Recovery

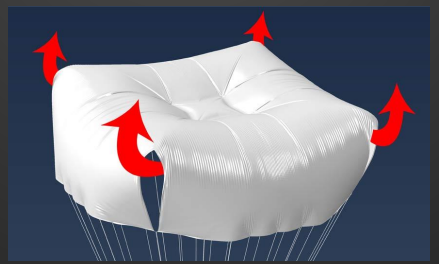
By: Paul and Victor

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)

Semi-Ellipsoid

Hexagonal



Square

Torodial (Half Doughnut)

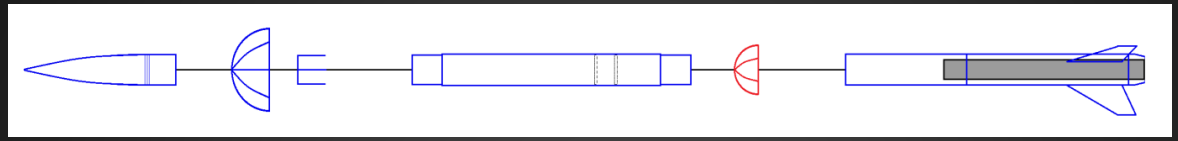
Victor's Update

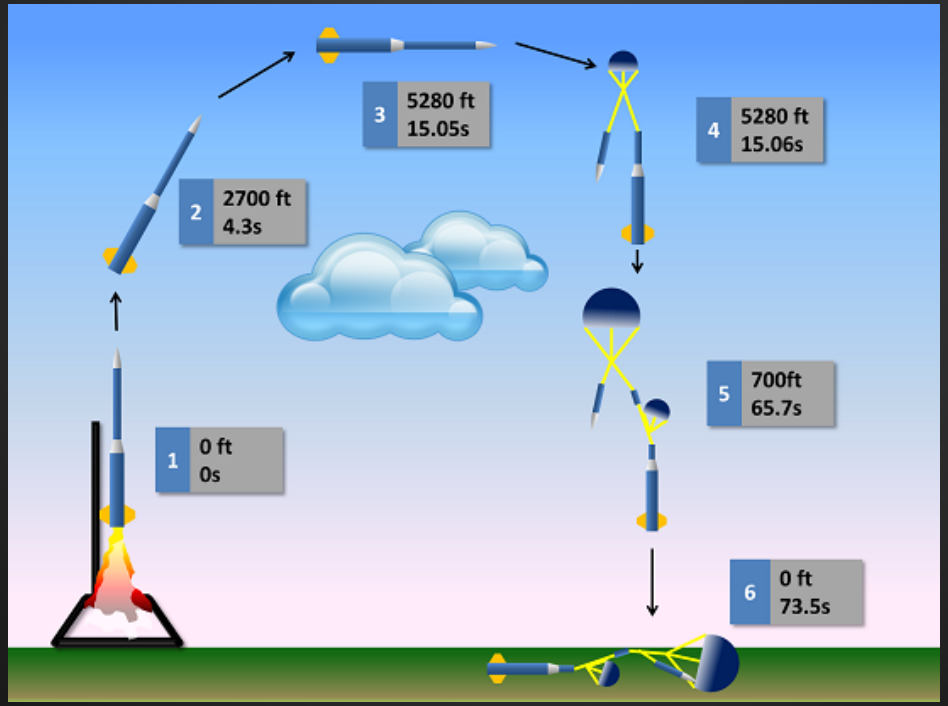
- University of Florida Report
  - Vehicle Characteristics: Weight 74lbs, 14ft long, 6.14" in diameter
  - Drogue = 48" in diameter
  - Main = 168" in diameter
  - Kept impact under 75ft-lbs of force
  - Further Research was done on Richard Nakka's Exper
- Design for Drogue Parachute (8 Gores)
  - Semi-Ellipsoid (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

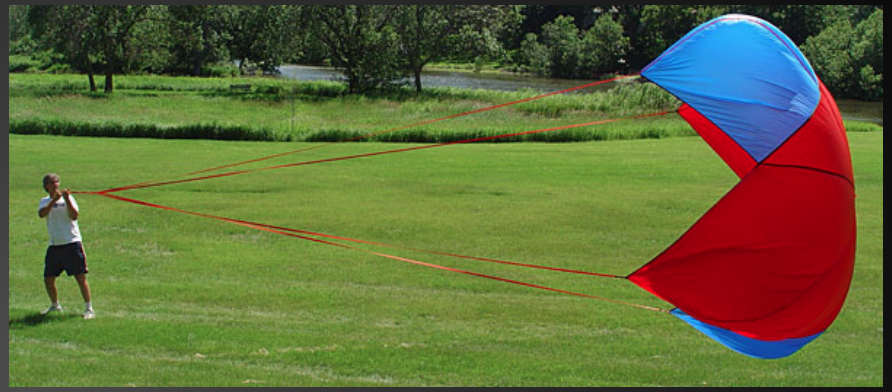
Design Overview

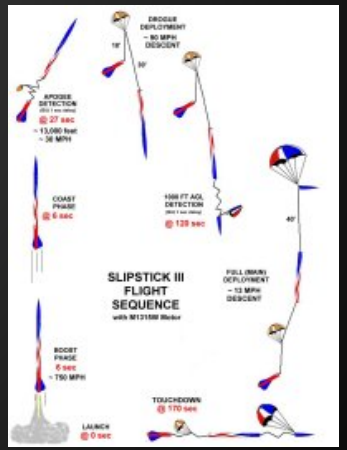




Design Elements

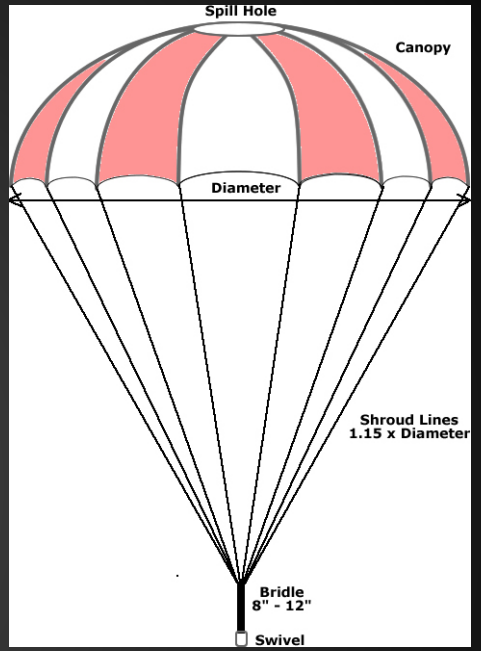
- Drogue Chute
- Parachute
- Shock Cord
- Charge Baffle
- Piston Ejection System
- Altimeters

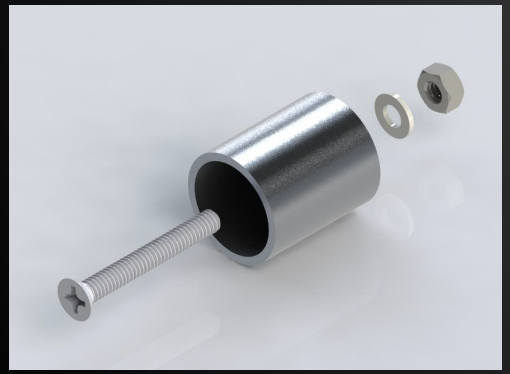


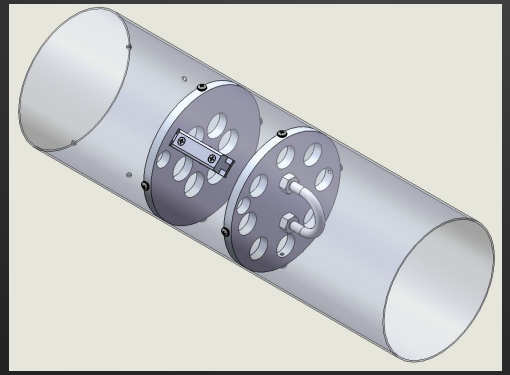


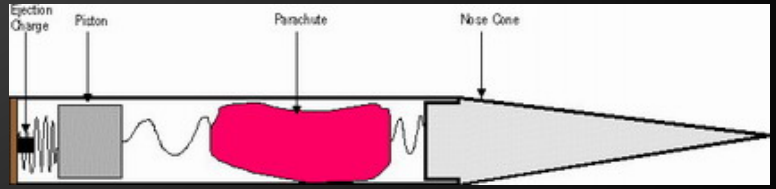
Manufacturing

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



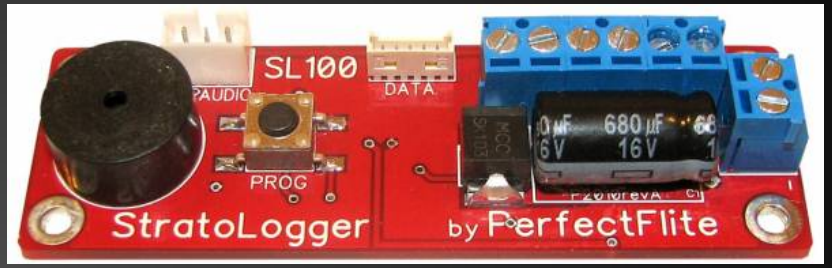


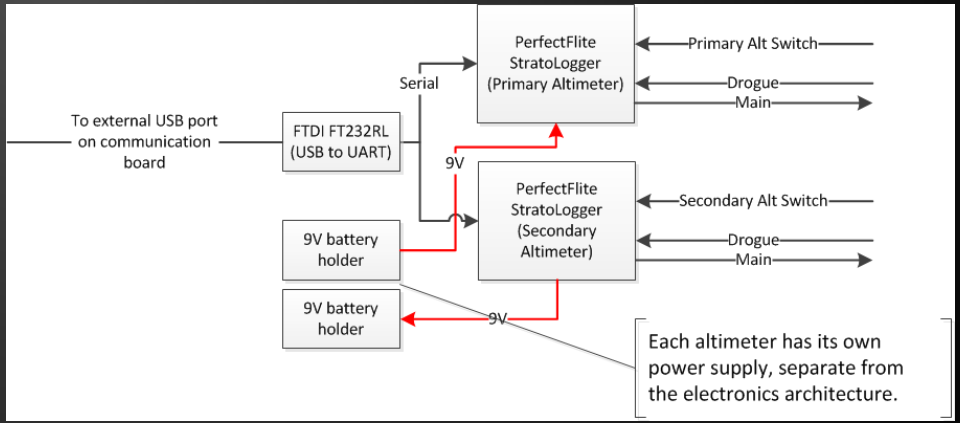




Electrical Design

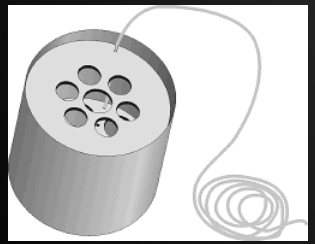
Recovery Electronics Board
- Two Commercial Altimeters
- Terminal Block
- Wires from Altimeters to Printed Circuit Board
- Two 9V battery (Independent)

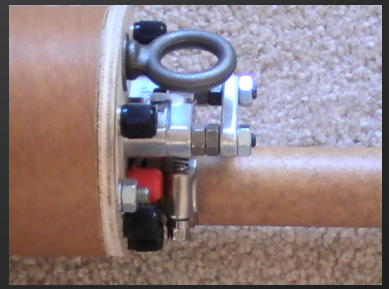




Integrating and Shielding

- 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

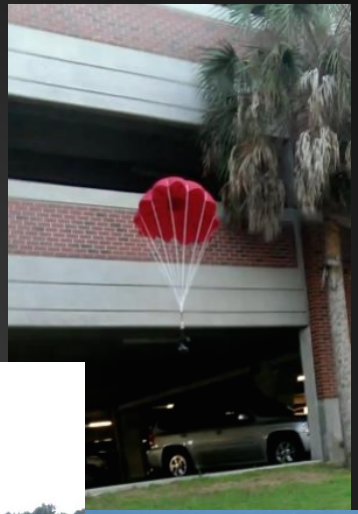
http://openrocket.sourceforge.net/shots/main.png

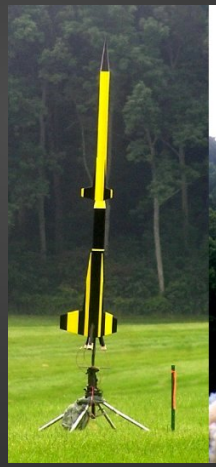
Table 7: Kinetic Energy at Impact

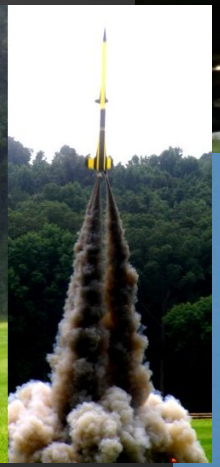
Component	Descent Rate (ft/s)	Mass (slugs)	Kinetic Energy (ft-lbf)
Nosecone	12.5	0.0979	7.744
Piston	12.5	0.0310	2.457
Upper Airframe	12.5	0.539	42.66
Lower Airframe	12.5	0.874	69.14

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

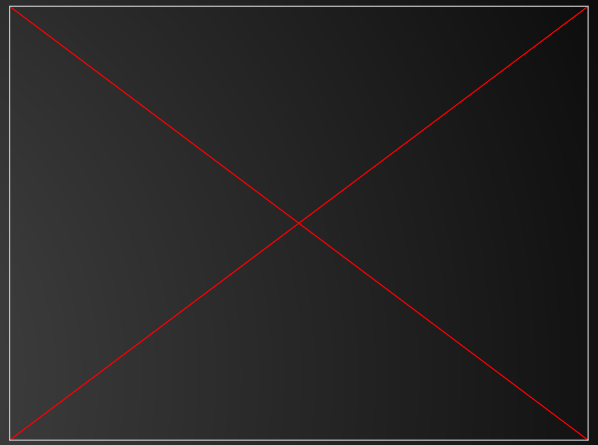
Failure Modes
- 1st Category (Hardware)
- 2nd Category (Electrical Components)
- 3rd Category (Detonation of Ejection Charges)

Table 8: Recovery Failure Analysis

Component	Max Rated Stress	Factor of Safety
SW-1500 Swivel Link	1500 lbs	2.77
9/16" Tubular Nylon Shock Cord	2000 lbs	3.69
¼" Type 361L Stainless Steel Quick Link	1400 lbs	2.58
⅛" Braided Nylon Shroud Lines	550lbs/shroud line * 18 shroud lines = 9900 lbs	18.27
3/8"-16 x 1-1/4" Type 304 Stainless Steel U-Bolt	1090 lbs	2.01
Body Tube to Charge Baffle Interface	440.6lbs/screw * 4 screws = 1762.4lbs	3.25

Drift Analysis

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



Questions?

Deployment Bags