Computational Design of a Modular Airbrake System

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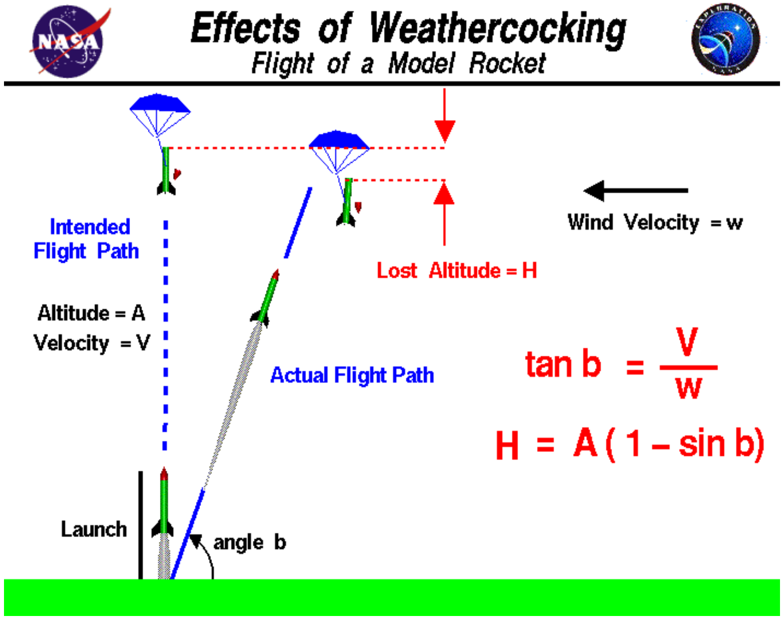
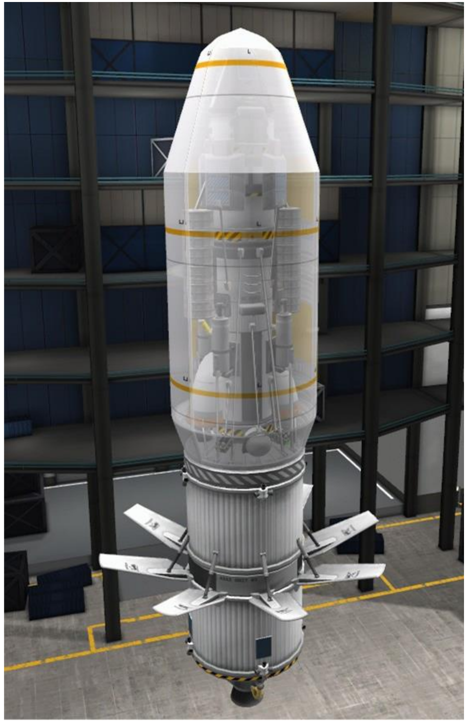
Introduction

- Problem: How to hit 10000 feet exactly?
  - Design rocket to exact weight?
  - Create an airbrake that deploys at a certain altitude?
  - **Design an airbrake that deploys intelligently**



Design Considerations

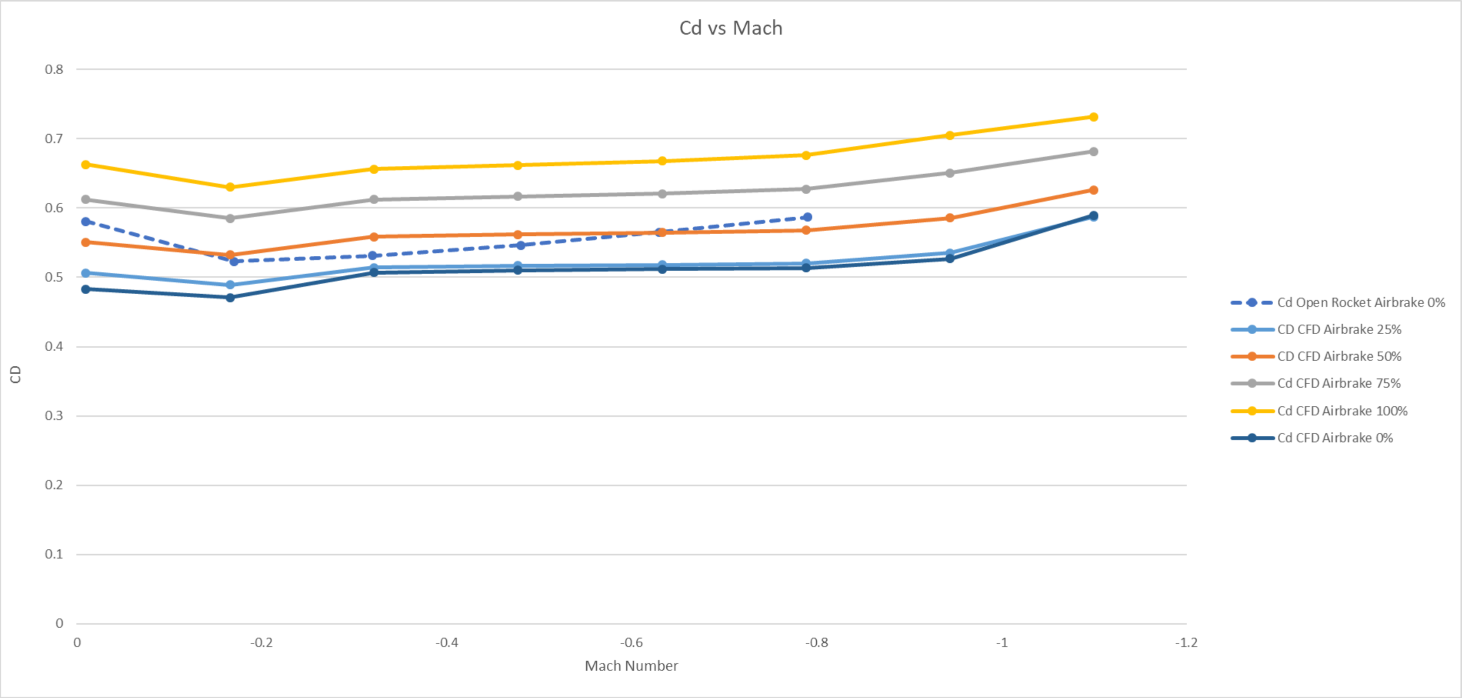
- Number of fins?
- Fin location?
- Fin size?



Simulating A Launch

- How to simulate a launch with an airbrake?
- Can't use Open Rocket
  - There is a plug in to add custom Cd vs Mach curves
  - Still doesnt work
- Created our own solution in MATLAB
  - Based off of equations and methods from Open Rocket
- Generated Cd vs Mach curves in Solidworks CFD
- Uses Open Rocket initial conditions

Simulating A Launch



Tuning An Airbrake

- Airbrake based around Arduino with array of sensors
- Fin deployment governed by Fehskens-Malewicki equations
- Run MATLAB sim tweaking deployment threshold until airbrake reaches desired outcome.
- Can tweak initial conditions to see how airbrake responds

Single Stage Fehskens-Malewicki Equations:

burnout velocity:

$$v_b = \sqrt{\frac{F-mg}{k}}\tanh\left[\frac{t_b}{m}\sqrt{k(F - mg)}\right]$$

burnout altitude:

$$y_b = \frac{m}{k}\ln\left\{\cosh\left[\frac{t_b}{m}\sqrt{k(F - mg)}\right]\right\}$$

coast altitude:

$$y_c = \frac{m_b}{2k}\ln\left[\frac{k v_b^2}{m_b g} + 1\right]$$

coast time:

$$t_c = \sqrt{\frac{m_b}{g k}}\tan^{-1}\left[v_b\sqrt{\frac{k}{g m_b}}\right]$$

Where:

$k = \frac{1}{2}\rho C_D A$

ρ = atmospheric density

C_D = drag coefficient

A = frontal area

t_b = burn time

F = average thrust

m = average thrusting mass

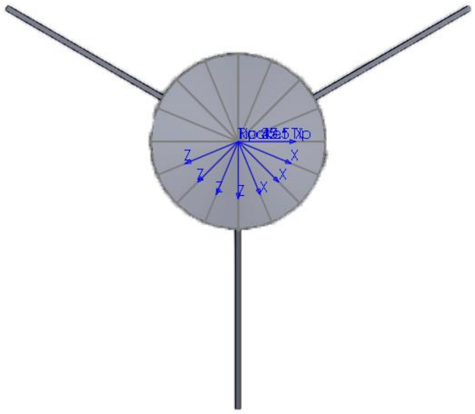
m_b = burnout mass

g = acceleration due to gravity

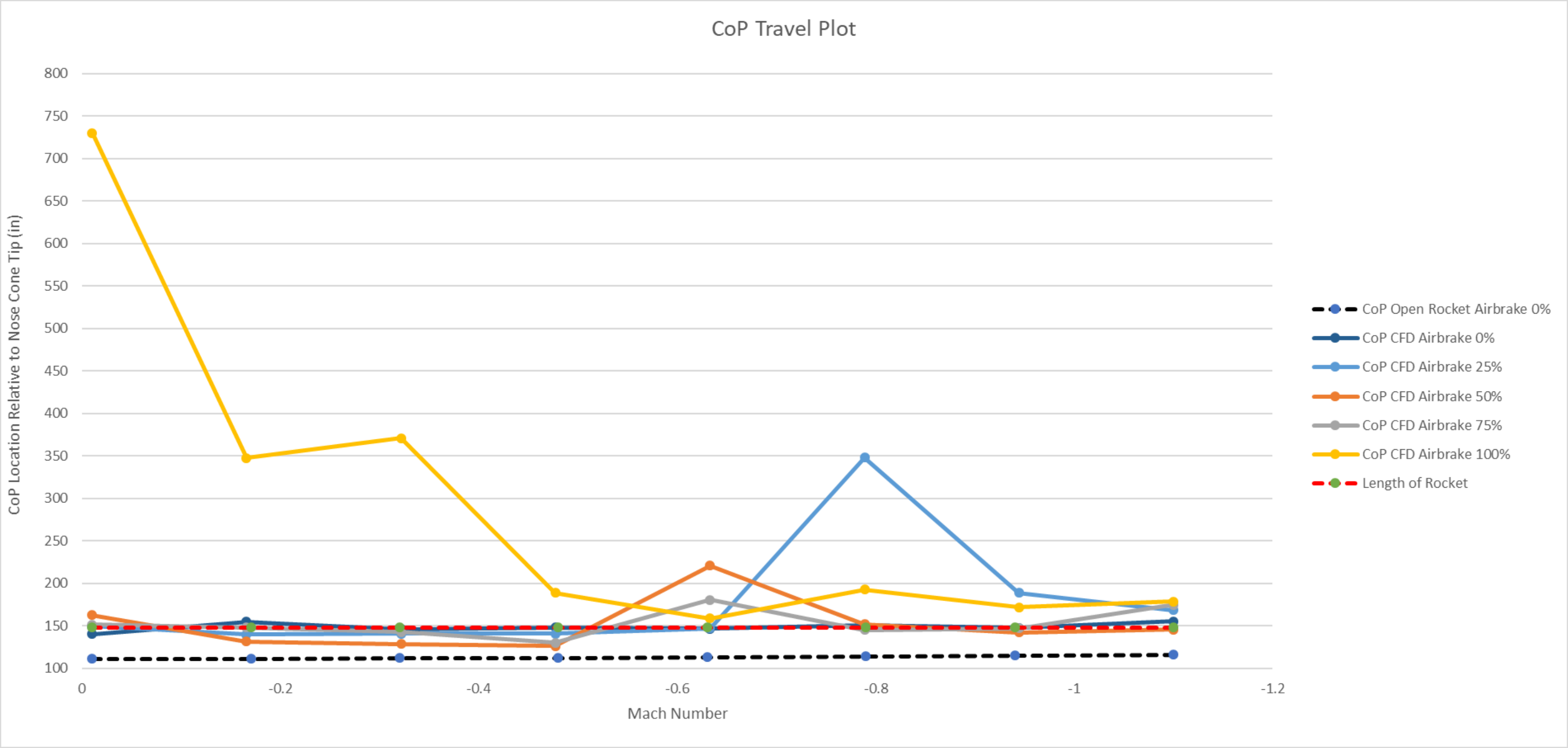
Return

Finding the Center of Pressure

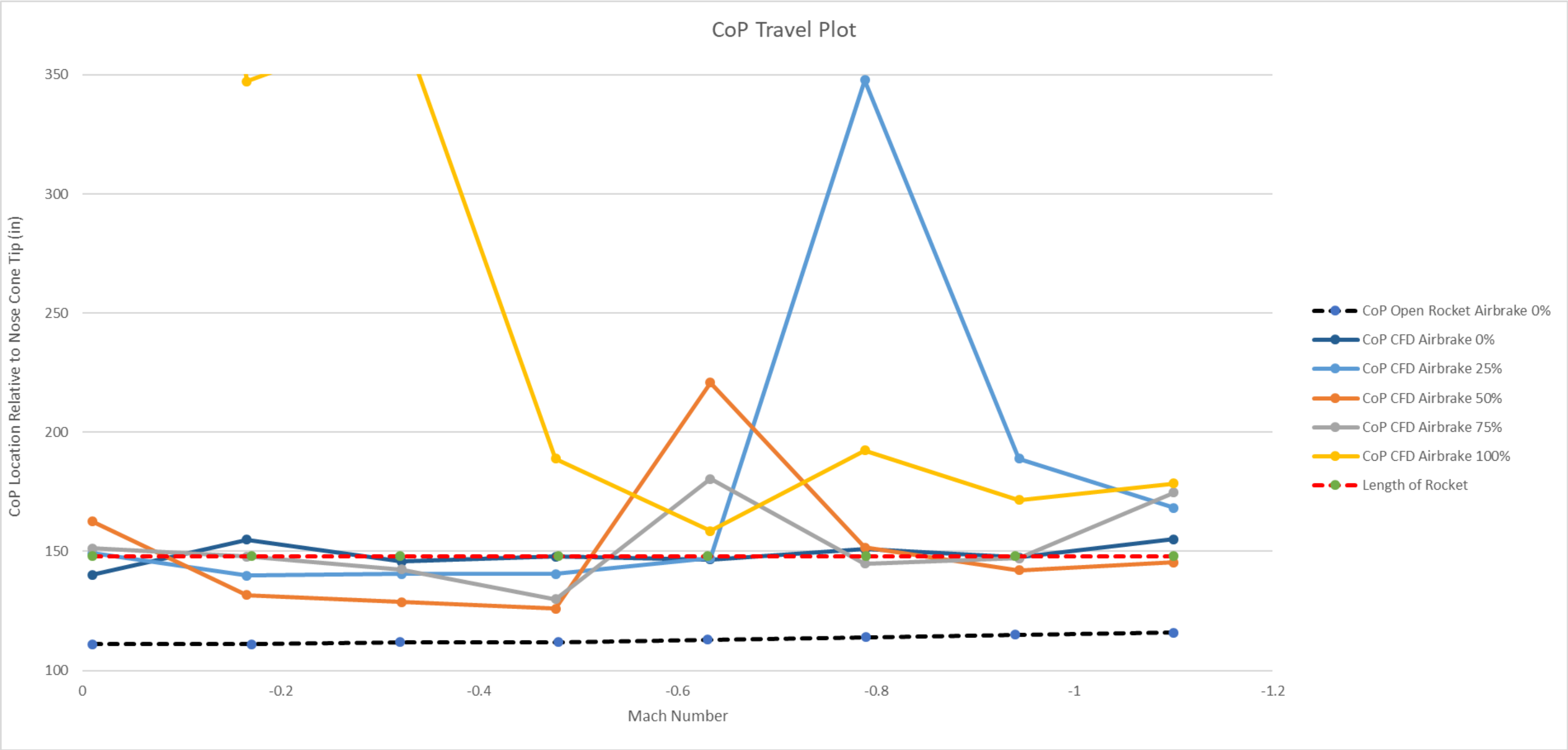
- Series of axes set up on nose cone offset 22.5 degrees
- Torque and force along each axis monitored
- Center of pressure found by $\frac{T}{F}$



Finding the Center of Pressure

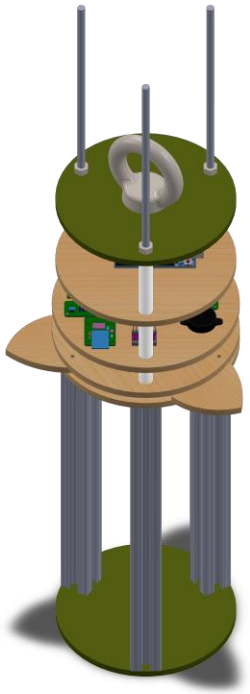


Finding the Center of Pressure



Results and Conclusions

- Future test flight will test simulations accuracy
- CFD is no replacement for real world tests
  - There is a lot of potential in CFD however
- Cost savings



Recommendations

- More wind tunnel and real flight tests
- Make MATLAB code more robust
- Redo center of pressure work
- Use potentially better standalone CFD program