AD Robotics – Long Reach Robot Arm

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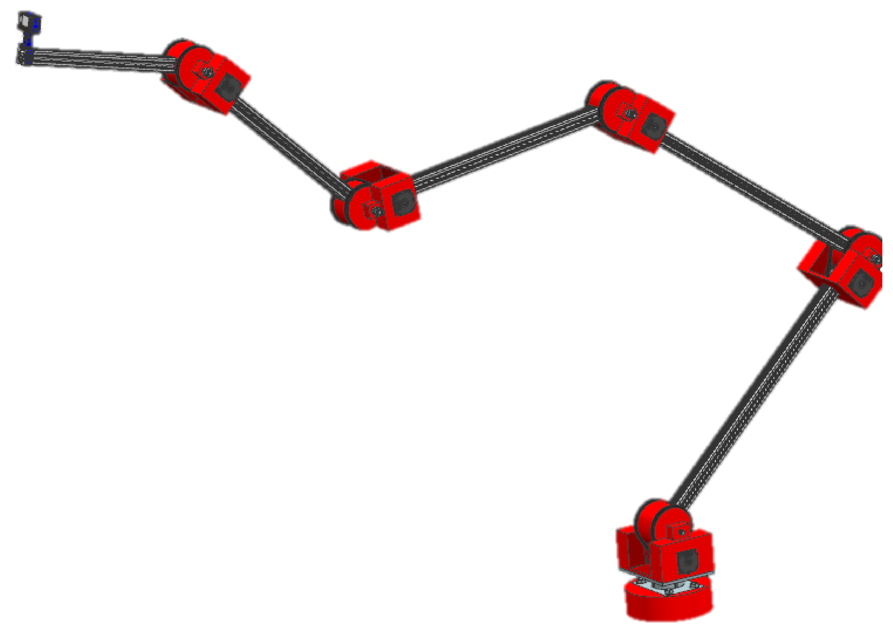
Application

Many critical systems sit behind the beamlines at Fermilab that requires constant analysis. The spatial compactness of components around the beamline poses the issue of adequately being able to view in these tight spaces for repairment. The multi-axial, long reach robotic arm allows the operator to remotely identify the point of issue while maneuvering around obstructions and the narrow spaces of the beamline. Refer to Amanda Hoeksema's poster for more info. regarding the robot's counterweight & spring-platform system.

Previous Design

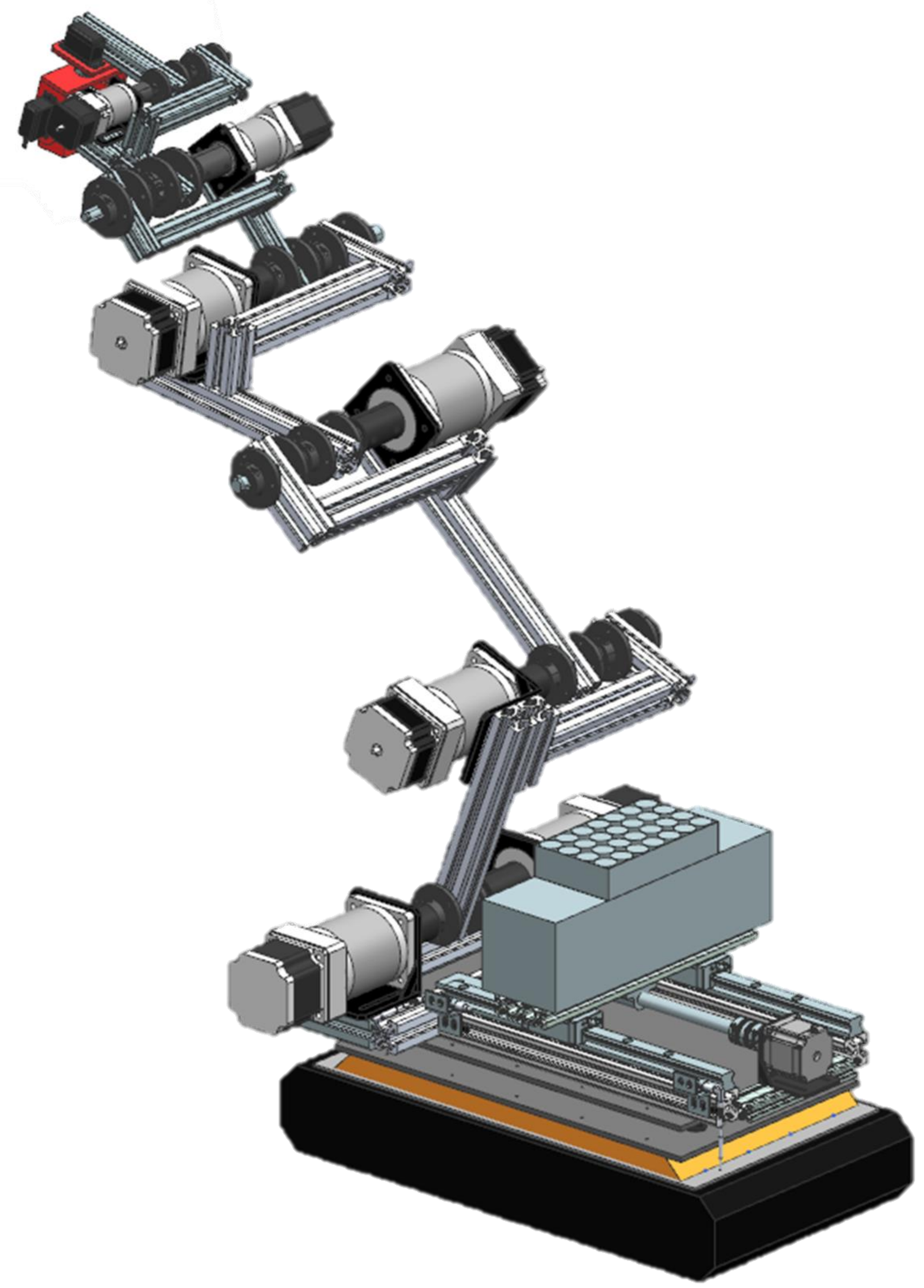
The first iteration of the self-balancing, long reach robot arm comprised mainly of 3D printed components. This posed a risk that compromises the structural integrity of the load-bearing components, causing the plastic to potentially break under stress. The main goal for this modified design was to produce a new model that uses off-the-shelf parts from vendors to guarantee the safety and reliability of the pre-manufactured components.



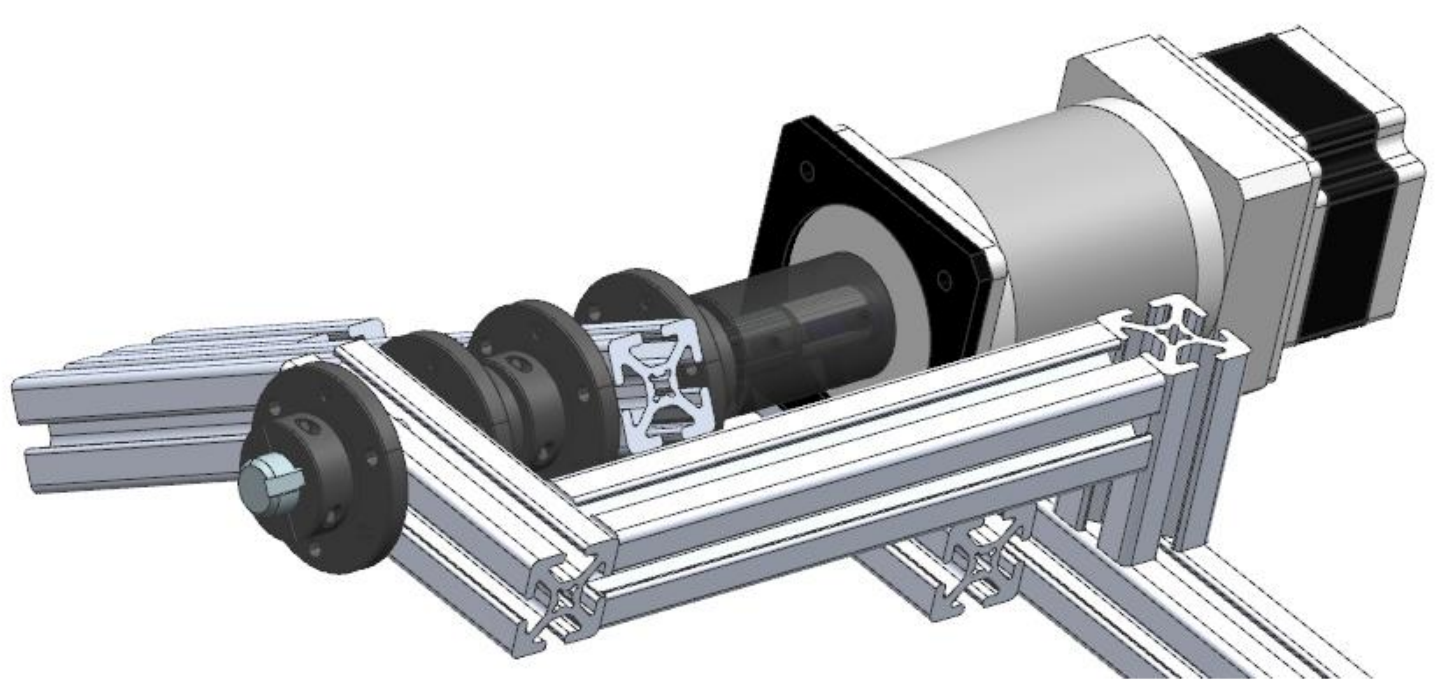
Long Reach Robotic Arm - Summer 2020 design

Robot Arm Design & Calculations

The modified design of the long reach robotic arm uses T-slotted aluminum framing. The versatility of 80/20 provides ease of assembly and simplicity of design. Rotation of each arm is possible with a flange-mount shaft collar is fastened on either side of the arm link. The ends of the extended rotary shaft are supported by the L-shaped 80/20 to prevent a bending load on the actuator shafts. This joint & arm design iterates throughout the six (6) total linkages.



Combined arm & counterweight system – Summer 2021 design



Joint assembly design iteration

The joint actuators were thoroughly specified by calculating the maximum torque required to hold the arm in place and rotate the linkages referencing the extreme point of complete horizontal extension.

$$\tau[Nm] = M \times g \times L + I \times \alpha$$

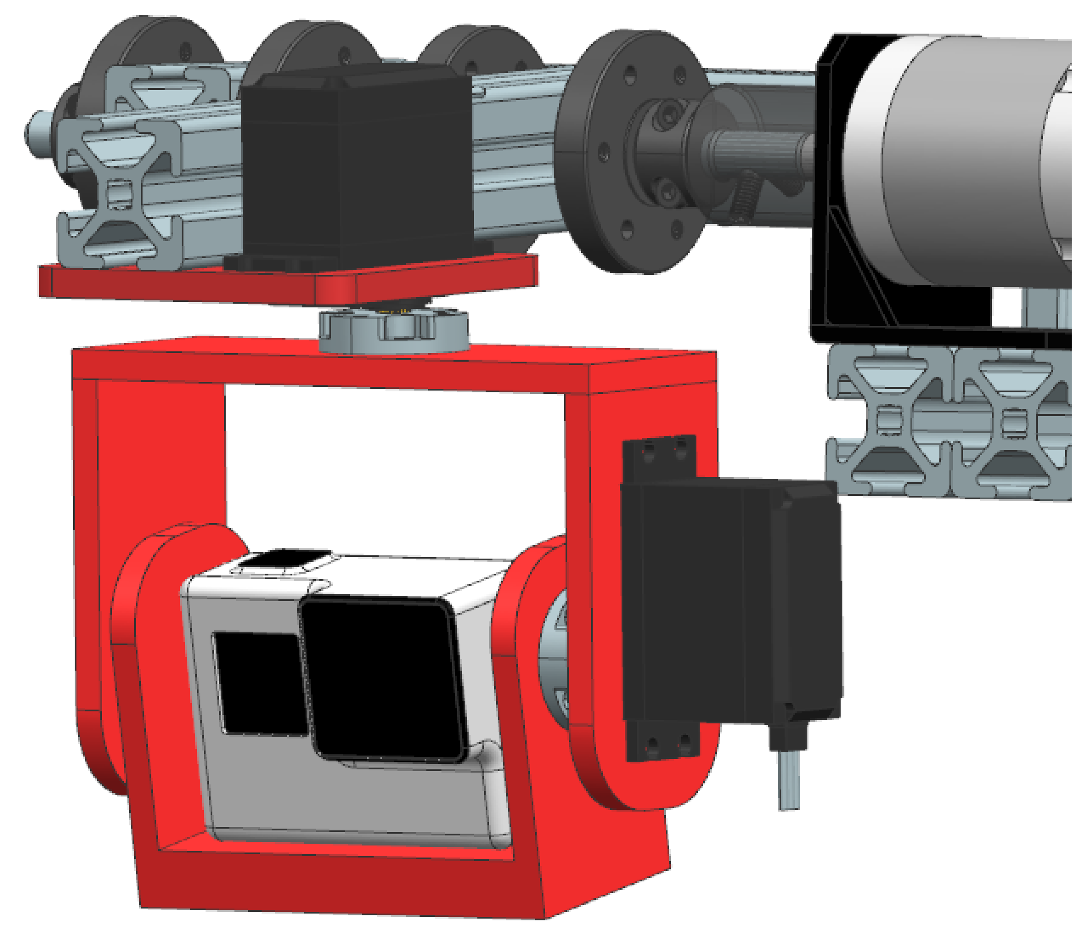
M = mass [kg]
g = gravitational acceleration constant [m/s²]
L = length [m]
I = moment of inertia [kg*m²]
α = angular acceleration [rad/sec²]

Maximum torque equation

The other worst-case scenario that was accounted to ensure proper specification of the motors was complete vertical extension of the arm linkages. Radial load is the maximum force exerted to the shaft perpendicular to the axial direction. After identifying the actuators according to the calculations, a >20% contingency was added to allocate for a margin of error.

$$R[N] = M \times g$$

Radial load equation for determining the total load acting vertically on the actuator shaft



3D-printed GoPro camera mount with two (2) degrees of rotation provided by servo motors

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