Wisconsin Space Grant Consortium Regional Competition
Post Flight Performance Report

Ad Astra

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Performance Comparison:

Data Values:	**Predicted Value:**	**Flight Value:**
Maximum Altitude (ft agl)	3009 feet	2690 feet
Maximum Velocity (ft/s)	564 ft/s	453 ft/s
Maximum Acceleration (ft/s/s)	574 ft/s/s	1103.5 ft/s/s*
Operation:	**Yes/No**	
Launch:	Yes	
Parachute Deployment:	Yes	
Recovered	Yes	
Determined to be in Flyable Condition:	Yes	

TABLE 1: A comparison of the predicted data values to the values measured using the Raven III altimeter. The predicted values were found using RockSim file for the rocket, which included the measurements taken in the wind tunnel. See the discussion for an explanation for the discrepancies in the data values.
*Likely an outlier, see Figure 1.

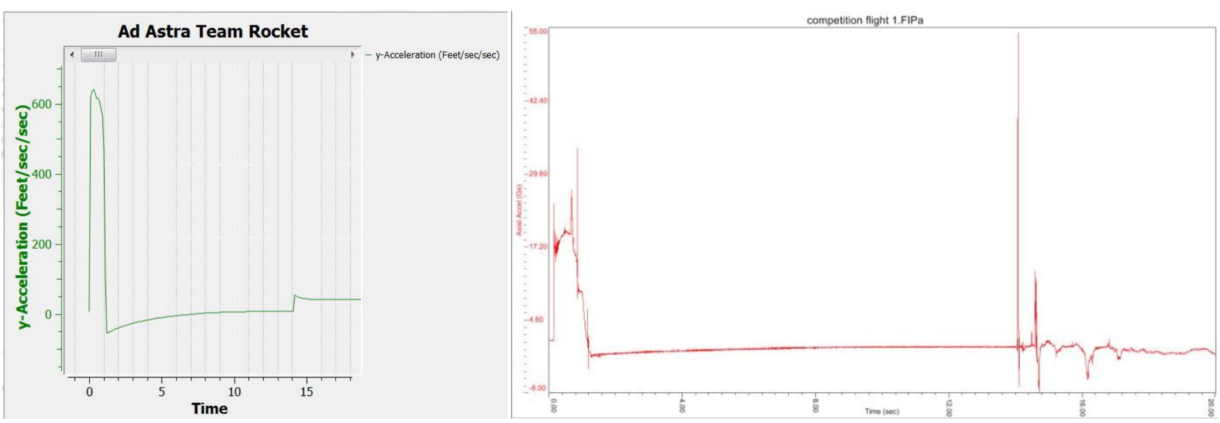

FIGURE 1: The predicted and measured accelerations of the rocket up through parachute deployment. The predicted values are on the left and are taken from RockSim, and the measured values are a graph of the data recorded using the Raven III.

Flight Performance and Discussion:

The rocket performed flawlessly. The launch was perfect, the motor functioned properly, and all of the ejection charges, including the motor eject, fired. The parachute deployed properly, and the rocket landed completely intact. The most difficult part of the launch was recovering the rocket, which required significant effort due to extremely difficult terrain and the misguided decision to remove the GPS tracking unit in order to preserve weight. After it was recovered, the rocket was found to be completely intact. The airbrakes did not deploy, which was proper considering the maximum altitude. Flying the rocket again requires little more than resetting the flight computers, refilling the ejection charges, and loading a new motor, and it is likely that this rocket will fly again in order to validate that the airbrakes operate properly and that the programs work correctly.

The variations between the predicted and measured data values are extremely large for maximum altitude, velocity, and acceleration. However, almost all of these discrepancies can be explained fairly simply. First, the fact that the measured maximum acceleration was double the predicted value is clearly an exaggeration, as a comparison of the data in Table 1 clearly shows that the measured acceleration was almost identical to the predicted acceleration except for a small jump near the end of the motor burn. Although the source of this erratic peak is unknown, it was likely some dramatic change in the motor burn, or potentially the ignition of the delay grain in the motor eject, that caused it. Aside from this point, the motor burned normally, producing an expected peak acceleration of 550-600 ft/s/s, which is completely in line with the predicted value once motor variation is accounted for. Following burnout, the graphs are remarkably similar, except for the fact that the flight data reflects minor variations in the data and also dramatically illustrates ejection and parachute deployment through the massive peak at 14 seconds into flight. Although the predicted data reflects this as well, it does not gage the violence of the ejection charges, and the resulting minor disparities in descent acceleration from the parachute.

When it comes to the maximum velocity and altitude, the significant variation between the predicted and measured values may be accounted for by another factor. Following bad performance at a test flight, decisions were made to dramatically alter the rocket. Most importantly, this involved removing three inches from the end of each fin, rounding the leading and trailing edges of each fin, and attaching wood fairings to the rail buttons to make them more aerodynamic. All of these changes clearly had a massive effect on the rocket's coefficient of drag, which had previously been calculated in a wind tunnel. However, due to time constraints, it was impossible to wind tunnel test again before the competition, and as such the new coefficient of drag had to be estimated by using the ratio between the RockSim coefficient of drag with the original fins and then the truncated fins. As a result, the final coefficient of drag used for simulations was essentially a scaled estimate which could not be tested before the competition flight. Thus, both the predicted maximum velocities and apogee directly depended on the accuracy of this coefficient of drag, and as expected there was significant variation between the values.

A second major source of difference between the measured and predicted apogees was the airbrakes. Although the assembly was in place for the wind tunnel tests, a different mechanism was used to hold them shut for the launches. This method, which actually allowed for the airbrakes to be deployed, meant that there was a slight gap between the airbrakes and the main body tube which had not existed during the wind tunnel tests, and it is extremely likely that this produced additional drag that seriously affected both maximum velocity and apogee. Once again, RockSim could not account for this drag, although addition wind tunnel testing with the rocket in its final configuration likely could have. Thus, overall differences in the data are either due to random inconsistencies or changes made to the rocket pre-launch that effectively nullified all of the data gathered in the wind tunnel used to make predictions. More accurate predictions could have been made if additional time had been available for further wind tunnel tests, but despite the relatively abstractly predicted coefficient of drag, the predicted value for maximum velocity was within 20% of the measured value, and the calculated apogee was only about 10% more than the actual apogee. Given that the motors can vary up to 20% and that RockSim could vary at least 3% on its own, these values are well within the expected uncertainties for the simulations.