

# Aerodynamics and Recovery

## Members:

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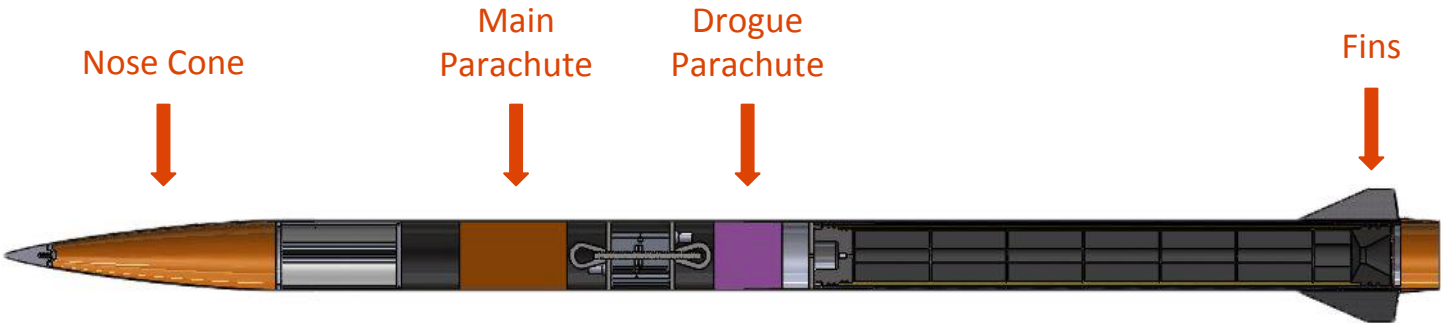


**Oregon State**  
University



# Objectives

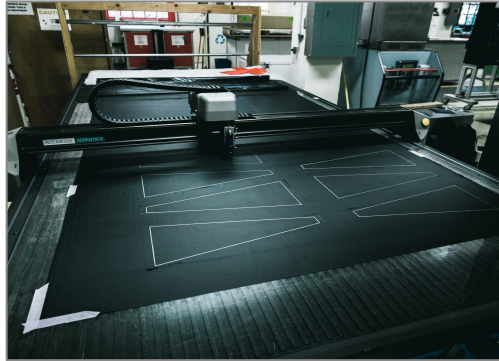
- Design a safe and reliable recovery and ejection system to ensure mission success.
- Perform simulations to ensure proper stability margins throughout the flight.
- Design fins, nose cone, and parachutes for favorable aerodynamic characteristics.





# Design Challenges

- Significant constraints were the weight of the rocket and the available space for the recovery system components
- Design for specified descent speeds as allowed by IREC
- Optimize fins for constantly changing variables to ensure rocket remained within stability margin allowed by IREC

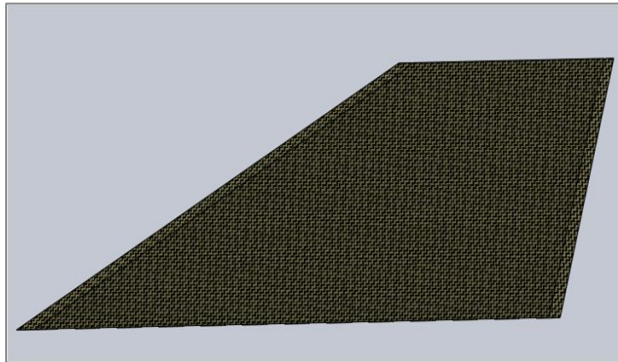




# Final Design

## Fins

- 4 trapezoidal fins with a double diamond cross-section
- Root Chord: 12 in.
- Tip Chord: 4.75 in.
- Span: 4.9 in.
- Sweep Angle:  $60^\circ$



## Nose Cone

- Von Karman Profile
- Length: 31.4 in.
- Outer Diameter: 6.4 in.
- Fineness Ratio: 4.9
- Thickness: 0.05 in.

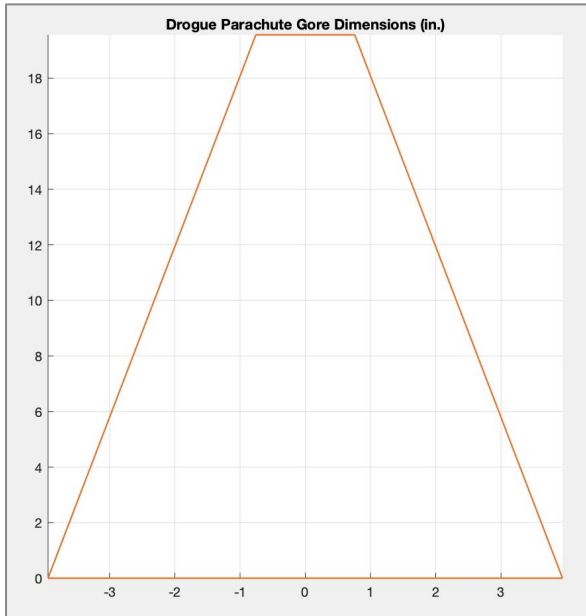




# Final Design

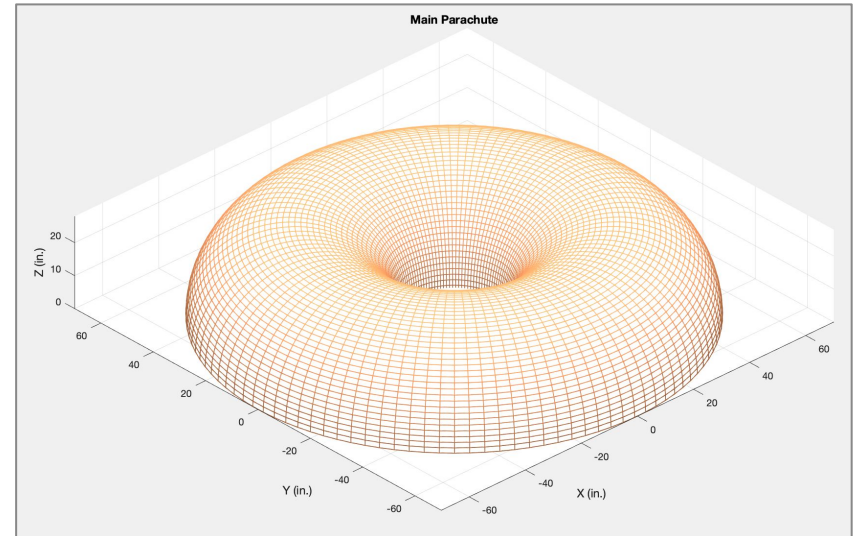
## Drogue Parachute: Annular

- Outer Diameter: 28.96 in. (2.41 ft)



## Main Parachute: Toroidal

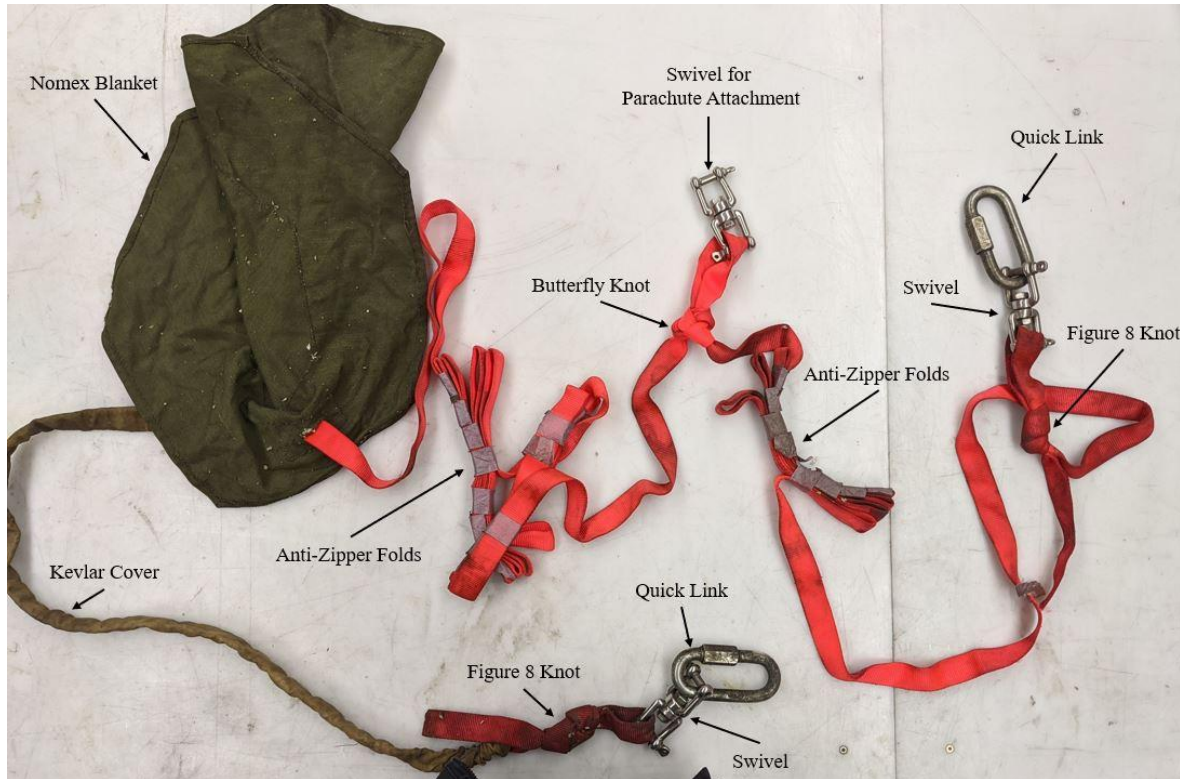
- Outer Diameter: 140.0 in. (11.67 ft)





# Final Design

## Recovery Harness

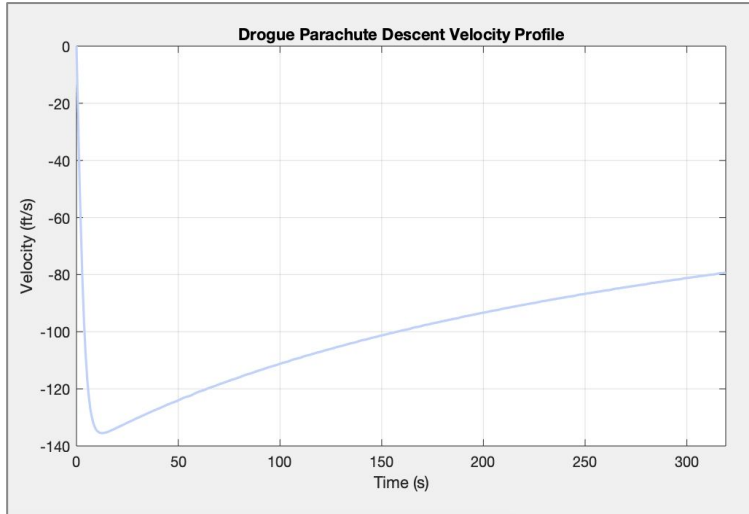




# Testing Results

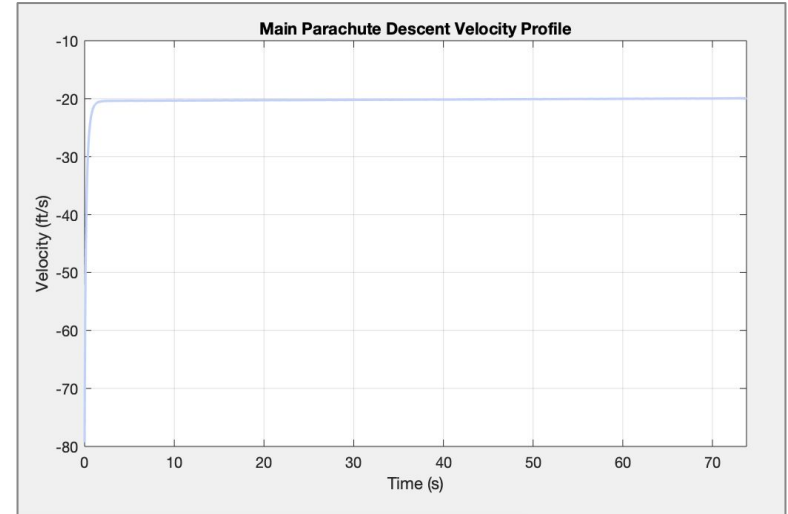
## Drogue Parachute Descent Rate

- Rocket Descent Rate:  $\sim 80$  ft/s
- IREC: Between 75 and 150 ft/s



## Main Parachute Descent Rate

- Touchdown Velocity:  $\sim 20$  ft/s
- IREC: Less Than 30 ft/s

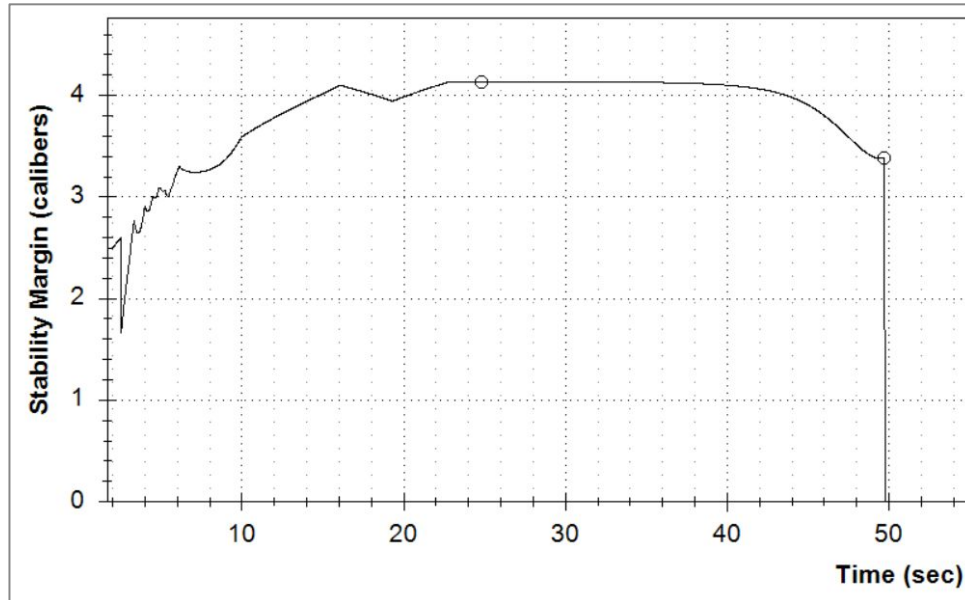




# Testing Results

## Stability Simulations

- Stability Criteria: Must be between 1.5 and 6 calibers for the entire flight profile.
- Current Stability: The stability margin for the entire flight profile has a minimum value of **1.65** and a maximum value of **4.18** calibers.



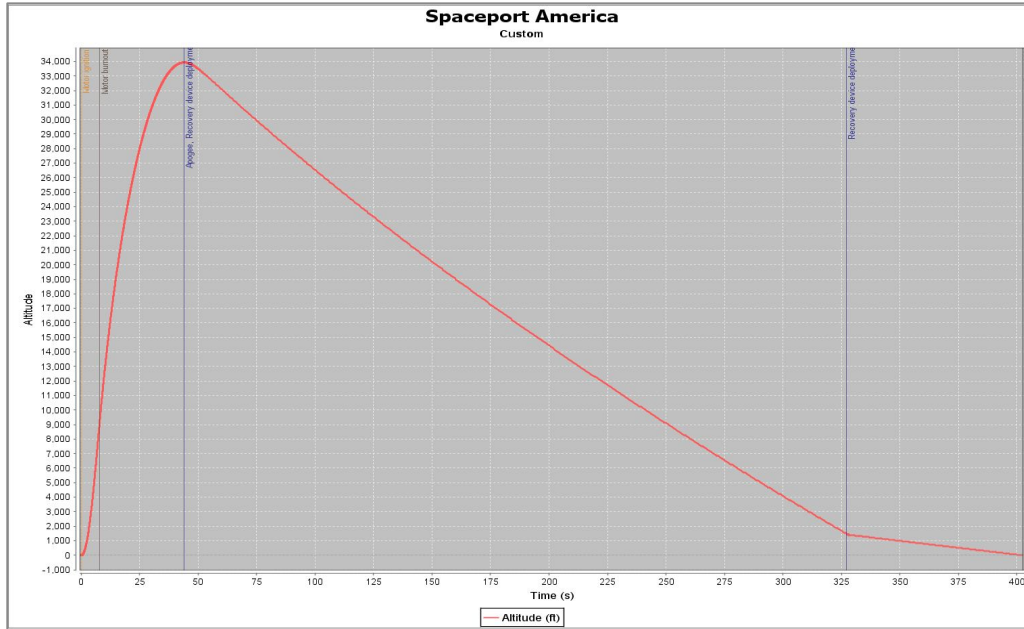




# Testing Results

## Altitude Simulations

- Altitude Goal: 30,000 ft AGL
- Current Simulated Altitude: The current OpenRocket simulation for Spaceport America has an altitude of **33,936 ft** AGL with 10 MPH wind.





# Testing Results

## Ejection System

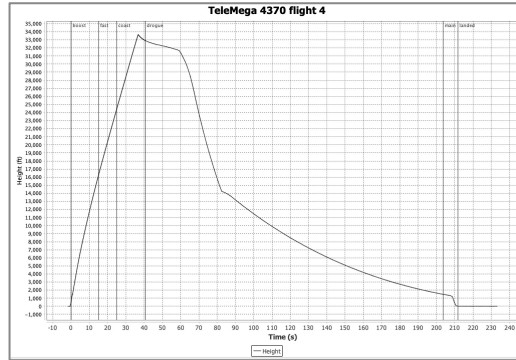
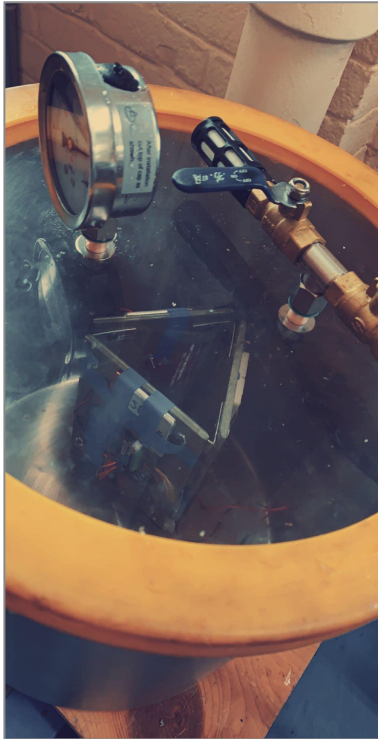
Date	Charge	Size	Shear Pins	Results
2/28/2020	Main Primary	5 g	4	Failed
2/28/2020	Drogue Primary	3 g	5	Failed
2/28/2020	Main Primary	6.5 g	4	Successful
2/28/2020	Drogue Primary	4.5 g	5	Successful
2/29/2020	Main Redundant	9.75 g	4	Successful
2/29/2020	Drogue Redundant	6.75 g	5	Successful





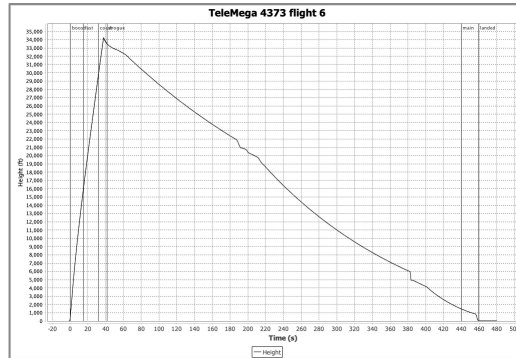
# Testing Results

## TeleMegas



### Primary TeleMega, SN-4370

- Simulated Altitude: 33,650 ft
- Drogue Deployment: 32,900 ft
- Main Deployment Target: 1,499 ft
- Main Deployment Actual: 1,488 ft
- Simulated Speed: 52 ft/s



### Redundant TeleMega, SN-4373

- Simulated Altitude: 34,260 ft
- Drogue Deployment: 33,550 ft
- Main Deployment Target: 1,475 ft
- Main Deployment Actual: 1,468 ft
- Simulated Speed: 65 ft/s



# Recommendations

## Ejection System

- Talk to Avionics early and determine responsibilities
- Familiarize yourself with AltOS and the TeleMega early on
- Perform ejection testing without TeleMegas to determine desired charge size
  - Or with the TeleMega outside the rocket
- If possible, use old parachutes for ejection tests

## Recovery System

- Repair parachutes with ripstop nylon tape rather than sewing patches
- Learn to sew early and practice

## General Recommendations

- Do L1 & L2 certifications early
  - Do an L2 with dual-deployment
- And... Be safe!