CanSat 2014 PDR

Team #: 1261

Sparky Sat

Presentation Outline

1. **Introduction** – Heather Zunino
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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 –** Rick Astrain
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

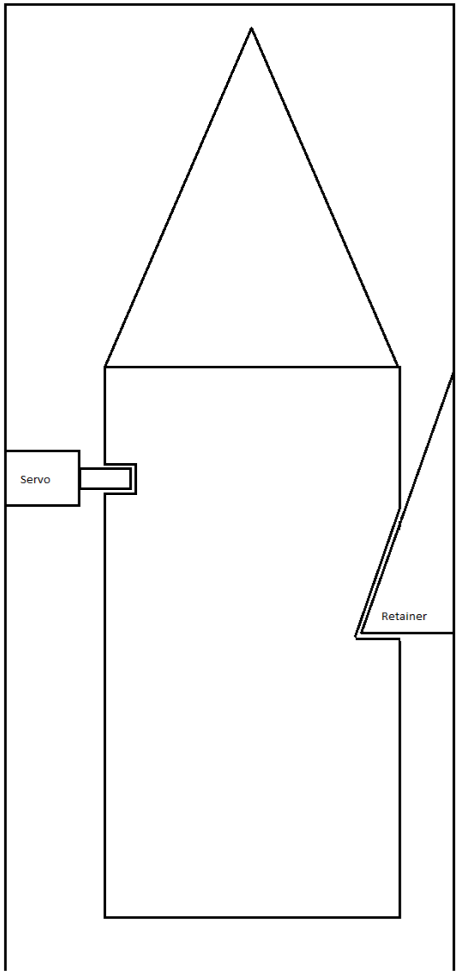
- **Main Objective:**
  - The CanSat shall safely land with the payload (egg) intact.
- **Other objectives:**
  - Container/CanSat descent shall be 12±1m/s while 500m above ground.
  - Deployable aero-braking structure shall reduce CanSat descent after 500m to 10 m/s .
  - Required telemetry shall be 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.

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			

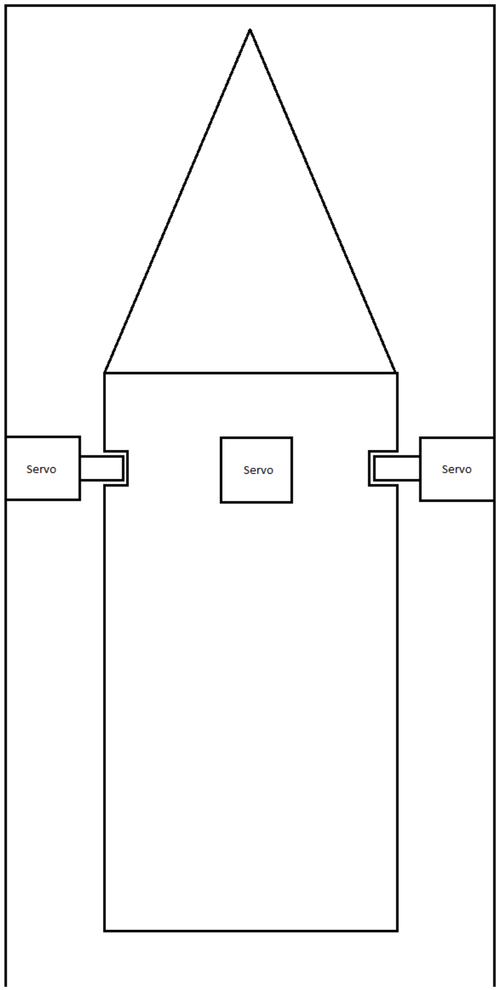
System Level CanSat Configuration Trade & Selection

- **Single Servo - Retainer Deployment**
  - CanSat maintained in container via servo and attachment point
  - Servo pulls pin and CanSat slides out of container
  - Challenges
    - 1. Servo may not be strong enough to maintain CanSat
    - 2. CanSat structure must be modified somewhat to accommodate retainer
  - Advantage
    - 1. Provides maximum stability with minimum weight and power consumption
  - This configuration was selected due to low weight and relative simplicity



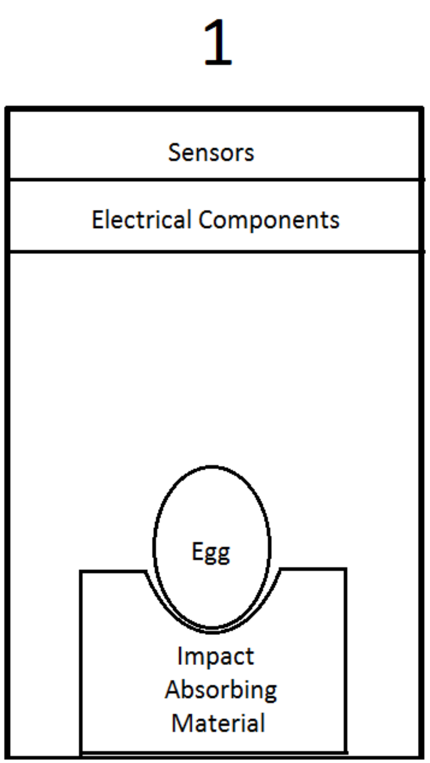
System Level CanSat Configuration Trade & Selection

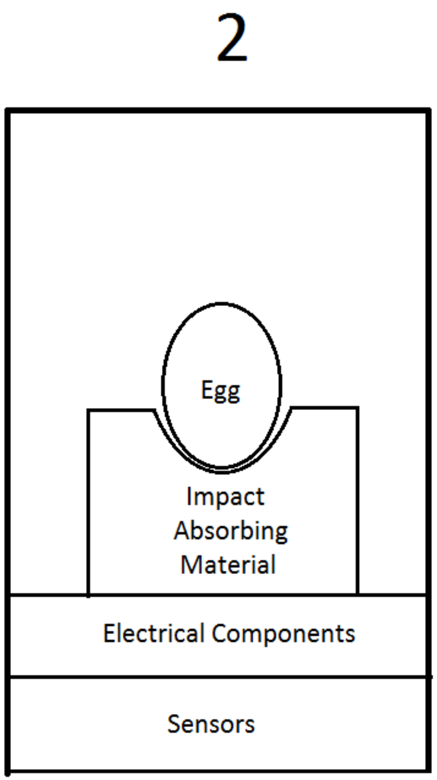
- **Triple Servo Deployment**
  - CanSat maintained in container by three servos
  - All three servos retract pins simultaneously to deploy CanSat.
  - Challenges
    - 1. Triples power consumption and weight of the system, as well as chance of failure
  - Advantage
    - 1. Increased stability



System Level CanSat Configuration Trade & Selection

CanSat configuration 1 was intended to provide optimal protection to electrical components, but configuration 2 was chosen to keep the center of gravity low.





System Concept of Operations

Pre-Launch

Pre-Launch Testing:
- Power
- Communication
- Telemetry
- Deployment
- Egg protection

CanSat-Rocket Integration:
- 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

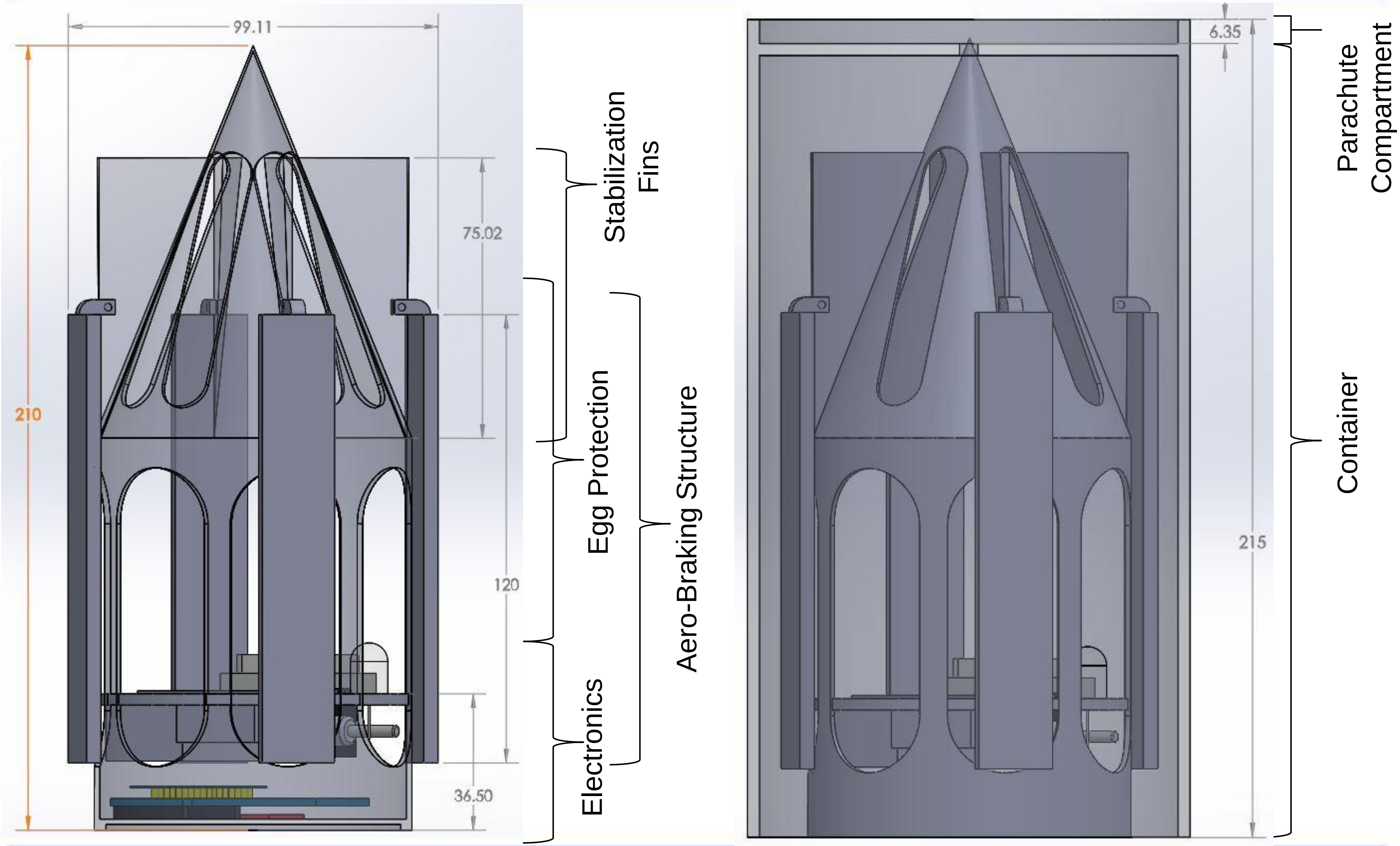
Landing:
- Receive/record telemetry deactivated

Post-Launch

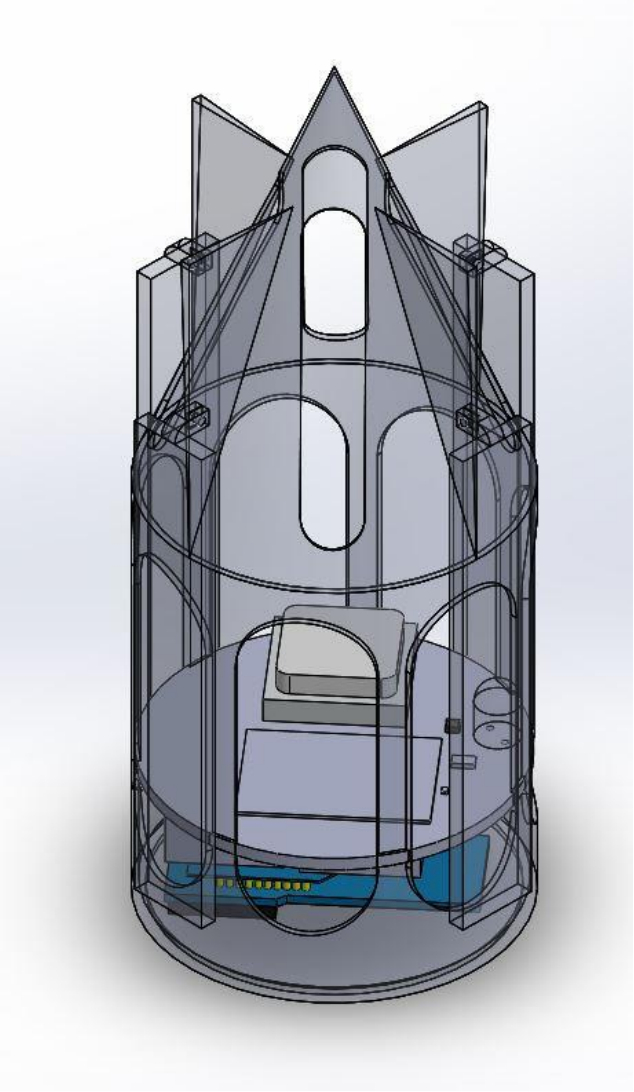
Recovery:
- Container and payload are retrieved

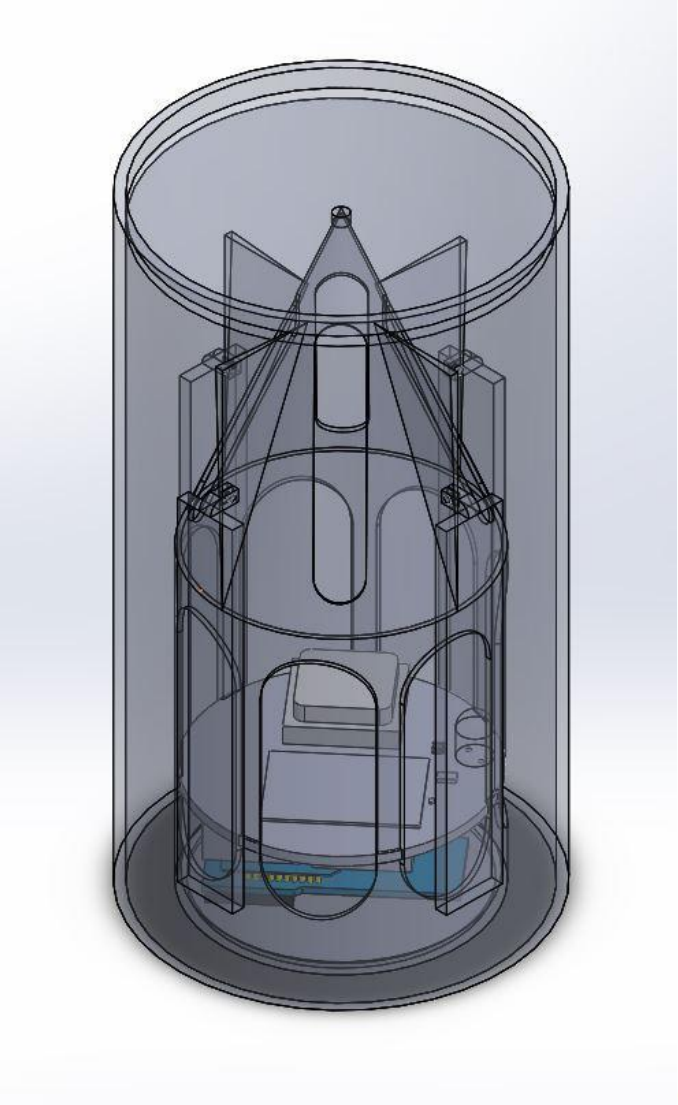
Post-mission reporting:
- Telemetry data is saved to file and reported
- Power down CanSat and GS

Physical Layout



Physical Layout



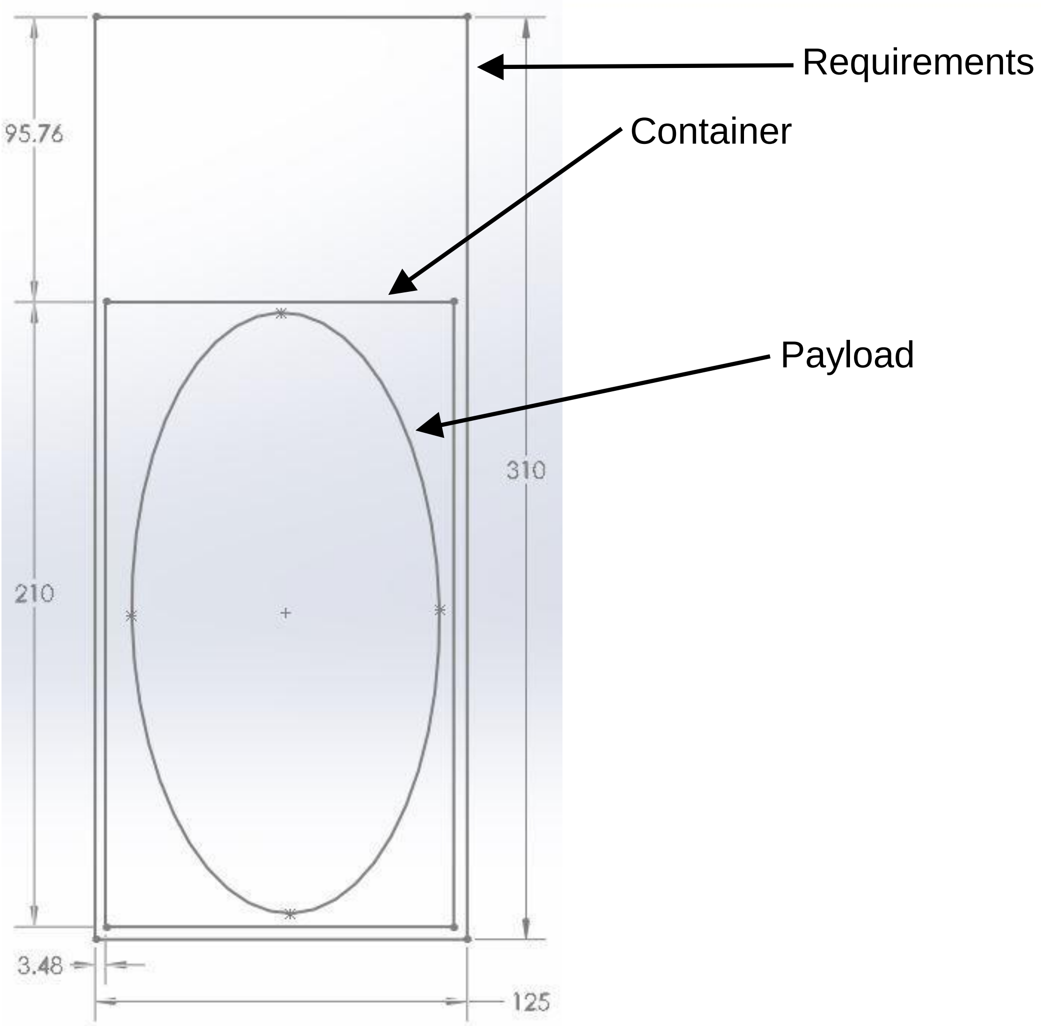


Launch Vehicle Compatibility

- **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 95.76mm vertical clearance.
  - All DCS and Payload components will be entirely confined in Container section before deployment from rocket payload section.
- **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 of CanSat’s deployment from rocket payload section
    - Parachute’s ability to operate after deployment from rocket payload section.

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

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 Trade & Selection

Model	Cost	Power Usage	Weight (Grams)	Accuracy (bits)	Dimensions (mm)
BMP085 Breakout	$19.95	5 µA	2	Pressure – 17 Temp – 16	15 x 15
MPL3115A2 Breakout	$14.95	N/A	2	Pressure – 20 Temp – 12	18 x 16

Selected Altitude/Temperature Sensor – MPL3115A2

-Transmission Rate

-Low Cost

-Accuracy (.3m/.5°C)

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	
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.

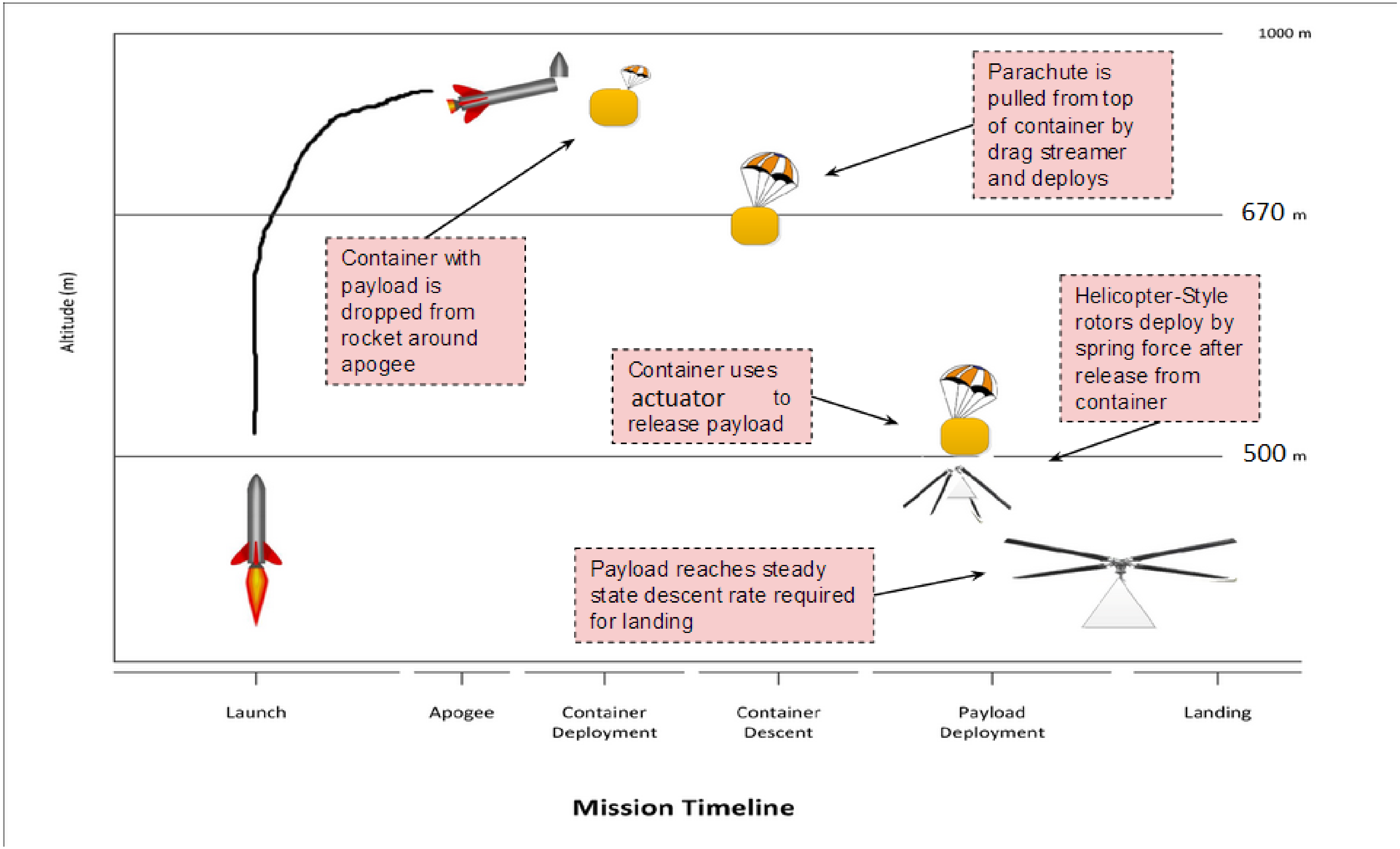
Payload Descent Control Strategy

Method: Autorotation w/ airfoil rotor blades

Components: Airfoil rotors
Spring 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.

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**

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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.

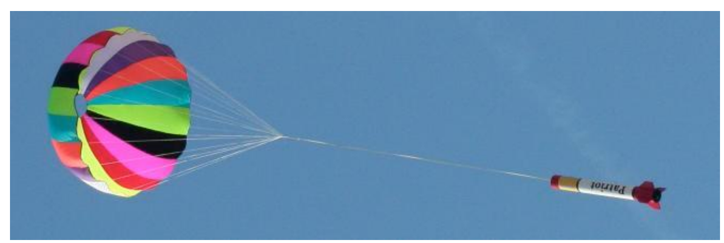


Photo courtesy of: http://spherachutes.com/construction.asp

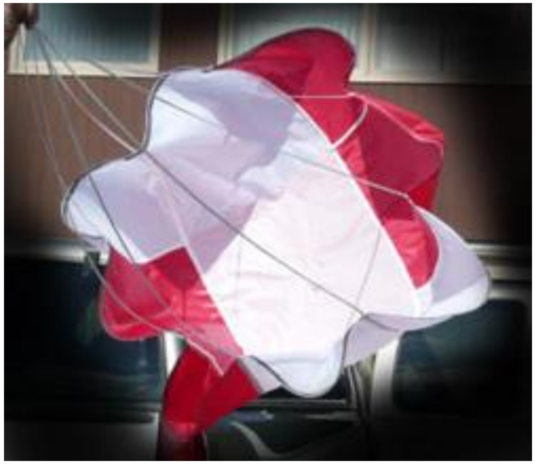
Container Descent Control Parachute Trade Study

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 1.7oz 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.



SDSL Sun Devil Satellite Laboratory

Payload Descent Control Method Trade Study

2014 Texas Annual CanSat Competition

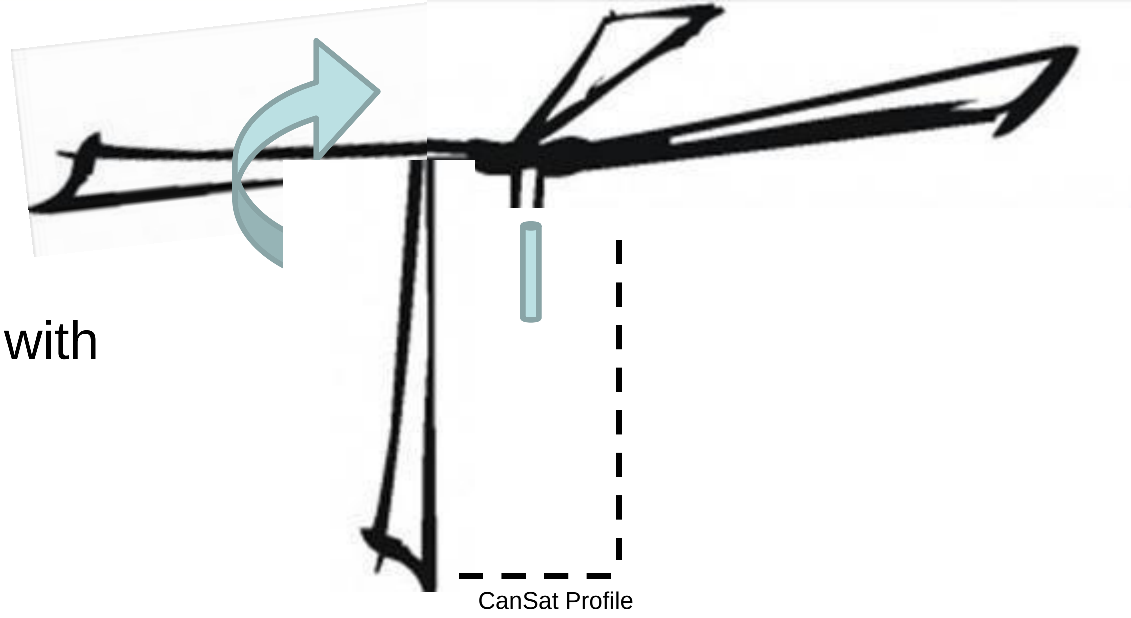
1. Auto-Rotation of Helicopter-Style Airfoil Blades

- **This method was evaluated to have the least design risk according to the evaluation criteria.**
- **Although the principles of passive decent 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



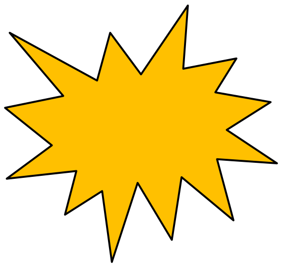
System Components

4x Rotary Airfoil Blades

4x Airfoil Blade Support Beam with hinge

System Color

Orange

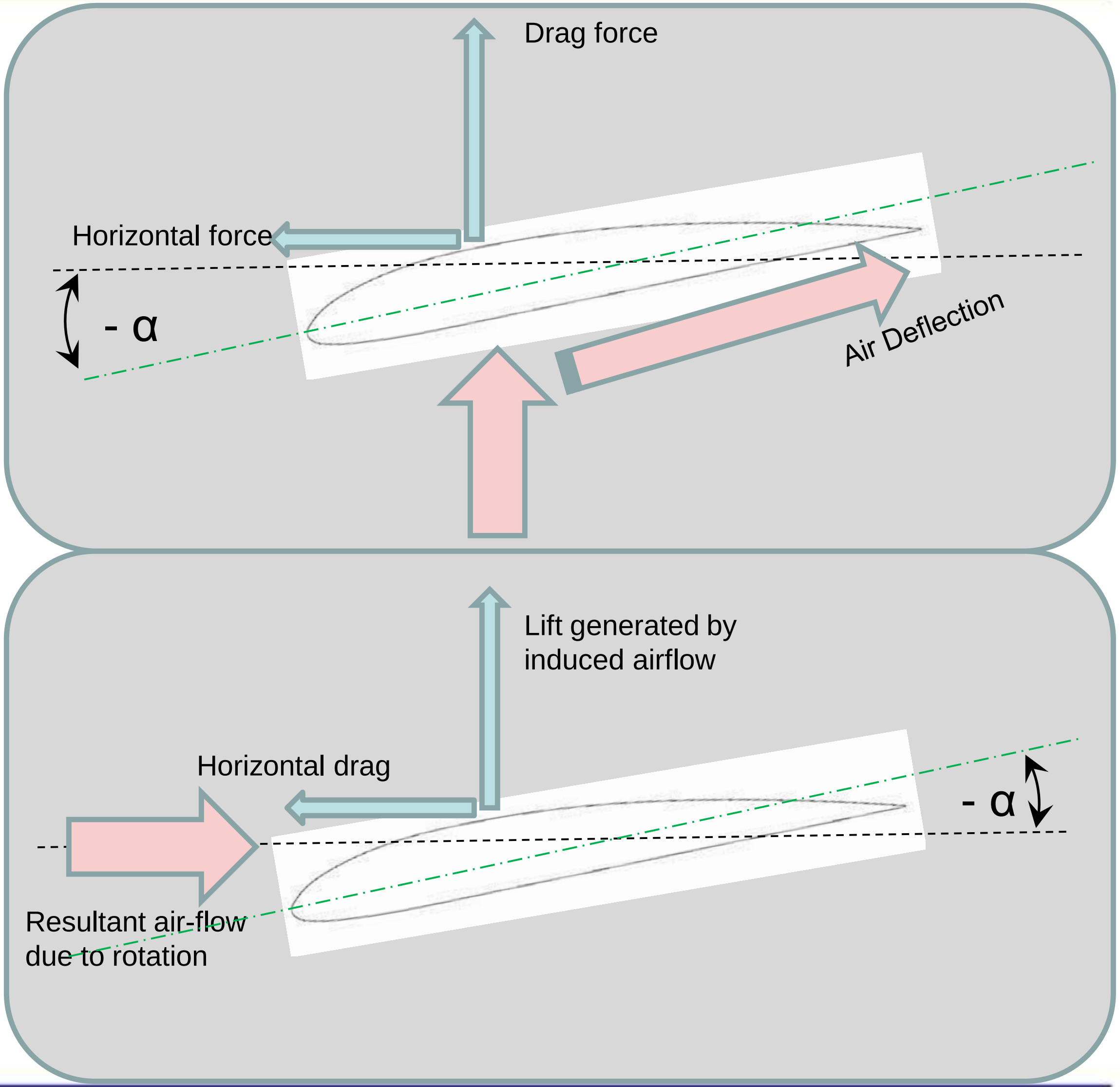


Connections

•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



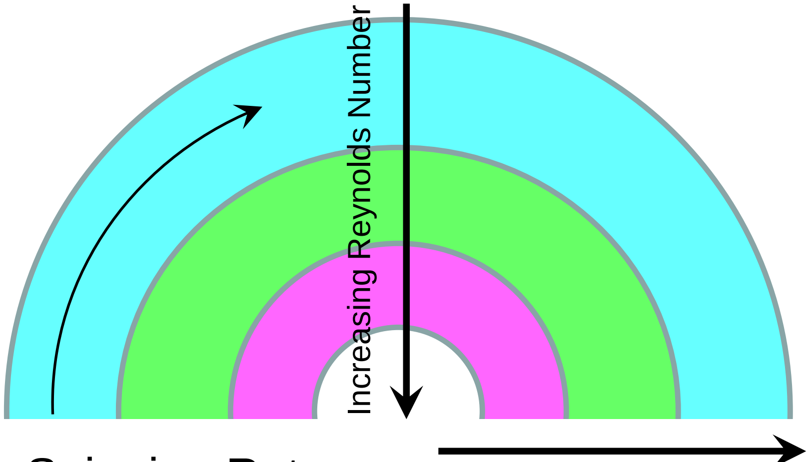
Design Considerations

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.

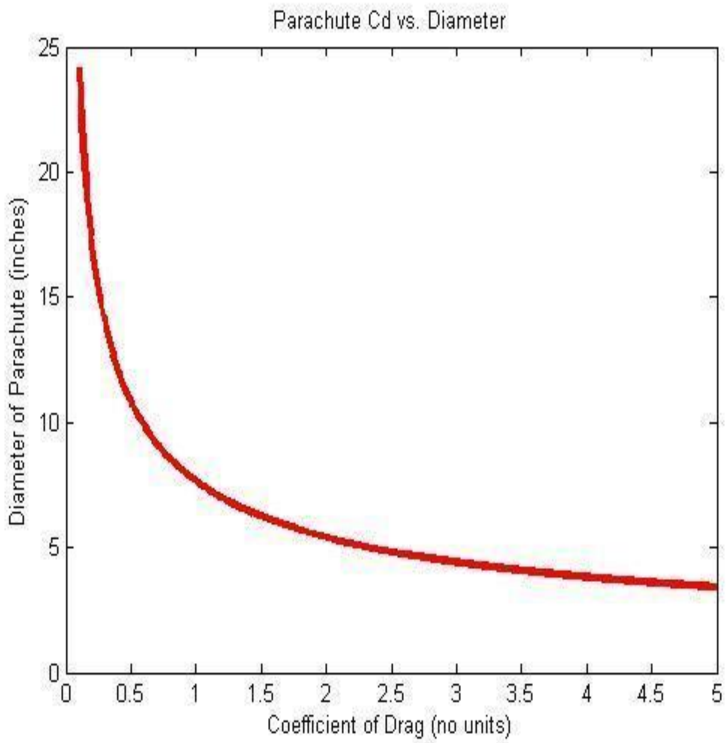
Reynolds Number and Radial Velocity



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**).

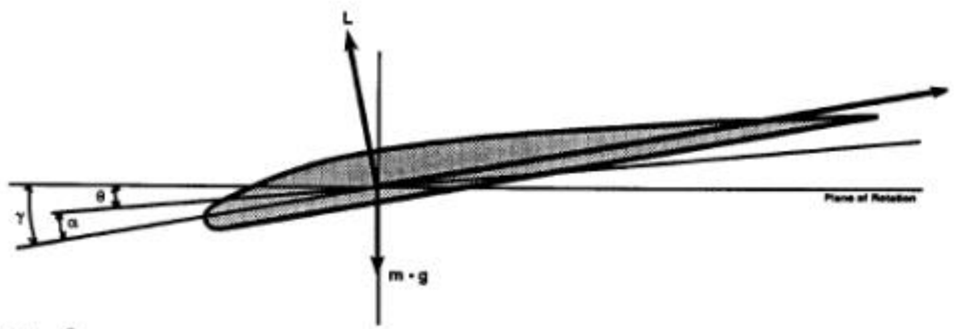


Figure 2

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

$\rho = [1.2, 1.14];$

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

Mechanical Subsystem Overview

Major Structural Elements

- Structure
  - Container consists of cardboard tube and acrylic cap
  - CanSat Payload consists of nylon shell 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 4 blade device will be used to recover the payload.
  - Located in container and released via spring.
- Electronics
  - Electronics placed on bottom of structure to create lower CG.
  - Electronics enclosed by nylon shell and mounted on plastic plates.

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 Trade & Selection

Egg Protection Trade Study				
Product	**Memory Foam**	**Mini Styrofoam Balls**	**Nylon Sling**	**Spray Foam**
Company	THG	Steve Spangler Science	L'eggs	3M
Dimensions	Area: 8" x 8"	2 mm -4mm diameter	Area: 5" x 2"	Volume: 4" h x 5" diameter
Price	$13.99	$6/sq. ft.	$1.75	$16.92
Weight	0.5 lbs.	0.02 lbs	0.01 lbs	1.5 lbs
Pros	Great absorption of weight, flexible	Lightweight, great shock absorption	Effectively reduces contact between egg and container	Full coverage of egg
Cons	Requires ample space	Requires large amount to be effective	Placement in container not ideal	Difficult to install, not fast-acting, heavy

Mechanical Layout of Components Trade & Selection

Mechanical Component Trade Study

Materials	Nylon shell	2L Soda Bottle	Water Gun Tank
Approx Wt.	108g	52g	est. 160g
Dimensions	235 x 81 mm	300 x 100 mm	Unk
Price	$9.99	$2.99	$41.81
Pros	Bomb shaped with fins, durable material, low cost, light	Plenty of space for components, low cost, very light	Thick plastic, space to hold all components, ideal overall shape
Cons	Small size, may pose a problem with fitting all components	Very thin plastic, shock durability in question, may be too large	Expensive, heavy

- **Mechanical layout issues**
  - Egg protection system integration
  - Structure shock requirements
  - Electrical wiring
  - Descent stability
  - Descent control system integration

- **Structural Materials Selection**
  - Egg Protection System will be molded around the egg using foam materials and mounted to the upper cone using a strong adhesive. Foam shall be used primarily for its ability to conform in shape and its light weight.
  - All electronics will be placed underneath the egg, to lower the center of gravity and minimize length of wires.
  - Nylon fins will be added to upper half of payload to stabilize descent. The descent stability fins will mount the descent control system.
  - Nylon/hard plastic will be used to as the body of the payload to meet shock requirements.

Material Selections

- **Container**
  - Hard cardboard shell for weight reduction
  - Plate separating parachute from payload made from acrylic plastic
- **Payload**
  - Structurally by made up of Nylon/plastic
  - Sensors, and other electronics mounted on plastic
  - Circuit board standoffs made of acrylic
  - Mounting done with J-B Weld adhesive epoxy or similar adhesive

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.**

Structure Survivability Trades

- **Electronic Mounting:**
  - Circuit boards will be glued to the payload base, plastic plate and container walls.
  - Payload shell will be used to enclose components
- **Acceleration and Shock Force Requirements:**
  - The structure must survive 15 Gs of acceleration and 30 Gs of shock
    - Plastic plate will be integrated to payload shell thru grooves to distribute forces
    - The JB Epoxy will be able to sustain the electronics through these forces
- **Descent Control Attachments**
  - Autorotative blades will be attached on descent stability fins
  - Mounted springs will expand the blades upon exit from the container

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 Mech.	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 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

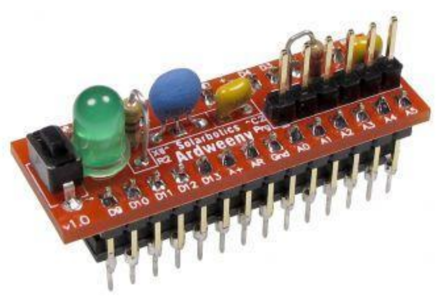
ID	Requirements	Parents	Children	VM			
				A	I	T	D
COMM.1.1	XBEE radios shall be used for telemetry. 2.4 GHz Series 1 and 2 radios are allowed. 900 MHz XBEE Pro radios are also allowed.	None	None	X	X		X
CDH.1.2	The XBEE radios shall have their NETID set to the team number.	None	None	X	X		
CDH.3	The XBEE 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 ground station. 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 Trade & Selection

Processor Model	Cost	Power Usage (V/mA)	Weight (Grams)	Speed (Mhz)	Memory	I/O Pins	Size (mm)
Arduino Fio	$24.95	3.3V / 40 mA/pin	8	8	32 kB	14 Digital/ 8 Analog	66 x 28
Arduino Uno (Ardweeny)	$9.95	3.3V / 40mA/pin	2	16	32 kB	14 Digital/ 6 Analog	35 x 7 x 15
Arduino Pro Mini 328	$18.95	5V / 150mA	2	16	16 kB	14 Digital/ 8 Analog	18 x 33



Selected Microcontroller – Arduino Uno (Ardweeny)
-Extremely Small Form-factor
-Lightweight
-3.3V operating voltage
Disadvantages: XBEE Socket not onboard, no onboard voltage regulator

Clock Trade & Selection

Clock	Cost	Power Usage (V/mA)	Weight (Grams)	Dimensions (mm)
DeadOn DS3234 RTC	$19.95	3.3V / 0.4 mA	2	21 x 21
DS1307 RTC	$14.95	5V / 1.5 mA	2	20 x 20
20 Channel EM-408 SiRF III Receiver (GPS)	$64.95	3.3V / 44 mA	20	35 x 36 x 8

Selected RTC Module – DeadOn DS3234 RTC

-Ease of interfacing

-Low power consumption

-Low input voltage

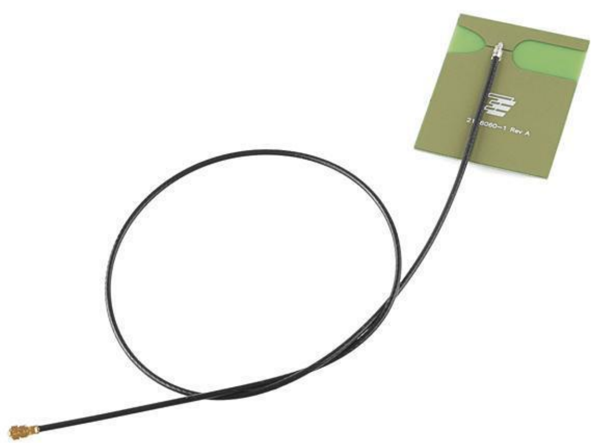
-Tutorials available

-Compatible with Microcontroller

-Lightweight

Antenna Trade & Selection

Model	Cost	Gain	Size	Weight (Grams)	Type	Connector
2.4 GHz Rubber Ducky – Large	$9.95	5 dBi	0.5 x 7.7 in	30	Dipole	RP-SMA
2.4 GHz Adhesive Antenna	$4.95	2 dB	41 x 30 mm	< 3.3	Omni-directional	U.FL



Selected Antenna – U.FL Adhesive Antenna

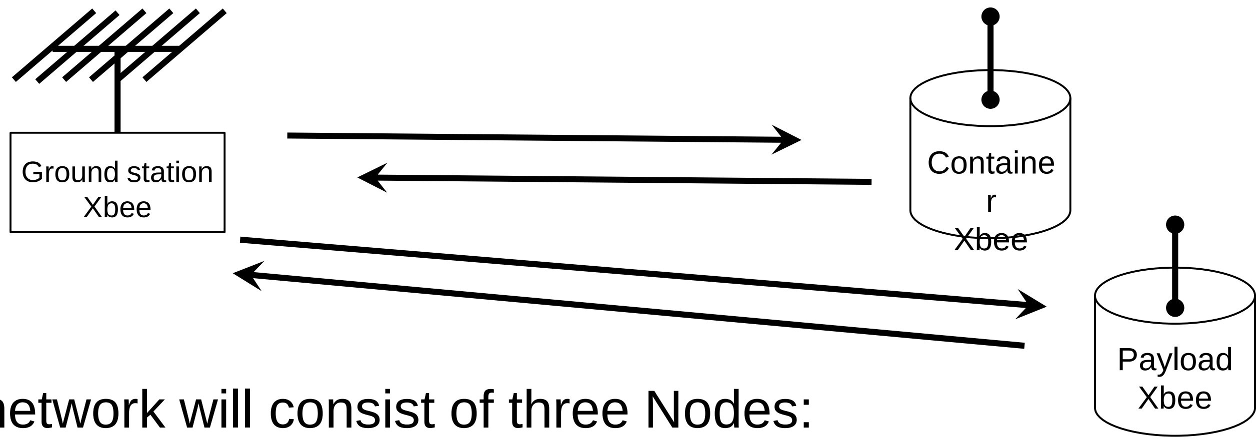
-Small Form-factor

-Lightweight

-XBEE proprietary

Disadvantages: Less 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

SDSL Sun Devil Satellite Laboratory

Telemetry Format

2014 Texas Annual CanSat Competition

- **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 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

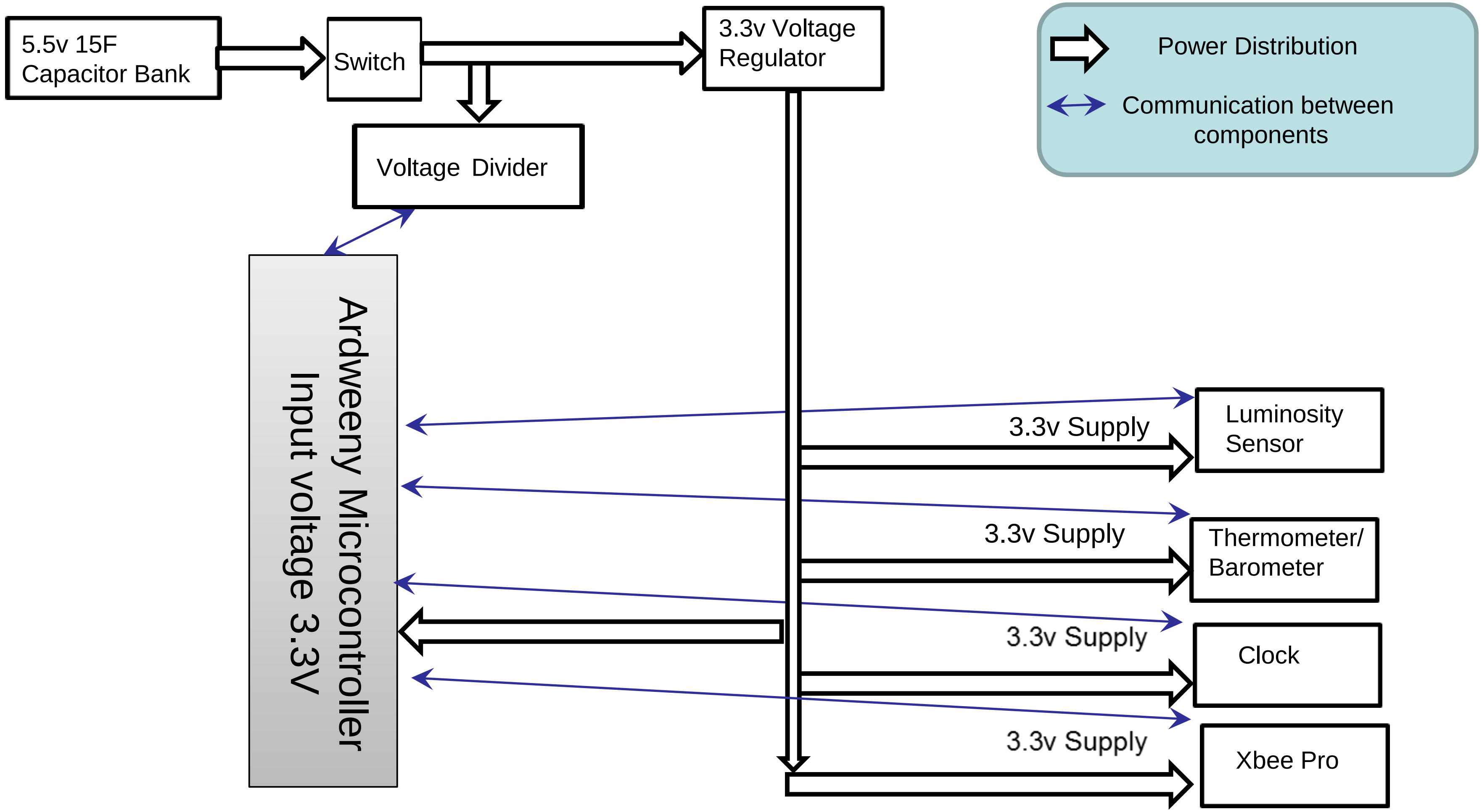
EPS Overview

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.
Voltage Regulator Boards and Supply Pins	3.3V Regulator 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.

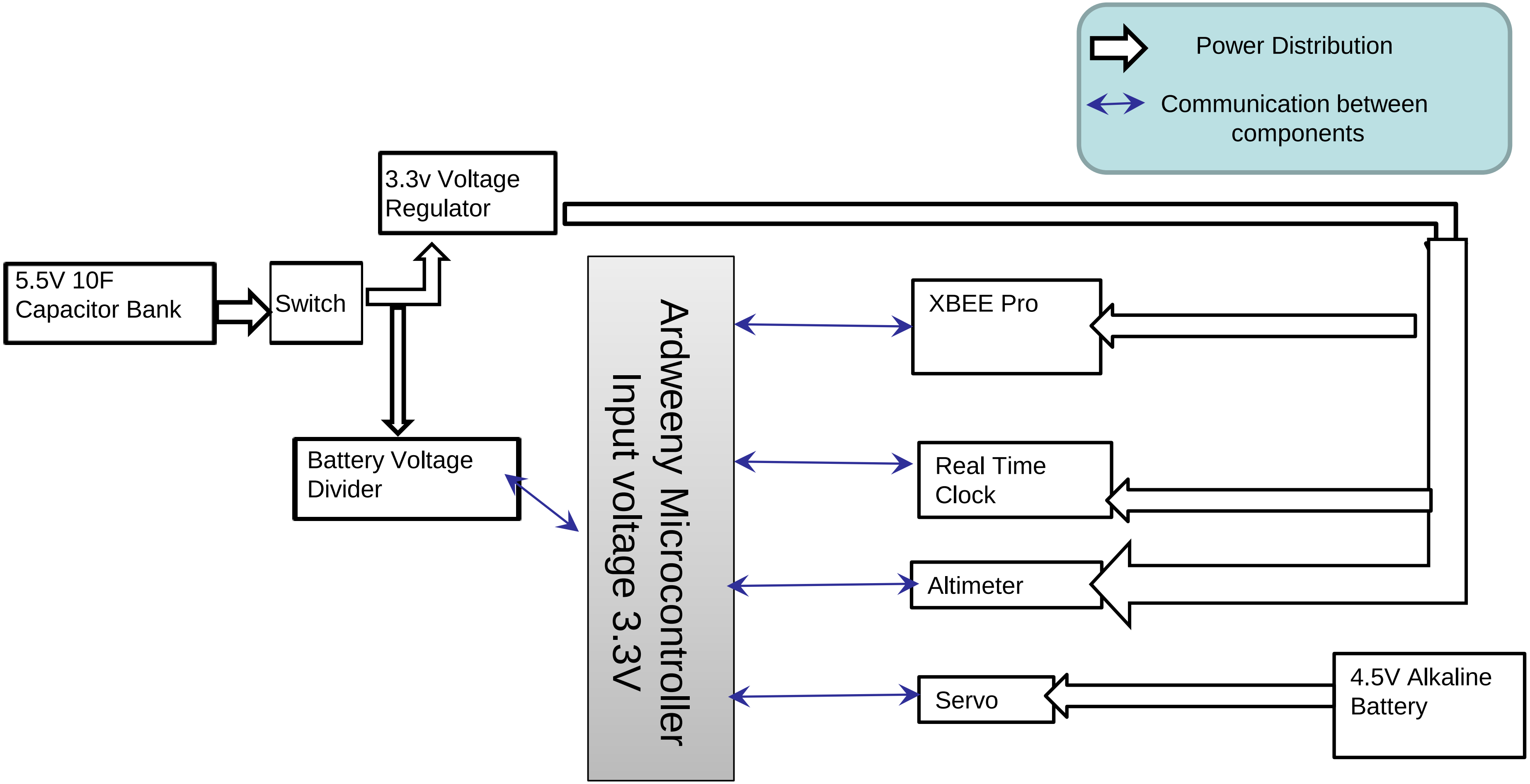
EPS Requirements

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 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
						Total Power [W]	.99	

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
						Total Power [W]	.98	

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 Trade & Selection

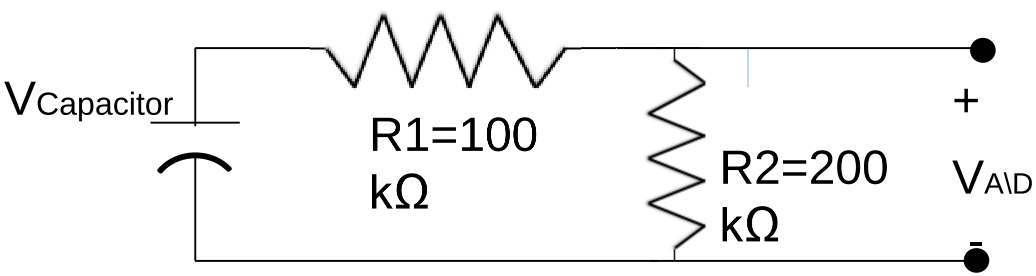
Battery types	Voltage	Nominal Capacity	Mass	Cost
.45W Solar Cell	4.5V	100mA	30g	$15.95
2.5W Solar Cell	8V	310mA	100g	$34.95
5.2W Solar Cell	9.55V	550mAh	230g	$44.95

Decided to use the .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**

Bus Voltage Measurement Trade & Selection

Device	Cost	Weight (g)	Dimensions (mm)
Voltage Divider	$0.08	2	5 x 5
MAX11068 Voltage Monitor		2	9.7 x 4.4
LTC2990 I2C Voltage, Current, and Temperature monitor	$3.21	2	35 x 36 x 8



Voltage Divide chosen for:

- **Inexpensive**
- **Easy to manufacture**
- **Easy to implement**

Flight Software Design

William Merino

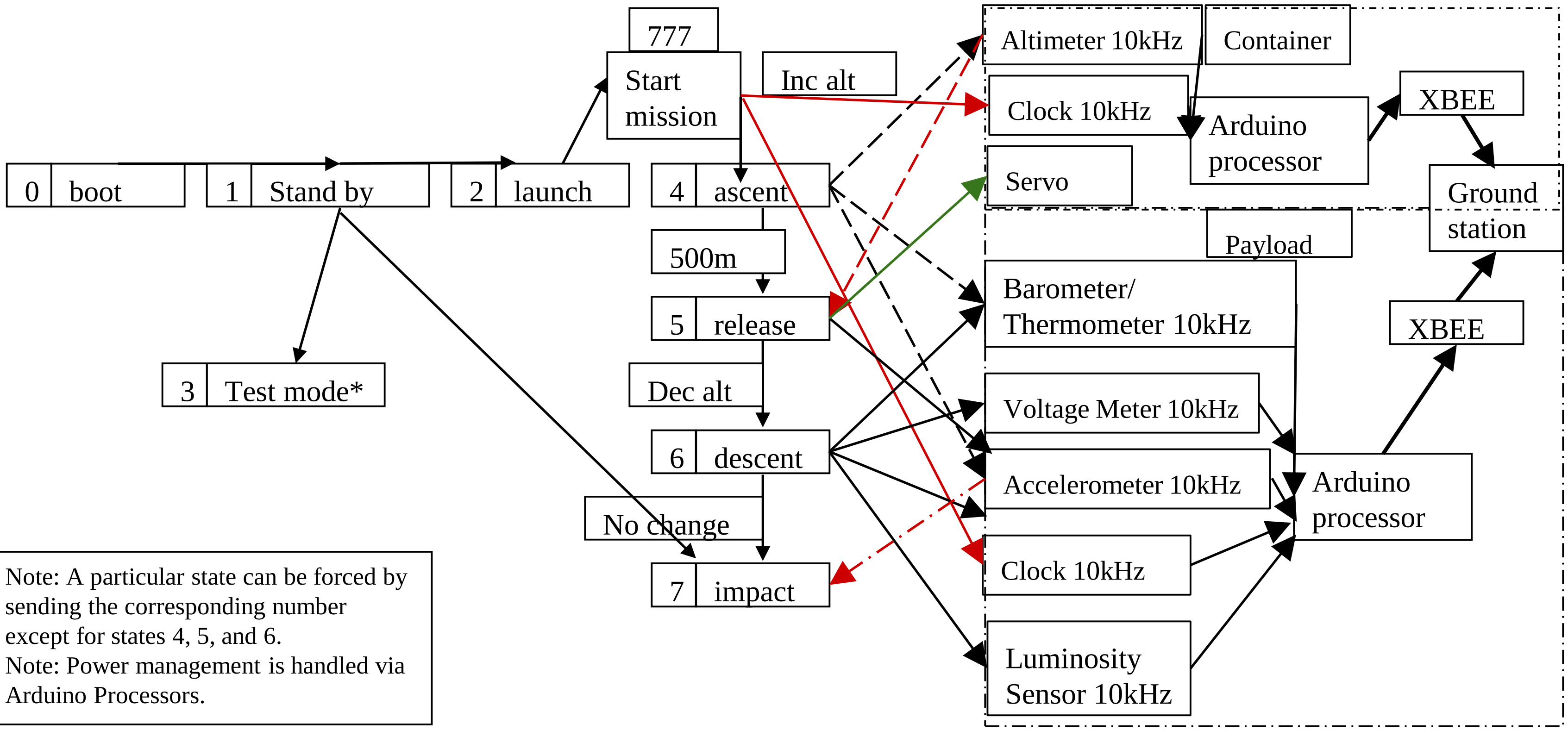
FSW Overview

- **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 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

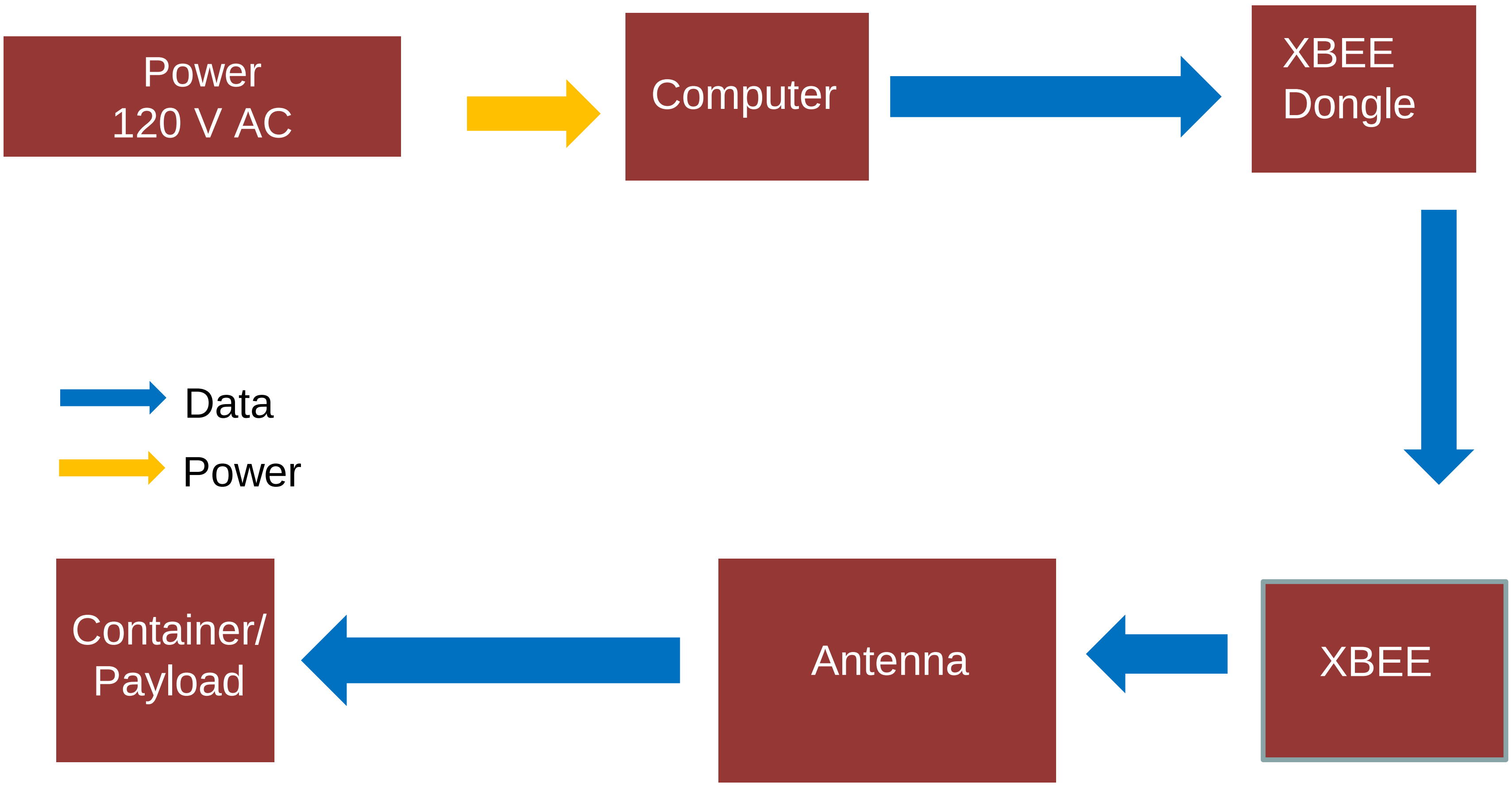
- **Use an Evolutionary Software Development Model**

- 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

Ground Control System Design

Zach Burnham

GCS Overview



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 Trade & Selection

Antenna	Price	Type	Gain
AW 15dBi Yagi 2.4Ghz Wifi Antenna N F	$39.95	Yagi	15 dBi
2.4GHz 15dBi TL-ANT2415d Antenna	$49.24	Omni-Directional	15 dBi
WiFi Antenna, Dipole (Rubber Duck) Indoor High Gain 9dBi	$13.11	Dipole	9 dBi

We chose 2.4GHz 15dBi TL-ANT2415d Antenna due to its:

- high gain
- ability to detect signal in all directions

GCS Software

- **Off the shelf software used**
  - Arduino IDE / Text Editor
  - Using C/C++ and the Arduino language (based on the former)
  - Possibly Excel or Mat Lab
- **Telemetry data written to a struct**
  - Data is extracted from the struct and passed to unique arrays
- **Keep running array, write to file as csv file.**
  - May also produce a distinct file that contains formatted data
  - Each piece of data is a function of time
  - Clocks onboard payload and container will keep track of mission time
- **Produce plots through another portion of the program or separate program by processing the csv file.**
- **Command software and interface**
  - Serial and radio frequency interfaced
  - Communication supplied by putty or hyperterminal

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
  - 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
    - Thermometer shall be tested alongside a trusted temperature measurement device for comparison verification of accuracy
  - 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
  - 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

CanSat Integration and Test Overview

- **Descent Control**
  - 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.
  - 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)
  - Tests will be completed by a freefall from a height of ~100 ft
- **Mechanical Subsystem**
  - 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 Uno 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
- **Data Handling/Flight Software**
  - Arduino Uno will be tested with each of the sensors to verify they can perform all needed telemetry requirements
  - Flight Software will be 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

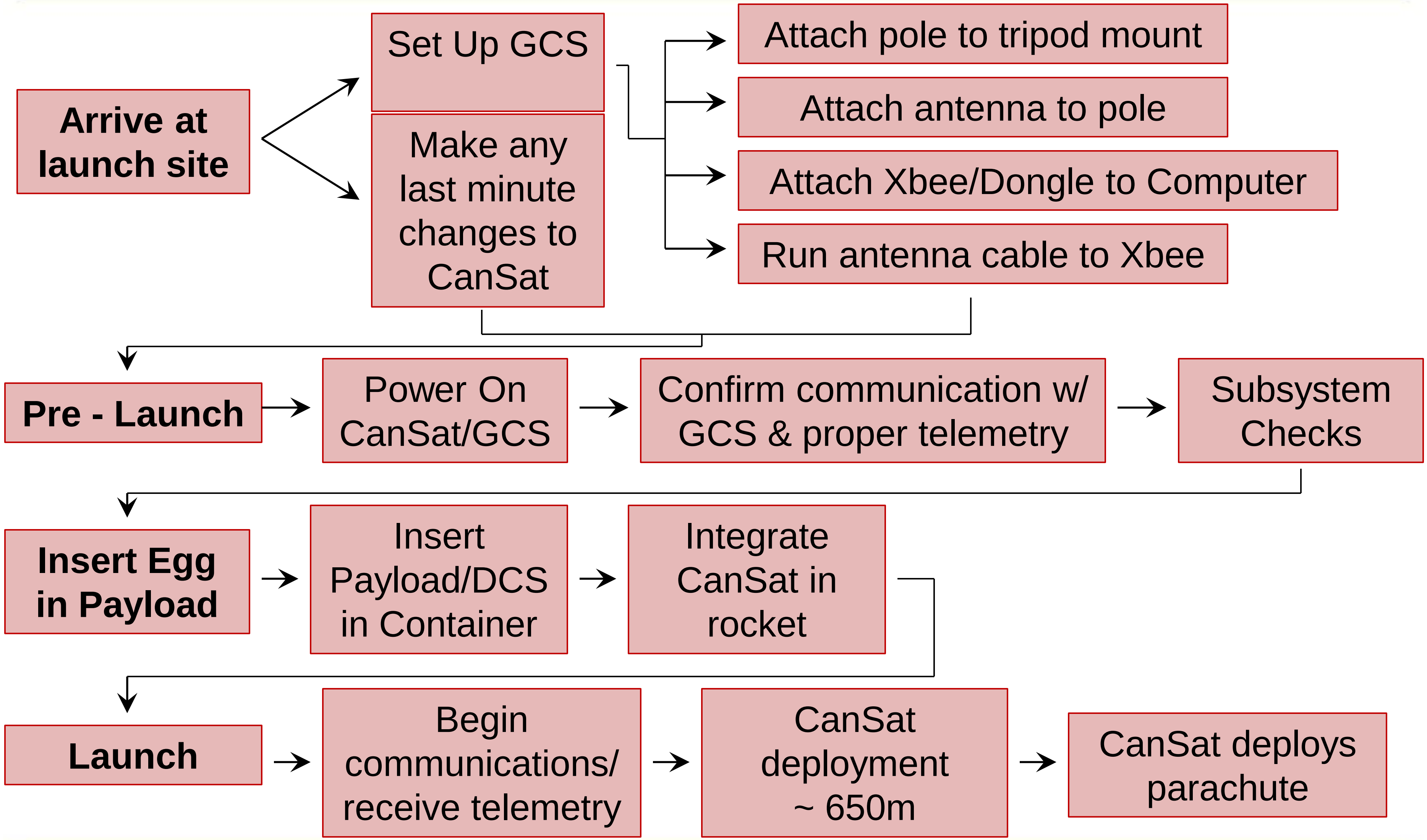
CanSat Integration and Test Overview

- **System Level Tests (CanSat is fully integrated)**
  - 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

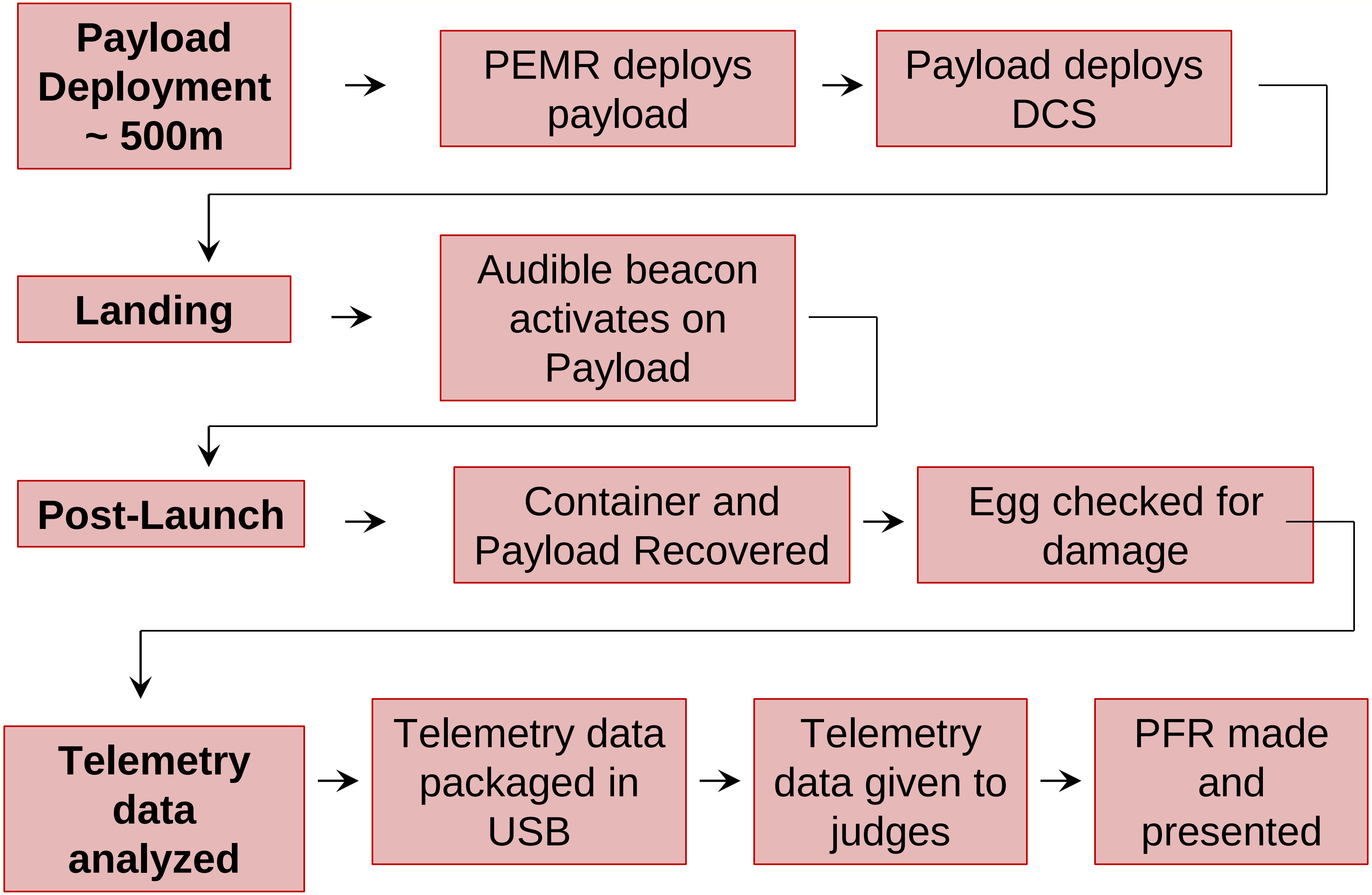
Mission Operations & Analysis

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
- **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 #).

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 the CanSat (container and payload) shall be 600 grams +/- 10 grams without the egg.	Comply	48	
2	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.	Comply	41	
3	The payload shall be completely contained in the container. No part of the payload may extend beyond the container.	Comply	13-14	
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.	Comply	13-14	
5	The container shall use a passive descent control system. It cannot free fall.	Comply	23	
6	The container shall not have any sharp edges to cause it to get stuck in the rocket fairing section.	Comply	13-14	
7	The container shall be a florescent color, pink or orange.	Comply	23	

Requirements Compliance

Rqmt Num	Requirement	Comply / No Comply / Partial	X-Ref Slide(s) Demonstrating Compliance	Team comments and notes
8	The rocket airframe shall not be used to restrain any deployable parts of the CanSat.	Comply	13-14	
9	The rocket airframe shall not be used as part of the CanSat operations.	Comply	13-14	
10	The CanSat (container and payload) shall deploy from the rocket fairing section.	Comply	8-10	
11	The descent control systems shall not use any flammable or pyrotechnic devices.	Comply	23	
12	The descent rate of the CanSat shall be 12 m/s above 500 meters.	Comply	23	
13	When the CanSat reaches 500 meters, the payload shall be released from the container.	Comply	10	
14	When released, the payload shall have a descent rate of less than 10 m/s.	Comply	23	
15	All descent control device attachments shall survive 30 Gs of shock.	Comply	13-14	
16	All descent control devices shall survive 30 Gs of shock.	Comply	23	

Requirements Compliance

Rqmt Num	Requirement	Comply / No Comply / Partial	X-Ref Slide(s) Demonstrating Compliance	Team comments and notes
17	All electronic components shall be enclosed and shielded from the environment with the exception of sensors.	Comply	13-14	
18	All structures shall be built to survive 15 Gs acceleration.	Comply	13-14	
19	All structures shall be built to survive 30 Gs of shock.	Comply	13-14	
20	All electronics shall be hard mounted using proper mounts such as standoffs, screws, or high performance adhesives.	Comply	13-14	
21	All mechanisms shall be capable of maintaining their configuration or states under all forces.	Comply	13-14	
22	Mechanisms shall not use pyrotechnics or chemicals.	Comply	51	
23	Mechanisms that use heat (e.g., nichrome wire) shall not be exposed to the outside environment to reduce potential risk of setting vegetation on fire.	Comply	13-14	
24	No batteries shall be allowed in the payload. Batteries are allowed only in the container to support releasing the payload.	Comply	51	
25	The container shall only use alkaline type batteries.	Comply	51	

Requirements Compliance

Rqmt Num	Requirement	Comply / No Comply / Partial	X-Ref Slide(s) Demonstrating Compliance	Team comments and notes
26	The container shall collect and store altitude data at a 1 Hz rate from launch to the moment of landing.	Comply	54	
27	The container shall transmit its altitude data at a 1 Hz rate during from	Comply	54	
28	The payload shall harvest energy from the environment during descent.	Comply	68	
29	During descent, the payload shall collect air pressure, air temperature and power source voltage once per second.	Comply	54	
30	During descent, the payload shall transmit all telemetry. The number of telemetry data transmitted shall be scored. The payload shall not generate telemetry at greater than 1 Hz rate.	Comply	54	
31	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.	Comply	54	
32	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	41	
33	XBEE radios shall have their NETID/PANID set to their team number.	Comply	41	

Requirements Compliance

Rqmt Num	Requirement	Comply / No Comply / Partial	X-Ref Slide(s) Demonstrating Compliance	Team comments and notes
34	XBEE radios shall not use broadcast mode. Both the container radio and payload radio shall use the same NETID/PANID.	Comply	41	
35	Teams are allowed to determine how to coordinate communications between the container, payload and ground station.	Comply	41	
36	The payload shall include an external umbilical power connection to allow for testing and safety checks when not harvesting energy.	Comply	41	
37	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.	Comply	41	
38	Cost of the CanSat shall be under $1000. Ground support and analysis	Comply	101-102	
39	Each team shall develop their own ground station.	Comply	14-17	
40	All telemetry shall be displayed in real time during descent.	Comply	24-39	
41	All telemetry shall be displayed in engineering units (meters, meters/sec, Celsius, etc.)	Comply	15	
42	Teams shall plot data in real time during flight.	Comply	29	
43	The ground station shall include an antenna mast of 3.5 meters height, which is to be measured from the ground to the tip of the antenna structure.	Comply	50	

Requirements Compliance

Rqmt Num	Requirement	Comply / No Comply / Partial	X-Ref Slide(s) Demonstrating Compliance	Team comments and notes
44	The ground station mast shall be free standing. The antenna mast cannot be attached to provided tent or other structures.	Comply	57	
45	The ground station mast shall be properly secured as to not fall over under any conditions with surface winds up to 30 mph.	Comply	41	
46	If guy wires are used to support the ground station antenna mast, the guy	Comply	41	
47	Both the container and payload shall be labeled with team contact information including email address.	Comply	90	
48	The flight software shall maintain a count of packets transmitted, which shall increment with each packet transmission throughout the mission. The value shall be maintained through processor resets.	Comply	58	
49	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 time may be maintained by software or by hardware real-time clock. If a power loss or processor reset. The 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.	Comply	15	

Management

Ricky Astrain

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

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	

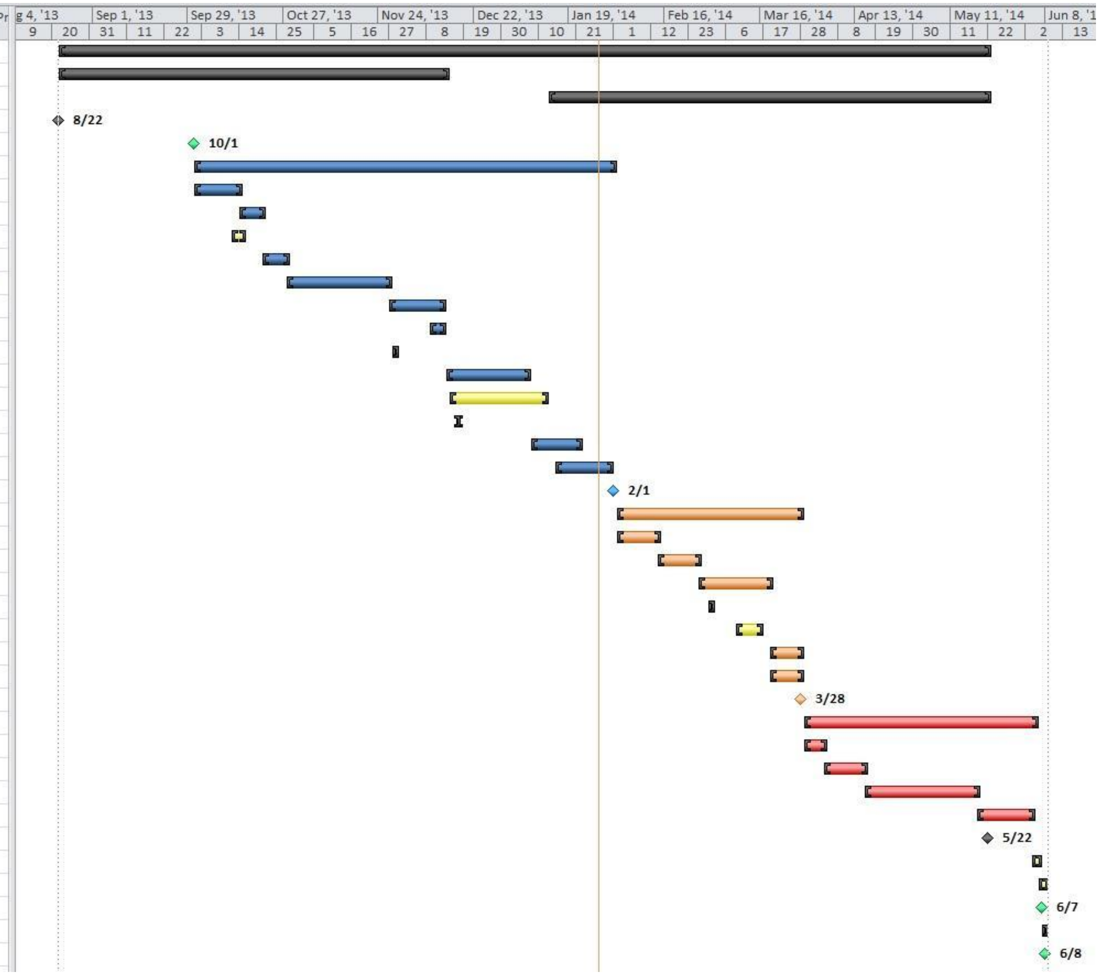
Description	Price (USD)	Verification
Vehicle for Transportation	400.00	Estimate*
Gas	350.00	Estimate*
Hotel	1000.00	Estimate*
Food	450.00	Estimate*
Travel Expenses Total	2200.00	
* assumes 7 members attending competition		

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/Subsytem 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



Conclusions

- **Major Accomplishments**
  - All subsystems have completed detailed design and have been evaluated.
    - Subsystems ready to begin purchasing/testing/building phases
  - All components are ready for purchase following PDR evaluation. All needed components have been selected
  - Egg protection has been successfully tested
- **Major Unfinished Work**
  - FSW is still to be completed.
  - Configuration design awaits component purchase for feasibility
  - Payload DCS system must finish detailed design/test.
- **Proceedings**
  - We are ready to proceed to the build phase and programming phase of our project
    - All designs are completed
    - All part purchases are made