



# UNH SEDS HAAMSHR

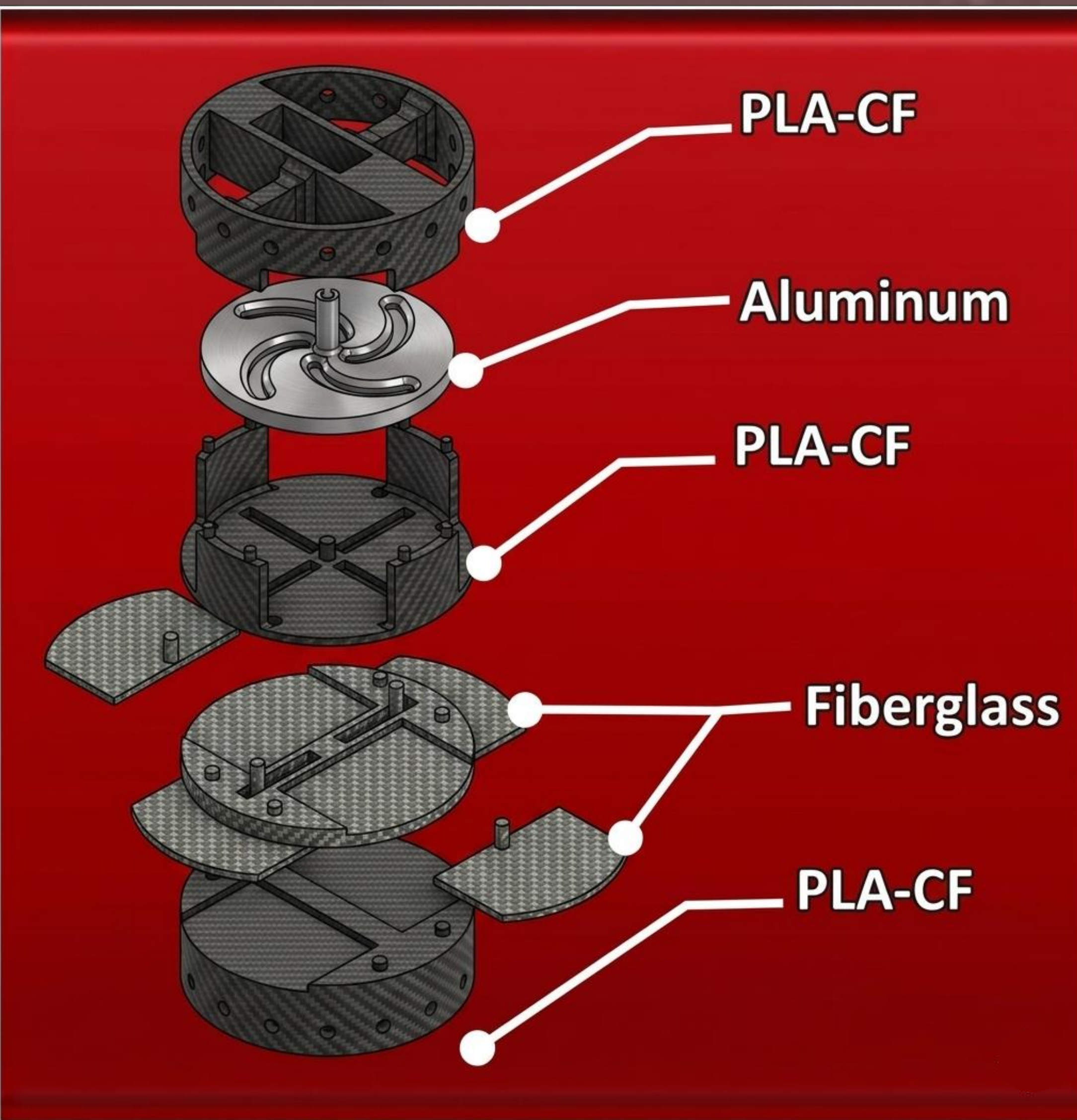
High-Altitude Autonomous Apogee Modulator System for High-Powered Rockets.

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## Background

The HAAMSHR is an air brake subsystem that allows for the modulation of the apogee of high-powered amateur rocketry, a critical ability when attempting to reach specific apogees for competition.



3D Model Exploded View

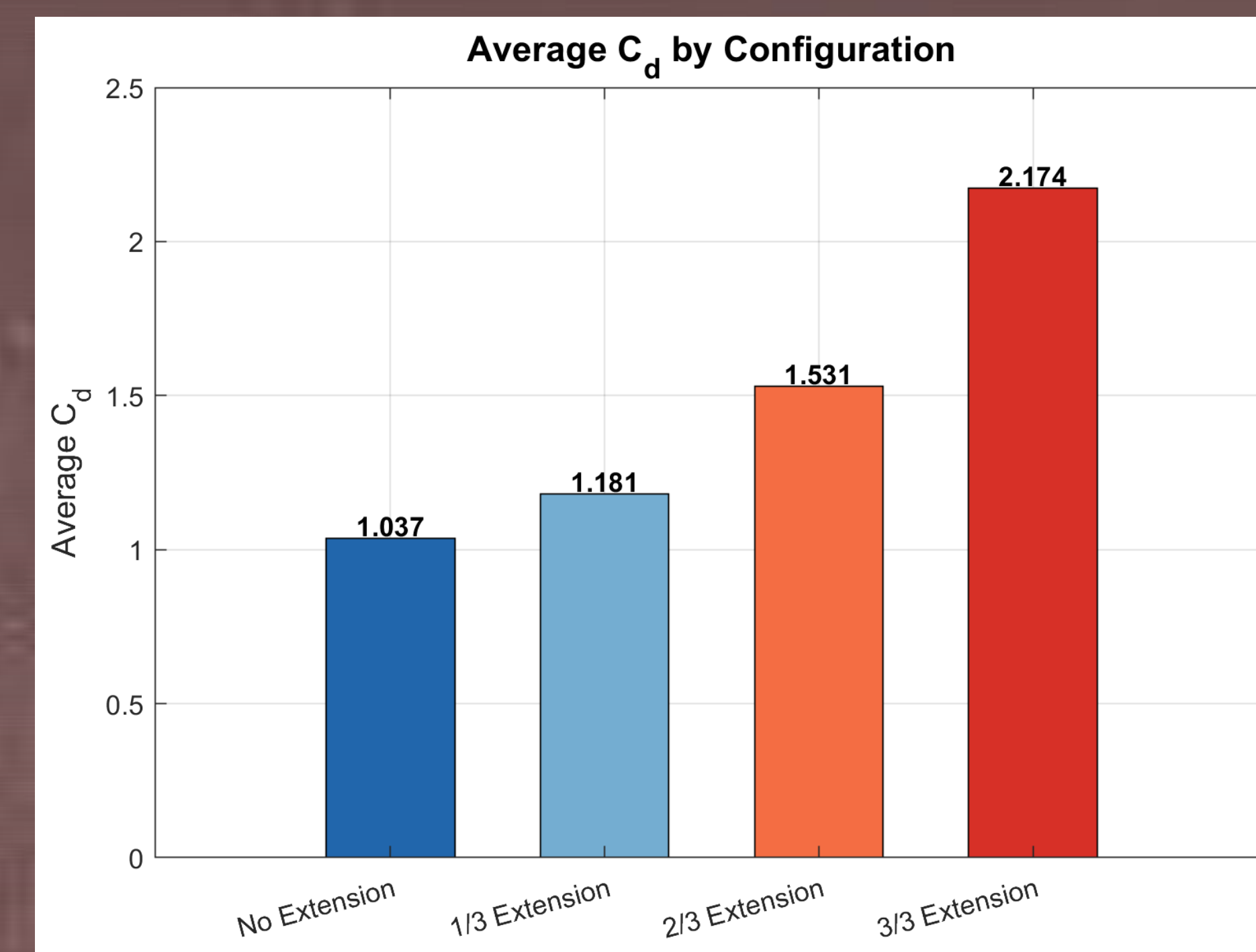
## Control System

### Real-Time Apogee Prediction

- Using tabulated coefficients of drag to calculate current drag forces
- Uses total drag to find reduced final altitude
- Actuates flaps to different lengths using these real-time calculations

	<b>Microcontroller:</b> Teensy 4.1
	<b>Accelerometer:</b> MPU-6500
	<b>Servo:</b> RAW-500

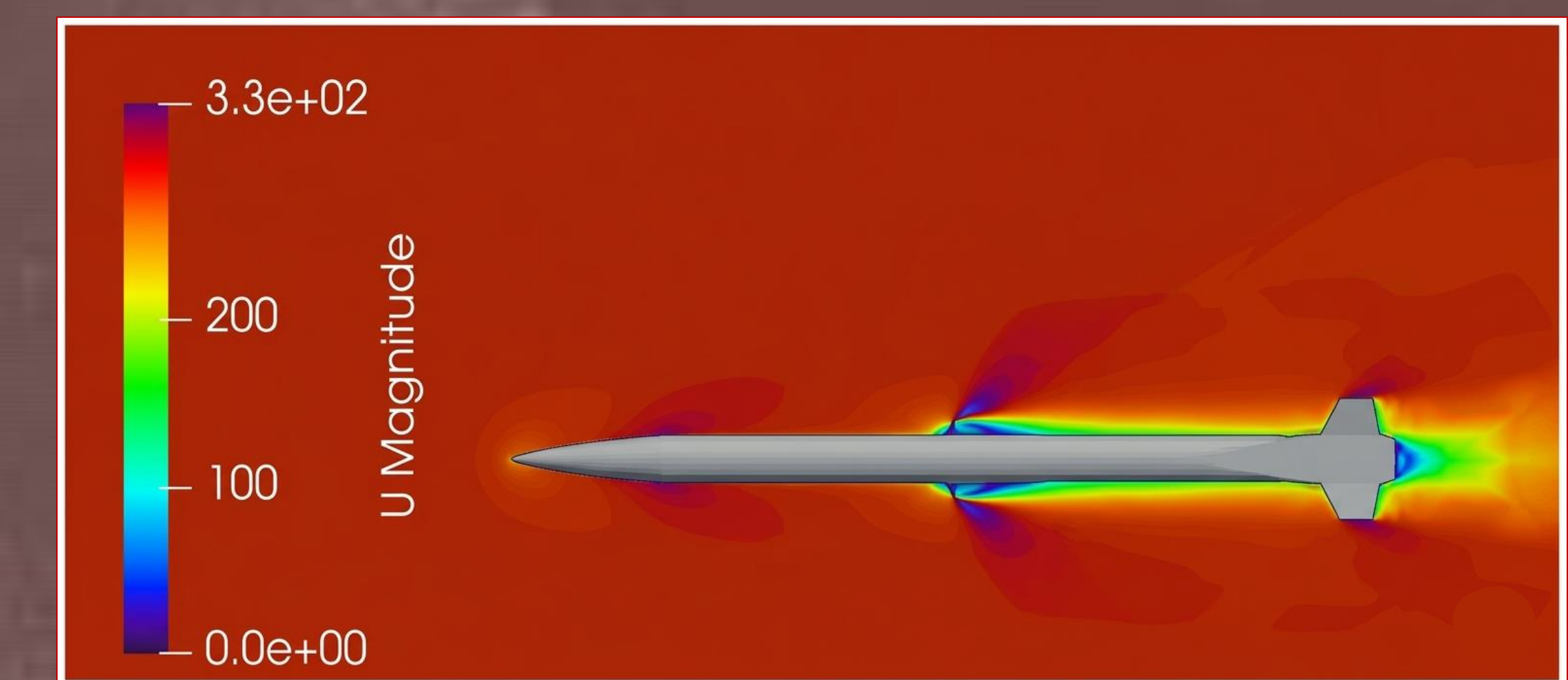
Table of Control System Components



Average Coefficient of Drag at Deployment Extensions

## Computational Fluid Dynamics

- Drag force evaluated to 800 N at 300 m/s
- Coefficient of drag evaluated to ~ 1.0
- K- $\omega$  SST RANS model
- Minimal air cavitation developed



OpenFOAM Fluid Dynamic Velocity Simulation Results

## Mechanical Design

- Slotted cam converts servo motor rotation into symmetric linear flap extension

### Archimedean Spiral

- $X(t) = (A + Bt)\cos(t)$
- $Y(t) = (A + Bt)\sin(t)$
- $A$  = starting radius of slot
- $B$  = radial gain



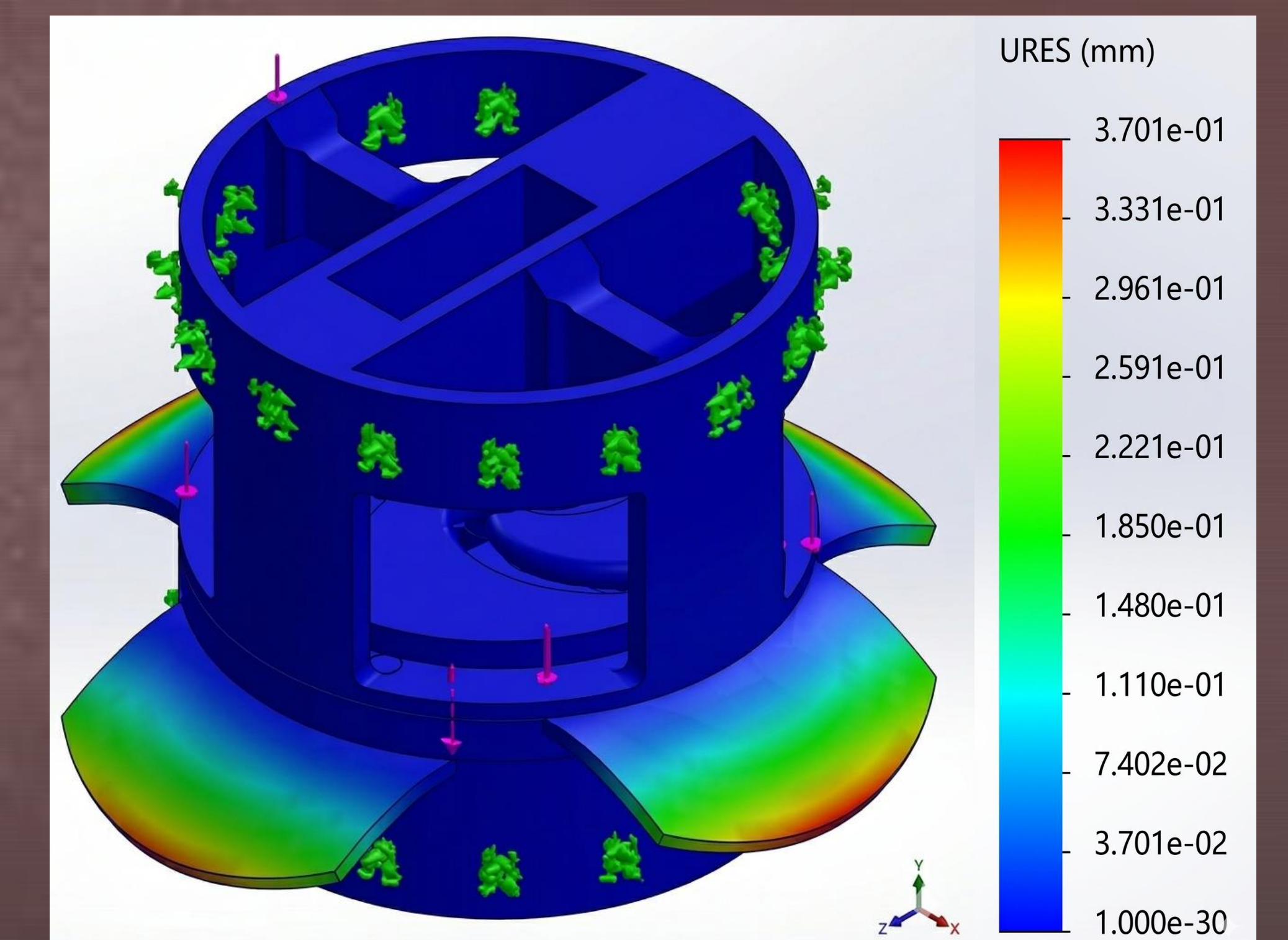
Archimedean Slotted Cam Plate

System Mass	≤ 5 lbs
Servo Torque	2.44 Nm
Operating Velocity Range	100-200 m/s
FOS	≥ 2

Operating Specs

## Finite Element Analysis

- Maximum tip deflection = ~ 0.37 mm
- Lowest FOS = ~ 9
- Max bending stress = 10.5 MPa
- Strain distribution



SolidWorks FEA Results Under 800 N Load

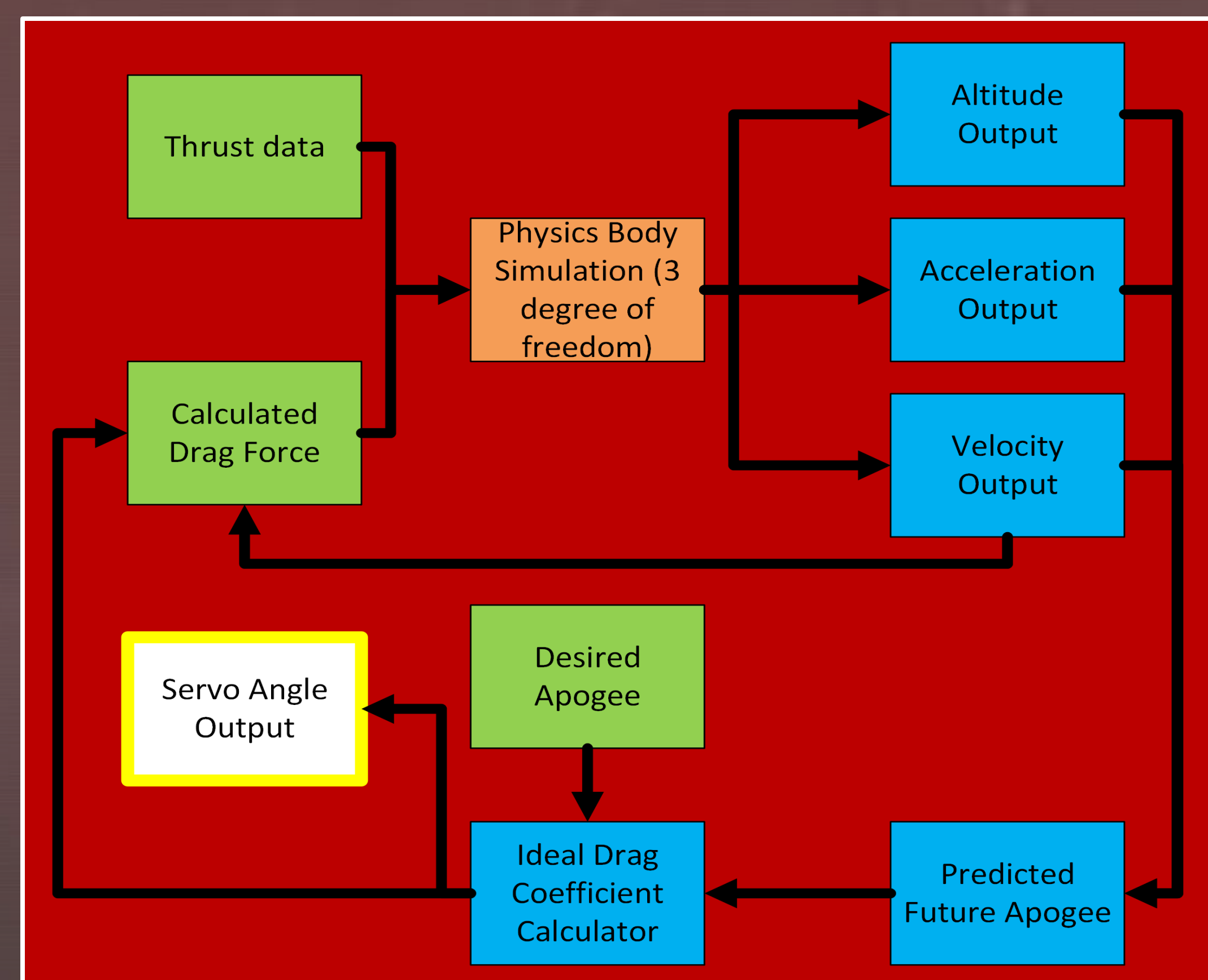


Diagram of Full Control Loop