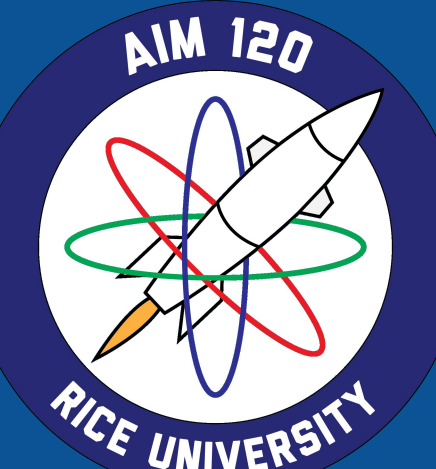




OEDK

Portable Testing Rig for Rocketry AFS System

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What is AFS?

Active Flight Stabilization (AFS) is a closed-loop control system that commands rocket canards in real time to **correct off-course** flight paths.



Why AFS?

- Rice University's competitive rocketry team, **Eclipse**, has long term goals to reach space
- Eclipse created the AFS System to **increase stability** and **maximize altitude** with trajectory realignment during flight
- Unpredictable environments** at **high speeds** leave **fixed fin rockets** extremely prone to **failure**
- Eclipse's Kraken 2025 IREC Rocket **sheared apart** after **tumbling** at mach speeds



Sheared Kraken Rocket

What do we AIM for?

- Eclipse can only test with **live rocket launches**, which are **infrequent** and **costly**
- No current solutions exist**, similar mounts provide simulated flight conditions, but no possibility of real-time angle adjustment.



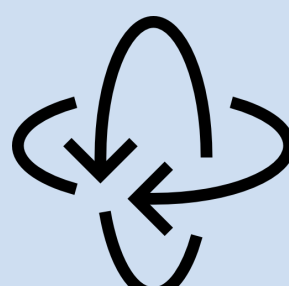
Wind Tunnel Strut Mount

Our goal is to create an **efficient**, **repeatable**, and **portable** testing rig that is capable of **simulating real rocket flight conditions** so Rice Eclipse can **properly test** their AFS system.

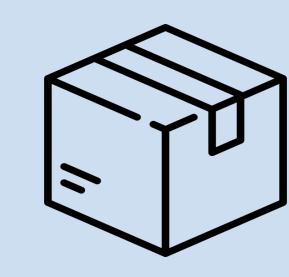
Design Criteria & Constraint



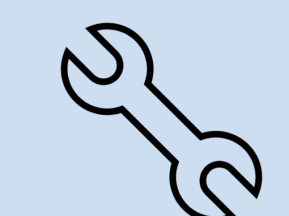
Max. Speed Maintaining Structural Integrity: ≥ 85 MPH



Degrees of Freedom: Pitch/Yaw $\geq \pm 20^\circ$ Free Roll



Portability: 1 Person Required



Modularity: Accommodate ≥ 6 Devices

Acknowledgements

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Thrust Vector Control (TVC) Inspired Solution

Design Features

Inspired by **rocket thrust vector control systems** and **Stewart platforms** precisely manipulating direction under high loads by moving **linear actuators** to change **deflection angles**.

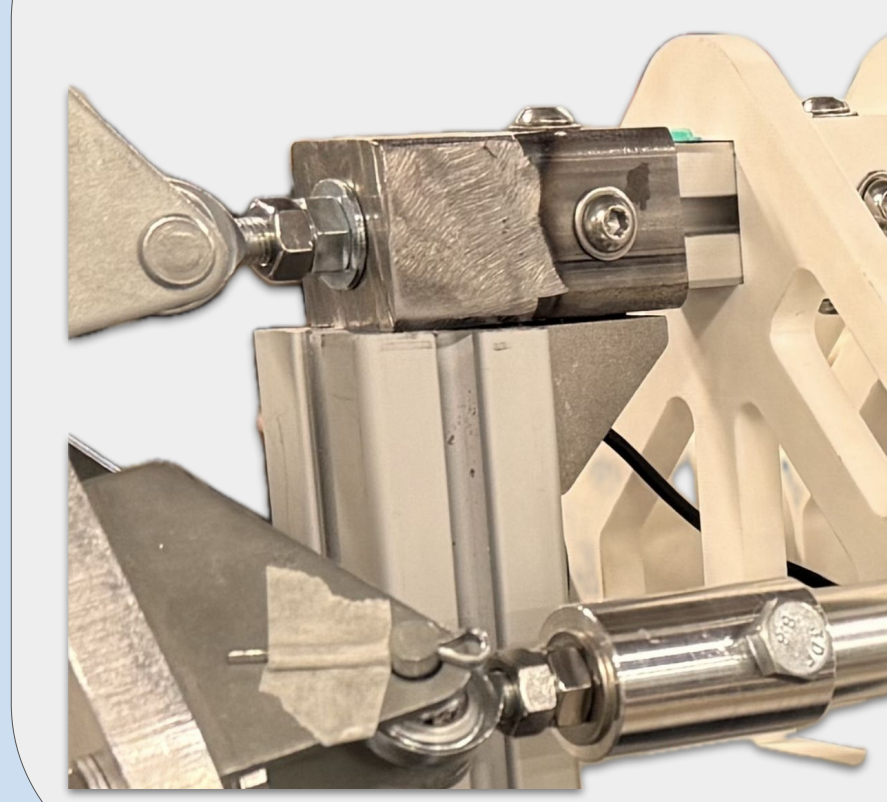
PITCH/YAW MECHANISM

- Linear actuators **push/pull** to rotate the mount and achieve desired angle.
- Controlled by an **Arduino** and powered by **motor drivers** to control actuator movement.



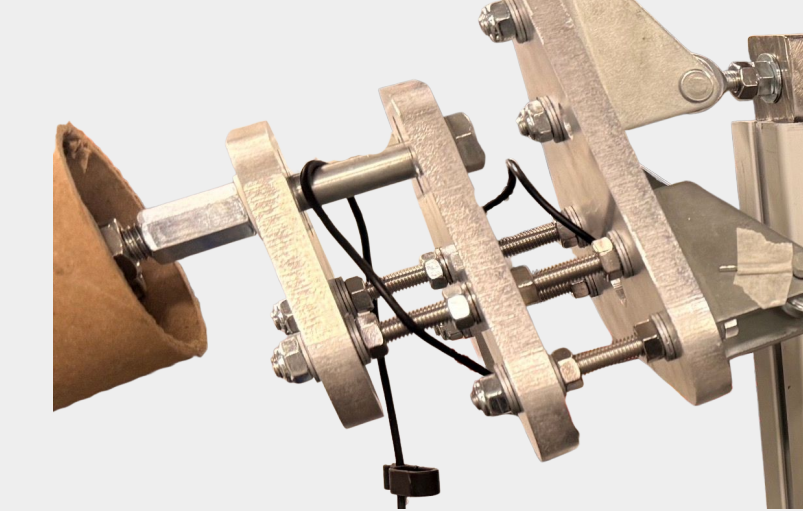
PIVOT POINT

- Custom** actuator ends support heim joints and allow complex **pitch/yaw** movements.
- Fixed central point** on rod that **connects** to the steel plates through solid steel block and **heim joints**.

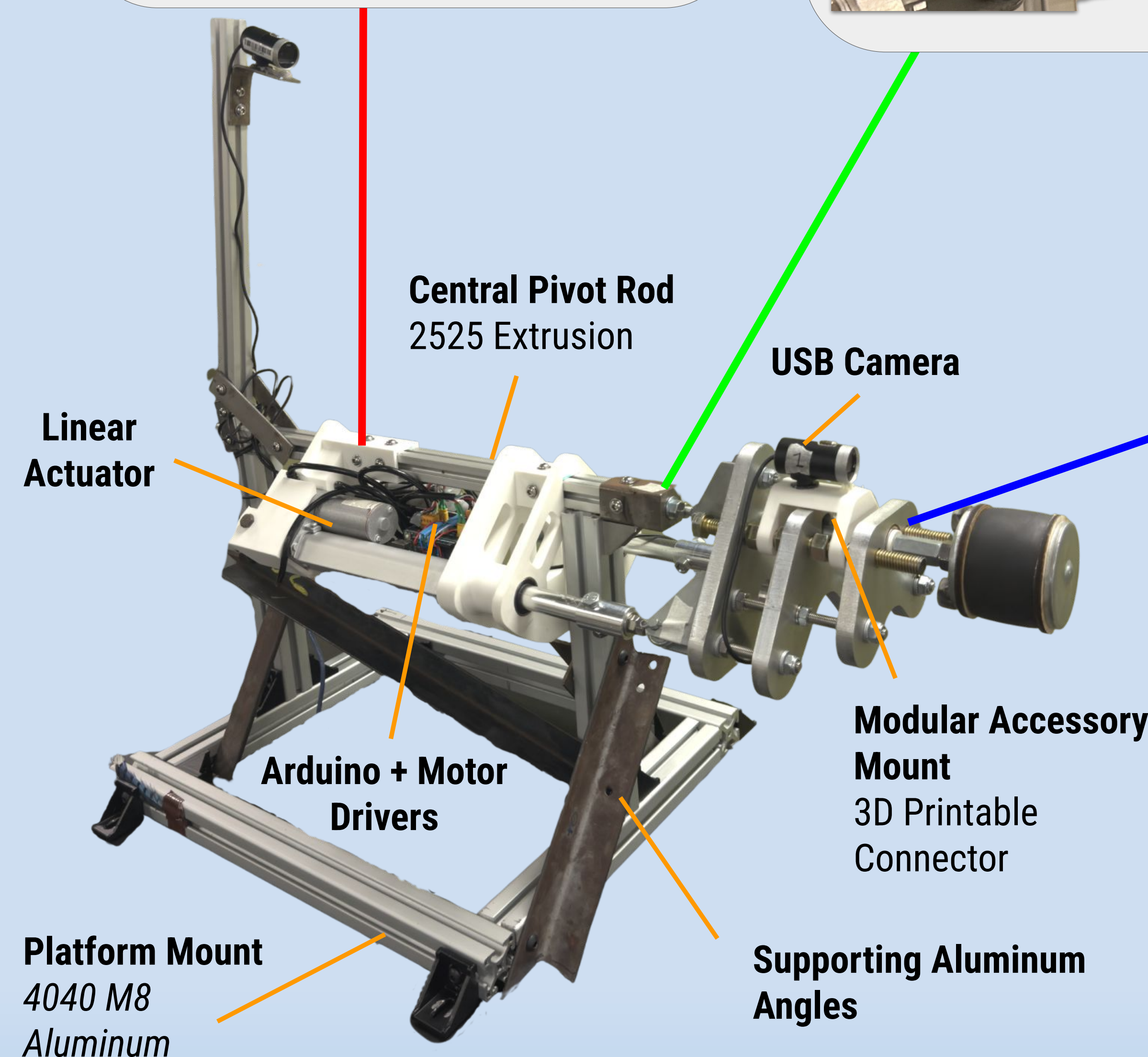
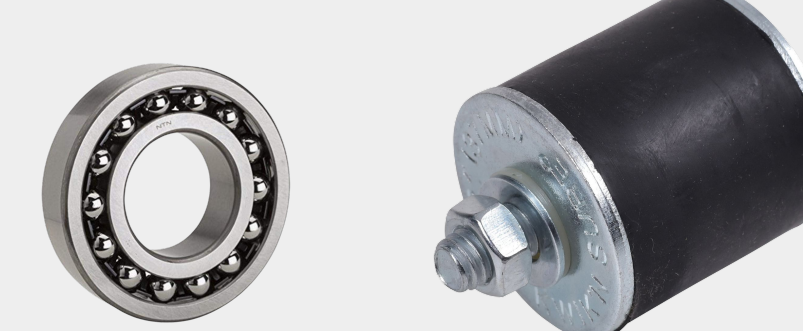


SUBJECT MOUNT

- Triple steel plate setup for distributing loads
- Plates secured through connecting bolts



- Expanding pipe plug withstands 80Gs of deceleration
- Connected to ball bearing for free movement, can be secured with bolts for static tests



USER INTERFACE

Executable App: Python interface, serial communication
Connectivity: Supports Arduino, webcams, other USB devices
Data Log: Records angle data and video footage

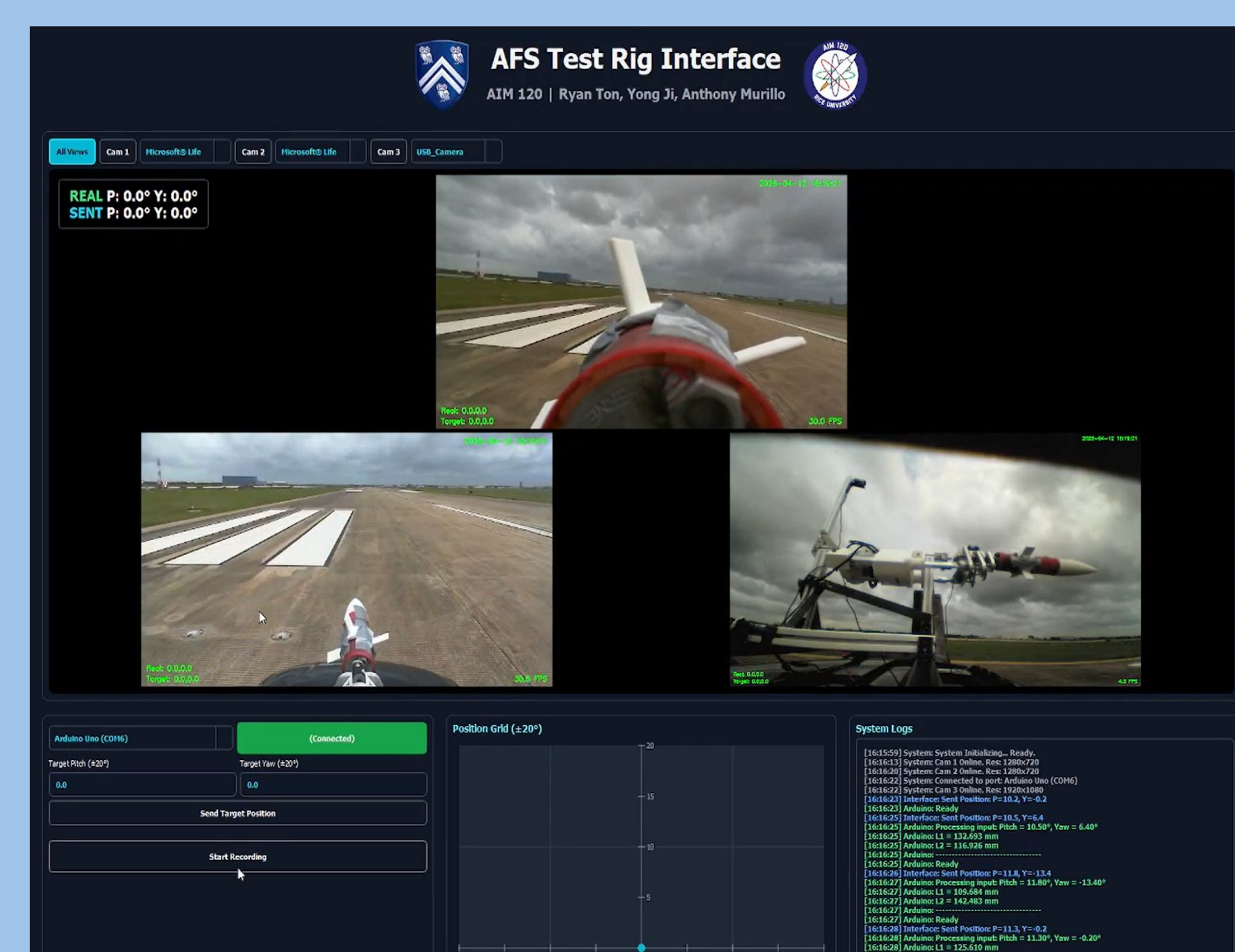


Image of AFS Test Rig User Interface

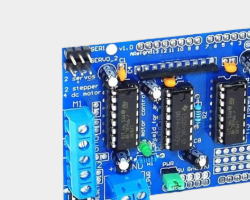
User types angle input into pitch/yaw box

User changes angle on interactive graph

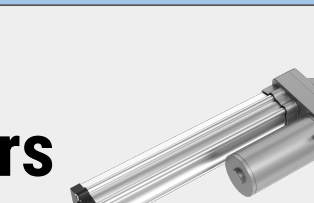
Arduino receives wanted inputs



Arduino calculates lengths and sends signal to motor drivers



Motor Drivers move linear actuators



Actuators move to calculated position for wanted angle, **repeatable within seconds**

Data & Testing Results

Operation Integrity:

- Successful operation at car speeds of 105 MPH $\rightarrow$ **120+ MPH** airspeeds
- "Rocket" **rotates** under resistance without failure or instability
- Road **vibrations** become noticeable at **65+ mph**
- Different **angles** achievable within **seconds** of input, more trials per run



Mounted Vehicle Testing

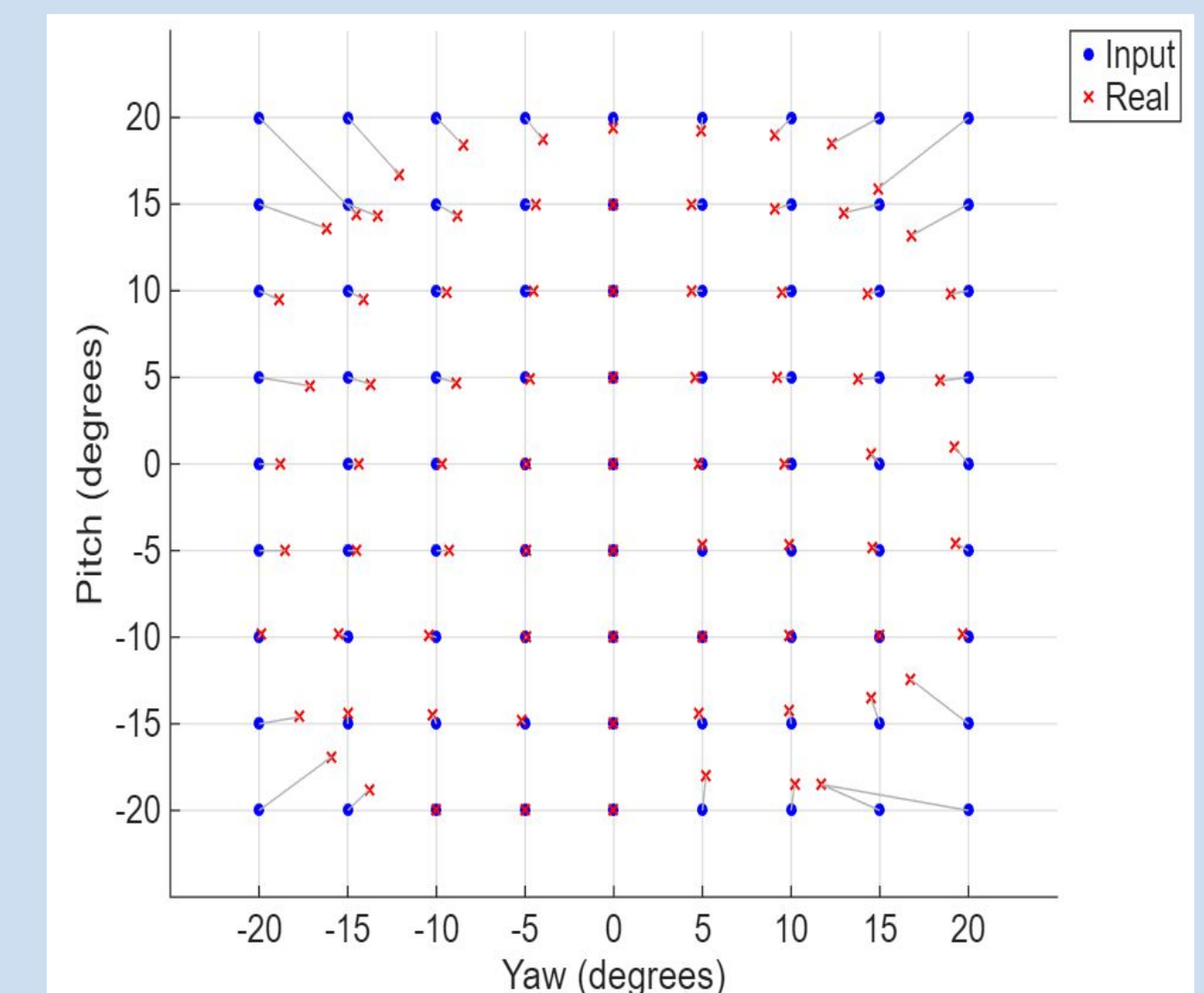


On Board Recorded Testing Footage

Angle Accuracy Testing:

Measured real angles via video analysis, plotted input/output charts for $\pm 20^\circ$ pitch and yaw:

- Within **1° of error** at use case ranges & within 5° outside use case range.
- Proof of **accurate** actuation means **client can test at necessary angles** without needing to accommodate for great inaccuracies.



Plot of Real Angle over Commanded Angle

Final Overview

- Able to test **pitch, yaw, and roll** on a test rocket tube under static/free-moving setups.
- Motor stroke **accurate** to within 3 mm, **< 1° error at all angles**.
- Testing achieved** at car speeds of up to 105 MPH, air speeds of 120+ mph.
- Stable** at low speed/flat terrain, **vibration** and fluttering at 65+ mph.
- Minimal reduction** in hardware **tightness** after extended road tests.
- Client can now **frequently** test with a mount that is **capable of** providing **simulated flight conditions** without needing manual adjustment between angles.

Future Work

- Thinner **heim joint spacers** for better **range flexibility** and **accuracy**
- Add **anemometers/pitot tube** for airspeed reading
- Increase** platform mounting **rigidity** with **ratchet straps** that secure to car roof during car mounted testing.