Recovery
By: Paul and Victor
Victor’s Update

- Design for Drogue Parachute (8 Gores)
  - Semi-Ellipsoid (Optimum drag to weight ratio)
  - Torodial (Half Doughnut/Higher drag to weight ratio)
  - Square

- Design for Main Parachute (12 Gores)
  - Semi-Ellipsoid (Optimum drag to weight ratio)
  - Torodial (Half Doughnut)
  - Hexagonal (Parasheet)
Victor’s Update

- University of Florida Report
  - Vehicle Characteristics: Weight 74lbs, 14ft long, 6.14” in diameter
  - Drogue = 48” in diameter
  - Main = 168” in diameter
  - Kept impact under 75ft-lbs of force
  - Further Research was done on Richard Nakka’s Exper
- Design for Drogue Parachute (8 Gores)
  - Semi-Ellipsoid (Optimum drag to weight ratio)
- Design for Main Parachute (12 Gores)
  - Semi-Ellipsoid (Optimum drag to weight ratio)
- 25 and 50 lb rockets
Requirements from ESRA

- Recovery uses a sensor for primary deployment
- An additional apogee sensor, with power supply, shall be used for backup deployment.
- Descent velocity should be between 50 and 100. **Deployment of main recovery system near apogee results in zero points for recovery**
- Maximum rocket landing speed shall not cause a hazard
- Ground or flight demonstration of the recovery system (apogee and low-altitude) shall be conducted prior to the IREC. For a ground test, sensors will need to be functionally included in the demonstration (need to be "fooled" into deployment). A video of the demonstration should be submitted to ESRA or posted on a publicly available web site such as YouTube by March 31, 2014.
- Each rocket stage shall carry a transmitter to locate rocket
Design Overview

1. 0 ft 0s
2. 2700 ft 4.3s
3. 5280 ft 15.05s
4. 5280 ft 15.06s
5. 700 ft 65.7s
6. 0 ft 73.5s
Design Elements

- Drogue Chute
- Parachute
- Shock Cord
- Charge Baffle
- Piston Ejection System
- Altimeters
Manufacturing

- Manufacturing Ourselves
  - Main and Drogue Parachutes
  - Piston Ejection System
  - Blast Caps
  - Charge Baffles (Charge Sizing)
Electrical Design

Recovery Electronics Board
- Two Commercial Altimeters
- Terminal Block
- Wires from Altimeters to Printed Circuit Board
- Two 9V battery (Independent)
Integrating and Shielding

- **Piston Ejection System**: expels hot air into the fuselage from the motor
- **Parachute System** to separate nosecone
- **Recovery Wadding**: separates hot particles from Piston Ejection system to keep parachute from burning
- **Charge Baffle**: eliminate the need for recovery wadding by trapping hot particles and not burning the parachute
- **Redundancy**: 2 altimeters
- **Shackle**: attach chutes to motor mount
- **Phenolic tube**: provides path for ejection gasses to bypass the main parachute
Kinetic Energy

Calculations
- Each tethered section
- Velocities found on OpenRocket
- Calculated Values < Maximum Allowed

http://openrocket.sourceforge.net/shots/main.png

<table>
<thead>
<tr>
<th>Component</th>
<th>Descent Rate (ft/s)</th>
<th>Mass (slugs)</th>
<th>Kinetic Energy (ft-lbf)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Nosecone</td>
<td>12.5</td>
<td>0.0879</td>
<td>7.744</td>
</tr>
<tr>
<td>Piston</td>
<td>12.5</td>
<td>0.0310</td>
<td>2.457</td>
</tr>
<tr>
<td>Upper Airframe</td>
<td>12.5</td>
<td>0.539</td>
<td>42.66</td>
</tr>
<tr>
<td>Lower Airframe</td>
<td>12.5</td>
<td>0.874</td>
<td>69.14</td>
</tr>
</tbody>
</table>
Test Results

- Ground based charge testing
- Subscale Launch Testing
- Scale Parachute Testing
- Full Scale Launch Testing
Drogue Testing
Safety and Failure Analysis

Recovery System Stress Analysis
- Drag Force Simulation
- Recovery Failure Analysis

Failure Modes
- 1st Category (Hardware)
- 2nd Category (Electrical Components)
- 3rd Category (Detonation of Ejection Charges)

Table 8: Recovery Failure Analysis

<table>
<thead>
<tr>
<th>Component</th>
<th>Max Rated Stress</th>
<th>Factor of Safety</th>
</tr>
</thead>
<tbody>
<tr>
<td>SW-1500 Swivel Link</td>
<td>1500 lbs</td>
<td>2.77</td>
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<tr>
<td>9/16&quot; Tubular Nylon Shock Cord</td>
<td>2000 lbs</td>
<td>3.69</td>
</tr>
<tr>
<td>1/4&quot; Type 361L Stainless Steel Quick Link</td>
<td>1400 lbs</td>
<td>2.58</td>
</tr>
<tr>
<td>3/4&quot; Braided Nylon Shroud Lines</td>
<td>550 lbs/shroud line * 18 shroud lines = 9900 lbs</td>
<td>18.27</td>
</tr>
<tr>
<td>3/8&quot;-16 x 1-1/4&quot; Type 304 Stainless Steel U-Bolt</td>
<td>1090 lbs</td>
<td>2.01</td>
</tr>
<tr>
<td>Body Tube to Charge Baffle Interface</td>
<td>440.0 lbs/screw * 4 screws = 1762.4 lbs</td>
<td>3.25</td>
</tr>
</tbody>
</table>
Drift Analysis

- Calculate Drift
  - Use online calculator
    - Predicts with winds aloft
Questions?