Strato Cats

Wisconsin Space Grant Consortium Regional Rocket Competition

Post Flight Performance Report

Jeffrey Allen
Kevin Eliason
Jacob Chesley
Nick Fagan
Brandon Horne

University of Cincinnati, Cincinnati, Ohio

Faculty Advisor – Grant Schaffner, Ph.D., University of Cincinnati

Special thanks to:
Curt Fox, Senior Research Associate, University of Cincinnati
Professor Kelly Cohen, University of Cincinnati
Professor Elad Kivelevitch, University of Cincinnati
Wei Wei, Graduate Student, University of Cincinnati
Team Ohio Rocketry Club

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1.0 Executive Summary

The goal of this competition was to design, construct, and fly a one-stage high-powered rocket that would accurately achieve an apogee of 3000 feet and be recovered safely and in flyable condition within the competition parameters. The team from the University of Cincinnati designed and constructed a rocket (*Icarus*) to meet the competition parameters as follows: The rocket motor to be used is the Cesaroni I540-16, and the dimensions of the rocket cannot exceed 4” in diameter, 72” in height, and must weigh no more than 7.5 lbs without the motor. The final rocket’s dimensions were 69” in height, 4” in diameter, and weighed approximately 5.8 lbs (7.2 lbs with motor).

This report contains the flight results of the competition flight for *Icarus* and discusses the performance of the rocket versus what was expected by the team.

2.0 Flight Results

The competition results presented are from two sources. The first source is the Raven altimeter supplied by the competition and shown in Figure 1. The second source is the SL100 Stratologger altimeter used as a backup as well as for ejection charges in recovery, shown in Figure 2.

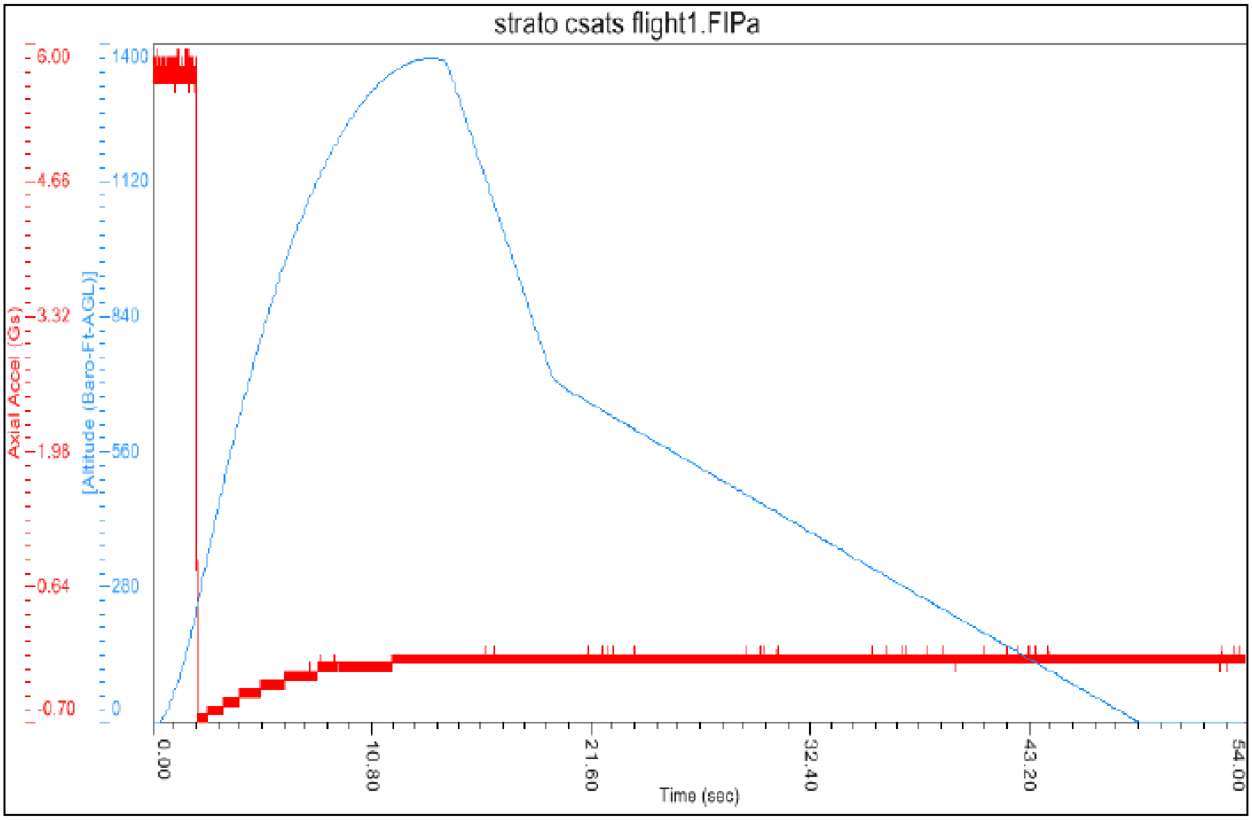


Figure 1: Raven Competition Flight Recorder Data, Altitude and Acceleration

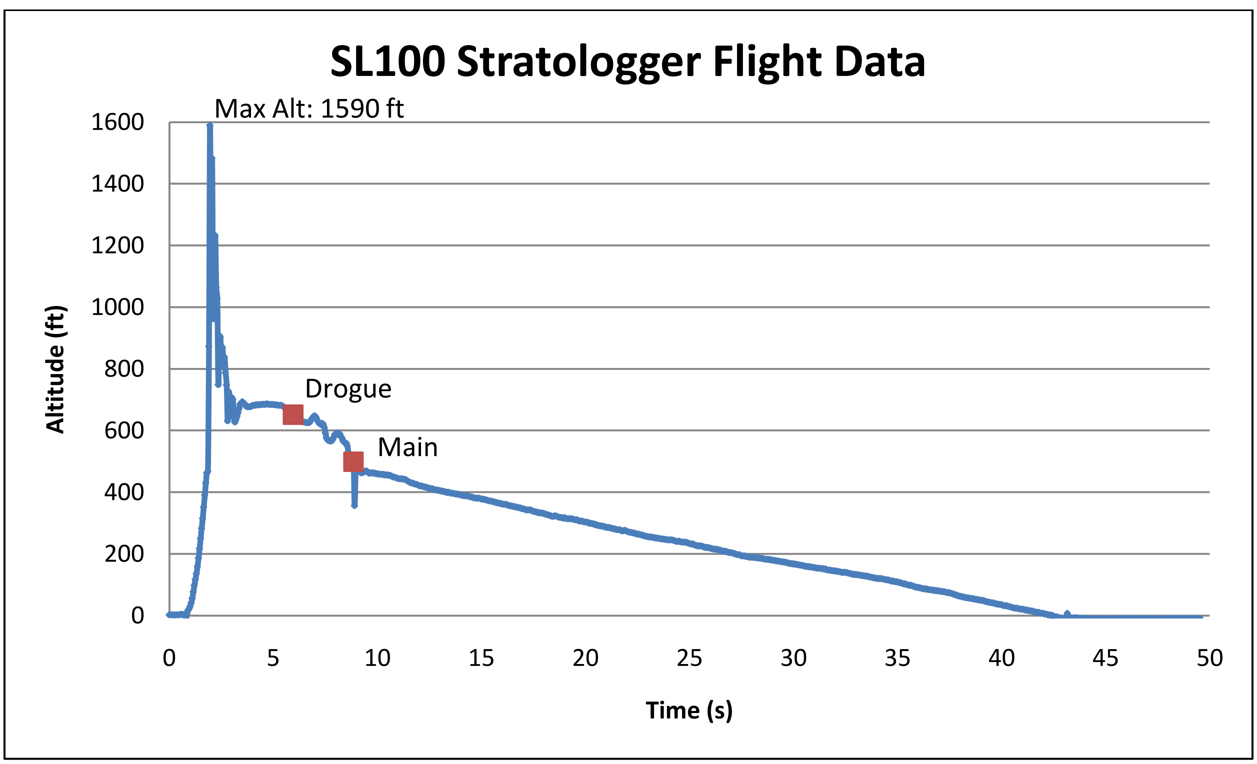


Figure 2: SL100 Stratologger On-Board Flight Recorder Data, Altitude

3.0 Discussion

Looking at both sets of data, it is evident the rocket did not reach a maximum altitude of 3000 feet. The max altitude from the Raven was 1372 feet, and was 1590 feet from the Stratologger. The rocket was expected to reach within the competition window of 2500-3500 feet, but did not reach more than halfway to the goal apogee due to unexpected issues during flight.

The initial burnout period of the competition flight was smooth and straight. During this period, the active air brakes that were used in the rocket (to control the max altitude the rocket reached in the flight) were suspended, to simplify the calculations for predicting the apogee of the rocket. Starting at ignition, the air brakes "slept" for 2 seconds – long enough to stay inactive during the burnout period of 1.2 seconds. After this delay of 2 seconds, the active control system initiated and started predicting the apogee of the rocket based on altitude and velocity readings, and adjusting the air brakes accordingly. As the rocket was designed to overshoot the goal apogee of 3000 feet, to use the airbrakes to control the apogee the rocket attained, it was expected for the airbrakes to deploy shortly after this 2 second delay.

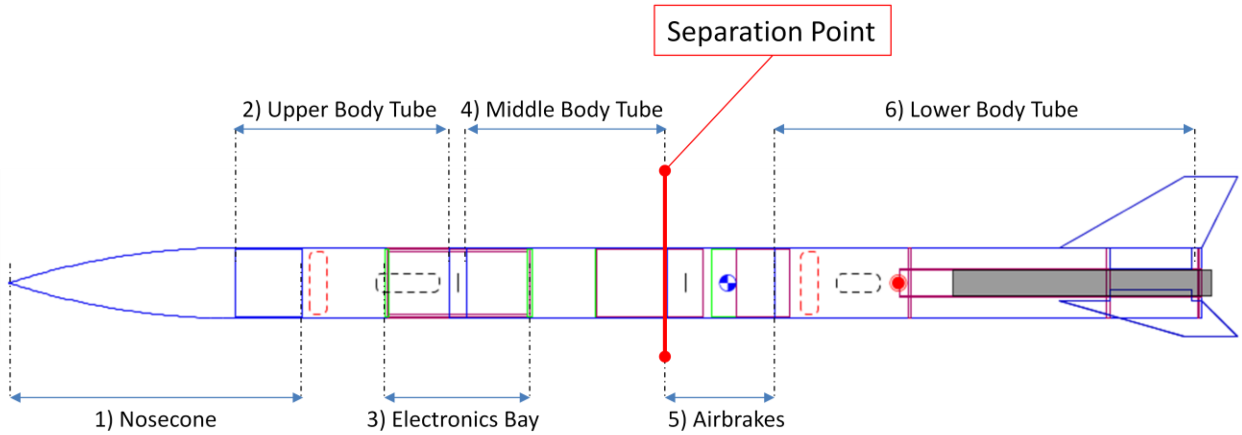
After burnout, disaster hit and ended the flight prematurely. The rocket separated in half above the air brake section; the rocket was modular so it was already a separate section, held together by a steel screw (See Appendix A and B). After the rocket split, the upper portion of the rocket and the lower portion tumbled about until the drogue parachute deployed at 650 feet, since the Stratologger calculated it was past what could be considered apogee, slowing and steadying the descent of the lower portion. The upper portion continued to descend in a wild manner until the main parachute deployed at 500 feet as programmed in the other Stratologger altimeter. Since both parachutes deployed, both sections were recoverable in order to assess the damage and deduce what happened. In addition to the rocket splitting in half, a fin was knocked off of the lower body tube during the tumble and ejection of the drogue parachute, and as the drogue parachute ejected, the force ripped the 3D printed mount for the air brake electronics in half, dumping them overboard (See Appendix C and D).

Reviewing the damaged rocket, it is obvious that one screw was not enough to secure the upper portion of the rocket to the air brake module. The screw ripped through the body, causing the upper portion of the rocket to separate from the lower. Looking at the Stratologger data in Figure 2 and recalling the events from the launch, the conclusion was made that the air brakes deployed after the 2 second delay for burnout, as was expected. As nothing else could have caused this separation at that time during the flight, it was concluded that the deployment of the air brakes had a stronger force than anticipated and ripped the modules apart. In the end, two or three more screws to secure the modules could have prevented this disaster by helping transfer the load, but ultimately, the strength of the material of the rocket body was to blame.

Overall, the rocket performed as expected until the air brakes were deployed. Unfortunately, as the air brakes deployed, the rocket separated into two causing the flight to end prematurely. Two modules consisting of thin cardboard held together by one screw at the location of the majority of load transfer during air brake deployment was an engineering oversight and the cause of disaster for the rocket flight. As a result, the rocket was recovered, but was damaged enough to the extent where repairs in the short amount of time left in the competition were not possible to try for a second flight. In the end, the rocket did not reach the expected 3000 feet, but fell short by under half of the goal apogee. Lessons learned include verifying that if the design is modular, important load paths need to be reinforced, and the load will be distributed evenly instead of in a concentrated area.

Appendix A

Schematic of *Icarus* Design, and location of Separation Point



Appendix B

Picture of Damage to Airbrake module: Location of Failure.

Appendix C

Picture of Damage to Lower Body Tube: Fin Damage.

Appendix D

Picture of Damage to Airbrake module: Electronics Mount Damage.