Camera Tracker CDR

Lola Anderson | 12/8/24

l.cuair.org/CameraTrackerCDR

Overview

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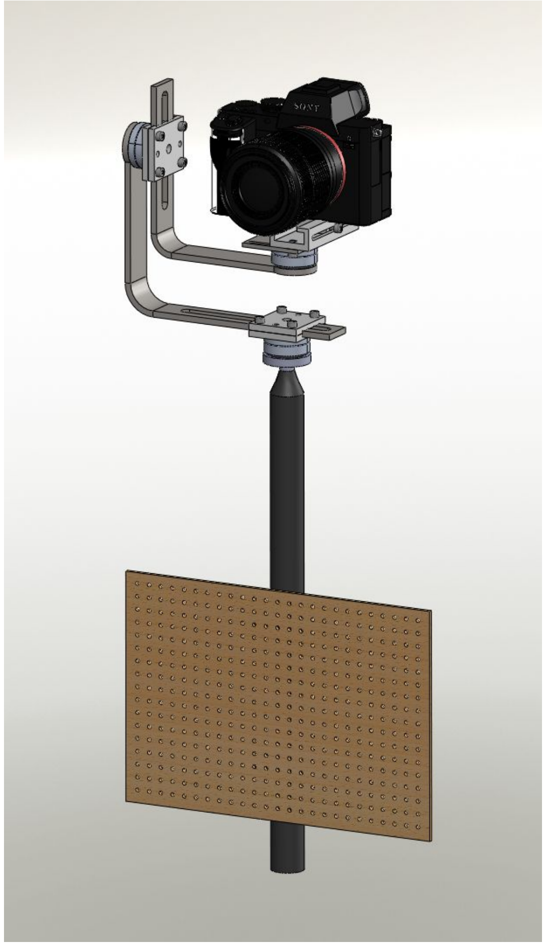
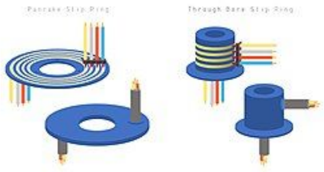
- The camera tracker will use the GPS location of the plane in order to keep the Sony A7III Camera pointed at the plane at all times.
- This will allow us to get smooth consistent footage of the plane.



Vocabulary

- Slip Ring: Device that transfers power and signal wires from a stationary part of a device to a rotating part
- CT-Gimbal: The part of the camera tracker containing the camera, arms and motors.
- CT-Ebay: The part of the camera tracker containing the electrical boards, batteries, and possibly a screen displaying the camera.



Why can't we just use ___?

- Antenna Tracker
  - Too few axes to maintain the same orientation for continuous footage.
  - Can't mount full camera with lens.
- DJI Gimbal
  - The DJI gimbal already has tracking, but it is meant for closer objects than the plane.
  - This gimbal is not capable of capturing the plane during on overhead pass
    - It cannot point straight up.

Functional Requirements

- **FR-1:** Camera Tracker must be capable of smoothly following the plane **at all times**, using the Sony A7III Camera
- **FR-2:** Wiring must not restrict motion of gimbal
    - Wiring here refers to motor wires, and camera wires.
- **FR-3:** Gimbal motion should not unplug or stress wiring.
- **FR-4:** The assembly must be able to **resist 20 mph gusts** without differences in quality
    - Based on Ovid monthly weather reports + what we'd reasonably fly in
- **FR-5:** The assembly must accommodate electrical needs
    - Batteries, wires, boards, buttons, screens, etc
- **FR-6:** The assembly **must not overheat or deform** over time and extended use
- **FR-7:** Must have adjustability to adjust camera CG location

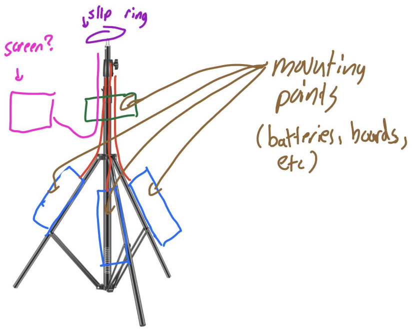
Non-Functional Requirements

- **NFR-1:** Should be **easily assembled** for test flights
  - Can be assembled by 1 person in 15 minutes
- **NFR-2:** Should be **compact and lightweight** for ease of transportation and use
  - Fit into SKB Case (will design next semester)
- **NFR-3:** Must keep the camera **safe**
  - All critical parts should follow an ultimate safety factor of 2
- **NFR-4:** Must allow room for extended camera lens
  - Aiming for about 3 centimeters of extended lens length.
- **NFR-5:** Must be manufacturable, (affordable), and assemblable
- **NFR-6:** Must include screen to display camera output
- **NFR-7:** Should interface with the tripod CUair already owns

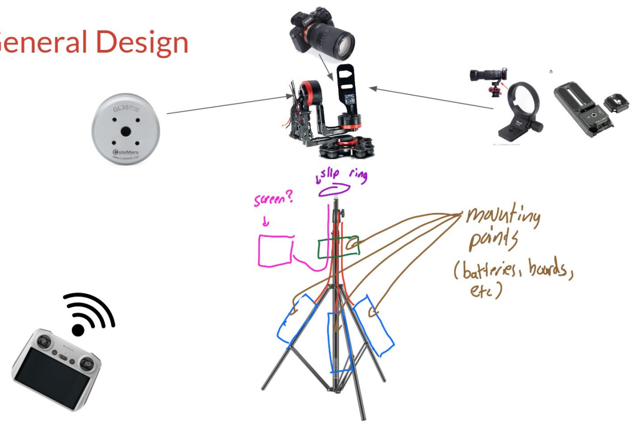
Background & PDR Considerations

Old Design/ EDR Notes

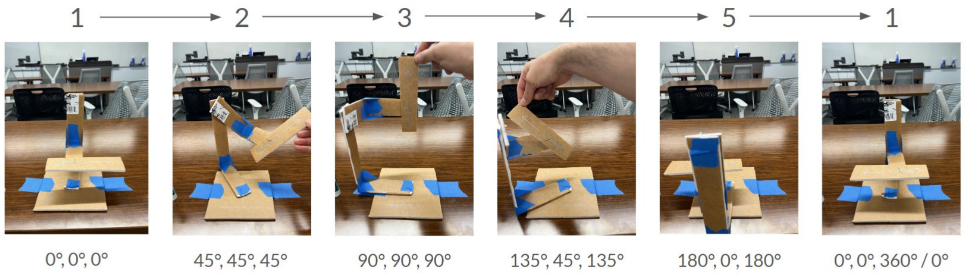
- Julius and Nate previously did a lot of background research for this project.
  - Came up with a general design, prototyped
  - Chose Motors, Tripod, etc
  - No CAD



General Design



Gimbal Design

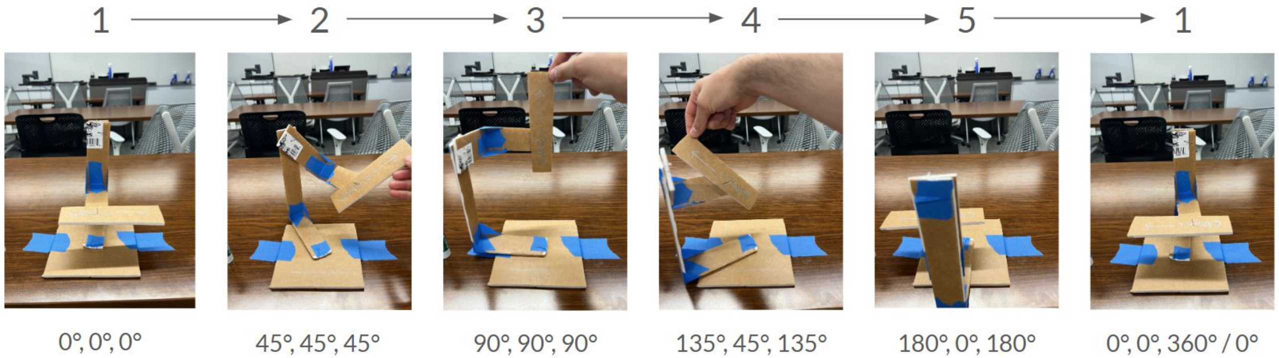


Demonstration of the camera following an overhead pass

With the 2.5 Axes, the gimbal can rotate the camera so that it follow the plane in any orientation

😎 👌

From EDR

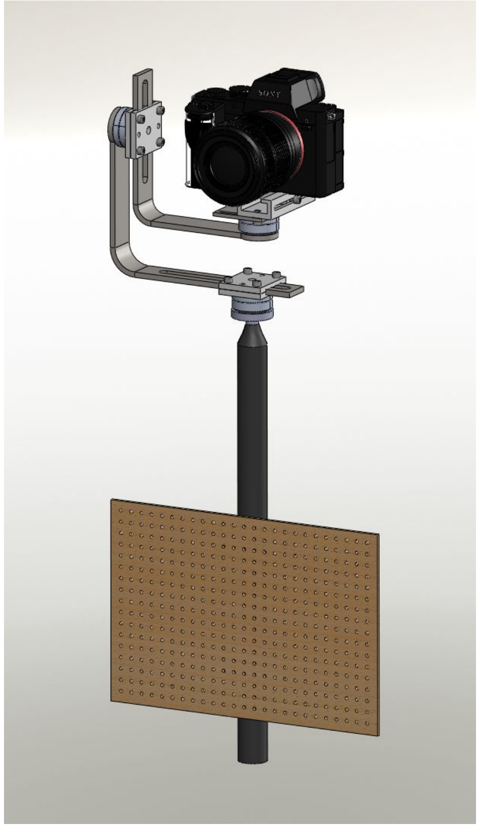


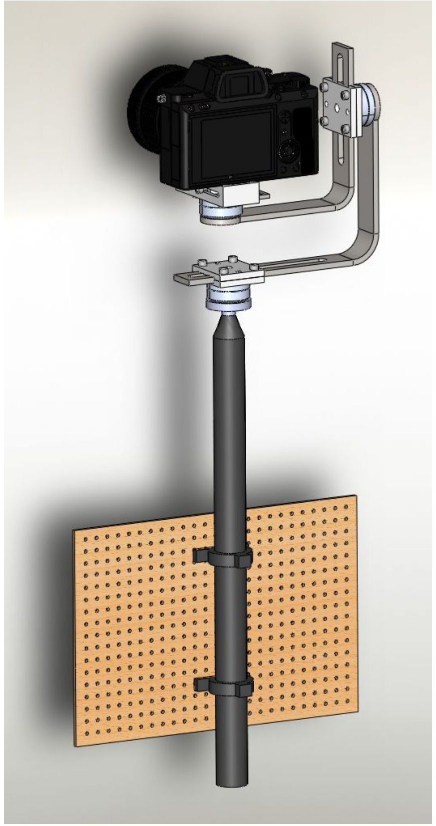
Demonstration of the camera following an overhead pass

FR-1: Camera Tracker must be capable of smoothly following the plane **at all times**, using the Sony A7III Camera

Design

Full CAD

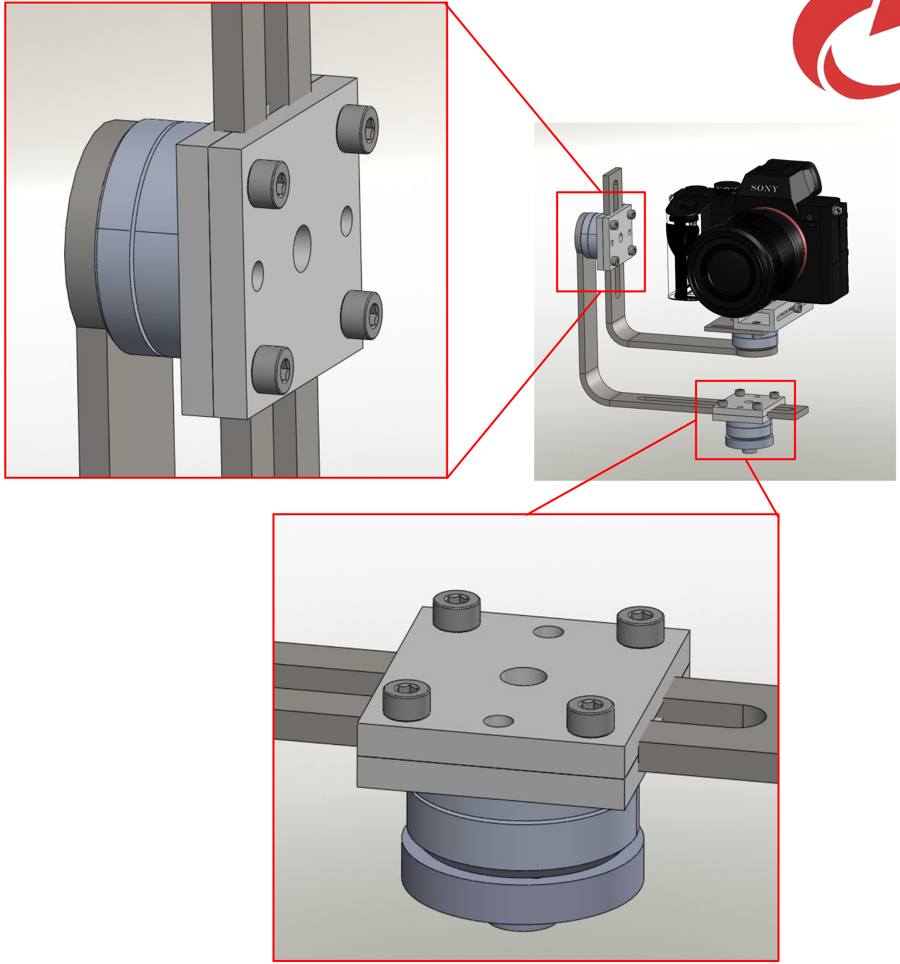




Camera Tracker- Gimbal

Gimbal Arm Joints

- Arms are attached to motors with these clamp pieces.
- Uses friction to lock arms in at exact needed length.
- **Four screws** are used to clamp the top piece onto the bottom piece.

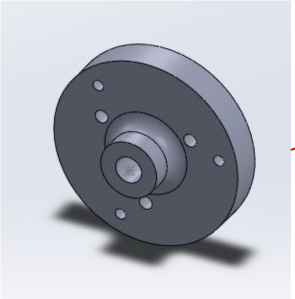


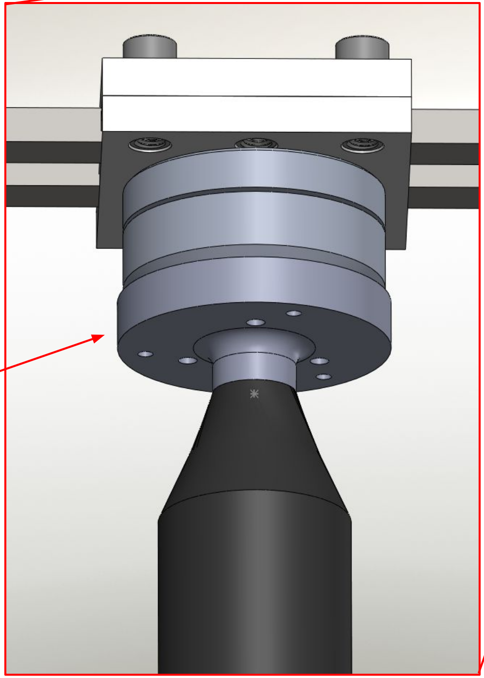
FR-7: Must have adjustability to adjust camera CG location

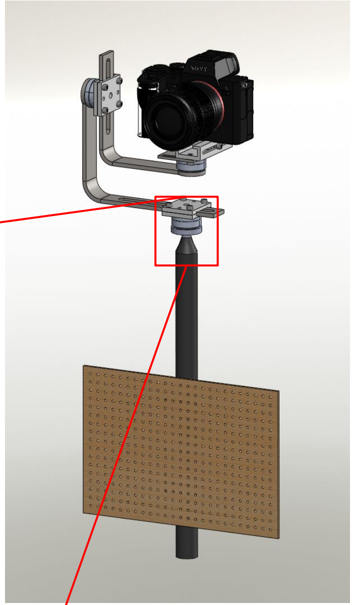
Tripod Mounting

- Most Tripods including the one CUAir has attack with a single 1/4 -20 screw.

Tripod mount piece interfaces between the yaw motor and the tripod

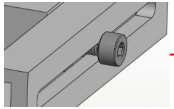




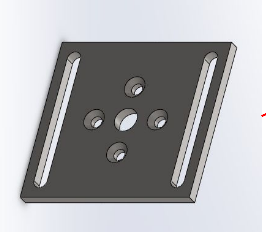


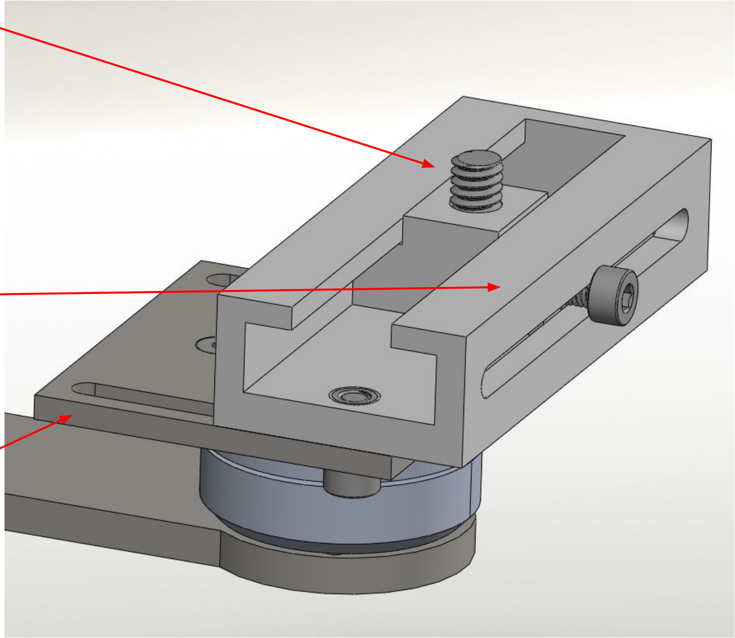
Camera Mounting

- Sony A7III Camera attaches with one ¼-20 screw.
- Front to back movement is allowed by one set screw which adjusts the position:



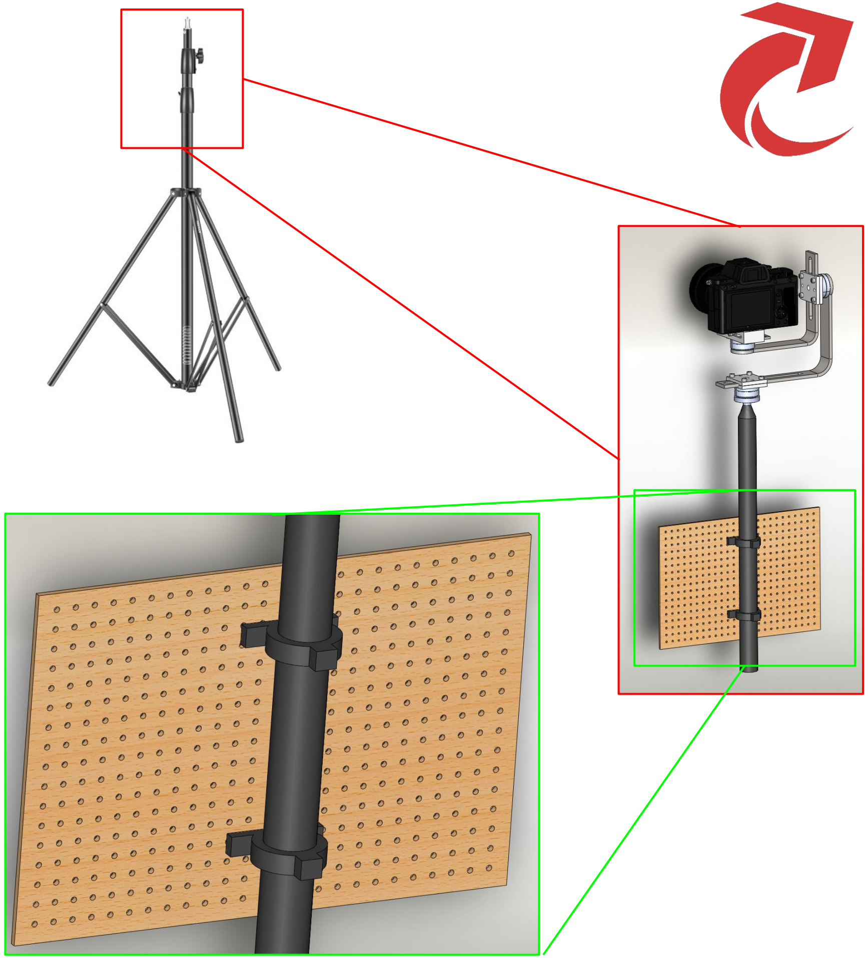
- Left to right movement is allowed by two set screws into this rail piece:





CT-EBay Mounting

- The ebay board will be mounted on the straight part of the CUAir tripod, so that wires can be shorter.
- Will be mounted using two clamping pieces with screw into the back of the wood board and clamp onto the tripod

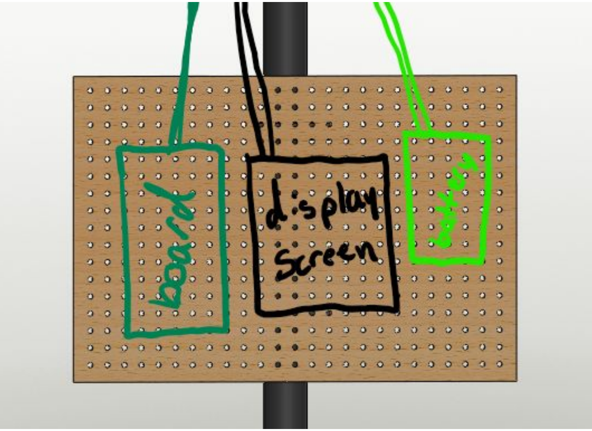


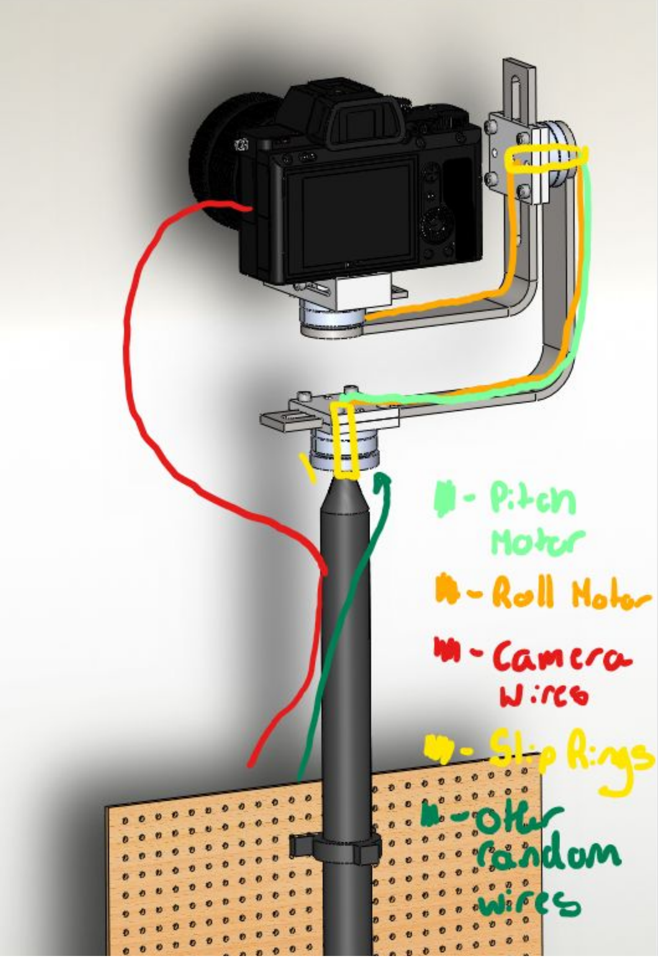
Side Note: I can't find the CUAir tripod (I think it's in the trailer) but if we don't have one, julius and nate recommended this one.

Wiring Paths/Ebay Organization

Camera wires stick off to the side with lots of slack. This was based off of the DJI Gimbal we have.

FR-2: Wiring must not restrict motion of gimbal
FR-3: Gimbal motion should not unplug or stress wiring.





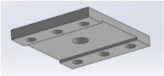
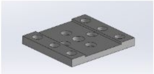
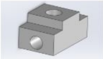
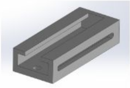
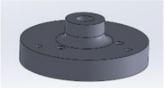
Integration

Impacted Subteams and Systems

- **Electrical**
  - Need **2 slip rings** to put through the motors so that wires are nice.
    - One slip ring should have room for the pitch and roll motor wires. (not strictly necessary but possible and would be nice)
  - Also the camera wires are going to be independent and free to move like the DJI gimbal has
- Imaging/software
  - Actual tracking of the plane
- DesOps
  - Uses DesOps camera
  - Getting useable footage of the plane

Manufacturing

CT-Gimbal Bill of Materials

Non COTS CT-Gimbal Parts					
Name	Picture	Quantity	Unit price	Total price	Where from
Yaw Arm		1	$20.99	$20.99	SendCutSend
Pitch Arm		1	$20.00	$20.00	SendCutSend
Top Clamp		2	$0.50	$1.00	3D Print
Bottom Clamp		2	$0.50	$1.00	3D Print
Camera Attachment		1	$0.50	$0.50	3D Print
Adjustable Camera Mount 1		1	$0.50	$0.50	3D Print
Adjustable Camera Mount 2		1	$0.50	$0.50	3D Print
Tripod Mount		1	$10	$10	Machined

Total Cost: $287.96

Total Cost before motors: $134.99

COTS CT-Gimbal Parts					
Name	Link	Quantity	Unit price	Total price	Where from
GL30 Gimbal Motor	https://store.tmotor.com/	3	$50.99	$152.97	T-Motor
91294A126	https://www.mcmaster.co	14	$5.45	$5.45	McMaster-Carr
91290A140	https://www.mcmaster.co	11	$12.94	$12.94	McMaster-Carr
91290A144	https://www.mcmaster.co	11	$13.24	$13.24	McMaster-Carr
91864A062	https://www.mcmaster.co	1	$7.51	$7.51	McMaster-Carr
94180A351	https://www.mcmaster.co	14	$21.82	$21.82	McMaster-Carr
94180A353	https://www.mcmaster.co	1	$12.72	$12.72	McMaster-Carr
91294A125	https://www.mcmaster.co	4	$6.82	$6.82	McMaster-Carr

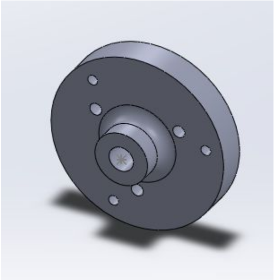
Manufacturing

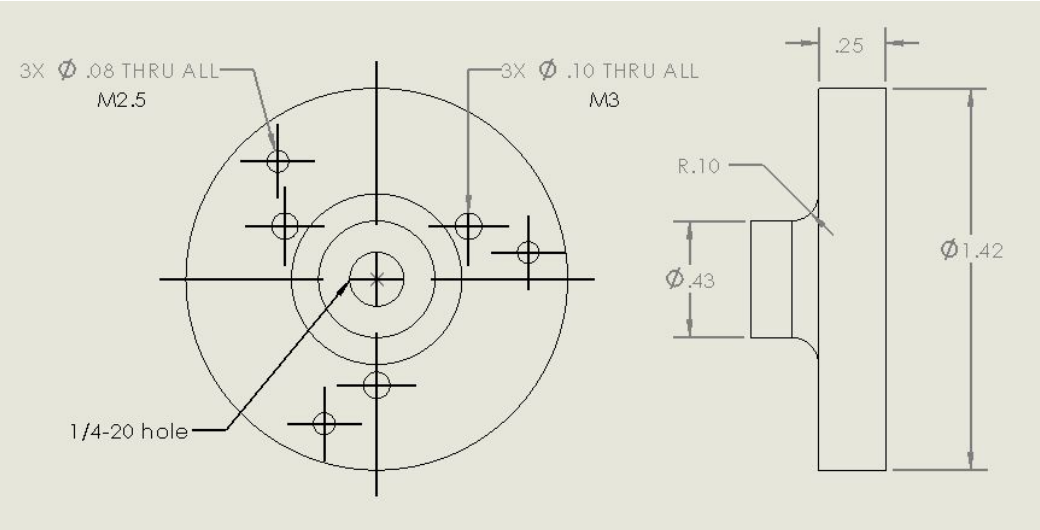
- Order 3 gimbal motors
- Order parts from send cut send, order all hardware and stock
- Send 3d prints and laser cuts to RPL
- Machine Tripod Mount
- Assemble according to CAD Layout/ mDOC
- Install wiring and cameras

- Link to mDOC

Tripod mount
(machined in machine shop)

- Order this stock but first check if we have already
- Machine first on lathe then on mill
- ***mill tolerances matter because the hole pattern must align with the motor.
- *no other tolerances matter



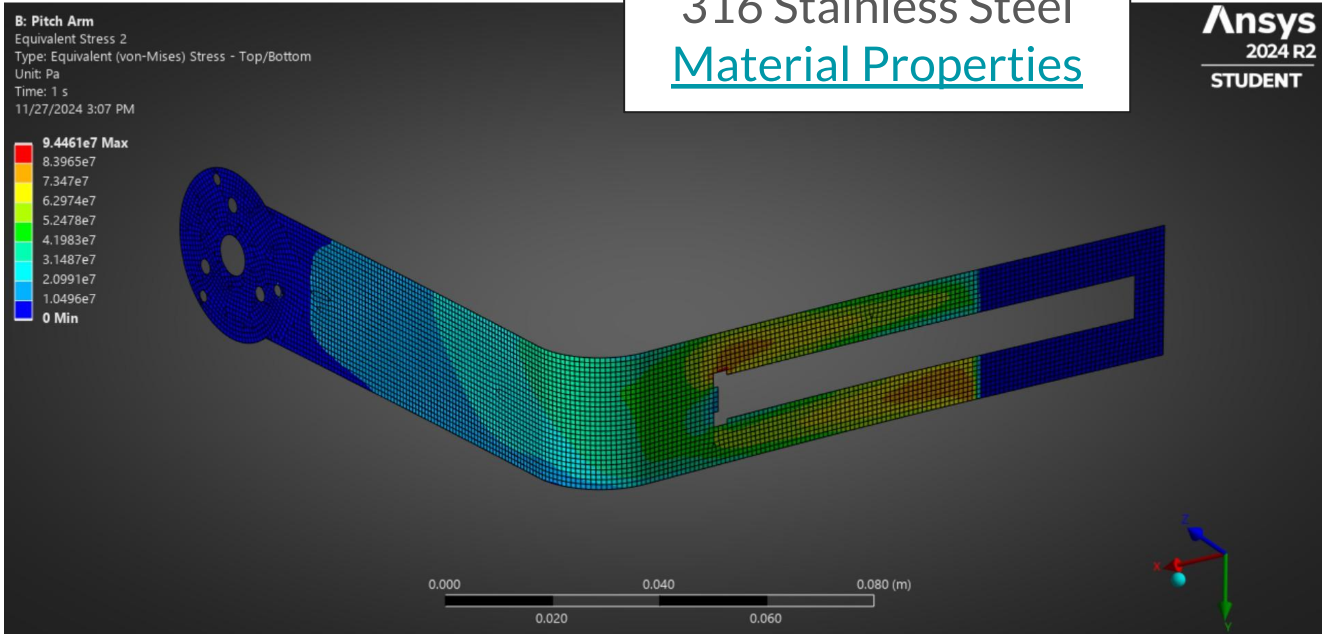


omg i hate making engineering drawings

Testing/ Hand Calcs/ ANSYS

ANSYS on Pitch Arm

Material:
.187” thick
316 Stainless Steel
[Material Properties]

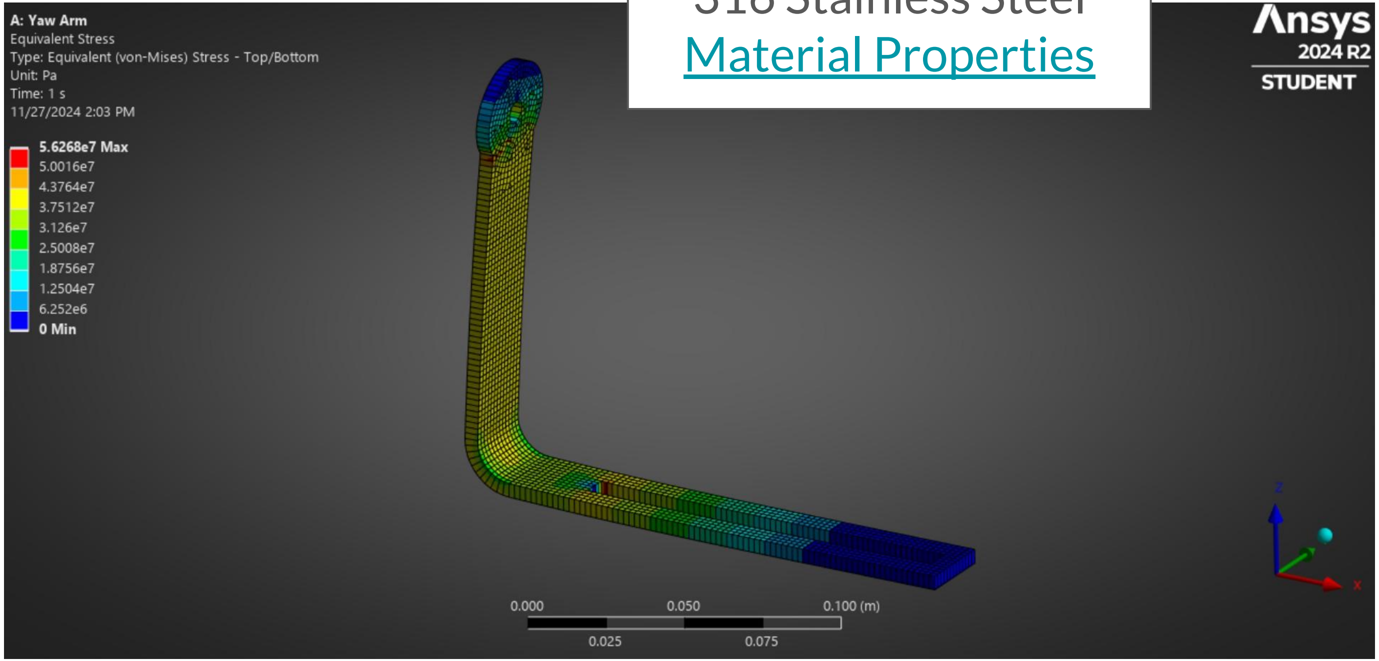


Max Stress with FOS of 2 on yield: 1.551e+8 pa

Deformation: 0.06157 in

ANSYS on Yaw Arm

Material:
.187" thick
316 Stainless Steel
[Material Properties]



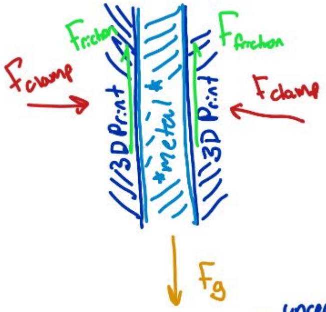
Max Stress with FOS of 2 on yield: 1.551e+8 pa

Deformation: 0.07125 in

Friction Hand Calcs for adjustability

Will friction be enough to hold the gimbal arms in place?

Yes →



AI Overview

The coefficient of friction between plastic and metal typically falls within the range of 0.2 to 0.6 depending on the specific plastic material and metal surface, with most plastics exhibiting a coefficient closer to the higher end of this range when sliding against steel; however, some specialized plastics like PTFE (Teflon) can have significantly lower coefficients of friction due to their low surface adhesion properties.

$\mu = .4$ for PLA w/ steel

uncertainty factor ≈ 4 kgs

$F_g = 1.6 \cdot (m_{camera} + m_{motor} \cdot 2 + m_{arm}) \cdot g$

$F_g = 62.784\,N$

$F_g = 2F_{friction}$

$31\,N = \mu F_{clamp}$

$F_{clamp} = 78.48\,N$

$F_{Bolt} = \frac{F_{clamp}}{4} = 19.5\,N$

from mcmaster

Bolt Max tension → 230 N

FOS = 4 → 57.5 N/bolt

we can safely acheive this!!

Testing Plans

- Will test the mechanical design in parallel with the electrical board.
    - **FR-4:** The assembly must be able to **resist 20 mph gusts** without differences in quality
    - **FR-5:** The assembly must accommodate electrical needs
    - **FR-6:** The assembly **must not overheat or deform** over time and extended use
    - **NFR-1:** Should be **easily assembled** for test flights

** These FRs and NFRs have been designed for already, we will just be verifying they were met.

Timeline

Timeline

- End of Semester: Order Non-3D Printed Parts
- Jan Fab: Put stuff together/ Documentation
- Next Sem: Troubleshooting/ Wrap up

Next Steps

Action Items

This Sem:

- Polish off CAD
  - Finalize CT-EBay design
- Order Send Cut Send Parts
- Order McMaster Parts
- Confluence Documentation

Thank you! :) Questions?