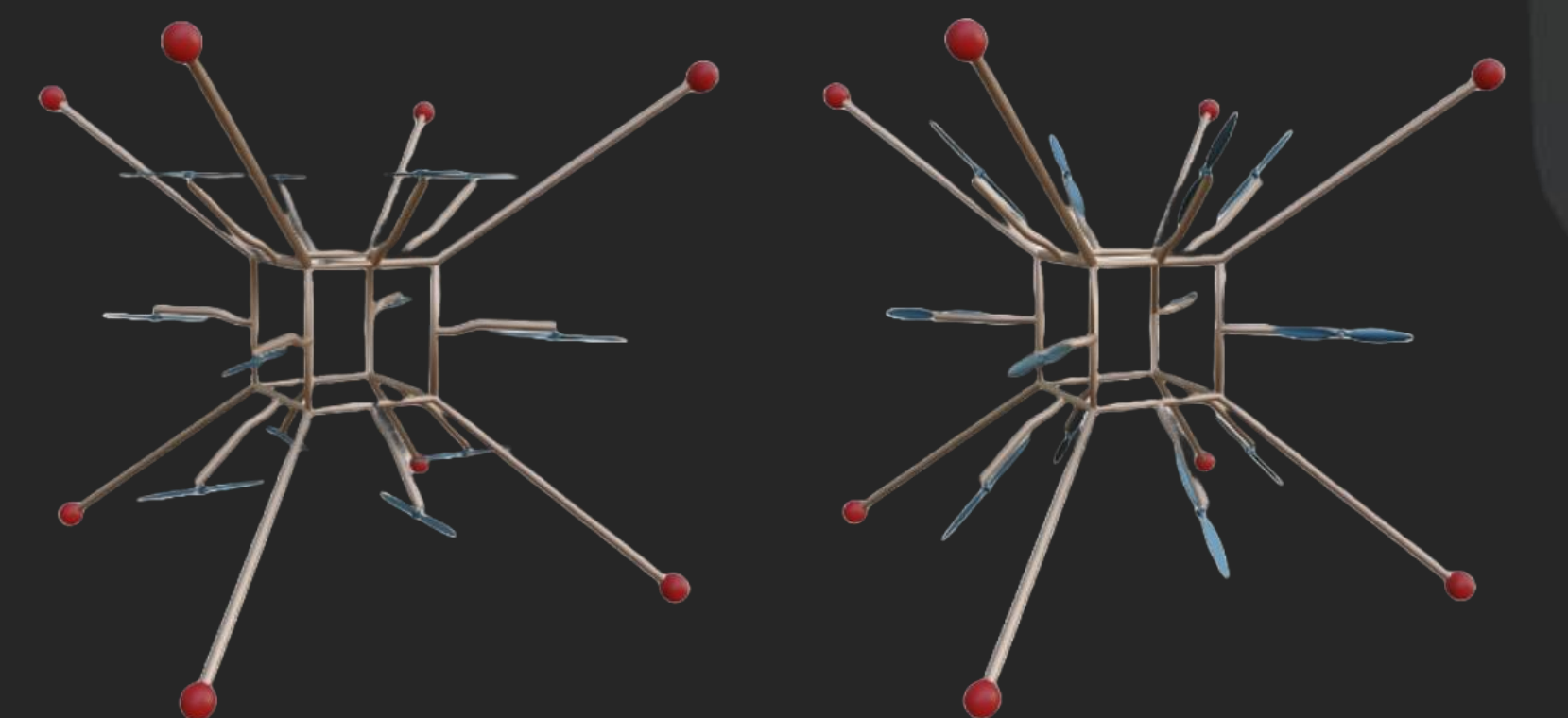


Mission & Background

Esotaira seeks to create an omnidirectional drone, one that can move about any axis, using multiple drone arms and thrust vectoring. This drone would be highly maneuverable through tight spaces, ideal for use in natural disasters or emergencies.

We have designed one of these drone arms, which quickly actuates between 0° and 45° using a four-bar linkage. This lightweight arm has high accuracy, allowing for a full drone to have both high speed and omnidirectionality.



Omnidirectional Drone Configuration

Key Requirements

- ✓ Propeller can move between 0° and 45°
- ✓ Arm aligns with drone's zero point
- ✓ Propeller alignment tolerance of +/- 0.5°
- ✓ Motor assembly rotates at a minimum of 400 deg/s
- ✓ Arm Weight less than 225 g
- ✗ Vibration no greater than 2.5 m/s² while operating
- ✓ Arm is durable and able to withstand minor impacts
- ✓ Pass IP53 dust- and water- based testing

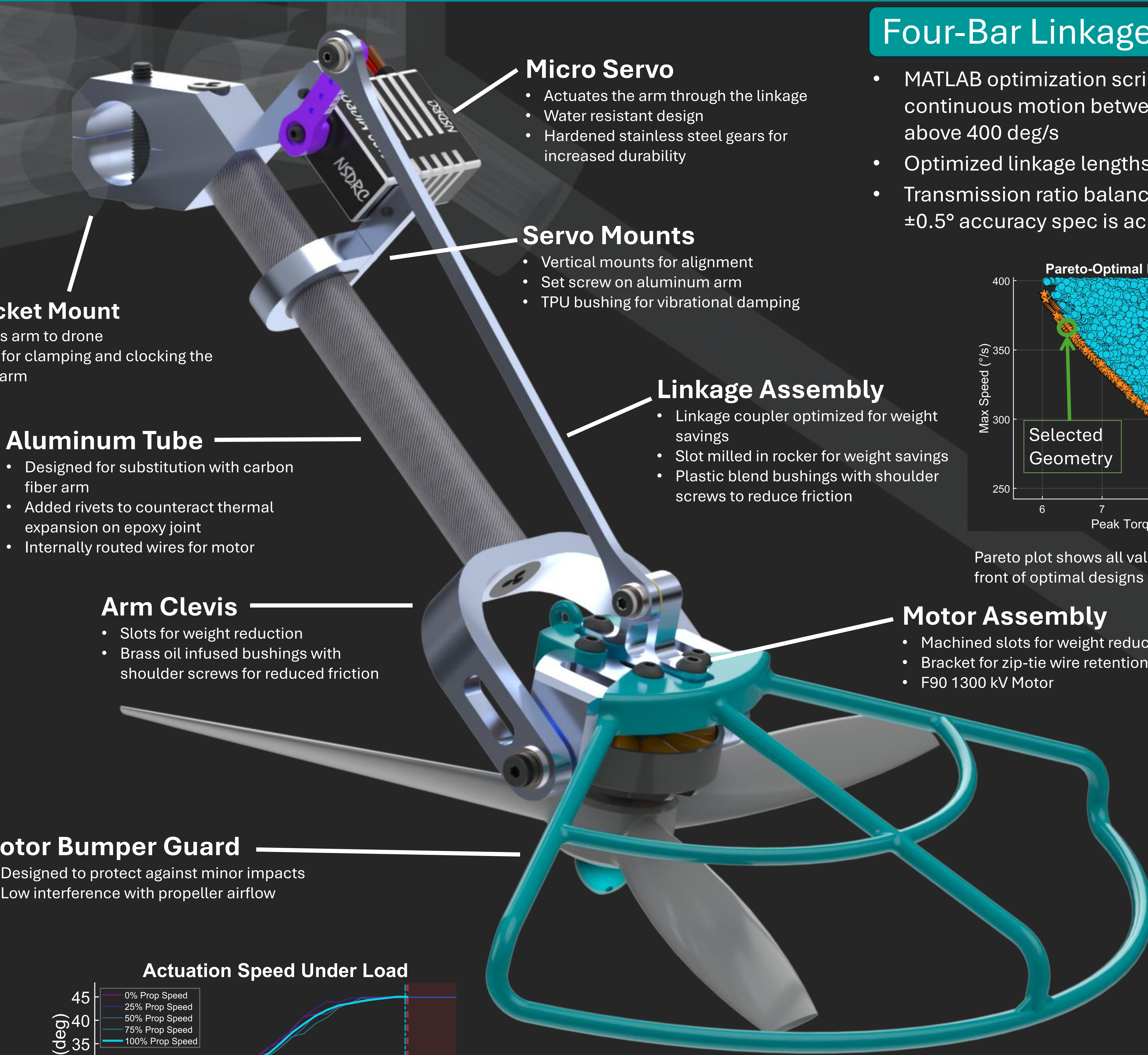


0° position 45° position

Testing & Results

Requirements	Expected	Achieved
Accuracy	±0.5 deg	±0.49 deg
Actuation Speed	400 deg/s	403 deg/s
Weight	225.0 g	158.7 g
IP53 Ingress	Compliance	Passed
Vibration	2.5 m/s ²	6 m/s ²

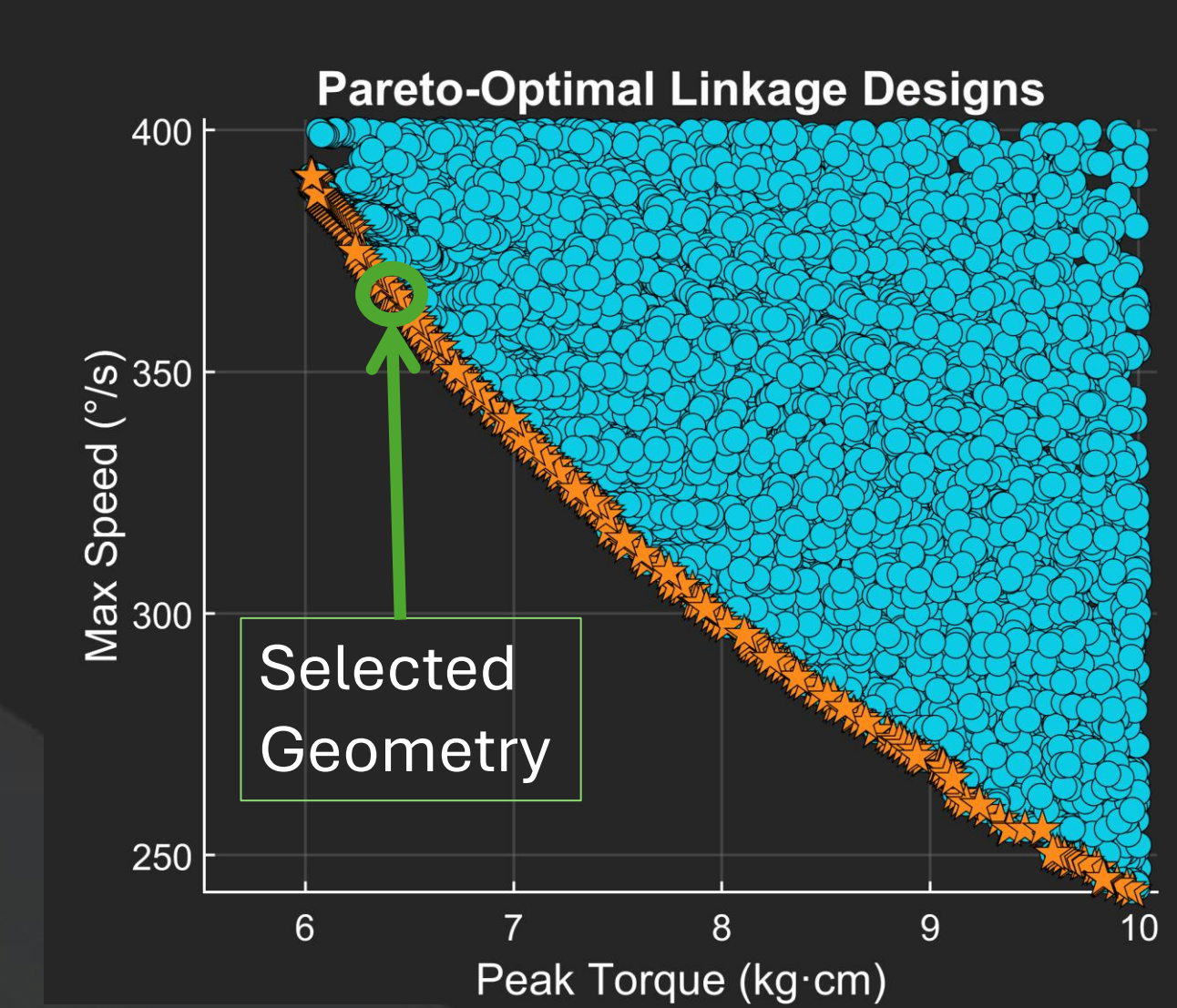
Research & Development	Results
Thrust w/o Bumper Guard	1499.1 g
Thrust w/ Bumper Guard	1451.9 g
3-Point Bending - Carbon Fiber	698.6 N
Tensile - Aluminum linkage	1919.0 N



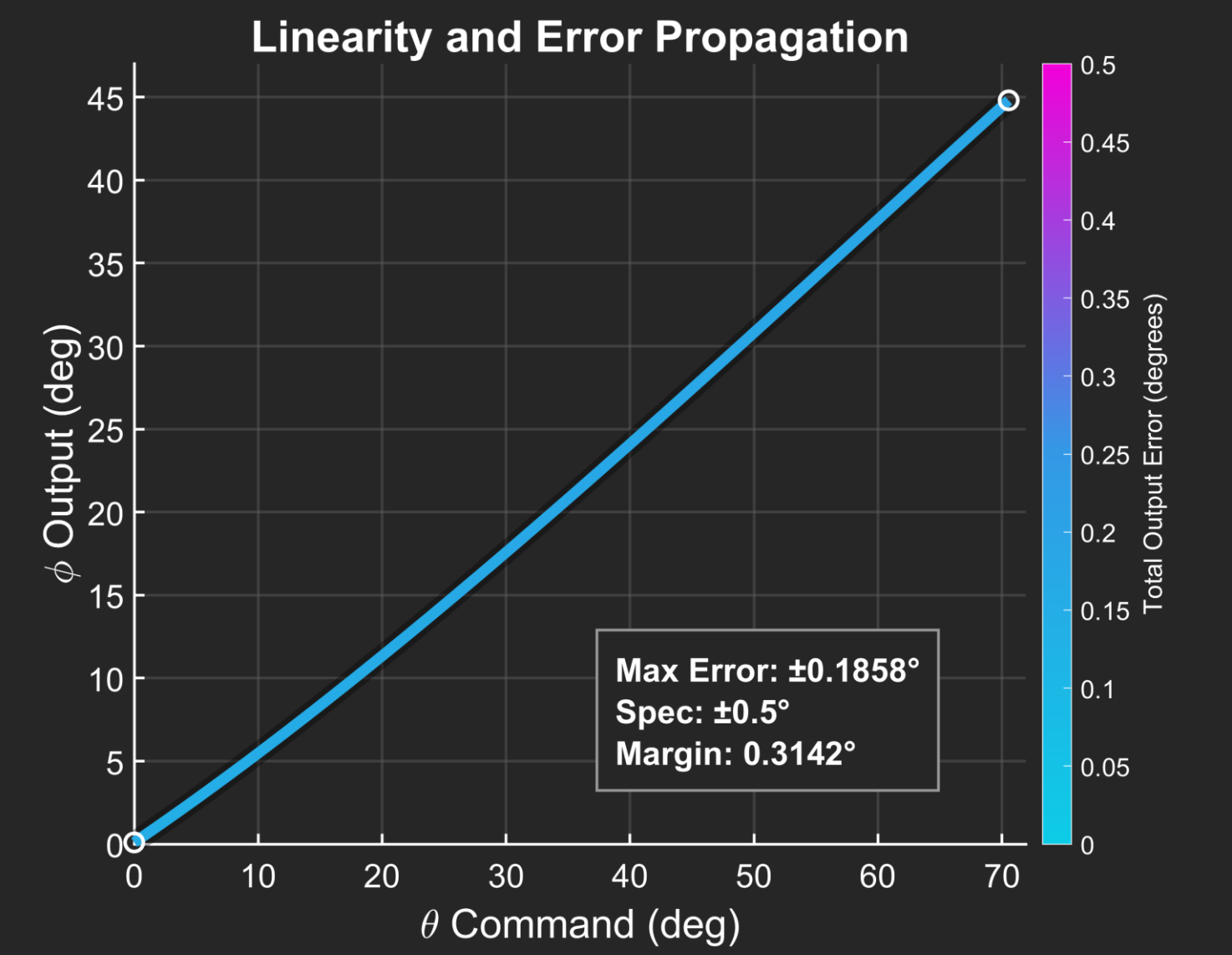
- Micro Servo**
 - Actuates the arm through the linkage
 - Water resistant design
 - Hardened stainless steel gears for increased durability
- Servo Mounts**
 - Vertical mounts for alignment
 - Set screw on aluminum arm
 - TPU bushing for vibrational damping
- Linkage Assembly**
 - Linkage coupler optimized for weight savings
 - Slot milled in rocker for weight savings
 - Plastic blend bushings with shoulder screws to reduce friction
- Aluminum Tube**
 - Designed for substitution with carbon fiber arm
 - Added rivets to counteract thermal expansion on epoxy joint
 - Internally routed wires for motor
- Arm Clevis**
 - Slots for weight reduction
 - Brass oil infused bushings with shoulder screws for reduced friction
- Motor Assembly**
 - Machined slots for weight reduction
 - Bracket for zip-tie wire retention
 - F90 1300 kV Motor
- Rotor Bumper Guard**
 - Designed to protect against minor impacts
 - Low interference with propeller airflow
- T-Bracket Mount**
 - Mounts arm to drone
 - Screw for clamping and locking the drone arm

Four-Bar Linkage Design Process

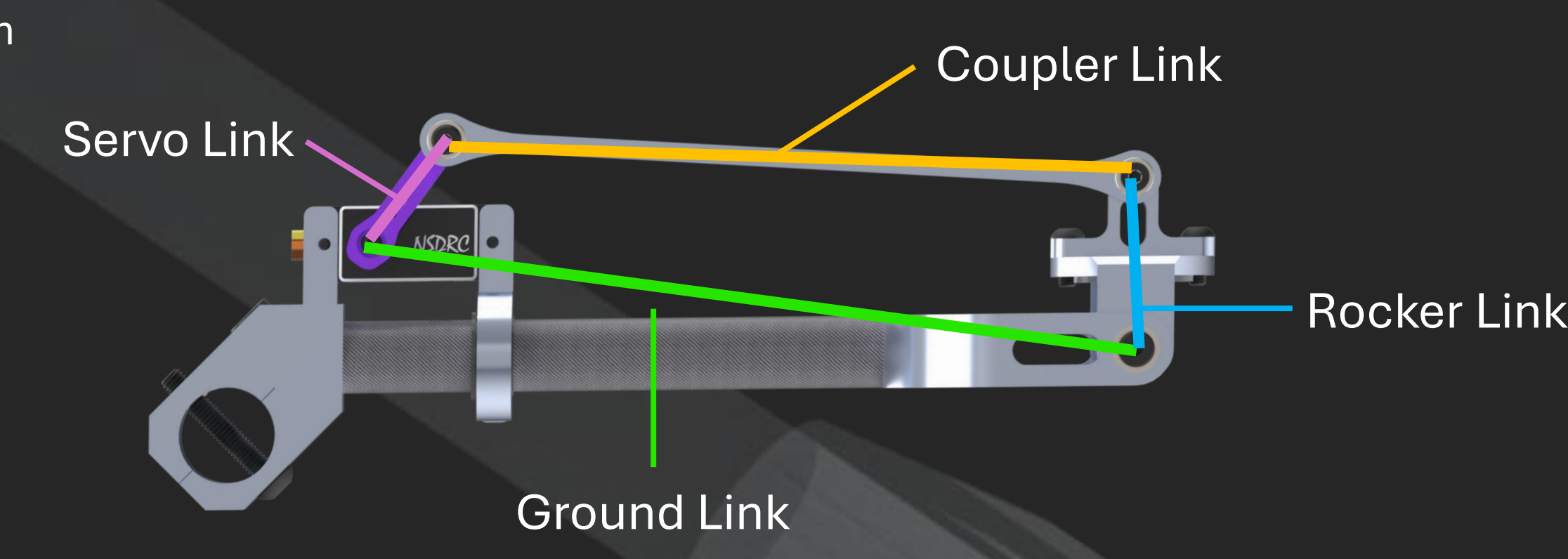
- MATLAB optimization script evaluated millions of geometries against constraints: continuous motion between 0° and 45°, peak torque 6 kg·cm limit, and actuation speed above 400 deg/s
- Optimized linkage lengths for the servo link, rocker link, coupler link, and ground link
- Transmission ratio balances torque, speed, and accuracy which directly affects whether ±0.5° accuracy spec is achievable



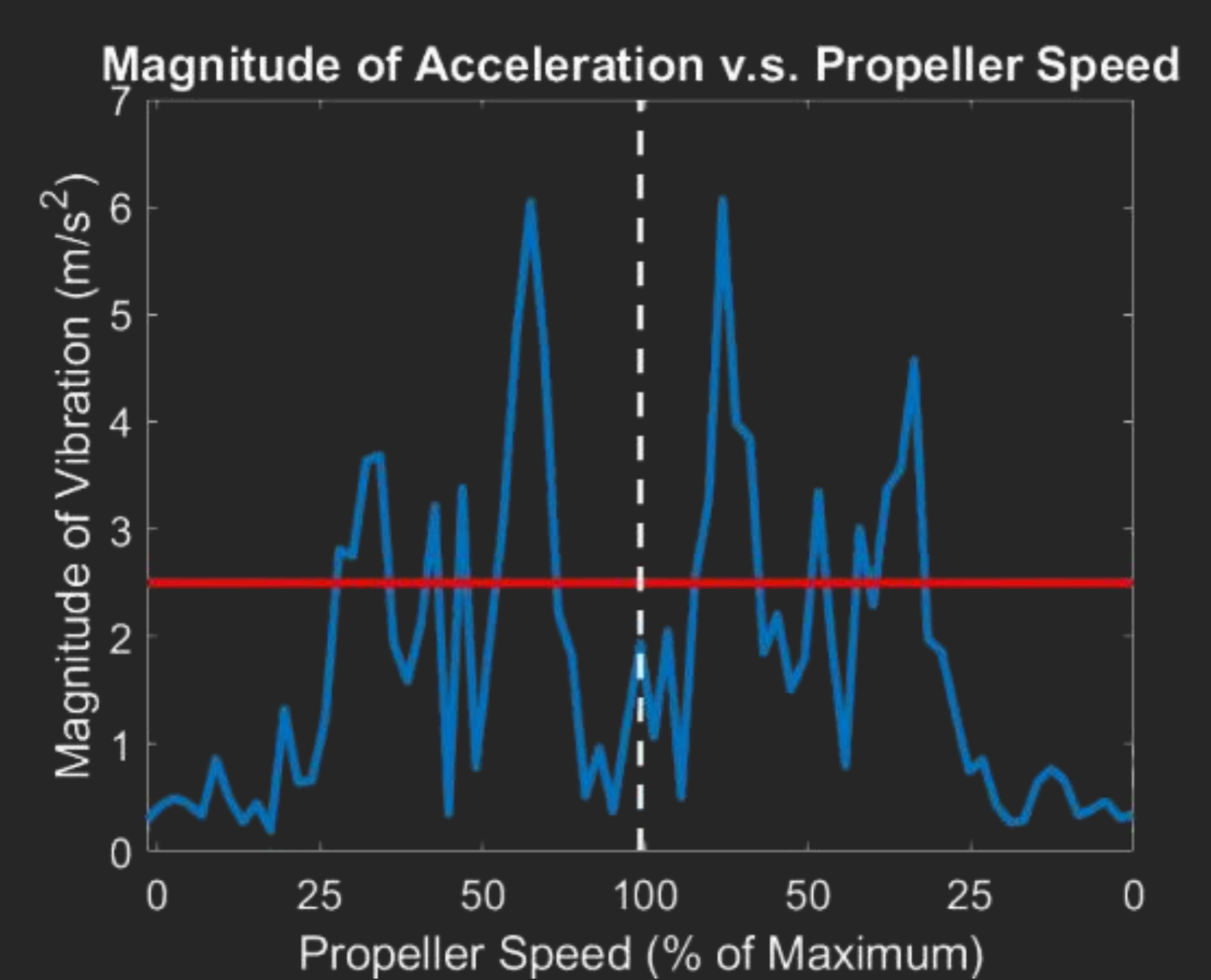
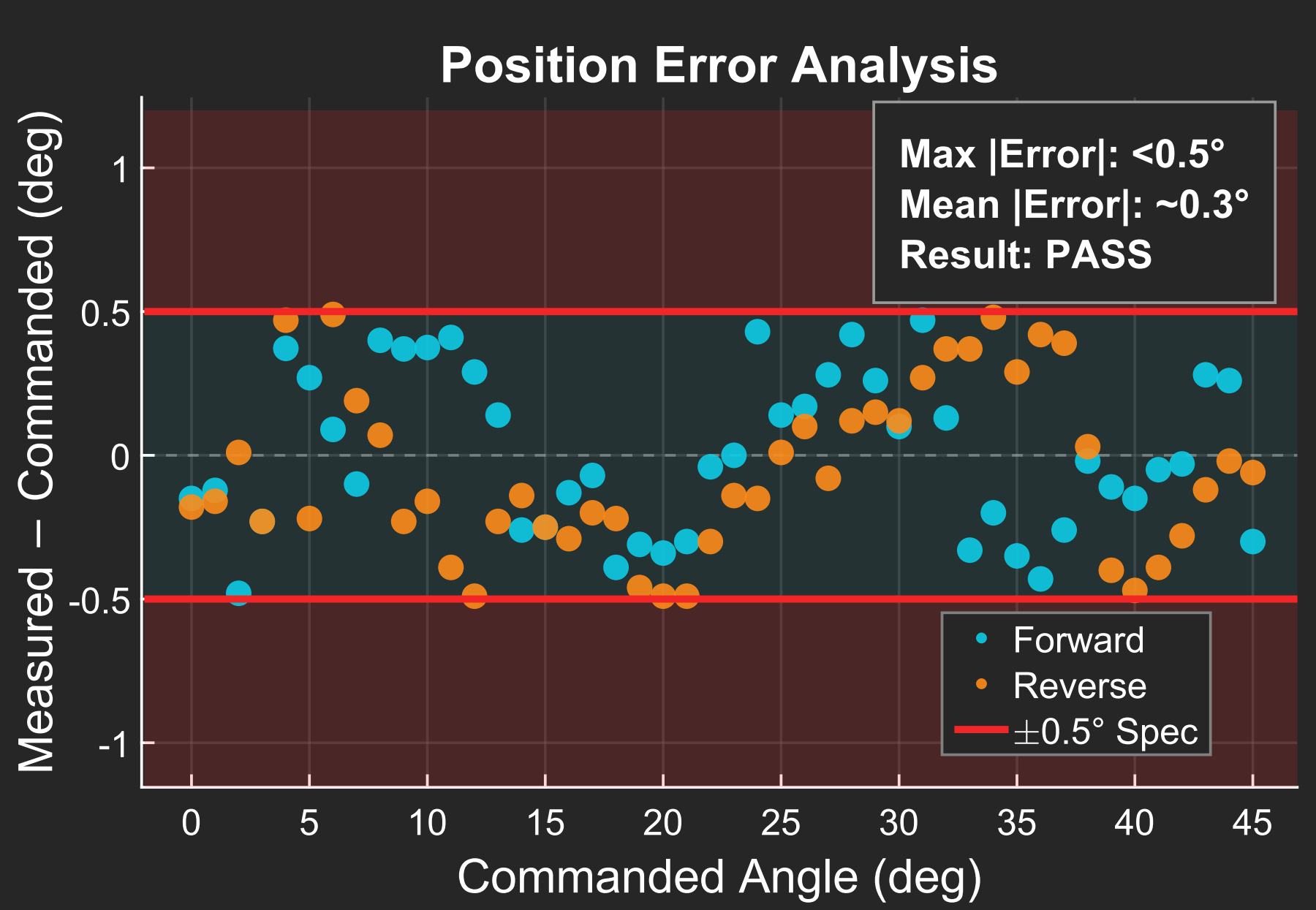
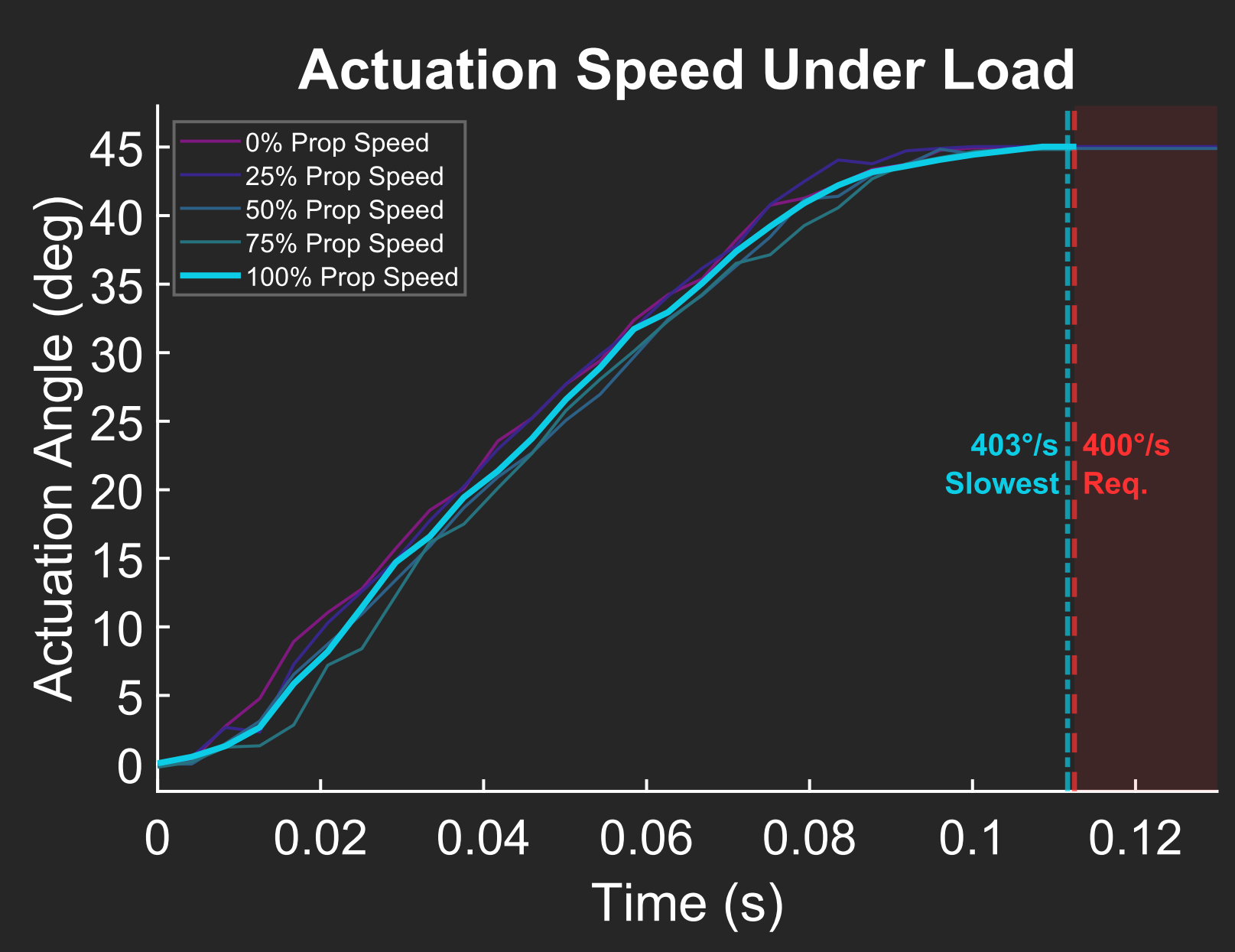
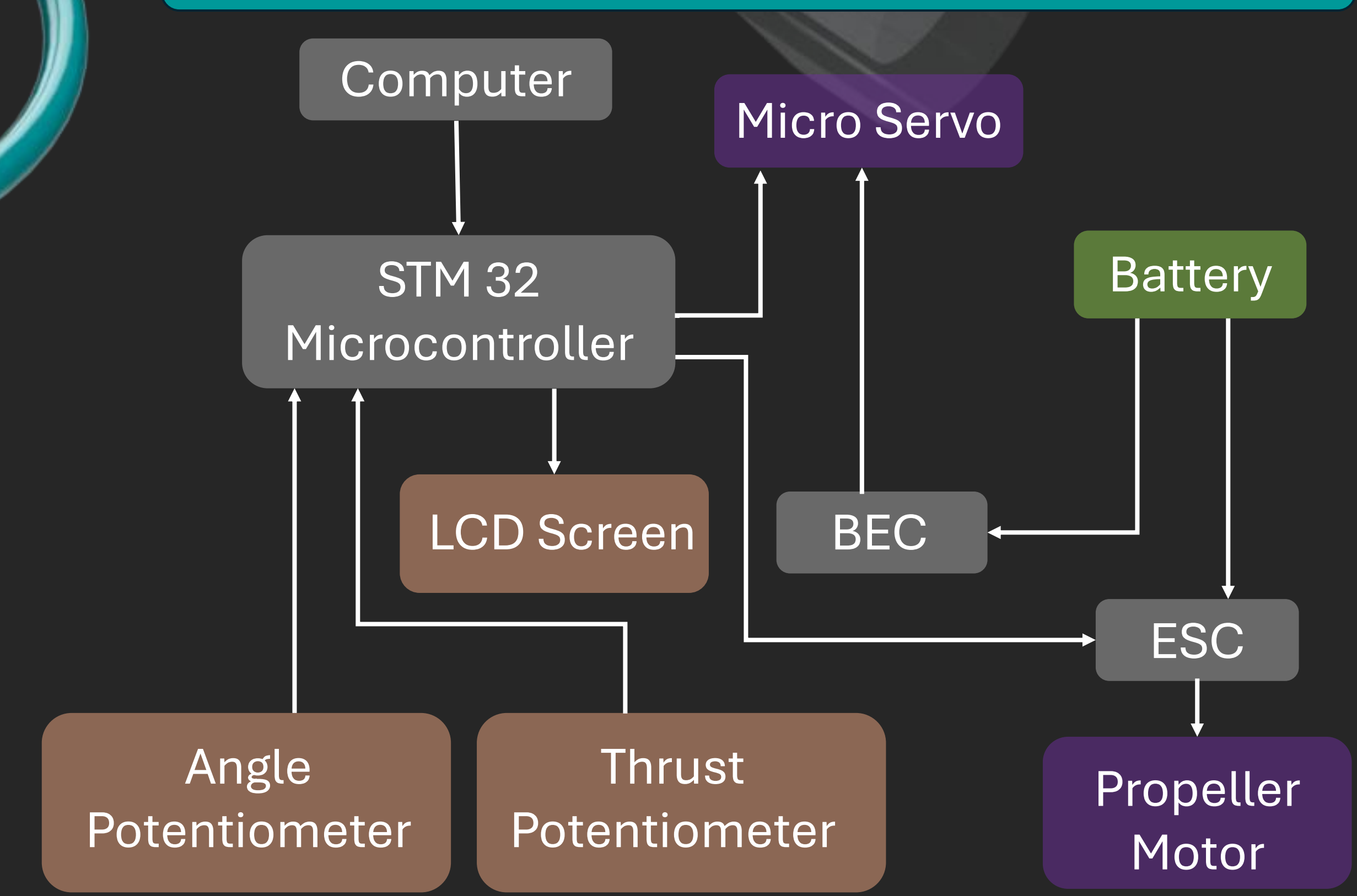
Pareto plot shows all valid designs and creates a front of optimal designs



Selected final geometry from Pareto front based on highest linearity and lowest error propagation across the full range of motion



System Diagram



Future Work

- Utilize carbon fiber as the primary arm tube material, to further reduce total drone weight, increasing flight time and agility
- Integrate 8-12 arms onto one drone to allow for omnidirectional flight, furthering the potential of the UAV industry
- Investigate strategies to reduce vibration in drone at resonant frequencies
- Use Cube Orange flight controller instead of STM 32 microcontroller