CanSat 2011
Critical Design Review

Team # 20
Jetfire
The University of Alabama in Huntsville

CanSat CAD Design
Designed by Grad Mentor Eric Becnel
UAH CanSat 2011
Presentation Outline

- Systems Overview
- Sensor Subsystem Design
- Descent Control Design
- Mechanical Subsystem Design
- Communication and Data Handling Subsystem Design
- Electrical Power Subsystem Design
- Flight Software Design
- Ground Control System Design
- CanSat Integration and Test
- Mission Operations & Analysis
- Management
- Presentation Scoring & Additional Information
- Questions?

Egg Drop Module
Designed by Team Leader John Alcorn
Fabricated by Grad Mentor Eric Becnel
UAH Student Shop, CNC Milled

Presenter: John Alcorn
Team Organization

MAE Chair
Dr. Frederick

CanSat Project Leader
John Alcorn
MAE Freshman

Faculty Advisor
Mr. Troy Skinner

Graduate Mentor
Eric Becnel
MAE Grad Student

Systems Engineer
Mark Becnel
MAE Senior

Electrical Systems
Tetsuya Toyama
EE Grad Student

Descent Control
Jennifer Hunt
MAE Senior

System Modeling
Stewart King, MAE Freshman
Caleb Lindsey, MAE Senior

Programming &
Communications Systems
Nathan Newcomb, CPE Senior
Max Avula, CPE Grad Student

Presenter: John Alcorn
CanSat 2011 CDR: Team 20
(Jetfire)
**Acronyms**

<table>
<thead>
<tr>
<th>Acronym</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>UAH</td>
<td>University of Alabama in Huntsville</td>
</tr>
<tr>
<td>PDR</td>
<td>Preliminary Design Review</td>
</tr>
<tr>
<td>MAE</td>
<td>Mechanical Aerospace Engineering</td>
</tr>
<tr>
<td>LiPo</td>
<td>Lithium Polymer</td>
</tr>
<tr>
<td>UTC</td>
<td>Universal Time Constant</td>
</tr>
<tr>
<td>Lat</td>
<td>Latitude</td>
</tr>
<tr>
<td>Lon</td>
<td>Longitude</td>
</tr>
<tr>
<td>GPS</td>
<td>Global Positioning System</td>
</tr>
<tr>
<td>Sats</td>
<td>Satellites</td>
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<tr>
<td>G.S.</td>
<td>Ground Station</td>
</tr>
<tr>
<td>Comm</td>
<td>Communications</td>
</tr>
<tr>
<td>Op. Voltage</td>
<td>Operational Voltage</td>
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<tr>
<td>ADC</td>
<td>Analog to Digital Converter</td>
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<tr>
<td>MCU</td>
<td>Micro-Controller Unit</td>
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<tr>
<td>CDR</td>
<td>Critical Design Review</td>
</tr>
<tr>
<td>PCB</td>
<td>Printed Circuit Board</td>
</tr>
<tr>
<td>SF</td>
<td>Safety Factor</td>
</tr>
<tr>
<td>Cd</td>
<td>Coefficient of Drag</td>
</tr>
</tbody>
</table>

Presenter: John Alcorn  
CanSat 2011 CDR: Team 20  
(Jetfire)
John Alcorn

SYSTEMS OVERVIEW
Mission Summary

CanSat
- a payload that is carried by rocket to approximately 1km and ejected.
- made of two systems, a Carrier and Lander.
- The carrier is the primary component, which mid-descent deploys the Lander unit.

Carrier System
- Ejects the Lander 500 m above the ground
- Maintains 4 m/s descent rate following Lander ejection
- Records and transmits live telemetry data during and after flight
- Beacons an audible signal upon landing

Lander System
- Carries a large egg safely through flight
- Maintains 5.5 m/s descent rate following ejection from the Carrier
- Stores all telemetry data onboard
- Records impact force

Presenter: John Alcorn
CanSat 2011 CDR: Team 20 (Jetfire)
Mission Summary

Carrier and Lander Sub-Systems

• Sensor Design
  – Sensor Testing
• Mechanical Design and Fabrication
  – Egg Protection Testing
  – Ground Station Tower Design
• Electrical Design and Fabrication
  – Sensor Wiring
  – Power System
• Command and Data Handling
  – Sensor Data Handling
  – Radio Transmission
• Ground Station Programming
  – Radio Reception
  – Graphical User Interface
  – Data Analysis
  – Post-Recovery Data Recovery and Analysis
• Descent Control Design and Fabrication

Prototype Lander Nose Cone
Designed by Descent Control Jennifer Hunt
UAH Student Shop, Rapid Prototyped

Presenter: John Alcorn
CanSat 2011 CDR: Team 20 (Jetfire)
Summary of Changes Since PDR

- No major changes since PDR

- Subsystem updates include
  - Mechanical Design Development
  - Structural Materials Testing
  - Egg Protection Testing
  - Decent Control Development
  - Sensor Testing
## System Requirements

<table>
<thead>
<tr>
<th>Section</th>
<th>ID</th>
<th>Requirement</th>
<th>Rationale</th>
<th>Priority</th>
<th>Parent(s)</th>
<th>Children</th>
</tr>
</thead>
<tbody>
<tr>
<td>MECH</td>
<td>01</td>
<td>Total mass of no more than 500g</td>
<td>Mission Requirement</td>
<td>High</td>
<td></td>
<td></td>
</tr>
<tr>
<td>MECH</td>
<td>02</td>
<td>Must fit inside cylinder 72mm dia, 279mm length</td>
<td>Launch system limitations</td>
<td>High</td>
<td></td>
<td></td>
</tr>
<tr>
<td>FINA</td>
<td>03</td>
<td>Total device materials cost less than $1000</td>
<td>Product price limit</td>
<td>Medium</td>
<td></td>
<td></td>
</tr>
<tr>
<td>POWR</td>
<td>04</td>
<td>Not LiPo batteries</td>
<td>Field Safety</td>
<td>High</td>
<td></td>
<td></td>
</tr>
<tr>
<td>MECH</td>
<td>11</td>
<td>Carrier Deploys Lander at 500m above ground</td>
<td>Mission Goal</td>
<td>High</td>
<td>42</td>
<td></td>
</tr>
<tr>
<td>MECH</td>
<td>12</td>
<td>Carrier Decent Rate shall be 4.0 +/- 1.0 m/s</td>
<td>Mission Goal</td>
<td>Medium</td>
<td>42</td>
<td></td>
</tr>
<tr>
<td>ELEC</td>
<td>13</td>
<td>Carrier Audible Beacon, activated at landing</td>
<td>Beacon reduces recovery time</td>
<td>Low</td>
<td>42</td>
<td></td>
</tr>
<tr>
<td>COMM</td>
<td>14</td>
<td>Carrier Laird AC4790-1000M at 200mW</td>
<td>Mission Requirement</td>
<td>Medium</td>
<td></td>
<td></td>
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<tr>
<td>COMM</td>
<td>15</td>
<td>Laird AC4790 API Packet Format</td>
<td>Direct Radio Communication</td>
<td>Medium</td>
<td></td>
<td></td>
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<tr>
<td>COMM</td>
<td>16</td>
<td>Transmission not in broadcast mode</td>
<td>Direct Radio Communication</td>
<td>High</td>
<td></td>
<td></td>
</tr>
<tr>
<td>COMM</td>
<td>17</td>
<td>Transmission terminates within 5 min of landing, verified at Ground Station</td>
<td>Limit transmissions to necessary data</td>
<td>Medium</td>
<td>42</td>
<td></td>
</tr>
<tr>
<td>POWR</td>
<td>18</td>
<td>External power switch and indicator on Carrier</td>
<td>Pre-launch power confirmation</td>
<td>High</td>
<td></td>
<td></td>
</tr>
<tr>
<td>COMM</td>
<td>19</td>
<td>Carrier transmits and records UTC, Lat, Lon, GPS-Alt, # Sats, pressure-based-altitude, air temp(°C), battery (v) every 2 seconds</td>
<td>Reasonable data records. Effective material for G.S. management.</td>
<td>Medium</td>
<td>41,43</td>
<td></td>
</tr>
</tbody>
</table>


Presenter: John Alcorn
## System Requirements

<table>
<thead>
<tr>
<th>Section</th>
<th>ID</th>
<th>Requirement</th>
<th>Rationale</th>
<th>Priority</th>
<th>Parent(s)</th>
<th>Children</th>
<th>VM</th>
</tr>
</thead>
<tbody>
<tr>
<td>MECH</td>
<td>21</td>
<td>Lander Decent Rate shall be 5.5 +/- 1.0 m/s</td>
<td>Decent rate to safely descend from altitude with fragile egg</td>
<td>High</td>
<td>42</td>
<td></td>
<td></td>
</tr>
<tr>
<td>POWR</td>
<td>23</td>
<td>External power switch and indicator on Lander</td>
<td>Pre-launch power confirmation</td>
<td>High</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>ELEC</td>
<td>24</td>
<td>Lander records pressure-based-altitude and battery(v) every 2 sec.</td>
<td>Reasonable data records</td>
<td>Medium</td>
<td>42</td>
<td></td>
<td></td>
</tr>
<tr>
<td>ELEC</td>
<td>25</td>
<td>Lander measures and records force of impact at 100Hz</td>
<td>Reasonable force measurement</td>
<td>Low</td>
<td>44</td>
<td></td>
<td></td>
</tr>
<tr>
<td>COMM</td>
<td>31</td>
<td>Ground Station Antenna more than 3.5m above the ground</td>
<td>Increase range of antenna for reception</td>
<td>High</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>


Presenter: John Alcorn  
CanSat 2011 CDR: Team 20 (Jetfire)
System Concept of Operations

Pre-Flight, Launch, Deployment, and Ejection

1. **Countdown and Launch**
   1. Systems on
   2. Ground station comm link confirmed
   3. Local altitude reset relative to launch site
   4. GPS obtains satellite lock
   5. Carrier and Lander record pressure based altitude onboard
   6. Transmit telemetry once every 2 seconds

2. **Rocket Separation** - At apogee
   Carrier Parachute Deployed

3. **Lander Ejection** - 500 meters above ground
   The Carrier releases the Lander unit
Carrier Descent

- **Final Descent**
  - Carrier Parachute Deployed at Apogee
  - Continue telemetry transmission
  - Ejects the Lander at 500m
  - Descent rate of 4.0 m/s accomplished, after ejection

- **Landing**
  - The force of touchdown will be measured using an 3 axis accelerometer
  - Disable data transmission after 3 min
  - Audible beacon activated, 100dB

- **Recovery**
  - All data will be retrieved at the ground station for post-flight analysis. This is in addition to the transmitted data.
Lander Concept of Operations, Lander

Lander Descent

- **Final Descent**
  - Lander Decelerator Deployed at Ejection (500 m)
  - Descent rate of 5.5 m/s accomplished

- **Landing**
  - Force of touchdown recorded at 100Hz using a 3 axis accelerometer
  - Audible beacon activated, 100dB

- **Recovery**
  - All data will be retrieved at the ground station for analysis
Physical Layout

Chute
Carrier
Lander
Egg

CanSat CAD Design
Designed by Grad Mentor Eric Becnel
UAH CanSat 2011

Presenter: John Alcorn
CanSat 2011 CDR: Team 20
(Jetfire)
Launch Vehicle Compatibility

- The mechanical dimensions must be within the guidelines set by the competition guide.

- To confirm the compatibility with the launch vehicle, we test our manufactured product in a 3" rocket body payload tube.

- No part of the CanSat will attach or be held by the payload tube.

- The orientation of our device within the rocket will be that the CanSat exits Lander nosecone first, and carrier chute last, with concern that the chute opens immediately when deployed.

CanSat CAD Design
Designed by Systems Engineer Mark Becnel
UAH CanSat 2011
Mark Becnel

SENSOR SUBSYSTEM DESIGN

CanSat 2011 CDR: Team 20
(Jetfire)
Sensor Subsystem Overview

Carrier Sensors
- Helical GPS ADH D2523T
- Pressure Sensor MS5534-CM
- Voltmeter ADC on MCU
- Thermistor Vishay 10kOhm
- Accelerometer STLIS3LV02D

Lander Sensors
- Pressure Sensor MS5534-CM
- Voltmeter ADC on MCU
- Thermistor Vishay 10kOhm
- Accelerometer STLIS3LV02D

Presenter: Mark Becnel

CanSat 2011 CDR: Team 20 (Jetfire)
# Sensor Subsystem Requirements

<table>
<thead>
<tr>
<th>Section</th>
<th>ID</th>
<th>Requirement</th>
<th>Rationale</th>
<th>Priority</th>
<th>Parent(s)</th>
<th>Children</th>
</tr>
</thead>
<tbody>
<tr>
<td>SENS</td>
<td>41</td>
<td>GPS Sensor</td>
<td>Collect GPS telemetry data</td>
<td>High</td>
<td>19</td>
<td></td>
</tr>
<tr>
<td>SENS</td>
<td>42</td>
<td>Pressure sensor 2Hz, 5 m altitude resolution</td>
<td>Collect pressure data to calculate altitude</td>
<td>Medium</td>
<td>11,12,13,17, 21,22,24</td>
<td></td>
</tr>
<tr>
<td>SENS</td>
<td>43</td>
<td>Temperature Sensor 2Hz, 1 Degree C resolution,</td>
<td>Collect temperature of air</td>
<td>Low</td>
<td>19</td>
<td></td>
</tr>
<tr>
<td>SENS</td>
<td>44</td>
<td>Force Sensor 100Hz, 1g resolution</td>
<td>Collect impact force of landing at 100Hz</td>
<td>Low</td>
<td>25</td>
<td></td>
</tr>
</tbody>
</table>

Sensor Changes Since PDR

- There are no changes of the Sensors
Carrier GPS Summary

50 Channel Helical, D2523T, S.P.K. Electronics Co.

"The module operates at 3.3VDC and outputs standard format NMEA strings over the TTL/UART pins. It has up to a 4Hz [position] update rate." (Sparkfun.com)

With NMEA format, we will use the GPGGA string, which provides the GPS fix data, which we then translate for position and altitude data.

Resolution of less than:
2 meters latitude and longitude
1 meter altitude

$GPGGA, hhmmss.ss, Latitude, N, Longitude, E, FS, NoSV, HDOP, msl, m, Altref, m, DiffAge, DiffStation*cs<CR><LF>
Carrier Non-GPS Altitude Sensor Summary

MS5534, AMSYS Piezo-resistive pressure cell and an ADC-Interface IC

0.15psi to 16psi within -40degC to 125degC.
Expected flight pressure range:
14.70psi to 12.93psi, which is 0 to 1000m in altitude.

Resolution of 0.00145psi
sufficient for 0.82m altitude resolution.

The rocket will most likely not reach mach 0.3 speed, so
compressibility of air is negligible due to rocket
forces. However, the rocket body may not equalize
totally until the nose cone is release near apogee.

The altitude (pressure) function is defined by:

\[ h[m] = \frac{1 - \left( \frac{p}{101.325[mbar]} \right)^{\frac{1}{5.25588}}}{2.25577 \times 10^{-7}} \]

*The Engineering ToolBox

Information from digikey.com

MS5534
Wired for Programming
UAH CanSat 2011

Presenter: Mark Becnel
CanSat 2011 CDR: Team 20
(Jetfire)
Carrier Air Temperature Summary

• The Carrier and Lander will have three temperature sensors:
  – External thermistor
  – Pressure sensor
  – MCU

• The thermistor installed will be monitored by the MCU ADC. We are using a basic voltage divider to measure the resistance of the thermistor.

• We will generate a temperature function from testing data.

Information from sparkfun.com

Vishay 10k Thermistor
Carrier Impact “Force Sensor” Summary

This sensor is additional to the requirements.

We are using the three accelerometer LIS3LV02DQ to measure the acceleration of impact. This device operates in a +/-6g range.

The expected force is not known. Drop tests are pending the programming of the sensor. These tests will demonstrate the effective maximum expected acceleration, or the saturation of the sensor, should the acceleration exceed 6g's.
MS5534, AMSYS Piezo-resistive pressure cell and an ADC-Interface IC

0.15psi to 16psi within -40degC to 125degC.
Expected flight pressure range:
14.70psi to 12.93psi, which is 0 to 1000m in altitude.

Resolution of 0.00145psi sufficient for 0.82m altitude resolution.

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*The Engineering ToolBox*
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The expected force is not known. Drop tests are pending the programming of the sensor. These tests will demonstrate the effective maximum expected acceleration, or the saturation of the sensor, should the acceleration exceed 6g's.
Jennifer Hunt

DESCENT CONTROL DESIGN
Descent Control Overview

Carrier (4.0 +/- 1.0 m/s)
- Hexagon shaped parasheet
- Center hole for stability
- Similar design to 2009 CanSat parasheet
  - Proven through test flights

Lander (5.5 +/- 1.0 m/s)
- Deployable Decelerator
- Sixty degree half-angle cone
  - Concept for 2011 CanSat
  - Requires carbon fiber and nitinol
- There is test data for cones
- Flight tests for deployable behavior underway

Carrier Descent Simulation
Operated by Descent Control
Jennifer Hunt
UAH CanSat 2011
March 18, 2011

Lander Descent Simulation
Operated by Descent Control
Jennifer Hunt
UAH CanSat 2011
March 18, 2011

Presenter: Jennifer Hunt
CanSat 2011 CDR: Team 20 (Jetfire)
Descent Control Changes Since PDR

- Need $C_d$ for hexagon parasheet
- From 2009 CanSat’s hexagon parasheet
  - Overall Avg. Descent Rate (from pressure and GPS data) = 2.4m/s
- Used to find $C_d$ value of hexagon parasheet

\[
F = m \cdot g \quad F_d = \frac{1}{2} \cdot \rho \cdot v^2 \cdot A \cdot C_d \quad m \cdot g = \frac{1}{2} \cdot \rho \cdot v^2 \cdot A \cdot C_d
\]

Hexagon parasheet $C_d \approx 1.0$
Descent Control Changes Since PDR

- Carrier and parasheet mass = 242 g
- Lander and deployable decelerator = 205 g
- The change in mass directly affects the size, mass, and volume of the parasheet and the deployable decelerator
  - These updated values will be presented in a few slides.
Descent Control Requirements

• Volume Constraints (with SF = 5)
  – Carrier: 21.8%
  – Lander: 0.78%

• Packaging
  – Carrier: Parasheet will fold and wrap around CanSat device
  – Lander: deployable decelerator will collapse and be secured with actuator device

Lander Descent Simulator
Designed by Descent Control Jennifer Hunt
UAH CanSat 2011

Presenter: Jennifer Hunt
Descent Control Requirements

• Masses
  – Combined: 447 grams
  – Carrier: 242 grams
  – Lander: 205 grams

• Descent Rates
  – Combined: 5.58 m/s
  – Carrier: 4.0 +/- 1.0 m/s
  – Lander: 5.5 +/- 1.0 m/s
Descent Control Hardware Summary

• Carrier
  – Passive deployment when exiting rocket body tube
    • Sizing based on aerodynamic equations

• Separation
  – Active actuator release mechanism
    • Actuator discussed further in later slides
Lander

- Passive deployment via nitinol
  - Sizing based on aerodynamic equations
- At equilibrium the aeroelastic force is 2.01N
- To predict deflection, apply the force across the triangle centroids
- Deflection of 10.15° expected
- Implies the legs should be mounted at half-angle of 70.15°
**Descent Rate Estimates**

- **Equations:**
  
  \[ F = m \cdot g \quad F_d = \frac{1}{2} \cdot \rho \cdot v^2 \cdot A \cdot C_d \quad m \cdot g = \frac{1}{2} \cdot \rho \cdot v^2 \cdot A \cdot C_d \]

- **Assumptions:**
  
  – Descent control devices quickly reach equilibrium
  – Standard air conditions (density)
  – Hexagon parasheet \( C_d \approx 1.0 \)
  – Deployable decelerator \( C_d = 0.834 \)
Deployable decelerator $C_d = 0.0112\varepsilon + 0.162$

From Fluid Dynamic Drag, Sighard Hoerner
### Descent Rate Estimates

<table>
<thead>
<tr>
<th></th>
<th>Combined</th>
<th>Carrier</th>
<th>Lander</th>
</tr>
</thead>
<tbody>
<tr>
<td>Descent Rate (m/s)</td>
<td>5.6</td>
<td>4.0 +/- 1.0</td>
<td>5.5 +/- 1.0</td>
</tr>
<tr>
<td>Total Mass (kg)</td>
<td>0.447</td>
<td>0.242</td>
<td>0.205</td>
</tr>
<tr>
<td>Surface Area (m^2)</td>
<td></td>
<td>0.248</td>
<td>0.133</td>
</tr>
<tr>
<td>Diameter (m)</td>
<td></td>
<td>0.562</td>
<td>0.412</td>
</tr>
<tr>
<td>Device Mass (kg)</td>
<td></td>
<td>0.019</td>
<td>0.044</td>
</tr>
<tr>
<td>Volume (mm^3)</td>
<td></td>
<td>49600</td>
<td>1763</td>
</tr>
<tr>
<td>Packed Can Height (mm)</td>
<td></td>
<td>12.2</td>
<td>N/A</td>
</tr>
<tr>
<td>Volume of Can (SF=5) (%)</td>
<td></td>
<td>21.8</td>
<td>0.8</td>
</tr>
</tbody>
</table>

**Mission Requirements**

**Presenter:** Jennifer Hunt

**CanSat 2011 CDR: Team 20 (Jetfire)**
John Alcorn

MECHANICAL SUBSYSTEM DESIGN

CanSat 2011 CDR: Team 20 (Jetfire)
Carrier Components

- Frame which hosts
  - PCB
  - Antenna
  - Deployment Actuator
  - Electronic Components

- Parachute

Lander Components

- Frame which hosts
  - Egg Protection
  - PCB
  - Decelerator Mounting
  - Electronic Components

- Deployable Decelerator

Presenter: John Alcorn
Only changes are development of previous objectives.
# Mechanical Subsystem Requirements

<table>
<thead>
<tr>
<th>Section</th>
<th>ID</th>
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<th>Priority</th>
<th>Parent(s)</th>
</tr>
</thead>
<tbody>
<tr>
<td>MECH</td>
<td>01</td>
<td>Shall have no more than 500g total mass</td>
<td>Total mass adjusts launch costs and must be limited</td>
<td>High</td>
<td>VM AI IT D</td>
</tr>
<tr>
<td>MECH</td>
<td>02</td>
<td>Shall not protrude cylinder of size of 72mm diameter, 279mm length</td>
<td>Total size is limited by launch capabilities</td>
<td>High</td>
<td></td>
</tr>
<tr>
<td>MECH</td>
<td>11</td>
<td>Carrier Deploys Lander at 500m</td>
<td>Mission Goal</td>
<td>Medium</td>
<td></td>
</tr>
</tbody>
</table>

Presenter: John Alcorn
Egg Protection Overview

- Egg protection mechanism consists of a polycarbonate shell holding an egg, mounted with bubble wrap.
- The bubble wrap insulates the force from being transferred directly to the egg, effectively.
- With the egg in place and filler on top of the egg, a compressor top is placed to secure the egg from travelling within the shell.

Egg Drop Module Fabrication

Designed by
Team Lead John Alcorn
UAH CanSat 2011

Fabricated by
Grad Mentor Eric Becnel
UAH Student Shop
Mechanical Layout of Components

**Carrier**
- GPS, Buzzer, Batteries
- Radio, Antenna, PCB

**Lander**
- Descent Control Legs
- Electronics Component and Egg Protection

Presenter: John Alcorn

CanSat 2011 CDR: Team 20 (Jetfire)
Material Selections

Billet Polycarbonate (Egg Protection Test Shell)
Carbon Fiber Poles mounted in RP ABS using RipStop Nylon Fabric

Carrier Descent Simulation
Operated by Descent Control Jennifer Hunt
UAH CanSat 2011
March 18, 2011

Egg Drop Module Fabrication
Designed by Team Lead John Alcorn
Fabricated by Grad Mentor Eric Becnel
UAH Student Shop

Lander Descent Simulator
Designed by Descent Control Jennifer Hunt
UAH CanSat 2011

Presenter: John Alcorn
CanSat 2011 CDR: Team 20 (Jetfire)
• The Carrier is the hosting device.
• At 500m above the ground in the decent, the Carrier will release the Lander.

The decelerator arms of the Lander are secured tightly around the Carrier by a rope and pin mechanism. The pin is operated by an actuator.

The arms have breaks to prevent Lander slipping off Carrier. When the arms are released, the Lander will immediately descend.

NM706 Actuator
# Mass Budget

<table>
<thead>
<tr>
<th>System</th>
<th>System Mass (g)</th>
<th>SubSystem</th>
<th>Percent</th>
<th>Subsystem Mass (g)</th>
</tr>
</thead>
<tbody>
<tr>
<td>CanSat</td>
<td>387 +/- 20g</td>
<td>(Carrier + Lander)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Carrier</td>
<td>242g +/- 10g</td>
<td>Frame</td>
<td>31%</td>
<td>75</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Electronics</td>
<td>23%</td>
<td>55</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Battery</td>
<td>4%</td>
<td>10</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Recovery</td>
<td>42%</td>
<td>102</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Contingency</td>
<td>-</td>
<td>+/- 10</td>
</tr>
<tr>
<td>Lander</td>
<td>145 +/- 10g</td>
<td>Frame</td>
<td>52%</td>
<td>75</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Electronics</td>
<td>9%</td>
<td>13</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Battery</td>
<td>1%</td>
<td>2</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Recovery</td>
<td>38%</td>
<td>55</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Contingency</td>
<td>-</td>
<td>+/- 10</td>
</tr>
<tr>
<td>Egg</td>
<td>60</td>
<td>Not part of mass limits.</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Presenter: John Alcorn
COMMUNICATION AND DATA HANDLING SUBSYSTEM DESIGN

Nathan Newcomb
CDH Overview

• Communication is a crucial part of any mission. In order to provide us with a clear picture of why a mission is a success or failure, adequate data must be collected and interpreted.
  • Data is collected from sensor modules by the MCU on board the Carrier and Lander.
  • The Carrier MCU then relays its information to the ground station via radio link for interpretation.
There are no changes from the PDR.
# CDH Requirements

<table>
<thead>
<tr>
<th>Section</th>
<th>ID</th>
<th>Requirement</th>
<th>Rationale</th>
<th>Priority</th>
<th>Parent(s)</th>
<th>Children</th>
<th>VM</th>
</tr>
</thead>
<tbody>
<tr>
<td>COMM</td>
<td>51</td>
<td>Carrier MCU requires 1 ADC unit</td>
<td>Thermistor</td>
<td>HIGH</td>
<td>A</td>
<td>I</td>
<td>T</td>
</tr>
<tr>
<td>COMM</td>
<td>52</td>
<td>Carrier MCU requires 2 UART ports</td>
<td>Transmitter, GPS</td>
<td>HIGH</td>
<td>I</td>
<td>A</td>
<td>T</td>
</tr>
<tr>
<td>COMM</td>
<td>53</td>
<td>Carrier MCU requires 3 SPI ports</td>
<td>Force Sensor, Memory, Alt Sensor</td>
<td>HIGH</td>
<td>I</td>
<td>A</td>
<td>T</td>
</tr>
<tr>
<td>COMM</td>
<td>54</td>
<td>Carrier MCU requires 1 DO unit</td>
<td>Audible Beacon</td>
<td>MEDIUM</td>
<td>A</td>
<td>I</td>
<td>T</td>
</tr>
<tr>
<td>COMM</td>
<td>55</td>
<td>Lander MCU requires 2 ADC units</td>
<td>Thermistor</td>
<td>HIGH</td>
<td>A</td>
<td>I</td>
<td>T</td>
</tr>
<tr>
<td>COMM</td>
<td>56</td>
<td>Lander MCU requires 3 SPI ports</td>
<td>Force Sensor, Memory, Alt Sensor</td>
<td>HIGH</td>
<td>A</td>
<td>I</td>
<td>T</td>
</tr>
<tr>
<td>COMM</td>
<td>57</td>
<td>Lander MCU requires 1 DO unit</td>
<td>Audible Beacon</td>
<td>MEDIUM</td>
<td>A</td>
<td>I</td>
<td>T</td>
</tr>
<tr>
<td>COMM</td>
<td>58</td>
<td>Sufficient Memory space</td>
<td>*Limited concern, considering 16Gb capacity</td>
<td>LOW</td>
<td>A</td>
<td>I</td>
<td>T</td>
</tr>
</tbody>
</table>

**Presenter:** Nathan Newcomb

**CanSat 2011 CDR: Team 20 (Jetfire)**
Processor & Memory Selection

Atmel ATXmega192A3
- 192 kB Flash
- 64 pin
- AVR Studio

External Flash Memory
- 2GB of memory
- Used for redundancy and auxiliary memory

Presenter: Nathan Newcomb  CanSat 2011 CDR: Team 20 (Jetfire)
Carrier Antenna Selection

- The Antenna was selected to work with the mandatory radio selection. It also provides a low mass due to its rubber duck ("whip") design, which will be stripped down to save weight.
Data Package Definitions

CanSat 2011 CDR: Team 20 (Jetfire)

Presenter: Nathan Newcomb
Communication Configuration

- The competition mandates the radio operate in API mode to ensure transmissions cannot be intercepted by other teams.

- Telemetry data will be sent at a frequency of 0.5 Hz as stated in the Communication Guide.

- The Lander will also stop transmitting telemetry data 3 minutes after landing to prevent network saturation of useless data.
Carrier Telemetry Format

• All data will be time-stamped as it is recorded, by GPS data.
• Data will be sent to the ground station at the earliest possible full transmission (2 seconds max).
• Telemetry Packet Components
  o GPS packet
  o Pressure sample
  o Temperature samples
  o Average of Recent Accelerometer samples
  o Battery Information

Presenter: Nathan Newcomb  CanSat 2011 CDR: Team 20 (Jetfire)
Autonomous Termination of Transmissions

• Radio transmissions will terminate 3 minutes after landing to provide a clear spectrum for the next CanSat.
• Our CanSat will send a final transmission to the ground station as the transmissions cease.
Both the Carrier and Lander will use a 3.5kHz 100dB buzzer attached via wire to the PCB and will be triggered by the MCU immediately after landing.
Tetsuya Toyama

ELECTRICAL POWER SUBSYSTEM DESIGN
EPS Overview

Power System
- Direct to Battery Supply
  - Release mechanism
- 3.3V Drop Voltage Regulator
  - All other components
  - LP3852EMP-3.3CT-ND
- Power Supply
  - Carrier
    - 2 x Surefire 3V 123A Lithium
  - Lander
    - 2 x CR2032 3V Lithium Button
EPS Changes Since PDR

• We have two boards for the Carrier system.
  – 1st board has: MCU, Memory, Thermistor, Beacon.
  – 2nd board has: Pressure Sensor, Accelerometer, GPS, Transmitter, Voltage regulator, Quartz Oscillator Circuit

• A quartz oscillator circuit has been added for the Pressure sensor

• A mechanical slide switch has been added between the batteries and voltage regulator

• Power source of Lander is much smaller.

Presenter: Tetsuya Toyama

CanSat 2011 CDR: Team 20 (Jetfire)
## EPS Requirements

<table>
<thead>
<tr>
<th>Section</th>
<th>ID</th>
<th>Requirement</th>
<th>Rationale</th>
<th>Priority</th>
<th>Parent(s)</th>
<th>Children</th>
</tr>
</thead>
<tbody>
<tr>
<td>EPS</td>
<td>61</td>
<td>3.3V Bus for All Digital Components</td>
<td>Single power bus</td>
<td>Low</td>
<td></td>
<td>A I T D</td>
</tr>
<tr>
<td>EPS</td>
<td>62</td>
<td>Maximum power for release mechanism, short duration of 5 seconds</td>
<td>To operate with challenging forces.</td>
<td>Med</td>
<td></td>
<td></td>
</tr>
<tr>
<td>EPS</td>
<td>63</td>
<td>Power sufficient for all components maximum operational time</td>
<td></td>
<td>High</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Carrier Electrical Block Diagram

(*) - implemented 2nd board
(#) - Implemented with wires

CanSat 2011 CDR: Team 20 (Jetfire)

Presenter: Tetsuya Toyama
Lander Electrical Block Diagram

- Regulator (3.3V)
- Switch
- Batteries (6.0V)

MCU

- Force sensor
- Pressure Sensor
- Memory
- Thermister

Quartz Oscillator Circuit

NO Buzzer, GPS and Transmitter

(#{}) - implemented with wires

Presenter: Tetsuya Toyama
## 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 (hrs or s)</th>
<th>Gross Power (mW hr)</th>
</tr>
</thead>
<tbody>
<tr>
<td>MCU</td>
<td>3.3V</td>
<td>200 mA</td>
<td>660 mW</td>
<td>1 hr</td>
<td>660 mW hr</td>
</tr>
<tr>
<td>Memory</td>
<td>3.3V</td>
<td>5 mA</td>
<td>17 mW</td>
<td>1 hr</td>
<td>17 mW hr</td>
</tr>
<tr>
<td>Transmitter</td>
<td>3.3V</td>
<td>61 mA</td>
<td>200 mW</td>
<td>1 hr</td>
<td>200 mW hr</td>
</tr>
<tr>
<td>GPS</td>
<td>3.3V</td>
<td>74 mA</td>
<td>244 mW</td>
<td>1 hr</td>
<td>244 mW hr</td>
</tr>
<tr>
<td>Pressure Sensor</td>
<td>3.3V</td>
<td>1 mA</td>
<td>1 mW</td>
<td>1 hr</td>
<td>1 mW hr</td>
</tr>
<tr>
<td>Accelerometer</td>
<td>3.3V</td>
<td>1 mA</td>
<td>3 mW</td>
<td>1 hr</td>
<td>3 mW hr</td>
</tr>
<tr>
<td>Thermistor</td>
<td>3.3V</td>
<td>1 mA</td>
<td>3 mW</td>
<td>1 hr</td>
<td>3 mW hr</td>
</tr>
<tr>
<td>Release Mechanism</td>
<td>6.0V</td>
<td>1000 mA</td>
<td>6000 mW</td>
<td>5 sec</td>
<td>60 mW hr</td>
</tr>
<tr>
<td>Buzzer</td>
<td>3.3V</td>
<td>9 mA</td>
<td>30 mW</td>
<td>2 hr</td>
<td>30 mW hr</td>
</tr>
</tbody>
</table>

| Total Current   | 350mA on 3.3V Bus  | Total Power            | 1200 mW hr     |

This is a worst case scenario with all devices on for power consumption. Testing will help refine these values.
# 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 (hrs or s)</th>
<th>Gross Power (mW hr)</th>
</tr>
</thead>
<tbody>
<tr>
<td>MCU</td>
<td>3.3V</td>
<td>200 mA</td>
<td>660 mW</td>
<td>1 hr</td>
<td>660 mW hr</td>
</tr>
<tr>
<td>Memory</td>
<td>3.3V</td>
<td>5 mA</td>
<td>17 mW</td>
<td>1 hr</td>
<td>17 mW hr</td>
</tr>
<tr>
<td>Pressure Sensor</td>
<td>3.3V</td>
<td>1 mA</td>
<td>1 mW</td>
<td>1 hr</td>
<td>1 mW hr</td>
</tr>
<tr>
<td>Accelerometer</td>
<td>3.3V</td>
<td>1 mA</td>
<td>3 mW</td>
<td>1 hr</td>
<td>3 mW hr</td>
</tr>
<tr>
<td>Thermistor</td>
<td>3.3V</td>
<td>1 mA</td>
<td>3 mW</td>
<td>1 hr</td>
<td>3 mW hr</td>
</tr>
<tr>
<td>Buzzer</td>
<td>3.3V</td>
<td>9 mA</td>
<td>30 mW</td>
<td>2 hr</td>
<td>30 mW hr</td>
</tr>
<tr>
<td><strong>Total Current</strong></td>
<td>Total Current 200mA on 3.3V Bus</td>
<td></td>
<td>Total Power 600 mW hr</td>
<td></td>
<td>Total Power 600 mW hr</td>
</tr>
</tbody>
</table>

This is a worst case scenario with all devices on for power consumption. Testing will help refine these values.

Presenter: Tetsuya Toyama
Power Source Summary

Carrier:
2 x SF123A (Surefire 123):
• Lithium battery
• 2 x 3VDC in series
• 1500mA continuous
• 3000mA instantaneous
• Capacity each: 1.5W hr
Power Supply: 6.0V, 1500mA

Lander:
2 x CR2032 Lithium Watch Battery
• 2 x 3VDC in Series
• Capacity each: 225 mAh
Power Supply: 6.0V, 225mA
Power Source Summary Continued

Estimation
Voltage regulator: Regulates 6.0V to 3.3V
Drain Current @ 3.3V => around 3.5mA
Current Supply
Carrier => 1496 mA
Lander => 221 mA

Total power supply
Carrier => 4936mWh
Lander => 729.3mWh

Power Consumption is less than Total Power supply for Lander and Carrier with room for error.
* Lander Power is overestimation assuming the MCU is operating at maximum power consumption. This is highly unlikely.

<table>
<thead>
<tr>
<th></th>
<th>Power Consumption</th>
<th>Power Supply</th>
</tr>
</thead>
<tbody>
<tr>
<td>Carrier</td>
<td>1194 mW</td>
<td>4936 mW/hr</td>
</tr>
<tr>
<td>Lander</td>
<td>682 mW*</td>
<td>729 mW/hr</td>
</tr>
</tbody>
</table>

EPS Testing
Operated by
EPS Lead Tetsuya Toyama
UAH CanSat 2011
Voltage Regulator Test

Objective:
To determine the performance of the LP3852EMP linear drop regulator.

Effectiveness:
A power supply of 3.3V by a the 2 SF123A batteries in series.
Expected results are a clean 3.3V potential across a load resistor.

Results:
The regulator has not passed full testing.
By observing with an oscilloscope, the potential demonstrated a square wave with amplitudes of 0 to 3.3V, and current 1.5 – 3.5A. This result is unexpected and is being analyzed for a solution.

Results Data
Batteries Output
5 – 6V , 1.6 – 3.5A => 8 – 21 W
Voltage Regulator Output
0 – 3.3 V, => 0 – 11.55W

We found if we applied supply voltage from batteries as 5V, the oscillation stopped. However, the oscillation started when we change load resistance.
Component Test and Measurement

Objective:
Test each component and verify compatibility with power system design. We also need to confirm power consumption.

Integrate onto the PCB
• Test PCB connections
  Verify each component operates as expected electrically.
• The voltage of the battery will be measured during flight using a voltage divider and the microprocessor ADC. The Carrier will report this with telemetry; the Lander will record the value on-board.
Carrier has two stacked boards: Carrier 1 and Carrier 2. Lander has one board.

Size: 41mm x 41mm each board

Space Hardware Club
Max Avula

FLIGHT SOFTWARE DESIGN

CanSat 2011 CDR: Team 20
(Jetfire)
FSW Overview

- Flight software is being developed for the CanSat Carrier and Lander in AVR Studio for use on the Atmel ATXmega MCU.
- AVR Studio is written in C.
- All hardware components are present on the Carrier.
- Flight software is responsible for the high level logic programming of our two processors. FSW will develop a testing code for each subsystem, and help qualify components for flight.
- FSW is critical to the final CanSat integration.
• Logic now defines the confirmation of descent as the time when the altitude changes negative 30m, as a function of pressure and/or GPS.
## FSW Requirements

### Carrier transmits and records UTC, Lat, Lon, GPS-Alt, # Sats, pressure-based-altitude, air temp(°C), battery (v) every 2 seconds
- **Rationale**: Reasonable data records. Effective material for G.S. management.
- **Priority**: Medium
- **Children**: 41, 43

### Lander Audible Beacon, activated at landing
- **Rationale**: Beacon reduces recovery time
- **Priority**: Low
- **Children**: 42

### Lander records pressure-based-altitude and battery(v) every 2 sec.
- **Rationale**: Reasonable data records
- **Priority**: Medium
- **Children**: 42

### Lander measures and records force of impact at 100Hz
- **Rationale**: Reasonable force measurement
- **Priority**: Low
- **Children**: 44

**Presenter:** Max Avula
Carrier flight software will include all components and component libraries.

Carrier FSW is responsible to define a packet for transmission to the GCS and save all data onboard.
Carrier Software Pseudocode

- Power Up Confirmation
  - GPS and Battery status
- Read ground pressure and set as local altitude, 0m.
- Immediately begin recording and transmitting telemetry packet.
- Wait until 30m drop in altitude by GPS
- When below 500m, activate the actuator to eject the Lander.
- At 30m above local altitude, begin recording accelerometer at 100Hz.
- After 15 seconds of no change in altitude
  - Stop recording accelerometer
  - Start 3 minute telemetry transmission shut down timer
  - Activate audible beacon for 1 hour
- Shut down system on manual override switch.

Telemetry Communication Loop

- Read GPS GPGGA string, UART
- Read 5 samples of acceleration information, SPI
- Read 5 samples of pressure, SPI
- Read all temperature sensors for 5 sensors
- Save all samples.
- Average all samples and generate one packet for transmission.
- Send packet to transmitter, UART

Landing Loop

- Read acceleration value
- Record to memory
- Record clock time
- Repeat
Lander CanSat FSW Overview

• Lander flight software will only include
  – Pressure Sensor
  – Thermistor
  – Accelerometer
  – Voltage Measurement

• Carrier FSW is responsible to save all data onboard.
Lander Pseudocode

**Flight Loop**
- Read pressure sensor
- Record clock time
- Wait

**Landing Loop**
- Read n acceleration samples
- Record to memory
- Record clock time
- Repeat

- **Power Up Confirmation**
  - Battery status
- Read ground pressure and set as local altitude, 0m.
- Immediately begin recording
- Wait until 30m drop in altitude by pressure sensor
- At 30m above local altitude, begin recording acceleration at 100Hz.
- After 15 seconds of no change in altitude
  - Stop recording accelerometer
  - Activate audible beacon for 1 hour
- Shut down system on manual override switch.
John Alcorn

GROUND CONTROL SYSTEM DESIGN
GCS Overview

- AC4790 receive data of Pressure, Altitude, Voltage, GPS and Temperature from CANSAT.
- Those data are transferred to LAPTOP to serial port
- MATLAB process the data.
# GCS Requirements

<table>
<thead>
<tr>
<th>Section</th>
<th>ID</th>
<th>Requirement</th>
<th>Rationale</th>
<th>Priority</th>
<th>Parent(s)</th>
<th>Children</th>
</tr>
</thead>
<tbody>
<tr>
<td>COMM</td>
<td>32</td>
<td>Development and use of ground station</td>
<td>Proper launch and decent organization</td>
<td>High</td>
<td></td>
<td></td>
</tr>
<tr>
<td>COMM</td>
<td>31</td>
<td>Ground Station Antenna more than 3.5m above the ground</td>
<td>Increase range of antenna for reception</td>
<td>High</td>
<td></td>
<td></td>
</tr>
<tr>
<td>COMM</td>
<td>33</td>
<td>Display real-time telemetry during launch and decent</td>
<td>Critical data for launch, flight and decent</td>
<td>High</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Presenter: John Alcorn
The ground control system antenna will be the Laird PC906 Antenna.

Our Space Hardware Club will debut our new mobile self-tracking antenna system.
Mark Becnel

CANSAT INTEGRATION AND TEST
CanSat Integration and Test Overview

• Prior to System Testing
  – Individual Component Programming
  – Individual Component Effectiveness Qualification
  – PCB Integration

• Full System Testing
  – Full System Programming
  – Full System Vacuum Chamber Test
  – Full System Rocket Testing
Sensor Subsystem Testing Overview

Pressure
• Programming Test
  – To accomplish communication with the target device.
  – To generate the library for each component.
• Vacuum Chamber Calibration Test
• Payload Demonstration, BalloonSat

GPS
• Sensitivity and Orientation effectiveness
• Payload Tube Reception

Temperature Sensor
• Calibration
Lander Impact “Force Sensor” Testing

• The accelerometer will be tested using a drop module to qualify the accelerometer.

• We will use a descent control system to maintain and calculate an impact force.

• The force data should demonstrate the effectiveness of the sensor, or demonstrate saturation of the sensor. If saturation (6g’s) occurs, a replacement will be necessary.

• Saturation will occur should impact take less than (1/50) seconds, assuming constant change in velocity, 5.5 m/s initial velocity, and no ricochet.
Descent control testing is in three parts:

- **Mass Simulator Balloon Drop Test and Mass Simulator Roof Drop Test**
  - To determine and confirm coefficient of drag, needed to determine final dimensions of D.C.

- **Vacuum Chamber Test**
  - To practice operation of release mechanism

- **Rocket Test**
  - To demonstrate full effectiveness of design and finalize descent control dimensions.
Mechanical testing focuses on material selection and frame design

- **Computer Analysis**
  - To reduce unnecessary material
    - MSC Patran/Nastran

- **Drop Test**
  - Structural Integrity of materials and design

---

**Egg Protection Simulation**

Designed by Descent Control Jennifer Hunt

UAH CanSat 2011 MSC Patran/Nastran

---

Presenter: Mark Becnel

CanSat 2011 CDR: Team 20 (Jetfire)
### Sensor Test

**Mission:** MCU needs to communicate with and collect data from Accelerometer, Pressure sensor, Thermister, External Flash Memory in simulated flight environment.

**Expected Results:**
1. Pressure
2. Voltage
3. Temperature
4. Force of Impact
5. Access to external flash memory data

### Radio and GPS Test

**Mission:** MCU needs to send sensor data embedded in a GPS packet over the AC4790 radio to the ground station for live visualization of data in simulated flight environment.

**Expected Results:** Data from the sensors in arranged in the GPS packet will be fed into GUI to be analyzed and verified with the test bed setup

### Release Mechanism

**Mission:** MCU needs to activate the actuator to release the pin for the deployment mechanism of the parachute/parasheet in simulated flight environment.

**Expected Results:** The actuator should release the pin when the MCU generates a HIGH(Vcc) signal at the actuator.
The Electrical Power Subsystem require the following tests:

1. Confirm the power supply effectiveness
2. Confirm the component electrical design
3. Confirm the integrated electrical design
FSW Testing Overview

Communication Test

**Mission**: Carrier transmits and records UTC, Lat, Lon, GPS-Alt, # Sats, pressure-based-altitude, air temp(°C), battery (v) every 2 seconds in simulated flight environment.

**Expected Results**: The ground station GUI application will process the received data and present it graphically. This data must be in agreement with test bed.

Data Recording Test

**Mission**: Lander records pressure-based-altitude and battery(v) every 2 sec & force of impact at 100Hz to the external flash memory for post flight analysis in simulated flight environment.

**Expected Results**: Pressure based altitude, battery life and force of impact data stored on the external flash memory should be in agreement with the test bed.

Beacon Mechanism

**Mission**: The beacon should be activated when the lander hits the ground from a test height.

**Expected Results**: The MCU should generate a HIGH(Vcc) voltage across the beacon when the altitude doesn’t change anymore which means the lander is on ground.
GCS Testing Overview

- GCS testing will be performed as each component packet is prepared by FSW.

- The integrated packet will be parsed and implemented in the Graphical User Interface (GUI)

- Finally, full systems test will require use of the GCS for testing.
Mark Becnel

MISSION OPERATIONS & ANALYSIS

CanSat 2011 CDR: Team 20
(Jetfire)
Overview of Mission Sequence of Events

Pre-Flight
• Arrival
• Deploy Ground Station
• Perform full systems test in mobile vacuum chamber
• Reset CanSat and install flight batteries.

Launch Countdown
• Power up and wait for confirmation by beacon
• Confirm Ground Station Link
• Install in rocket, 30 minute launch window

Flight
• Collect and transmit data during flight

Post-Flight
• Identify carrier location by transmitted data
• Estimate Lander location
• Recover both devices
• Download data from both devices for analysis
Lander Location [LL] as a function of:
   Carrier Location [CL]
   Ejection Location [EL]
   Descent Rate of Carrier [DRC]
   Descent Rate of Lander [DRL]

\[
(\text{LL-EL}) = \frac{(\text{CL-EL})}{\text{DRL}} \times \text{DRC}
\]

Or

\[
\text{LL} = \text{EL} + \frac{\text{DRL}}{\text{DRC}} \times (\text{CL-EL})
\]

So the if we test to find DRL and DRC ahead of time, and we receive EL and CL from the coordinates, we can estimate the Lander location. This method assumes the devices fall at a constant rate, and the environmental conditions are steady state (as in the wind patterns stay the same, and can be different at different altitudes.)
CanSat Location and Recovery

• The Carrier will transmit a final location for 3 minutes. We will calculate the Lander location. With these coordinates, we will be able to locate both devices.

• Both units will have audible beacons at 100dB, sufficient to find the units. Power down instructions will be given to the recovery teams.
Mission Rehearsal Activities

- Rehearsal will be preformed at the full systems rocket test.
  - Ground Control Setup
  - Launch Preparations
  - Mission OPS
  - Recovery
  - Data Analysis

Laser, 38mm, 3” rocket
Operated by
Systems Engineer Mark Becnel
UAH CanSat 2011

Presenter: Mark Becnel
CanSat 2011 CDR: Team 20 (Jetfire)
John Alcorn
MANAGEMENT

CanSat 2011 CDR: Team 20
(Jetfire)
Status of Procurements

Most devices have arrived and are being tested.

Complete
- Descent Control
- Egg Protection
- Release Mechanism

Pending
- Telemetry
  - GPS on Backorder
- Electronics
# CanSat Budget – Hardware

<table>
<thead>
<tr>
<th>Part</th>
<th>Vendor</th>
<th>Manufacturer</th>
<th>Price Each</th>
<th># Required</th>
<th>Cost</th>
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<tbody>
<tr>
<td>MCUs</td>
<td>Mouser</td>
<td>Atmel</td>
<td>10.03</td>
<td>2</td>
<td>20.06</td>
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<tr>
<td>GPSs</td>
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<td>GPS Cables</td>
<td>SparkFun</td>
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<td>2.95</td>
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<td>Audible Beacons</td>
<td>Mouser</td>
<td>PUI Audio</td>
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<td>5.80</td>
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<td>Pressure Sensors</td>
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<td>Measurement Specialties Inc.</td>
<td>41.27</td>
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<tr>
<td>Memories</td>
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<td>Micron</td>
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<td>National Semiconductor</td>
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**TOTAL DEVICE COST** $564.91

---

Presenter: John Alcorn

CanSat 2011 CDR: Team 20

Jetfire
### CanSat Travel Costs

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<tr>
<th>Number optional</th>
<th>Price Per</th>
<th>Days</th>
<th>Applicable</th>
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<tr>
<td>Hotel Expenses</td>
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<td>4</td>
<td>$960.00</td>
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<td>Arrive Feb 9, Leave Feb 13</td>
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<tr>
<td>Students</td>
<td>8 $40.00</td>
<td>5</td>
<td>$1,600.00</td>
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<td>Price questionable, but approximately the gas cost of two university cars.</td>
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<tr>
<td>Miles</td>
<td>1800 $0.50</td>
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<td>$900.00</td>
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Program Schedule

Presenter: John Alcorn

CanSat 2011 CDR: Team 20 (Jetfire)
Conclusions

• This review demonstrates our CanSat as a feasible product ready for fabrication and competition.
• Each mission requirement is addressed in this presentation.
• Our team is excited to have this opportunity. This experience so far has been very rewarding.
Questions?
Presentation Scoring & Additional Information

The following slides provide additional information regarding presentation scoring, as well as recommendations for the presentations and slides.
Presentation Scoring

- Each slide is scored on a scale of 0 to 10 points
- Each section of the presentation (Systems Overview, Sensor Systems, etc.) is weighted according to the table
- Each team will receive a link to a summary score sheet that will contain all their competition scores

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<thead>
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<td>Systems Overview</td>
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<tr>
<td>Sensor Subsystem Design</td>
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<td>Descent Control Design</td>
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<tr>
<td>Mechanical Subsystem Design</td>
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<tr>
<td>Communication &amp; Data Handling Subsystem Design</td>
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<tr>
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<td>Quality</td>
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<tr>
<td>Total:</td>
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