CanSat 2015
Post Flight Report (PFR)

Team 4401
SkyHammer
June 14, 2015
1. Introduction
2. System Overview
3. Concept of Operations & Sequence of Events
4. Flight Data Analysis
5. Failure Analysis
6. Lessons Learned
7. Conclusions
Team Organization

Alex Christley (Sophomore)
**Team Lead**

Tony Mai
*CanSat Mentor*

Dr. John Gregory
**Faculty Advisor**

Dr. Francis Wessling
**Faculty Advisor**

Will Hill (Sophomore)
**Alternate Team Lead**

Will Hill (Sophomore)
**Mechanical Lead**

Evan Root
**Ground Station Lead**

Nick Jordan (Freshman)
**Electrical Lead**

Evan Root (Sophomore)
**Software Lead**

Prehit Patel (Freshman)

Nick Jordan

Akifumi Takeyama (Freshman)

Prehit Patel (Freshman)

Alex Christley

Presenter: Alex Christley

CanSat 2015 PFR: Team 4401 (SkyHammer)
Systems Overview

Prehit Patel
Akifumi Takeyama
Will Hill
Mission Summary

A container must descend via parachute, securing the science payload within.

At an ideal point, the SV will separate from the container and begin normal operations.

Upon separation from the container, the SV will use passive helicopter/auto-gyro recovery to descend between 4-10 m/s.

The SV must stabilize and descend properly at 300 m.

The SV will record video in the nadir direction; the vehicle must be stabilized in real time so that it does not spin.

The SV will collect telemetry data and transmit the data to a ground station at a rate of 1 Hz.

The SV will hold a raw hen’s egg and protect it from breaking during the mission.
Selectable Objectives

Bonus Objective 1: Use a three-axis accelerometer to measure the stability and angle of descent of the Science Vehicle during descent, sample at appropriate rate, and store data for later retrieval.

Personal Objective 1: Measure SV rotation during descent, information at appropriate rates.
CanSat Overview

- CanSat descent with a parachute
- *Working hotwire to separate payload from container at ideal point
- Ideal point is based on altitude and pressure data
- *The payload used contra-rotating blades as our helicopter descent system
- *PID controller and a fin control plant
- *The Micro HD MiNi Camera takes nadir video
- Radio transmission from Xbee Pro 900HP
- Ground station with MatLab and Yagi antenna
- Polyethylene foam with cotton for protecting egg from breaking
## Mechanical Components Summary

<table>
<thead>
<tr>
<th>Component Description</th>
<th>Material</th>
<th>Cost/unit</th>
<th>Quantity</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Blade Surface</td>
<td>Monokote</td>
<td>1/ft$^2$</td>
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<td>1</td>
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<tr>
<td>Blade Cross Sections</td>
<td>Polycarbonate Lexan Sheet</td>
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<td>2</td>
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<tr>
<td>Blade Struts</td>
<td>Balsa</td>
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<td>2</td>
<td>.56</td>
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<tr>
<td>Bulkheads</td>
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<tr>
<td>Hinges + Mounting Surfaces</td>
<td>Makerbot ABS</td>
<td>0.05/g</td>
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<td>Hubs</td>
<td>Fortus ABS</td>
<td>0.37/g</td>
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<td>Bearings</td>
<td>Delrin/Glass</td>
<td>7.55</td>
<td>2</td>
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<td>Control Fins</td>
<td>Servo/Plastic</td>
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<td>SV Frame</td>
<td>Aluminum 6/32 Rod</td>
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<td>Blade Deployment</td>
<td>1” Springs</td>
<td>0.64</td>
<td>4</td>
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<tr>
<td>Egg Protection</td>
<td>Polyethylene</td>
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</table>

**Presenter:** Will Hill  
**CanSat 2015 PFR: Team 4401 (SkyHammer)**
## Electrical Components Summary

<table>
<thead>
<tr>
<th>Component Description</th>
<th>Supplier</th>
<th>Cost/unit</th>
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<tbody>
<tr>
<td>Xmega-128A4U, MCU</td>
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<td>MPU-9250, IMU</td>
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<td>8 GB Micro SD Card</td>
<td>Kingston</td>
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<td>Micro HD MiNi Camera with Motion Sensing</td>
<td>ProofPronto</td>
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<td>PCB</td>
<td>Advanced Circuits</td>
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<td>Box of Surefire CR123</td>
<td>Amazon</td>
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<td>A09-HASM-675, Antenna</td>
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<td>Xbee PRO 900HP (S3P)</td>
<td>Digi Int'l</td>
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<td>Resitors</td>
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</table>

Presenter: Will Hill  
CanSat 2015 PFR: Team 4401 (SkyHammer)
Total Cost of CanSat

- **Mechanical Components Cost**
  - $104.46

- **Electrical Components Cost**
  - $189.09

- **Total Cost of CanSat**
  - $293.55
Science Vehicle Physical Layout

- Contra-rotating Blades
- Electronics and Batteries are above Egg Protection
- Camera Unit in Bottom Bulkhead
- Control Fins on Side
Container Physical Layout

- There are NO Electronics in the Container
- 125mm Diameter, 294mm Length
- 580mm Diameter Parasheet, 190mm Spill Hole
- Polycarbonate Bulkhead with Quarters for Ballast
Concept of Operations and Sequence of Events

Presenter: Nick Jordan and Evan Root
Comparison of Planned and Actual ConOps

Concept of Operations and Flight States

- Pre-Flight Procedures & Loading CanSat
- Reach Apogee at ~670 m
- CanSat Deployment
- Container Stabilization Apogee-Estimated 500m
- SV Stabilization 500m-400m
- SV Final Descent 300m-Ground
- Container Separation Descent
- SV Deployment at Optimal Stability (Estimated 500m)
- Landing and Recovery
- Container Stabilization Apogee-Estimated 500m

Presenter: Nick Jordan
Comparison of Planned and Actual ConOps

• Actual Con-Ops
  – Rocket ascended
  – Nose Cone and CanSat separated at apogee
  – Science Vehicle failed to cut down from Container
  – CanSat Landed
## Comparison of Planned and Actual Sequence of Events

<table>
<thead>
<tr>
<th>Event</th>
<th>Planned</th>
<th>Actual</th>
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<tr>
<td>Arrival</td>
<td>0700</td>
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<tr>
<td>Check-in</td>
<td>1000</td>
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<tr>
<td>Turn-in</td>
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<tr>
<td>Launch</td>
<td>1430</td>
<td>1440</td>
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<tr>
<td>Recovery</td>
<td>After Launch</td>
<td>1458</td>
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</tbody>
</table>
Release Logic

Flight State 2:
Entered upon apogee detection
Falls for 50 meters, then turns on hotwire
Failsafe: hotwire also cuts if below 350 meters of our starting altitude

Flight State 3:
Starts control system and descent operations
Flight Data Analysis

Evan Root
Altitude Telemetry

• **Altitude:**
  – Flight lasted ~98 seconds
  – Max height reached: 583 meters
  – Descent rate for entire flight: ~7.091 m/s
  – No separation point; software failure
Video

• Reference Desktop
Temperature (°C) Telemetry

– Inside temperature sensor (orange)
  • Much higher resolution sensor; stable sensing conditions.

– Outside temperature sensor
  • Much lower resolution; caustic sensing conditions.
- Didn’t switch out of flight state 5
**Accelerometer Telemetry**

- **Selectable objective data:**
  - Range is ±2G’s. Steps are in milli G’s.

![Accelerometer Bonus Chart](chart.png)
Failure Analysis

Alex Christley
Failure Analysis

• Failures:
  – Flight Procedure Breakdown
    • Failed to send command to start flight states
  – Software Breakdown
    • Added flight state 5
  – Camera mechanical failure
    • Switch broke off on flight line

• Root Causes:
  – Failed to send command to start flight states
  – Last minute addition of flight state 5
  – Lack of testing
  – Bad Camera
Failure Analysis

• Corrective Actions:
  – Implement failsafe interrupts in software for cutdown
  – Improved understanding and execution of flight changes
  – NO last minute changes; test everything a LOT
  – Choose a more reliable camera
  – Test with flight procedures and planned CONOPS
Lessons Learned

Alex Christley
Discussion of Results

• What did not work:
  – Flight States
  – Mission operations procedure
  – Camera failure

• Unproven Systems:
  – Flight readiness of control fins untested

• What worked:
  – Electrical and Power Systems
  – Ground Station and Telemetry; no lost packets
  – Mechanical design and fail-safes
  – Egg protection
  – Sensors
Conclusions

• Prior to CanSat
  – Most members were freshman, and had minimal knowledge of engineering systems.
  – Today, SkyHammer highlights their understanding of:
    • Radios and communication data handling
    • Electronic design and PCB design
    • Ground station
    • Microcontroller software
    • Control systems
    • Auto-gyrational descent systems and aerodynamics
    • System integration
    • Flight states and flow of process
    • Machining
    • Composites and egg protection
Thank You

• Alabama Space Grant: Dr. John Gregory
• Space Hardware Club: Adam Bower, Ethan Hopping, Trey McFerrin, Matt Rodencal, Nathan Stepp, Jordan Teats, Evan Tingley, Zachary Riffle
• UAH: Dr. Francis Wessling, Mr. Steve Collins
• CanSat coordinators and volunteers: Ivan Galysh, Jim Kirkpatrick, Tony Mai
• Photo Credit: Zachary Riffle