NASA USLI 2012-13

# PRELIMINARY DESIGN REVIEW

University of California, Davis – SpaceED Rockets Team

# OUTLINE

- School Information
- Launch Vehicle Summary
- Motor Selection
- Mission Performance and Predictions
- Structures
- Air-brake System
- Payload
- Recovery System
- Mass Budget
- Safety & Testing

# SCHOOL INFORMATION

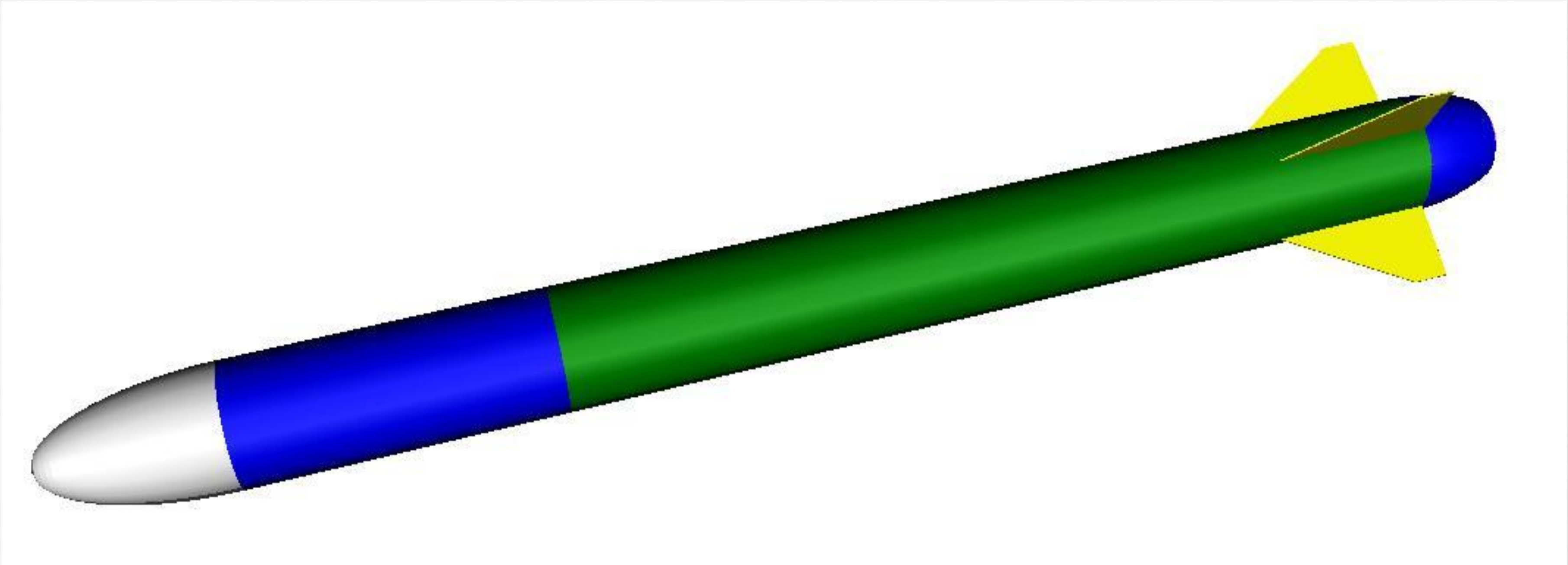
- **Name of school/organization**: UC Davis – SpaceED Rockets Team
- **Mailing Address:**
  Attn: Nesrin Sarigul-Klijn
  Professor and Director of SpaceED
  Mechanical and Aerospace Engineering Department
  2132 Bainer Drive
  Davis, CA 95616-5294
- **Reusable Rocket Vehicle Proposed**: Eclipse-I
- **Team Faculty Advisor:** Dr. Nesrin Sarigul-Klijn
- **Launch Assistance/Mentor:** Steve Kendall (NAR 73704 L3 & TRA 10478 L3)
  LUNAR #600
  AeroPAC #445

# LAUNCH VEHICLE SUMMARY

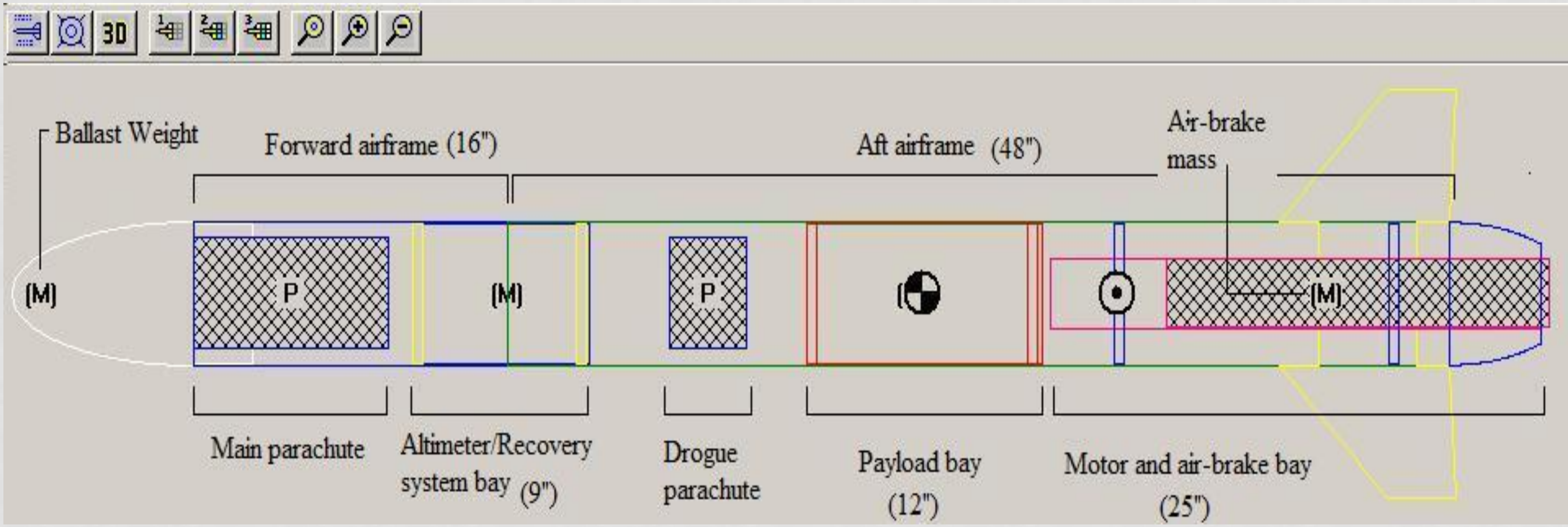
# LAUNCH VEHICLE SUMMARY

- Length: 77.88”
- Diameter: 6”
- Nose cone: Elliptical at 9.25” long
- Avionic/Recovery Bay: 9”
- Payload Bay: 12”
- Forward Airframe: 16”
- Booster/Payload Airframe: 48”
- Motor: Animal Motor Works L777WW-0
- Total Mass: 32.71 lb.

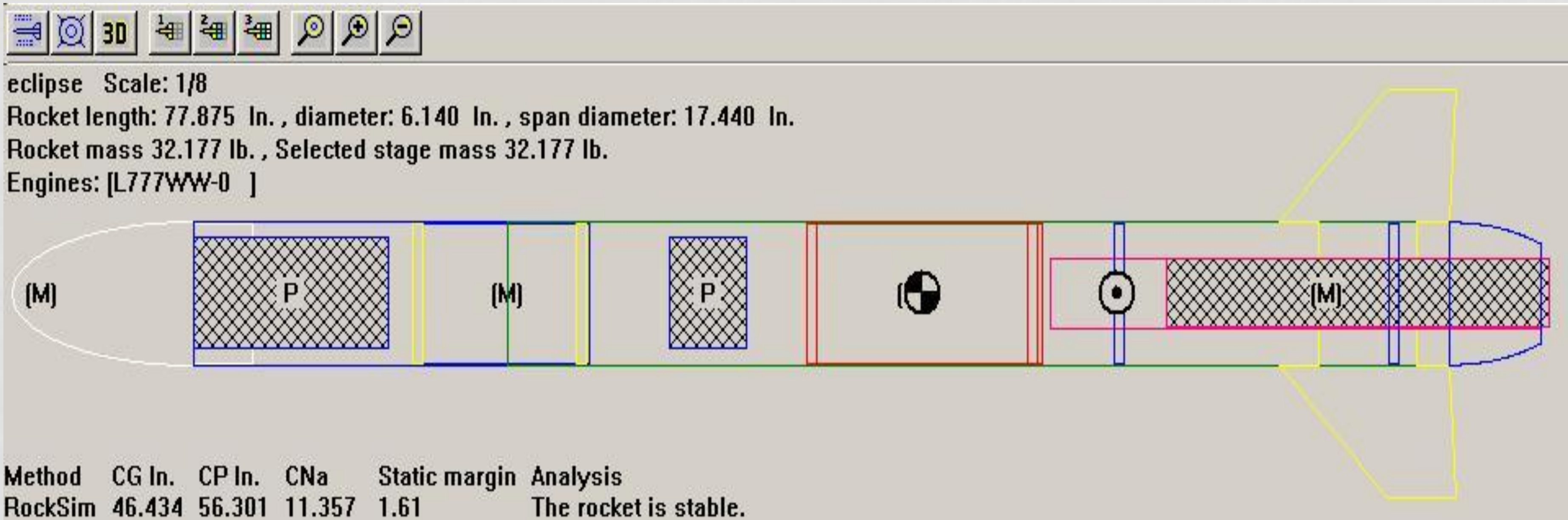
# LAUNCH VEHICLE SUMMARY



# COMPONENT LAYOUT



# STATIC MARGIN




Desirable static margin is at least 1.5 caliber but under 2

# COMPONENT WEIGHT

| | |
|---|---|
| **Nose Cone** | **3.8** |
| *Nose* | *1.8* |
| *Ballast Weight* | *2.0* |
| **Forward Airframe** | **3.5** |
| *Airframe* | *0.7* |
| *Main Parachute* | *0.4* |
| *Altimeter/Recovery System Bay* | *2.4* |
| **Aft Airframe** | **14.75** |
| *Airframe* | *2.2* |
| *Drogue Parachute* | *0.05* |
| *Payload Bay* | *5.5* |
| *Motor Bay* | *1.6* |
| *Airbrake System* | *3.8* |
| *Fins* | *1.1* |
| *Boattail* | *0.5* |
| **Total Mass without Motor** | **22.05** |

# MOTOR SELECTION

# POTENTIAL MOTORS

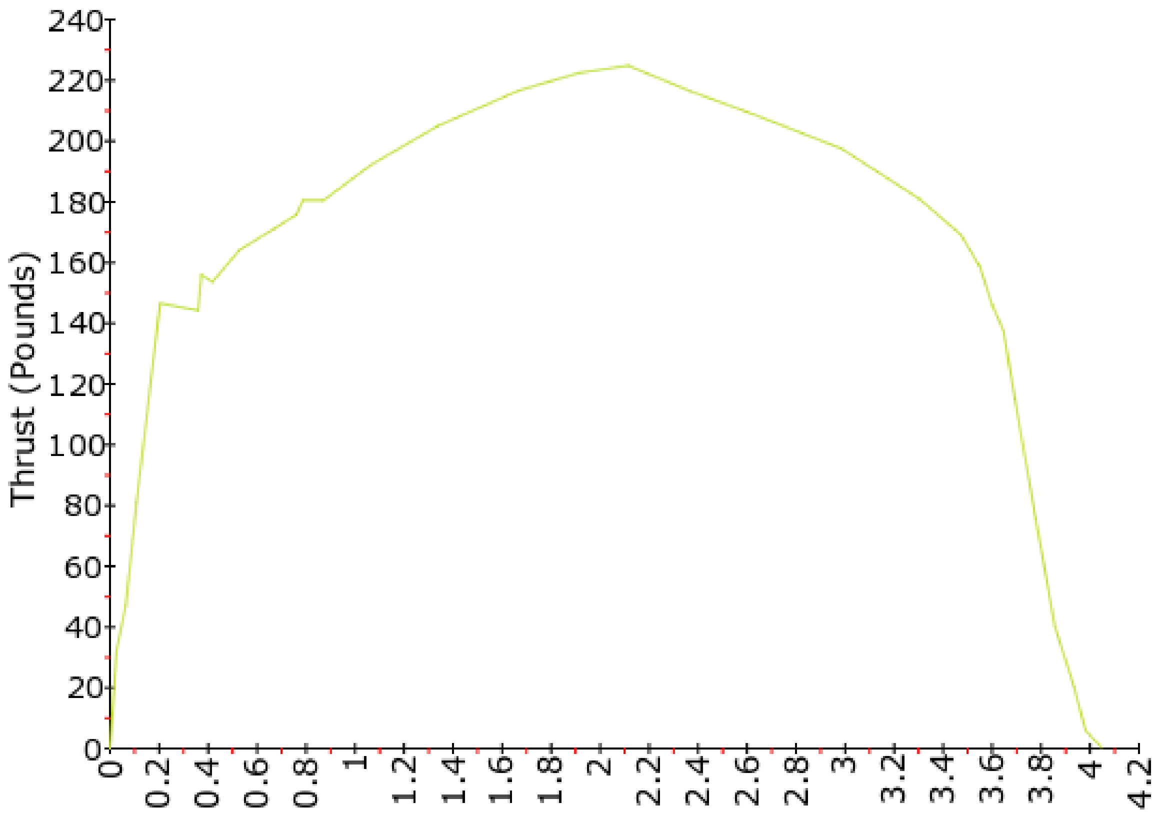
| Manufacturer | Motor | Overshoot (ft) |
|---|---|---|
| Animal Motor Works | L1080BB | 1306 |
| Cesaroni | L890SS | 1104 |
| Animal Motor Works | L1060GG | 970 |
| Animal Motor Works | L900RR | 553 |
| Animal Motor Works | L777WW | 163 |

# FINAL MOTOR SELECTION

| | |
|---|---|
| Diameter | 75 mm (2.95 in.) |
| Length | 497 mm (19.6 in.) |
| Propellant Mass | 3.89 lb |
| Total Mass | 8.15 lb |
| Average Thrust | 174.1 lb |
| Peak Thrust | 224.8 lb |
| Total Impulse | 3136.6 N-s |
| Thrust Duration | 4.05 s |

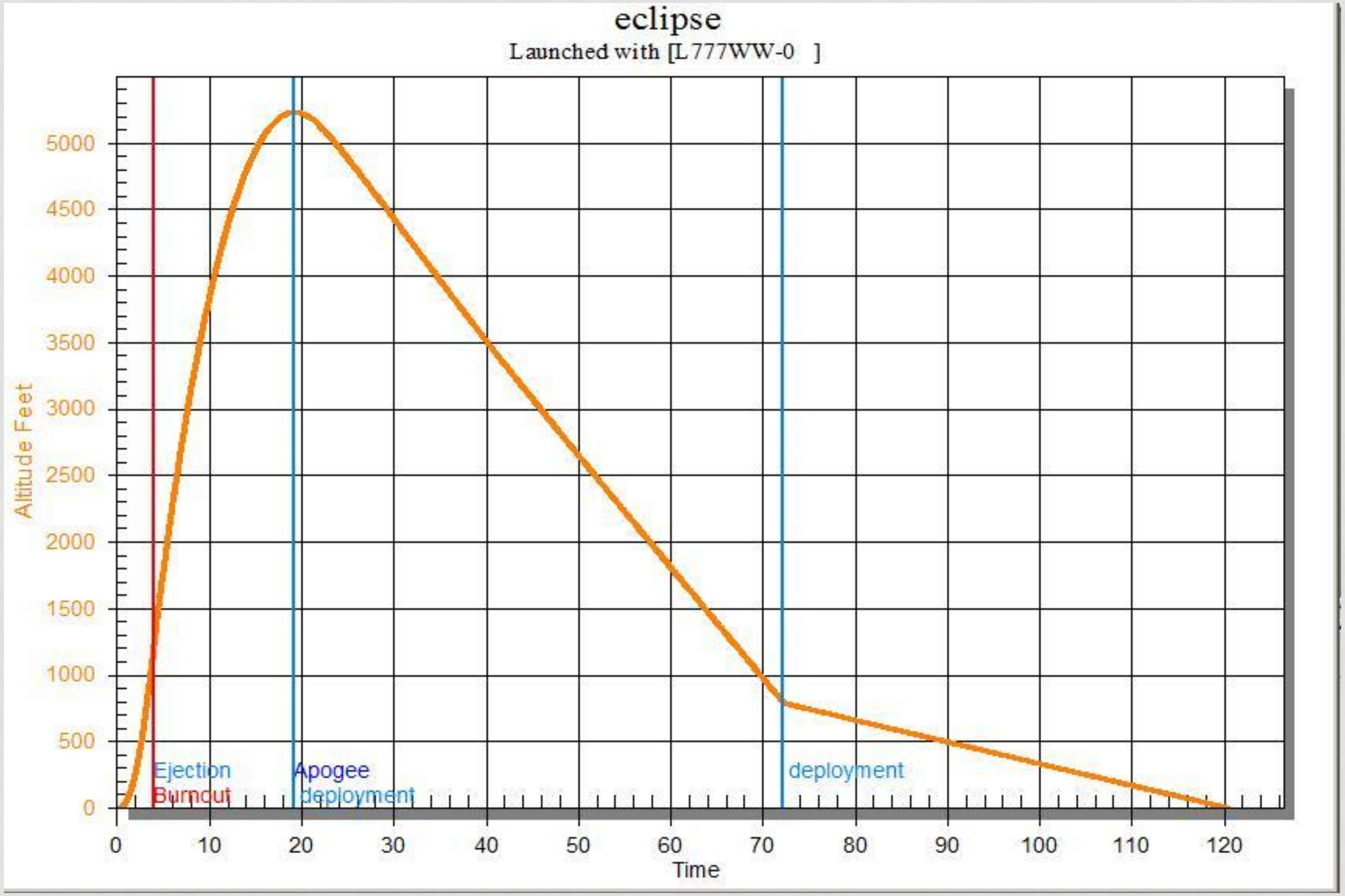
Thrust-to-weight ratio = 5.5

# THRUST PROFILE



# MISSION PERFORMANCE AND PREDICTIONS

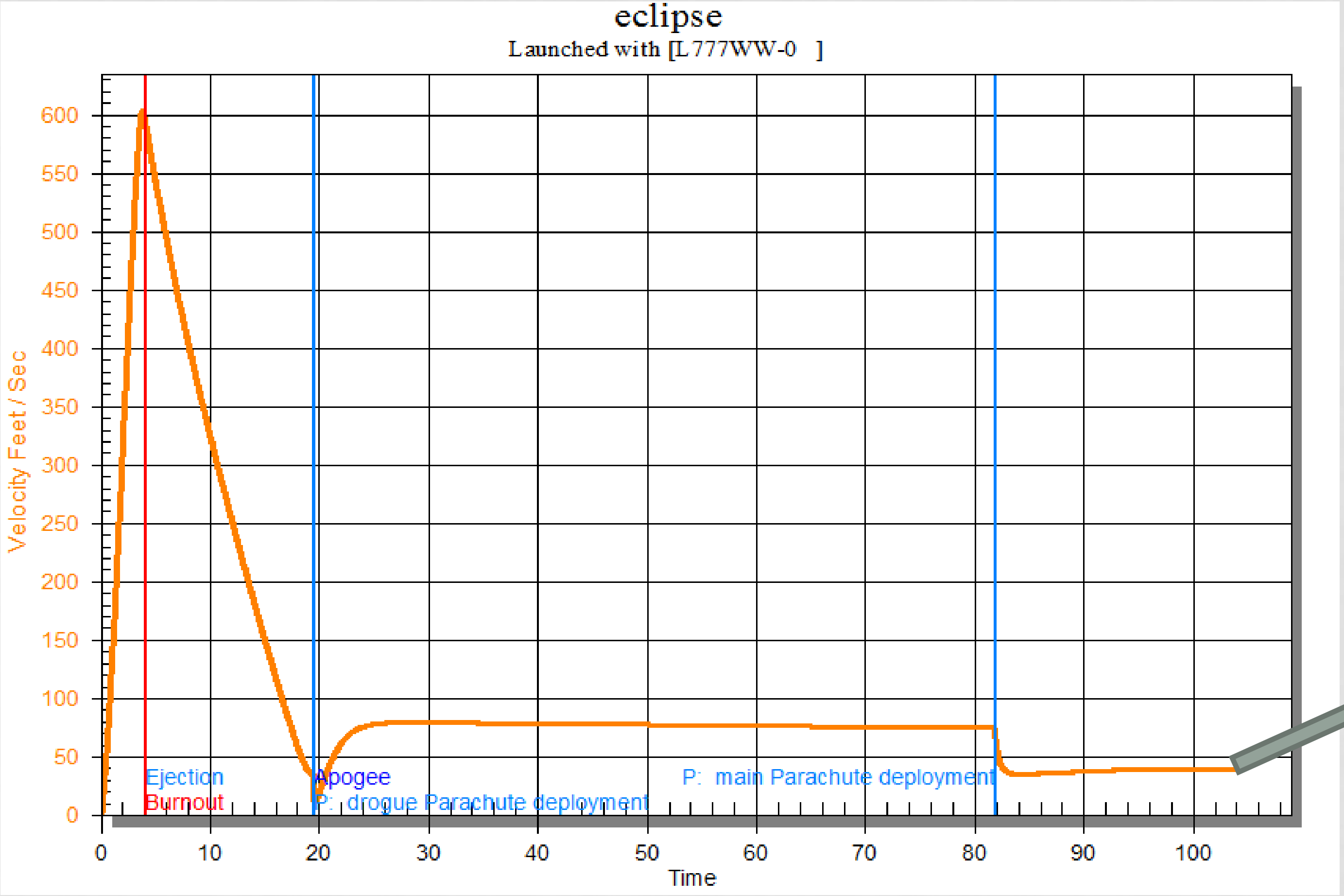
# ALTITUDE PROFILE



# DRIFT RANGE

| Wind Speed (MPH) | Range (ft) |
|---:|---|
| 5 | 512 |
| 10 | 822 |
| 15 | 2207 |
| 20 | 3187 |

# VELOCITY PROFILE




Impact velocity is about 17.12 ft/s

Impact energy is about 67 lbf-ft.

# STRUCTURES

# AIRFRAME

- **Final Selection: *Giant Leap Magnaframe*** tube
  - Pros:
    - Light, stiff material with thin wall thickness;
    - Lower peak load but can be used up to its peak load;
    - Strong with the highest peak stress.
  - Cons:
    - Requires special machining that will lead to some additional costs.
- *Other possible tubes* included a Blue Tube, PML Phenolic tube, and Giant Leap's Dynawind, but they were more all more costly.
  - Blue Tube can only be used to half its peak load.
  - PML Phenolic tube has a low strength to weight ratio.
  - Dynawind is the same as Magnaframe reinforced with fiberclass, which can be done if necessary.

# AIRFRAME MATERIALS INFORMATION

General information of the observed materials is compared to better illustrate the Magnaframe tube’s advantage over the other materials.

| Name | Blue Tube | PML Phenolic | Giant Leap Magnaframe |
|---|---|---|---|
| ID | 3.002" | 3.000" | 3.004" |
| OD | 3.128" | 3.132" | 3.096" |
| Area | 0.60662 $in^2$ | 0.63572 $in^2$ | 0.43757 $in^2$ |
| Modulus | 574.1 ksi | 765.9 ksi | 823.7 ksi |
| Peak Load | 3052.6 lbf | 2573.6 lbf | 2226.5 lbf |
| Peak Stress | 5032.1 psi | 4048.3 psi | 5114.0 psi |

**Source:** "Axial Tube Crush Tests." *HPR Strength of Materials*. N.p., 4 July 2010. Web. 28 Aug. 2012. <http://www.rocketmaterials.org/datastore/tubes/Axial/index.php>.

# ADDITIONAL STRUCTURAL COMPONENTS

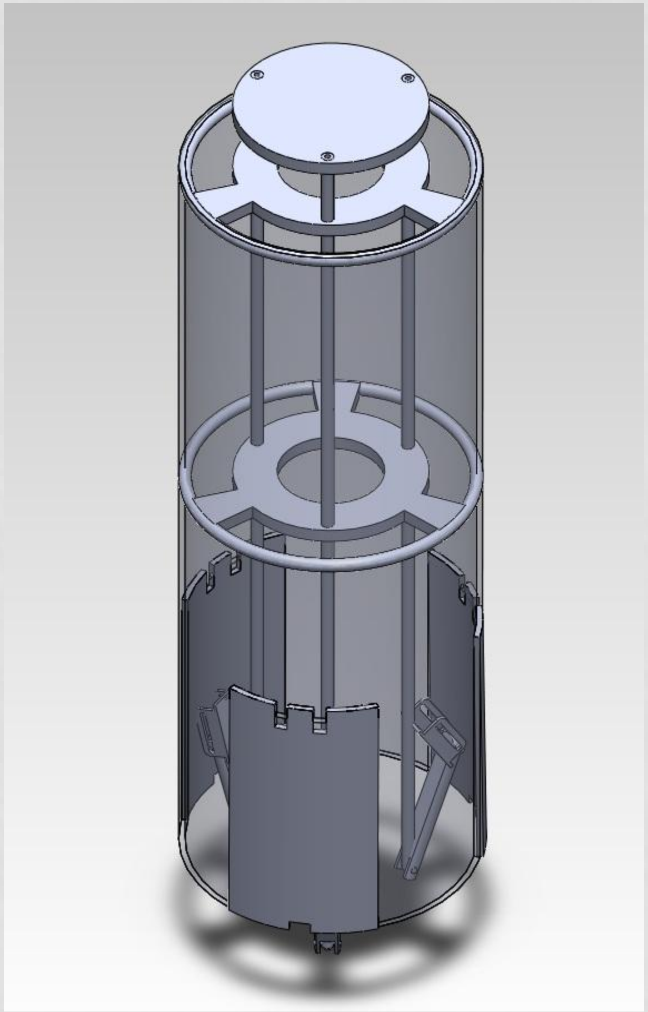
- Additional components will be made of *fiberglass*.
- Necessary couplers will be purchased from Great Leap Rocketry to stay consistent with the use of Magnaframe.

**Source:** **h**ttp://giantleaprocketry.com/products/components_airframes.aspx

# AIRBRAKE SYSTEM

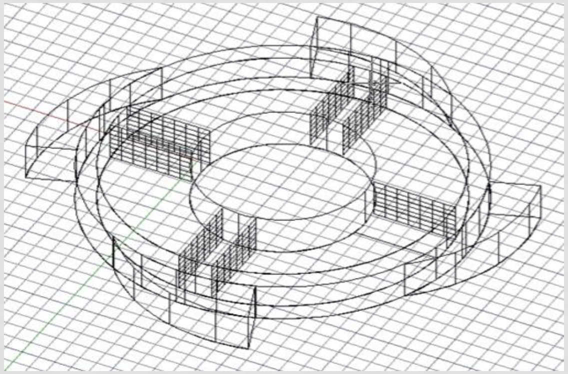
# CONCEPT DEVELOPMENT

- PURPOSE
  - To create the additional drag required to slow the rocket in the case that the rocket is approaching the desired 1mile apogee too rapidly.

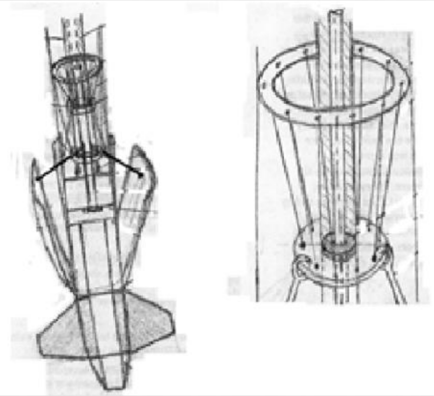


# CONCEPT EVOLUTION

- Spikes System
  - **Description**: Disk with spikes coming off of it twists around motor mount, pushing spikes out so that horizontal shark-tooth fins come out of rocket's body.
  - **Pros**: Compact.
  - **Cons**: Expensive due to cuts in Magnaframe tube and complex manufacturing process.



- Umbrella System
  - **Description**: Suspension of wire cables from a ring attached to servo. As top ring is lowered, loosened cables allow brake panels to open out of rocket.
  - **Pros**: Simple mechanical system with little components; structural strength.
  - **Cons**: Heavy.



# FINAL CONFIGURATION

- **DESCRIPTION:** Four rods, joined on a disk in the airframe, that can move up and down around the motor mount. When the four rods are pulled up, a second rod attached to their ends is forced against the brake panels, pushing panels. Each panel is hinged to the rocket so that when the airbrakes are opened, the panels are pushed out and fold upward.

- Dimensions:
  - $Arc\ length = \frac{2\pi r}{number\ of\ panels} \approx 4.712\ in$
  - *4 in* height
- Materials:
  - Brake Panels: Fiberglass
  - Mechanical components: Aluminum
- Location:
  - Directly beneath Magnaframe body frame (as an extension to the rocket) under the fins.
- Power Source:
  - air chamber to ensure simultaneous pulling of the rods.

# COMPONENT BREAKDOWN

| Component | Dimensions Used | Quantity | Mass (lb) | Cost* |
|---|---|---|---|---|
| Body Tube Disks | 3in ID x 6in OD | 2 | 2.068487 | $20.00 |
| Circular Rod | 0.25in OD x 0.12in ID x 18in L | 3 | 0.795954 | $18.12 |
| Compressed Air | - | 1 | 0.25 | $15.00 |
| Insulation Blanket | - | 1 | 0.1 | $30.00 |
| Panel Connector | 1.25in x 0.75in x 0.5in | 3 | 0.137171 | $15.00 |
| Pins | 0.125in OD x 0.5125in L | 3 | 0.007362 | $1.85 |
| Pins | 0.125in OD x 0.76in L | 3 | 0.010917 | $1.85 |
| Rectangular Rod | 0.5in x 0.25in x 3in | 3 | 0.109737 | $7.13 |
| Rod Mount | 0.25in D x 18.064in L | 1 | 0.689496 | $18.15 |
| Miscillaneous (Epoxy, screws) | - | - | 0.2 | $30.00 |
| Airbrake Panels | 0.0625in x 6.283in x 6in | 3 | 0.041177 | $70.00 |
| | | **TOTAL:** | 4.4103 lb | $227.10 |

# PAYLOAD

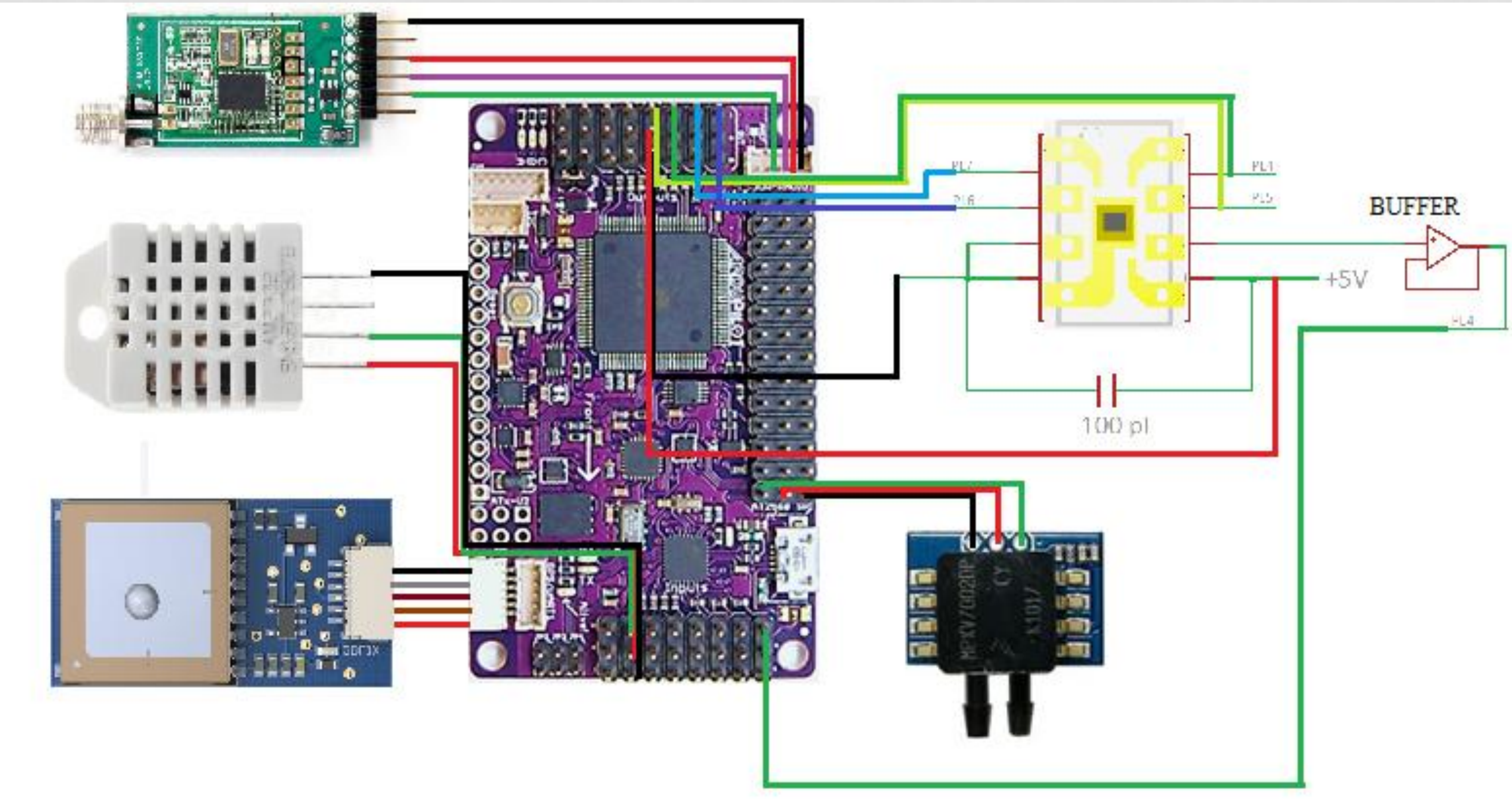
# PAYLOAD ELECTRONICS

The avionics payload will consist of the ArduPilot Mega 2.5 with the ATMEGA 2560 as the core processor.

The payload will record data including:

- Acceleration
- Velocity
- Flight path via a 10 Hz GPS
- Solar irradiance
- Live video
- Barometric pressure
- Temperature
- Humidity
- Inertial angular rotation

# PAYLOAD WIRING



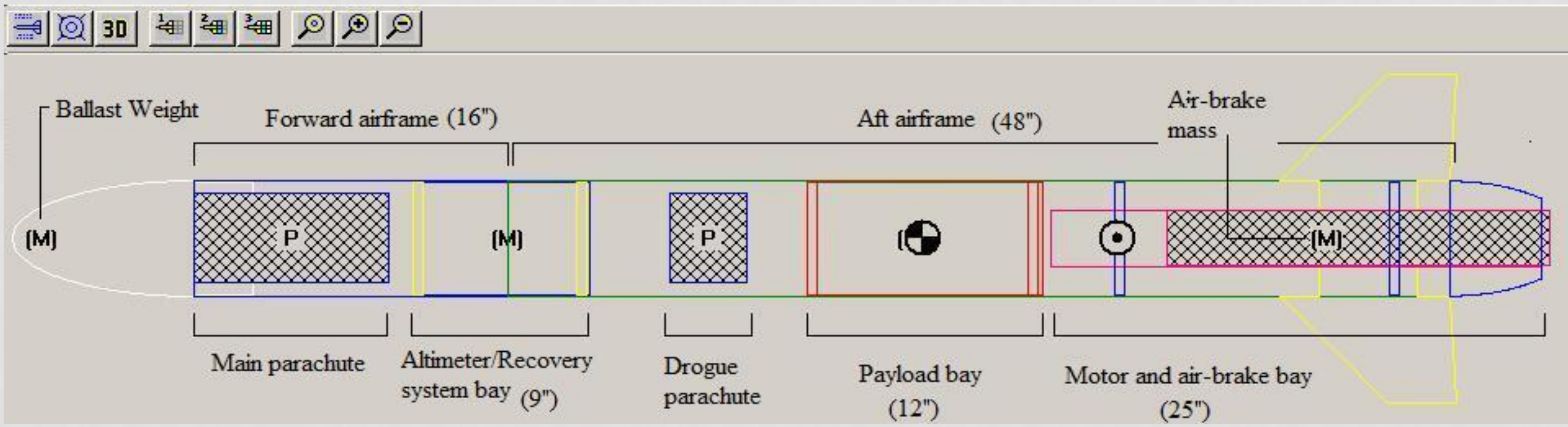
# LIVE VIDEO

# RECOVERY SYSTEM

# RECOVERY SUMMARY

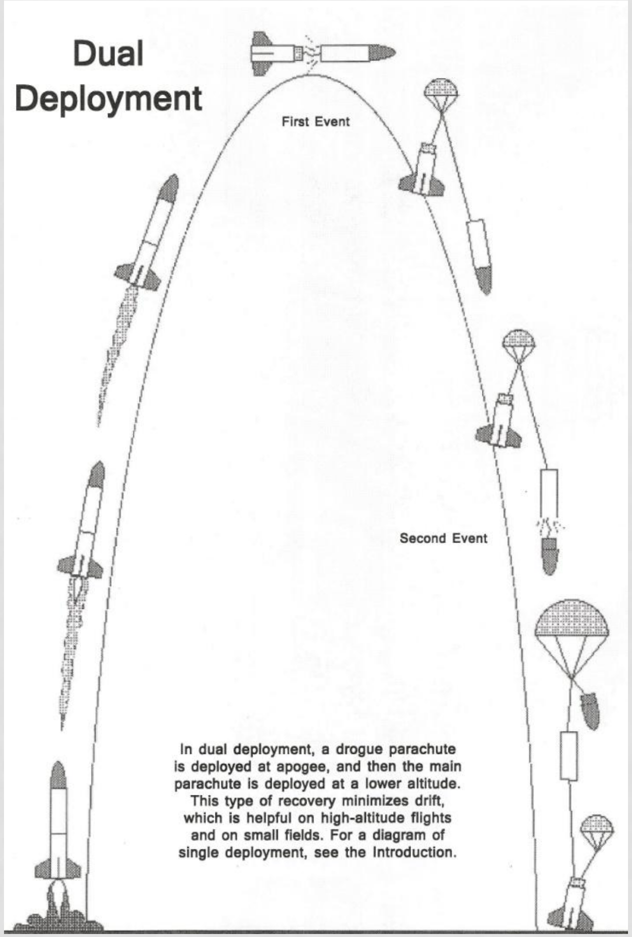
- Attachment Scheme
- Deployment Process
- Parachutes
- Altimeters/Ejection Charges
- Recovery Harness/Points of Attachment

# ATTACHMENT SCHEME



# DEPLOYMENT PROCESS

- Dual Deployment
  - Stage 1: Drogue parachute deployed at apogee
  - Stage 2: Main parachute fully deployed by 800ft altitude




Source: Modern High Power Rocketry 2 by Mark Canepa

# PARACHUTES

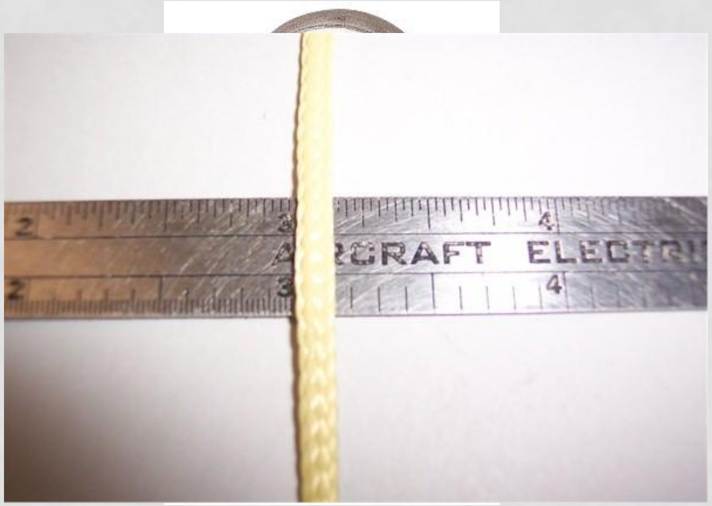
- Drogue:
  - 36’’ diameter
- Main:
  - 84’’ diameter fully deployed by 800ft altitude

# ALTIMETERS/EJECTION CHARGES

- The Featherweight Raven 3 Altimeter
  - Accelerometer-based apogee deployment (Output)
  - Barometric apogee backup deployment (Output)
  - Main (Output)
  - Main backup (Output)
- Redundant altimeter
- Redundant ejection charges with FFFF black powder
- Ground testing/live testing

# RECOVERY HARNESS/POINTS OF ATTACHMENT

- ¼'' Kevlar recovery harness
  - 3-4 times the length of Eclipse-1
- Closed eyebolts attached to altimeter bay bulkhead
- Quick-link connector

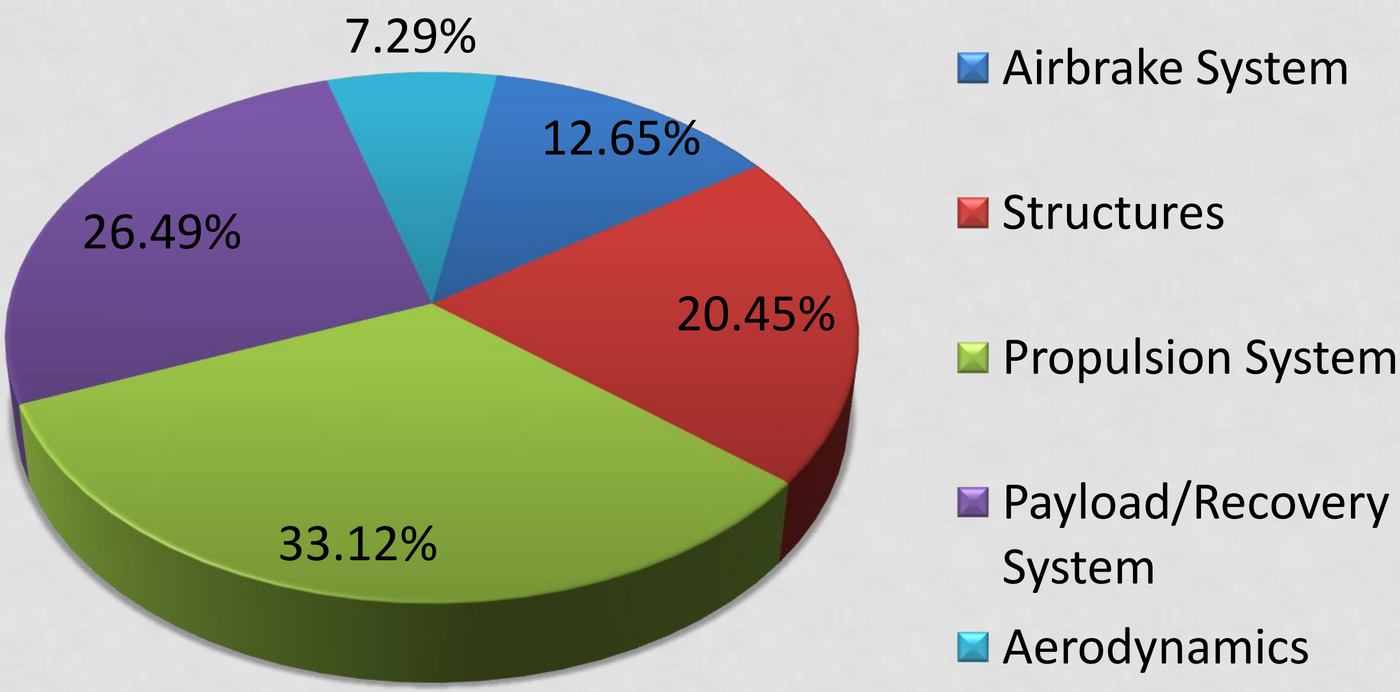


# MASS BUDGET

# MASS BUDGET BREAKDOWN

| Rocket Component | Approx. Mass |
|---|---|
| Aerodynamics | 2.20 lb |
| Airbrake System | 3.819 lb |
| Propulsion System | 10.0 lb |
| Payload/Recovery System | 8.0 lb |
| Structures | 6.175 lb |
| TOTAL: | ~30.195 lb |

# MASS BUDGET




**Total Mass = 30.20 lb**

# PLAN FOR VEHICLE SAFETY

# ECLIPSE SAFETY VERIFICATION

- Take into account the risks and corresponding mitigations
- Verify risks according to the degree of probability
- Verify potential modes of failure and follow the pre-flight solutions

# TESTING

# TESTING CHECKLIST

- Payload System Verification
- Recovery System Verification
- Motor System Verification