CanSat 2015
Critical Design Review (CDR)

Team 4996

Team Phoenix

Presentation Outline

Introduction

Ruben Perez

Team Organization

- **2015 CanSat Team:** PHOENIX
  - **CanSat Team Mentor:** Caitlin Marsh
  - **Faculty Advisor:** Y. Andreopoulos
  - **Team Leaders:** Ruben P.
    - **Mechanical Systems:** Majlinda M.
    - **Descent Control:** Patrick G.
    - **Sensor Systems:** Maria C.
    - **Electrical Power System:** Joel A.
    - **Communication & Data Handling:** Demetrios D.
    - **CanSat Integration & Testing:** Sakif C .
    - **Mission Operations & Analysis:** Ruben P.
    - **Management:** Ruben P. .

Acronyms

- **A**– Analysis
- **CDR** – Critical Design Review
- **CONOP** – Concept of Operations
- **D** – Demonstration
- **DCS** – Descent Control System
- **FSW** – Flight Software
- **GCS** – Ground Control Station
- **HW** – Hardware
- **HWR** – Hardware Review
- **I** – Inspection
- **LCO** – Launch Control Officer
- **PDR** – Preliminary Design Review
- **PFB** – Pre Flight Briefing
- **PFR** – Post Flight Review
- **RSO** – Range Safety Officer
- **SOE** – Sequence of Events
- **T** – Test
- **TBD** – To Be Determined
- **TBR** – To Be Resolved
- **VM** – Verification method

Systems Overview

Ruben Perez

Mission Summary

- **BASE MISSION SUMMARY**
  - Mass: 600 grams +/- 10
  - Dimensions: 125mm x 310mm cylindrical
  - Apogee Deployment at 600m
  - Payload separation from container at 500m
  - Passive helicopter/auto-gyro recovery
  - Stabilize and descend properly at a minimum altitude of 300m
  - Payload Descent rate must be <10m/s and >4m/s
  - Payload lands a large hen egg intact
- **SELECTABLE OBJECTIVE REQUIREMENTS**
  - Three-axis accelerometer to measure the stability and angle of descent of the payload during descent
  - Easier to implement with our CanSat configuration

Summary of Changes Since PDR

- **Electrical System Changes**
  - Using LSM303 (accelerometer and magnetometer) instead of ADXL345
  - Chrono Dot
- **Mechanical System Changes**
  - No changes

System Requirement

ID	Req. No	REQUIREMENT
MR-01	1	Mass: 600 $^{+}$/- 10 grams (CanSat + container + all descent control devices)
MR-02	3	Dimensions: Container must fit in cylindrical payload section of 125mm x 310mm
MR-03	4	Container must use passive descent control system
MR-04	5	Container must not have sharp edges
MR-05	6	Container must be a florescent color, pink, or orange
MR-06	9	CanSat will deploy from rocket payload section
MR-07	10	CanSat will deploy from the rocket payload section
MR-08	11	Use Helicopter recovery system
MR-09	12	All descent control device attachments must survive 50 Gs of shock
MR-10	14	All electronics must be enclosed and shielded from the environment except for sensor
MR-11	15	All structures must be built to survive 15 Gs acceleration

System Requirement Cont'd

ID	Req. No	REQUIREMENT
MR-12	16	All structures shall be built to survive 30 Gs of shock.
MR-13	18	All mechanisms must be capable to maintain their configurations under all forces
MR-14	19	Mechanisms shall not use pyrotechnics or chemical
MR-15	21	During descent, the Science Vehicle shall collect and telemeter air pressure, outside and inside air temperature, flight software state, battery voltage, and bonus objective data.
MR-16	22	CanSat will transmit telemetry data every one second
MR-17	24	900 MHz XBEE Pro radio will be used
MR-18	25	XBEE NETID/PANID set to the team number
MR-19	26	XBEE radio shall not use broadcast mode
MR-20	27-28	The Science Vehicle shall have a video camera installed and recording the complete descent from deployment and landing and include time stamp on the video.
MR-21	29	Science Vehicle descent needs to <10m/s, but >4m/s

System Requirement Cont'd

ID	Req. No	REQUIREMENT
MR-22	30	During descent, the video camera must not rotate. The image of the ground shall maintain one orientation with no more than +/- 90 degree rotation.
MR-23	31	Budget: $1000
MR-24	33-34	Telemetry must be display in real time and engineering unit during descent
MR-25	35	Teams shall plot data in real time during flight on the ground station computer.
MR-26	36-37	The ground station shall include one laptop computer, xbee radio and ah and held or table top antenna. Ground station shall be portable.
MR-27	38	The Science Vehicle shall hold one large raw hen's egg which shall survive launch, deployment and landing.
MR-28	40	The CanSat flight software shall maintain and telemeter a variable indicating its operating state.
MR-28	42	Include an easily accessible power switch which does not require removal from the container for access.

System Concept of Operations

Pre launch

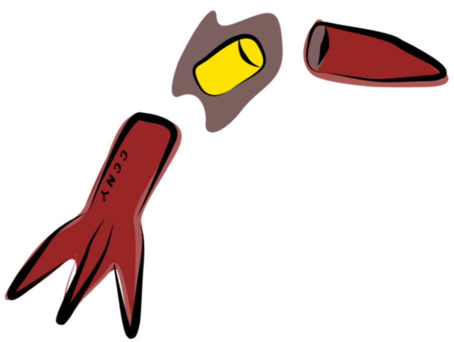
- Preflight briefing
- The mechanical & electrical components will be placed into the CanSat
- Integrate CanSat into Payload

Rocket Launched

- CanSat will rest in payload envelope
- Rocket is launched
- Receive telemetry

CanSat Deployment

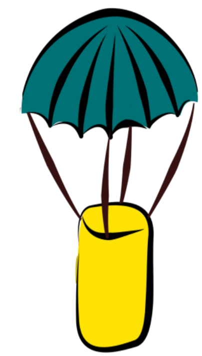
- 600m altitude the CanSat is deployed
- Data will be received for the following
  - altitude,
  - pressure
  - temperature data.



System Concept of Operations Cont'd

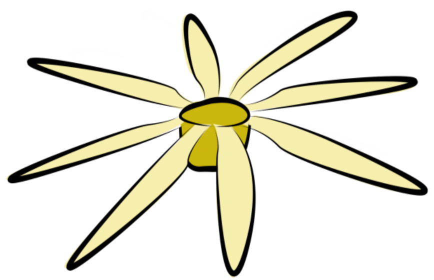
PAYLOAD SEPERATES FROM CONTAINER

- At 500m altitude the payload will separate from the container
- This is where the Autorotative blades are deployed
- The CanSat should stabilize at a minimum of 300m.
- Descent rate must be <10m/s and >4m/s

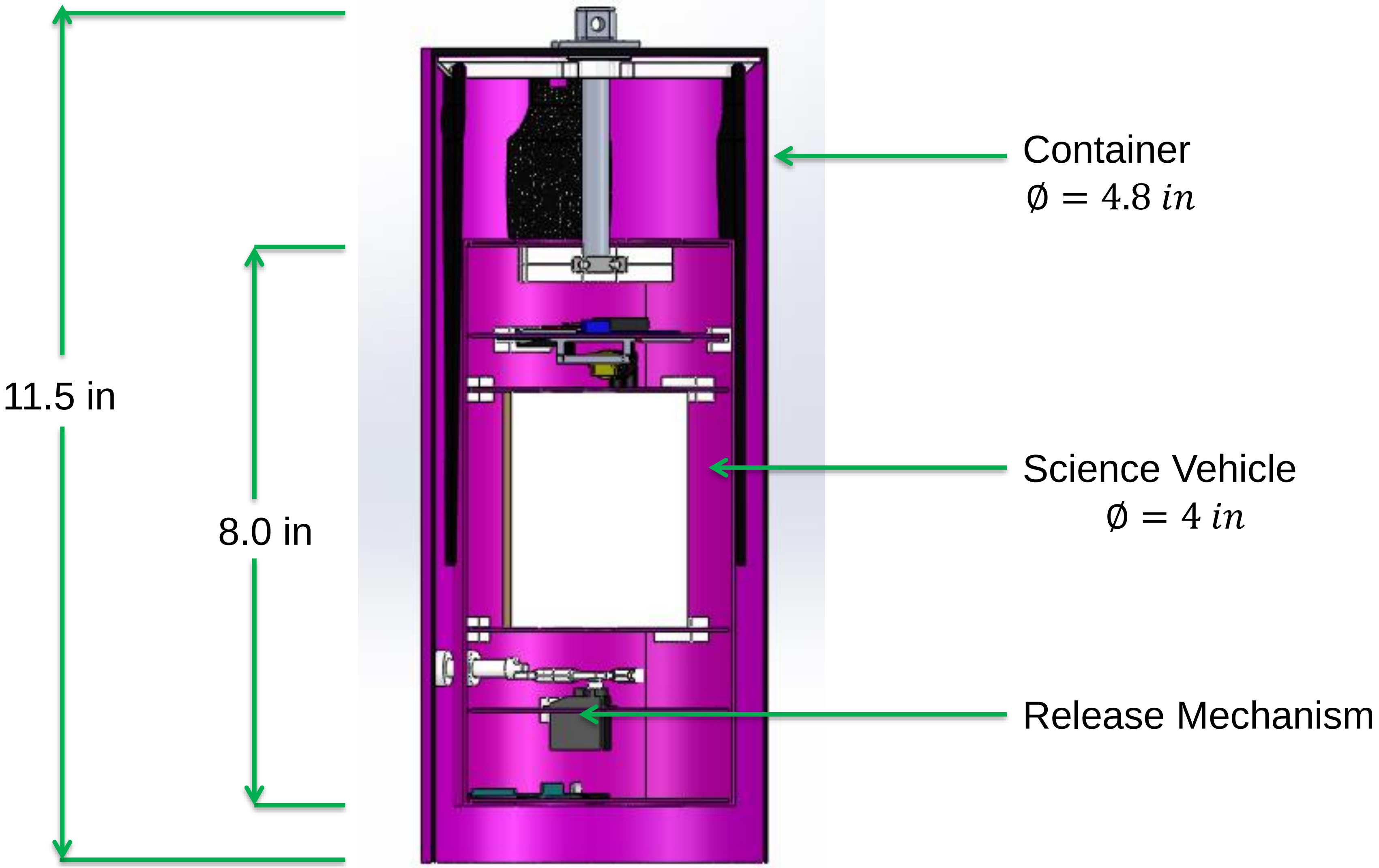


POST-FLIGHT

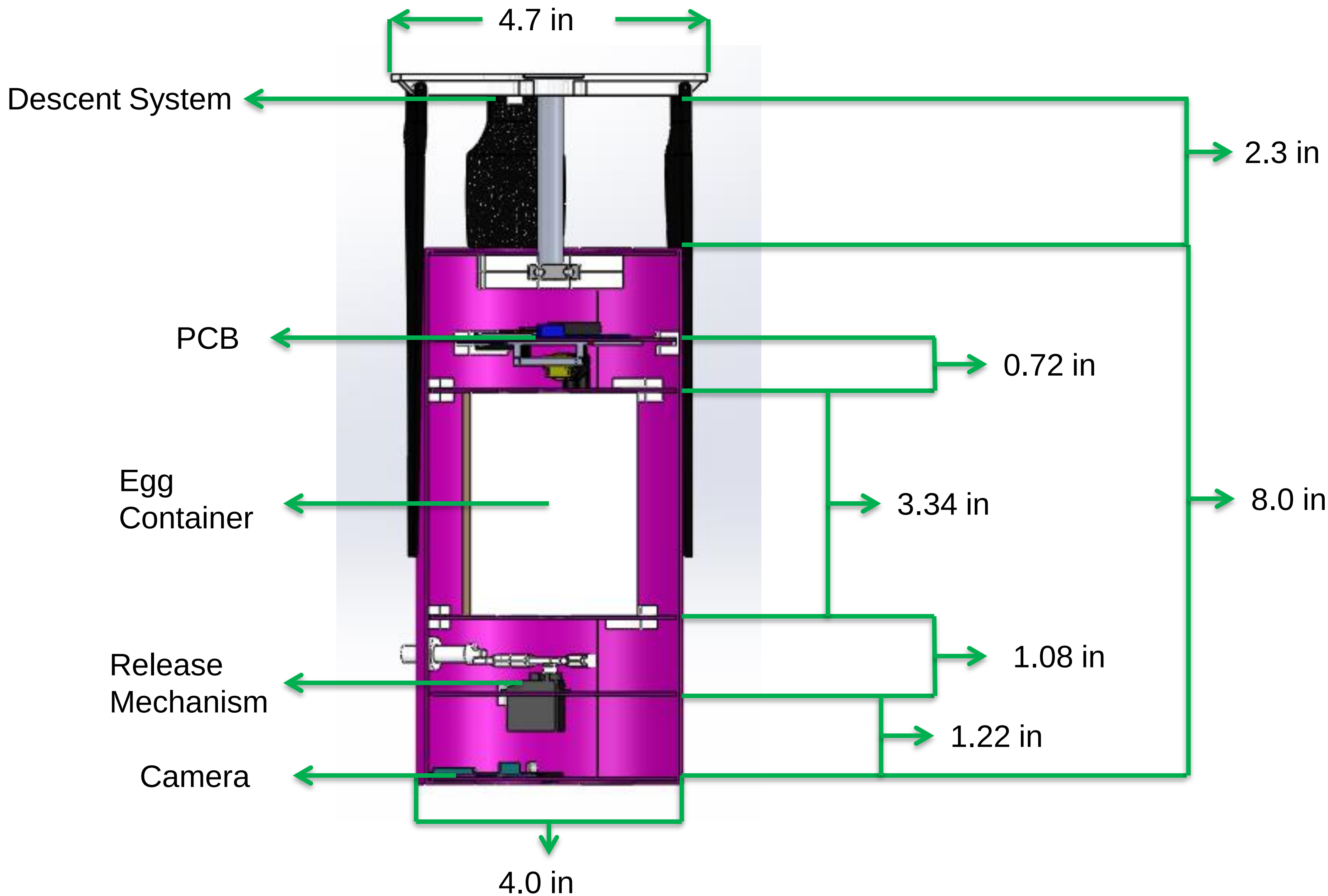
- At this stage the payload will be at 0m altitude.
- The payload will be located
- The egg will be checked to determine if it survived.



Physical Layout
Full Assembly



Physical Layout Science Payload



- In order to test the fit of all components, tubing of inner diameter equal to that of the max required Container diameter will be purchased
  - The Payload will fit inside a double open-ended cylindrical tube: the Container
    - The container will have a diameter close to the inner diameter of the rocket ($\emptyset_{max}$) with enough space to prevent the science payload from getting stuck because of friction.

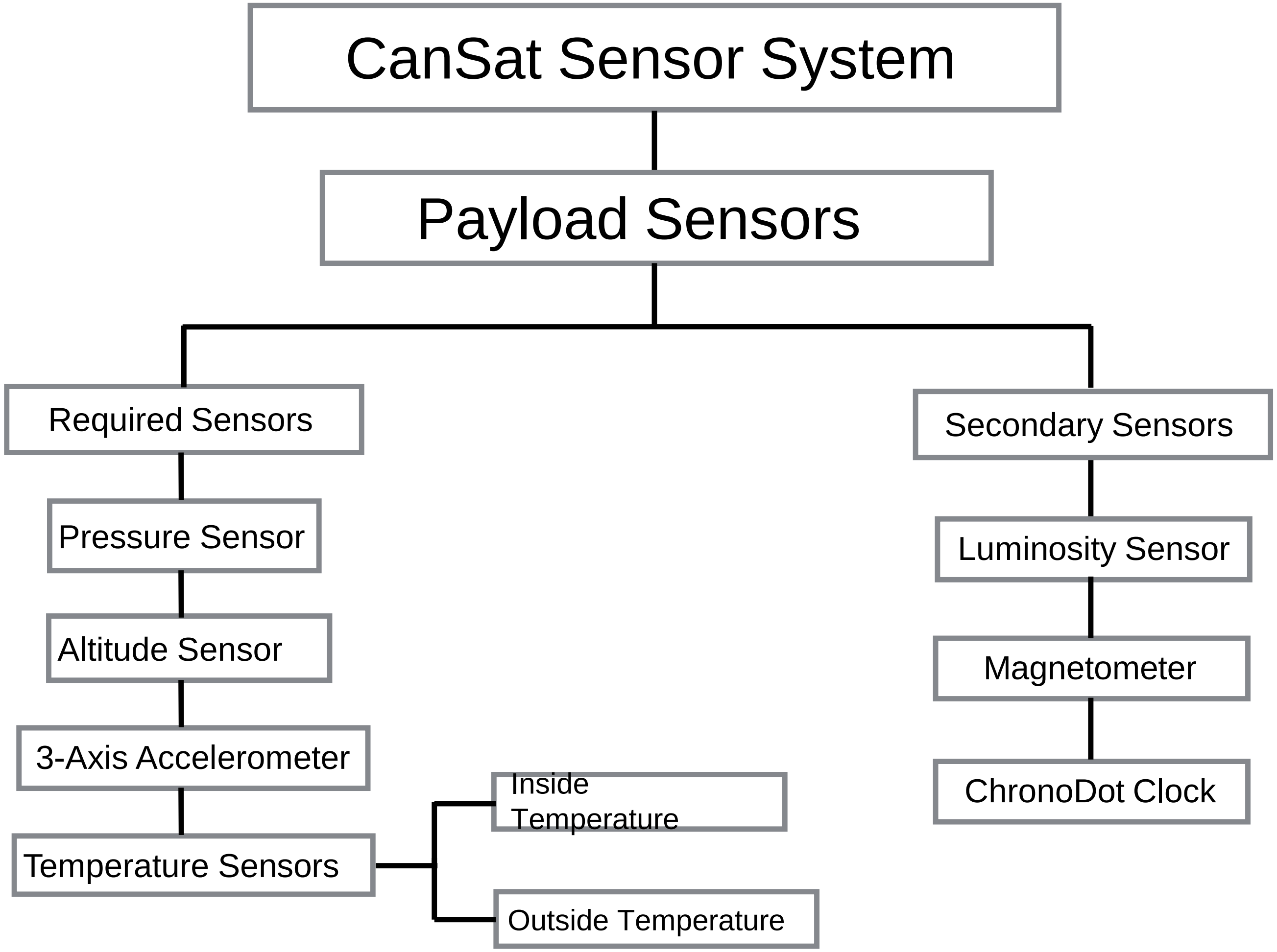
$$\emptyset_C = 4.8\ in < \emptyset_{max} \cong 5\ in$$

(Rocket inner diameter)

Sensor Subsystem Design

Maria F. Caceres

Sensor Subsystem Overview



Sensor Subsystem Overview

Sensors	Model	Description	Placement Location
Altitude Sensor	BMP180	Provides barometric (altitude derived from barometric measurements) and inside temperature measurements	Payload
Temperature Sensor	TMP36	Provides the outside temperature measurement.	Payload
3-Axis Accelerometer + Magnetometer Sensor	LSM303	The 3-axis accelerometer measures stability and angle of descent (objective), while the magnetometer measures magnetic field (in our case, North).	Payload
Camera	Spycrushers Keychain Camera	This camera comes with a time stamp and will record a video during descent.	Payload
Luminosity Sensor	TSL2591	Its precision allows for exact lux calculations that would come in handy for the flight software.	Payload
Clock	ChronoDot Clock	The Chronodot is an extremely accurate clock that would be used as our mission time recorder in case of a reset.	Payload

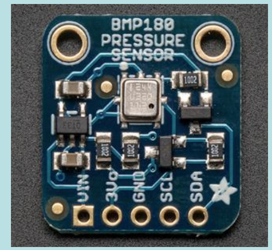
Sensor Changes Since PDR

Change	Reason
Accelerometer (from ADXL345 to LSM303)	The LSM303 is a 2-in-1 sensor (accelerometer + magnetometer) which helps saving space. The addition of the magnetometer is for camera stability.
Addition of a clock (ChronoDot)	The clock in the Arduino would not survive in case of a reset.

Sensor Subsystem Requirements

ID	Req. No	REQUIREMENT
SSR-01	*21*	***During descent, the Science Vehicle shall collect and telemeter air pressure (for altitude determination), outside and inside air temperature, flight software state, battery voltage, and bonus objective data (accelerometer data and/or rotor rate).***
SSR-02	*22*	**The Science Vehicle shall transmit telemetry at a 1 Hz rate.**
SSR-03	*23*	***Telemetry shall include payload mission time with one second or better resolution, which begins when the payload is powered on.***
SSR-04	*27*	***The Science Vehicle shall have a video camera install and recording the complete descent from deployment to landing. The video recording can start at any time and must support up to one hour of recording.***
SSR-05	*28*	***The video camera shall include a time stamp in the video. The time stamp must work from the time of deployment to the time of landing.***
SSR-06	*40*	***The CanSat flight software shall maintain and telemeter a variable indicating its operating state. In the case of processor reset, the flight software shall re-initialize to the correct state either by analyzing sensor data and/or reading stored state data from non-volatile memory. The states are to be defined by each team. Example states include: PreFlightTest(0), LaunchWait(1), Ascent(2), RocketDeployment(3), Stabilization(4), Separation(5), Descent(6), and Landed(7).***
Derived from Bonus		***Use a three-axis accelerometer to measure the stability and angle of descent of the Science Vehicle during descent.***

Altitude Sensor for Payload

Sensor Model Adafruit BMP180	
Voltage Operation	3V - 5V
Pressure range	300hPa – 1100hPa
Altitude range	9000m to - 500m
Absolute Accuracy	±2.5hPa

Data processing:

- Processed using:
  - Altitude = 44330*(1-(p/1013.25)$^{1/5.255}$ (from datasheet)
- Pressure processed using Adafruit_BMP085_Unified-master

Temperature Sensor

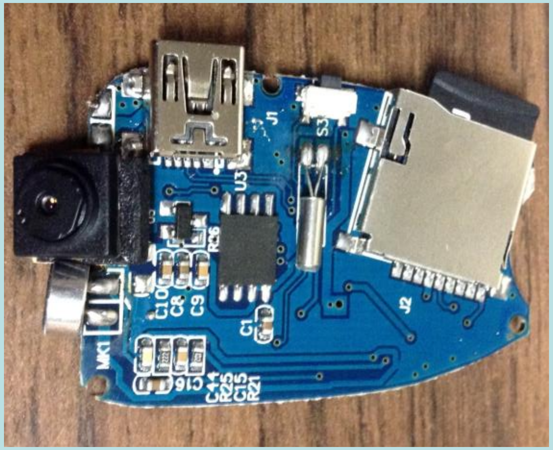
Sensor Model **Adafruit TMP36**	
Voltage Operation	2.7V - 5.5V
Temperature range	-40ºC to 125ºC
Output Scale factor	10 mV/ºC
Precision	0.1 ºC

Data processing:

- Processed using:
  - Temp in °C = [(V_{out} in mV) - 500] / 10 (from datasheet)

Camera Summary

Camera

Spycrushers Car Key Chain Spy Camera **Keychain SpyCamera**	
Video Resolution	720x480
Video Format	AVI
Video Frame Rate	30±1 fps
Time Stamp	Processed on board, no further processing required
Recording medium	On board SD card writer

3-Axis Accelerometer Sensor Summary

3-Axis Accelerometer Sensor for Container

Sensor Model	**Adafruit ±16g Accelerometer + Magnetometer**
Adafruit LSM303	
Full scale range (Accelerometer)	±16Gs
Accuracy (Accelerometer)	±10%
Full scale range (Magnetometer)	±1.3Gs to ±8.1Gs
Accuracy (Magnetometer)	±10%

Descent Control Design

Patrick Guillaume

Descent Control Overview

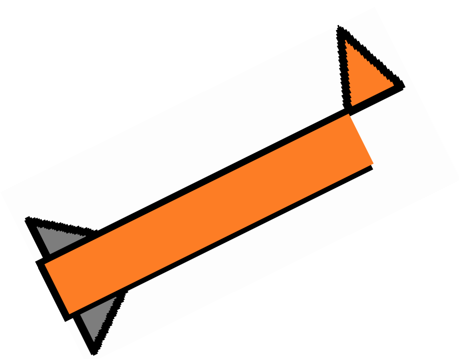
- Descent control is used in both the Container and Payload components of the CANSAT:
  - Container: *Drag by Parachute*
  - Payload: *Auto-gyro system using Carbon fiber blades*

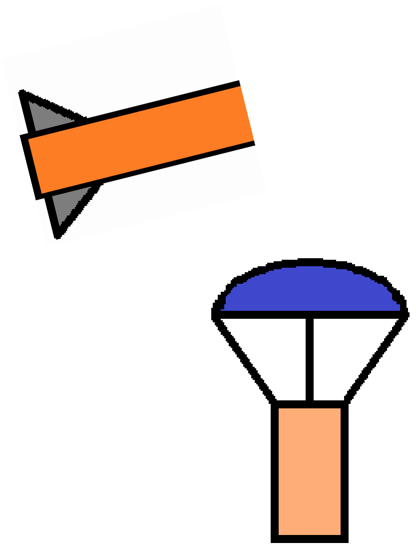
CANSAT Section	Control Scheme	Descent Required	Dependencies	Components	Configurations
Container	Parachute	N/A	-Air Flow -CANSAT mass -Parachute Area	-Kevlar string -Ripstop Nylon -Swivel	Upon separation from the rocket, the container's parachute will deploy, allowing the CanSat to descend at a controlled rate.
Payload	Auto-gyro	4m/s<**v**<10 m/s	- Air Flow - CANSAT mass - Rotor Area - Angle of attack	-Carbon-Fiber propellers -Torsion Springs -Ball bearing	Upon release from container, propellers will fold out and will start to rotate due to air flow

Descent Control Overview (Cnt'd)

1) <u>Altitude = 600 m</u>
Ejection charge deploys CANSAT from bay as well as nose cone at apogee. Each has its own descent control system.

2) <u>Altitude = 600→500m</u>
CANSAT (C+P) descends via parachute at a predicted rate of 10.7 m/s

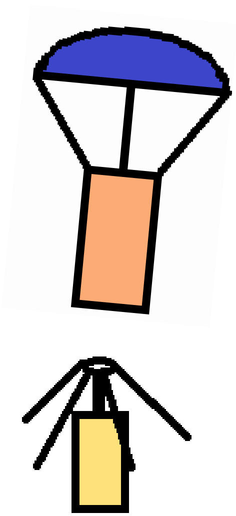


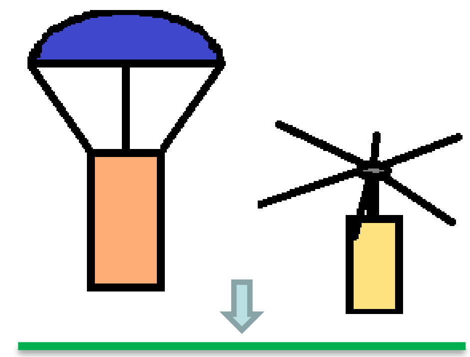


Descent Control Overview (Cnt'd)

3) <u>Altitude = 500 m</u>
CANSAT P deploys blades. CANSAT C Still attached to parachute. Blades open up cache some air and start to rotate providing a net upward force for a terminal velocity in the range 4m/s<Vter<10m/s

4) <u>Altitude = 500 m to 0 m</u>
CANSAT P continues to descend with blades and comes in contact with ground. C lands with parachute.





Descent Control Changes Since PDR

- **No changes since PDR**
- **Prototype not yet tested**
  - Reason: delay in acquiring materials due to funding

Descent Control Requirements

ID	Req. No	REQUIREMENT
DCSR-01	4	The Container shall use a passive descent control system. It cannot free fall. A parachute is allowed and highly recommended. Include a spill hole to reduce swaying.
DCSR-02	10	The Container or Science Vehicle shall include electronics and mechanisms to determine the best conditions to release the Science Vehicle based on stability and pointing. It is up to the team to determine appropriate conditions for releasing the Science Vehicle.
DCSR-03	11	The Science Vehicle shall use a helicopter recovery system. The blades must rotate. No fabric or other materials are allowed between the blades
DCSR-04	12	All descent control device attachment components shall survive 50 Gs of shock.
DCSR-05	13	All descent control devices shall survive 50 Gs of shock.
DCSR-06	29	The descent rate of the Science Vehicle shall be less than 10 meters/second and greater than 4 meters/second

Container Descent Control Hardware Summary

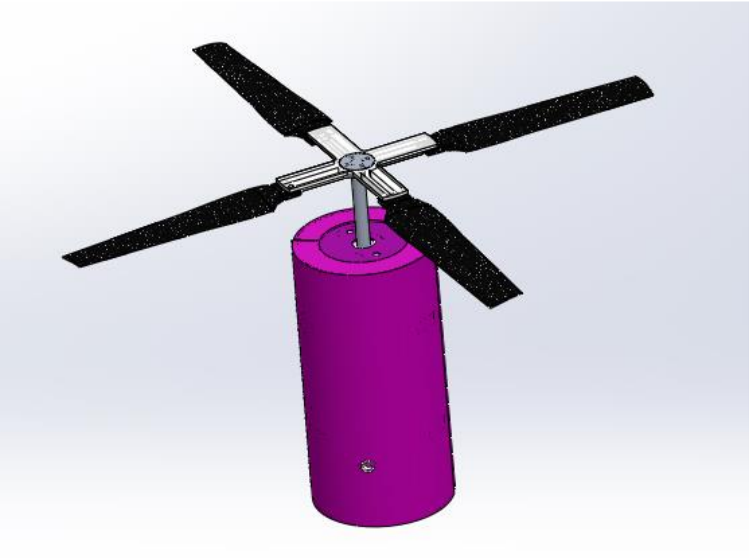
- Only passive components used: Parachute, Swivel clip
- Color selection: Make apparatus stand out
- Key considerations:
  - Parachute size
  - Attachment method

Container Descent	12” Parachute
Color	Neon pink
Descent Control Capability (CanSat weight: 660g)	≈11 m/s
Weight	≈3g
Cost	$10
Preflight Review Testability	Will be tested using object of similar mass
Shock Force Survival (withstand 30Gs)	Kevlar thread (tensile strength: 3620 MPa) Swivel clip (able to survive 160kg pull)
DCS Connections	Follows DCS rules

Payload Descent Control Hardware Summary

- Only Passive components: Auto-gyro blades and rotor
- Key Considerations:
  - Blade Profile Blade Material
  - Blade Dimensions Number of Blades

Payload Descent	Auto-gyro
Profile	**SG6043**
Material	Carbon Fiber
Size	Blade Length: **6in**
Color	Black
Weight	≈64g
Trigger	Blades deploy when released from C
Preflight Review Testability	Decent system will be tested in wind tunnel
Survivability (30Gs)	Awaiting Testing
DCS Connections	Follows DCS rules



Blade Length: **6in**
Material: **Carbon-Fiber**

Calculations used for CANSAT (C+P) Descent

- CanSat descent will be dictated by the carrier parachute
- Approximate CANSAT descent rate can be determined from the following equation:

$$V_{terminal} = \sqrt{\frac{8mg}{\pi\rho C_D D^2}}$$

- With:

Parachute Diameter	$D = 0.457m$
Coefficient of Drag:	$C_D = 1.3$
CanSat Mass:	$m = 660g$
Gravitational acceleration:	$g = 9.81m/s^2$
Air density:	$\rho = 1.2kg/m^3$

- From this we find:

$$\boxed{\boldsymbol{V_{terminal} = 10.7m/s}}$$

Calculations used for Container Descent

- Container descent (after payload deploys) will be dictated by the carrier parachute
- Approximate Container descent rate can be determined from the following equation:

$$V_{terminal} = \sqrt{\frac{8mg}{\pi\rho C_D D^2}}$$

- With:

Parachute Diameter	$D = 0.457m$
Coefficient of Drag:	$C_D = 1.3$
Container Mass:	$m \approx 230g$
Gravitational acceleration:	$g = 9.81m/s^2$
Air density:	$\rho = 1.2kg/m^3$

- From this we find:

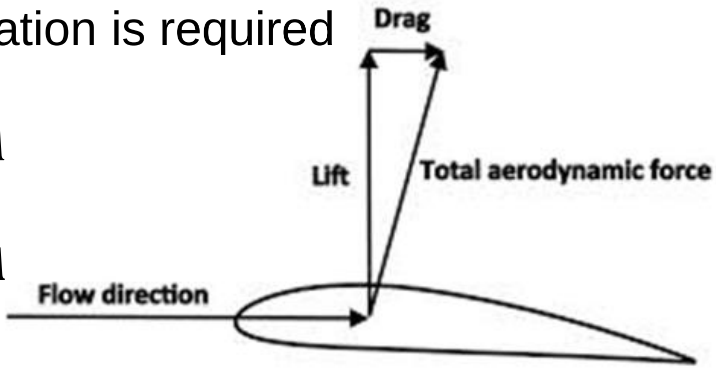
$$\boxed{\boldsymbol{V_{terminal} = 4.2m/s}}$$

Descent Rate Estimates

- AutoGyro requires asymmetric airfoil SG-6043 Blade Profile
- The blades are at a negative angle of attack relative to the rotor disk the air moving up through the rotor captures energy like a wind turbine.
- Rotational Energy is dissipated through the generation of aerodynamic lift by the blades.
- Cannot solve it analytically. Numerical approximation is required

$$dF_\theta = dF_L \sin(\alpha) - dF_D \cos(\alpha)$$
$$dF_v = dF_L \cos(\alpha) + dF_D \sin(\alpha)$$

$$dF_L = \frac{1}{2}\rho C_L V^2 dA$$
$$dF_D = \frac{1}{2}\rho C_D V^2 dA$$



Where :

F_θ *and* F_v *are the forces in the rotational and vertical directions respectively*

F_L *and* F_D *are the Lift and Drag forces respectively*

C_L *and* C_D *are the Lift and Drag Coefficients respectively*

α *is the angle of attack*

Solving equations

- 2 softwares used: Fluent and Matlab

- Fluent: Simulations run in Fluent to determine range of Cd and Cl values at various Reynold's number and angle of attacks
  - Assumptions:
    1. No crosswind
    2. Steady flow
    3. Constant air density
    4. Constant dynamic viscosity
    5. Constant air pressure

- Matlab: Matlab code estimates velocity on impact with ground
  - Assumptions:
    1. No crosswind
    2. Constant density

Fluent

Inputs for Fluent:

- x and y component of velocity for given Reynold’s number
- x and y components of local Cd and Cl values for given angle of attack

Outputs for Fluent:

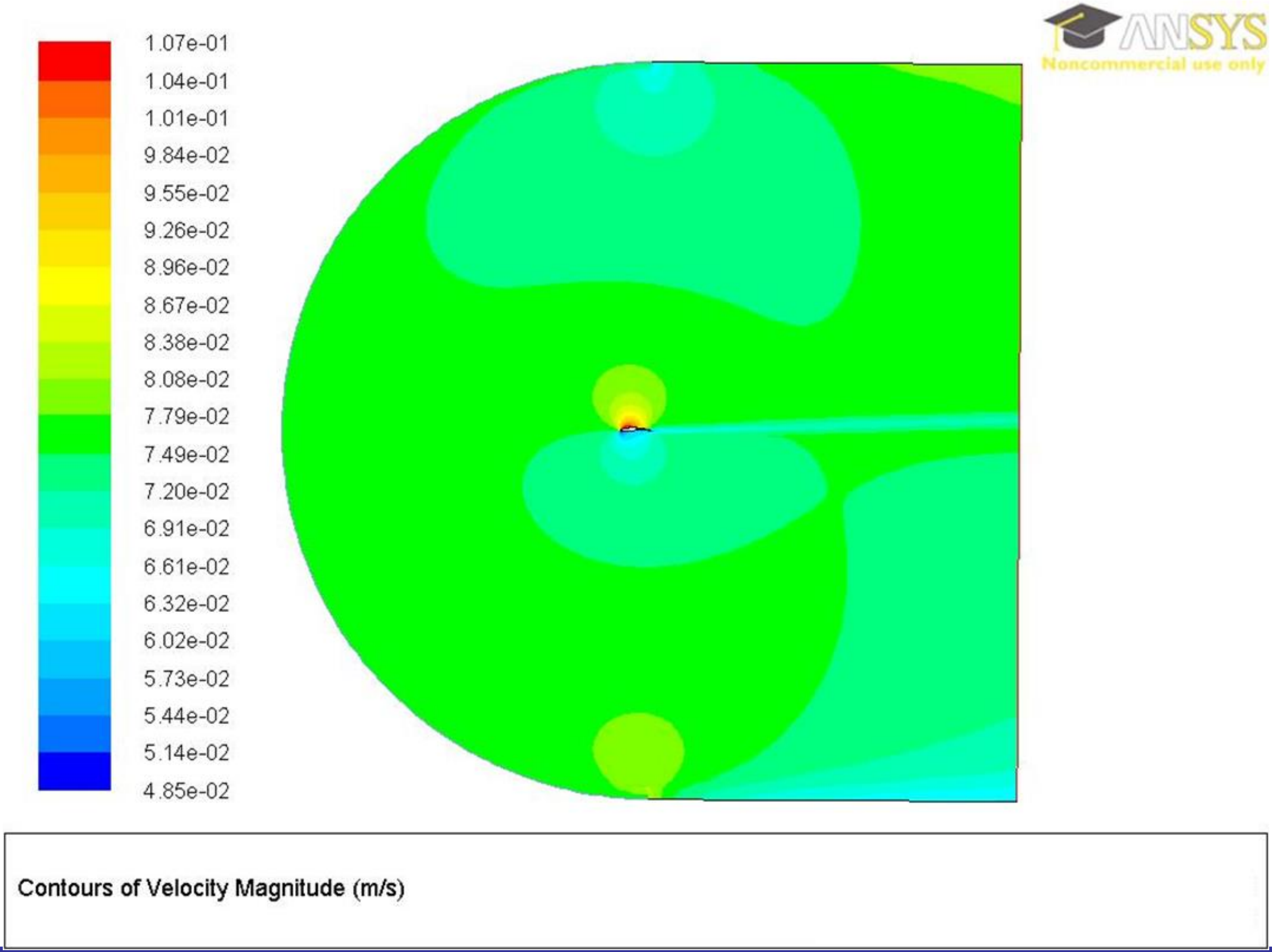
- Average Cd and Cl values

Results:

Value ranges

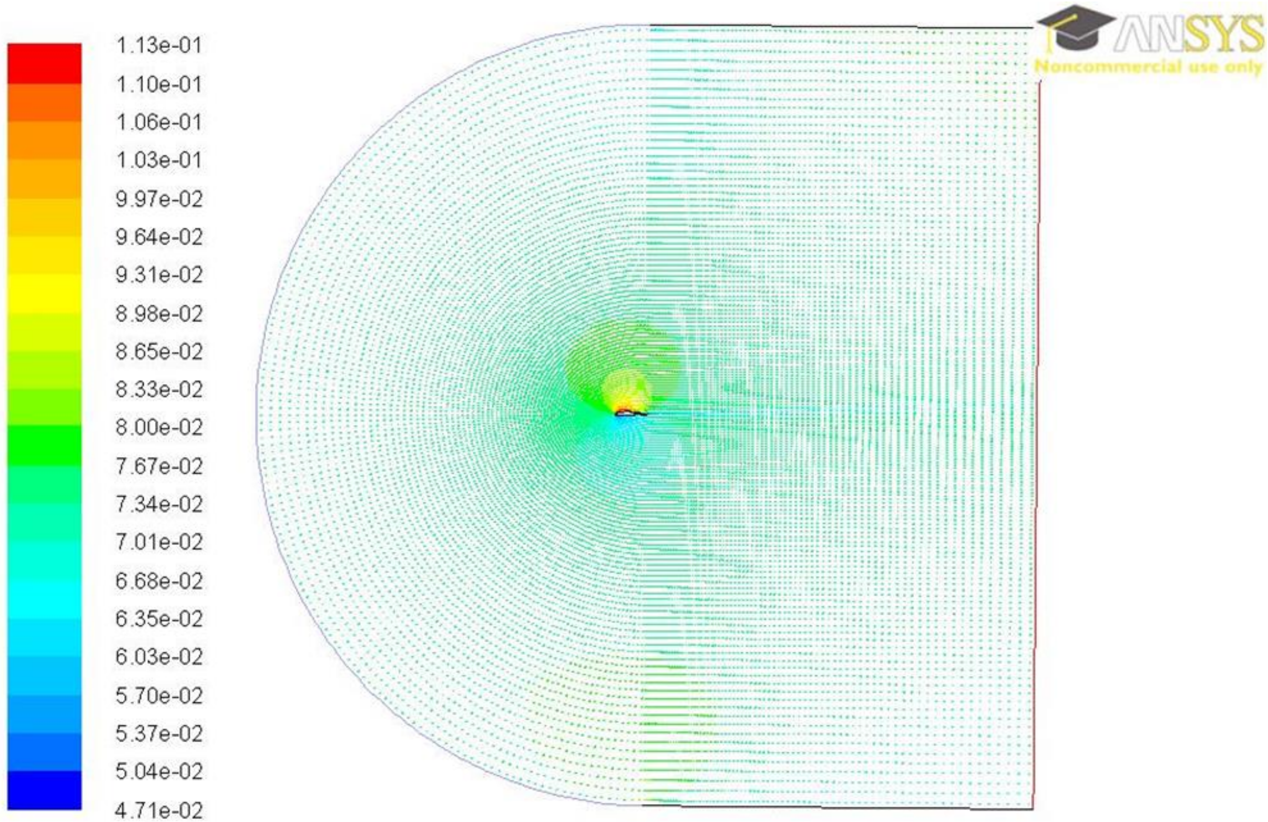
- Cd:(0.00194-1.32)
- Cl: (-0.268 - 1.321)

Velocity Contour Plot



ANNUAL CANSAT COMPETITION

Velocity Vector Plot



Velocity Vectors Colored By Velocity Magnitude (m/s)

Descent Rate Estimates

Matlab

Algorithm:

- CD and CL values used to calculate Forces on differential segments of the blade
- Forces are then integrated along the length of the blade
- Forces are broken into Tangential (Rotational) and Vertical components
- Vertical and Angular accelerations are computed
- Velocities for the next time step are computed
- Process is repeated until terminal velocity is reached

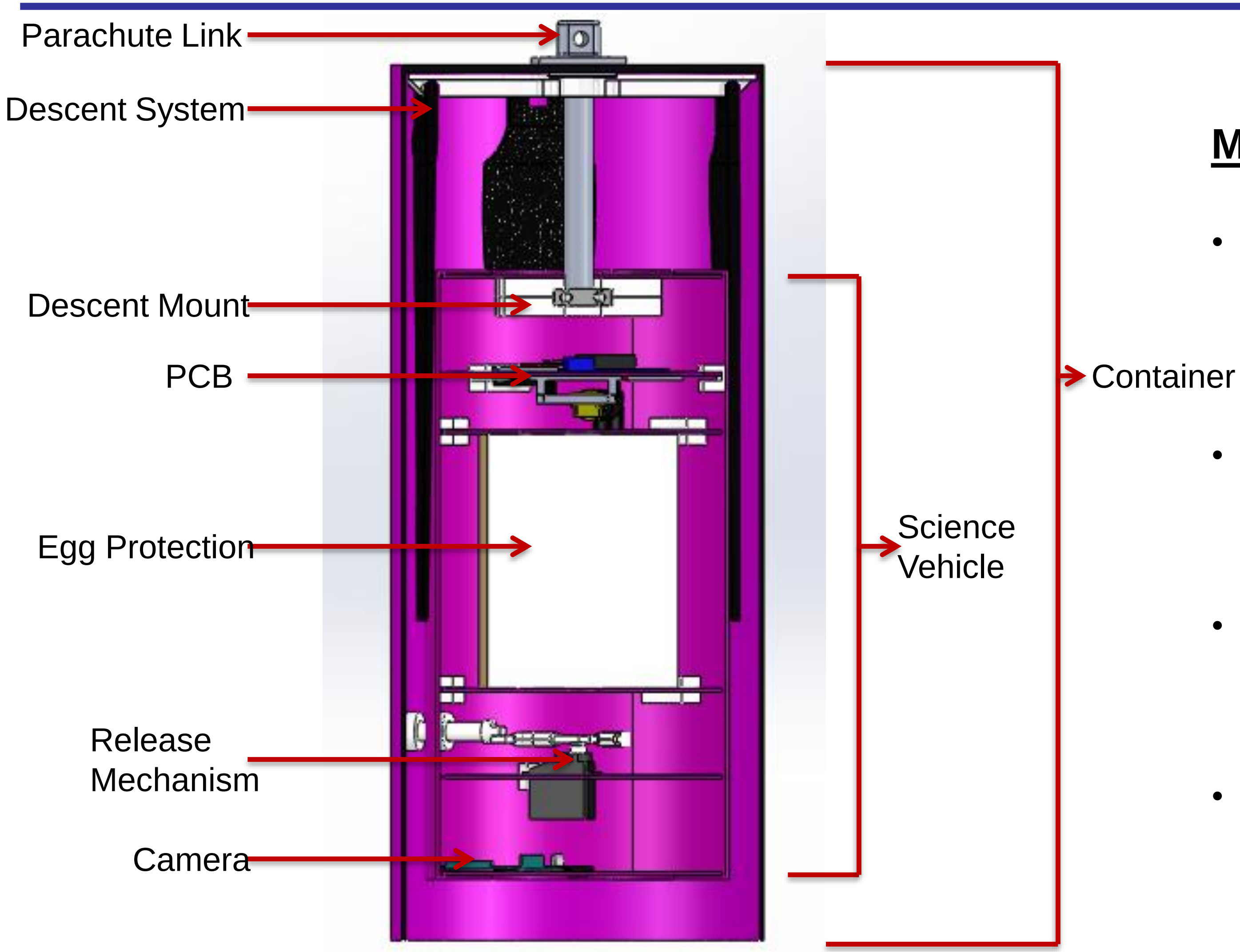
Output:

- Approximate terminal velocity obtained **4.3 m/s**
- Time to reach terminal velocity: **18s**

Mechanical Subsystem Design

Majlinda Malellari

Mechanical Subsystem Overview



Material Selection

- Container and Science Vehicle: Kevlar and Fiberglass
- Hub and connectors: Nylon and ABS plastic
- Egg Protection: Cardboard
- Egg Protection Mat: Polystyrene

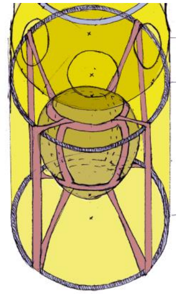
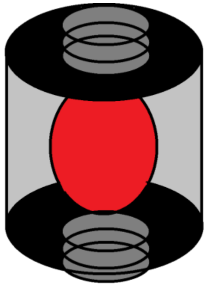
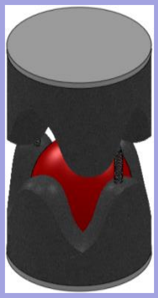
Mechanical Subsystem Changes Since PDR

- There were no changes made since the PDR

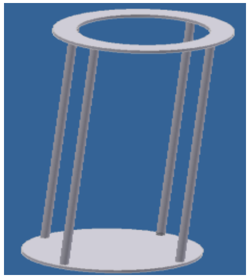
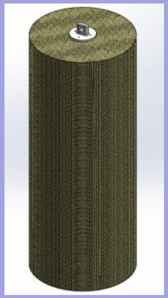
Mechanical Sub-System Requirements

ID	Req. NO°	Requirement
MSR-01	1	Complete mass of CanSat will be 600 grams +/- 10 grams (without the egg)
MSR-02	2-3	The Science Vehicle shall be completely contained in the container. The container shall fit in the envelope of 125 mm x 310 mm.
MSR-03	4-6	The container shall use a passive descent system (ex. parachute). No sharp edges on the Container and the body shall be a florescent color.
MSR-04	11	The Science Vehicle shall use a auto-gyro recovery system. No fabric can be used between the blades.
MSR-05	12-13	All the descent control device attachment components shall survive 50 Gs od shock.
MSR-06	15-16	All the structures shall be built to survive 15 Gs acceleration, and 30 Gs of shock.
MSR-07	18	All mechanism shall be able to maintain their configuration under all forces.
MSR-08	19	No pyrotechnics or chemicals allowed.
MSR-09	31	Cost of the CanSat shall be under $1000.

Egg Protection Trade & Selection

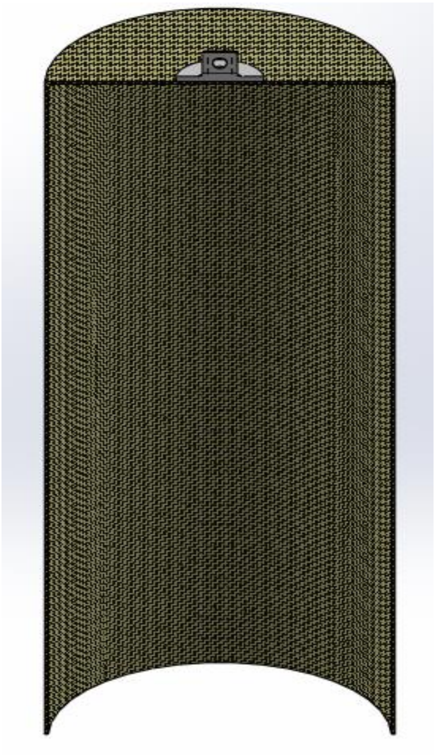
Egg Protection (EP) • Egg is strongest when force is applied along higher vaulted arc • Test using a statistical approach to determine best overall solution. •We chose Polystyrene because it is easy to manufacture, and it is light weight.		Elastic Support 		Oobleck 		Polystyrene 	
Criteria	**Weight**	**Rating**	**Reason**	**Rating**	**Reason**	**Rating**	**Reason**
Integration	30%	3	Suspended fabric pouch	2	Requires water tight container	4	Egg crate foam cut to size
Damping Effect	50%	4	Compresses egg along main arcs	4	Highly viscous	4	Spreads force over entire surface
Size/Mass	20%	4	Lightweight fabric and elastic	2	Avg size, very heavy	4	Large volume & lightweight
Total Score	100%	3.7		3.6		4	
Rank		2		3		1	
Decision		**DECLINE**		**DECLINE**		**ACCEPT**	

Mechanical Layout of Components Container: Trade & Selection

Reentry Container Chassis		Column & Plate Frame		Kevlar, Fiberglas & Epoxy Structural Shell	
-We chose this because: •Primary structural support for CanSat • Design requirements: impact resistant, workable, lightweight, full enclosure					
Criteria	**Weight**	**Rating**	**Reason**	**Rating**	**Reason**
Workability	30%	4	Columns and plastic shell are easily made	3	OK for simple shapes
Impact Resistance	50%	2	Columns deform, plastic is brittle	5	Kevlar and Fiberglas is impact resistant
Size/Mass	20%	3	Lightweight, multiple plates are heavy	4	Kevlar and Fiberglas is dense and has minimum thickness
Total Score	100%	3.0		4.0	
Rank		2		1	
Decision		Decline		**Accept**	

Re-Entry Container Shell

Full View of Container
(without paint)

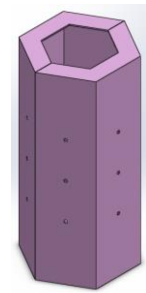
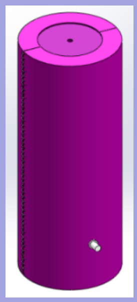


Section View
(without paint)

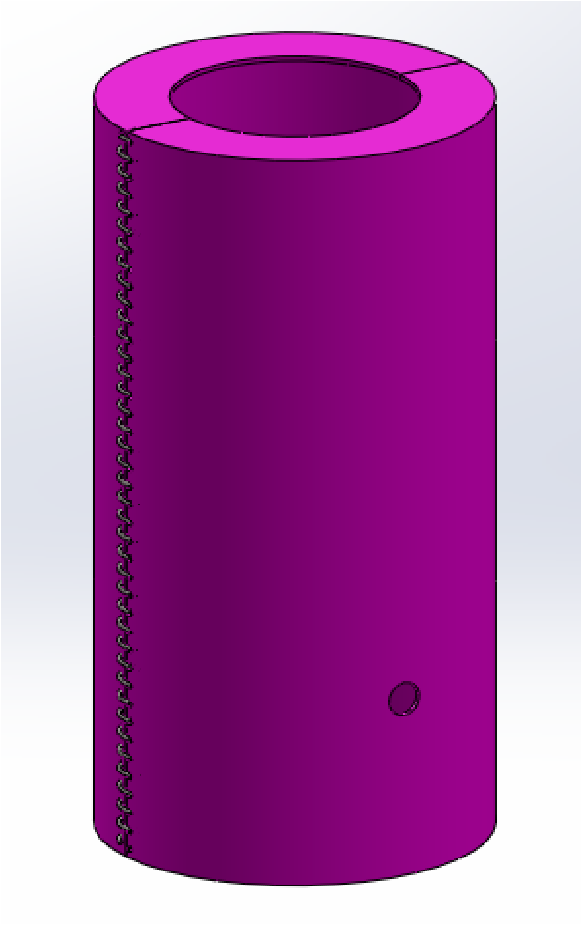
Mechanical Layout of Components Science Vehicle: Trade & Selection

Science Payload Chassis (shape)

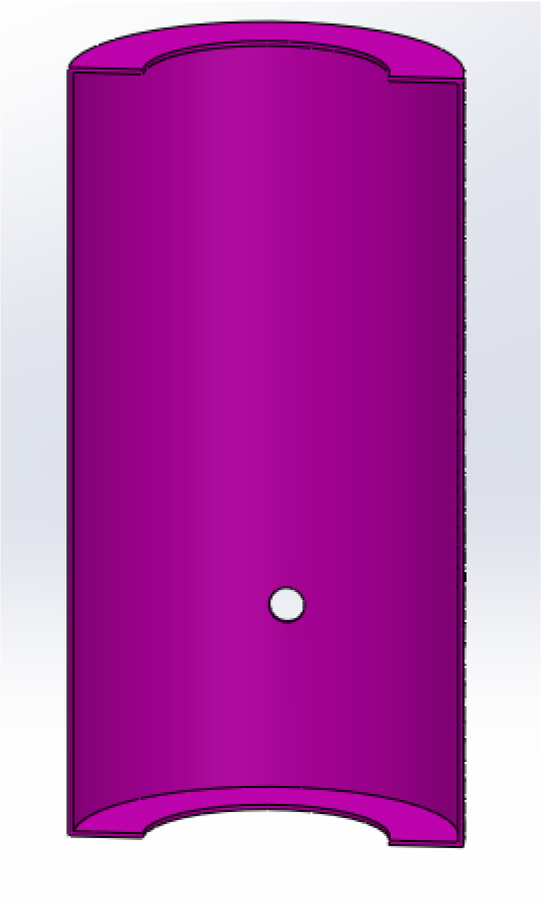
- We chose this because it will:
  - **Increase aerodynamic effect**
  - **Utilize maximum spacing for components**
  - **Circular shape provides less stress conentration**

		Hexagonal		Cylindrical	
					
Criteria	**Weight**	**Rating**	**Reason**	**Rating**	**Reason**
Strength	30%	2	Stress concentrates on edges	4	Cylindrical shape dissipates stress
Drag	30%	4	Fluent simulation shows no differences	4	Fluent simulation shows no differences
Component Spacing	40%	3	More spacing	3	Reasonable attachment on curved surfaces
Total Score	100%	3.0		3.7	
Rank		2		1	
Decision		**DECLINE**		**ACCEPT**	

Science Payload Shell

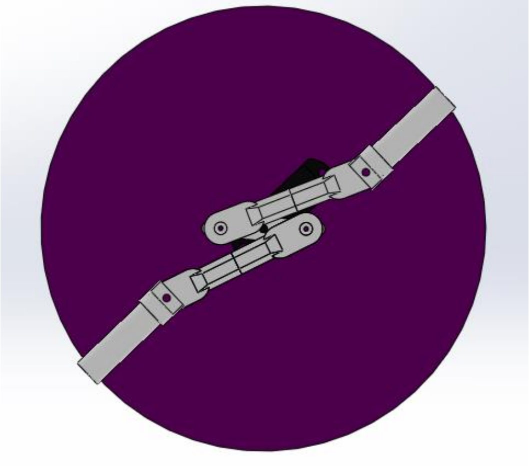


Science Vehicle

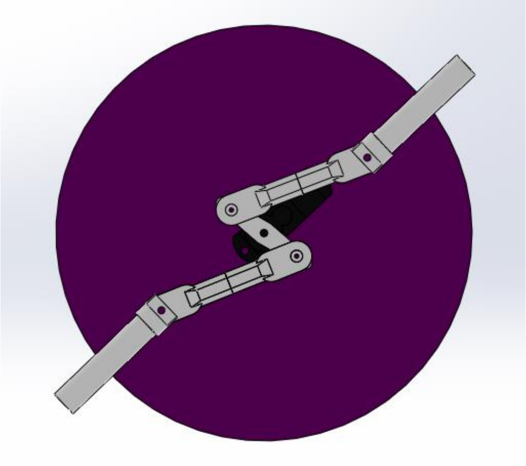


Science Vehicle
(Section view)

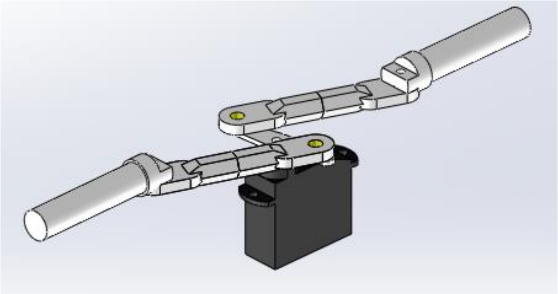
Pivot Release



Retracted (detach from container)

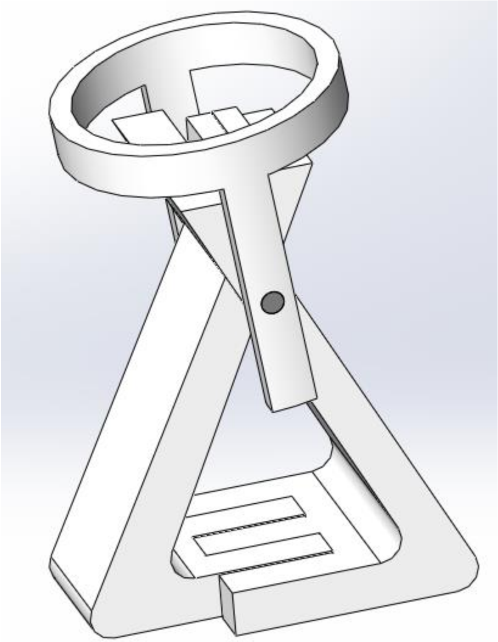


Enforced (connected to the container)

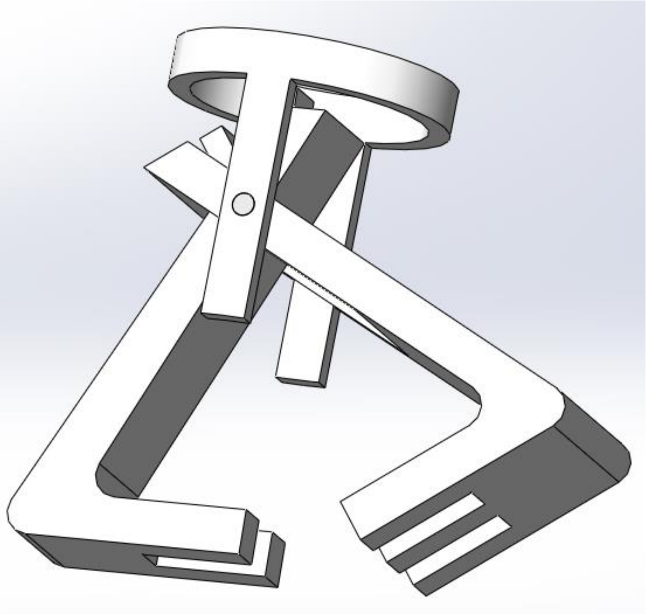


Release without support plate

Claw Release

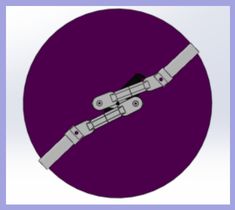


Closed

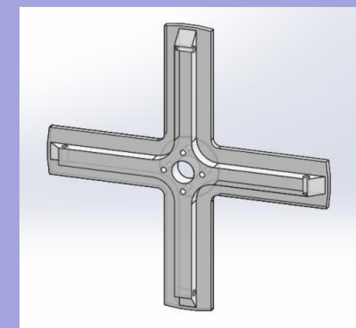


Open

Mechanical Layout of Components Release Mechanism: Trade & Selection

Release Mechanism		Claw Lock		Pivot Release	
• We chose this because: – Simple & Efficient – Easy to mount and compact					
Description		Servo triggered in combination with spring load		Servo Triggered, linkage connection within mechanism	
Criteria	**Weight**	**Rating**	**Reason**	**Rating**	**Reason**
Simplicity	30%	3	Many parts	3	Many parts.
Easy to Manufacture and Feasibility	40%	4	Few parts to manufactures	4	Few parts will be manufactured, most parts will be purchased
Component Spacing & Placement	20%	2	Hard to mount servo and the overall mechanism	4	Servo mounted on fiberglass plate
Total Score	100%	3.00		3.70	
Rank		2		1	
Decision		**DECLINE**		**ACCEPT**	

Material Selections for Descent System: Rotor Hub

Rotor Hub Material		Aluminum		Nylon	
• Primary attachment point for the blades of the Autorotation Subsystem •Must accommodate four blades and fit within a cylinder of 130mm diameter •Design requirements: impact resistant, strong, workable, lightweight,					
Criteria	**Weight**	**Rating**	**Reason**	**Rating**	**Reason**
Workability	20%	3	More easily machined	3	Susceptible to breakage during machining
Strength	50%	4	Low chance of plastic deformation	3	Very strong, but less than aluminum
Size/Mass	30%	2	Very dense, heavy	4	Lightweight
Total Score	100%	3.0		3.3	
Rank		2		1	
Decision		Decline		**Accept**	

Material Selections for Descent System: Blade Material

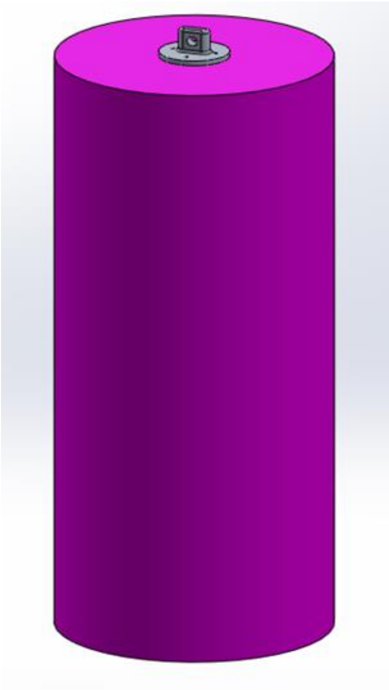
Blade System		305 Polyurethane		Carbon Fiber	
• Hollow Carbon Fiber material. Strong and light. • Test using a statistical approach to determine best overall solution.					
Criteria	**Weight**	**Rating**	**Reason**	**Rating**	**Reason**
Rigidity	20%	3	Test result	4	Reasonable rigidity and high heat tolerance
Density	30%	3	Test result	3	Good
Yield Strength	20%	2	Test result	3	Good Tensile strength
Size/Mass	30%	2	Heavy	4	Light Weight
Total Score	100%	2.5		3.5	
Rank		2		1	
Decision		Decline		**Accept**	

Material Selections
Payload & Container Shells

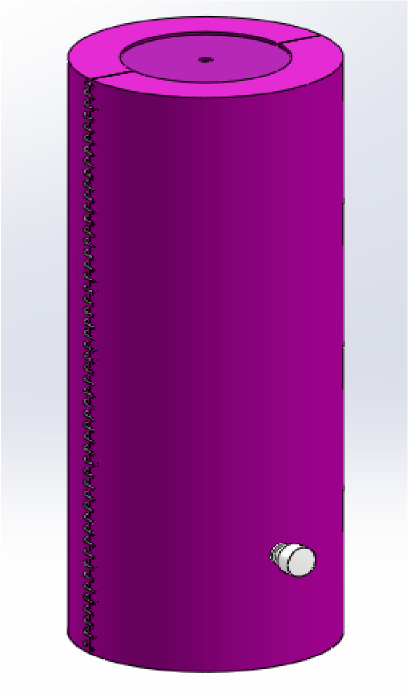
Material: Resin enforced Kevlar and Fiberglas Fabric

Reasons:

- Light weight
- Shock force resistance, durability and strength due to woven composition of Kevlar fabric and its high strength to weight ratio
- Resin reinforced



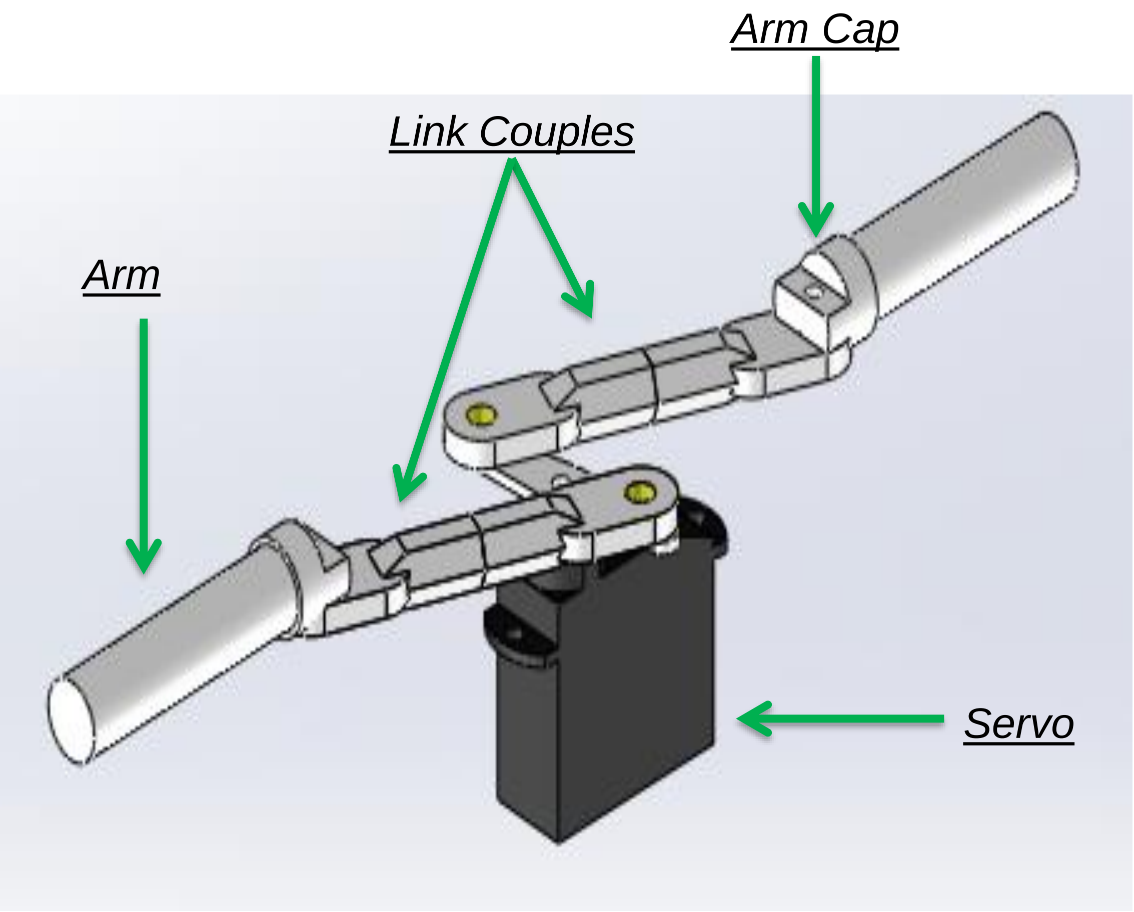
Container



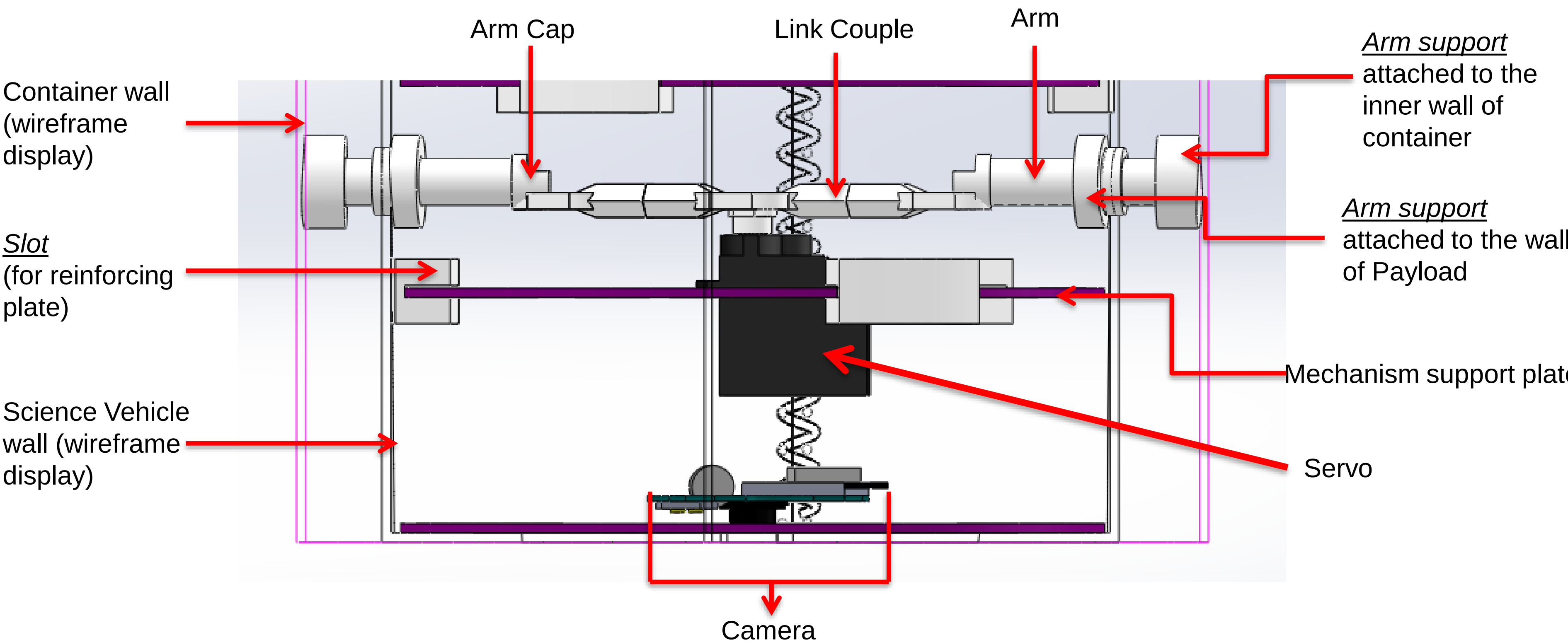
Payload

Container - Payload Interface

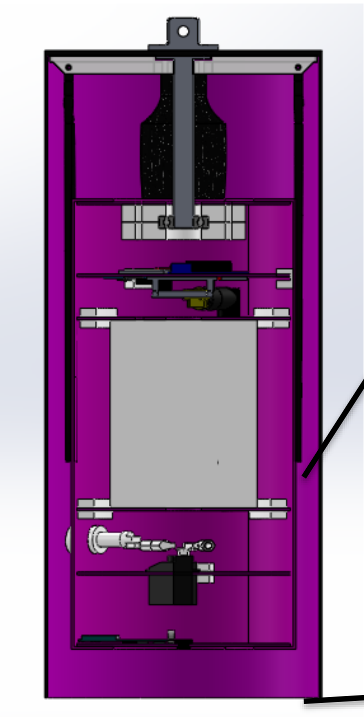
- <u>Servo</u> will be attached into a *fiberglass plate*
- <u>Arms</u> will be pushing into the inner surface of container as the servo is originally placed into right position
- As the servo is being triggered the Arms will retract inside the Science Vehicle allowing it to detach itself from the container and separate for descent
- <u>Note:</u> Support plate for the release mechanism is not included

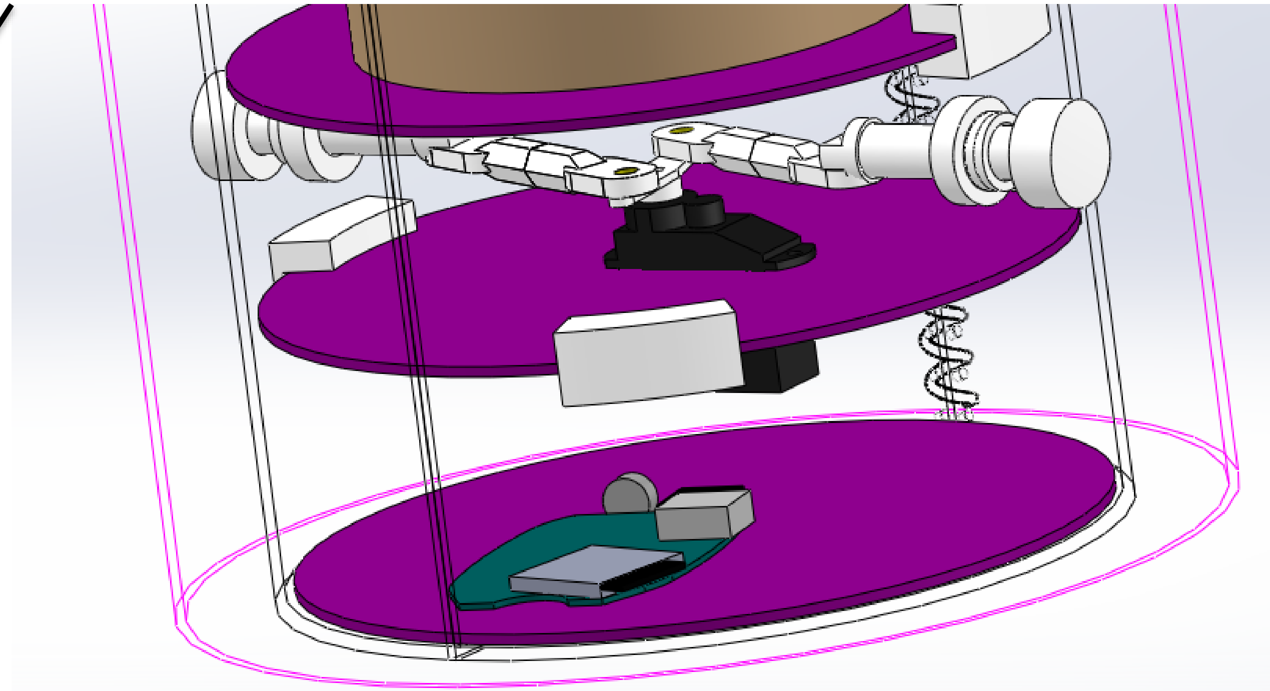


Container - Payload Interface Cont'd



- Arm cap and Arm supports will be 3D printed and the material that will be used *ABS plastic*

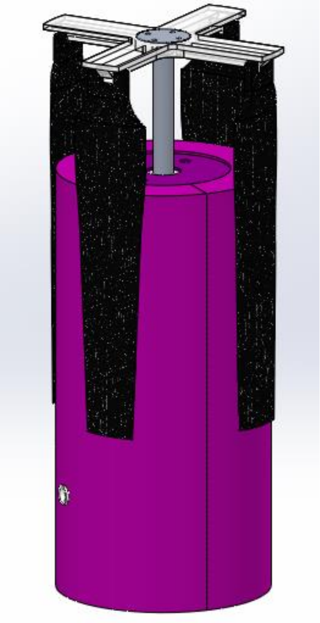


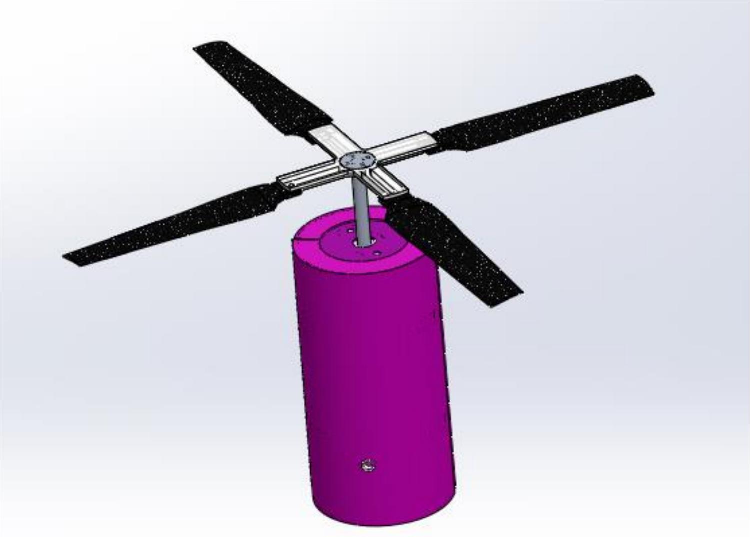


Full view of CanSat

Additional view of the *Pivot Release* (Parts indicated on the pervious slide)

Deployment of Descent Control System

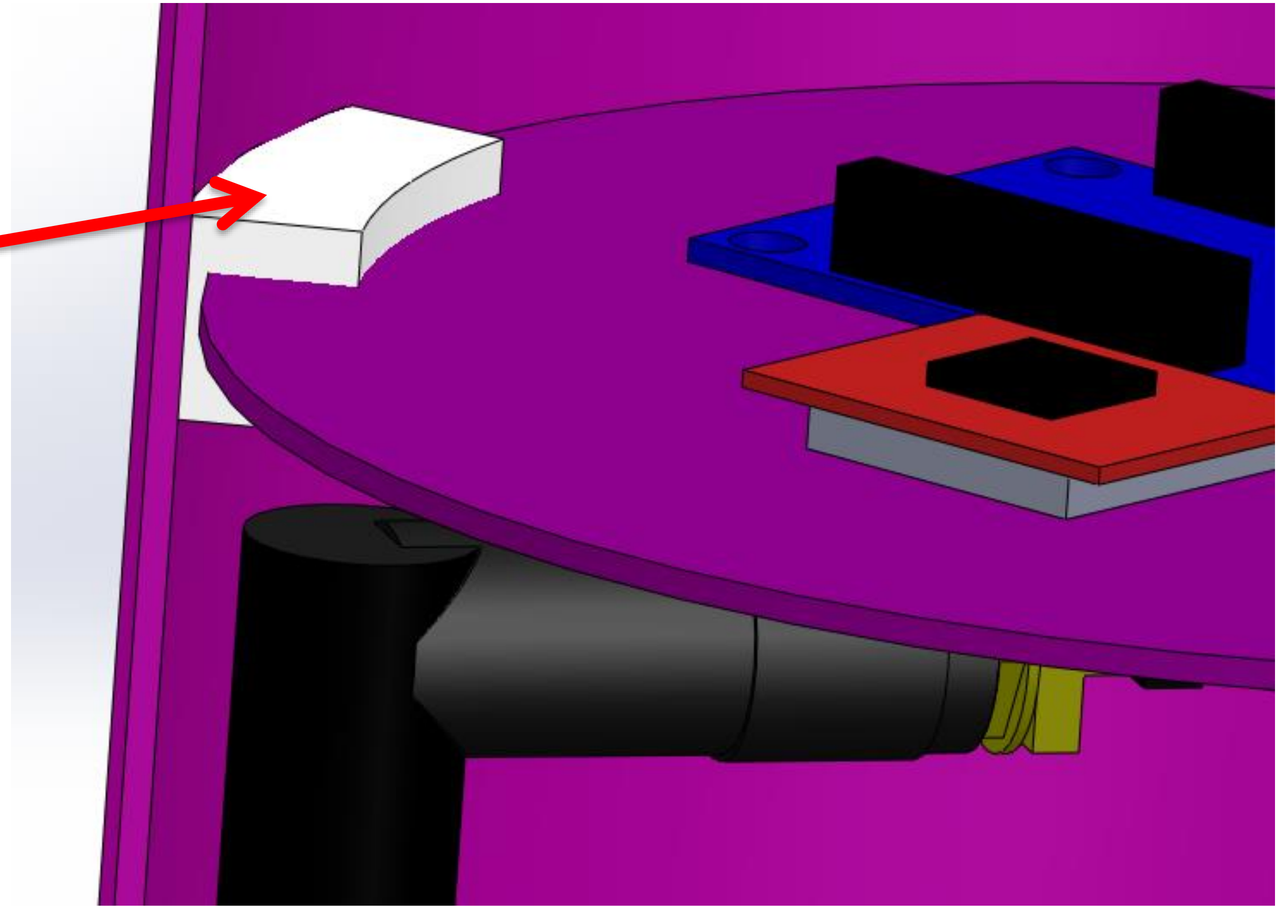




- The rotor blades will be in a closed position while Science Vehicle is pared with the Container
- At separation from container, blades will open and be held on that position due to the spring attachment into the hub-blade interference

Structure Survivability Trades: Electronics Enclosures and Connections

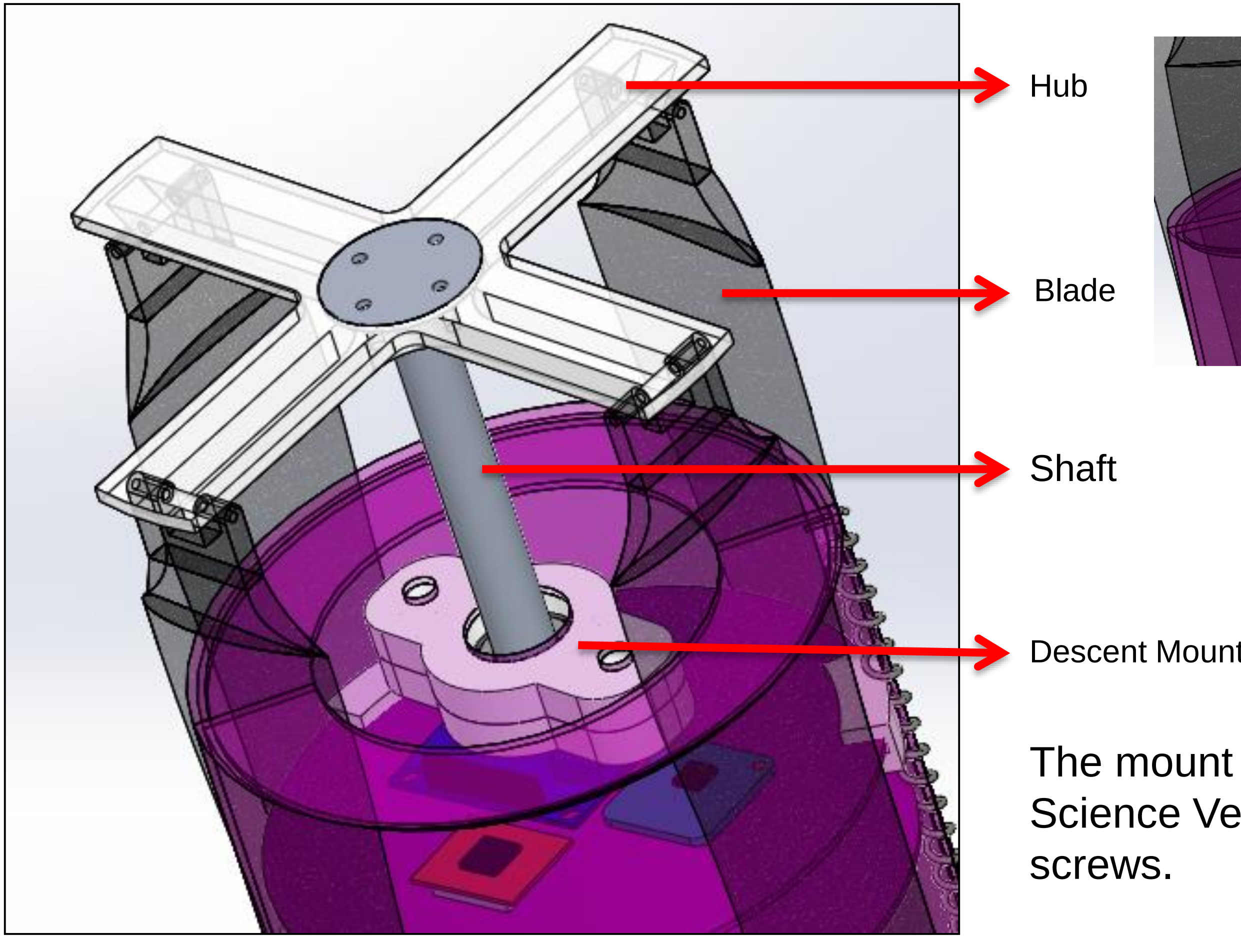
- Electronics mounted onto PCBs
- PCBs mounted to payload via ***slots*** enclosed in payload shell
- Payload is enclosed in a container

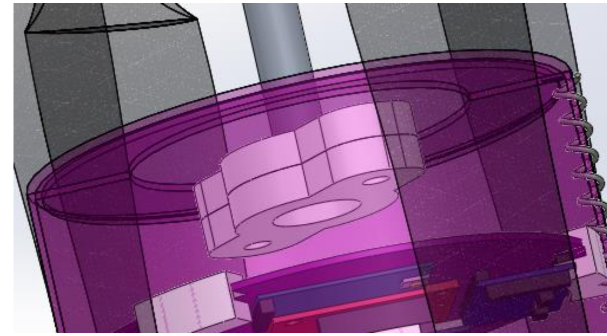


Structure Survivability Trades: Electronics Mount

Payload Mounting Plate Material		Kevlar Panel		PCB	
• Primary structural support for Payload interior components: Electronics, antennae, egg enclosure, etc. •125mm diameter •Design requirements: impact resistant, workable, lightweight, full enclosure, withstand force from 30 G's of acceleration					
Criteria	**Weight**	**Rating**	**Reason**	**Rating**	**Reason**
Workability	20%	4	Easily cut to size	5	Simplifies layout
Impact Resistance	50%	5	Impact resistant	4	Mount brackets will ensure stability
Size/Mass	30%	3	Lightweight	5	Very lightweight and eliminates wiring weight
Total Score	100%	4.2		4.5	
Rank		2		1	
Decision		Decline		**Accept**	

Structure Survivability Trades: Descent Control Mount

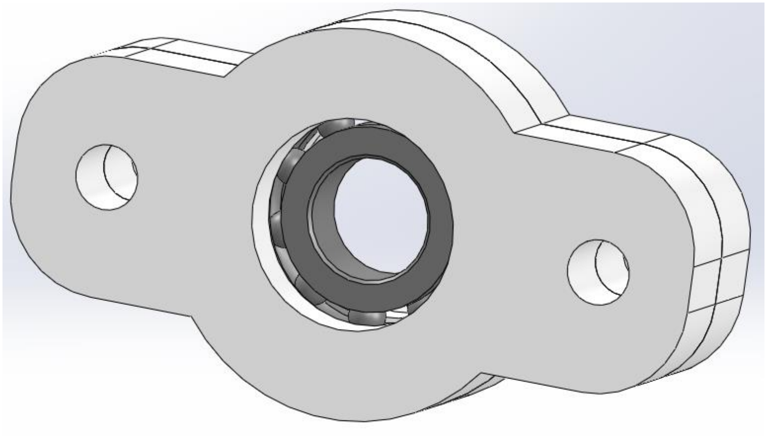




Bottom View of the Mount

The mount will be placed inside the Science Vehicle and attached to it via screws.

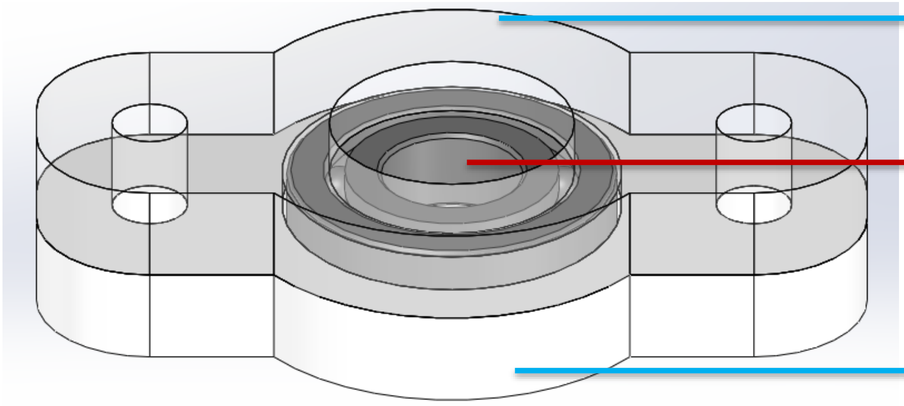
Structure Survivability Trades: Descent Control Mount (Cont'd)



Descent Mount

composed of three parts:

- Top Housing
- Bottom Housing
- Ball Bearing



Top Housing

Ball Bearing

Bottom Housing

Note: Top shown transparent for better inner view

Structure Survivability Trades: Testing

- Testing has **not** yet been performed to determine if structure and connections can resist 30 Gs of shock and 15 Gs of acceleration.

- Electronic plates mounts are planned to be tested under a *vibrations test*.

- *Thermal Test* will also be performed to ensure survivability of the system in a hot environment.

Mass Budget (Container)

Component	Mass per unit (g)	Quantity	Grand Mass (g)	Source/Uncertainties
Chassis	219.9	1	209.9	Estimates
Parachute attachment link	7.3	1	7.1	Estimates
Parachute with hook	20.6	1	20.6	Estimates

Total Container Mass: 247.8 grams

Mass Budget (Payload)

Component	Mass per unit (g)	Quantity	Grand Mass (g)	Source/Uncertainties
Chassis	98.16	1	98.16	Estimates
Plates	6.24	6	37.44	Estimated
Arm Supports	0.35	2	0.7	Estimated
Arm Caps	0.13	2	0.26	Estimated
Egg Protection System	20	1	20	Measured
PCB	8.46	1	8.46	Estimates
Plate bracket	1.17	9	10.53	Estimates
Spring	3.85	1	3.85	Estimates
Descent Mechanism	64.54	1	64.54	Estimates
Descent Mount	13.8	1	13.8	Estimates
Total Payload Mass: 258.19 grams				

Mass Budget (Electronics)

Component	C or P	Mass per unit (g)	Quantity	Grand Mass (g)	Source/Uncertainties
Arduino Pro Mini	P	3.8	1	3.8	Manufacturer's specs
ADXL345	P	2.2	1	2.2	Manufacturer's specs
BMP 180	P	1.6	1	1.60	Manufacturer's specs
XBEE	P	8.37	1	8.37	Manufacturer's specs
Breakout Board	P	2.03	1	2.03	Manufacturer's specs
TMP36	P	1.5	1	1.5	Manufacturer's specs
Antenna	P	14	1	14	Manufacturer's specs
Battery	P	60	1	60	Measured
Servo	P	4.7	1	4.7	Measured

Total Electronics Mass: 98.2 grams

Mass Budget (Summary)

CanSat Section	Mass (g)
Container	247.8
Payload (including descent mechanism and descent mount)	258.19
Electronics	98.2
Total Mass (without egg)	**604.19**

Communication and Data Handling Subsystem Design

Demetrios Doumas

CDH Overview

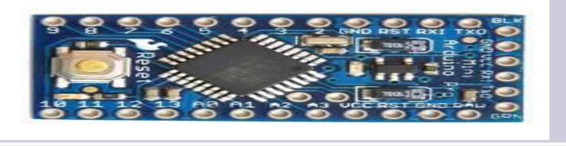
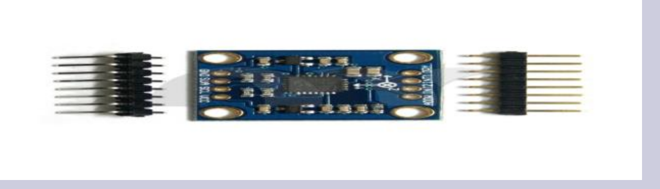
Communication Data Handling components:

Sensors	Role
Arduino Pro Mini 5 volt	Micro Controller
Xbee Series 3	Radio Transmitter
ADXL345	Read x, y, z acceleration of the CanSat
BMP180	Calculate inside temperature and altitude
TMP36	Calculate Outside temperature.
900MHz 3 dBi Rubber Duck Antenna	Send telemetry data over a far range

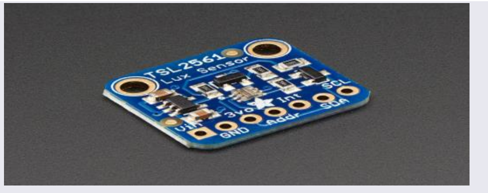
CDH Overview (Continue)

Sensors	Role
Luminosity sensor TSL2561	Is needed to check rocket deployment
Chronodot	Is needed to fix mission time if a processor reset has happen.
24LC256 EEproms	Store external time from Chronodot

CDH Overview (Continue)

Sensors	Picture
Arduino Pro Mini 5 volt	
Xbee Series 3	
LSM303DLH 3-Axis Electronic Compass Accelerometer Module Compass Sensor	
BMP180	
TMP36	

CDH Overview (Continue)

Sensors	Picture
900MHz 3 dBi Rubber Duck Antenna	
Luminosity sensor TSL2561	
Chronodot	
24LC256 EEproms	

CDH Changes Since PDR

Changes:

1.) Added the Chronodot and 24LC256 EEproms in case of a processor reset.

2.) Replace the ADXL345 with the LSM303DLH 3-Axis Electronic Compass Accelerometer Module Compass Sensor

- The LSM303DLH will help track the cameras movement.

CDH Requirements

ID	Req. No	REQUIREMENT
CDHR-01	21	During descent, the Science Vehicle shall collect and telemeter air pressure (for altitude determination), outside and inside air temperature, flight software state, battery voltage, and bonus objective data (accelerometer data and/or rotor rate).
CDHR-02	22	The Science Vehicle shall transmit telemetry at a 1 Hz rate.
CDHR-03	23	Telemetry shall include mission time with one second or better resolution, which begins when the Science Vehicle is powered on.
CDHR-04	24	XBEE radios shall be used for telemetry. 2.4 GHz Series 1 and 2 radios are allowed. 900 MHz XBEE Pro radios are also allowed.
CDHR-05	25	XBEE radios shall have their NETID/PANID set to their team number (decimal).
CDHR-06	26	XBEE radios shall not use broadcast mode.
CDHR-07	27	The Science Vehicle shall have a video camera installed and recording the complete descent from deployment to landing. The video recording can start at any time and must support up to one hour of recording.

CDH Requirements Cont’d

ID	Req. No	REQUIREMENT
CDHR-08	28	The video camera shall include a time stamp on the video. The time stamp must work from the time of deployment to the time of landing.

Processor & Memory Trade & Selection

Criteria	**Weight**	**Arduino Pro Mini 5V** (ATmega328)	**Grade**	**Pro Micro 5V** (ATmega32U4)	**Grade**
Processor speed	20%	16MHz	3	16MHz	3
Data interfaces	20%	Digital: 14 Analog: 8 PWM: 6	4	Digital: 12 Analog: 10 PWM: 5	3
Flash Memory	20%	32KB	3	32kB	3
Size	20%	39x18mm (w/ FTDI adapters)	4	33x17.7mm	5
Cost	20%	$9.95	5	$19.95	4
Weighted Total	100%		3.8	Does not need FTDI adapters	3.6

Processor & Memory Trade & Selection

- **Selected Arduino Pro Mini 5V**

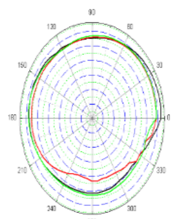
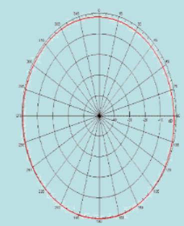
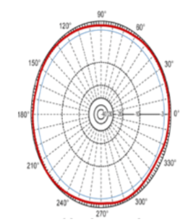
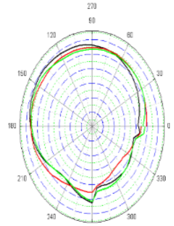
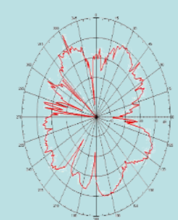
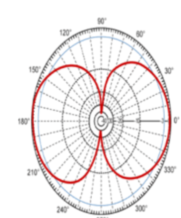
1.) Cost less than the Pro Micro 5V (ATmega32U4)

2.) Has more Digital interfaces than the Pro Micro 5V (ATmega32U4)

Real-Time Clock

- The flight software on the 5 volt Arduino pro mini will keep track of time throughout the flight time.
- The external clock (Chronodot) will be running in parallel.
- If the processor resets then the flight state is retrieved from the EEproms and the time from the Chronodot will be saved to mission time.

Antenna Trade & Selection

Criteria	**Weight**	**SFE Cellular Helical Antenna**	**Grade**	**SFE 900MHz Duck Antenna**	**Grade**	**HyperLink HG903D-RSP**	**Grade**
Frequency	30%	900-1990 MHz	5	900/1800 MHz	5	860-960 MHz	5
Gain	20%	2 dbi	4	2 dbi	4	3 dbi	3
VSWR	30%	< 3	2	<1.8	5	<2	4
Radiation Pattern H-Plane	20%		4		3		4
E-Plane							
Weighted Total			3.7		4.4		4.1

Antenna Trade & Selection

- **Selected SFE 900MHz Duck Antenna**

1.) Low gain of 2 dbi, which means more coverage on the H-plane.

2.) Has a low voltage standing wave ratio, which means less power loss of the signal coming from the xbee radio transmitter.

Radio Configuration

- The XBee-PRO 900MHz XSC S3B radios will be configured with the XCTU -firmware.
- Modem ID will be the Team ID.
- When powered on, the XBee will automatically join network. No management needed.

Telemetry Format

- **Data Included:**
  - Team-ID -Mission Time
  - Altitude -Outside Temperature
  - Inside Temperature -Voltage
  - Flight state - X,Y,Z Acceleration
- **Data format: <TeamID>,<MissionTime>,<Altitude>,<Outside Temperature>,<Inside Temperature>,<Voltage>,<Flight State> <3-AxisAccel(tilt)>**
- **Data rate:**
  - 9600 (bytes per second)
  - Continuous transmission

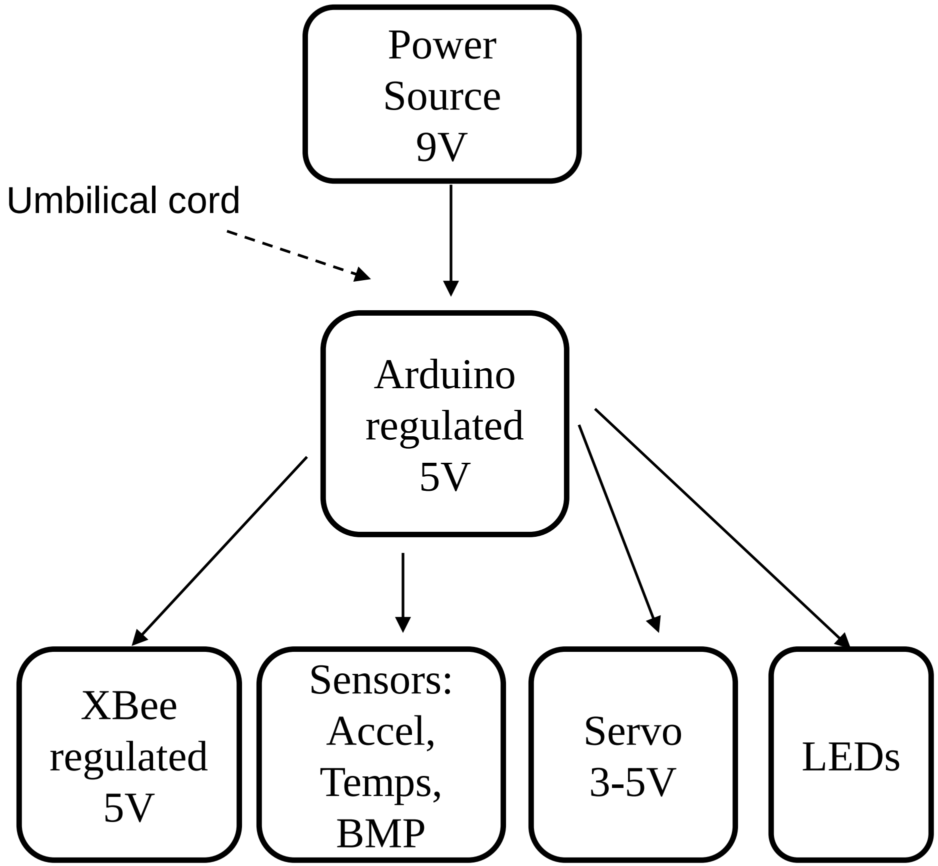
Electrical Power Subsystem Design

Joel Annenberg

EPS Overview

- **Payload:**
  - 9V Battery– power source
  - 1k ohm voltage divider – for voltage sensing
  - TL431 diode - voltage reference for precision voltage sensing
  - 3V CR1632 lithium coin cell – to power external clock
  - LEDs – to verify payload status
- **Container:**
  - No electronics in container

EPS Overview Continued



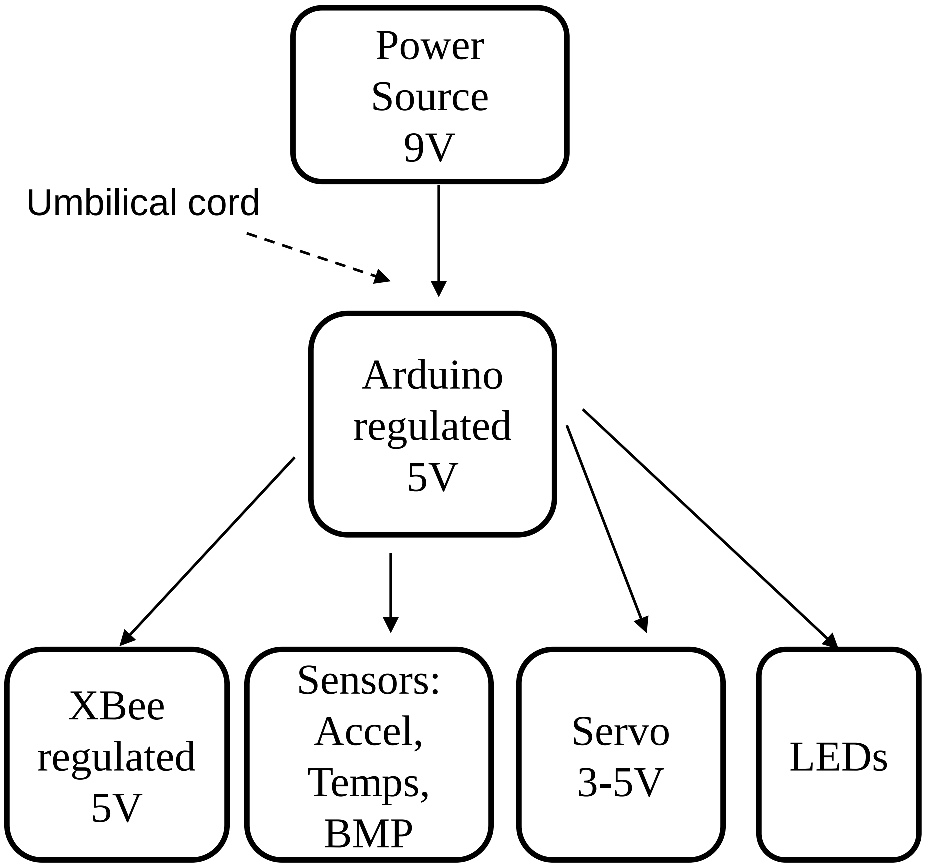
EPS Changes Since PDR

Change	Reason
Added 3V coin cell	Required to power the external clock that was added to the electrical system
Added external voltage reference	Increase accuracy of voltage measurement
Power requirements changed	Added more sensors, which led to the consumption of more power

EPS Requirements

ID	Req. No	REQUIREMENT
EPSR-01	42	The Science Vehicle shall include an easily accessible power switch which does not require removal from the Container for access. An access hole or panel in the Container is allowed.
EPSR-02	43	The Science Vehicle must include a battery that is well secured.
EPSR-03	44	Lithium polymer cells are not allowed due to being a fire hazard.
EPSR-04	45	Alkaline, Ni-MH, lithium ion built with a metal case, and Ni Cad cells are allowed.

Electrical Block Diagram (Payload)



- **An externally accessible switch will be installed between the 9V battery and the microcontroller.**
- **A power umbilical cord will be attached to the microcontroller to allow for testing**
- **LEDs will be externally visible for status verification (for testing only)**
- **Sensors are all rated for use with 5V power (some regulate voltage down to 3.3V).**

Electrical Block Diagram: Container

There will be no container electronics, as all of the required electronics will be contained in the payload.

Power Source Trade & Selection (Payload)

Criteria	Weight	Energizer Advanced	Grade	Duracell Coppertop	Grade
Weight	75%	33.9 g	4	45 g	2
Price	25%	$5.99	3	$3.99	4
Weighted Total	100%		3.75		2.50

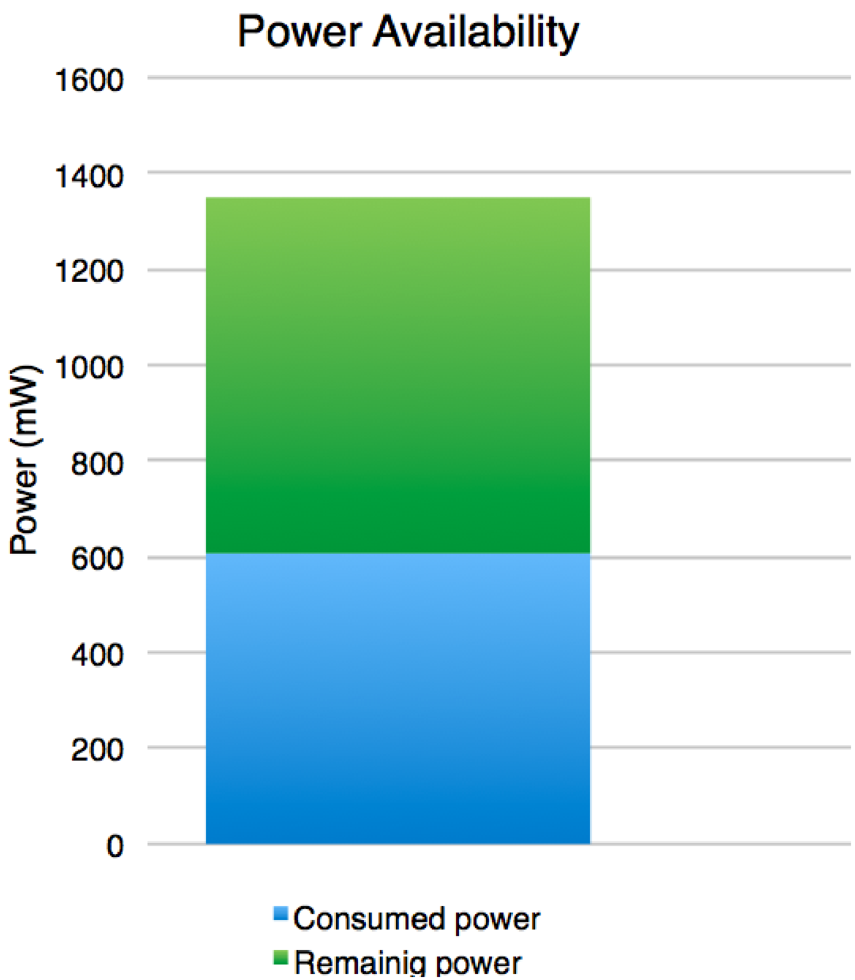
Power Source Summary

- **Payload Power Source:**
  - Energizer Advanced Lithium Alkaline
  - 9V @ 150mA
  - 46.4 x 26.5 x 17.5 mm
  - 33.9g / unit
  - $5.99 / unit
  - Powerful, light, reliable

- **Container Power Source:**
  - None

Payload Power Source Selection and Design

- **Power will be generated from 1 Energizer Advanced Lithium-Alkaline 9V Battery (9V @ 150 mA min.)**
- **Supplies ample power and is lighter and more reliable than traditional 9V batteries.**
- **Total power consumption will be 606.48 mW out of a total availability of 1350 mW.**



Power Budget (Payload)

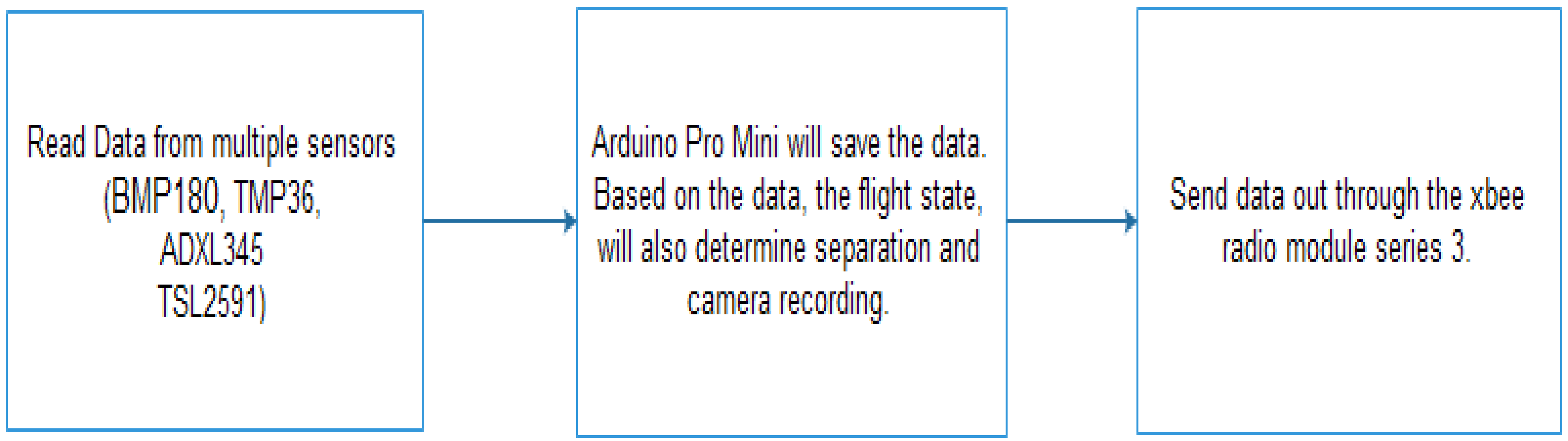
Components	Power Consumed	Duty Cycle	Source	Total Power Consumed
Arduino	15.8 mW	14%	Measurement	2.6 mWh
Xbee Pro XSC 900MHz (P.L.2)	126.7 mW	14%	Measurement	20.7 mWh
Accelerometer & Magnetometer LSM303	0.363 mW	14%	Data Sheet	0.061 mWh
Barometer BMP180	.05 mW	14%	Data Sheet	0.008 mWh
Servo	396 mW	~0%	Measurement	0.11 mWh
LED	66 mW	14%	Data Sheet	11 mWh
Temperature Sensor TMP36	0.25 mW	14%	Data Sheet	0.042 mWh
Luminosity Sensor TSL2591	1.32 mW	14%	Data Sheet	0.22 mWh
			Total:	100.62 mWh
	Power Available			**Total Power Supplied**
9V Battery @ 150 mA	1350 mW	100%		225 mWh

Est. Mission Duration: 4200s
Est. Powered Time: 600s

Flight Software (FSW) Design

Demetrios Doumas

Flight Software



FSW Overview

- **Language**

  C programming language

- **Development Environment**

  Arduino software (free open source)

- **FSW Tasks**

  Record, store and transmit data.

  Activate release mechanism at designated altitude.

  Camera record descent

FSW Requirements

ID	Req. No	REQUIREMENT
FSWR-01	10	The Container or Science Vehicle shall include electronics and mechanisms to determine the best conditions to release the Science Vehicle based on stability and pointing. It is up to the team to determine appropriate conditions for releasing the Science Vehicle.
FSWR-02	21	During descent, the Science Vehicle shall collect and telemeter air pressure (for altitude determination), outside and inside air temperature, flight software state, battery voltage, and bonus objective data (accelerometer data and/or rotor rate).
FSWR-03	22	The Science Vehicle shall transmit telemetry at a 1 Hz rate.
FSWR-04	23	Telemetry shall include mission time with one second or better resolution, which begins when the Science Vehicle is powered on.
FSWR-05	27	The Science Vehicle shall have a video camera installed and recording the complete descent from deployment to landing. The video recording can start at any time and must support up to one hour of recording.
FSWR-06	28	The video camera shall include a time stamp on the video. The time stamp must work from the time of deployment to the time of landing.

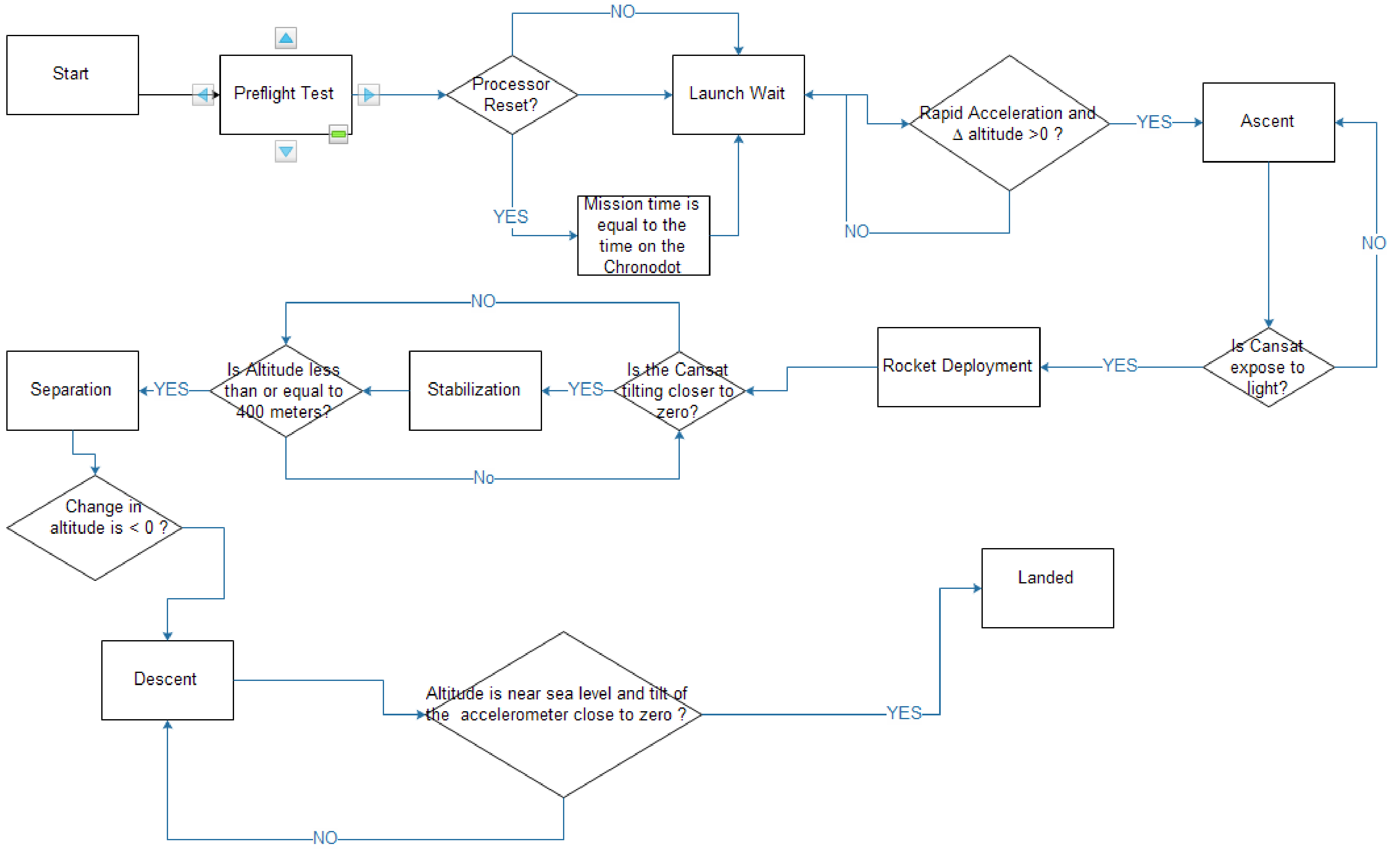
FSW Requirements

ID	Req. No	REQUIREMENT
FSWR-07	40	The CanSat flight software shall maintain and telemeter a variable indicating its operating state. In the case of processor reset, the flight software shall re-initialize to the correct state either by analyzing sensor data and/or reading stored state data from non-volatile memory. The states are to be defined by each team. Example states include: PreFlightTest(0), LaunchWait(1), Ascent(2), RocketDeployment(3), Stabilization(4), Separation(5), Descent(6), and Landed(7).

CanSat FSW State Diagram

States	Conditions	Sensors
Pre-FlightTest (0)	CanSat Boot	External switch
LaunchWait(1)	Passes Pre-FlightTest	
Ascent(2)	Change in Altitude is >0	Accelerometer @ 1Hz, and Pressure Sensor @ 1Hz
Rocket Deployment(3)	Cansat is expose to light	Luminosity sensor TSL2561 @ 1Hz
Stabilization(4)	Accelerometer tilt is closer to zero.	Accelerometer @ 1Hz
Separation(5)	Altitude has reached 300 meters	Pressure Sensor @ 1Hz
Descent(6)	Change in Altitude is <0	Accelerometer @ 1Hz
Landed(7)	Altitude at ground level	Accelerometer @ 1Hz

CanSat FSW State UML-Diagram



Software Development Plan

- **A common CanSat problem is late software development**
- **Present a slide describing the plan for software development and plans to reduce the risk of late software development**
- **Include:**
  - Prototyping and prototyping environments
  - Software subsystem development sequence
  - Development team
  - Test methodology
- **Discuss progress since PDR**

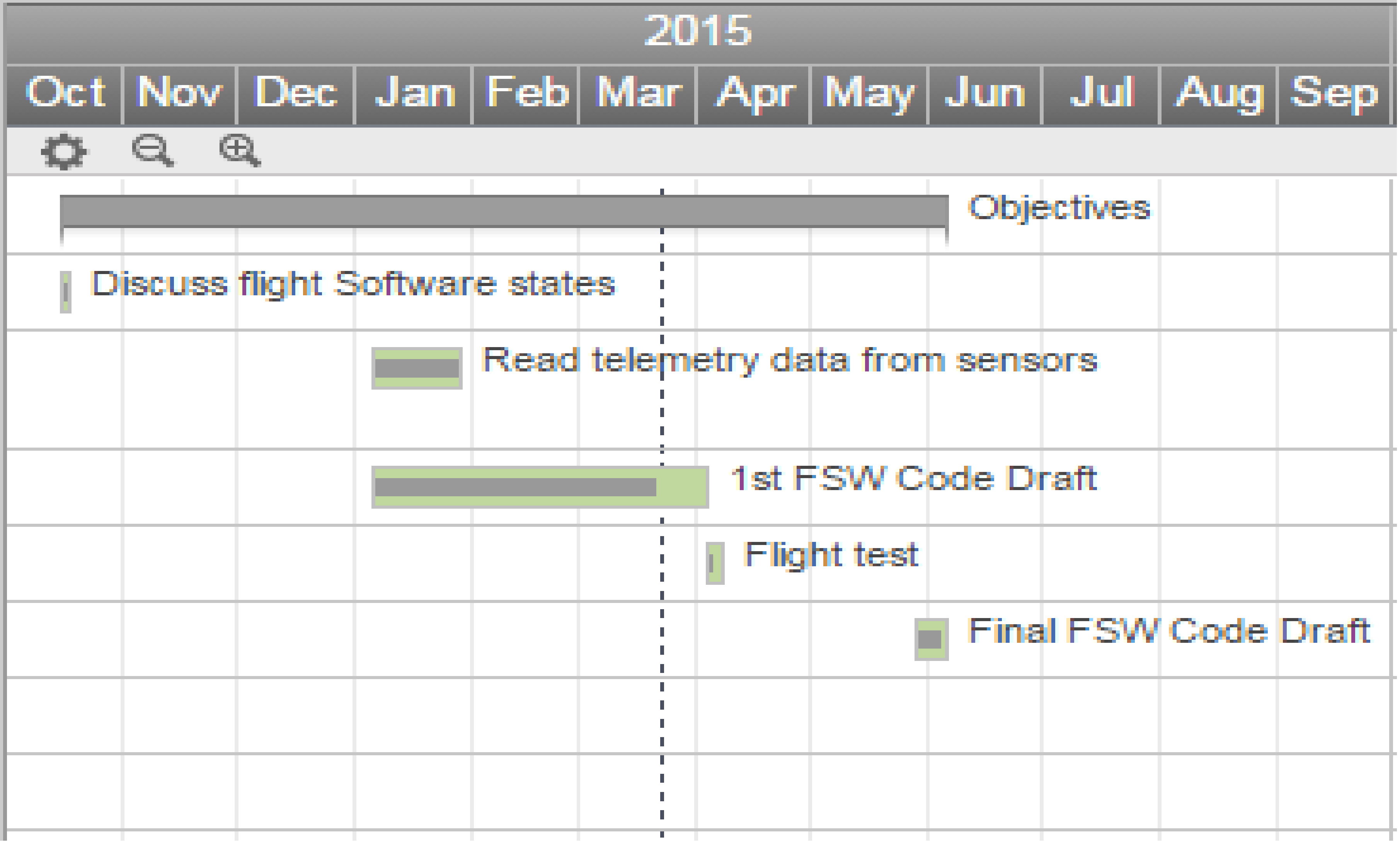
Software Development Progress

Progress:

1.) Calculate all required telemetry data.

2.) Able to transmit telemetry data.

Software Development Plan

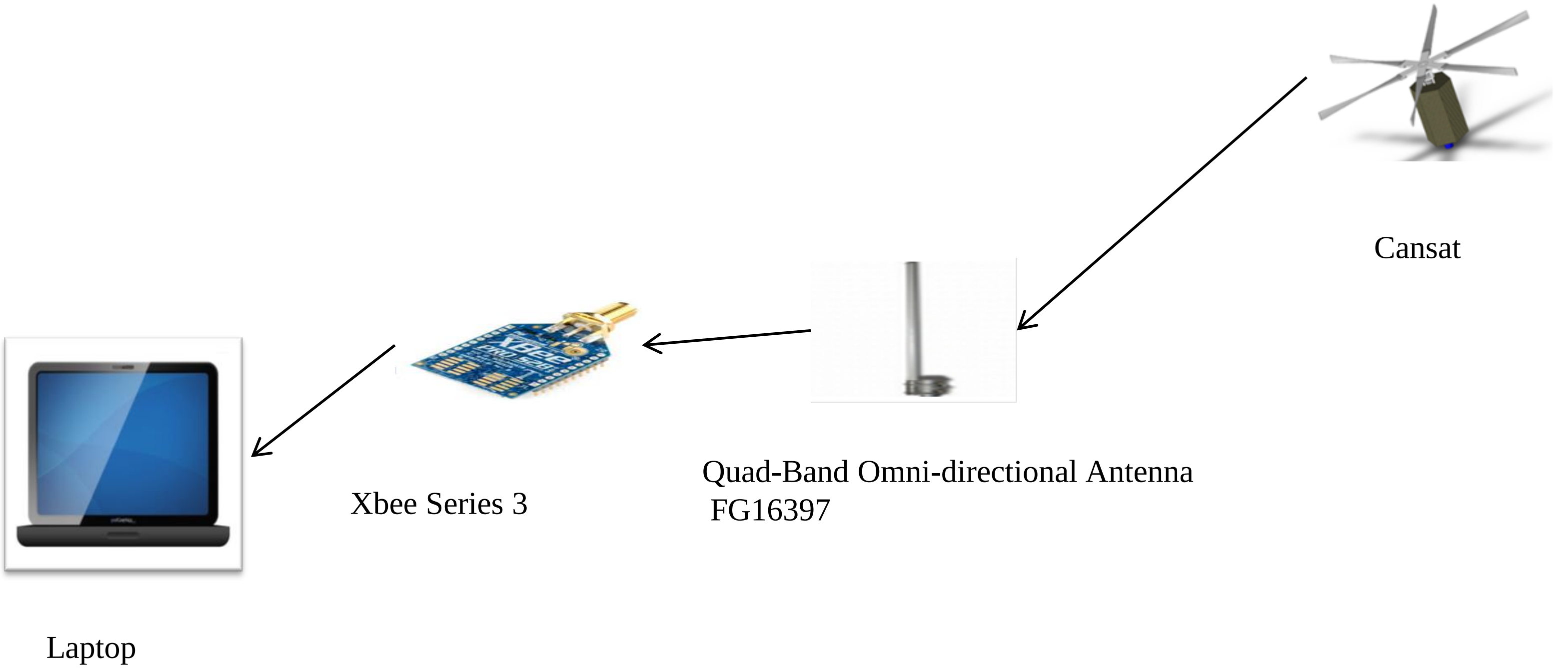


Ground Control System (GCS) Design

Demetrios Doumas

GCS Overview

Telemetry data flow:



GCS Requirements

ID	Req. No	REQUIREMENT
GCSR-01	24	XBEE radios shall be used for telemetry. 2.4 GHz Series 1 and 2 radios are allowed. 900MHZ XBEE Pro radios are also allowed.
GCSR-02	25	XBEE radios shall have their NETID/PANID set to their team number.
GCSR-03	26	XBEE radios shall not use broadcast mode.
GCSR-04	32	Each team shall develop their own ground station.
GCSR-05	33	All telemetry shall displayed in real time during descent.
GCSR-06	34	All telemetry shall be displayed in engineering units (meters, meter/sec, Celsius, etc).
GCSR-07	35	Teams shall plot data in real time during flight on ground station computer.
GCSR-08	36	The ground control station shall include one laptop computer with a minum of two hours of battery operation, XBEE radio and a hand held or table top Antenna.

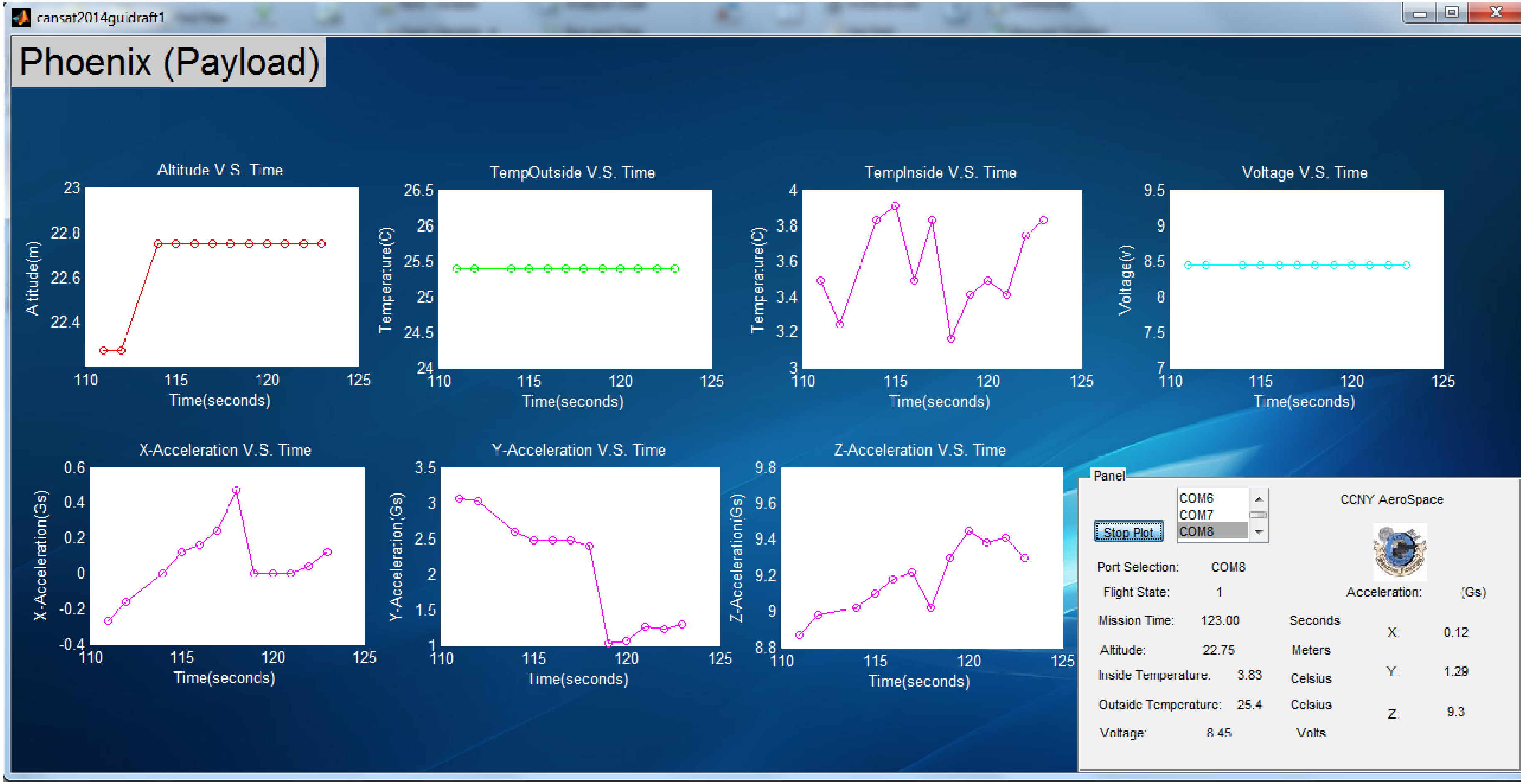
GCS Requirements Cont'd

ID	Req. No	REQUIREMENT
GCSR-09	37	The ground station shall be portable so the team can be positioned at the ground station operation site along the flight line. AC power will not be available at the ground station operation site.

GCS Antenna

- **Discussion of the selection of the GCS antenna**
- **Include:**
  - Antenna placement and coverage
    - Diagram is recommended
  - Antenna height and mounting strategy
    - Launch day construction
  - Distance link predictions and margins
  - Screen shot of ground control software in operation

Screen shot of ground control software in operation



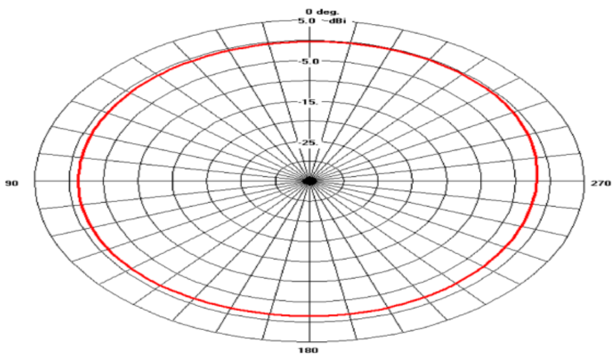
GCS Antenna Trade selection

Criteria	Quad-Band Omni-directional Antenna FG16397	Hyper Link Yagi HG903YE	Die Cast Grid Antenna
			
Gain:	1dBi	3dBi	15dBi
Type:	Omni Directional	Directional	Directional
Cost:	$100	$30	$ 90
Weight:	0.844 lbs	1.5 lbs	6.55 lbs
Polarization:	Linear vertical	Horizontal or vertical	Horizontal or vertical
Frequency:	900MHz	900MHz	824~960 Hz

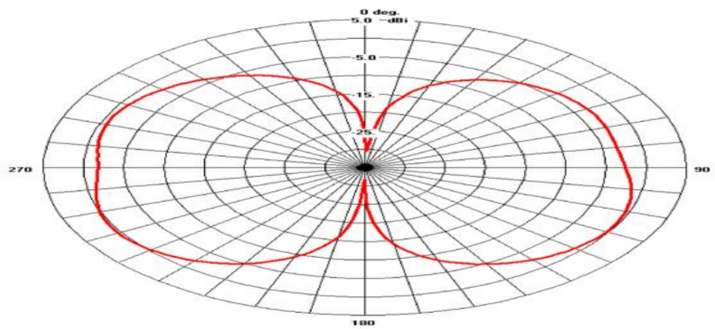
Distance Link and Predictions

- The antenna will be mounted as a tabletop antenna during the launch day.
- The selected antenna radiation pattern is:

Azimuth



Elevation



The Omni-directional Antenna
FG16397 was chosen because of its 360 degree coverage in the horizontal plane.

Elevation Beamwidth at Half-Power: 90 degrees
Azimuth Beamwidth at Half-Power: 360 degrees

GCS Software

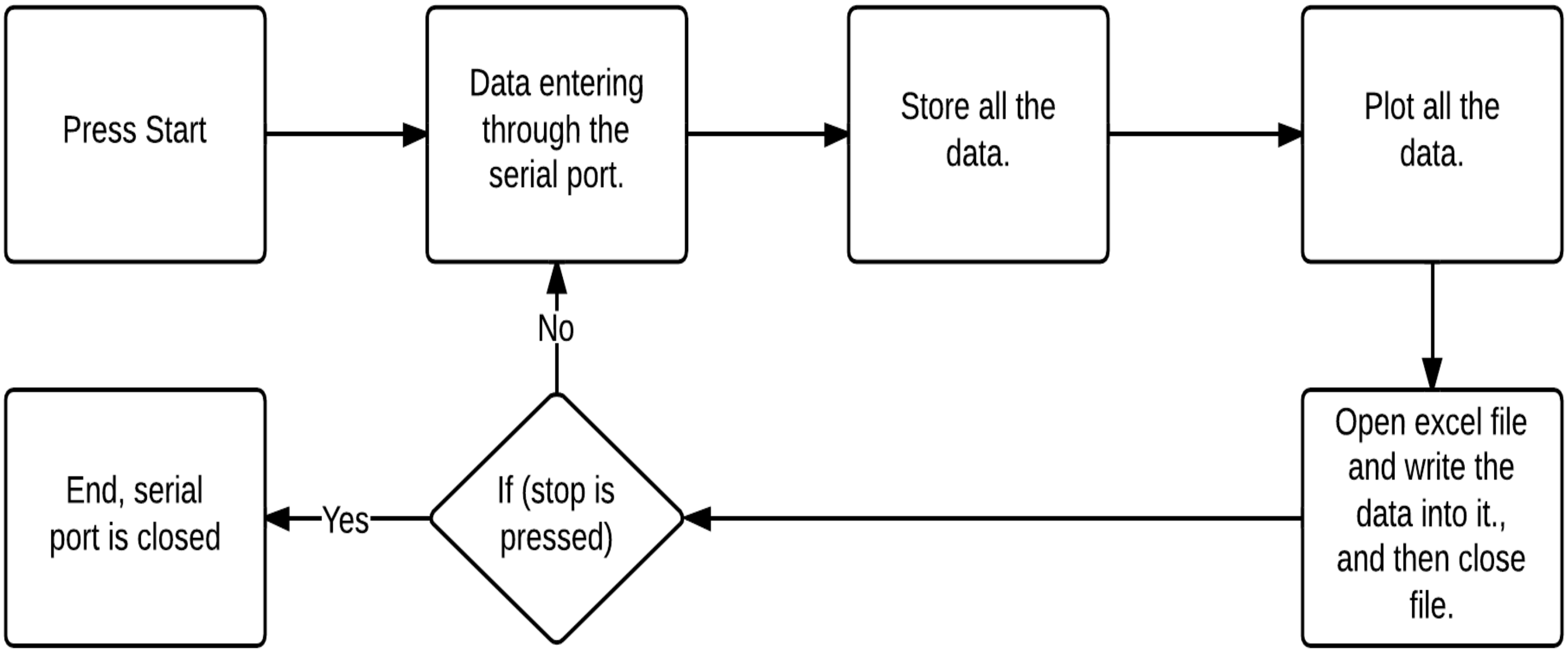
- Telemetry display screen shots
- Commercial off the shelf (COTS) software packages used
- Real-time plotting software design
- Data archiving and retrieval approach
- Command software and interface
- Progress since PDR
- Testing

Commercial off the shelf (COTS) software packages used:

- **Matlab 2013:** Creating a Graphic User Interface (GUI).
- **Arduino:** Diagnostic purposes for checking serial port readings.

GCS Software: Flow Chart

Real-time plotting software design:



GCS Software: Data archiving and retrieval approach

Data archiving Steps:

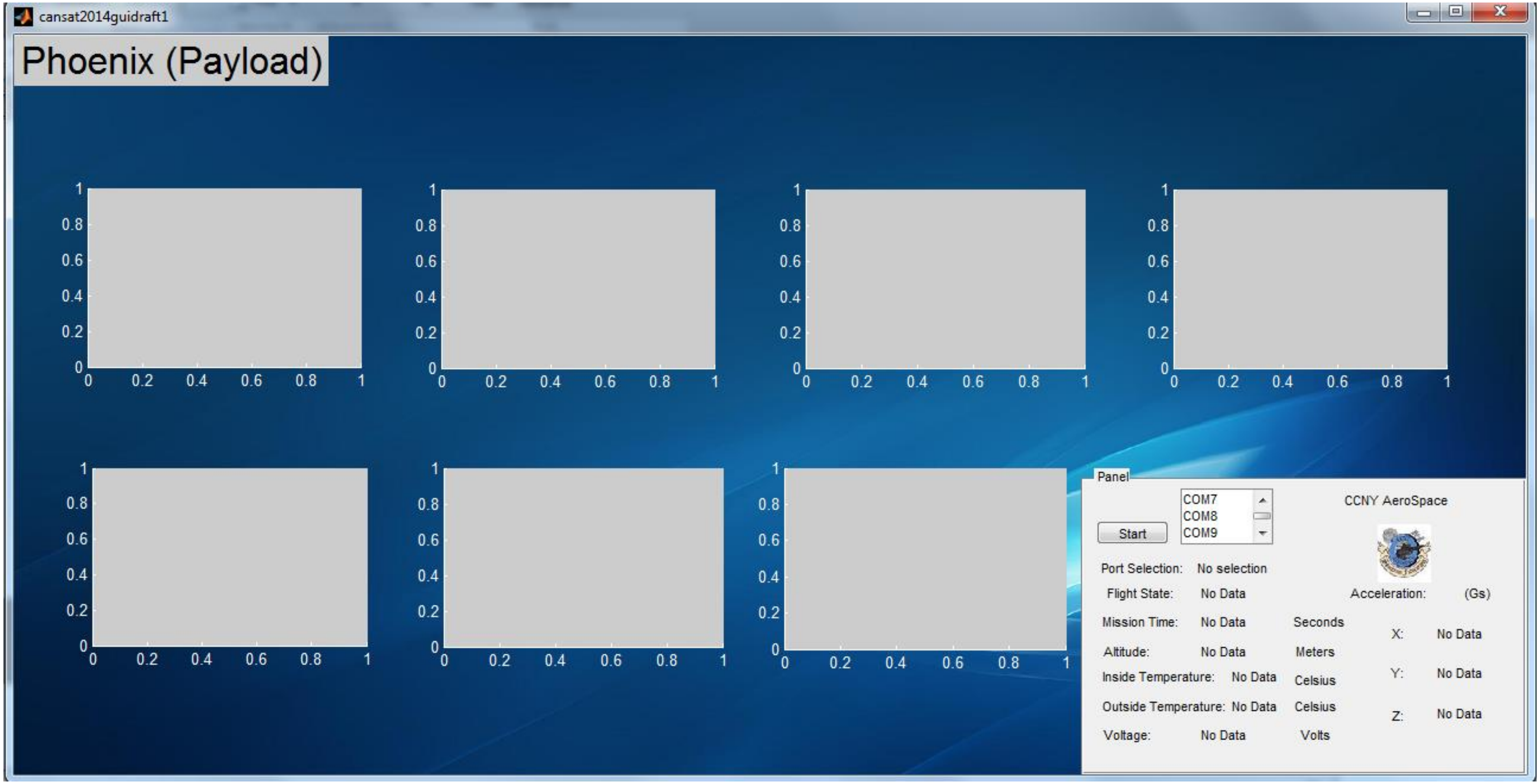
1.) Read data from serial port every 1 Hz.

2.) Save the data in an excel file.

3.) Plot current data on the screen

4.) Repeat

GCS Software Interface



Telemetry data recording and media presentation:

Payload Telemetry Data:

- Team id, mission time, alt sensor, outside temperature, inside temperature, voltage, flight state, X, Y, and Z.
- X, Y, and Z are accelerometer readings.

Progress Since PDR

- Radio communication established between the GCS software and cansat prototype.
- GCS software finished

Testing

Indoors:

- The electronics are connected directly to the laptop, where the GCS software is reading the data.
- Also, test the flight states operation by doing an altitude test inside an elevator.

Outdoors:

- The CanSat will be placed in a rocket (similar to the CanSat competition rocket) and released in an open area in Pennsylvania.
- Antenna Testing, whether data is being received with the Arduino software

CanSat Integration and Test

Sakif Chowdhury

CanSat Integration and Test Overview

- **Flight Software**
  - Test Navigation Software
- **Mechanical Systems**
  - Drop test and Vibration Test
  - Temperature Test
- **Sensors**
  - Individual testing for reliability, accuracy, and precision of each sensor
- **Communications and Data Handling**
  - 1 mile line of sight test
  - Test communication systems
  - Tests data analysis conducted at ground station
- **Electrical Power Systems**
  - Measure estimated necessary power

CanSat Assembly

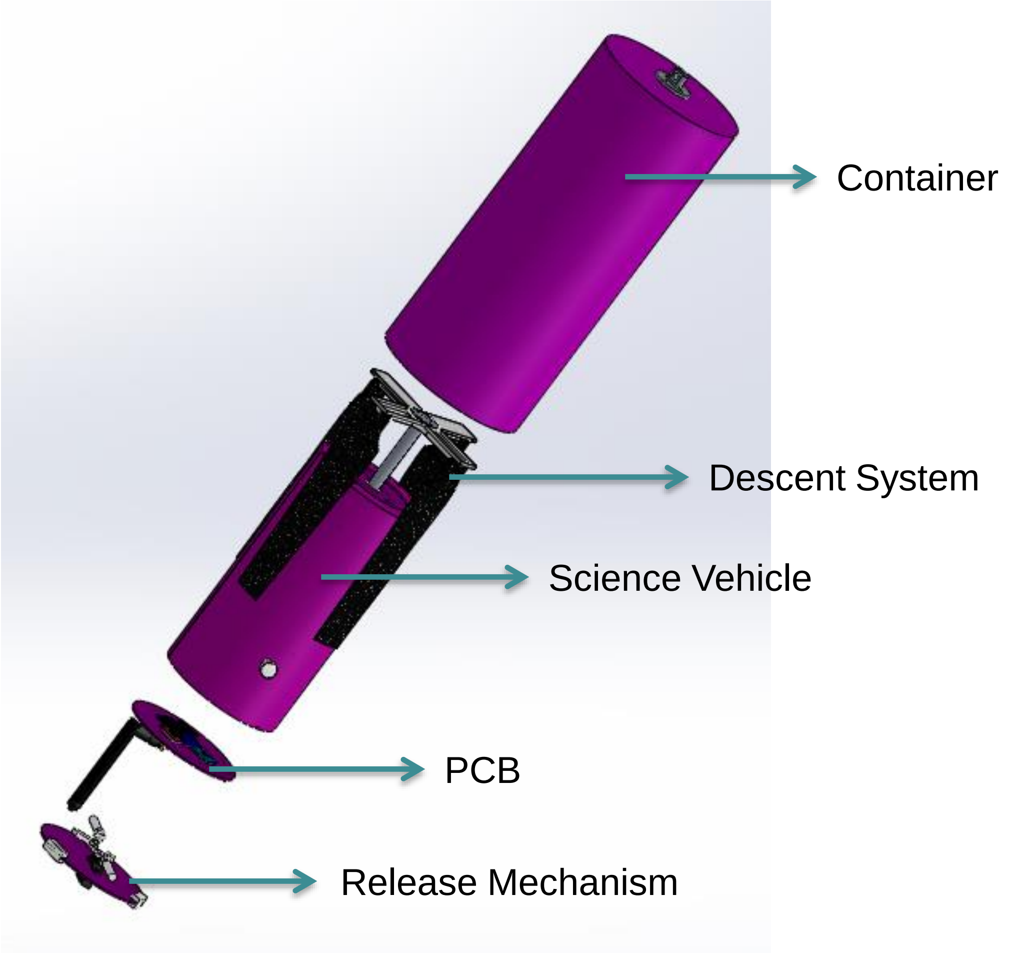
Assembly of primary components of CanSat:

Container will be housing the Science Vehicle

Science Vehicle is connected to the reentry container via the release

Mechanism

The Electronics Plates are slotted on the upper section on the Payload and the Egg Protection is placed on the bottom section along with the camera.



Integration and Testing Goals

- **Current Goals**
  - To be able to complete most of the manufacturing in April in order to perform proper testing
  - Complete a proto type of the CanSat for fully integrated testing
  - Analyze tests thoroughly in order to make changes/improvements
  - To be able to make sufficient improvements while meeting competition requirements

Tests and Scheduled Dates

Test Type	Brief Description	Reason	Test Date
Drop Test	Shock Absorbance measurement using Kevlar thread	To observe the resistivity of fracture of the mechanical body and release mechanism	April 9th 2015
Wind Tunnel	Apply wind flow through mechanical structure	To observe the functionality of descent system and behavior of blades due to air flow	April 13th 2015
Thermal	Use Thermal Chamber on electronics at various temperatures	To observe the capability of electronics to withstand high temperatures and stability of mechanical design	April 6th 2015
Vibration Analysis	Apply vibrational forces up to 29 G forces	To measure the stability of electronics and analyze stress on mechanical system	April 10th 2015

DCS Subsystem Testing Overview

Test	Reason	Passing Criteria
Wind Tunnel	Correlate simulation data with experimental values for descent rate estimates	Terminal angular velocity and forces measured close to approximated data
Shock (Blades)	Determine effectiveness of blade attachment mechanism	Blades remain attached to rotor with no damage incurred
Shock (Parachute)	Determine effectiveness of parachute cord	Cord does not break, parachute remains intact

Mechanical Subsystem Testing Overview

Test	Reason	Passing Criteria
Container and Payload shell	Determine survivability	Survive landing impact
Release Mechanism	Determine effectiveness of mechanism	Payload deploys from Container with ease
Egg Protection System	Determine effectiveness of system	Egg survives landing

CDH Subsystem Testing Overview

Test	Reason	Passing Criteria
XBEE Communications	Determine effectiveness of the communication between XBEE transmitter and receiver	Data is transmitted and received without interference

FSW Code Testing

Test	Reason	Passing Criteria	Date
Container Code	Debug and remove possible glitches	Transmits necessary data and releases payload as programmed	April 6, 2015
Payload Code	Debug and remove possible glitches	Transmits necessary data	April 6, 2015

GCS Testing Overview

Test	Reason	Passing Criteria
Antenna	Determine maximum effective range	Works within 1 mile radius

Mission Operations & Analysis

Ruben Perez

Overview of Mission Sequence of Events

8:00am-12:00pm

- Launch preparations
- Check in
- Obtaining the Science vehicle egg
- Assemble antennas and ground station
- Perform Final CanSat Tests and reparations

12:00pm-1:00pm

- CanSat is submitted
- Any Ground Station problem are worked

1:00pm

- Launch will start
- Data is recovered

Overview of Mission Sequence of Events

Mission Control Officer:
- Ruben Perez

CanSat Crew:
- Patrick Guillaume & Joel Annenberg

Ground Station Crew:
- Demetrios Doumas

Recovery Crew:
- Maria Caceres & Majlinda Malellari

Antenna Construction and Ground Station Set Up

- Ground station computers will be set up and connected to antenna in preparation for mission.
- Any glitches will be sorted out before launch

Field Safety Rules Compliance

- The Mission Operation Manual from previous year will be used with changes.
- Mission Operation Manual will be broken down into two part.
  - Necessary procedures are imbedded into the Competition Operations and Launch Day Sequence of Events
  - Manual will contain major tasks to be executed by each team for the time intervals mentioned above
- Part I- General Mission Operation that includes CanSat Integration, launch Preparation, launch and removal procedures.
  - The manual will be organized into three launch-day time intervals
  - 8AM-12PM
  - 12-1PM
  - 1PM- MISSION END
- An example of procedure is provided in the next slide for Part I and Part II

Field Satefy Compliance Con't

08:00-12:00

1.Arrive at launch site. (SEE GROUND STATION SETUP PROCEDURES)

2.Check-in with flight line judge. The flight line judge will perform the following tasks:

a. Perform weight check of completed Cansat.

b. Perform fit-check of the CanSat using a sample payload section

c. Perform antenna mast height check

3.Prep and test CanSat for Flight (SEE CANSAT PREPARATION PROCUDURES)

12:00-13:00

- Mission Control Officer (MCO) and CanSat Crew (CC) will submit CanSat to Flight Line Judge.

13:00→

1.Upon the team round, the team will collect their CanSat and load into a rocket.

2.Remove nose cone

3.Insert Cansat inverted making sure to place PARACHUTE SIDE DOWN

4.Ensure parachute is not caught on rocket interior

5.Be sure to pull off **REMOVE BEFORE FLIGHT** tag and give to judge

6.Replace nose cone

CANSAT PREPARATION AND TEST

STATE 1 (TOG 1-ON : TOG 2-ON)

- IDLE
  - System is on
  - No data recording
  - No transmission

STATE 2 (TOG 1-ON : TOG 2-OFF)

- SYSTEMS TEST
  - Runs through electronics; testing operations
  - Press PUSH 2 to move to next component
  - Press PUSH 1 to move to previous component

STATE 3 (TOG 1-OFF : TOG 2-ON)

- INTERFACE MODE
  - Press AND Hold PUSH 1 to open servo mechanism
  - Release to close servo mechanism

STATE 4 (TOG 1-OFF : TOG 2-OFF)

- SYSTEM RUN
  - System runs Mission Software
  - Turn onboard switch ON to resent clock and packet count
  - Equivalent to the Diagnostic Pack being disconnected

Field Safety Rules Compliance

- Part II- CanSat Preparation & Test and Ground Station Setup
- The CanSat preparation procedures still needs to be written.

CanSat Location and Recovery

- The container and Payload will be painted neon pink.
- The school address will be written on the Container and Payload

Mission Rehearsal Activities

- **Ground system radio link check procedure**
  - Two xbee adapater were used. One was connected to the computer and the other connected to the electronics. Testing was done in order to determine if data was being transmitted into the FSW and that was successful.
- **Loading the egg payload**
  - The egg will be placed inside a cardboard container and surrounded by foam on the inside. This has been tested by dropping the egg and seeing that it survives the fall.
- **Powering on/off the CanSat**
  - The use of a switch and an LED light to determine if the CanSat is on/off.

Mission Rehearsal Activities

- **Launch configuration preparations**
  - A rocket similar to the one that is use in the competition will be made and used to test the placement of the CanSat.
- **Loading the CanSat in the launch vehicle**
  - The size of the max inner tubing of the container will be bought in order to test that the payload fits perfectly.
- **Telemetry processing, archiving, and analysis**
  - When the electronics are all connected to the PCB a test will be done to determine if the electronics are working properly and transmitting/receiving data.
- **Recovery**
  - Members of this team will practice keeping track of the cansat visually (with binoculars) during our fully integrated test

Requirements Compliance

Ruben Perez

Requirements Compliance Overview

- Design of the CanSat complies to most of the requirements.
- Those that remain depend on testing which will be done in the future
- The following Color Code was used:
  - Green: Full Compliance
  - Yellow: Partial Compliance (tests not completed yet but planned)
  - Red: No Compliance

Requirements Compliance

Req #	Requirement	Compliance	See Slide	Comments
1	Total mass of the CanSat (container and payload) shall be 600 grams +/- 10 grams without the egg.	COMPLY	67	
2	The Science Vehicle shall be completely contained in the Container. Shall not extend beyond the container.	COMPLY	42	
3	Container shall fit in the envelope of 125 mm x 310 mm including the container passive descent control system. Tolerances are to be included to facilitate container deployment from the rocket fairing.	COMPLY	13, 15	
4	The Container shall use a passive descent control system.	COMPLY	26	
5	The container shall not have any sharp edges to cause it to get stuck in the rocket fairing section.	COMPLY	15	
6	The container shall be a florescent color, pink or orange	COMPLY	45	
7	The rocket air frame shall not be used to restrain any deployable parts of the CanSat.	COMPLY	15	
8	The rocket airframe shall not be used as part of the CanSat operations.	COMPLY	15	
9	The CanSat (container and payload) shall deploy from the rocket fairing section.	COMPLY	15	

Requirements Compliance Cont'd

Req #	Requirement	Compliance	See Slide	Comments
10	The Container or Science Vehicle shall include electronics and mechanisms to determine the best conditions to release the Science Vehicle based on stability and pointing.	COMPLY	13,18, 89	
11	The science Vehicle shall use a helicopter recovery system. The blades must rotate and not use any fabric or other material between the blades.	COMPLY	26,31 34	
12	All descent control device attachments shall survive 50 Gs of shock.	COMPLY		
13	All descent control devices shall survive 50 Gs of shock	COMPLY		
14	All electronic components shall be enclosed and shielded from the environment with the exception of sensors.	COMPLY		
15	All structures shall be built to survive 15 Gs acceleration.	COMPLY		
16	All structures shall be built to survive 30 Gs of shock	COMPLY		
17	All electronics shall be hard mounted using proper mounts such as standoffs, screws, or high performance adhesives.	COMPLY	59	

Requirements Compliance Cont'd

Req #	Requirement	Compliance	See Slide	Comments
18	All mechanisms shall be capable of maintaining their configuration or states under all forces.	COMPLY		
19	Mechanisms shall not use pyrotechnics or chemicals.	COMPLY	11,12	
20	Mechanisms that use heat (e.g., chrome wire) shall not be exposed to the outside environment to reduce potential risk of setting vegetation on fire.	COMPLY	11,12	
21	During descent, the science Vehicle shall collect and telemeter air pressure, outside and inside air temperature, flight software state, battery voltage, and bonus objective.	COMPLY		
22	The Science Vehicle shall transmit telemetry at a 1 Hz rate.	COMPLY		
23	Telemetry shall include mission time with one of the second or better resolution, which begins when the Science Vehicle is powered on.	COMPLY		
24	XBEE radios shall be used for telemetry. 2.4 GHz Series 1 and 2 radios are allowed. 900 MHz XBEE Pro radios are also allowed	COMPLY	69,75	
25	XBEE radios shall have their NETID/PANID set to their team number.	COMPLY	75	

Requirements Compliance Cont'd

Req #	Requirement	Compliance	See Slide	Comments
26	XBEE radios shall not use broadcast mode	COMPLY	75	
27	The Science Vehicle shall have a video camera installed and recording a complete descent from deployment to landing.	COMPLY	22	
28	The video camera shall include a time stamp on the video.	COMPLY	22	
29	The descent rate of the Science Vehicle shall be less than 10m/s and greater than 4m/s.	COMPLY	40	
30	During Descent , the video camera must not rotate.	COMPLY		
31	Cost of the CanSat shall be under $1000. Ground support and analysis tools are not included in the cost.	COMPLY	134	
32	Each team shall develop their own ground station	COMPLY	95,	
33	All telemetry shall be displayed in real time during descent.	COMPLY	102,103	
34	All telemetry shall be displayed in engineering units (meters, meters/sec, Celsius, etc.)	COMPLY	104	
35	Teams shall plot data in real time during flight.	COMPLY	102,103	

Requirements Compliance Cont'd

Req #	Requirement	Compliance	See Slide	Comments
43	The Science Vehicle must include a battery that is well secured.	COMPLY		
44	Lithium polymer cells are not allowed due to being a fire hazard.	COMPLY	82	
45	Alkaline, Ni-MH, lithium ion built with a metal case, and Ni-Cad cells are allowed.	COMPLY	82	
46	The Science Vehicle and Container must be subjected to the drop test.	COMPLY		
47	The Science Vehicle and Container must e subjected to the vibration test.	COMPLY		
48	CanSat Vehicle and Container must be subjected to the thermal test.	COMPLY		
49	Environmental test results must be documented and submitted to the judges at the flight readiness review.	COMPLY		

Management

Ruben Perez

Status of Procurements

Part	Quantity	Order Status
Luminosity Sensor TSL2591	1	Ordered

All other electronic components have been ordered .

CanSat Budget – Electrical

Electrical(Payload)	Cost	Cost Type	Reused?
Arduino Pro Mini- 5.0V	$9.95	Actual	New
BMP 180	$9.95	Actual	New
TMP 36	$1.50	Actual	New
XBEE 900 MHz	$53.69	Actual	New
Keychain Camera	$24.99	Actual	New
LSM303	$14.95	Actual	New
XBEE Adapter	$9.95	Actual	New
Data Logger	$24.95	Actual	New
TSL2591	$6.95	Actual	New
PCBs	$60	Estimate	New
900 MHz 3 dBi Rubber Duck Antenna	$12.43	Actual	New

CanSat Budget – Electrical

Electrical(Payload)	Cost	Cost Type	Reused?
9V Battery	$5.99	Actual	New
Luminosity sensor TSL2591	$6.95	Actual	New
Chronodot	$17.50	Actual	New
24LC256 EEproms	$1.95	Actual	New
Total	**261.61**		

CanSat Budget – Other Costs

Electrical	Cost
Payload	$261.61
Miscellaneous (Replacing Damaged Components)	$50
Total	**$311.61**

CanSat Budget – Mechanical

Mechanical	Cost	Cost Type	Reused?
Miniature 12L14 Drive Steel Shaft	$4.76	Actual	New
Rigid HDPE Polyethylene Rod	$50.69	Actual	New
Aluminum Blind Rivet with Aluminum Mandre	$7.01	Actual	New
Fabric Snaps	$5.57	Actual	New
Lightweight Aluminum Socket Head Cap Screw (4-40 Thread, 1/4" Length)	$9.71	Actual	New
Lightweight Aluminum Socket Head Cap Screw (4-40 Thread, 1/2" Length)	$9.71	Actual	New
4-40x3/16" Nylon Female Plastic Ball Linkages	$5.99	Actual	New
Easy Clean Mold Release for Urethanes	$29.95	Actual	New

CanSat Budget – Mechanical Cont’d

Mechanical	Cost	Cost Type	Reused?
302 Stainless Steel Cut-to-Length Compression Spring 20" Length, .312" OD, .035" Wire Diameter	$4.70	Actual	New
Bi-directional E-Glass	$26.35	Actual	New
Woven Fiberglass Tape	$7.00	Actual	New
Kevlar and hybrid Sample Pack	$14.95	Actual	New
Kevlar-Twill Weave Fabric	$153.95	Actual	New
2120 Epoxy Hardner	$44.95	Actual	New
Parting Wax	$10.25	Actual	New
Release Wedge (Think Flexible)	$3.45	Actual	New
Yellow Sealant Tape	$7.95	Actual	New
Miscellaneous	$50	Estimated	N/A
Total	**$446.94**		

CanSat Budget – Other Costs

Type of Components	Cost
Electrical	$311.61
Mechanical	$446.94
Total	**$758.55**

Total Competition Budget

Items	Cost	Cost type
CanSat	759.55	Estimated
Airfare	$1,855.00	Estimated
Baggage	$250.00	Estimated
Hotel	$722.14	Estimated
Car Rental – Enterprise	$457.17	Estimated
Total Expenditures	$4042.86	

Program Schedule Table 1/3

Task	Start Date	Duration(Days)	End Date
Presentations			
First Draft PDR	1-9-2015	20	1-28-2015
Final Draft PDR	1-28-2015	4	1-31-2015
PDR Submission	2-1-2015	1	2-1-2015
First Draft CDR	2-23-2015	19	3-13-2015
Final Draft CDR	3-16-2015	10	3-25-2015
CDR Submission	3-31-2015	1	3-31-2015
Design			
Reentry Container	1-5-2015	2	1-9-2015
Science Payload	1-12-2015	24	1-16-2015
Release Mechanism	1-16-2015	16	1-22-2015
Preliminary Solid Model	1-5-2015	18	1-22-2015
Software/Code			
Electronic Code	1-5-2015	18	1-22-15
Flight Software	2-16-2015	21	3-9-15
Matlab code for fan blade sim	11-10-2014	26	12-5-14

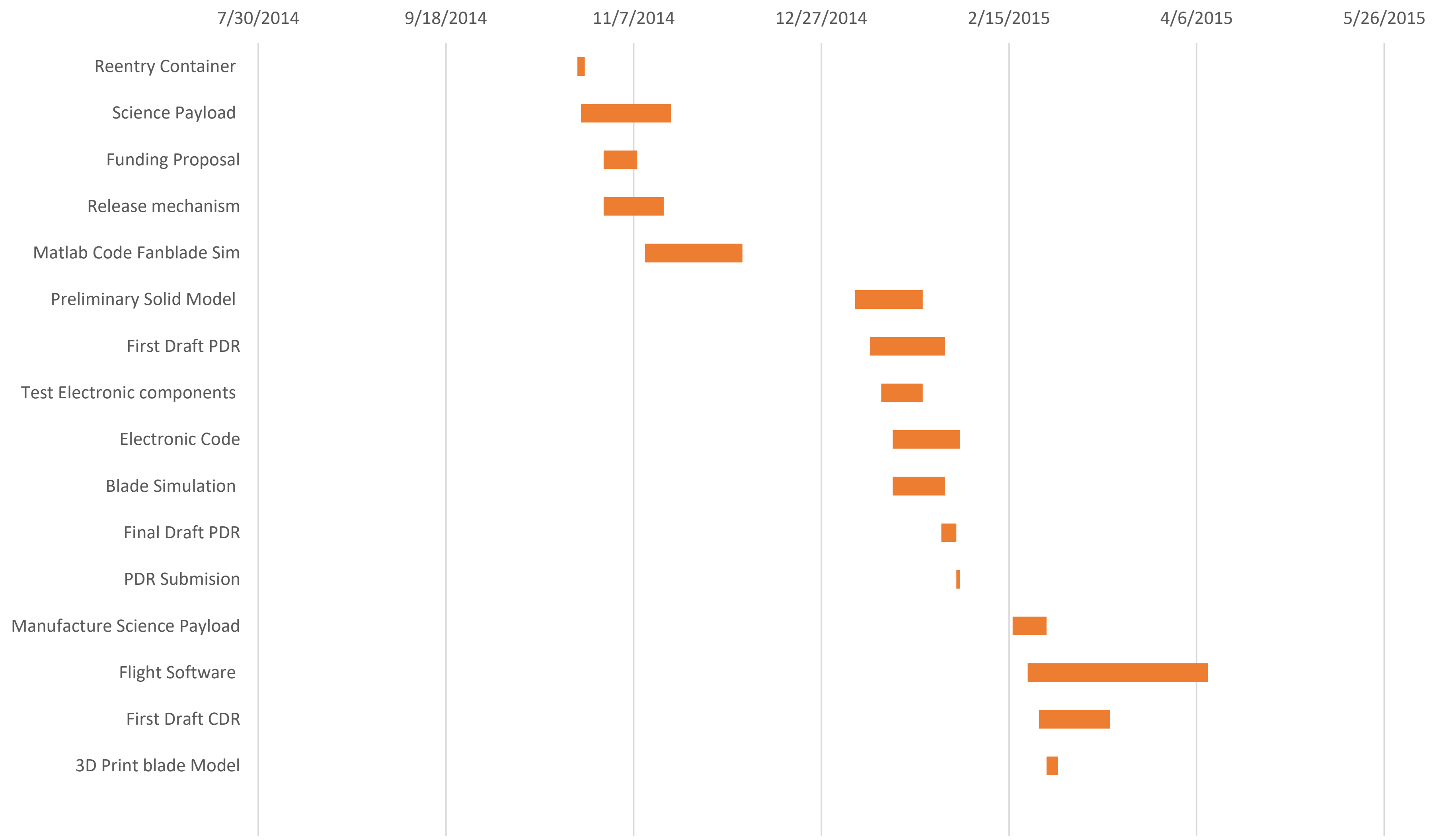
Program Schedule Table 2/3

Task	Start Date	Duration(Days)	End Date
Budget			
Funding Proposal	10-30-2015	9	1-22-15
Purchasing Materials	3-9-2015	3	3-11-2015
Tests			
Test electronic Components	1-12-2015	11	1-23-2015
Blade Simulation	1-15-2015	14	1-28-2015
Wind tunnel blade test	3-24-2015	7	3-30-2015
Thermal test	4-3-2015	1	4-3-2015
Vibration test	4-3-2015	1	4-3-2015
Drop test			
Manufacture			
Manufacture Reentry Container	2-17-2015	7	2-23-2015
Manufacture rotor system	2-23-2015	3	2-25-2015
Manufacture Science Payload	2-25-2015	9	3-5-2015
Manufacture release mechanism	3-1-2015	16	3-16-2015
3D Print blade Model	3-5-2015	1	3-5-2015

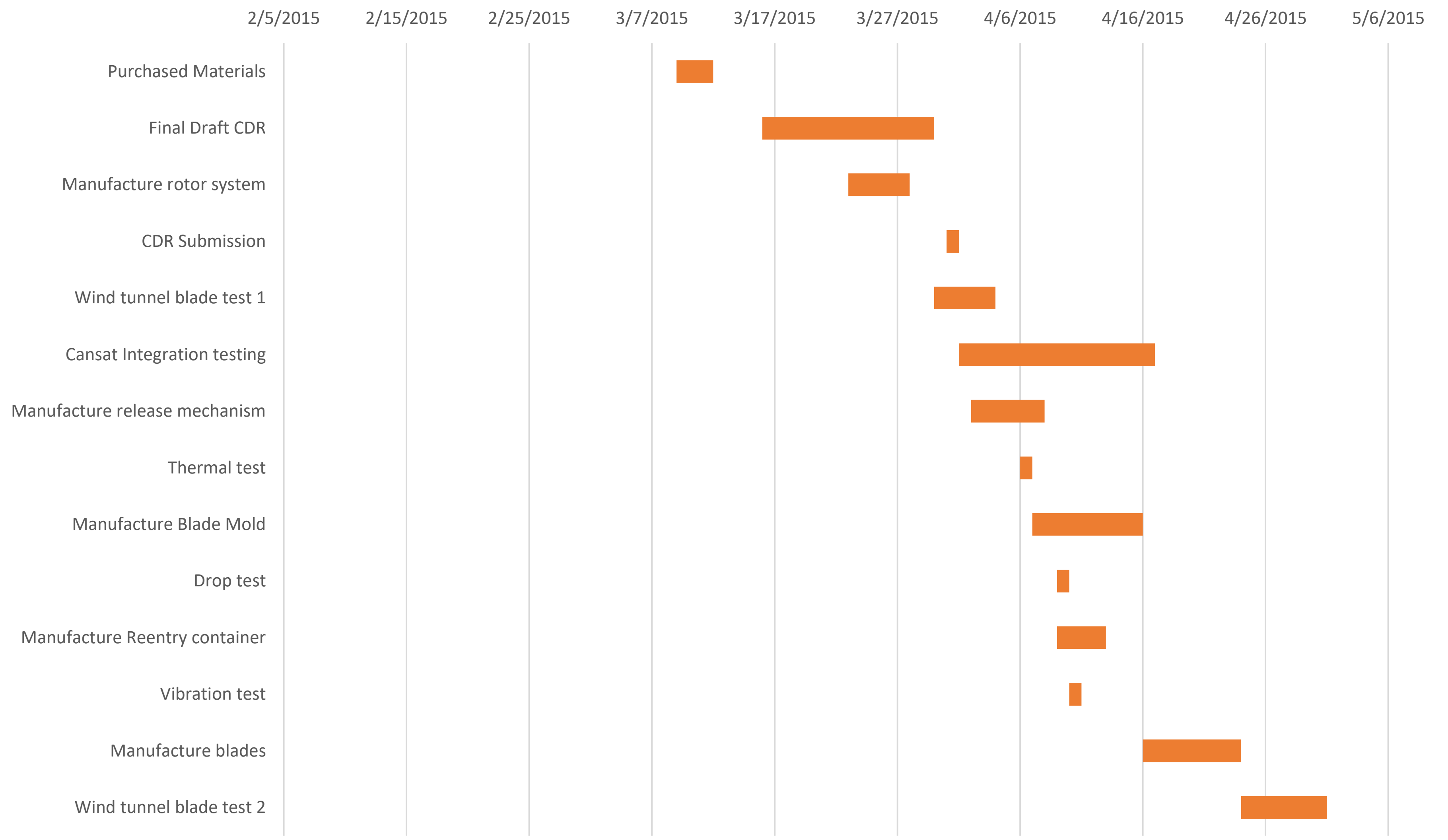
CanSat Gantt Chart 3/3

Task	Start Date	Duration(Days)	End Date
Manufacture Blade Mold	3-11-2015	3	3-13-2015
Manufacture blades	3-16-2015	8	3-23-2015

CanSat Gantt Chart 1/2



CanSat Gantt Chart 2/2



Conclusions

Ruben Perez

Shipping and Transportation

- **CanSat hardware will be transported with the team to Burkett.**
  - Hardware will be checked-in at the time of arrival in the airport.
  - They will be carry-on items to prevent loss and damage.
- **Alternative: Shipping via delivery service**
  - UPS/FedEx ground shipping.

Conclusions

- **Flight Software status**
  - In progress
- **Testing to Complete**
  - Environmental Testing
- **Major unfished work**
  - PCB
  - Manufacturing Blades
- **Major accomplishments**
  - Mold for re-entry container
  - All remainder materials have been bought

Conclusions Cont'd

- **Due to delay in acquiring materials because of funding there has been a setback.**

Potential Challenges

- **If we keep on having delays, this will cause problems towards completing the CanSat.**
- **Manufacturing the blades because we have never done our own.**