CanSat 2014 CDR

Team #: 1261

Sparky Sat

Presentation Outline

1. **Introduction** – Heather Zunino
2. **Systems Overview** – Heather Zunino
3. **Sensor Subsystem** – Zach Burnham
4. **Descent Control Design** – Justin Walker
5. **Mechanical Subsystem** – Ryan Teves & Sarah Smallwood
6. **Communication and Data Handling Subsystem** – Raymond Barakat
7. **Electrical Power Subsystem** – Zach Burnham
8. **Flight Software Design** – William Merino
9. **Ground Control System –** Zach Burnham
10. **CanSat Integration and Test –** Heather Zunino
11. **Mission Operation and Analysis** – Heather Zunino
12. **Management –** Heather Zunino
13. **Conclusion –** Heather Zunino

Team Organization

- Heather Zunino, Graduate Student — Team Lead
- Iman Alizadeh — Faculty Advisor
- Brian Bone — Mentor
- Raymond Barakat, Freshman — Communication & Data Handling Subsystem Lead
- Ryan Teves, Junior — Alternate Team Lead & Mechanical Subsystem Lead
- Zach Burnham, Freshman — Sensor Subsystem Lead
- Zach Burnham, Freshman — Electrical Power Subsystem Lead
- Justin Walker, Senior — DCS Subsystem Engineer
- Sarah Smallwood, Freshman — Egg Protection Subsystem Engineer
- William Merino, Sophomore — FSW Subsystem Engineer
- Ryian Hunter, Freshman — Subsystem Engineer

Acronyms

A – Analysis
ADR – Average Descent Rate
CDH – Communication and Data Handling
CG – Center Gravity
COMM – Communications
D – Demonstrate
DCD – Descent Control Design
DCS – Descent Control System
EOPM – Electrically Operated Permanent Magnet
EPS – Electrical Power Subsystem
FOS – Factor Of Safety
FSW – Flight Software
GCS – Ground Control System
GS – Ground Station
I – Inspect
I/O – Input/Output
PFR – Post Flight Review
SoE – Sequence of Events
SMS – Structures and Mechanisms Subsystem
SS – Sensor Subsystem
SYS – System
T – Test
VM – Verification Matrix

Systems Overview

Heather Zunino

Mission Summary

- **Main Objective:**
  - The CanSat shall safely land with the payload (egg) intact.
- **Other objectives:**
  - Container/CanSat descent shall be 12±1m/s while 500m above ground.
  - Deployable aero-braking structure shall reduce CanSat descent after 500m to 10 m/s .
  - Required telemetry shall be transmitted from container and CanSat every 1 second
- **Bonus Objective:**
  - CanSat shall measure the light intensity in the infrared and visible spectrum and include with the required telemetry.
    - This was chosen so the team could learn how to use light sensors.

Summary of Changes Since CDR

- **DCS**
  - The changes made since the PDR have not been complete design reworks but modifications of the designs described in the PDR.
    - Number of rotor blades has been changed from 4 to 8
    - The rotor blades now rotate a rotor hub instead of the entire structure
- **Mechanical Subsystem**
  - CanSat Payload is now made of ABS P430, was nylon.
  - Payload and container dimensions have increased.
  - Stability fins removed in favor of cone shaped design on the bottom for aero-stability.
  - Top structure re-designed to support DCS.
  - Second mounting plate added on the bottom for electronics hardware
- **EPS**
  - DC-DC Booster chosen over voltage regulator
- **All other systems remain the same since the PDR without any major changes.**

System Requirement Summary

ID	Requirements	Parents	Children	VM			
				A	I	T	D
SYS.1	Total mass of CanSat, container, and all descent control devices shall be 600 grams. Mass shall not vary more than +/-10 grams.	None	SMS.1-3	X	X		
SYS.2	The cost of the CanSat flight hardware shall be under $1000 (USD). Ground support and analysis tools are excluded.	None	SMS.1-3	X	X		
SYS.3	The container shall fit inside the cylindrical payload section of the rocket defined by the cylindrical payload envelope of 125 mm x 310 mm length including the descent control system.	None	SMS.1-3	X	X		
SYS.4	Team number, email address and a phone number must be placed on the structure to aid in recovery.	None	None	X			

System Concept of Operations

Pre-Launch

Pre-Launch Testing: Ray and Zach
- Power
- Communication
- Telemetry
- Deployment
- Egg protection

CanSat-Rocket Integration: Heather
- Insert Egg in Payload
- Insert Payload in Container
- Power On CanSat
- Insert CanSat in Rocket

Launch

Ascent:
- Initiate GS communication with CanSat
- Receive/record Telemetry initiates

Deployment (~650 meters):
- CanSat deploys from rocket
- Container parachute deploys
- Descent rate @ ~ 12 m/s

System Concept of Operations

Launch

Separation (~500 meters):
- Payload separates from container
- Payload DCS deployed
- Payload descent rate decreased to ~ 10 m/s

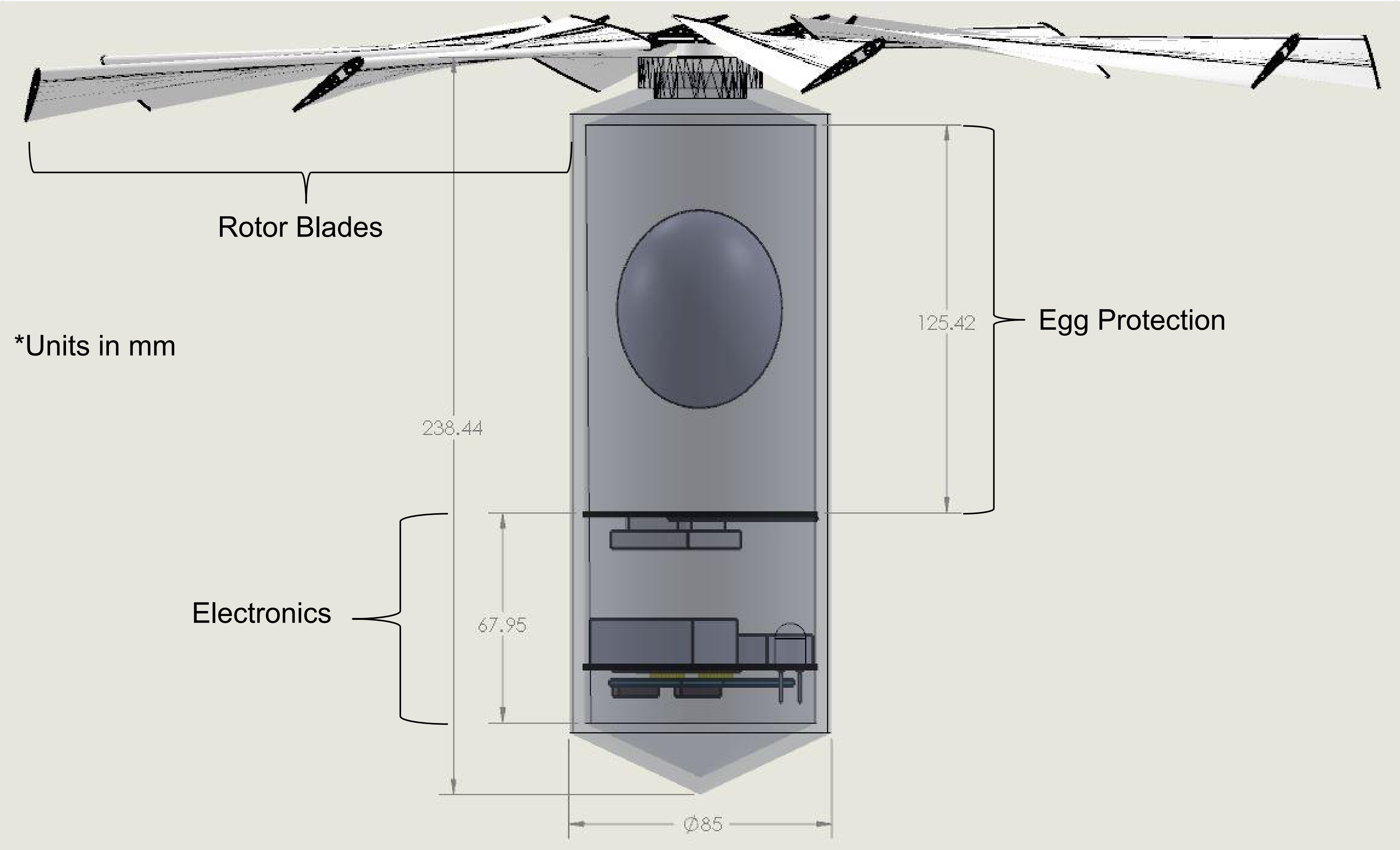
Landing:
- Receive/record telemetry deactivated

Post-Launch

Recovery: Ryan
- Container and Payload are retrieved

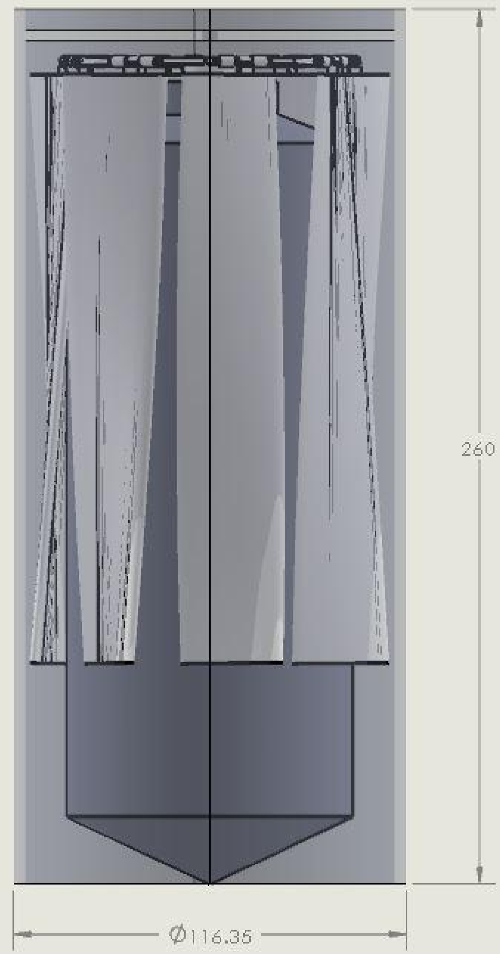
Post-mission reporting: Ryian, Sarah, Zach, Ray, William
- Telemetry data is saved to file and reported
- Power down CanSat and GS

Physical Layout



Physical Layout

- Units in mm

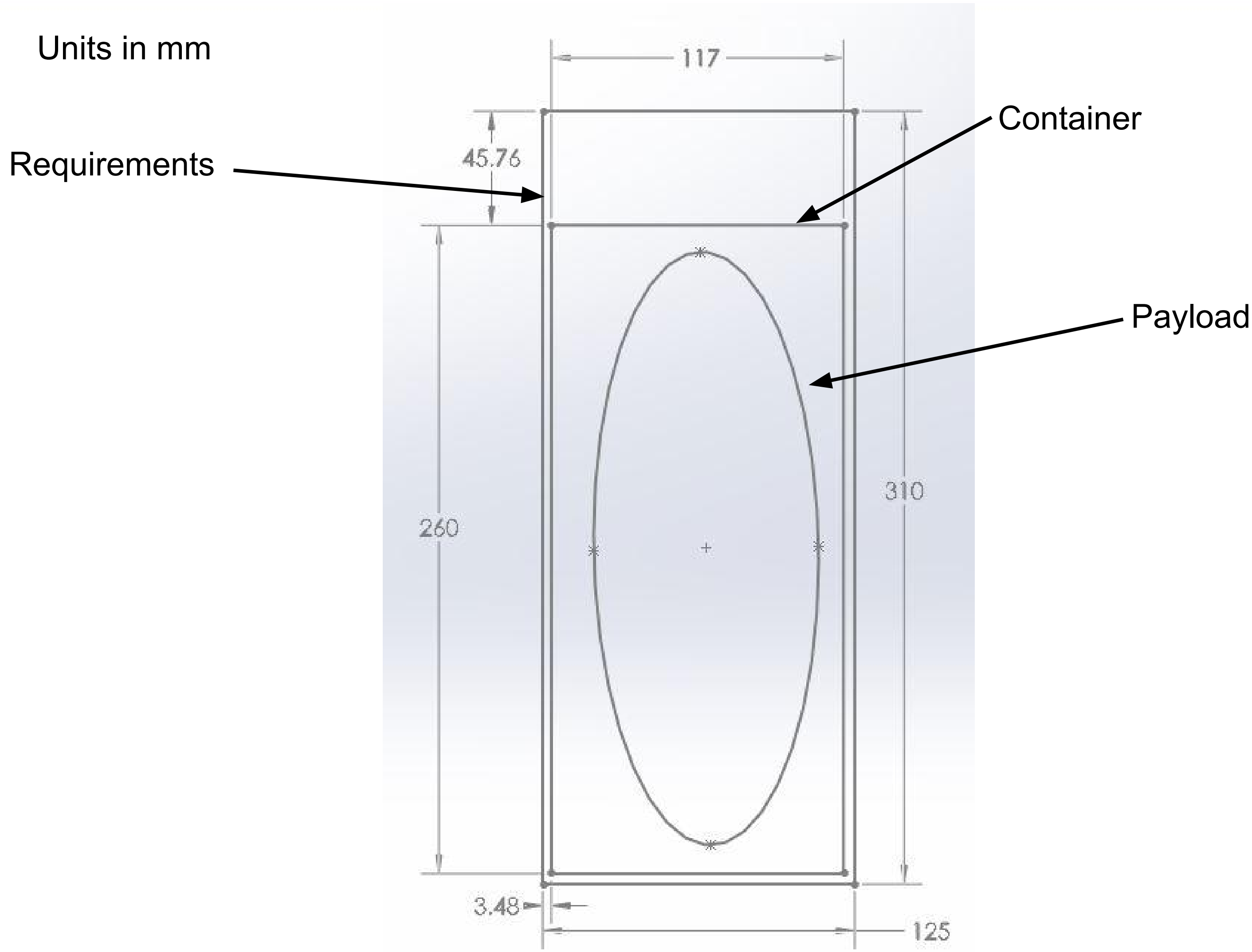


Launch Vehicle Compatibility

- **CanSat – Rocket Integration**
  - The Container of CanSat will provide a 3.84mm clearance diameter with the specified 125mm(~5in) diameter rocket payload section.
  - The Container of CanSat will provide a 45.76mm vertical clearance.
  - All DCS and Payload components will be entirely confined in Container section before deployment from rocket payload section without significant protrusions.
  - Actual deployment will involve the activation of a retracting servo allowing the CanSat to slide off of an anchor point and out of the container.
- **CanSat – Rocket Integration Verification**
  - A test apparatus will be constructed with a "rough" material with the specified 125x310mm to analyze:
    - Ease of CanSat entry into rocket payload section.
    - Ease and reliability of CanSat's deployment from rocket payload section.
    - Parachute's ability to open after deployment from the rocket.

Launch Vehicle Compatibility

- Units in mm



Sensor Subsystem Design

Zach Burnham

Sensor Subsystem Overview

Sensor Type	Model	Purpose
Clock*	DeadOn RTC	Maintain mission time on CanSat
Barometric Altitude/Pressure Sensor*	MPL3115A2	Measure the Altitude of the CanSat during descent
Temperature Sensor*	MPL3115A2	Record air temperature of the CanSat during descent
Luminosity Sensor	TSL2561	Record light levels on the CanSat for the bonus requirement

* Same sensors for both payload and container.

Sensor Subsystem Changes Since PDR

- **No major changes were made to the sensor subsystems since the PDR.**

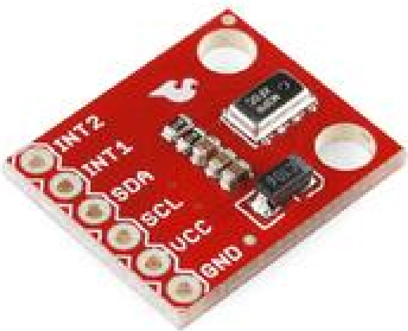
Sensor Subsystem Requirements

ID	Requirements	Parents	Children	VM			
				A	I	T	D
CDH. 1.1	Telemetry shall include payload mission time with one second or better resolution, which begins when the payload is powered on. Mission time shall be maintained in the event of a processor reset during the launch and mission.	CDH.2.2	None	X	X	X	
CDH. 1.2	The container and payload shall maintain a mission time which is the number of seconds since each vehicle is powered on. The mission time shall be maintained in the event of a power loss or processor reset. The time may be maintained by software or by hardware real-time clock. If a hardware real-time clock is used, a separate, dedicated power source may be used to power the clock; however, this power source may not be used to power any other vehicle functions.	None	None	X	X		

Non-GPS Altitude/Temperature Sensor Summary

Selected Altitude/Temperature Sensor – MPL3115A2

-Transmission Rate
-Low Cost ($14.95)
-Accuracy (.3m/.5°C)
-Lightweight (2g)
-Dimensions (18 mm x 16 mm)
-Data format (I2C)
  -Pressure 20-bits (Pascals)
  -Altitude 20-bits (Meters)
  -Temperature 12-bits(Degrees Celsius)



Light Sensor Trade & Selection

Camera Model	Cost	Power Usage	Weight (Grams)	Data Protocol	Resolution	Dimensions (mm)
TSL2561 Luminosity Sensor	$5.95	3.3V /0.6mA	2g	I2C	16-bit	2.6 x 3.8
Color Light Sensor - Avago ADJD-S311-CR999	$4.95	2.5V / 3mA	0.01g	Serial	10-bit	2.2 x 2.2 x 0.76

Selected Light Sensor – TSL2561 Luminosity Sensor

-Well-Documented

-Easy to interface with hardware and using software

-High Resolution

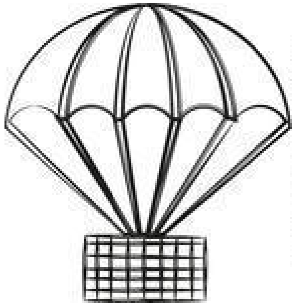
-Easily compatible with Microcontroller

Descent Control Design

Justin Walker

Descent Control Overview

Container Descent Control Strategy:



Method: Parachute

Components: Parachute
Parachute cords

Description: Parachute will deploy naturally upon separation from rocket. Parachute is permanently attached to container by nylon cords.

Payload Descent Control Strategy:

Method: Autorotation w/ airfoil rotor blades

Components: Airfoil rotors
Hub Mechanism
Shaft

Description: Helicopter-style rotary blades will produce drag due to descent velocity. Air deflection creates angular moment on rotor shaft and spins blades. Special rotor airfoil pitch allows blade rotation to cause lift, which acts as increased drag on the descent velocity.

DCS Changes since the PDR

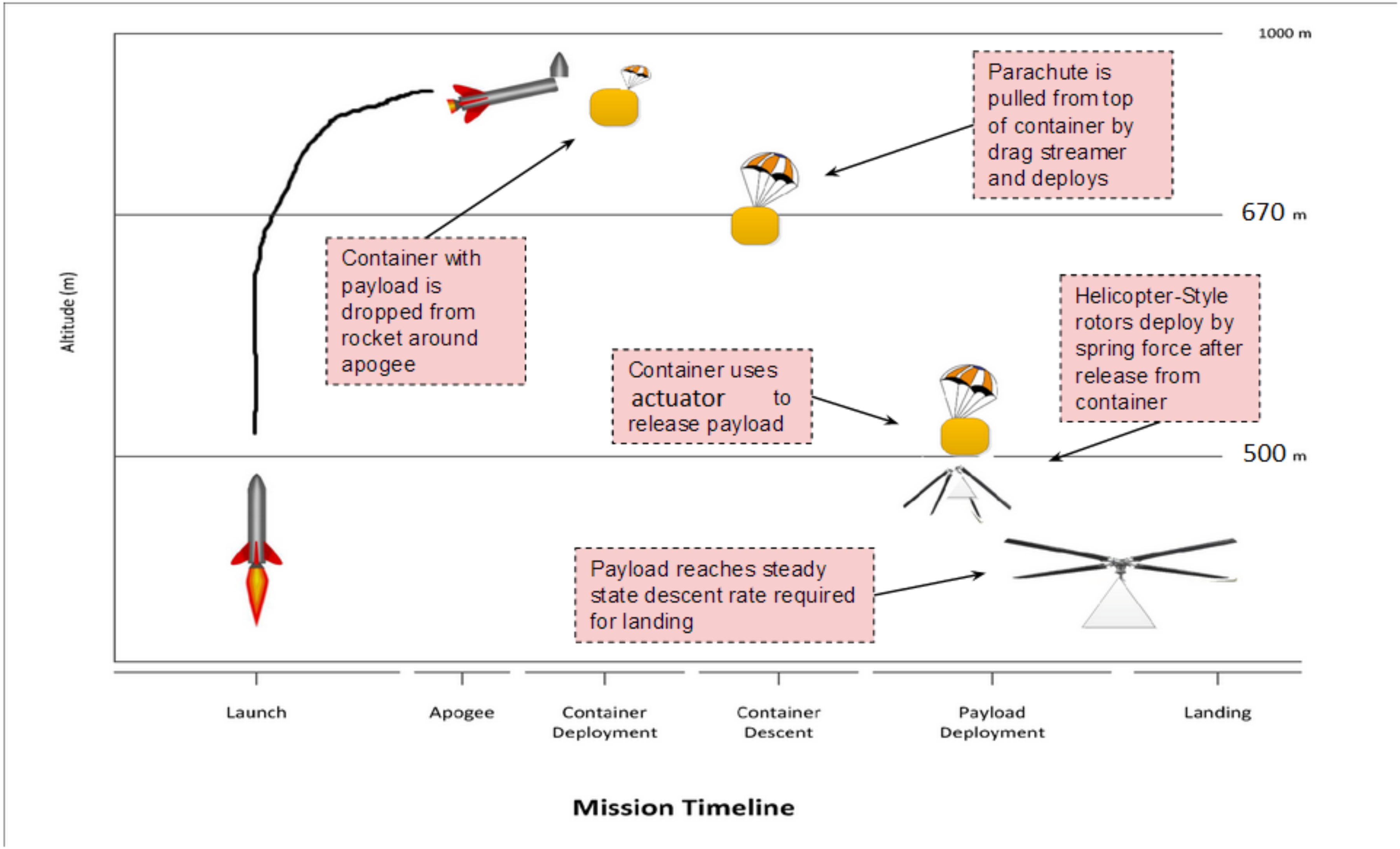
The changes made since the PDR have not been complete design reworks but modifications of the designs described in the PDR.

- Number of rotor blades has been changed from 4 to 8.
    - This is done to increase the surface area to increase overall lift.

- The rotor blades now rotate a rotor hub instead of the entire structure.
    - This is done to increase the angular momentum and thus the total lift that can be generated by the DCS.

- No prototypes have been tested in freefall setting at this point in the design process.

Descent Control CONOPS



Descent Control Requirements

Requirement Number	Requirement	Parent(s)	Children	VM			
				A	I	T	D
SYS .1	Total mass of the CanSat (container and payload) shall be 600 grams +/- 10 grams without the egg.	None	None	X	X		
SYS .3	4 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.	None	None	X	X		
SMS 1.2	The container shall use a passive descent control system. It cannot free fall.	None	None	X	X		
SMS.2.1	The descent control systems shall not use any flammable or pyrotechnic devices.	None	None	X	X		
SMS.2.2	12 The descent rate of the CanSat shall be 12 m/s above 500 meters.	None	None	X	X		
SMS.2.3	When the CanSat reaches 500 meters, the payload shall be released from the container.	None	None	X			
SMS.2.4	When released, the payload shall have a descent rate of less than 10 m/s.	None	None	X			
SMS.2.5	All descent control device attachments shall survive 30 Gs of shock.	None	None		X		
SMS 2.6	All descent control devices shall survive 30 Gs of shock.	SYS	None	X	X		

Container Descent Control Trade Study

1. Parachute

- **This method is easiest to manipulate in order to achieve a precise decent rate from 670 meters to 500 meters with low cost and low weight material.**

2. Streamer(s)
   - This requires more material which adds weight and cost. This method also makes it tough to obtain a precise decent rate without very predictable conditions.
3. Rigid drag-creating aero-braking structure
   - This would require specific material with numerous types of tests.
   - This would also be difficult to find a design that wouldn't use lot material and thus add too much weight

Container DCS Trade Study	Evaluation Criteria (1- Desireable, 10-undesireable)					
Descent Control Strategy	Design Difficulty	Cost to Manufacture	System Mass/Volume	Mechanical Complexity	Confidence Level	SCORE
Parachute	2	3	1	1	2	**1.8**
Streamers	4	4	2	4	5	**3.8**
Rigid Braking Structure	5	6	7	5	4	**5.4**

Container Descent Control Strategy

- **Connections**
  - The parachute will be connected by drilling holes into the lip at the top of the cansat where the chute lines will be tied.
  - Other methods considered were using high powered glue or using a swivel connected to an eye-hook bolt attached to the center of the top of the cansat.
- **Color**
  - Orange
- **Shock force Survival**
  - The mass of the parachute is small enough that 30 Gs of shock should be readily absorbed by the strong nylon parachute and cord material. However, test drops with the same material will be performed to verify this requirement.
- **Preflight review testability**
  - Parachute will be connected and stored at the highest point of the container. It will be shown prior to flight that the parachute is flush with the top of the container and does not protrude.
  - For the Payload decent control the autorotation wings will be stored and folded to fit within the container. This can be pulled out prior to launch to verify the wings fold out and would rotate with minimal lift force.

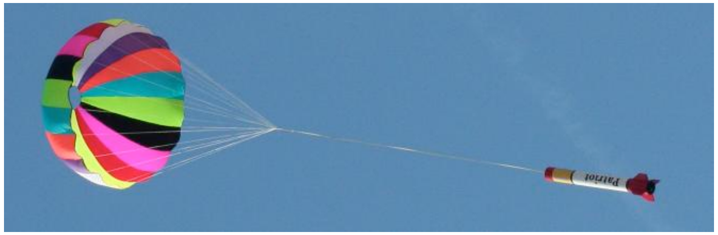


Photo courtesy of: http://spherachutes.com/construction.asp

Container Descent Control Parachute Trade Study

Company	Price	Pre-A	Material	Shape
Spherachutes	$17	Y	1.1oz rip-stop nylon (custom)	Circle
Top Flight Recovery	**$6.95**	**Y**	**1.7oz rip-stop nylon**	**Circle**
Rocketman	$25	Y	Low-porosity 1.1oz rip-stop nylon	Circle
Rocky Woods (material)	$9.95	N	1.3oz Silicone Coated rip-stop nylon	NA

Selected Component

Top Flight Recovery's 1.7 oz rip-stop nylon

-This parachute is available C.O.T.S. in the correct size and C_d configuration needed for the container and payload descent control

Payload Descent Control Method Trade Study

1. **Auto-Rotation of Helicopter-Style Airfoil Blades**
   - **This method was evaluated to have the least design risk according to the evaluation criteria.**
   - **Although the principles of passive descent control using helicopter style airfoil blades are complex, the volume, mass, and complexity of this design are manageable.**
2. Inflatable Airbag
   - Both inflation and pre-deployment storage were major design issues
   - Presents issues with use of payload camera
3. Deployable Aerodynamic Gliding Structures
   - Mechanical complexity is assumed to be large due to the small allowable launch volume and the necessary characteristics needed for a stable flight system.

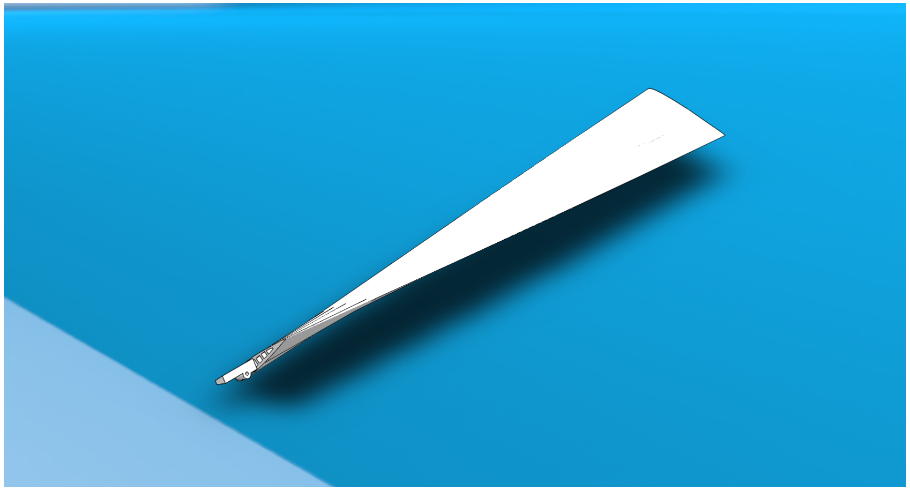
Science Payload DCS Trade Study	Evaluation Criteria (1- Desireable, 10-Undesireable)					
Descent Control Strategy	**Design Difficulty**	**Cost**	**Mass & Volume**	**Mechanical Complexity**	**Confidence**	**SCORE**
Auto-Rotation of Rotary Airfoil Blades (Aerodynamic Lift/Drag)	7	5	4	6	3	**5.0**
Inflatable Airbag (Energy Absorption)	6	2	8	5	6	**5.4**
Savonius Wind Turbine (Stable Flight at Low Descent Rate)	10	7	9	10	7	**8.6**

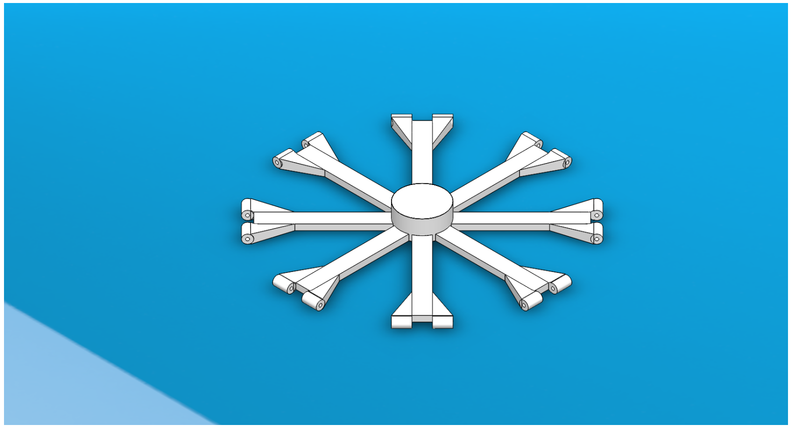
Payload Descent Control Strategy

System Components

8x Rotary Airfoil Blades with hinge attachment

1 x rotor hub with hinge attachments



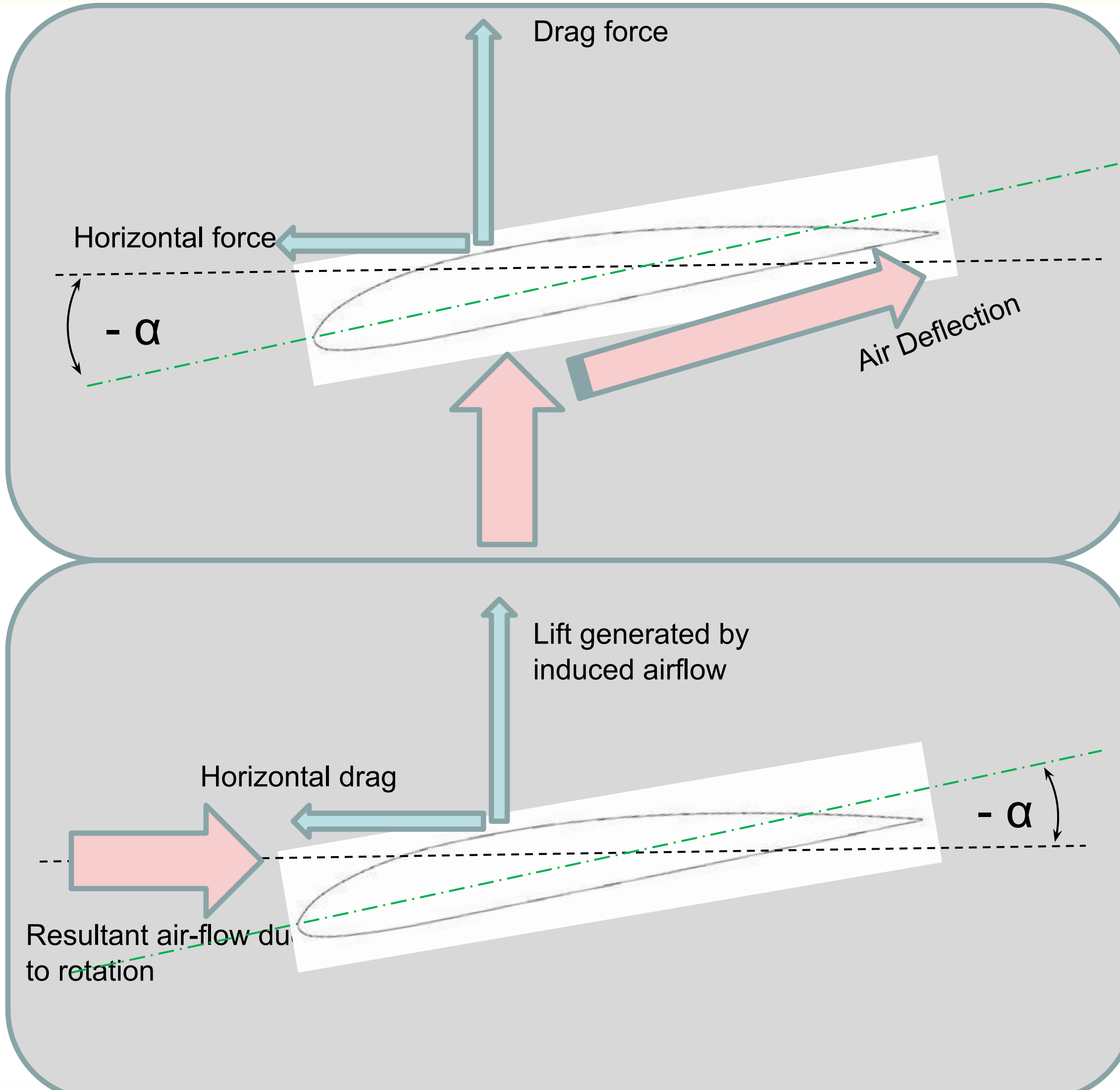


Connections

- Airfoil Blades will be attached near top of payload container along Aerodynamic Vane Structures

Principle of Design

- **Airflow** due to descent velocity acts on bottom surface of airfoil and is deflected up and to the right
- **Vertical Drag** (Lift) due to air-flow acting on airfoil blades slows decent velocity
- Air deflection provides horizontal force acting on airfoil blades, creating a moment on the rotor shaft leading to **rotation**
- Shallow negative angle of attack (-α) allows rotation due to air-flow deflection as well as **lift** due to rotation. Airfoil selection is critical for this design feature
- System is designed to reach **steady-state balance** at desired descent velocity



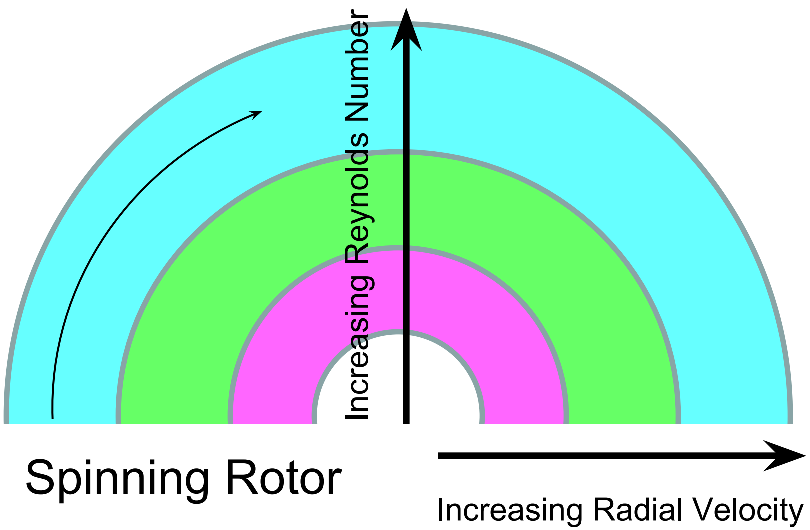
Design Considerations

Rotor velocity increases with radius of blades

Reynolds number is proportional to rotor velocity and determines airfoil lift. Low speeds will lower the Reynolds number, lowering lift coefficients of airfoils.

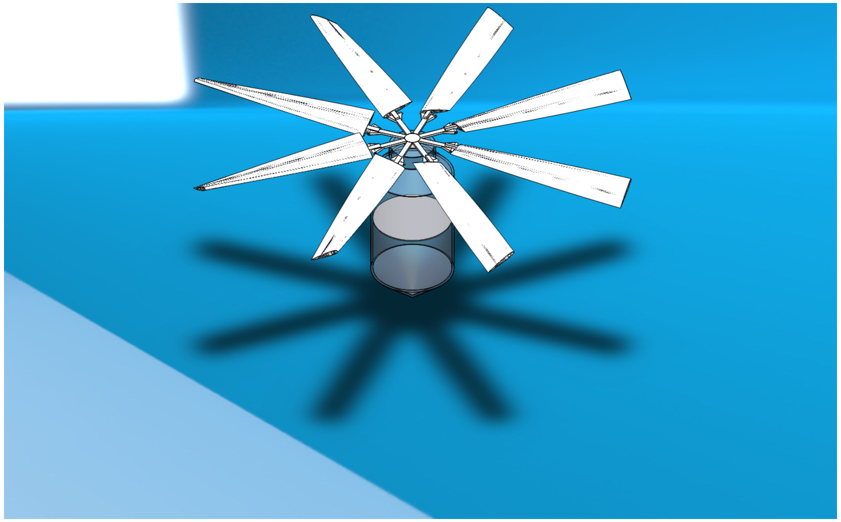
Airfoil Selection will be critical and must be done carefully.

Reynolds Number and Radial Velocity

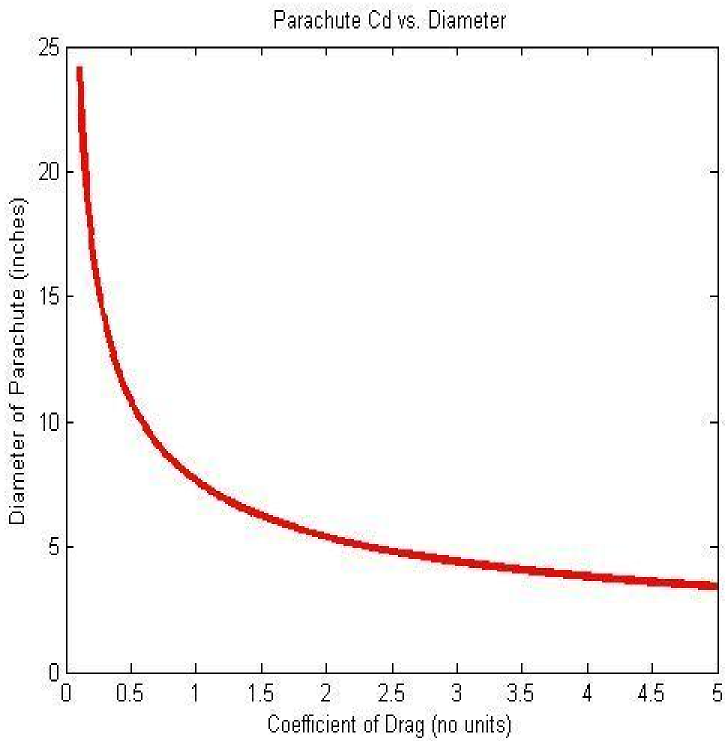


Preflight Review Testability

- Rotors and rotor mount can be visually inspected
- Deployment springs can be visually inspected and tested
- The blades and shaft can demonstrate freedom to move due to an airflow (wind or blowing of air).



Container Descent Rate Estimate



Based on the trend to the left, the drag coefficient tends to increase as the parachute diameter is decreased. The drag coefficient is a dimensionless quantity and cannot be directly related to the drag force unless the dynamic pressure of the surrounding medium is known. The larger diameter parachutes could have a lower drag coefficient because the local dynamic pressure is lower. This could be due to turbulence or any other number of factors.

For a Container Weight of (610 + 67) grams = (Container Weight and Egg Weight), the suggested diameter parachute is approximately 14 inches to have a rate of descent of 12 m/s.

Payload Descent Rate Estimate

The Rate of Descent (RD) is determined by the Weight (W) of the falling aircraft, the Wing Surface Area (S), the density of air (**ρ**), and the Lift (CL) and Drag (Cd) coefficients of the wing.

$$RD = V \cdot \frac{C_d}{C_L} = \sqrt{\frac{W}{S} \cdot \frac{2}{\rho} \cdot \frac{C_d^{\,2}}{C_L^{\,3}}}$$

Airfoil selection will have to be done on a spanwise basis, with special attention given to the angle of attack (α), the angle of twist (**θ**), and the angle (**γ**).

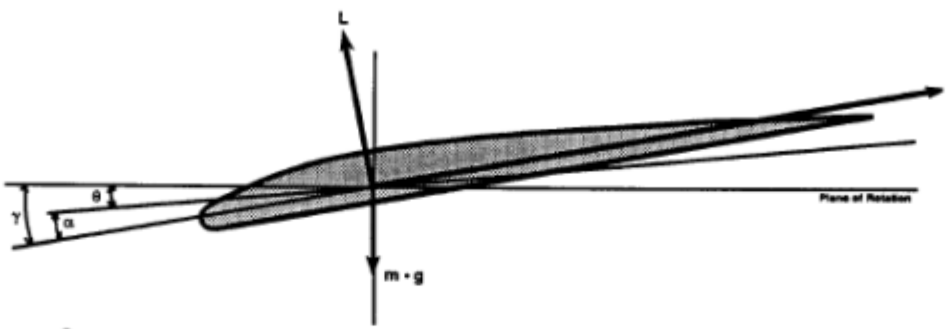


Figure 2

Payload Descent Rate Estimate

The Design Descent Rate estimate is 10 m/s, RD = 10 (m/s);

The Weight is also known as approximately W = .67 (kg);

The density for the altitude range of 0 - 700 m is

ρ = [1.2,1.14];

The Planform Area is selectable but also limited by allowable space in the container and launch vehicle. It can be estimated.

Also a selectable criteria is the Drag and Lift Coefficient for the overall wing. These can be adjusted by changing the spanwise airfoil characteristics which will have a different drag polar than the adjacent sections.

Twist Angle Determination

The angle γ, which the angle-of-attack plus the angle-of-twist can be found from the equation:

$$\tan g = \frac{RD}{\omega \cdot r}$$

$$\tan(\theta + \alpha) = \frac{RD}{\omega \cdot r}$$

Taking the tangent of both sides yields:

$$(\theta + \alpha) = \tan^{-1}\left[\frac{RD}{\omega \cdot r}\right]$$

Or finally the angle-of-twist is:

$$\theta = \tan^{-1}\left[\frac{RD}{\omega \cdot r}\right] - \alpha$$

How do you use this twist angle? Well, you need to design it into your wing by choosing the rotation rate (ω) that you want your model to spin at. A good estimate to start at is 3 revolutions per second or 6π rad/sec (where π has a value of 3.14). From this point you calculate θ for different portions of the wing along the span and then build in twist to match the angles you've calculated.

Mechanical Subsystem Design

Ryan Teves

Major Structural Elements

- Structure
  - Container consists of cardboard tube and acrylic cap
  - CanSat Payload consists of ABS P430 with plastic mounting plates.
- Egg Protection Chamber
  - Egg padded by memory and 'egg crate' foam and stabilized by memory foam strips. Empty gaps will be filled with styrofoam material.
- Recovery Device
  - Auto-rotating device will be used to recover the payload.
  - Located in container and released via upward airflow.
- Electronics
  - Electronics placed on bottom of structure to create lower CG.
  - Electronics enclosed by ABS P430 shell and mounted on plastic plates.

Mechanical Subsystem Changes Since PDR

Major Design Changes

- Structure
  - CanSat Payload is now made of ABS P430, was nylon.
  - Payload and container dimensions have increased.
  - Stability fins removed in favor of cone shaped design on the bottom for aero-stability.
  - Top structure re-designed to support DCS.
- Egg Protection Chamber
  - No Mechanical Changes.
- Recovery Device
  - DCS now has 8 smaller blades, was 4.
  - Released via upward airflow, was spring released.
- Electronics
  - Second mounting plate added on the bottom for electronics hardware

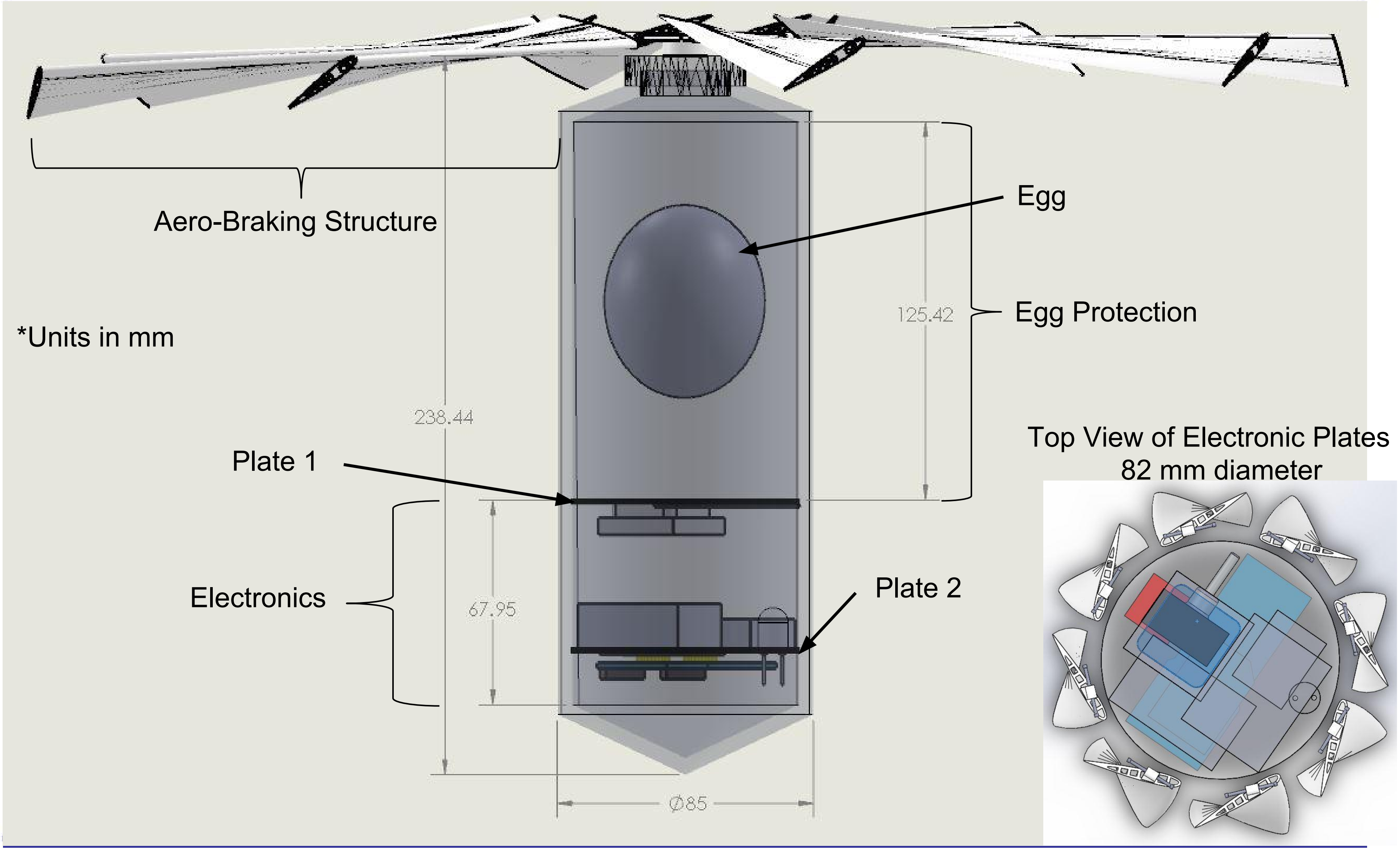
Mechanical Sub-System Requirements

ID	Requirements	Parents	Children	VM			
				A	I	T	D
SYS.1	Total mass of the CanSat (container and payload) shall be 600 grams +/- 10 grams without the egg.	None	None	X			
SMS.1.1	The payload shall contain and protect the egg from cracking or breaking during flight through landing. The egg will weigh not more than 67 grams.	SYS.3, SYS.4	None	X			
SMS.1.5	The payload shall be completely contained in the container. No part of the payload may extend beyond the container.	None	None	X			
SYS.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.	None	None	X			
SMS.1.3	The container shall not have any sharp edges to cause it to get stuck in the rocket fairing section.	None	None	X			
SMS.1.4	The container shall be a florescent color, pink or orange.	SYS.4	None	X			
SMS.2.5	All descent control device attachments shall survive 30 Gs of shock.	None	None	X			
SMS.2.6	All descent control devices shall survive 30 Gs of shock.	None	None	X			
SMS.3.1	All electronic components shall be enclosed and shielded from the environment with the exception of sensors.	None	CDH 1.1 , EPS1.1, EPS 1.3	X			
SMS.3.2	All structures shall be built to survive 15 Gs acceleration.	None	None	X			
SMS.3.3	All structures shall be built to survive 30 Gs of shock.	None	None	X			
SMS.4.1	All mechanisms shall be capable of maintaining their configuration or states under all forces.	None	None	X			
SMS.4.2	Mechanisms shall not use pyrotechnics or chemicals.	None	None	X			
SMS.4.3	Mechanisms that use heat (e.g., nichrome wire) shall not be exposed to the outside environment to reduce potential risk of setting vegetation on fire.	None	None	X			

Egg Protection Overview

- **Material**
  - We have chosen a combination of THG memory foam and mini Styrofoam beads to protect the egg during flight and landing.
- **System**
  - Due to a smaller clearance on either side of the egg due to the limited width of the container, a thinner layer of foam, similar to egg crate foam, may be utilized with mini Styrofoam beads employed to fill the gaps, adding more shock absorption.
  - On the top and bottom of the egg, thicker pads of THG memory foam will encase the egg within the container, protecting the payload from shock due to impact upon landing.

Mechanical Layout of Components

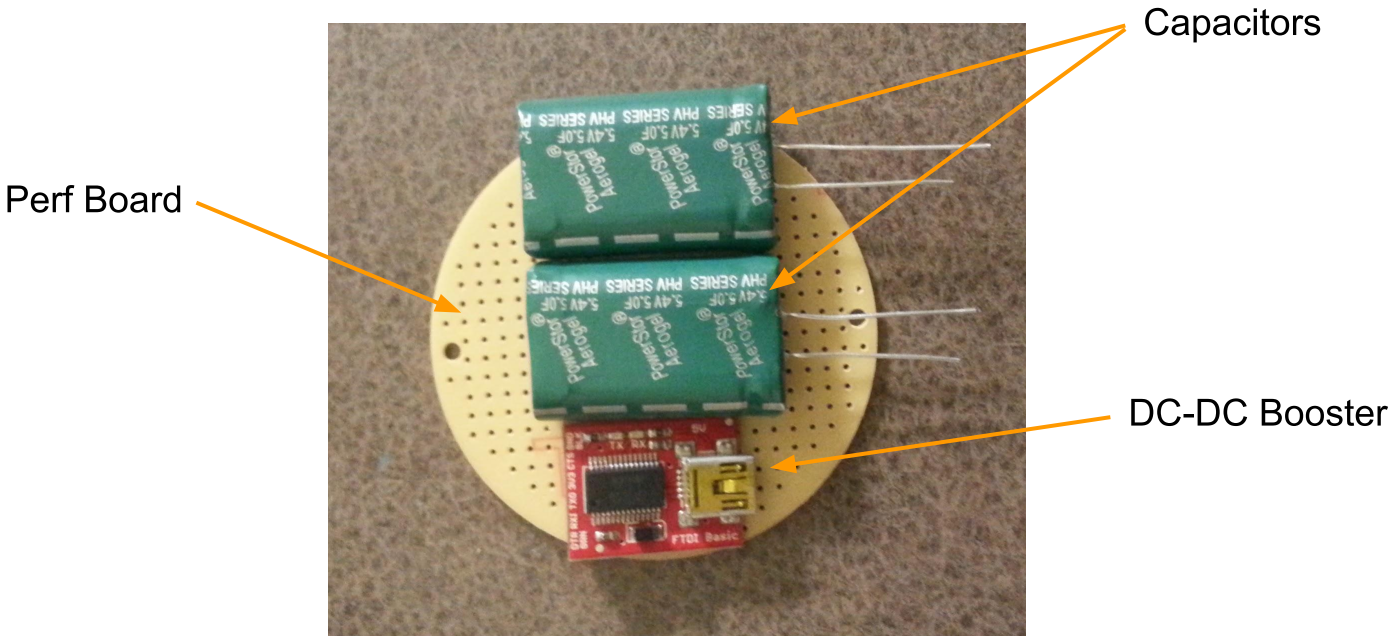


Top View of Electronic Plates
82 mm diameter

Mechanical Layout of Components

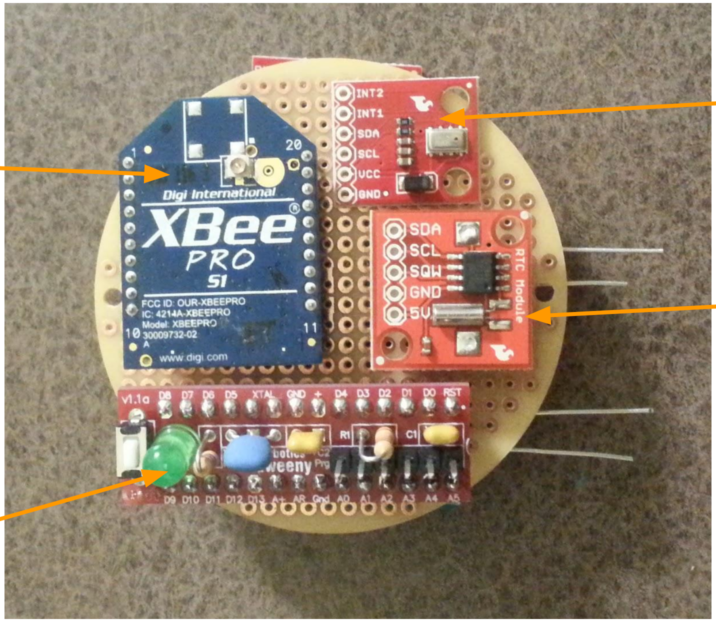
Electronics for Plate 1

*Plastic Mounting Plate not shown



Electronics for Plate 2

*Plastic Mounting Plate not shown



Material Selections

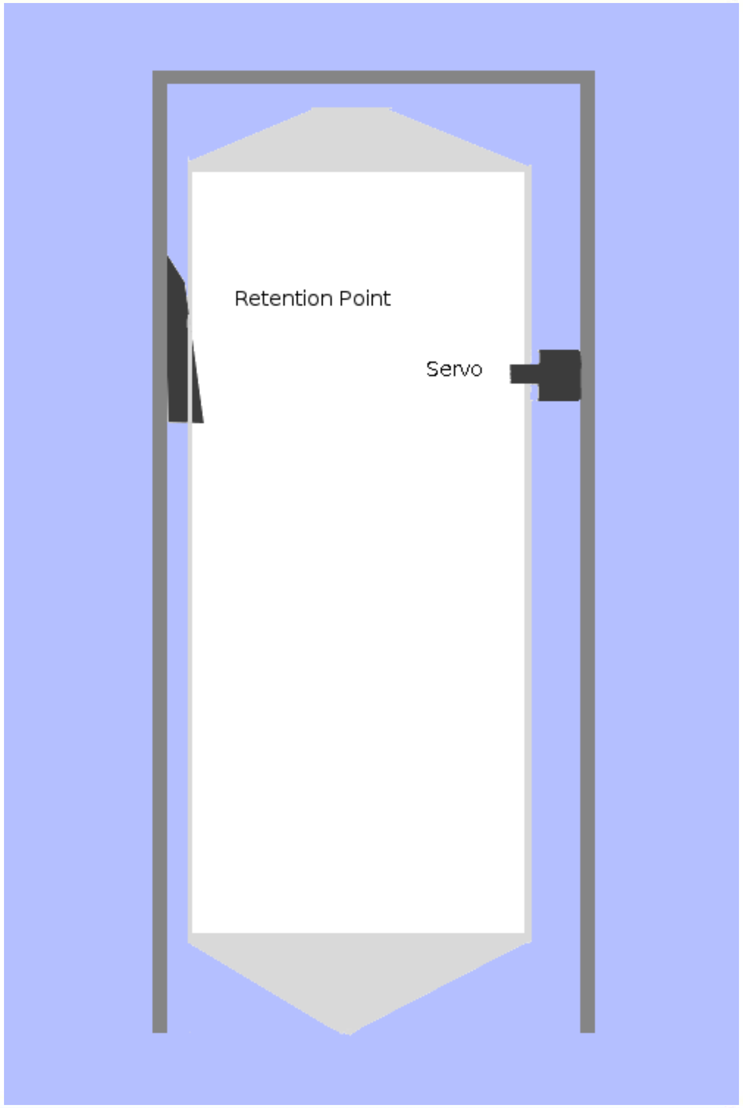
- **Container**
  - Hard cardboard shell for weight reduction and design simplicity
  - Plate separating parachute from payload made from acrylic plastic for weight reduction and strength
- **Payload**
  - Structurally is made up of ABS-P430. This material has similar properties as the previously selected Nylon material but offers greater freedom of design due to 3D printing.
  - Sensors, and other electronics mounted on trimmed Perf Boards for functionality and weight reduction.
  - Mounting done with J-B Weld adhesive epoxy or similar adhesive for strength.
- **Egg Protection**
  - Egg Protection System will be made using THG foam for its ability to conform in shape, lightweight, and shock absorption during testing. Mini Styrofoam balls will fill empty spaces for additional shock absorption.

Container - Payload Interface

- **CanSat Payload will be retained in the Container via a servo and corresponding retention point.**
- **CanSat Payload will be released by sending a DC voltage via the Container Electronics Package.**
  - The servo will be sent the “release voltage” during the telemetry state activated at deployment altitude (~500m).
- **Payload Descent Control System will be constrained by Container walls and will deploy upon Payload release from Container.**
- **Estimated clearance between payload and container shall be no more than 10 mm.**

Container - Payload Interface

*Please note, image is not to scale



Structure Survivability

- **Electronic Mounting:**
  - Perf Boards will be mounted on round plastic shelves that attach to the payload walls.
  - Payload shell will be used to enclose all electrical components.
- **Acceleration and Shock Force Requirements:**
  - The structure must survive 15 Gs of acceleration and 30 Gs of shock.
    - Plastic shelves will be integrated to payload shell through designed grooves to distribute impact forces.
    - The JB Epoxy will be able to sustain the electronics through these forces.
- **Descent Control Attachments:**
    - Autorotative blades will be attached to a free spinning rotor hub.
    - Rotor hub will be mounted atop the payload through pre-designed holes and light weight nuts and bolts.
    - Blades will deploy upon exiting the container due to aerodynamic drag forces.

Mass Budget

Subsystem Designation	Component	Mass (g)	Method
CDH	Ardweeny x2	4.00	Estimate
CDH	XBEE Pro 60mW U.FL Connection Series 1 x2	7.60	Measured
CDH	2.4 GHz Antenna - Adhesive (U.FL Connector) x2	6.60	Data Sheet
EPS	Toggle Switch and Cover - Illuminated	10.00	Estimate
EPS	5.5V 5 Farad Capacitor x5	34.00	Data Sheet
EPS	Power Regulation Circuit x2	5.00	Estimate
SMS	Payload	110	Estimate
SMS	Container	60	Estimate
SMS	Separation Mechanism	30	Estimate
SMS	Egg Protection	60	Measured
SMS	Helicopter Blades	200	Estimate
SMS	Parachute	20	Measured

Sub. Des.	Component	Mass (g)	Method
CDH	DeadOn DS3234 RTC x2	4.00	Estimate
SS	Altitude/Temperature Sensor MPL3115A2 Breakout	2.00	Estimate
SS	Luminosity Sensor TSL2561 Breakout	2.00	Estimate
SS	Voltage Divider	3.00	Allocated
EPS	Alkaline Coin Cell	5.00	Allocated
	SUM	563.20	

Communication and Data Handling Subsystem Design

Raymond Barakat

CDH Overview

- **Communication and Data Handling System**
  - Main board: Arduino Uno (Ardweeny)
    - Communication with ground station using XBEE Pro
  - Sub-components
    - The Ardweeny will retrieve data from the peripheral sensors, including the luminosity, temperature and altitude sensors.
    - The Ardweeny will also control several components, including the descent system and the payload release
  - Data Retrieval/Component control will be dependent on the Flight Software

CDH Changes Since PDR

- **No major changes have been made to the Telemetry plans**
  - Pseudo-code has been written for the flight software that will control the telemetry
  - Connections between components have been determined by the subsequent circuit diagrams

CDH Requirements

ID	Requirements	Parents	Children	VM			
				A	I	T	D
CDH.1.4	The container shall collect and store altitude data at a 1 Hz rate from launch to the moment of landing.	None	None	X	X		X
CDH.1.5	The container shall transmit its altitude data at a 1 Hz rate during from launch time to landing.	None	None	X	X		
CDH.2.1	During descent, the payload shall collect air pressure, air temperature and power source voltage once per second.	None	None	X	X		
CDH.2.2	During descent, the payload shall transmit all telemetry. The number of telemetry data transmitted shall be scored. The payload shall not generate telemetry data transmitted shall be scored. The payload shall not generate telemetry at greater than 1 Hz rate.	None	None	X			

COMM Requirements

ID	Requirements	Parents	Children	VM			
				A	I	T	D
COMM.1.1	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.	None	None	X	X		X
CDH.1.2	The XBEE radios shall have their NETID set to the team number.	None	None	X	X		
CDH.3	The XBEE radio shall not use the broadcast mode.	None	None	X	X		
CDH.4	The ground control station antenna shall be elevated a minimum of 3.5 meters (11.5 feet) from ground level to ensure adequate coverage and range. It must be secured so it cannot fall.	None	None	X			
CDH.5	The cansat shall not transmit telemetry until commanded by the team groundstation. Commanding can be executed while the cansat is in the rocket on the launch pad.	FSW.2	None	X	X		
CDH.6	The XBEE radio can operate in any mode as long as it does not interfere with other XBEE radios	None	None	X	X		

CDH Requirements

ID	Requirements	Parents	Children	VM			
				A	I	T	D
CDH.7	The CanSat shall have an external power control such as a power switch and some indication of being turned on or off.	None	None	X	X		
CDH.8	The CanSat shall have battery capacity to support up to a one hour wait on the launch pad plus time for flight operations	None	None	X	X		
CDH.9	The CanSat shall not utilize lithium polymer batteries.	None	None	X	X		
CDH.10	The flight software shall maintain and telemeter an indicator of the cansat flight software state.	None	None	X			
CDH.11	In the event of a processor reset during the mission, the flight software shall be able to determine the correct state	None	FSW.1	X			

Processor Selection Summary

Selected Microcontroller – Arduino Uno (Ardweeny)

-Processor Speed - 16MHz

-Data Interface

    -Digital (14) and Analog (6)

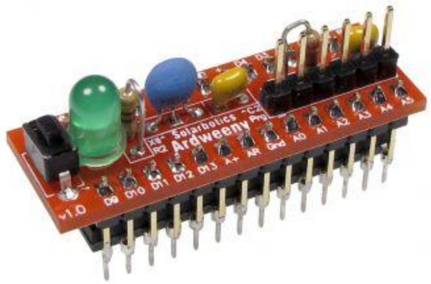
    -I2C and SPI (Digital)

-Extremely Small Form-factor (18 mm by 33 mm)

-Lightweight (2g)

-3.3V operating voltage

Disadvantages: XBEE Socket not onboard, no onboard voltage regulator



Clock Trade & Selection

Selected RTC Module – DeadOn DS3234 RTC

-Hardware Clock

-Will not reset in the event of a power failure

Antenna Trade & Selection

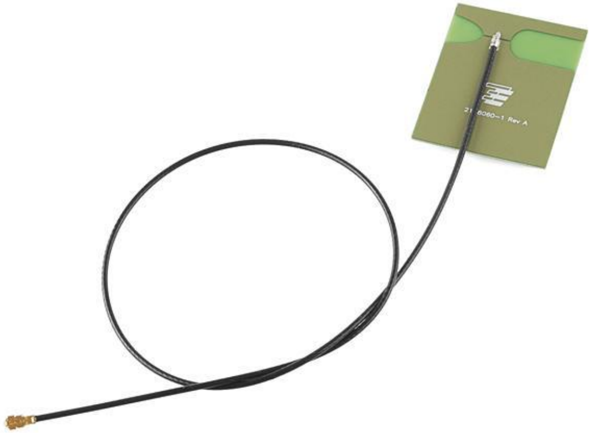
Selected Antenna – U.FL Adhesive Antenna

-Small Form-factor

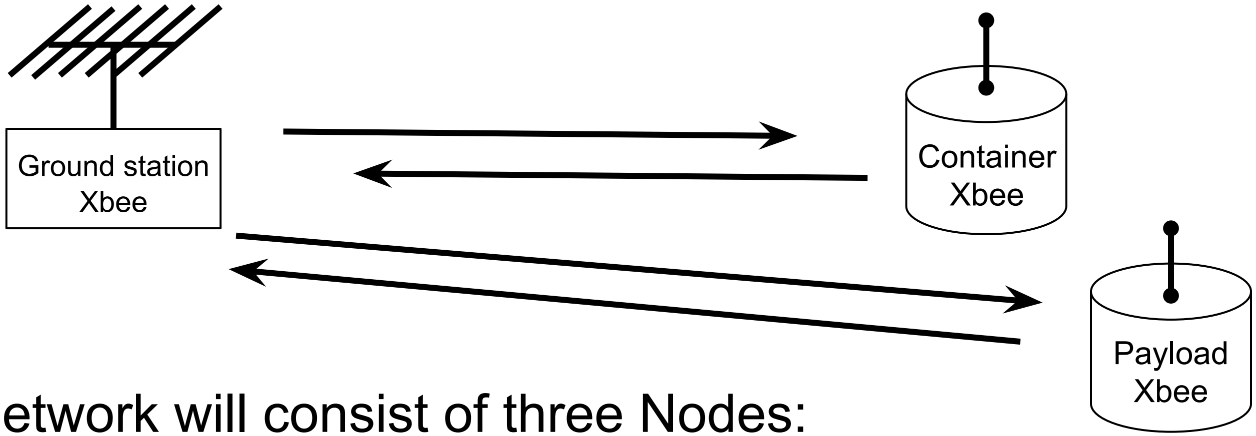
-Lightweight (3g)

-XBEE proprietary

Disadvantages: Low gain



Radio Configuration



- The XBEE network will consist of three Nodes: Coordinator (ground station) and two End Devices (Container, Payload).
- The NETID will prevent interference from other teams by pairing our devices to a specified network
- Packet Transmission will be coordinated by the software
- Testing with XBEEs is currently underway

Telemetry Format

- **Telemetry data will be sent in packets which will include:**

  PAYLOAD- Team ID, packet count, mission time, altitude, air temperature, supply voltage, and the bonus data.

  CONTAINER- Team ID, packet count, mission time, and altitude data.

- **The packet will be written at a rate of 57600 bps and transmitted at a rate of 250 kB/s every 2 seconds**
- **Packets will be formatted for writing to a file, in order to plot data in real-time.**

Example Payload Packet:

"1337,184,00:02:42,567,32.32,3.87,9001"

<TEAM_ID>, <PACKET_COUNT>, <MISSION_TIME>, <ALTSENSOR>, <TEMP>, <VOLTAGE>, [<BONUS_LIGHT>]

Telemetry Transmissions

- **Transmissions will be enabled from boot up of microcontrollers**
  - Ground station will receive signal from both the XBEEs in the canister and the payload

Electrical Power Subsystem Design

Zach Burnham

EPS Overview

Electrical Power System Components	Description
Power Supply	Solar Panels will supply power to capacitors which will fulfill power requirements needed by all subsystem electrical components.
DC-DC Booster	DC-DC Booster will regulate power supply and provide electrical components with required operating voltages and currents.
Battery Voltage Measurement	Ardweeny's voltage measuring capability, in combination with a Voltage Divider Circuit used to scale down Voltage input to ADC pins, will transmit voltage levels at a rate of 10,000 times\second.
Power Control	External power switch to control power from capacitors/generators to electrical components.

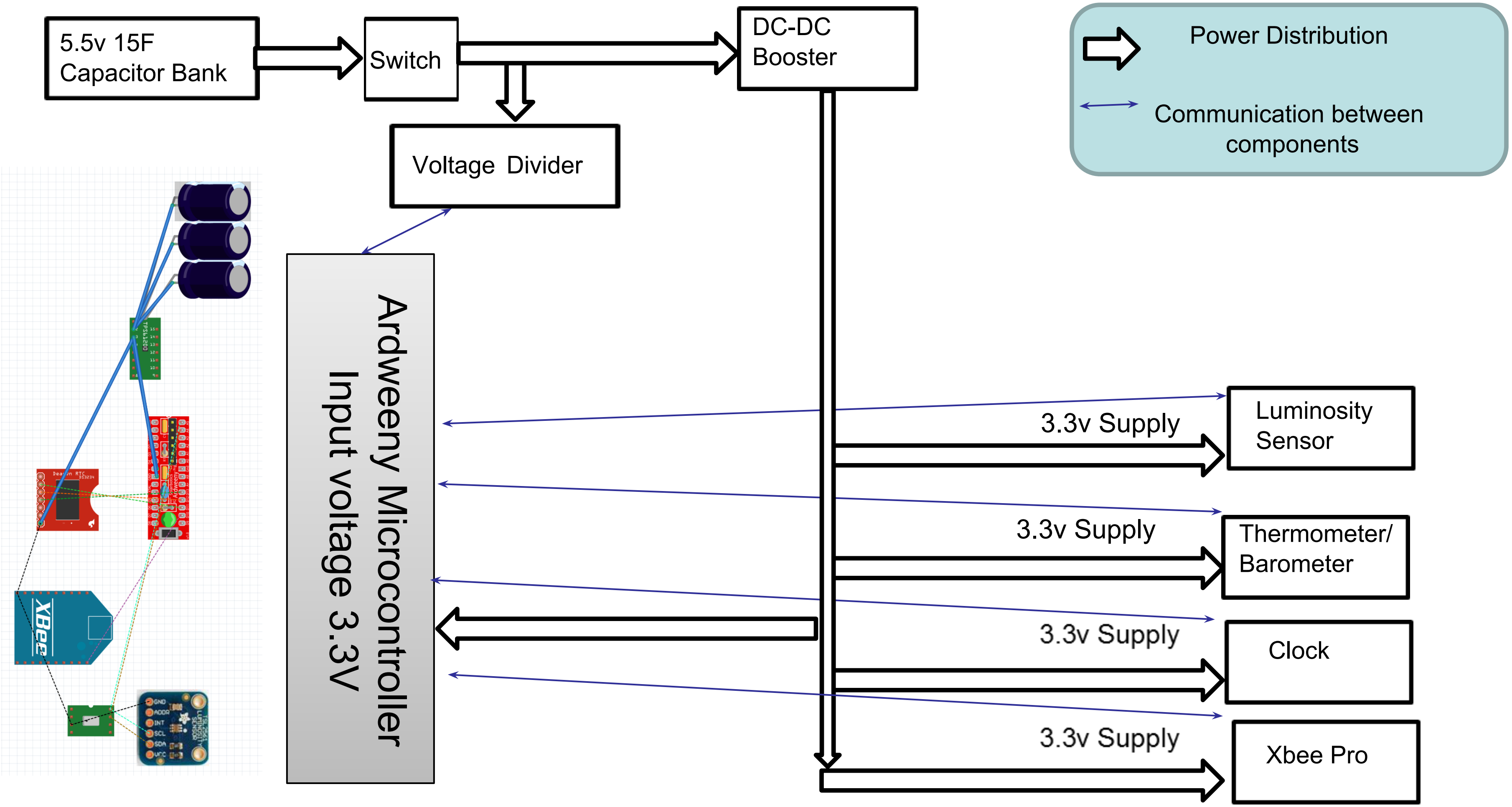
EPS Changes Since PDR

- **DC-DC Booster chosen over voltage regulator**
  - Accepts wider range of input voltages
  - Convenient breakout board

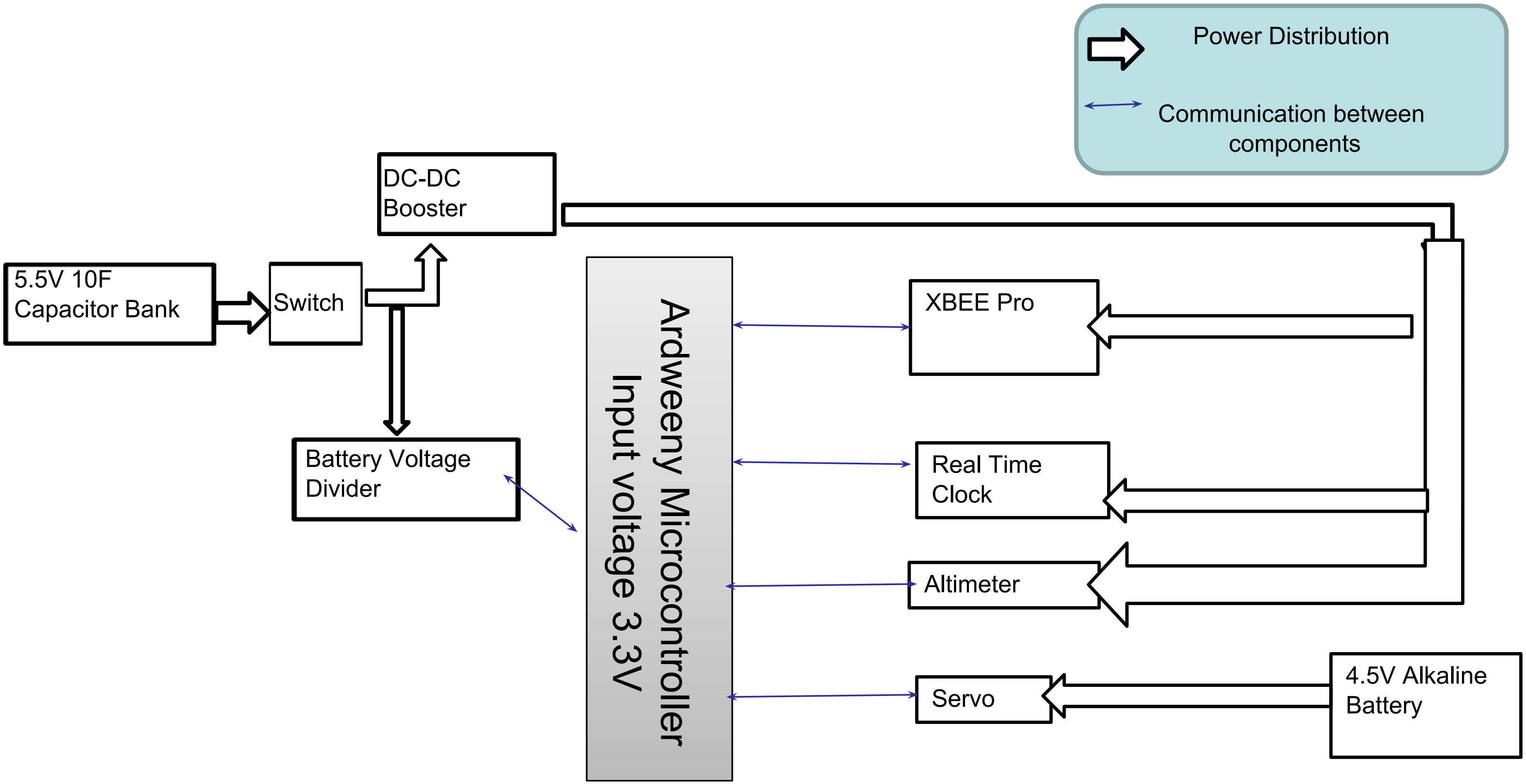
EPS Requirements

ID	Requirements	Parents	Children	VM			
				A	I	T	D
EPS.1.1	The payload shall include an external umbilical power connection to allow for testing and safety checks when not harvesting energy.	None	None	X	X		
EPS.1.2	The external power connection shall be a sturdy connector that is easily accessible when the payload is stowed in the container. Loose wires are not allowed.	None	None	X	X		
EPS.1.3	The container shall only use alkaline type batteries.	None	None	X	X		
EPS.1.4	No batteries shall be allowed in the payload. Batteries are allowed only in the container to support releasing the payload.	None	None	X			
EPS.2.1	The payload shall harvest energy from the environment during descent.	None	None	X			

Electrical Block Diagram (Payload)



Electrical Block Diagram (Container)



Power Source

.45W Solar Cell.

-Light in mass

-Supplies the amount of power needed for the CanSat Satellite with multiples

-Reasonable price for our budget

-Reasonable voltage levels

-Energy stored in capacitors

Power Budget (Payload)

Subsystem	Components	Current (mA)	Idle Current (mA)		Voltage (V)		Source	Power Consumption (W)
CDH	Ardweeny	3	-	-	3.3	3.3	Data Sheet	.0099
CDH	DeadOn RTC	.4	-	-	3.3	3.3	Data Sheet	.00132
SS	MPL3115A2 Breakout (Thermometer/Barrometer)	0.04	-	-	3.3	3.3	Data Sheet	.000132
SS	TSL2561 Breakout Luminosity Sensor	0.6	-	-	3.3	3.3	Data Sheet	.00198
CDH	Xbee Pro 60mW U.FL Connection Series 1 (802.15.4)	295	55 mA	3.5 uA	2.7 - 3.6 V	3.3	Data Sheet	.973
EPS	Battery Voltage Divider	-	-	-	-	-	Data Sheet	Negligible
EPS	Voltage Regulator Board	-	-	-	-	-	Data Sheet	Negligible
EPS							.99	Total Power (W)

Power Budget (Container)

Subsystem	Components	Current (mA)	Idle Current (mA)		Voltage (V)		Source	Power Consumption (W)
CDH	Ardweeny	3	-	-	3.3	3.3	Data Sheet	.0099
CDH	DeadOn RTC	.4	-	-	3.3	3.3	Data Sheet	.00132
SS	MPL3115A2 Breakout (Thermometer/Barrometer)	0.04	-	-	3.3	3.3	Data Sheet	.000132
CDH	Xbee Pro 60mW U.FL Connection Series 1 (802.15.4)	295	55 mA	3.5 uA	2.7 - 3.6 V	3.3	Data Sheet	.973
EPS	Battery Voltage Divider	-	-	-	-	-	Data Sheet	Negligible
EPS	Voltage Regulator Board	-	-	-	-	-	Data Sheet	Negligible
EPS							.98	Total Power (W)

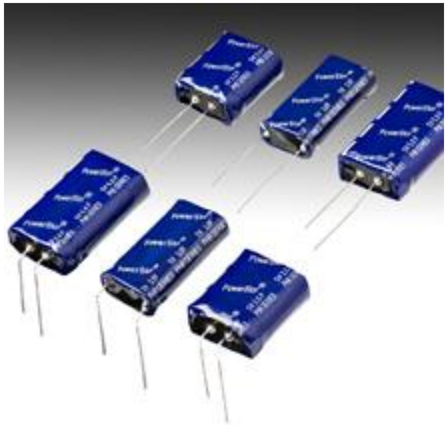
Power Budget

Total Power Available	**.9W**
Total Power Consumption (max)	1.97W
Ideal Power Consumption	.832W
Voltage of System's components (Volts)	3.3V
Margin	**.068W**

- **CanSat Ideal Power Consumption calculation based on assumption that each XBee is only in transmit mode less than 35% of the time**

Power Source/Storage

A bank of three 5.4V, 5F electrolytic capacitors were chosen for power storage on the payload. Two will be used for power storage on the container. Capacitors will be used for all of the power storage needs on both the container and the payload. A DC-DC booster will be used to regulate the power.



Bus Voltage Measurement

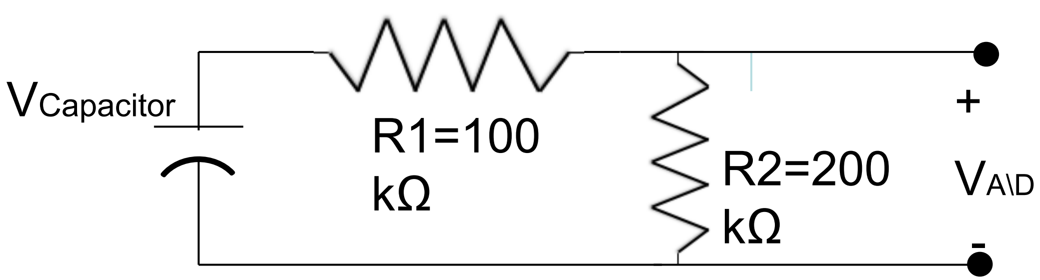
Voltage Divider:

-100kΩ and 200kΩ

-Measurements between 0V and 3.7V

-Resolution: .01V

-Ardweeny analog value will be scaled to the voltage range



Flight Software Design

William Merino

FSW Overview

- **Architecture**
  - On initial turn on, immediately takes data for altitude (calculates vertical speed) and functions as validation for the flight state. System determines if we have just restarted from an error, and if so, which state to jump to.
  - If no error is detected, awaits the signal for the following functions: boot (reset), launch pad (prepares for mission, awaits initialization of data capture, once started, cycles through mission based on trajectory and altitude), test mode (runs through pre-selected states).
- **Arduino language which is based on C/C++**
- **Text editor/Arduino IDE**
- **FSW determines what the system is doing at a given time and performs vital mission tasks**

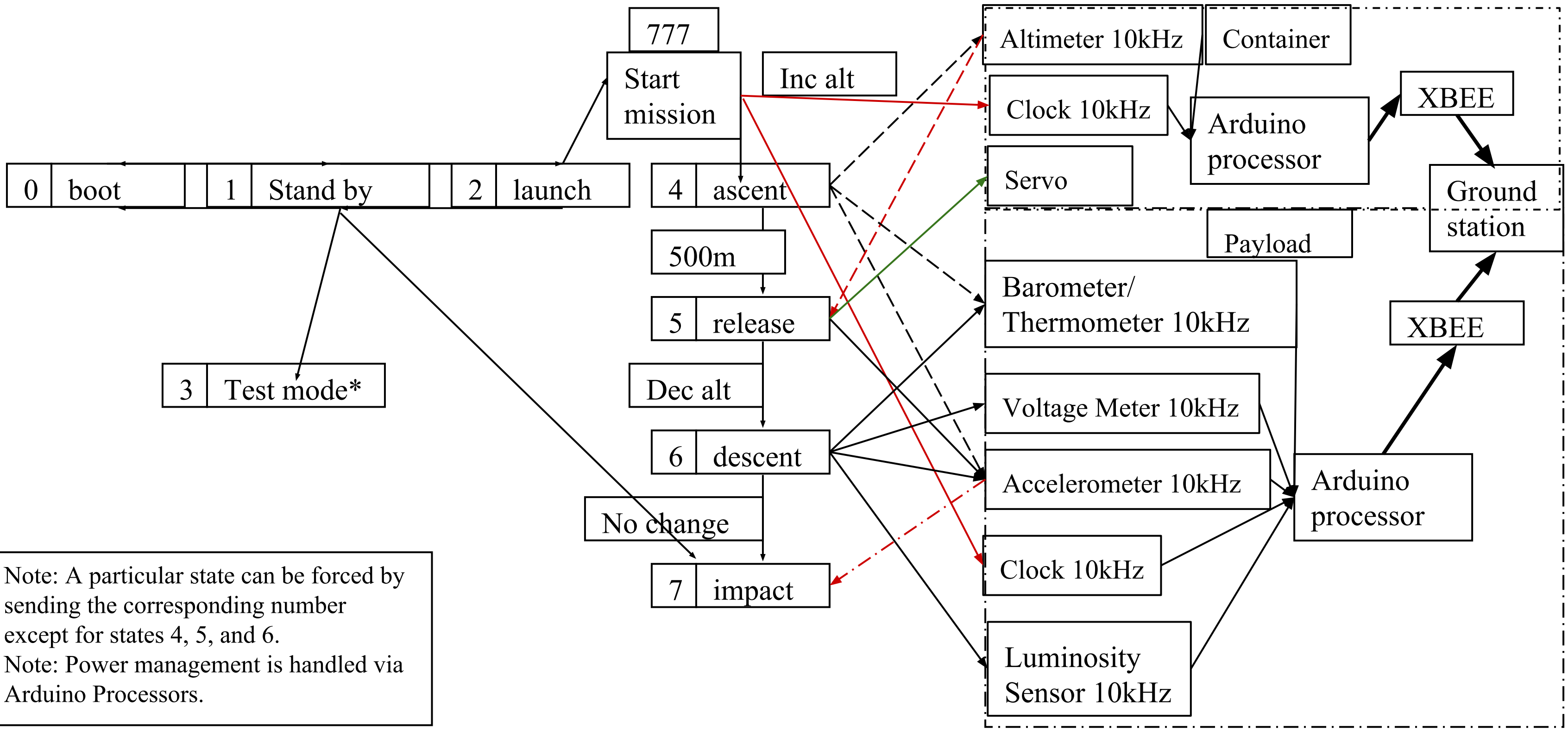
FSW Changes Since PDR

- **No major changes have been made to the overall flight software design since the presentation of the PDR.**

FSW Requirements

ID	Requirements	Parents	Children	VM			
				A	I	T	D
CDH1.3	The Flight software shall maintain a count of packets transmitted, which shall increment with each packet transmission throughout the mission. The value shall be maintained through processor resets.	None	None	X			

CanSat FSW State Diagram



Note: A particular state can be forced by sending the corresponding number except for states 4, 5, and 6.
Note: Power management is handled via Arduino Processors.

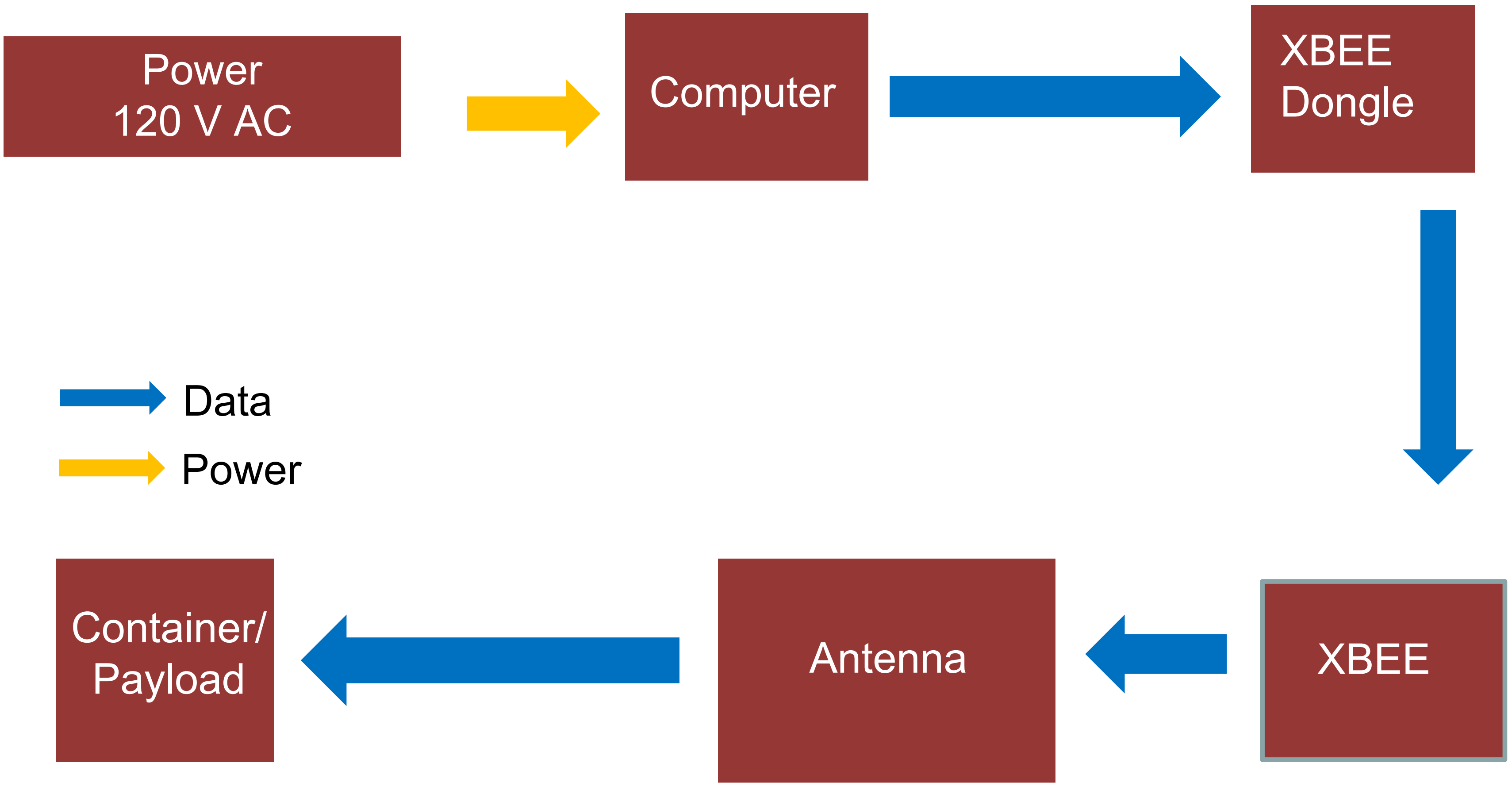
Software Development Plan

- **Use an Evolutionary Software Development Model**
- Develop prototypes early, introducing simple functionality tests using the Microcontroller.
- Distribute programing and testing tasks amongst team members in a modular fashion to facilitate efficient development schedule.
- As testing progresses, integrate components and thoroughly test functionality.
- Development Team: Ryian Hunter, Sarah Smallwood, William Merino
- **Code has been outlined and some segments of functional code written; development will progress more rapidly once hardware is fully assembled and integrated.**

Ground Control System Design

Zach Burnham

GCS Overview



GCS Changes Since CDR

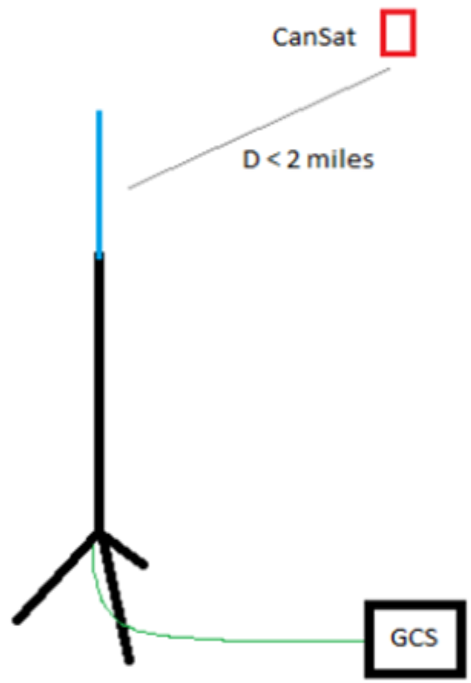
No major changes were made to the ground station design since the PDR.

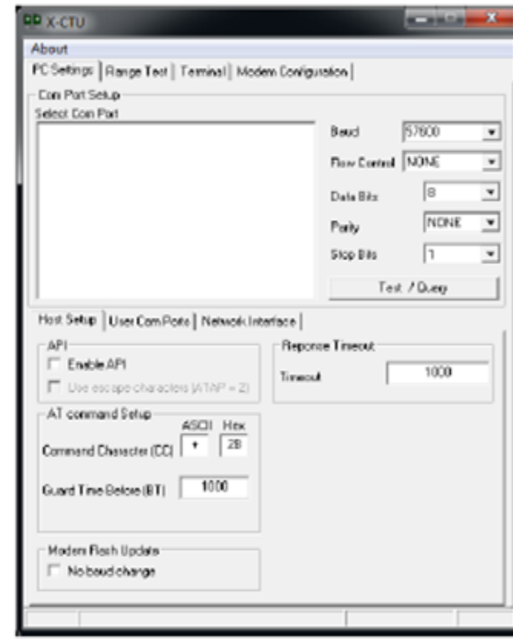
GCS Requirements

ID	Requirements	Parents	Children	VM			
				A	I	T	D
COMM.1.2	The XBEE radios shall have their NETID set to the team number.	None	None	X			
COMM.1.3	The XBEE radio shall not use the broadcast mode.	None	None	X			
COMM.1.4	Both the container radio and payload radio shall use the same NETID/PANID. Teams are allowed to determine how to coordinate communications between the container, payload and ground station.	None	None	X	X		
COMM.1.5	Each team shall develop their own ground station.	None	None	X			
COMM.1.6	All telemetry data shall be displayed in real time during descent.	None	None	x			
COMM.1.7	All telemetry data shall be displayed in engineering units (meters, meters/sec, Celcius, etc.)	None	None	X			
COMM 1.8	Teams shall plot data in real time during flight	None	None	x			

GCS Antenna Selection

- **Antenna height and mounting strategy**
  - tripod base 3 ft
  - shaft with additional 9 ft
  - antenna is 4.92 ft
  - cable running down the shaft from antenna
  - other side has a connector convertor
- Predicted to have a range of 2 miles while in line of sight
  - in urban areas, a range of 300 ft.





TP Link TL-ANT2415D
15 dBi Omnidirectional Antenna

GCS Software

- **Telemetry Display**

    `1261,30,00:03:35,567,20,4.2,1500,`

- **MatLab, XCTU, and Arduino IDE will be used**
- **Real-time plotting software**
    - Need to interface program with MatLab
    - Plotting software will be constantly reading from file that has filtered out relevant parameters to be visualized
- **Data Archiving done through a *.CSV file**
- **XCTU directly interfacing with the Ardweeny onboard the CanSat**
- **Progress since PDR**
    - Still need to create data plotting software
- **Main objectives in testing**
    - Speed and reliability

CanSat Integration and Test

Heather Zunino

CanSat Integration and Test Overview

- **Sensor Subsystem**
  - Altimeter: Will be used to measure altitude of the CanSat throughout the flight
    - Altimeter will be tested at a system level when we do a wholly integrated test launch. We will need all systems ready for this test. We expect it to be accurate within 0.1%
  - Barometer/Thermometer: Will be used to provide pressure and temperature readings.
    - Barometer shall be tested alongside a trusted pressure measurement device for comparison verification of accuracy. We need our FSW functional for this test. We expect it to be accurate within 0.1%
    - Thermometer shall be tested alongside a trusted temperature measurement device for comparison verification of accuracy. We need our FSW functional for this test. We expect it to be accurate within 0.1%
  - Luminosity sensor: Will be used to measure visible light and infrared light intensity.
    - Luminosity sensor shall be tested by using it to measure a light source with known intensity. We need our FSW functional for this test. We expect it to be accurate within 0.1%
  - Voltage divider: Will be used to measure voltage throughout the flight
    - The voltage divider shall be tested by using it to measure a known voltage. We need our FSW functional for this test. We expect it to be accurate within 0.1%

CanSat Integration and Test Overview

- **Descent Control**
  - All descent control tests will occur during freefall starting at ~100 ft
  - Container Parachute Deployment
    - Parachute will be tested for its ability to release from Container parachute compartment using only acceleration due to gravity, parachute will be tested to fall at specified speed (~12m/s) with entire CanSat mass. We will need all systems ready for this test. We expect it to be accurate within 0.1%
  - Payload DCS
    - Payload DCS will be tested for it ability to deploy after being release from Container encapsulation and to fall a specified descent rate (~ 10 m/s). We will need all systems ready for this test. We expect it to be accurate within 0.1%
- **Mechanical Subsystem**
  - All mechanical subsystems tests will require all systems ready. We expect these tests to demonstrate functionality and integrity of our design (no structural failures).
  - Egg Protection system
    - Egg protection system was tested from a height (30ft) and a worst case expected final velocity (~15 m/s).
    - Egg protection system will be tested with integrated CanSat in order to optimize test condition and refine protection system therefore.
  - Payload deployment mechanism
    - Will be tested with the fully integrate CanSat (after DCS is verified through test)
  - Structural Survivability: Will be tested in conjunction with failed/successful DCS tests

CanSat Integration and Test Overview

- **Communication/Ground Station**
  - Arduino will be configured with Xbee Pro prior to full CanSat integration along with ground station system to verify ability to communicate.
    - Long distance tests will be completed to ensure proper communication to GCS. All subsystems must be functional for this test. We expect to see zero programming errors in telemetry.
- **Data Handling/Flight Software**
  - Arduino will be tested with each of the sensors to verify they can perform all needed telemetry requirements. All subsystems must be functional for this final test. We expect to see zero programming errors in data handling and flight software.
  - Flight Software development has already begun and will be continually created on an as-needed basis, as other subsystem designs progress.
- **Electrical Power Subsystem**
  - Electrical Power subsystem will be last subsystem to be integrated
    - Power regulation and battery voltage measurement circuits will be tested for functionality.
    - Battery will be test with fully integrated CanSat to ensure it meets power requirements
    - Power production system will be tested with fully integrated CanSat to ensure it performs acceptably. All subsystems must be complete for this final test. No failure is expected.

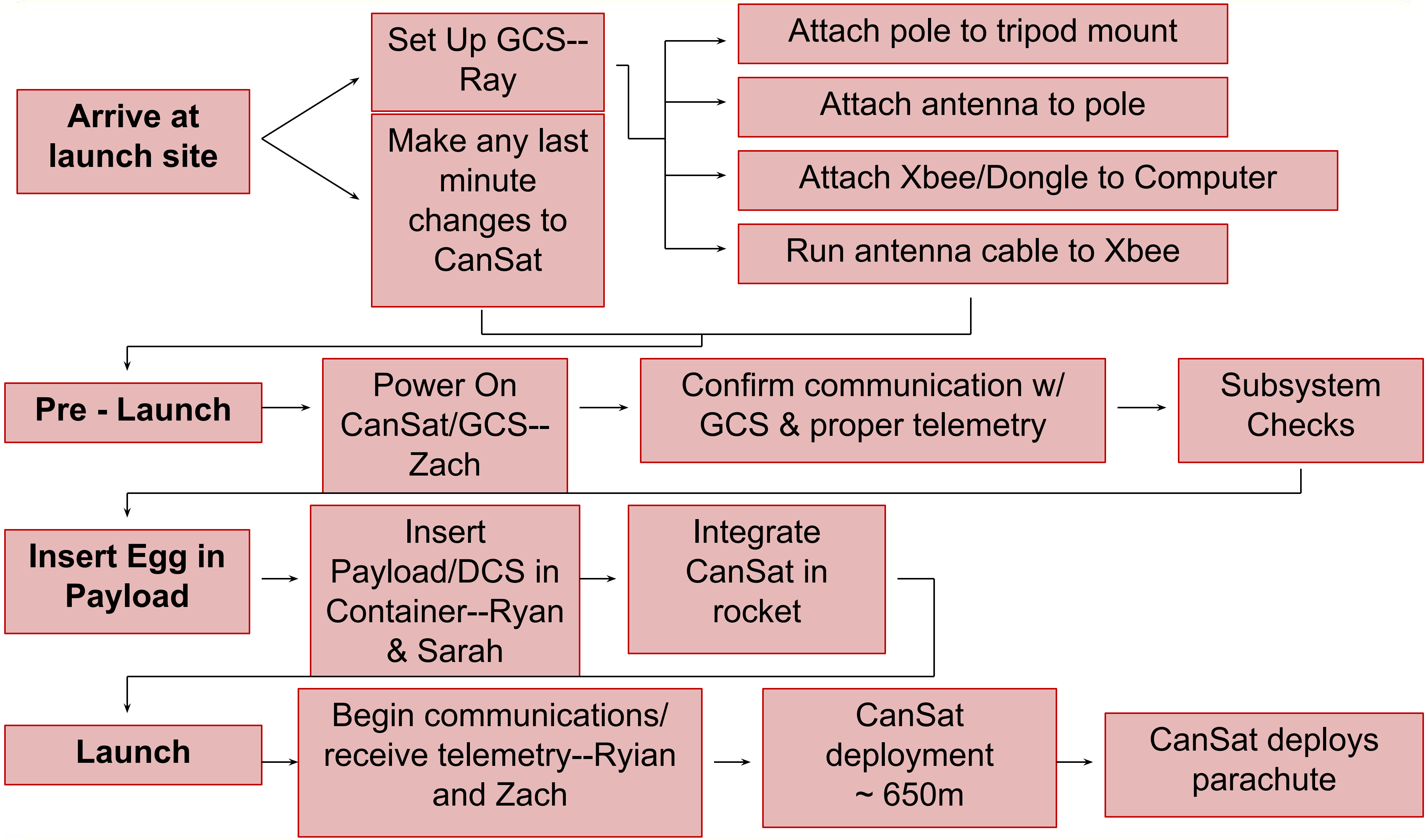
CanSat Integration and Test Overview

- **System Level Tests (CanSat is fully integrated and wholly tested)**
  - System level tests will be completed after subsystems design are verified through tests.
  - Will need some apparatus to bring CanSat to test altitude (high altitude weather balloon)
  - Goal of tests will be to simulate mission sequence
    - Test will confirm deployment of Container DCS
    - Test will confirm proper release of a CanSat Payload using PEMR
    - Test will confirm the deployment of Payload DCS after release
    - Test will demonstrate its ability to reach objective impact velocity
    - Test will confirm egg protection system
    - Test will demonstrate ability to meet all telemetry requirements

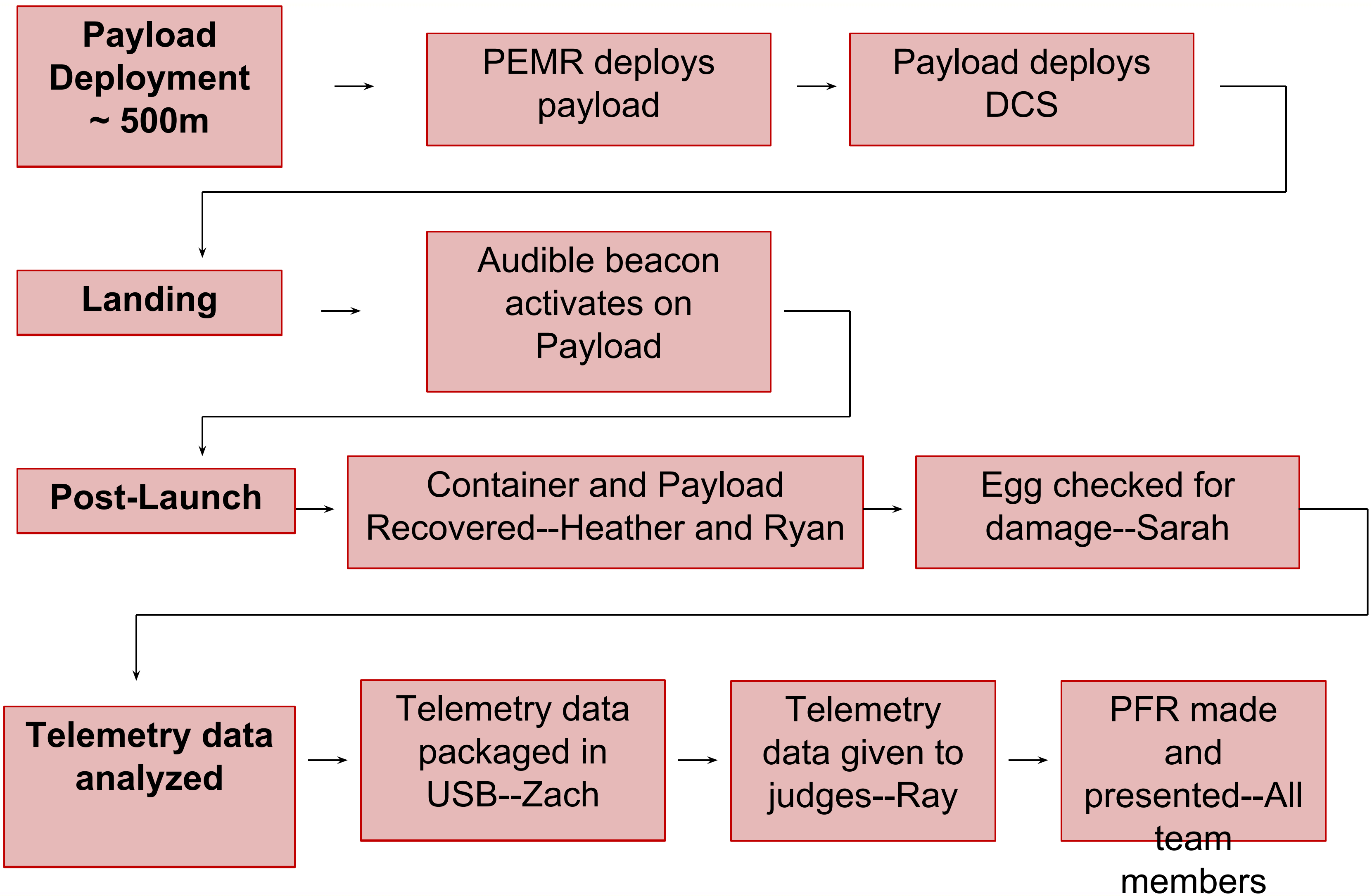
Mission Operations & Analysis

Heather Zunino

Overview of Mission Sequence of Events



Overview of Mission Sequence of Events



Mission Operations Manual Development Plan

- Launch Operations Crew Assignments
  - Mission Control Officer (1) – Team Leader or Alternate TL
  - Recovery Crew (2) – 1 for Container & 1 for Payload recovery
  - CanSat Crew (2) – Mech. Subsystem Lead & Member
  - Ground Station Crew (3-5) – CDH Subsystem Lead & Members
- Ground Station Configuration checklist
  - Will outline every procedure to begin operation of GCS at competition
  - Consists of physically building GCS and operation of CDH components
- CanSat Preparation checklist
  - Will outline instructions on how to perform subsystem checks to verify ability to perform full operation
    - Will include final tests of descent control deployment and telemetry/FSW checks

Mission Operations Manual Development Plan

- CanSat Integration checklist
  - Will provide a checklist to ensure that all components are mounted in the CanSat payload before integration.
  - This is when we will perform check-in with flight line judge
  - This will end with integration into competition rocket
- Launch Preparation procedure
  - Consists of completing previously mentioned checklists
  - Competition Ops & SoE steps 1-7
- Launch Procedure
  - This will describe the responsibilities of all members during launch
    - Mission Control Officer, Recovery Crew, Ground Station Crew, CanSat Crew
- Recovery Procedure
  - This will describe procedure to recover CanSat after launch
  - This will also describe procedure to record telemetry and submit it

CanSat Location and Recovery

- **Container Recovery**
  - Container will be color fluorescent orange for high contrast
    - Retro-reflective material may be used as well
    - Team members will watch with binoculars to find general landing area, then rely on fluorescent color to recover.
- **Payload Recovery**
- 1 team member is solely responsible for container recovery and 1 for payload recovery during launch sequence.
- Sticker will be placed on both Container and Payload with return address labeling (team #, email address, phone #).

Field Safety Rules Compliance

- **Missions Operations Manual is currently under development**
  - Currently being compiled and edited for clarity
  - Adding figures and flow charts
- **Two copies will be printed and assembled into three ring binders.**

Mission Rehearsal Activities

- **Preliminary integration tests have been rehearsed**
  - Loading egg into payload has been rehearsed
  - Powering on/off the CanSat
    - Incomplete - Completed by May
  - Final assembly
    - Incomplete - Completed by May
  - Loading the CanSat into the launch vehicle
    - Incomplete - Completed by May
  - Telemetry processing, archiving, and analysis
    - In progress - Completed by April
  - Recovery test
    - Incomplete - Completed by May
- **Final written procedures will be completed by May**

Requirements Compliance

Heather Zunino

Requirements Compliance Overview

- **Current State**
  - The current design of the CanSat complies with all requirements set forth by the CanSat Competition
    - Mass requirement
      - Comply
    - Completely enclosed by container
      - Comply
    - Dimensional requirements
      - Comply
    - Use of descent system
      - Comply
    - Container has no sharp edges
      - Comply
    - Container is fluorescent color
      - Comply

Requirements Compliance

Rqmt Num	Requirement	Comply / No Comply / Partial	X-Ref Slide(s) Demonstrating Compliance	Team comments and notes
1	Total mass of CanSat, container, and all descent control devices shall be 700 grams. Mass shall not vary more than +/-10 grams.	Comply	50	
2	The cansat must be installed in a container to protect it from deployment out of the rocket.	Comply	14-17	
3	The container shall fit inside the cylindrical payload section of the rocket defined by the cylindrical payload envelope of 130 mm x 250 mm length control system including the descent.	Comply	14-17	
4	The container must use a descent control system. It cannot free fall.	Comply	24-39	
5	The container shall not have any sharp edges that could cause it to get stuck in the rocket payload section.	Comply	15	
6	The container must be a fluorescent color: pink or orange.	Comply	29	

Management

Heather Zunino

CanSat Budget – Hardware

Subsytem Designation	Component	Unit Cost (USD)	QTY	Cost (USD)	Verification
CDH	Arduino Uno (Ardweeny)	24.94	2	49.88	Actual
CDH	CanSat Xbee	37.95	2	75.90	Actual
CDH	CanSat Antenna	4.95	2	9.90	Actual
EPS	Slide Switch	0.75	2	1.50	Actual
EPS	Power Indicator Light	0.35	2	0.70	Actual
EPS	Container Batteries	10.00	1	10.00	Estimate
EPS	Votalge Measurement Circuit	0.50	1	0.50	Actual
EPS	Container Batteries	19.93	1	19.93	Actual
EPS	Payload Capacitors	18.00	5	90.00	Actual
EPS	Voltage Regulator	1.95	2	3.90	Actual
SMS	Container Structure	19.00	1	19.00	Estimate
SMS	Payload Strucutre	9.99	1	9.99	Actual
SMS	Container Parachute	6.95	1	6.95	Actual
SMS	Descent Control System	149.50	1	149.50	Estimate
SMS	Egg Protection System	19.99	1	19.99	Actual
SMS	Small Component Mounting Adhesive	7.55	2	15.10	Actual

Status of Procurements

- **All sensors have been purchased and have arrived**
- **Nylon shell delivery has been delayed**
  - 3D printed model will be completed by April 15th
- **All other purchased have proceeded on schedule**

CanSat Budget – Hardware

SMS	Deployemt Actuator	50.00	1	50.00	Estimate
SS	Micro SD Card	10.98	1	10.98	Estimate
SS	Altitude/Pressure Sensor	14.95	1	14.95	Actual
SS	Visible and Infrared Light Sensor	5.95	1	5.95	Actual
SS	Real Time Clock	19.95	1	19.95	Actual
SS	Tempurature Sensor	5.95	1	5.95	Actual
GCS	Ground Station Xbee	37.95	1	37.95	Actual
GCS	Ground Station Antenna	49.24	1	49.24	Actual
GCS	Antenna Tripod	16.95	1	16.95	Actual
GCS	Xbee Explorer Dongle	24.95	1	24.95	Actual
GCS	Antenna Cable (N-Male to N-Male)	53.99	1	53.99	Actual
GCS	12' Antenna Pole	15.00	1	15.00	Estimate
GCS	Xbee to Cable adapter (RP-Male to N-Female)	8.99	1	8.99	Actual
		CanSat Hardware Total		508.79	
		GCS Hardware Total		207.07	
				125.00	Estimate
		Hardware Total		840.86	

CanSat Budget – Hardware

Subsytem Designation	Component	Unit Cost (USD)	QTY	Cost (USD)	Verification
GCS	Xbee Pro 60mW U.FL Connection Series 1	37.95	1	37.95	Actual
GCS	2.4GHz 15dBi TL-ANT2415d Antenna	49.24	1	49.24	Actual
GCS	Antenna Mast Tripod Mount 3' FT	16.95	1	16.95	Actual
GCS	Xbee Explorer Dongle	24.95	1	24.95	Actual
GCS	Antenna Cable (RP-SMA to N-female)	55.00	1	55	Estimate
GCS	12' Antenna Pole	20.00	1	20	Estimate
GCS	Xbee to Cable connector (GCS)	4.95	1	4.95	Actual
			CanSat Total	986.91	
			GCS Total	209.04	
			S/H	150.00	Estimate
			Total	1345.95	

CanSat Budget – Other Costs

Description	Price (USD)	Verification
Test Facilities and Equipment	0.00	Provided by University
Computers	0.00	Provided by Team
Testing Expenses	1650.00	University Funding
Testing Expenses Total	1650.00	

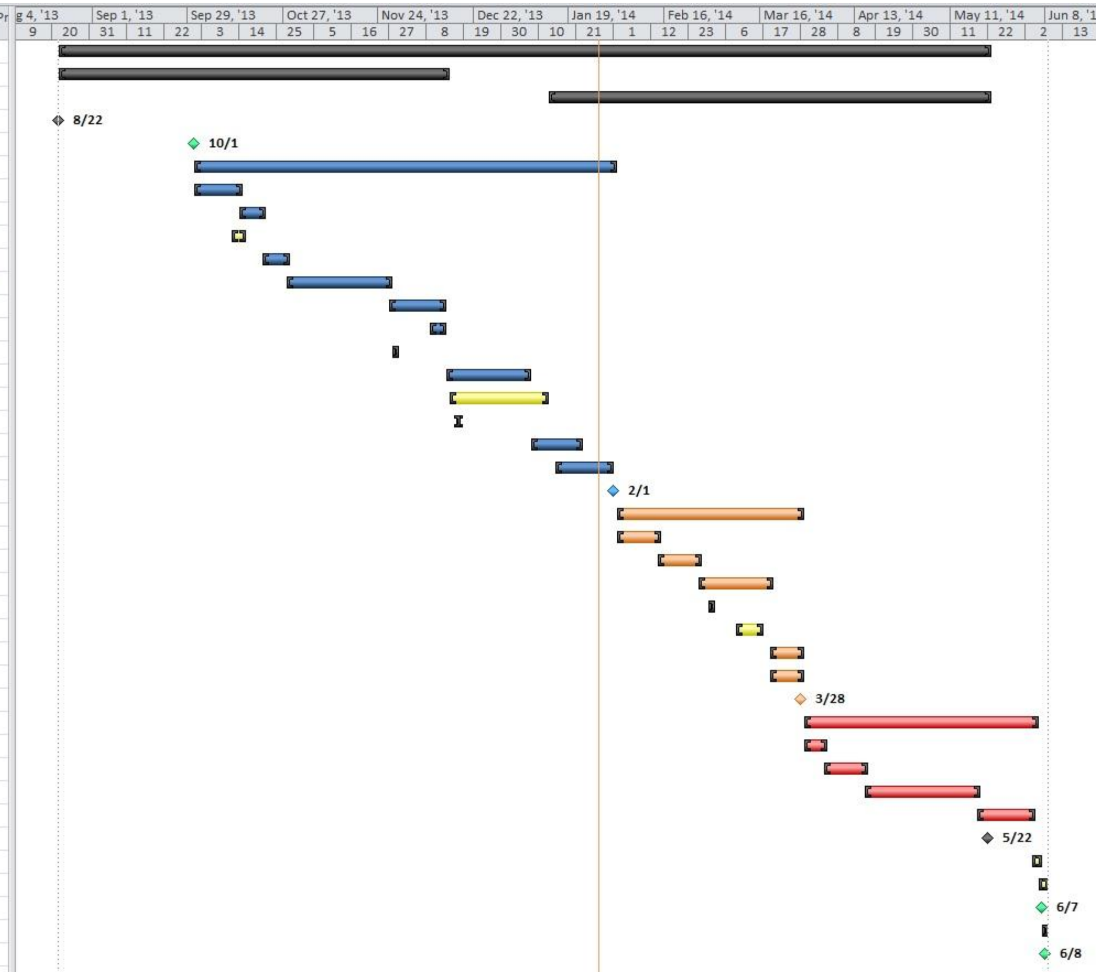
Description	Price (USD)	Verification
Vehicle for Transportation	400.00	Estimate*
Gas	350.00	Estimate*
Hotel	1000.00	Estimate*
Food	450.00	Estimate*
Travel Expenses Total	2200.00	
* assumes 7 members attending competition		

Description	Price (USD)
CanSat Hardware Expenses	840.86
Testing Expenses	1650.00
Total Hardware Cost	2490.86
Current University Funding	2750
Current Surplus	259.14

Description	Price (USD)
Travel Expenses	2200.00
Total Travel Cost	2200.00
Current University Funding	1650.00
Current Surplus	-550.00

Program Schedule

Task Name	Duration	Start	Finish
ASU School Year	196 days	Thu 8/22/13	Thu 5/22/14
ASU Fall 2013 Semester	83 days	Thu 8/22/13	Sat 12/14/13
ASU Spring 2014 Semester	94 days	Mon 1/13/14	Thu 5/22/14
First Day of Classes	0 days	Thu 8/22/13	Thu 8/22/13
CanSat Competition Begins	0 days	Tue 10/1/13	Tue 10/1/13
CanSat Preliminary Design Phase	90 days	Tue 10/1/13	Sat 2/1/14
Define Competition	10 days	Tue 10/1/13	Mon 10/14/13
Define/Allocate Subsystem Requirements	6 days	Mon 10/14/13	Mon 10/21/13
ASU Fall Holiday	3 days	Sat 10/12/13	Tue 10/15/13
CanSat Hardware Design Brainstorm	6 days	Mon 10/21/13	Mon 10/28/13
CanSat Design Trade Studies	23 days	Mon 10/28/13	Wed 11/27/13
CanSat Design	13 days	Wed 11/27/13	Fri 12/13/13
Purchase Preliminary Components	5 days	Mon 12/9/13	Fri 12/13/13
Thanksgiving Holiday	2 days	Thu 11/28/13	Fri 11/29/13
Component Prototype Fabrication & Prelimnary (Subsytem) Testing	18 days	Sat 12/14/13	Tue 1/7/14
ASU Winter Holiday	22 days	Sun 12/15/13	Sun 1/12/14
SESE Open House	1 day	Tue 12/17/13	Tue 12/17/13
Finalize Preliminary Design	11 days	Wed 1/8/14	Wed 1/22/14
Create PDR Presentation	13 days	Wed 1/15/14	Fri 1/31/14
PDR Presentation	0 days	Sat 2/1/14	Sat 2/1/14
CanSat Critical Design/Testing Phase	41 days	Sun 2/2/14	Fri 3/28/14
Finalized Preliminary Design Components Purchased	11 days	Sun 2/2/14	Fri 2/14/14
Fabricate CanSat Testing System from Prelinary Design	9 days	Fri 2/14/14	Wed 2/26/14
CanSat System/Subsystem Testing	16 days	Wed 2/26/14	Wed 3/19/14
Engineering Open House	2 days	Sat 3/1/14	Sun 3/2/14
ASU Spring Holiday	7 days	Sun 3/9/14	Sun 3/16/14
Finalize CanSat Critcal Design	8 days	Wed 3/19/14	Fri 3/28/14
Create CDR Presentation	8 days	Wed 3/19/14	Fri 3/28/14
CDR Presentation	0 days	Fri 3/28/14	Fri 3/28/14
CanSat Integration Phase	50 days	Sat 3/29/14	Thu 6/5/14
Finalized Critical Design Components Purchased	6 days	Sat 3/29/14	Fri 4/4/14
Fabricate CanSat Testing System from Critcal Design	9 days	Fri 4/4/14	Wed 4/16/14
Final CanSat System/Subsystem Testing	24 days	Wed 4/16/14	Mon 5/19/14
Final Fabrication of CanSat	13 days	Mon 5/19/14	Wed 6/4/14
Last Day of Classes	0 days	Thu 5/22/14	Thu 5/22/14
Travel to 2014 CanSat Competition	3 days	Wed 6/4/14	Fri 6/6/14
2014 CanSat Competition	2 days	Fri 6/6/14	Sun 6/8/14
2014 CanSat Competition Launch Day	0 days	Sat 6/7/14	Sat 6/7/14
Finalize PFR Presentation	2 days	Sat 6/7/14	Sun 6/8/14
Present PFR	0 days	Sun 6/8/14	Sun 6/8/14



Shipping and Transportation

- **All CanSat parts, materials, and team members will be transported to the launch site by rental car.**
- **All materials will be secured in the back of a van to ensure no parts get damaged or broken.**

Conclusions

- **Major Accomplishments**
  - All subsystems have completed detailed design and have been evaluated.
    - Subsystems have all parts purchased
  - All sensor components are purchased.
  - Egg protection has been successfully tested.
  - Flight software has entered development phase
  - All designs are final and ready for printing and assembly
- **Major Unfinished Work - High-Level Tasks**
  - 3D printed payload must be finished
  - Payload DCS system must finish detailed design/test.
- **Proceedings**
  - We are ready to proceed to the build phase and continue the programming for our project
    - All designs are completed
    - All part purchases are made
    - Assembly will occur in May as a low-level task.