CALIFORNIA STATE SCIENCE FAIR
2017 PROJECT SUMMARY

Name(s)

Benjamin T. Kolland

Project Number

S0309

Project Title

Drag-n-Fly: Optimization of Drag Coefficient Calculations from Rocket Altimeter Data

Abstract

Objectives/Goals

Flight simulations help optimize model rocket design. The TARC competition requires flying a model rocket repeatedly to a specific altitude, but the results can be inconsistent without an accurate drag coefficient (Cd). The solution: Use altimeter data to compare and optimize Cd calculations from peak altitude, peak velocity, and a curve fit using coast-down acceleration data from motor burnout to peak altitude. The hypothesis was that curve fitting the acceleration data would be optimal, as more data points per flight (60) are recorded rather than a single point peak altitude or velocity reading.

Methods/Materials

A Jolly Logic AltimeterThree recorded barometric pressure, altitude, and 3-axis acceleration data for each flight. Data analysis used RockSim (a rocketry-specific simulation program), Excel, and MATLAB. For altitude and velocity Cd, data was entered into the simulation with conditions set to match the actual flight, then the Cd was iterated and backsolved until the simulation matched the actual flight. Coast-down acceleration data was analyzed in MATLAB using linear regression to solve for Cd.

Results

Data was collected from 36 TARC flights in 2016 and 2017. Altitude backsolving using RockSim provided the most accurate Cd, but induced bias: the simulation was adjusted to match the flight altitude recorded. Velocity provided the least accurate Cd, varying from altitude Cd by 1.1% to 45.5%. Acceleration Cd values differed by 0.6% to 8.2% for all but one rocket (Pink=16.1%). The standard deviations for altitude and acceleration data were very low (<0.05), vs. high (0.13 to 0.6) using velocity. Statistical analysis showed that the medians for altitude Cd and acceleration Cd were statistically the same for all rockets except Pink. Wind tunnel tests were conducted to provide another cross-reference point.

Conclusions/Discussion

This project successfully determined model rocket drag coefficients from altitude, velocity, and acceleration. Altitude and acceleration methods yielded more accurate and consistent results than velocity. The hypothesis was partially disproved because the altitude Cd from backsolving results in the most accurate Rocksim predictions; however it may not reflect the actual Cd as well as the acceleration Cd. Observed Cd from recent wind tunnel testing supported the viability of both methods. Acceleration data is especially useful for planned integration into an altimeter.

Summary Statement

To correctly predict and optimize model rocket performance, this project analyzed altimeter/accelerometer flight data comparing three methods of determining the drag coefficient.

Help Received

Supervised rocketry testing (D. Raimondi, J. Dougherty, J. Friedland). L. Stephenson Haskins & G. Wahlstrand for data analysis. J. Beans for altimeter expertise. D. Cornelius for flight error analysis. N. Mourtos & G. Manzanares for wind tunnel access & support. 2016 & 2017 AFE Rocketry TARC teams.