Cansat 2012
Preliminary Design Review

Team # 1024
“Bumblebee”
The University of Alabama in Huntsville
# Cansat 2012 PDR: Team 1024, “Bumblebee”

## Presentation Outline

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**Presenter:** John Alcorn
Mr. Troy Skinner
Faculty Advisor

Mr. Mark Becnel
Graduate Mentor

John Alcorn
Project Manager
Junior, Aerospace Eng

Yang Wang
Chief Engineer
Soph, Mechanical Eng

Byron Hall II
Electrical Systems
Junior, Mechanical Eng

Tyler Hughes
Ground Control
Junior, Electrical Eng

Amun Jarzembski
Software Development
Soph, Mechanical Eng

Glenn Nesbitt II
Ground Control
Fresh, Electrical Eng

Amy Parlett
Descent Control
Soph, Aerospace Eng

Brittani Searcy
Mechanical Systems
Soph, Aerospace Eng

Geoff Suiter
Descent Control
Fresh, Chemical Eng

Angela Yi
Electrical Systems
Fresh, Chemical Eng

Presenter: John Alcorn
### Acronyms

<table>
<thead>
<tr>
<th>A</th>
<th>Analysis</th>
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<tr>
<td>ADC</td>
<td>Analog to Digital Converter</td>
</tr>
<tr>
<td>BMR</td>
<td>Base Mission Requirement</td>
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<tr>
<td>CD</td>
<td>Coefficient of Drag</td>
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<td>CDH</td>
<td>Communications and Data Handling</td>
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<tr>
<td>CDR</td>
<td>Critical Design Review</td>
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<td>CONOP</td>
<td>Concept of Operations</td>
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<td>CRR</td>
<td>Carrier Requirement</td>
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<td>D</td>
<td>Demonstration</td>
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<td>Descent Control System</td>
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<td>GCS</td>
<td>Ground Control System</td>
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<td>GPS</td>
<td>Global Positioning System</td>
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<td>GUI</td>
<td>Graphical User Interface</td>
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<td>HW</td>
<td>Hardware</td>
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<td>HWR</td>
<td>Hardware Review</td>
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<td>I</td>
<td>Inspection</td>
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<td>LCO</td>
<td>Launch Control Officer</td>
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<td>LDR</td>
<td>Lander Requirement</td>
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<tr>
<td>LiPo</td>
<td>Lithium Polymer</td>
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<td>MAE</td>
<td>Mechanical and Aerospace Engineering</td>
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<td>MCU</td>
<td>Microcontroller Unit</td>
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<td>PCB</td>
<td>Printed Circuit Board</td>
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<td>PDR</td>
<td>Preliminary Design Review</td>
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<td>PFR</td>
<td>Post Flight Review</td>
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<td>PFB</td>
<td>Pre Flight Briefing</td>
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<td>RPSMA</td>
<td>Reverse Polarity SubMiniature Version A</td>
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<td>SF</td>
<td>Safety Factor</td>
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<td>SOE</td>
<td>Sequence of Events</td>
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<tr>
<td>SOR</td>
<td>Selectable Objective Requirement</td>
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<td>SPI</td>
<td>Serial Peripheral Interface Bus</td>
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<td>Testing</td>
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<tr>
<td>UAH</td>
<td>University of Alabama Huntsville</td>
</tr>
<tr>
<td>USART</td>
<td>Universal Asynchronous Receiver/Transmitter</td>
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<tr>
<td>UTC</td>
<td>Universal Time Constant</td>
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<tr>
<td>VM</td>
<td>Verification Method</td>
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</table>
Systems Overview

John Alcorn
Junior, Aerospace Engineering
Mission Summary

- **Cansat**
  - A mock-satellite engineering demonstration carried by a rocket to an altitude of 600 meters and ejected. The Cansat is made of two systems, the Carrier and the Lander. The Carrier is the primary unit, which deploys the Lander during descent.

- **The Carrier unit will**
  - Deploy secondary descent control at 200 meters altitude
  - Separate from the Lander at 91 meters altitude
  - Capture video of the Lander separation
  - Transmit and record telemetry at 0.5 Hz
  - Beacon audible signal upon landing

- **The Lander unit will**
  - Carry an egg safely to the ground
  - Separate from the Carrier at 91 meters
  - Store sensor data onboard
  - Beacon audible signal upon landing
## System Requirements, Mission

<table>
<thead>
<tr>
<th>Section</th>
<th>ID</th>
<th>Requirement</th>
<th>Rationale</th>
<th>Priority</th>
<th>Parent</th>
<th>Children</th>
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<tbody>
<tr>
<td>MECH</td>
<td>01</td>
<td>System mass less than 750 g, greater than 400 g</td>
<td>Rocket constraint</td>
<td>HIGH</td>
<td>MECH 02</td>
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<tr>
<td>MECH</td>
<td>02</td>
<td>System compatible with Loc/Precision Mini-Magg rocket</td>
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<td>MECH 03</td>
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<tr>
<td>MECH</td>
<td>03</td>
<td>System shall fit inside section of 130 mm diameter and 152 length</td>
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<td>MECH 02</td>
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<tr>
<td>MECH</td>
<td>04</td>
<td>Descent control may occupy 76 mm above payload section</td>
<td>Decent control releasability upon ejection</td>
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<tr>
<td>MECH</td>
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<td>No protrusions beyond payload envelop prior to ejection</td>
<td>Autonomous operation</td>
<td>HIGH</td>
<td>MECH 02</td>
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<td>No parts may be restrained by rocket airframe</td>
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<td>MECH 02</td>
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<td>MECH</td>
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<td>Operations shall not employ rocket airframe or payload section</td>
<td>Autonomous operation</td>
<td>HIGH</td>
<td>MECH 08</td>
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<td>MECH</td>
<td>08</td>
<td>System must deploy from payload section</td>
<td>Rocket constraint</td>
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<td>MECH 07</td>
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<td>DCTR</td>
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<td>No pyrotechnics may be used by descent control subsystem</td>
<td>Safety constraint</td>
<td>MED</td>
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<td>DCTR</td>
<td>02</td>
<td>System descent rate must be 10 m/s while above 200 m</td>
<td>Base mission requirement</td>
<td>HIGH</td>
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<tr>
<td>DCTR</td>
<td>03</td>
<td>System descent rate must be 5 m/s between 91 m and 200 m</td>
<td>Base mission requirement</td>
<td>HIGH</td>
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<tr>
<td>MECH</td>
<td>09</td>
<td>Lander must be deployed at 91 m</td>
<td>Base mission requirement</td>
<td>HIGH</td>
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<td>DCTR</td>
<td>04</td>
<td>Lander descent rate must be 5 m/s; drift must be less than 500 m</td>
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<td>ELEC</td>
<td>01</td>
<td>Carrier and Lander must have locating device with 3 hour operation</td>
<td>Increases ability to locate systems</td>
<td>MED</td>
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<tr>
<td>ELEC</td>
<td>02</td>
<td>Locator devices must be independently powered with switch</td>
<td>Power conservation and control</td>
<td>MED</td>
<td>ELEC 04</td>
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<td>Carrier and Lander must descend as a unit prior to separation</td>
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<td>MECH 09</td>
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<td>SENS</td>
<td>01</td>
<td>Altitude sensor non-GPS; minimum 2 m accuracy</td>
<td>Competitive ability to manage multiple sensors</td>
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<td>Radio must be XBEE XBP24BZ7SIT-004 or XBP24BZ7UIT-004</td>
<td>Communications control; fairness</td>
<td>HIGH</td>
<td>CDH 02</td>
<td></td>
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<tr>
<td>CDH</td>
<td>02</td>
<td>Radio must have NETID set to team number</td>
<td>Communications control</td>
<td>MED</td>
<td>CDH 01</td>
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<td>Radio must not use broadcast mode</td>
<td>Communications control</td>
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<td>GND</td>
<td>01</td>
<td>Ground control antenna must be elevated 3.5 m minimum</td>
<td>Prevention of signal loss</td>
<td>MED</td>
<td>GND 03</td>
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<td>GND</td>
<td>02</td>
<td>Ground control must initiate system telemetry transmission</td>
<td>Demonstrates ability to communicate with system</td>
<td>HIGH</td>
<td>GND 01</td>
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<tr>
<td>MGT</td>
<td>01</td>
<td>Operations must comply with field safety regulations</td>
<td>Safety constraint</td>
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<td>MGT</td>
<td>02</td>
<td>System launch must occur within assigned launch window</td>
<td>Launch control; fairness</td>
<td>MED</td>
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<td>ELEC</td>
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<td>Carrier and Lander must have external power switch</td>
<td>Power conservation and control</td>
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<td>ELEC 02</td>
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<td>ELEC</td>
<td>04</td>
<td>System must be capable of one hour wait plus flight time</td>
<td>Prevention of power exhaustion</td>
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<td>System must not use LiPo batteries</td>
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<td>03</td>
<td>System flight hardware must not exceed 1000 USD</td>
<td>Fairness</td>
<td>MED</td>
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<td>GND</td>
<td>03</td>
<td>Ground control station with real-time data must be used</td>
<td>Demonstration of ability to locate system</td>
<td>HIGH</td>
<td>GND 01</td>
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**Presenter:** John Alcorn

**Cansat 2012 PDR: Team 1024, “Bumblebee”**
## System Requirements, Carrier

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<tbody>
<tr>
<td>DCTR</td>
<td>05</td>
<td>No pyrotechnics may be used by Carrier descent control subsystem</td>
<td>Safety constraint</td>
<td>MED</td>
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<tr>
<td>ELEC</td>
<td>06</td>
<td>Carrier must have locating device with 3 hour operation</td>
<td>Increases ability to locate system</td>
<td>MED</td>
<td>ELEC 04</td>
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<td>DCTR</td>
<td>06</td>
<td>Carrier descent control and attachment points must support 30 g shock</td>
<td>Failure prevention</td>
<td>MED</td>
<td>MECH 13</td>
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<td>DCTR</td>
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<td>Carrier descent control must be unstowable</td>
<td>Demonstrates ability to replace descent control</td>
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<td>MECH 11</td>
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<td>Descent control color must be florescent pink or florescent orange</td>
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<td>MECH</td>
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<td>Electronics must be enclosed with the exception of sensors</td>
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<td>Structure must support 10 g shock</td>
<td>Failure prevention</td>
<td>MED</td>
<td>MECH 11</td>
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<td>Structure must survive 30 g shock</td>
<td>Failure prevention</td>
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<td>MECH 11</td>
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<td>Electronics must be hard-mounted</td>
<td>Failure prevention; safety constraint</td>
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<td>MECH 11</td>
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<td>MGT</td>
<td>04</td>
<td>Contact info must be placed on structure</td>
<td>Increases ability to locate system</td>
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<td>Mechanisms must be capable of withstanding shock force</td>
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<td>GPS based UTC time must be transmitted at 0.5 Hz</td>
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<td>GPS based latitude in degrees must be transmitted at 0.5 Hz</td>
<td>Demonstrates ability to communicate with system</td>
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<td>CDH</td>
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<td>GPS based longitude in degrees must be transmitted at 0.5 Hz</td>
<td>Demonstrates ability to communicate with system</td>
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<td>GPS based mean sea level altitude must be transmitted at 0.5 Hz</td>
<td>Demonstrates ability to communicate with system</td>
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<td>CDH</td>
<td>08</td>
<td>GPS number of satellites tracked must be transmitted at 0.5 Hz</td>
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<tr>
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<td>Non-GPS altitude in meters must be transmitted at 0.5 Hz</td>
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<td>Air temperature in celsius must be transmitted at 0.5 Hz</td>
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<td>Battery voltage in volts must be transmitted at 0.5 Hz</td>
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<td>CDH</td>
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<td>Carrier must video separation</td>
<td>Selectable objective requirement</td>
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</table>

**Presenter:** John Alcorn

**Cansat 2012 PDR: Team 1024, “Bumblebee”**
## System Requirements, Lander

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<th>Section</th>
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<th>Children</th>
</tr>
</thead>
<tbody>
<tr>
<td>MECH</td>
<td>18</td>
<td>Lander must safely land an egg</td>
<td>Base mission requirement</td>
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<tr>
<td>DCTR</td>
<td>09</td>
<td>No pyrotechnics may be used by descent control subsystem</td>
<td>Safety constraint</td>
<td>MED</td>
<td></td>
<td></td>
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<tr>
<td>DCTR</td>
<td>10</td>
<td>Lander descent rate must be 5 m/s; measured and recorded</td>
<td>Base mission requirement</td>
<td>HIGH</td>
<td></td>
<td></td>
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<tr>
<td>ELEC</td>
<td>07</td>
<td>Lander must have locating device with 3 hour operation</td>
<td>Increases ability to locate system</td>
<td>MED</td>
<td>ELEC 01</td>
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<td>MECH</td>
<td>19</td>
<td>Electronics must be enclosed</td>
<td>Failure prevention; safety constraint</td>
<td>MED</td>
<td>MECH 12</td>
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<td>MECH</td>
<td>20</td>
<td>Structure must support 10 g shock</td>
<td>Failure prevention</td>
<td>MED</td>
<td>MECH 13</td>
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<td>MECH</td>
<td>21</td>
<td>Structure must survive 30 g shock</td>
<td>Failure prevention</td>
<td>MED</td>
<td>MECH 13</td>
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<td>MECH</td>
<td>22</td>
<td>Electronics must be hard-mounted</td>
<td>Failure prevention; safety constraint</td>
<td>MED</td>
<td>MECH 13</td>
<td></td>
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<tr>
<td>MGT</td>
<td>05</td>
<td>Contact info must be placed on structure</td>
<td>Increases ability to locate system</td>
<td>MED</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Presenter:** John Alcorn
**System Level Cansat Configuration Trade**

- **Options considered**
  - Top to bottom Carrier Lander configuration
    - Each unit has circular cross section; symmetrical
    - This was last year’s Cansat configuration
  - Side to side Carrier Lander configuration
    - Each unit has half-circle cross section
    - This would allow more room for descent control

- **Criteria for selection**
  - Must be capable of housing all subsystems
  - Minimal risk to mission success
  - Must be within manufacturing capabilities
  - Must be capable of meeting mass constraints
  - Must be capable of meeting dimensional constraints
System Level Cansat Configuration Selection

• Configuration selection and rationale
  – A side to side Carrier Lander configuration is the preferred option
  – Low risk gravity driven separation; simple interface
  – Volume allocation for high priority mechanisms, specifically descent control
Arrival at competition
- Assemble ground station
- Receive launch approval
- Reset altitude relative to ground

Launch

Apogee
- Ejection from rocket at 600 meters
- System descends at 10 m/s
- At 200 meters, system decelerates to 5 m/s

Separation at 91 meters
- Carrier initiates separation and ejects Lander descent control
System Concept of Operations, Carrier

- **Separation**
  - Carrier initiates separation and Lander descent control ejection
  - Continues to store and transmit telemetry

- **Touchdown**
  - Initiate audible beacon
  - Stop transmitting telemetry after 3 minutes

Presenter: John Alcorn
System Concept of Operations, Lander

• **Separation**
  – Descends independent of Carrier after 91 m
  – Descent rate of less than 5 m/s
  – Continues to store data onboard

• **Touchdown**
  – Soft packaging material and external crush pad protect egg from impact
  – Initiate audible beacon

CST-931AP audible beacon used by Carrier and Lander
Physical Layout

*All dimensions in mm*
Launch Vehicle Compatibility

- **Payload integration into rocket airframe**
  - Rocket payload section has 130 mm diameter
  - Cansat dimensions must not exceed 127 mm in diameter and 152 mm in length, to allow for margin
  - Positioned without attachment into rocket payload bay

- **Payload integration verification**
  - A rocket with a payload bay with dimensions identical to the Loc/Precision Mini-Magg will be fabricated internally for systems testing and compatibility verification
  - A full systems test will be performed prior to competition and system compatibility will be confirmed
Sensor Subsystem Design

John Alcorn
Junior, Aerospace Engineering
# Sensor Subsystem Overview

<table>
<thead>
<tr>
<th>Sensor</th>
<th>Model</th>
<th>Trade</th>
<th>Description</th>
<th>Vendor</th>
<th>Quantity Carrier, Lander</th>
</tr>
</thead>
<tbody>
<tr>
<td>GPS</td>
<td>LS20031</td>
<td>Locosys</td>
<td>66 Channel GPS</td>
<td>Sparkfun</td>
<td>1 0</td>
</tr>
<tr>
<td>Temperature</td>
<td>NTCLE100E3103JB0</td>
<td>Vishay</td>
<td>Thermistor</td>
<td>Digikey</td>
<td>1 1</td>
</tr>
<tr>
<td>Pressure</td>
<td>MP3H6115A6U</td>
<td>Freescale Semi.</td>
<td>Piezoresistive pressure transducer</td>
<td>Digikey</td>
<td>1 1</td>
</tr>
<tr>
<td>Camcorder</td>
<td>VCC-004</td>
<td>Veho</td>
<td>Micro camcorder</td>
<td>Amazon</td>
<td>1 0</td>
</tr>
</tbody>
</table>
## Sensor Subsystem Requirements

<table>
<thead>
<tr>
<th>Section</th>
<th>ID</th>
<th>Requirement</th>
<th>Rationale</th>
<th>Priority</th>
<th>Parent</th>
<th>Children</th>
</tr>
</thead>
<tbody>
<tr>
<td>SENS</td>
<td>01</td>
<td>Altitude sensor non-GPS; minimum 2 m accuracy</td>
<td>Competitive ability to manage multiple sensors</td>
<td>HIGH</td>
<td>CDH 10</td>
<td></td>
</tr>
<tr>
<td>SENS</td>
<td>02</td>
<td>GPS based UTC time must be transmitted at 0.5 Hz</td>
<td>Demonstrates ability to communicate with system</td>
<td>MED</td>
<td></td>
<td></td>
</tr>
<tr>
<td>SENS</td>
<td>03</td>
<td>GPS based latitude in degrees must be transmitted at 0.5 Hz</td>
<td>Demonstrates ability to communicate with system</td>
<td>MED</td>
<td></td>
<td></td>
</tr>
<tr>
<td>SENS</td>
<td>04</td>
<td>GPS based longitude in degrees must be transmitted at 0.5 Hz</td>
<td>Demonstrates ability to communicate with system</td>
<td>MED</td>
<td></td>
<td></td>
</tr>
<tr>
<td>SENS</td>
<td>05</td>
<td>GPS based mean sea level altitude must be transmitted at 0.5 Hz</td>
<td>Demonstrates ability to communicate with system</td>
<td>MED</td>
<td></td>
<td></td>
</tr>
<tr>
<td>SENS</td>
<td>06</td>
<td>GPS number of satellites tracked must be transmitted at 0.5 Hz</td>
<td>Demonstrates ability to communicate with system</td>
<td>MED</td>
<td></td>
<td></td>
</tr>
<tr>
<td>SENS</td>
<td>07</td>
<td>Non-GPS altitude in meters must be transmitted at 0.5 Hz</td>
<td>Demonstrates ability to communicate with system</td>
<td>MED</td>
<td>ELEC 03</td>
<td></td>
</tr>
<tr>
<td>SENS</td>
<td>08</td>
<td>Air temperature in celsius must be transmitted at 0.5 Hz</td>
<td>Demonstrates ability to communicate with system</td>
<td>MED</td>
<td></td>
<td></td>
</tr>
<tr>
<td>SENS</td>
<td>09</td>
<td>Carrier must video separation; video must not start more than 2 seconds prior to separation</td>
<td>Selectable objective requirement</td>
<td>MED</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Carrier GPS Trade & Selection

- **Options considered**
  - USGlobalSat EM-408, 20 Channel, 10 Hz
  - ADH Tech D 2523T Helical, 50 channel, 4 Hz
  - Locosys LS20031, 66 channel, 10 Hz
- **Criteria for selection**
  - Antenna configuration
  - Capable of gathering required data
  - Startup time, satellite acquisition time
  - Data sample rate 0.5 Hz minimum
- **Selection and rationale**
  - The Locosys LS20031 is the preferred option
  - Up to 10 Hz refresh rate

Presenter: John Alcorn
Carrier Non-GPS Altitude Sensor Trade & Selection

- **Options considered**
  - Intersema MS5534CM Barometric
  - Bosch BMP085 Barometric
  - Freescale Semi. MP3H6115A6U, Piezoresistive

- **Criteria for selection**
  - Altitude resolution of 2 meters minimum
  - Capability of 0.5 Hz sample rate

- **Selection and rationale**
  - MP3H6115A6U Piezoresistive is the preferred option
  - 1.5 meter altitude resolution
  - Temperature compensated
  - Surface mount
Carrier Air Temperature Trade & Selection

• Options considered
  – Vishay NTCLE100 10k, thermistor
  – Siemens B5977B 10k, thermistor

• Criteria for selection
  – Resolution of 1 °C
  – Ability to sample at 0.5 Hz

• Selection and rationale
  – NTCLE100 10k thermistor is the preferred option
  – Tolerance of 5%, corresponds to 1.0 – 1.5 °C error
  – Thermistor used for Cansat 2011
Identical to **Carrier Non-GPS Altitude Sensor Trade and Selection**

- **Options considered**
  - Intersema MS5534CM Barometric
  - Bosch BMP085 Barometric
  - Freescale Semi. MP3H6115A6U, Piezoresistive

- **Criteria for selection**
  - Altitude resolution of 2 meters minimum
  - Capability of 0.5 Hz sample rate

- **Selection and rationale**
  - MP3H6115A6U Piezoresistive is the preferred option
  - 1.5 meter altitude resolution
  - Temperature compensated
  - Surface mount
Carrier Video Camera Trade & Selection

• Options considered
  – Mini DC VD80, Digital Video Camera
  – Veho VCC-003 Muvi, High Resolution Micro Camcorder
  – Veho VCC-004 ATOM Muvi, High Resolution Micro Micro Camcorder

• Criteria for selection
  – Capable of storing video autonomously
  – Capable of electronic activation
  – Must have dedicated power source
  – Compatible with Carrier dimensions

• Selection and rationale
  – The Muvi VCC-004 ATOM is the preferred option
  – Internal micro-SD data storage
  – Video resolution of 640 x 480 pixels, temporal resolution of up to 30 frames/s
  – 80° FOV
  – Dimensions of 40 x 20 x 19 mm
Descent Control Design

Amy Parlett
Sophomore, Aerospace Engineering
Descent Control Overview

- Descent control must slow the descent velocity to the following requirements
  - $10 \pm 1 \frac{m}{s}$ (entire system above 200m)
  - $5 \pm 1 \frac{m}{s}$ (entire system below 200, before separation)
  - $5 \pm 1 \frac{m}{s}$ (91m and below, after separation)

- A multi-stage streamer is being considered for the system descent control.
  - After separation, the streamer remains on the carrier and a parasheet deploys for the lander.

- Carrier initiates all descent control systems
  - Avoids time inconsistencies between operations vs. Lander control

- Descent control systems constrained and deployed using monofilament and nichrome wire setup
  - Must be enclosed from the environment for safety purposes

- All descent control systems must be fluorescent pink or orange
  - The preferred selection is fluorescent pink

Presenter: Amy Parlett
## Descent Control Requirements

<table>
<thead>
<tr>
<th>Section ID</th>
<th>Requirement</th>
<th>Rationale</th>
<th>Priority</th>
<th>Parent</th>
<th>Children</th>
</tr>
</thead>
<tbody>
<tr>
<td>DCTR 01</td>
<td>No pyrotechnics may be used by descent control subsystem</td>
<td>Safety constraint</td>
<td>MED</td>
<td></td>
<td></td>
</tr>
<tr>
<td>DCTR 02</td>
<td>System descent rate must be 10 m/s while above 200 m</td>
<td>Base mission requirement</td>
<td>HIGH</td>
<td></td>
<td></td>
</tr>
<tr>
<td>DCTR 03</td>
<td>System descent rate must be 5 m/s between 91 m and 200 m</td>
<td>Base mission requirement</td>
<td>HIGH</td>
<td></td>
<td></td>
</tr>
<tr>
<td>DCTR 04</td>
<td>Lander descent rate must be 5 m/s; drift must be less than 500 m</td>
<td>Base mission requirement</td>
<td>HIGH</td>
<td></td>
<td></td>
</tr>
<tr>
<td>DCTR 05</td>
<td>No pyrotechnics may be used by Carrier descent control subsystem</td>
<td>Safety constraint</td>
<td>MED</td>
<td></td>
<td></td>
</tr>
<tr>
<td>DCTR 06</td>
<td>Carrier descent control and attachment points must support 30 g shock</td>
<td>Failure prevention</td>
<td>MED</td>
<td>MECH 13</td>
<td></td>
</tr>
<tr>
<td>DCTR 07</td>
<td>Carrier descent control must be unstowable</td>
<td>Demonstrates ability to replace descent control</td>
<td>MED</td>
<td>MECH 11</td>
<td></td>
</tr>
<tr>
<td>DCTR 08</td>
<td>Descent control color must be florescent pink or florescent orange</td>
<td>Increases ability to locate system</td>
<td>MED</td>
<td></td>
<td></td>
</tr>
<tr>
<td>DCTR 09</td>
<td>No pyrotechnics may be used by descent control subsystem</td>
<td>Safety constraint</td>
<td>MED</td>
<td></td>
<td></td>
</tr>
<tr>
<td>DCTR 10</td>
<td>Lander descent rate must be 5 m/s; must be measured and recorded</td>
<td>Base mission requirement</td>
<td>HIGH</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Carrier Descent Control Strategy Selection and Trade

• **Strategy**
  – Multi-stage device that can be used in combination with another type of device and control Carrier descent after separation

• **Options considered**
  – Parasheet: Flat sheet forming semi-hemisphere when inflated
  – Streamer: thin strip of material using flapping to create drag

• **Criteria for selection**
  – Meet descent velocity requirements; including the deceleration between descent stages and after system separation
    • $10 \pm 1 \frac{m}{s}$ between apogee and 200m
    • $5 \pm 1 \frac{m}{s}$ between 200m and 91m (separation)
    • Controlled descent after separation
  – Survive 30 G shock force
  – Fit within allowed envelope
  – Protect electronics
  – Multi-stage system

• **Selection**
  – Streamer
    • Easily extends for multi-stage descent, occupies comparatively small volume, low opening shock force
Lander Descent Control Strategy Selection and Trade

• **Strategy**
  – Single stage system that can be used in combination with another device and initiated upon separation of Carrier and Lander

• **Options considered**
  – Parasheet: Flat sheet forming semi-hemisphere when inflated.
  – Decelerator: cone-shaped device constructed from carbon-fiber legs and Rip Stop nylon
  – Streamer: thin strip of material using flapping to create drag

• **Criteria for selection**
  – Meet descent velocity requirement
    • $5 \pm 1 \frac{m}{s}$ from 91m to ground (after separation occurs)
  – Fit in space between Carrier and Lander and can be initiated by separation of Carrier and Lander
  – Protect egg on landing

• **Selection**
  – Parasheet (orange Rip Stop nylon)
    • Folds to occupy small volume, provides more controlled descent and better protection for egg
Descent Rate Estimates

\[
F_D = \frac{1}{2} \rho C_D A v^2
\]

\[
F = mg
\]

\[
\frac{1}{2} \rho C_D A v^2 = mg
\]

- Parasheet drag force equation
- Newton’s Second Law
- Equated

Using these equations, the following values were determined

<table>
<thead>
<tr>
<th></th>
<th>Streamer</th>
<th>Streamer Extension</th>
<th>Parasheet</th>
</tr>
</thead>
<tbody>
<tr>
<td>System</td>
<td>Carrier</td>
<td>Carrier</td>
<td>Lander</td>
</tr>
<tr>
<td>Descent Velocity</td>
<td>10 m/s</td>
<td>5 m/s</td>
<td>5 m/s</td>
</tr>
<tr>
<td>Diameter (in)</td>
<td>N/A</td>
<td>N/A</td>
<td>27.6</td>
</tr>
<tr>
<td>Thickness</td>
<td>2mil</td>
<td>2mil</td>
<td>N/A</td>
</tr>
<tr>
<td>Area (in^2)</td>
<td>280</td>
<td>1121</td>
<td>265.8</td>
</tr>
</tbody>
</table>
Mechanical Subsystem Design

Brittani Searcy
Sophomore, Aerospace Engineering
## Mechanical Subsystem Overview

<table>
<thead>
<tr>
<th>Device</th>
<th>Material</th>
<th>Description</th>
<th>Interface</th>
<th>Quantity</th>
</tr>
</thead>
<tbody>
<tr>
<td>Frame</td>
<td>Polycarbonate</td>
<td>Contains payload components including structure for batteries, electronics</td>
<td>Attached by high strength wire</td>
<td>1,1</td>
</tr>
<tr>
<td>Release Mechanism</td>
<td>Chromium Wire</td>
<td>Carrier releases the Lander at an altitude of 91m. Chrome wire burns high strength cord</td>
<td>Lander/Carrier attachment by high strength cord</td>
<td>1,0</td>
</tr>
<tr>
<td>Electronics mounting structure</td>
<td>Polycarbonate</td>
<td>Mounts directly to frame using screws or adhesive</td>
<td>Hard mounts to frame</td>
<td>1,1</td>
</tr>
<tr>
<td>Egg Protection</td>
<td>TBD</td>
<td>Egg protection is to be determined pending test results</td>
<td>Enclosure is built into the frame</td>
<td>0,1</td>
</tr>
<tr>
<td>Electronics Enclosure</td>
<td>Polycarbonate</td>
<td>Electronics enclosed by frame</td>
<td>Sides of frame slide in to enclose electronics</td>
<td>1,1</td>
</tr>
<tr>
<td>Contact Info</td>
<td>N/A</td>
<td>Team Number, e-mail, phone number, and address must be placed on carrier and lander.</td>
<td>N/A</td>
<td>1,1</td>
</tr>
</tbody>
</table>
## Mechanical System Requirements

<table>
<thead>
<tr>
<th>Section ID</th>
<th>Requirement</th>
<th>Rationale</th>
<th>Priority</th>
<th>Parent</th>
<th>Children</th>
</tr>
</thead>
<tbody>
<tr>
<td>MECH 02</td>
<td>System compatible with Loc/Precision Mini-Magg rocket</td>
<td>Rocket constraint</td>
<td>HIGH</td>
<td>MECH 03</td>
<td></td>
</tr>
<tr>
<td>MECH 03</td>
<td>System shall fit inside section of 130 mm diameter and 152 length</td>
<td>Rocket constraint</td>
<td>HIGH</td>
<td>MECH 02</td>
<td></td>
</tr>
<tr>
<td>MECH 04</td>
<td>Descent control may occupy 76 mm above payload section</td>
<td>Decent control releasability upon ejection</td>
<td>LOW</td>
<td></td>
<td></td>
</tr>
<tr>
<td>MECH 05</td>
<td>No protrusions beyond payload envelop prior to ejection</td>
<td>Autonomous operation</td>
<td>HIGH</td>
<td>MECH 02</td>
<td></td>
</tr>
<tr>
<td>MECH 06</td>
<td>No parts may be restrained by rocket airframe</td>
<td>Autonomous operation</td>
<td>HIGH</td>
<td>MECH 02</td>
<td></td>
</tr>
<tr>
<td>MECH 07</td>
<td>Operations shall not employ rocket airframe or payload section</td>
<td>Autonomous operation</td>
<td>HIGH</td>
<td>MECH 08</td>
<td></td>
</tr>
<tr>
<td>MECH 08</td>
<td>System must deploy from payload section</td>
<td>Rocket constraint</td>
<td>HIGH</td>
<td>MECH 07</td>
<td></td>
</tr>
<tr>
<td>MECH 09</td>
<td>Lander must be deployed at 91 m</td>
<td>Base mission requirement</td>
<td>HIGH</td>
<td></td>
<td></td>
</tr>
<tr>
<td>MECH 10</td>
<td>Carrier and Lander must descend as a unit prior to separation</td>
<td>Base mission requirement</td>
<td>HIGH</td>
<td>MECH 09</td>
<td></td>
</tr>
<tr>
<td>MECH 11</td>
<td>Electronics must be enclosed with the exception of sensors</td>
<td>Failure prevention; safety constraint</td>
<td>MED</td>
<td>MECH 19</td>
<td></td>
</tr>
<tr>
<td>MECH 12</td>
<td>Structure must support 10 g shock</td>
<td>Failure prevention</td>
<td>MED</td>
<td>MECH 11</td>
<td></td>
</tr>
<tr>
<td>MECH 13</td>
<td>Structure must survive 30 g shock</td>
<td>Failure prevention</td>
<td>MED</td>
<td>MECH 11</td>
<td></td>
</tr>
<tr>
<td>MECH 14</td>
<td>Electronics must be hard-mounted</td>
<td>Failure prevention; safety constraint</td>
<td>MED</td>
<td>MECH 11</td>
<td></td>
</tr>
<tr>
<td>MECH 15</td>
<td>Mechanisms must be capable of withstanding shock force</td>
<td>Failure prevention; safety constraint</td>
<td>MED</td>
<td>MECH 11</td>
<td></td>
</tr>
<tr>
<td>MECH 16</td>
<td>Mechanisms must not use pyrotechnics</td>
<td>Safety constraint</td>
<td>MED</td>
<td></td>
<td></td>
</tr>
<tr>
<td>MECH 17</td>
<td>Mechanisms utilizing heat must be enclosed</td>
<td>Safety constraint</td>
<td>MED</td>
<td>MECH 12</td>
<td></td>
</tr>
<tr>
<td>MECH 18</td>
<td>Lander must safely land an egg</td>
<td>Base mission requirement</td>
<td>HIGH</td>
<td></td>
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</tr>
<tr>
<td>MECH 19</td>
<td>Electronics must be enclosed</td>
<td>Failure prevention; safety constraint</td>
<td>MED</td>
<td>MECH 12</td>
<td></td>
</tr>
<tr>
<td>MECH 20</td>
<td>Structure must support 10 g shock</td>
<td>Failure prevention</td>
<td>MED</td>
<td>MECH 13</td>
<td></td>
</tr>
<tr>
<td>MECH 21</td>
<td>Structure must survive 30 g shock</td>
<td>Failure prevention</td>
<td>MED</td>
<td>MECH 13</td>
<td></td>
</tr>
<tr>
<td>MECH 22</td>
<td>Electronics must be hard-mounted</td>
<td>Failure prevention; safety constraint</td>
<td>MED</td>
<td>MECH 13</td>
<td></td>
</tr>
</tbody>
</table>
Lander Egg Protection Trade & Selection

- **Options Considered**
  - Bread dough
  - Lightweight bubble wrap
  - Lightweight packaging foam

- **Criteria for Selection**
  - Must effectively prevent egg from being damaged
  - Capable of absorbing 30G shock force from egg
  - Mass efficiency, cost efficiency

- **Selection and Rationale**
  - Selection had not been made
  - Testing is currently underway
Mechanical Layout of Components
Trade & Selection

• **Options considered**
  – Isolate components
    • Have individual mounting structure for each
    • This was last year’s layout method
  – Group components
    • Have components all mounted to the PCB
    • Eliminate mass otherwise allocated for mounting
    • Requires larger PCB area

• **Criteria for selection**
  – Space efficiency
  – Accessibility to electronics, egg, decent control, camera
  – Machinability
  – Low risk of interfering with decent control

• **Selection and rationale**
  – Grouping the components before mounting is the preferred option
  – A Cansat prototype has already been developed using this method

Presenter: Britanni Searcy
Material Selections

- **Carrier and Lander frame will be machined from Polycarbonate billet**
  - Low density, $1190 \frac{kg}{m^3}$
  - Robust structural integrity, $\sigma_{tensile} = 75 \text{ MPa}$
  - Easily machined

- **Electronics will be enclosed by thin sheets of Polycarbonate**
  - Completely transparent
  - 0.75 mm thickness
  - Readily available

**Polycarbonate Chemical Structure**

![Thin Polycarbonate](image-url)
• The Carrier and Lander will be connected by monofilament cord
  – At 91m chromium wire will cut the monofilament cord, separating the units
  – The chromium wire will also release a parasheet for the Lander
Structure Survivability Trades

- All Electronics and Frame must withstand 10G acceleration
  - On Carrier and Lander, the PCB will be mounted directly to frame with standoffs
  - A removable structural enclosure made of polycarbonate will be used to prevent damage to electronics
- A prototype will be developed for testing
- The final design will be analyzed with Patran/Nastran
## Mass Budget

**Expected system mass:** 420 g (system) + 60 g (egg)

<table>
<thead>
<tr>
<th>System</th>
<th>Subsystems</th>
<th>System Mass (g)</th>
<th>Subsystem</th>
<th>Subsystem Mass (g)</th>
<th>Percent</th>
</tr>
</thead>
<tbody>
<tr>
<td>CanSat</td>
<td>Carrier</td>
<td>240</td>
<td>Frame</td>
<td>70</td>
<td>29</td>
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<tr>
<td></td>
<td></td>
<td></td>
<td>Electronics</td>
<td>140</td>
<td>58</td>
</tr>
<tr>
<td></td>
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<td>Streamer</td>
<td>20</td>
<td>8</td>
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<tr>
<td></td>
<td></td>
<td></td>
<td>Margin</td>
<td>10</td>
<td>4</td>
</tr>
<tr>
<td></td>
<td>Lander</td>
<td>180</td>
<td>Frame</td>
<td>80</td>
<td>44</td>
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<tr>
<td></td>
<td></td>
<td></td>
<td>Parasheet</td>
<td>20</td>
<td>11</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Electronics</td>
<td>70</td>
<td>39</td>
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<tr>
<td></td>
<td></td>
<td></td>
<td>Margin</td>
<td>10</td>
<td>6</td>
</tr>
<tr>
<td>Egg</td>
<td></td>
<td>Not Part of Mass Limits</td>
<td>60</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Note: All values are estimates.
Communications and Data Handling Subsystem Design

Amun Jarzembski
Sophomore, Mechanical Engineering
CDH Overview

- **Data collected by Cansat is handled two ways:**
  - On board storage for post processing
    - Carrier and lander
  - Radio transmission to ground station for real time observation – XBEE radio
    - Carrier only
- **Processor**
  - Holds flight software
- **Locator device**
  - For finding Cansat after flight

Data from high altitude balloon test. UAH SHC
December 8, 2011

Temperature data

Accelerometer data
## CDH Requirements

<table>
<thead>
<tr>
<th>Section ID</th>
<th>Requirement</th>
<th>Rationale</th>
<th>Priority</th>
<th>Parent</th>
<th>Children</th>
</tr>
</thead>
<tbody>
<tr>
<td>CDH 01</td>
<td>Radio must be XBEE XBP24BZ7SIT-004 or XBP24BZ7UIT-004</td>
<td>Communications control; fairness</td>
<td>HIGH</td>
<td>CDH 02</td>
<td></td>
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<tr>
<td>CDH 02</td>
<td>Radio must have NETID set to team number</td>
<td>Communications control</td>
<td>MED</td>
<td>CDH 01</td>
<td></td>
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<tr>
<td>CDH 03</td>
<td>Radio must not use broadcast mode</td>
<td>Communications control</td>
<td>MED</td>
<td>CDH 01</td>
<td></td>
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<tr>
<td>CDH 04</td>
<td>GPS based UTC time must be transmitted at 0.5 Hz</td>
<td>Demonstrates ability to communicate with system</td>
<td>MED</td>
<td></td>
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<tr>
<td>CDH 05</td>
<td>GPS based latitude in degrees must be transmitted at 0.5 Hz</td>
<td>Demonstrates ability to communicate with system</td>
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<tr>
<td>CDH 06</td>
<td>GPS based longitude in degrees must be transmitted at 0.5 Hz</td>
<td>Demonstrates ability to communicate with system</td>
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<tr>
<td>CDH 07</td>
<td>GPS based mean sea level altitude must be transmitted at 0.5 Hz</td>
<td>Demonstrates ability to communicate with system</td>
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<td>CDH 08</td>
<td>GPS number of satellite tracked must be transmitted at 0.5 Hz</td>
<td>Demonstrates ability to communicate with system</td>
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<tr>
<td>CDH 09</td>
<td>Non-GPS altitude in meters must be transmitted at 0.5 Hz</td>
<td>Demonstrates ability to communicate with system</td>
<td>MED</td>
<td>ELEC 03</td>
<td></td>
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<tr>
<td>CDH 10</td>
<td>Air temperature in celsius must be transmitted at 0.5 Hz</td>
<td>Demonstrates ability to communicate with system</td>
<td>MED</td>
<td></td>
<td></td>
</tr>
<tr>
<td>CDH 11</td>
<td>Battery voltage in volts must be transmitted at 0.5 Hz</td>
<td>Demonstrates ability to communicate with system</td>
<td>MED</td>
<td></td>
<td></td>
</tr>
<tr>
<td>CDH 12</td>
<td>Carrier must video separation; video must not start more than 2 seconds prior to separation</td>
<td>Selectable objective requirement</td>
<td>MED</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Presenter:** Amun Jarzembski
Processor Trade & Selection

- **Microcontrollers:**
  - ATMega 2560 – 8 MHz processing when operating at 3.3V
    - 4 serial USARTs
  - ATMega 328p – 8 MHz processing
    - 1 serial USARTs

- **Selection Criteria**
  - Multiple serial USARTs for carrier
    - GPS and radio
  - SPI communication
    - SD card
  - Arduino compatibility – ease of programming

- **Selection:** ATMega 2560 – both lander and carrier
  - Duplication of circuit boards

Presenter: Amun Jarzembski
Memory Trade & Selection

- **Data Storage:**
  - Kingston 4Gb Micro SD-HC card – “high capacity”
  - Micron 4Gb embedded USB mass storage drive (e230)

- **Selection Criteria**
  - Small mass and volume consumption
  - Software compatibility - ease of programming

- **Selection: Kingston 4Gb Micro SD-HC card**
  - Use of surface mount SD adapter
  - Easy data retrieval
  - Will be used for internal camera storage
Carrier Antenna Trade & Selection

- **Antenna options:**
  - Digi A24-HASM-450 - 2.4 GHz and 2.1 dBi gain
  - Laird MAF94016 whip antenna - 2.4 GHz

- **Selection criteria:**
  - Small mass and volume consumption
  - Same operational frequency as XBEE radio

- **Selection: Digi A24-HASM-450**
  - RPSMA connection – interface

- **Antenna will be stripped down to save mass**

Presenter: Amun Jarzembski
Radio Configuration

• **Cansat radio:**
  – Correct radio operation is essential for many aspects of the Cansat mission
  – Operates through serial USART on microcontroller
  – 2.4 GHz operation frequency
  – API operation mode as oppose to broadcast

• **Testing**
  – The radios will be used throughout testing
    • Helicopter drop test
Carrier Telemetry Format

- **Data to be transmitted from carrier every 2 seconds:**
  - Time stamp
  - Altitude from launch ground
  - GPS data
    - UTC time
    - Latitude
    - Longitude
    - Mean Sea level altitude
    - Number of satellites tracked
  - Temperature
  - Battery voltage
- **Data will be separated by commas and formatted onboard to observable values.**

Presenter: Amun Jarzembski
Activation of Telemetry Transmissions

- Telemetry transmissions are enabled via remote command on the launch pad
  - Using a Graphical User Interface (GUI) created by the Ground Station team we are able to tell the Cansat to begin sending telemetry with the press of a single button.
Locator Device Trade & Selection

• **Buzzer options:**
  – CST-931AP - magnetic buzzer
  – PS1420P02CT – “plug n’ play buzzer”

• **Selection criteria:**
  – Small volume and mass consumption
  – 80db volume level

• **Selection: CST-931AP for both carrier and lander**

• **Autonomous activation:**
  – Locator devices will be activated 45s after falling below 30m.
  – Secondary check: receiving the same latitude and longitude data from GPS for 3 minutes will also initialize locator devices.

• **Deactivation will be done manually when the Cansat has been found**
Electrical Power Subsystem Design

Angela Yi
Freshman, Chemical Engineering
EPS Overview

**SENSORS**
- Pressure
- Temperature
- GPS

**MCU**

**MEMORY**

**POWER**
- Camera
- Voltage Regulator
- MOSFET
- Battery
- Antenna
- Buzzer
- Radio
### EPS Requirements

<table>
<thead>
<tr>
<th>Section</th>
<th>ID</th>
<th>Requirement</th>
<th>Rationale</th>
<th>Priority</th>
<th>Parent</th>
<th>Children</th>
</tr>
</thead>
<tbody>
<tr>
<td>ELEC</td>
<td>01</td>
<td>Carrier and Lander must have locating device with 3 hour operation</td>
<td>Increases ability to locate systems</td>
<td>MED</td>
<td></td>
<td></td>
</tr>
<tr>
<td>ELEC</td>
<td>02</td>
<td>Locator devices must be independently powered with switch</td>
<td>Power conservation and control</td>
<td>MED</td>
<td>ELEC 04</td>
<td></td>
</tr>
<tr>
<td>ELEC</td>
<td>03</td>
<td>Carrier and Lander must have external power switch</td>
<td>Power conservation and control</td>
<td>MED</td>
<td>ELEC 02</td>
<td></td>
</tr>
<tr>
<td>ELEC</td>
<td>04</td>
<td>System must be capable of one hour wait plus flight time</td>
<td>Prevention of power exhaustion</td>
<td>MED</td>
<td></td>
<td></td>
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<tr>
<td>ELEC</td>
<td>05</td>
<td>System must not use LiPo batteries</td>
<td>Safety constraint</td>
<td>MED</td>
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<td></td>
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<tr>
<td>ELEC</td>
<td>06</td>
<td>Carrier must have locating device with 3 hour operation</td>
<td>Increases ability to locate system</td>
<td>MED</td>
<td>ELEC 04</td>
<td></td>
</tr>
<tr>
<td>ELEC</td>
<td>07</td>
<td>Lander must have locating device with 3 hour operation</td>
<td>Increases ability to locate system</td>
<td>MED</td>
<td>ELEC 01</td>
<td></td>
</tr>
</tbody>
</table>

Presenter: Angela Yi
Cansat 2012 PDR: Team 1024, “Bumblebee”

Lander Electrical Block Diagram

- Microcontroller
- Altitude Sensor
- Memory
- FTDI
- Temperature sensor
- LED
- Altitude reset
- Audible beacon
- I/O switch
- Voltage regulator
- Reset button

No Radio
No GPS
No Camera
No Hotwires

Presenter: Angela Yi
# Carrier Power Budget

<table>
<thead>
<tr>
<th>Device</th>
<th>Supply Voltage (V)</th>
<th>Operating Current (mA)</th>
<th>Max Power (mW)</th>
<th>Operating Time (hr)</th>
<th>Gross Energy (mW·hr)</th>
</tr>
</thead>
<tbody>
<tr>
<td>MCU</td>
<td>3.3</td>
<td>80</td>
<td>264</td>
<td>1.2</td>
<td>316.8</td>
</tr>
<tr>
<td>Memory</td>
<td>3.3</td>
<td>5</td>
<td>16.5</td>
<td>1.2</td>
<td>19.8</td>
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<tr>
<td>Antenna</td>
<td>3.3</td>
<td>60</td>
<td>198</td>
<td>1.2</td>
<td>237.6</td>
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<tr>
<td>GPS</td>
<td>3.3</td>
<td>60</td>
<td>198</td>
<td>1.2</td>
<td>237.6</td>
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<td>Pressure Sensor</td>
<td>3.3</td>
<td>4</td>
<td>13.2</td>
<td>1.2</td>
<td>15.84</td>
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<tr>
<td>Hotwire</td>
<td>6</td>
<td>1000</td>
<td>6000</td>
<td>0.03</td>
<td>200</td>
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<tr>
<td>Thermistor</td>
<td>3.3</td>
<td>2</td>
<td>6.6</td>
<td>1.2</td>
<td>7.92</td>
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<tr>
<td>Buzzer</td>
<td>3.3</td>
<td>12</td>
<td>39.6</td>
<td>5</td>
<td>198</td>
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<tr>
<td>Camera</td>
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<td>80</td>
<td>264</td>
<td>0.2</td>
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<td>LED</td>
<td>3.3</td>
<td>40</td>
<td>132</td>
<td>1.2</td>
<td>158.4</td>
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<tr>
<td><strong>TOTAL</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td><strong>1444.76 mW·h</strong></td>
</tr>
</tbody>
</table>

CR123A battery capacity: 4500 mW·hr (each)
## Lander Power Budget

<table>
<thead>
<tr>
<th>Device</th>
<th>Supply Voltage (V)</th>
<th>Operating Current (mA)</th>
<th>Max Power (mW)</th>
<th>Operating Time (hr)</th>
<th>Gross Energy (mW·hr)</th>
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<td>80</td>
<td>264</td>
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<tr>
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<td>5</td>
<td>16.5</td>
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<td>Pressure Sensor</td>
<td>3.3</td>
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<td>LED</td>
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<td>40</td>
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<td>158.4</td>
</tr>
<tr>
<td><strong>TOTAL</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td><strong>716.76 mW·h</strong></td>
</tr>
</tbody>
</table>

CR123A battery capacity: 4500 mW·hr (each)
Power Source Trade & Selection

• **Options considered**
  – CR123A Lithium (typically used in cameras)
    • 3 V DC, 1500 mA·hr capacity
    • 1500 mA continuous, 3000 mA instantaneous discharge
  – CR2032 Lithium (typically used in watches)
    • 3 V DC, 225 mA·hr capacity

• **Criteria for selection**
  – Capable of supplying required power
  – Low mass and volume
  – Not lithium polymer

• **Selection, Carrier**
  – The CR123A is the preferred option, two will be used
  – Capable of the 1445 mW·hr required

• **Selection, Lander**
  – No selection made
  – The EPS team is investigating the options

Presenter: Angela Yi
**Battery Voltage Measurement**  
**Trade & Selection**

- **Selection**
  - ADC Measurement
  - Battery voltage will be measured by reading the microcontroller’s ADC for both Carrier and Lander
  - This information will be recorded and transmitted by the Carrier; just recorded by the Lander

- **Rationale**
  - This method had proved trustworthy in the past
  - Used on Cansat 2011
  - Requires no additional devices or inputs
Flight Software Design

Amun Jarzembski
Sophomore, Mechanical Engineering
FSW Overview

• **Basics**
  - Initialization of pins and variables
  - Acquisition of data through the pins
  - Completing commands based on the data

• **Arduino interface**
  - Language similar to C
  - Arduino built in libraries
    • SD.h, analogRead(), digitalWrite(), etc.
  - Compatibility with microcontrollers

---

Presenter: Amun Jarzembski

Cansat 2012 PDR: Team 1024, “Bumblebee”
FSW Overview

- **Acquisition of Data**
  - Altitude, temperature, GPS telemetry, and battery voltage
  - Conversion to altitude from pressure

- **Commands**
  - Carrier executes decent control stages and initializes video based on altitude.
  - Both carrier and lander initialize audible beacons.

- **Lander software is the same as the carrier’s without GPS telemetry, radio transmission, decent control execution, and video initialization.
## FSW Requirements

<table>
<thead>
<tr>
<th>Section</th>
<th>ID</th>
<th>Requirement</th>
<th>Rationale</th>
<th>Priority</th>
<th>Parent</th>
<th>Children</th>
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</thead>
<tbody>
<tr>
<td>SOFT</td>
<td>01</td>
<td>GPS based UTC time must be transmitted at 0.5 Hz</td>
<td>Demonstrates ability to communicate with system</td>
<td>MED</td>
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<tr>
<td>SOFT</td>
<td>02</td>
<td>GPS based latitude in degrees must be transmitted at 0.5 Hz</td>
<td>Demonstrates ability to communicate with system</td>
<td>MED</td>
<td></td>
<td></td>
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<td>SOFT</td>
<td>03</td>
<td>GPS based longitude in degrees must be transmitted at 0.5 Hz</td>
<td>Demonstrates ability to communicate with system</td>
<td>MED</td>
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<tr>
<td>SOFT</td>
<td>04</td>
<td>GPS based mean sea level altitude must be transmitted at 0.5 Hz</td>
<td>Demonstrates ability to communicate with system</td>
<td>MED</td>
<td></td>
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<tr>
<td>SOFT</td>
<td>05</td>
<td>GPS number of satellites tracked must be transmitted at 0.5 Hz</td>
<td>Demonstrates ability to communicate with system</td>
<td>MED</td>
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<tr>
<td>SOFT</td>
<td>06</td>
<td>Non-GPS altitude in meters must be transmitted at 0.5 Hz</td>
<td>Demonstrates ability to communicate with system</td>
<td>MED</td>
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<td>ELEC 03</td>
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<tr>
<td>SOFT</td>
<td>07</td>
<td>Air temperature in celsius must be transmitted at 0.5 Hz</td>
<td>Demonstrates ability to communicate with system</td>
<td>MED</td>
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<tr>
<td>SOFT</td>
<td>08</td>
<td>Battery voltage in volts must be transmitted at 0.5 Hz</td>
<td>Demonstrates ability to communicate with system</td>
<td>MED</td>
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<tr>
<td>SOFT</td>
<td>09</td>
<td>Ground control must initiate system telemetry transmission</td>
<td>Demonstrates ability to communicate with system</td>
<td>HIGH</td>
<td>GND 01</td>
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<tr>
<td>SOFT</td>
<td>10</td>
<td>Carrier must video separation; video must not start more than 2 seconds prior to separation</td>
<td>Selectable objective requirement</td>
<td>MED</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Carrier Cansat FSW Overview

• Transmissions through radio
• Carrier data will be stored to a 4Gb Micro SD-HC card for post processing – non volatile memory
  – Stored in the same format as transmitted
• Major decision points:
  – Set local altitude as a reference
  – Make sure that carrier has begun its decent
  – Decent control can now be executed as well as the carrier/lander separation
  – Before carrier/lander separation, video will be initialized
  – Activation of beacon
  – Ending transmissions

```c
//Establishing that the payload has reached 250 meters
//Stage3: after reaching 250 meters, apogee, and falling to 200 meters
if (alt_ground > 250 && d==1)
{
  c = 1;
  progress = 3;
  d = d+1;
}
```
Carrier Cansat FSW Flow Diagram

**Launch**
- **Set launch ground alt' as reference**
- **Alt' >250 m ?**
  - No
  - **Collect data (Temp, Alt, GPS)**
  - **Write and transmit data**
- **Alt' <200 m ?**
  - Yes
  - **Collect, Write, & Transmit Data**
- **Alt' <91 m ?**
  - Yes
  - **Decent control 1**
  - **Collect, Write, & Transmit Data**
  - **Collect, Write, & Transmit Data**
  - **Alt' <101 m ?**
    - Yes
    - **Record video**
    - **Collect, Write, & Transmit Data**
  - No
- **Alt' <30 m for 45s?**
  - Yes
  - **Collect, Write, & Transmit Data**
  - **Stop writing & transmitting data**
  - **Stop recording video**
  - **Turn on beacon**

**Flight**
- **Collect, Write, & Transmit Data**
- **Alt' <200 m ?**
  - Yes
  - **Decent control 1**
  - **Collect, Write, & Transmit Data**
  - **Collect, Write, & Transmit Data**
  - **Alt' <91 m ?**
    - Yes
    - **Decent control 2 Payload separation**
    - **Collect, Write, & Transmit Data**
    - **Collect, Write, & Transmit Data**
    - **Alt' <30 m for 45s?**
      - Yes
      - **Collect, Write, & Transmit Data**
      - **Stop writing & transmitting data**
      - **Stop recording video**
      - **Turn on beacon**
  - No

**Landing**
- **Collect, Write, & Transmit Data**
- **Alt' <30 m for 45s?**
  - Yes
  - **Collect, Write, & Transmit Data**
  - **Stop writing & transmitting data**
  - **Stop recording video**
  - **Turn on beacon**

*Will have secondary check*
Lander Cansat FSW Overview

• Lander data will be stored to a 4Gb Micro SD-HC card for post processing – non volatile memory
  – Altitude will be the only observable value.
  • Pressure to altitude for lander decision points

• Major decision points:
  – Set local altitude as a reference
  – Make sure that the lander has begun its decent.
  – Activation of beacon

```c
//Reference level initialization: “altitude of launch ground”
if (analogRead(refin) > 780)
{
    alt_ref = alt_sea;
    f = 1;
}
else
{
    if (f==0)
    {
        alt_ref = 0;
    }
}
```
//Stage6: On ground
if (alt_ground < 20 && c==1 && h < 108000)
{
    g = g+1;
    if (g > 300)
    {
        digitalWrite(buzzin,HIGH);
        h = h+1;
        if (d==4)
        {
            progress = 6;
            d = d+1;
        }
    }
}
else
{
    g = 0;
    digitalWrite(buzzin,LOW);
}
Software Development Plan

• Software prototyping was done in the Arduino environment, where all data values can be viewed in the serial port.
• High priority decision points will have a secondary check system
• Testing: high altitude balloon flights and helicopter drop test.
• Software development sequence:
  – Communications with sensors, storing to memory, and command execution using Arduino breakout boards
  – Switching from Arduino breakout boards to single ATMega microcontrollers
  – Transmitting data values with the radio
• Team
  – Amun Jarzembski – primary software developer
  – Yang Wang – secondary software developer
Ground Control System Design

Tyler Hughes
Sophomore, Electrical Engineering
GCS Overview

- GCS initiates telemetry transmission
- Live data display; real time plot
- Currently investigating MATLAB versus C# for software interface

CANSAT

GCS

Telemetry transmits at 0.5 Hz

Receiver must be elevated 3.5 meters

RPSMA connection type

• Cansat will be recovered based on final GPS coordinates

Presenter: Tyler Hughes
# GCS Requirements

<table>
<thead>
<tr>
<th>Section</th>
<th>ID</th>
<th>Requirement</th>
<th>Rationale</th>
<th>Priority</th>
<th>Parent</th>
<th>Children</th>
</tr>
</thead>
<tbody>
<tr>
<td>GND</td>
<td>01</td>
<td>Ground control antenna must be elevated 3.5 m minimum</td>
<td>Prevention of signal loss</td>
<td>MED</td>
<td>GND 03</td>
<td></td>
</tr>
<tr>
<td>GND</td>
<td>02</td>
<td>Ground control must initiate system telemetry transmition</td>
<td>Demonstrates ability to communicate with system</td>
<td>HIGH</td>
<td>GND 01</td>
<td></td>
</tr>
<tr>
<td>GND</td>
<td>03</td>
<td>Ground control station with real-time data must be used</td>
<td>Demonstration of ability to locate system</td>
<td>HIGH</td>
<td>GND 01</td>
<td></td>
</tr>
</tbody>
</table>
GCS Antenna Trade & Selection

- **Antenna**
  - The Digi A24-HASM-450, 2.4 GHz will be used

- **Internally fabricated antenna**
  - Will use our internally fabricated self tracking antenna, known as MUGSEE
  - Was used as the GCS receiver for Cansat 2011

- **Placement and coverage**
  - The MUGSEE antenna will be elevated 3.5 meters with a retractable tower made from 80-20 Aluminum beams; internally fabricated
GCS Software

- Telemetry display prototypes
  - Displayed using C#, Matlab GUI
- Commercial off the shelf (COTS) software packages used
  - None will be used.
- Real-time plotting software design
  - We are currently investigating the options of designing the software in Matlab vs C#
- Data archiving and retrieval approach
  - We will be exporting data to a text file.
- Command software and interface
  - The command software will be the same as the plotting software.
Cansat Integration and Testing

Yang Wang
Sophomore, Mechanical Engineering
Cansat Integration and Test Overview

• Testing
  – Extensive system, subsystem, and component testing is necessary to ensure a successful flight
  – It is important to perform lower level tests first

• Integration
  – The individual components and subsystems will be integrated after low-level testing is complete
  – The integrated Cansat will then be tested as a interdependent system

Cansat team members testing devices with an Arduino Uno
Subsystem Test Sequence

• The following test sequence will be performed
  – Component testing
    • Sensors
      – GPS, radio, camera
    • EPS devices
      – Buzzer, voltage regulator, power switch, batteries
    • Memory system
  – Subsystem testing
    • Descent control
      – Parasheet, steamer, mechanical structure effects on drag coefficient
    • Printed circuit board with components
    • Mechanical structure
      – Resistance to breaking, ability to absorb shock
  – Full systems test
    • The Cansat will be tested as a system; fully autonomous
    • Will be launched to 600 meters altitude
Testing Environments and Equipment

• Equipment usage
  – The Cansat team has access to a wide arrangement of test equipment through its parent organization, the Space Hardware Club

• Testing will proceed in the following environments
  – Sensors and EPS components will be tested individually on a breadboard, then on printed circuit board
    • Pressure sensor will be tested in a vacuum chamber and on high altitude balloon flights
  – Descent control will be tested by two types of drop tests
    • Rocket – drop canisters have been manufactured for Cansat mass simulation
    • Helicopter – a research platform belonging to UAHuntsville, the Cansat team has received permission to test descent control
  – Egg protection will be tested with small drop modules
Mission Operations and Analysis

Yang Wang
Sophomore, Mechanical Engineering
Overview of Mission - Sequence of Events

• **Pre-Launch**
  – Arrival at competition site
  – Set up ground control station
  – Perform system data storage and communication test

• **Launch preparation**
  – Install flight batteries
  – Verify system power-up
  – Install egg and record system mass
  – Receive approval for launch
  – Ground Control initiates data transmission
  – COMM link confirmed

• **Launch**

• **Flight**
  – Ground Control receives telemetry real time
  – Recovery Team located rocket and Cansat during descent

• **Recovery**
  – Ground Control verifies touchdown
  – Recovery permission received from RSO
  – Recover hardware based on GPS coordinates and telemetry based predictions

• **Post flight**
  – Retrieve data from Carrier and Lander memory to verify successful flight

Cansat programmers Amun Jarzembski and Yang Wang prepare a high-altitude balloon payload
Overview of Mission – Team Member Responsibilities

- Setup Team
  1. Setup tarp
  2. Take gear to work area

- Test and Assembly Team
  1. Perform final tests
  2. Assemble Cansat

- Recovery Team
  1. Tracks Cansat descent
  2. Recovers Cansat safely

- Ground Control Team
  1. Starts data transmission
  2. Reports flight telemetry

- Data Analysis Team
  1. Analyzes stored data
  2. Verifies flight success

- Team Lead
  1. Communicate with LCO, RSO, judge
  2. Designates tasks
  3. Ensures job completion
  4. Verifies flight readiness

- RSO
- LCO

- The chain of command is an important contributing factor to mission success
- Designated tasks will be rehearsed prior to launch day for optimal performance
- The Mission Ops Manual will include details specific to each operation team

Presenter: Yang Wang
• **Mission Operations Manual**
  – A step-by-step guide to all launch-day operations including setup, final testing, assembly, rocket integration, launch, and recovery
  – The Mission Ops Manual will be closely followed by all subteams

• **Development plan**
  – Authored by several team members, based on section
    • Ground Station Configuration – Ground Control Officer
    • Cansat Test Procedure – Chief Engineer
    • Cansat Preparation – Chief Engineer
    • Cansat Integration – Chief Engineer
    • Launch Preparation – Chief Engineer
    • Launch Procedure – Team Lead
    • Removal Procedure – Team Lead
  – Final publication approval will be given by the team lead
  – Each operation team will have a copy on launch-day
Cansat Location and Recovery

• **Location**
  - Recovery team will attempt to spot system during descent
  - System is programmed to store and transmit telemetry for three minutes after touchdown
  - Final GPS based latitude and longitude received by Ground Control will be used to obtain directional heading
  - Coordinates will be put into a GPS tracking system
  - The Lander’s buzzer will aid in its recovery

• **Recovery**
  - The system will be powered off by the external power switch
  - Data analysis will be performed after recovery to verify telemetry storage and decent rate measurement
Management

John Alcorn
Junior, Aerospace Engineering
## Cansat Budget – Hardware

<table>
<thead>
<tr>
<th>Device</th>
<th>Manufacturer Model #</th>
<th>Vendor Part #</th>
<th>Trade</th>
<th>Vendor</th>
<th>Quantity</th>
<th>Price Each</th>
<th>Subtotal</th>
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</thead>
<tbody>
<tr>
<td>Antenna</td>
<td>A24-HASM-450-ND</td>
<td>A24-HASM-450-ND</td>
<td>Digi</td>
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<td>Audible Beacon</td>
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<td>Veho</td>
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<td>Frame/Housing</td>
<td>INTERNAL FABRICATION</td>
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<tr>
<td>GPS</td>
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<td>#1249</td>
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<td>Memory</td>
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<td>eTech</td>
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<td>Microcontroller</td>
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<td>Radio</td>
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<td>Ripstop Nylon</td>
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**TOTAL** $ 407.52

Expected hardware cost: $ 407.52
Cansat Budget – Testing

<table>
<thead>
<tr>
<th>Item</th>
<th>Description</th>
<th>Trade</th>
<th>Quantity</th>
<th>Price</th>
<th>Cost</th>
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<tbody>
<tr>
<td>Rocket Tubing</td>
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<td>Rocketry Warehouse</td>
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**TOTAL:** $536.00

Expected testing cost: $536.00
## Cansat Budget – Travel

### Item Description

<table>
<thead>
<tr>
<th>Item</th>
<th>Description</th>
<th>Quantity</th>
<th>Rate</th>
<th>Duration</th>
<th>Total Costs</th>
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<tbody>
<tr>
<td>Hotel expenses</td>
<td>Lodging in Abilene</td>
<td>4 rooms</td>
<td>$99.00</td>
<td>4 nights</td>
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<td>Food expenses</td>
<td>Dining</td>
<td>10 Students + 2 Advisors</td>
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<td>Vehicle</td>
<td>University vehicle usage</td>
<td>1800 miles</td>
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</table>

**TOTAL:** $4,704.00

Expected travel cost: $4,704.00
Program Schedule

Presenter: John Alcorn

Cansat 2012 PDR: Team 1024, “Bumblebee”
Conclusions

• Accomplishments
  – The team has made major development in electrical, mechanical, software, and descent control
  – This design review highlights our major accomplishments

• Major unfinished work
  – Extensive device testing
  – Mechanical design improvement
  – PCB design
  – Descent control testing
  – Fabrication
  – Systems Testing

• We are ready to continue development
  – Extensive preparation and research have been put into our hardware, concept development, design review, and project organization
  – The design process has been very rewarding so far, the team is excited to continue development

Parts being fabricated in the UAH student machine shop

Presenter: John Alcorn
Questions?

Team Bumblebee at the launch of the UAHuntsville Space Hardware Club’s BalloonSat 16

Left to right: Amun Jarzembski, Glenn Nesbitt, John Alcorn, Yang Wang, Angela Yi, Byron Hall II, Brittani Searcy, Amy Parlett, Tyler Hughes, Geoff Suiter