consumed is shown in CDH

Software (Lander) flow diagram(High Level)



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Sensors

- **Pressure Sensor:**
  - » Interfaced via ADC
  - » sampled at 50kHz
- **Battery Voltage Sensor:**
  - » Interfaced via ADC
  - » sampled at 50kHz.
- **Accelerometer X,Y and Z:**
  - » Interfaced via ADC(3 ADC ports)
  - » sampled at 100Hz.
- **Memory :** Memory chip is interfaced via SPI

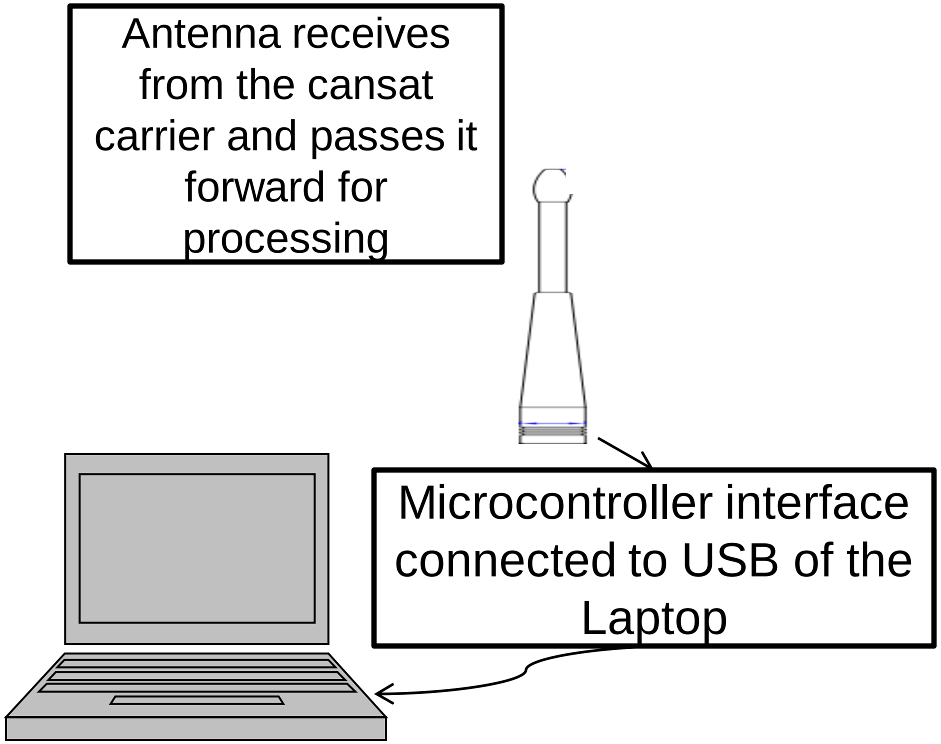
A total of 90 KB of accelerometer data is stored for a flight time of 5 minutes.

A total of 1.5 KB of sensor data is stored for a flight time of 5 minutes.

Ground Control System Design

Presenter : Palash Jain

GCS Overview



GCS uses the data received to populate various tables and plot graphs. The software clearly indicates the phases of flight, i.e. pre-launch, moving upwards, deployment, coming down, landed etc..

GCS Requirements

ID	Requirement	Rationale	Priority	Parent	Children	VM A	VM I	VM T	VM D
GCS01	Antenna placement : Antenna must point upward, towards the cansat	For better signal reception.	Medium	None	GCS02 GCS03			X	
GCS02	Computational requirements : Data is received at 0.5 Hz.	Computational speed is not a big issue. (Assuming GCS laptop has a reasonably fast processor)	Low	GCS01	None			X	
GCS03	Power Requirement : Should be able to receive and display data for about 4 hrs.	GCS has to be ready always for the communication. Not a big issue as ample power is available.	Medium	GCS01	GCS05			X	
GCS04	Analysis Software requirements : Should support Java, C/C++.	To be able to run analysis software.	High	None	None		X	X	
GCS05	Mission operations : Includes the detection of various phases by the GCS	To be able to distinguish between various states of flight.	Medium	GCS03	None			X	

GCS Antenna Trade & Selection

Name	Range	Gain	Radiation Direction	Mass
Antenova B58124	1 Km	1.8dB	Omni	2g
S467XX-915S	**5 Km**	**2.0dB**	**Omni**	**21g**

The first one is small easy to accommodate and light weight, but lacks in providing the required range hence communication fails, which is an extremely important objective of the cansat mission. Thus we select the one which gives us the required range.

CanSat Integration and Test

Presenter : Palash Jain

Integration of CANSAT subsystems

- **Integration of Carrier and Lander**
  - We used a servo motor to control a hook that holds the Lander and the Carrier.
- **Integrations in Carrier**
  - EPS, SS, CDHS and DC
    - On one side frame there will be the PCB while on the other side there will be the battery. They both will be attached to the base frame structure and the power supply to the PCB will be provided by this battery source.
- **Integrations in Lander**
  - EPS and SS
    - Just like Carrier the Lander will also have PCB and battery source on either side of the frame but it will also have the egg container. Above this container only, the PCB and battery source will be kept.

Tests Performed

- **Sensor Testing**
  - The sensor are same as we us we used in last year. They all are tested and are working fine.

    The sensors are :-

    ✓Temperature Sensor (LM35)

    ✓Pressure Sensor (MPX6115A)

    ✓Accelerometer (MMA7260Q)

  GPS Sensor (GSC3) is also used. We are facing little difficulties with the last year's GPS. It is currently under test and will be procured soon if it doesn't work.

Tests Performed

Mechanical Testing

- Egg drop tests (To decide the cushioning material and parachute size)
  - Evaluated under free fall and windy conditions - *worst case analysis.*

Trial	Outer case	Inner filling	Drop Height (feets)	Velocity at Ground Level (metres/second) $V = \sqrt{2gh}$	Results
1	Coke Can	Sponge	10	7.75	FAIL
2	Aluminum container	Paper Cushion	10	7.75	PASS
3	Aluminum container	Sponge + Paper Cushion	20	11	PASS
4	Aluminum container	Sponge + Paper Cushion	40	15.5	FAIL
6	Aluminum container	Sponge + thermacol balls	20	11	PASS
7	Aluminum container	Sponge + polystyrene balls	40	15.5	Pass
8	**Aluminum container**	**Sponge + polystyrene balls**	**60**	**19**	**Pass**

Electronics Testing

- **Objective** :- Verification of the working of Motor-Hook
  - ✓ The detachment of Lander and Carrier with the help of a microcontroller and servo motor(as explained earlier) is the main motive of the test.
  - ✓ The Lander and Carrier are getting detached at various angles tested by manually tilting the structure.
  - ✓ They are also getting detached at an angle of 90degree.

Tests to be Performed

1) Communication Testing
2) Flight Software Testing
3) Detachment Testing during Flight
4) Lander Position Estimation Testing
5) Final Structure Testing

Mission Operations & Analysis

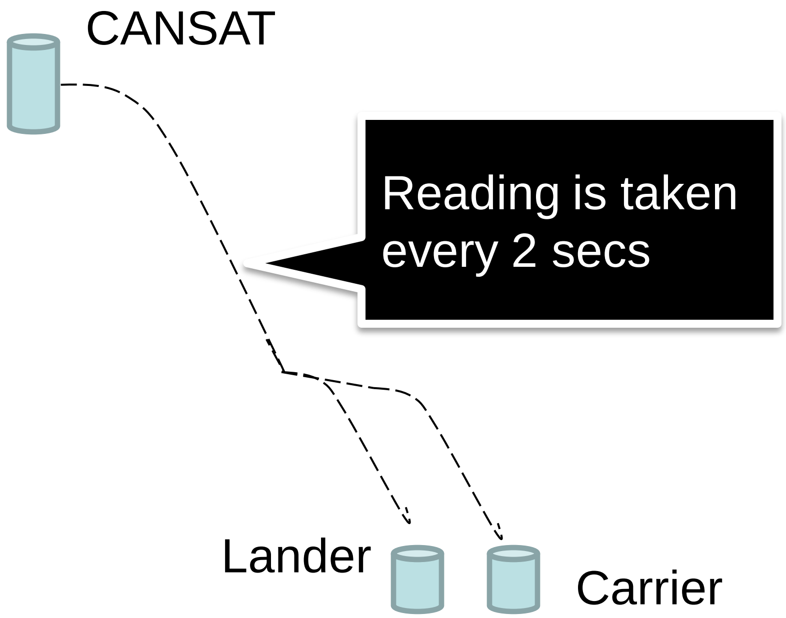
Presenter : Roopak Dubey

Overview of Mission Sequence of Events

- •**Preliminary launch-day sequence of events**
- –Arrive at the Launch site will in-time
- –Locate a workspace for the team
- –Layout the team's equipment and put up the team's banner
- –Collect the launch time schedule
- –Assemble the CANSAT carrier and lander for final check
- –Setup GCS
- –Verify communication between CANSAT and GCS
- –Collect and place the Egg in its container
- –Proceed to place the CANSAT in the payload section of the rocket
- –Post Launch – run all the GCS operations
- –On successful landing of CANSAT, proceed for recovery
- –Pack up and leave the Launch site

Lander Landing Coordinate Prediction

- DCS will keep track of GPS readings during descent.
- The sensor data will be taken after each 2 seconds. This timing is done by the onboard controller.
- After detachment the co-ordinates of Lander will be predicted on the basis of GPS readings at the carrier.
- After some Readings Trajectory of the Lander can be estimated.
- The DCS will be enabled as soon as Cansat will come out of Rocket.
- It keeps track of height using GPS.
- At 500 Meter height Lander and Carrier detach with DCS on Carrier tracking co-ordinates of Lander.
- Further Trajectory can be estimated by extrapolation.



Cansat Location and Recover

- **Lander Recovery**
  - The co-ordinates of lander will be estimated by FSW in the carrier that will help us to find the exact location of Lander on the ground. The exact method for determination of lander location is under construction. However a heuristic approach based upon GPS data is as follows :
    - We store the position of cansat before separation of carrier and lander in the memory at every 2 sec interval.. This will depict the trajectory of the cansat as it falls. This can be extrapolated taking into consideration local wind effect as altitude decreases to predict the trajectory and final position of lander.
  - The Lander will have a shiny parachute after detachment from carrier. That parachute will be helpful in spotting the lander from a far distance.

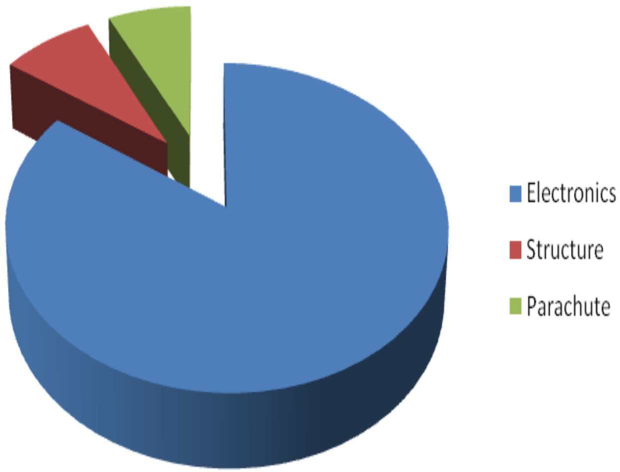
- **Carrier Recovery**
  - A buzzer will be there on carrier and it start beeping as soon as Carrier will hit the ground this will help in recovery of carrier.
  - Shiny and colorful parachute will help in spotting the carrier from far distances.
  - Telemetry data received by the GCS towards the end (when the cansat has landed) will also be used to discover the location of the carrier.

Management

Presenter : Roopak Dubey

Cansat Budget – Hardware

Component	Quantity	Unit Price (in USD)	Cost (in USD)
Atmega128 microcontroller	2	6.8	13.6
Temperature Sensor	1	0.7	0.7
Accelerometer	1	20	20
Battery	2	10	20
Mini Servo Motor	1	5	5
Circuit Fabrication	2	10	10(original) + 2(Replicate)
GPS Equipment	1	108	108
Electronics system			71.3
Structure material and Fabrication		60	60
Rip-Stop Nylon	3	18	54
Miscellaneous		20	20
Margin	15%	41.3	41.3
Total			350.7



Cansat Budget – Other Costs

Component	Cost (in USD)
Ground Control Station	1140$ (for laptop and AC4790 + antenna)
Test facilities and equipment	20$ till now
Rentals	Nil
Travel	40$
Total	1200 $

Any external financial support for the project is not yet available.

Program Schedule

Electronics Team					
Task	Scheduled Dates (dd/mm/yy)		Actual Dates (dd/mm/yy)		Reasons for not completing
1. Recognition of Tasks	1/1/11	7/1/11	1/1/11	7/1/11	
2. Allocation and Division of Tasks	8/1/11	10/1/11	8/1/11	10/1/11	
3. Identification of Systems and System Architecture	11/1/11	15/1/11	11/1/11	15/1/11	
4. Testing of Available components from previous year	15/1/11	27/1/11	15/1/11	24/1/11	
5. PDR Report and Presentation	27/1/11	31/1/11	21/1/11	31/1/11	
6. Hardware Procurement Begins	1/2/11	15/2/11			
7. Basic System Integration	15/2/11	15/3/11			
8. Work on Image Sensing and Orientation	15/3/11	25/3/11			

Program Schedule(contd.)

Electronics Team					
Task	Scheduled Dates		Actual Dates		Reasons for not completing
9. CDR PPT and PDF	25/3/11	29/3/11			
10. Accelerometer Interfacing	1/4/11	10/4/11			
11. Flight Software Development	11/4/11	25/4/11			
12. Testing of Prototype	25/4/11	5/5/11			
13. Fabrication of Final PCB	6/5/11	15/5/11			
14. Field Testing of Hardware with System	16/5/11	5/6/11			
15. Flight Operations Preparation	6/6/11	11/6/11			

Mechanical Team Schedule

Mechanical and Descent Control Team					
Task	Scheduled Dates		Actual Dates		Reasons
1. Recognition of Tasks	1/1/11	15/1/11	1/1/11	15/1/11	
2. Egg Canopy Design	16/1/11	20/1/11	16/1/11	20/1/11	
3. Egg Landing Test on Materials	20/1/11	25/1/11	23/1/11	25/1/11	
4. Mechanical Structure Design	25/1/11	27/1/11	25/1/11	27/1/11	
5. PDR report and presentation	27/1/11	31/1/11	27/1/11	31/1/11	

Mechanical Team Schedule(contd.)

Mechanical and Descent Control Team					
Task	Scheduled Dates		Actual Dates		Reasons
6. Descent Control Hardware	1/2/11	15/2/11			
7. Designing Descent Control	16/2/11	25/2/11			
8. Integrating Descent Control with Egg Canopy	25/2/11	5/3/11			
9. Testing of Structure for operation	5/3/11	15/3/11			
10. Make necessary changes in descent or Egg mechanism	15/3/11	15/4/11			
11. Testing with Changes	15/4/11	1/5/11			
12. Fabrication of Final Structure	1/5/11	10/5/11			
13. Testing with integrated Hardware	10/5/11	25/5/11			

Conclusions

- **Accomplishments :**
  - Detachment mechanism finalized.
  - Physical structure layout finalized.
  - Sensors and components are decided (except locator device).
  - Descent mechanism decided and parachutes are ready.
  - Sensors tested.
- **Yet to be done :**
  - PCB design and locator device is yet to be finalized.
  - Physical structure needs to be prepared.
  - FSW code has to be written.
  - GCS code has to be written.

We are ready for the next stage which is - Implementation of the subsystems according to the conclusions we've reached upon.

THANK YOU