CanSat 2014 CDR

Team #: 1261
Sparky Sat
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Team Organization

Iman Alizadeh
Faculty Advisor

Heather Zunino
Graduate Student
Team Lead

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

Presenter: Heather Zunino
CanSat 2014 CDR: Team #: 1261 (Sparky Sat)
### 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.**
<table>
<thead>
<tr>
<th>ID</th>
<th>Requirements</th>
<th>Parents</th>
<th>Children</th>
<th>VM</th>
</tr>
</thead>
<tbody>
<tr>
<td>SYS.1</td>
<td>Total mass of CanSat, container, and all descent control devices shall be 600 grams. Mass shall not vary more than +/-10 grams.</td>
<td>None</td>
<td>SMS.1-3</td>
<td>X  X</td>
</tr>
<tr>
<td>SYS.2</td>
<td>The cost of the CanSat flight hardware shall be under $1000 (USD). Ground support and analysis tools are excluded.</td>
<td>None</td>
<td>SMS.1-3</td>
<td>X  X</td>
</tr>
<tr>
<td>SYS.3</td>
<td>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.</td>
<td>None</td>
<td>SMS.1-3</td>
<td>X  X</td>
</tr>
<tr>
<td>SYS.4</td>
<td>Team number, email address and a phone number must be placed on the structure to aid in recovery.</td>
<td>None</td>
<td>None</td>
<td>X</td>
</tr>
</tbody>
</table>
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

- Rotor Blades
- Egg Protection
- Electronics

*Units in mm
Physical Layout

- Units in mm

Presenter: Ryan Teves
• **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

Requirements

Container

Payload
Sensor Subsystem Design

Zach Burnham
<table>
<thead>
<tr>
<th>Sensor Type</th>
<th>Model</th>
<th>Purpose</th>
</tr>
</thead>
<tbody>
<tr>
<td>Clock*</td>
<td>DeadOn RTC</td>
<td>Maintain mission time on CanSat</td>
</tr>
<tr>
<td>Barometric Altitude/Pressure</td>
<td>MPL3115A2</td>
<td>Measure the Altitude of the CanSat during descent</td>
</tr>
<tr>
<td>Sensor*</td>
<td></td>
<td>(same as payload)</td>
</tr>
<tr>
<td>Temperature Sensor*</td>
<td>MPL3115A2</td>
<td>Record air temperature of the CanSat during descent</td>
</tr>
<tr>
<td>(same as payload)</td>
<td></td>
<td>(same as payload)</td>
</tr>
<tr>
<td>Luminosity Sensor</td>
<td>TSL2561</td>
<td>Record light levels on the CanSat for the bonus</td>
</tr>
<tr>
<td></td>
<td></td>
<td>requirement</td>
</tr>
</tbody>
</table>

* Same sensors for both payload and container.
Sensor Subsystem Changes Since PDR

- No major changes were made to the sensor subsystems since the PDR.
<table>
<thead>
<tr>
<th>ID</th>
<th>Requirements</th>
<th>Parents</th>
<th>Children</th>
<th>VM</th>
</tr>
</thead>
<tbody>
<tr>
<td>CDH.1.1</td>
<td>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.</td>
<td>CDH.2.2</td>
<td>None</td>
<td></td>
</tr>
<tr>
<td>CDH.1.2</td>
<td>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.</td>
<td>None</td>
<td>None</td>
<td></td>
</tr>
</tbody>
</table>
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)

Presenter: Zach Burnham
## Light Sensor Trade & Selection

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

**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
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.
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

Container with payload is dropped from rocket around apogee

Container uses actuator to release payload

Parachute is pulled from top of container by drag streamer and deploys

Payload reaches steady state descent rate required for landing

Helicopter-Style rotors deploy by spring force after release from container

Mission Timeline

Presenter: Justin Walker
### Descent Control Requirements

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

Presenter: Justin Walker

CanSat 2014 CDR: Team #: 1384 (Sun Devil Satellite Lab)
## 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

<table>
<thead>
<tr>
<th>Descent Control Strategy</th>
<th>Design Difficulty</th>
<th>Cost to Manufacture</th>
<th>System Mass/Volume</th>
<th>Mechanical Complexity</th>
<th>Confidence Level</th>
<th>SCORE</th>
</tr>
</thead>
<tbody>
<tr>
<td>Parachute</td>
<td>2</td>
<td>3</td>
<td>1</td>
<td>1</td>
<td>2</td>
<td>1.8</td>
</tr>
<tr>
<td>Streamers</td>
<td>4</td>
<td>4</td>
<td>2</td>
<td>4</td>
<td>5</td>
<td>3.8</td>
</tr>
<tr>
<td>Rigid Braking Structure</td>
<td>5</td>
<td>6</td>
<td>7</td>
<td>5</td>
<td>4</td>
<td>5.4</td>
</tr>
</tbody>
</table>

Presenter: Justin Walker
CanSat 2014 CDR: Team #: 1261 (Sparky Sat)
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
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.
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

<table>
<thead>
<tr>
<th>Descent Control Strategy</th>
<th>Design Difficulty</th>
<th>Cost</th>
<th>Mass &amp; Volume</th>
<th>Mechanical Complexity</th>
<th>Confidence</th>
<th>SCORE</th>
</tr>
</thead>
<tbody>
<tr>
<td>Auto-Rotation of Rotary Airfoil Blades (Aerodynamic Lift/Drag)</td>
<td>7</td>
<td>5</td>
<td>4</td>
<td>6</td>
<td>3</td>
<td>5.0</td>
</tr>
<tr>
<td>Inflatable Airbag (Energy Absorption)</td>
<td>6</td>
<td>2</td>
<td>8</td>
<td>5</td>
<td>6</td>
<td>5.4</td>
</tr>
<tr>
<td>Savonius Wind Turbine (Stable Flight at Low Descent Rate)</td>
<td>10</td>
<td>7</td>
<td>9</td>
<td>10</td>
<td>7</td>
<td>8.6</td>
</tr>
</tbody>
</table>

**Evaluation Criteria**

- **Desireable (1)**
- **Undesireable (10)**
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
Payload Descent Control Strategy

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 descent 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 (-\(\alpha\)) 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.

---

Presenter: Justin Walker  
CanSat 2014 CDR: Team #: 1261 (Sparky Sat)
Payload Descent Control System

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).
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.
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).
The Design Descent Rate estimate is 10 m/s, \( \text{RD} = 10 \text{ (m/s)} \); 

The Weight is also known as approximately \( W = .67 \text{ (kg)} \); 

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.
The angle $\gamma$, which the angle-of-attack plus the angle-of-twist can be found from the equation:

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

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

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 ($\omega$) that you want your model to spin at. A good estimate to start at is 3 revolutions per second or $6\pi$ rad/sec (where $\pi$ has a value of 3.14). From this point you calculate $\theta$ 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

<table>
<thead>
<tr>
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<td>None</td>
<td>None</td>
<td>X</td>
</tr>
<tr>
<td>SMS.1.1</td>
<td>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.</td>
<td>SYS.3, SYS.4</td>
<td>None</td>
<td>X</td>
</tr>
<tr>
<td>SMS.1.5</td>
<td>The payload shall be completely contained in the container. No part of the payload may extend beyond the container.</td>
<td>None</td>
<td>None</td>
<td>X</td>
</tr>
<tr>
<td>SYS.3</td>
<td>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.</td>
<td>None</td>
<td>None</td>
<td>X</td>
</tr>
<tr>
<td>SMS.1.3</td>
<td>The container shall not have any sharp edges to cause it to get stuck in the rocket fairing section.</td>
<td>None</td>
<td>None</td>
<td>X</td>
</tr>
<tr>
<td>SMS.1.4</td>
<td>The container shall be a fluorescent color, pink or orange.</td>
<td>SYS.4</td>
<td>None</td>
<td>X</td>
</tr>
<tr>
<td>SMS.2.5</td>
<td>All descent control device attachments shall survive 30 Gs of shock.</td>
<td>None</td>
<td>None</td>
<td>X</td>
</tr>
<tr>
<td>SMS.2.6</td>
<td>All descent control devices shall survive 30 Gs of shock.</td>
<td>None</td>
<td>None</td>
<td>X</td>
</tr>
<tr>
<td>SMS.3.1</td>
<td>All electronic components shall be enclosed and shielded from the environment with the exception of sensors.</td>
<td>None</td>
<td>CDH 1.1, EPS1.1, EPS1.3</td>
<td>X</td>
</tr>
<tr>
<td>SMS.3.2</td>
<td>All structures shall be built to survive 15 Gs acceleration.</td>
<td>None</td>
<td>None</td>
<td>X</td>
</tr>
<tr>
<td>SMS.3.3</td>
<td>All structures shall be built to survive 30 Gs of shock.</td>
<td>None</td>
<td>None</td>
<td>X</td>
</tr>
<tr>
<td>SMS.4.1</td>
<td>All mechanisms shall be capable of maintaining their configuration or states under all forces.</td>
<td>None</td>
<td>None</td>
<td>X</td>
</tr>
<tr>
<td>SMS.4.2</td>
<td>Mechanisms shall not use pyrotechnics or chemicals.</td>
<td>None</td>
<td>None</td>
<td>X</td>
</tr>
<tr>
<td>SMS.4.3</td>
<td>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.</td>
<td>None</td>
<td>None</td>
<td>X</td>
</tr>
</tbody>
</table>
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.

Presenter: Sarah Smallwood

CanSat 2014 CDR: Team #: 1261 (Sparky Sat)
Mechanical Layout of Components

*Units in mm

Aero-Braking Structure

Egg Protection

Top View of Electronic Plates
82 mm diameter

Plate 2

Egg

CanSat 2014 CDR: Team #: 1261 (Sparky Sat)

Presenter: Ryan Teves
Mechanical Layout of Components

Electronics for Plate 1
*Plastic Mounting Plate not shown

Perf Board

Capacitors

DC-DC Booster
Mechanical Layout of Components

Electronics for Plate 2
*Plastic Mounting Plate not shown

- XBee
- Altitude/Pressure/Temperature Sensors
- Real Time Clock
- Ardweeny

CanSat 2014 CDR: Team #: 1261 (Sparky Sat)
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.
- 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.
*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

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

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

<table>
<thead>
<tr>
<th>ID</th>
<th>Requirements</th>
<th>Parents</th>
<th>Children</th>
<th>VM</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
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<td>A</td>
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<td>T</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>D</td>
</tr>
<tr>
<td>CDH.1.4</td>
<td>The container shall collect and store altitude data at a 1 Hz rate from launch to the moment of landing.</td>
<td>None</td>
<td>None</td>
<td>X</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>X</td>
</tr>
<tr>
<td>CDH.1.5</td>
<td>The container shall transmit its altitude data at a 1 Hz rate during from launch time to landing.</td>
<td>None</td>
<td>None</td>
<td>X</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>X</td>
</tr>
<tr>
<td>CDH.2.1</td>
<td>During descent, the payload shall collect air pressure, air temperature and power source voltage once per second.</td>
<td>None</td>
<td>None</td>
<td>X</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>X</td>
</tr>
<tr>
<td>CDH.2.2</td>
<td>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.</td>
<td>None</td>
<td>None</td>
<td>X</td>
</tr>
</tbody>
</table>
## COMM Requirements

<table>
<thead>
<tr>
<th>ID</th>
<th>Requirements</th>
<th>Parents</th>
<th>Children</th>
<th>VM</th>
</tr>
</thead>
<tbody>
<tr>
<td>COMM.1.1</td>
<td>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.</td>
<td>None</td>
<td>None</td>
<td>X</td>
</tr>
<tr>
<td>CDH.1.2</td>
<td>The XBEE radios shall have their NETID set to the team number.</td>
<td>None</td>
<td>None</td>
<td>X</td>
</tr>
<tr>
<td>CDH.3</td>
<td>The XBEE radio shall not use the broadcast mode.</td>
<td>None</td>
<td>None</td>
<td>X</td>
</tr>
<tr>
<td>CDH.4</td>
<td>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.</td>
<td>None</td>
<td>None</td>
<td></td>
</tr>
<tr>
<td>CDH.5</td>
<td>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.</td>
<td>FSW.2</td>
<td>None</td>
<td>X</td>
</tr>
<tr>
<td>CDH.6</td>
<td>The XBEE radio can operate in any mode as long as it does not interfere with other XBEE radios</td>
<td>None</td>
<td>None</td>
<td>X</td>
</tr>
</tbody>
</table>
## CDH Requirements

<table>
<thead>
<tr>
<th>ID</th>
<th>Requirements</th>
<th>Parents</th>
<th>Children</th>
<th>VM</th>
</tr>
</thead>
<tbody>
<tr>
<td>CDH.7</td>
<td>The CanSat shall have an external power control such as a power switch and some indication of being turned on or off.</td>
<td>None</td>
<td>None</td>
<td>X</td>
</tr>
<tr>
<td>CDH.8</td>
<td>The CanSat shall have battery capacity to support up to a one hour wait on the launch pad plus time for flight operations</td>
<td>None</td>
<td>None</td>
<td>X</td>
</tr>
<tr>
<td>CDH.9</td>
<td>The CanSat shall not utilize lithium polymer batteries.</td>
<td>None</td>
<td>None</td>
<td>X</td>
</tr>
<tr>
<td>CDH.10</td>
<td>The flight software shall maintain and telemeter an indicator of the cansat flight software state.</td>
<td>None</td>
<td>None</td>
<td>X</td>
</tr>
<tr>
<td>CDH.11</td>
<td>In the event of a processor reset during the mission, the flight software shall be able to determine the correct state</td>
<td>None</td>
<td>FSW.1</td>
<td>X</td>
</tr>
</tbody>
</table>
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
Selected RTC Module – DeadOn DS3234 RTC
- Hardware Clock
- Will not reset in the event of a power failure
Selected Antenna – U.FL Adhesive Antenna

- Small Form-factor
- Lightweight (3g)
- XBEE proprietary

Disadvantages: Low gain
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>]```
• 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
### Electrical Power System Components

<table>
<thead>
<tr>
<th></th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Power Supply</strong></td>
<td>Solar Panels will supply power to capacitors which will fulfill power</td>
</tr>
<tr>
<td></td>
<td>requirements needed by all subsystem electrical components.</td>
</tr>
<tr>
<td><strong>DC-DC Booster</strong></td>
<td>DC-DC Booster will regulate power supply and provide electrical</td>
</tr>
<tr>
<td></td>
<td>components with required operating voltages and currents.</td>
</tr>
<tr>
<td><strong>Battery Voltage Measurement</strong></td>
<td>Ardweeny’s voltage measuring capability, in combination with a Voltage</td>
</tr>
<tr>
<td></td>
<td>Divider Circuit used to scale down Voltage input to ADC pins, will</td>
</tr>
<tr>
<td></td>
<td>transmit voltage levels at a rate of 10,000 times/second.</td>
</tr>
<tr>
<td><strong>Power Control</strong></td>
<td>External power switch to control power from capacitors/generators to</td>
</tr>
<tr>
<td></td>
<td>electrical components.</td>
</tr>
</tbody>
</table>
EPS Changes Since PDR

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

<table>
<thead>
<tr>
<th>ID</th>
<th>Requirements</th>
<th>Parents</th>
<th>Children</th>
<th>VM</th>
</tr>
</thead>
<tbody>
<tr>
<td>EPS.1.1</td>
<td>The payload shall include an external umbilical power connection to allow for testing and safety checks when not harvesting energy.</td>
<td>None</td>
<td>None</td>
<td>X</td>
</tr>
<tr>
<td>EPS.1.2</td>
<td>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.</td>
<td>None</td>
<td>None</td>
<td>X</td>
</tr>
<tr>
<td>EPS.1.3</td>
<td>The container shall only use alkaline type batteries.</td>
<td>None</td>
<td>None</td>
<td>X</td>
</tr>
<tr>
<td>EPS.1.4</td>
<td>No batteries shall be allowed in the payload. Batteries are allowed only in the container to support releasing the payload.</td>
<td>None</td>
<td>None</td>
<td>X</td>
</tr>
<tr>
<td>EPS.2.1</td>
<td>The payload shall harvest energy from the environment during descent.</td>
<td>None</td>
<td>None</td>
<td>X</td>
</tr>
</tbody>
</table>

**CanSat 2014 CDR: Team #: 1261 (Sparky Sat)**
Electrical Block Diagram (Payload)

5.5v 15F Capacitor Bank → Switch → DC-DC Booster

Voltage Divider

Ardweeny Microcontroller

Input voltage 3.3V

Power Distribution

Communication between components

3.3v Supply

Luminosity Sensor

3.3v Supply

Thermometer/Barometer

3.3v Supply

Clock

3.3v Supply

Xbee Pro
Electrical Block Diagram (Container)

- Ardweeny Microcontroller
  - Input voltage 3.3V

- DC-DC Booster
- Switch
- 5.5V 10F Capacitor Bank
- Battery Voltage Divider

- Power Distribution
- Communication between components

- XBEE Pro
- Real Time Clock
- Altimeter
- Servo
- 4.5V Alkaline Battery

Presenter: Zach Burnham
CanSat 2014 CDR: Team #: 1261 (Sparky Sat)
.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)

<table>
<thead>
<tr>
<th>Subsystem</th>
<th>Components</th>
<th>Current (mA)</th>
<th>Idle Current (mA)</th>
<th>Voltage (V)</th>
<th>Source</th>
<th>Power Consumption (W)</th>
</tr>
</thead>
<tbody>
<tr>
<td>CDH</td>
<td>Ardweeny</td>
<td>3</td>
<td>-</td>
<td>3.3</td>
<td>3.3</td>
<td><a href="#">Data Sheet</a> .0099</td>
</tr>
<tr>
<td>CDH</td>
<td>DeadOn RTC</td>
<td>.4</td>
<td>-</td>
<td>3.3</td>
<td>3.3</td>
<td><a href="#">Data Sheet</a> .00132</td>
</tr>
<tr>
<td>SS</td>
<td>MPL3115A2 Breakout (Thermometer/Barrometer)</td>
<td>0.04</td>
<td>-</td>
<td>3.3</td>
<td>3.3</td>
<td><a href="#">Data Sheet</a> .000132</td>
</tr>
<tr>
<td>SS</td>
<td>TSL2561 Breakout Luminosity Sensor</td>
<td>0.6</td>
<td>-</td>
<td>3.3</td>
<td>3.3</td>
<td><a href="#">Data Sheet</a> .00198</td>
</tr>
<tr>
<td>CDH</td>
<td>Xbee Pro 60mW U.FL Connection Series 1 (802.15.4)</td>
<td>295</td>
<td>55 mA</td>
<td>2.7 - 3.6 V</td>
<td>3.3</td>
<td><a href="#">Data Sheet</a> .973</td>
</tr>
<tr>
<td>EPS</td>
<td>Battery Voltage Divider</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td><a href="#">Data Sheet</a> Negligible</td>
</tr>
<tr>
<td>EPS</td>
<td>Voltage Regulator Board</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td><a href="#">Data Sheet</a> Negligible</td>
</tr>
<tr>
<td>EPS</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td><strong>Total Power (W)</strong> .99</td>
</tr>
<tr>
<td>Subsystem</td>
<td>Components</td>
<td>Current (mA)</td>
<td>Idle Current (mA)</td>
<td>Voltage (V)</td>
<td>Source</td>
<td>Power Consumption (W)</td>
</tr>
<tr>
<td>-----------</td>
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<td>---------------------</td>
</tr>
<tr>
<td>CDH</td>
<td>Ardweeny</td>
<td>3</td>
<td>-</td>
<td>3.3</td>
<td>3.3</td>
<td>Data Sheet</td>
</tr>
<tr>
<td>CDH</td>
<td>DeadOn RTC</td>
<td>.4</td>
<td>-</td>
<td>3.3</td>
<td>3.3</td>
<td>Data Sheet</td>
</tr>
<tr>
<td>SS</td>
<td>MPL3115A2 Breakout (Thermometer/Barrometer)</td>
<td>0.04</td>
<td>-</td>
<td>3.3</td>
<td>3.3</td>
<td>Data Sheet</td>
</tr>
<tr>
<td>CDH</td>
<td>Xbee Pro 60mW U.FL Connection Series 1 (802.15.4)</td>
<td>295</td>
<td>55 mA</td>
<td>3.3</td>
<td>3.3</td>
<td>Data Sheet</td>
</tr>
<tr>
<td>EPS</td>
<td>Battery Voltage Divider</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>Data Sheet, Negligible</td>
</tr>
<tr>
<td>EPS</td>
<td>Voltage Regulator Board</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>Data Sheet, Negligible</td>
</tr>
<tr>
<td>EPS</td>
<td></td>
<td></td>
<td></td>
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</tr>
</tbody>
</table>
CanSat Ideal Power Consumption calculation based on assumption that each XBee is only in transmit mode less than 35% of the time
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

\[ \frac{V_{\text{Capacitor}}}{R_1} + \frac{V_{\text{Capacitor}}}{R_2} = \frac{V_{\text{Capacitor}}}{R_1 + R_2} \]

\[ V_{\text{Capacitor}} = \frac{V_{\text{A\&D}} \times (R_1 + R_2)}{R_1} \]

\[ V_{\text{A\&D}} = \frac{V_{\text{Capacitor}} \times R_1}{R_1 + R_2} \]
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**
No major changes have been made to the overall flight software design since the presentation of the PDR.
### FSW Requirements

<table>
<thead>
<tr>
<th>ID</th>
<th>Requirements</th>
<th>Parents</th>
<th>Children</th>
<th>VM</th>
</tr>
</thead>
<tbody>
<tr>
<td>CDH1.3</td>
<td>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.</td>
<td>None</td>
<td>None</td>
<td>X</td>
</tr>
</tbody>
</table>

Presenter: William Merino

CanSat 2014 CDR: Team #: 1261 (Sparky Sat)
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 programming 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

Power
120 V AC

Computer

XBEE Dongle

Container/
Payload

Antenna

XBEE

Data

Power
No major changes were made to the ground station design since the PDR.
<table>
<thead>
<tr>
<th>ID</th>
<th>Requirements</th>
<th>Parents</th>
<th>Children</th>
<th>VM</th>
</tr>
</thead>
<tbody>
<tr>
<td>COMM.1.2</td>
<td>The XBEE radios shall have their NETID set to the team number.</td>
<td>None</td>
<td>None</td>
<td>X</td>
</tr>
<tr>
<td>COMM.1.3</td>
<td>The XBEE radio shall not use the broadcast mode.</td>
<td>None</td>
<td>None</td>
<td>X</td>
</tr>
<tr>
<td>COMM.1.4</td>
<td>Both the container radio and payload radio shall use the same NETID/PANID.</td>
<td>None</td>
<td>None</td>
<td>X</td>
</tr>
<tr>
<td></td>
<td>Teams are allowed to determine how to coordinate communications between the container, payload and ground station.</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>COMM.1.5</td>
<td>Each team shall develop their own ground station.</td>
<td>None</td>
<td>None</td>
<td>X</td>
</tr>
<tr>
<td>COMM.1.6</td>
<td>All telemetry data shall be displayed in real time during descent.</td>
<td>None</td>
<td>None</td>
<td>x</td>
</tr>
<tr>
<td>COMM.1.7</td>
<td>All telemetry data shall be displayed in engineering units (meters, meters/sec, Celcius, etc.)</td>
<td>None</td>
<td>None</td>
<td>X</td>
</tr>
<tr>
<td>COMM 1.8</td>
<td>Teams shall plot data in real time during flight</td>
<td>None</td>
<td>None</td>
<td>x</td>
</tr>
</tbody>
</table>
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 converter
- 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

Presenter: Zach Burnham

CanSat 2014 CDR: Team #: 1261 (Sparky Sat)
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 its ability to deploy after being released from Container encapsulation and to fall at 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 integrated 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 tested 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

Arrive at launch site
- Set Up GCS--Ray
  - Make any last minute changes to CanSat
  - Attach pole to tripod mount
  - Attach antenna to pole
  - Attach Xbee/Dongle to Computer
  - Run antenna cable to Xbee

Pre-Launch
- Power On CanSat/GCS--Zach
  - Confirm communication w/ GCS & proper telemetry

Insert Egg in Payload
- Insert Payload/DCS in Container--Ryan & Sarah

Launch
- Begin communications/receive telemetry--Ryan and Zach
  - CanSat deployment ~ 650m
  - CanSat deploys parachute
Overview of Mission Sequence of Events

Payload Deployment ~ 500m

PEMR deploys payload

Payload deploys DCS

Landing

Audible beacon activates on Payload

Post-Launch

Container and Payload Recovered--Heather and Ryan

Egg checked for damage--Sarah

Telemetry data analyzed

Telemetry data packaged in USB--Zach

Telemetry data given to judges--Ray

PFR made and presented--All team members

Presenter: Heather Zunino

CanSat 2014 CDR: Team #: 1261 (Sparky Sat)
● 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
• **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 #).
• 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
● **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
<table>
<thead>
<tr>
<th>Rqmt Num</th>
<th>Requirement</th>
<th>Comply / No Comply / Partial</th>
<th>X-Ref Slide(s) Demonstrating Compliance</th>
<th>Team comments and notes</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Total mass of CanSat, container, and all descent control devices shall be 700 grams. Mass shall not vary more than +/-10 grams.</td>
<td>Comply</td>
<td>50</td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>The cansat must be installed in a container to protect it from deployment out of the rocket.</td>
<td>Comply</td>
<td>14-17</td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>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.</td>
<td>Comply</td>
<td>14-17</td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>The container must use a descent control system. It cannot free fall.</td>
<td>Comply</td>
<td>24-39</td>
<td></td>
</tr>
<tr>
<td>5</td>
<td>The container shall not have any sharp edges that could cause it to get stuck in the rocket payload section.</td>
<td>Comply</td>
<td>15</td>
<td></td>
</tr>
<tr>
<td>6</td>
<td>The container must be a fluorescent color: pink or orange.</td>
<td>Comply</td>
<td>29</td>
<td></td>
</tr>
</tbody>
</table>
Management

Heather Zunino
### CanSat Budget – Hardware

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

<table>
<thead>
<tr>
<th>Category</th>
<th>Description</th>
<th>Quantity</th>
<th>Cost</th>
<th>Unit Cost</th>
<th>Estimate/Actual</th>
</tr>
</thead>
<tbody>
<tr>
<td>SMS</td>
<td>Deployement Actuator</td>
<td>1</td>
<td>50.00</td>
<td></td>
<td>Estimate</td>
</tr>
<tr>
<td>SS</td>
<td>Micro SD Card</td>
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<td>10.98</td>
<td></td>
<td>Estimate</td>
</tr>
<tr>
<td>SS</td>
<td>Altitude/Pressure Sensor</td>
<td>1</td>
<td>14.95</td>
<td></td>
<td>Actual</td>
</tr>
<tr>
<td>SS</td>
<td>Visible and Infrared Light Sensor</td>
<td>1</td>
<td>5.95</td>
<td></td>
<td>Actual</td>
</tr>
<tr>
<td>SS</td>
<td>Real Time Clock</td>
<td>1</td>
<td>19.95</td>
<td></td>
<td>Actual</td>
</tr>
<tr>
<td>SS</td>
<td>Temperature Sensor</td>
<td>1</td>
<td>5.95</td>
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<td>Actual</td>
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<tr>
<td>GCS</td>
<td>Ground Station Xbee</td>
<td>1</td>
<td>37.95</td>
<td></td>
<td>Actual</td>
</tr>
<tr>
<td>GCS</td>
<td>Ground Station Antenna</td>
<td>1</td>
<td>49.24</td>
<td></td>
<td>Actual</td>
</tr>
<tr>
<td>GCS</td>
<td>Antenna Tripod</td>
<td>1</td>
<td>16.95</td>
<td></td>
<td>Actual</td>
</tr>
<tr>
<td>GCS</td>
<td>Xbee Explorer Dongle</td>
<td>1</td>
<td>24.95</td>
<td></td>
<td>Actual</td>
</tr>
<tr>
<td>GCS</td>
<td>Antenna Cable (N-Male to N-Male)</td>
<td>1</td>
<td>53.99</td>
<td></td>
<td>Actual</td>
</tr>
<tr>
<td>GCS</td>
<td>12’ Antenna Pole</td>
<td>1</td>
<td>15.00</td>
<td></td>
<td>Estimate</td>
</tr>
<tr>
<td>GCS</td>
<td>Xbee to Cable adapter (RP-Male to N-Female)</td>
<td>1</td>
<td>8.99</td>
<td></td>
<td>Actual</td>
</tr>
</tbody>
</table>

**CanSat Hardware Total:** $508.79  
**GCS Hardware Total:** $207.07  
**Hardware Total:** $840.86
# CanSat Budget – Hardware

<table>
<thead>
<tr>
<th>Subsystem Designation</th>
<th>Component</th>
<th>Unit Cost (USD)</th>
<th>QTY</th>
<th>Cost (USD)</th>
<th>Verification</th>
</tr>
</thead>
<tbody>
<tr>
<td>GCS</td>
<td>Xbee Pro 60mW U.FL Connection Series 1</td>
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<td>1</td>
<td>37.95</td>
<td>Actual</td>
</tr>
<tr>
<td>GCS</td>
<td>2.4GHz 15dBi TL-ANT2415d Antenna</td>
<td>49.24</td>
<td>1</td>
<td>49.24</td>
<td>Actual</td>
</tr>
<tr>
<td>GCS</td>
<td>Antenna Mast Tripod Mount 3' FT</td>
<td>16.95</td>
<td>1</td>
<td>16.95</td>
<td>Actual</td>
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<tr>
<td>GCS</td>
<td>Xbee Explorer Dongle</td>
<td>24.95</td>
<td>1</td>
<td>24.95</td>
<td>Actual</td>
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<tr>
<td>GCS</td>
<td>Antenna Cable (RP-SMA to N-female)</td>
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<td>55</td>
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<td>20.00</td>
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<td>20</td>
<td>Estimate</td>
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<tr>
<td>GCS</td>
<td>Xbee to Cable connector (GCS)</td>
<td>4.95</td>
<td>1</td>
<td>4.95</td>
<td>Actual</td>
</tr>
</tbody>
</table>

|                        | CanSat Total                                    | 986.91          |
|                        | GCS Total                                       | 209.04          |
|                        | S/H                                             | 150.00          |
| Total                  |                                                 | 1345.95         |
# CanSat Budget – Other Costs

## Test Facilities and Equipment
- **Price (USD):** 0.00
- **Verification:** Provided by University

## Computers
- **Price (USD):** 0.00
- **Verification:** Provided by Team

## Testing Expenses
- **Price (USD):** 1650.00
- **Verification:** University Funding

## Testing Expenses Total
- **Price (USD):** 1650.00

## Vehicle for Transportation
- **Price (USD):** 400.00
- **Verification:** Estimate*

## Gas
- **Price (USD):** 350.00
- **Verification:** Estimate*

## Hotel
- **Price (USD):** 1000.00
- **Verification:** Estimate*

## Food
- **Price (USD):** 450.00
- **Verification:** Estimate*

## Travel Expenses Total
- **Price (USD):** 2200.00

* assumes 7 members attending competition

## Total Hardware Cost
- **Price (USD):** 2490.86

## Current University Funding
- **Price (USD):** 2750.00

## Current Surplus
- **Price (USD):** 259.14

## Total Travel Cost
- **Price (USD):** 2200.00

## Current University Funding
- **Price (USD):** 1650.00

## Current Surplus
- **Price (USD):** -550.00
**Program Schedule**

**Presenter:** Heather Zunino

**CanSat 2014 CDR: Team #: 1261 (Sparky Sat)**
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.