Utah State Sounding Rocket CHIMAERA

Paul Mueller III
Utah State University
4120 Old Main Hill
Logan, Utah 84322
Paul.Mueller@sdl.usu.edu

David Omer
Utah State University
4120 Old Main Hill
Logan, Utah 84322
dome@cc.usu.edu

Shannon Eilers
Utah State University
4120 Old Main Hill
Logan, Utah 84322
seilers@cc.usu.edu

Design Team:
Mike Awalt; Ben Bodrero; Mitch Bott; Jacob Brown; Joel Ellsworth; Patrick Jolley; Aaron Jones

Support Team:
Spencer Chandler; Michael Mamanakis; Guy Schauerhammer; Brian Solomon

Project Summary

The primary goals of the Chimaera sounding rocket project are:

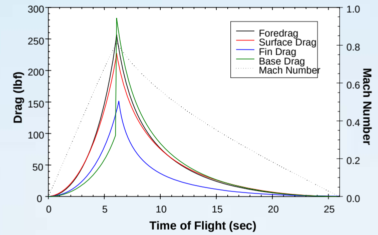
- Carry payloads (~10 kg) to altitudes between 100,000-250,000 ft AGL and safely recover them. This is to be accomplished through a series of lower-altitude flights, proving flight hardware and programmatic development.
- Provide senior design experience to students.

This project builds on the legacy of the Unity IV project, which previously employed teams from Utah State University, Brigham Young University, University of Utah, and Weber State University. In recent years, however, the latter two universities have withdrawn from the program, and USU and BYU have begun concurrent development of their own rockets.

Over many years, several design teams have contributed to this design. The motor uses a hydroxyl-terminated poly-butadiene (HTPB) casting in an 8-inch diameter, fiber-reinforced aluminum tube for the propellant. Nitrous oxide is used as a the oxidizer. The nozzle is ablative, and is fabricated using silica-phenolic. Finally, nitrogen is used to pressurize the system. The motor has produced up to 2700 pounds of thrust in static testing and is designed to operate for up to 60 seconds.

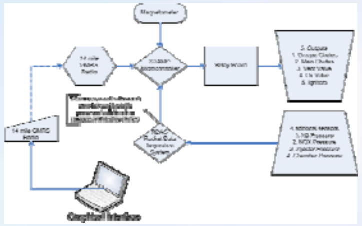
The goal of the system presented herein was to reach 10,000 ft AGL during an ESRA-sponsored launch competition. While the casting is capable of far exceeding this altitude, the current team was constrained by availability of acceptable oxidizer tanks, reducing the altitude attainable on this launch to near 6,000 ft. The system was built to be able to incorporate a larger oxidizer tank, facilitating higher altitude launches after proving all other systems.

Aerodynamics



Drag was predicted by separating the drag into its four major sources: pressure foredrag, surface skin drag of the fuselage, drag on the fins, and drag caused by the separated wake behind the fuselage. The sudden spike in base drag is due to the cessation of thrust, and hence a larger area to which the separation pressure drag applies.

Avionics

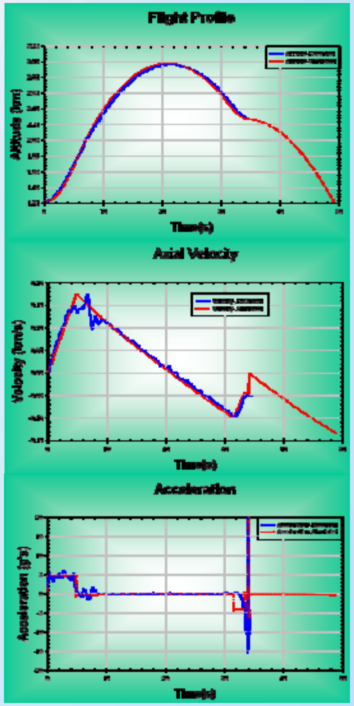


The avionics operates in two modes: safe and arm. When the rocket is in safe mode, only the vent valve can be opened or closed. When the rocket is armed, all commands can be implemented, including launch and emergency recovery operations. The avionics system is also fully capable of commanding a two-stage recovery system, but it is not implemented on this rocket.

Results and Simulation

Chimaera was launched on Jan. 5, 2006 to approximately 5740 ft AGL. Limited data was collected, including axial acceleration and range data. This information was filtered and compared against a flight simulation. This data comparison allows us to back out estimates of the motor thrust, overall drag, and specific impulse of the motor.

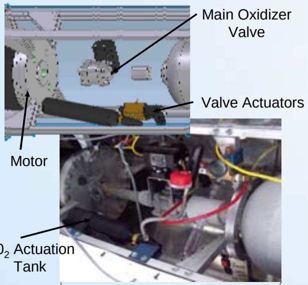
It was found that the average specific impulse of the motor was 200 seconds. Thrust stayed fairly constant around 1800 lbf.



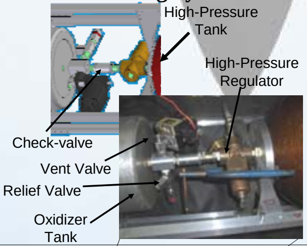
Recovery

When the rocket is launched, the avionics system takes over flight control and determines when to deploy the recovery system. The recovery system uses nichrome cutters to cut the dyneema line holding the nosecone in place. When the nosecone is released, three springs separate the nose from the fuselage, and the nose pulls the parachutes from their canisters. The nosecone descends on a 9-foot cross chute, and the fuselage descends on a 35-foot T-10C Army troop chute.

Oxidizer Valve System

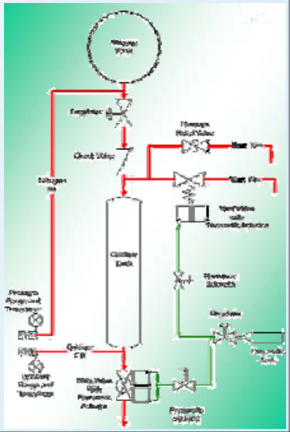


Pressurizing System

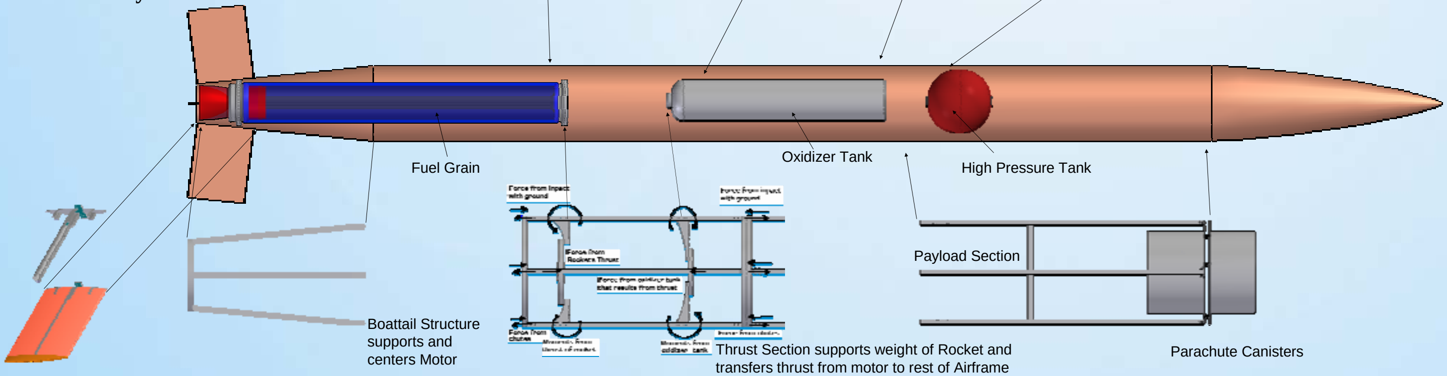


Oxidizer System

Nitrous Oxide is used as an oxidizer, with an operating pressure of 600 psi; Nitrogen is used to pressurize the system. Carbon Dioxide is used to actuate all valves. This oxidizer system is designed such that the oxidizer vent line fails open and the main valve fails closed, ensuring safety during fill, operation and recovery.



Hardware Layout



Conclusions and Future Work

Based on the information gathered from the launch (on-board data recorder, video, photos, recovered hardware, etc.), it was determined that the on-board flight-termination systems failed to detect apogee. Although unconfirmed, we suspect that flight was terminated by our ground-based signal. Parachutes deployed almost 12 seconds after apogee was reached, resulting in opening loads (~50+ g) greater than those for which they were designed (12 g). Failure was along the sectional interfaces, previously known to be the weakest point. Secondary failure occurred along the main parachute lines.

Future work aims to keep with the original project goals, i.e. achieve successively higher altitude launches until reaching sounding-rocket range (150-250,000 ft). While research into flight termination systems will undoubtedly be undertaken, emphasis may also be placed on more efficient motors and nozzle development.