FERMILAB-POSTER-21-091-AD-STUDENT

# AD Robotics – Long Reach Robot Arm

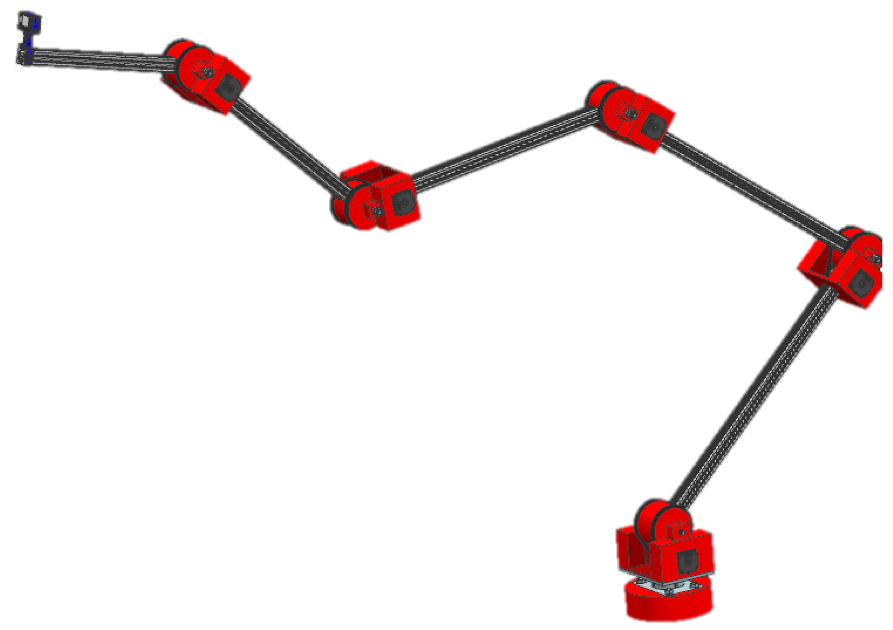
Brenda Sanchez, CCI Internship - Summer 2021, Accelerator Division
Under the Mentorship of Adam Watts

## Background

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

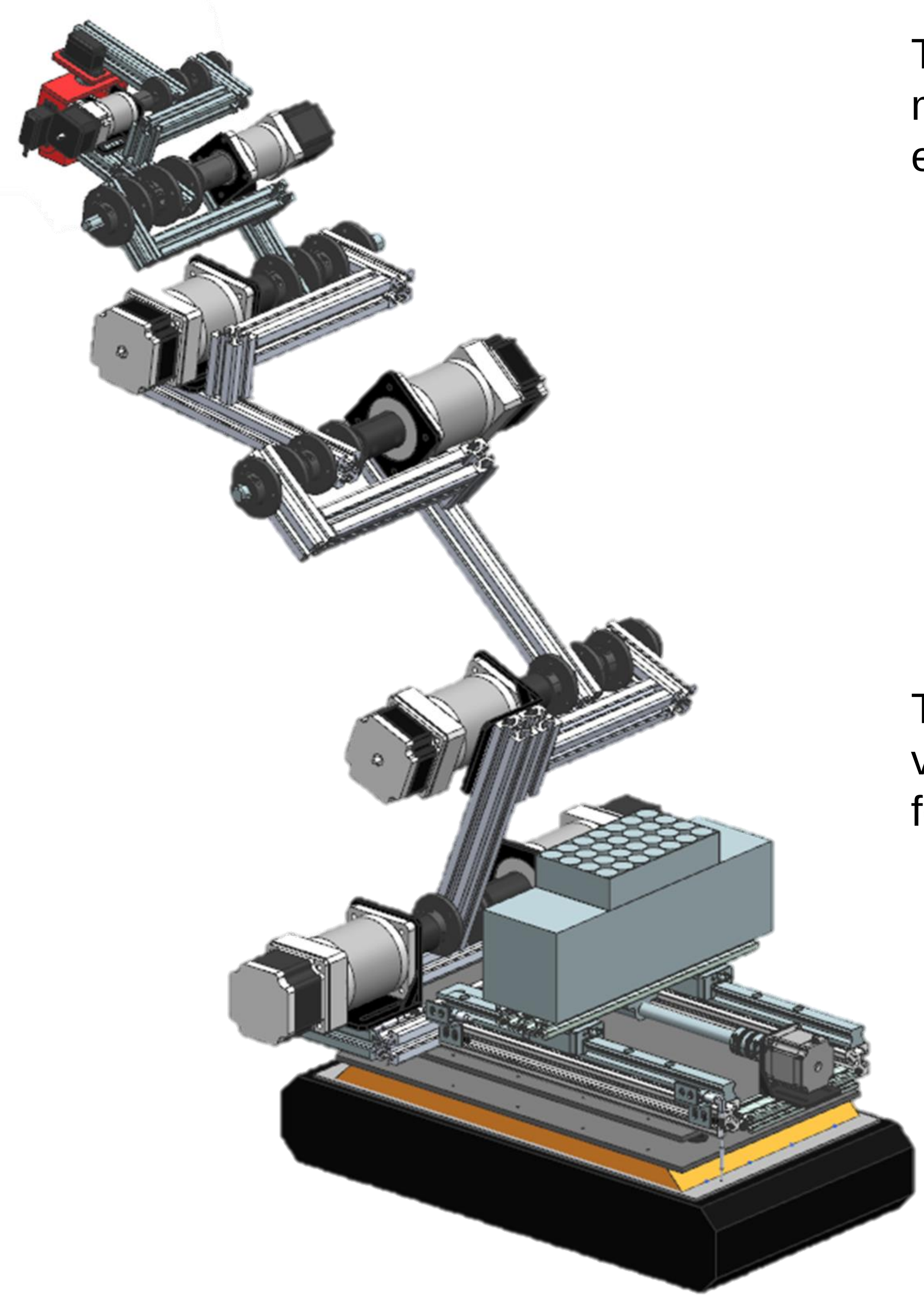
The first iteration of the self-balancing, long reach robot arm comprised mainly of 3D printed components. This posed a risk that compromises the structural integrity of the load-bearing components, causing the plastic to potentially break under stress. The main goal for this modified design was to produce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



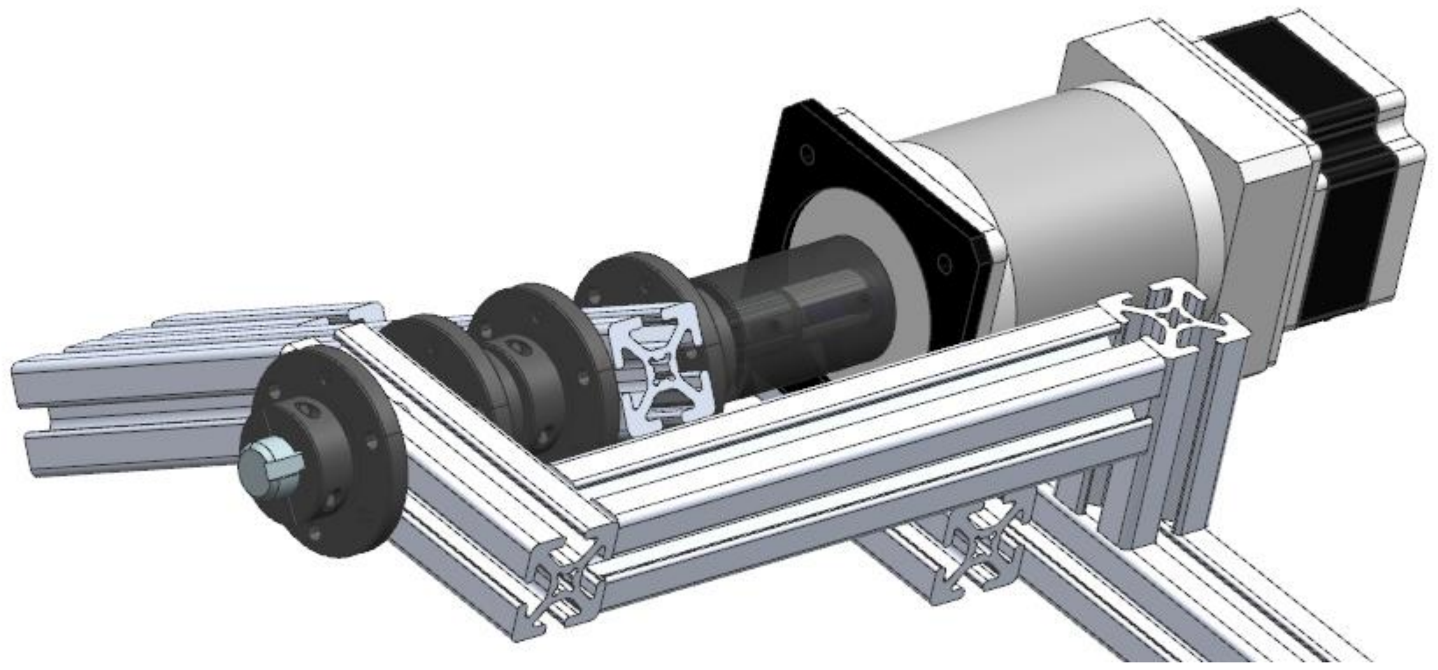
Long Reach Robotic Arm - Summer 2020 design

## 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 seven (7) total linkages.



Combined arm & counterweight system – Summer 2021 design



Joint assembly design iteration

The actuators had to be thoroughly specified by calculating the maximum holding torque needed hold the arm in place at the extreme point of complete horizontal extension.

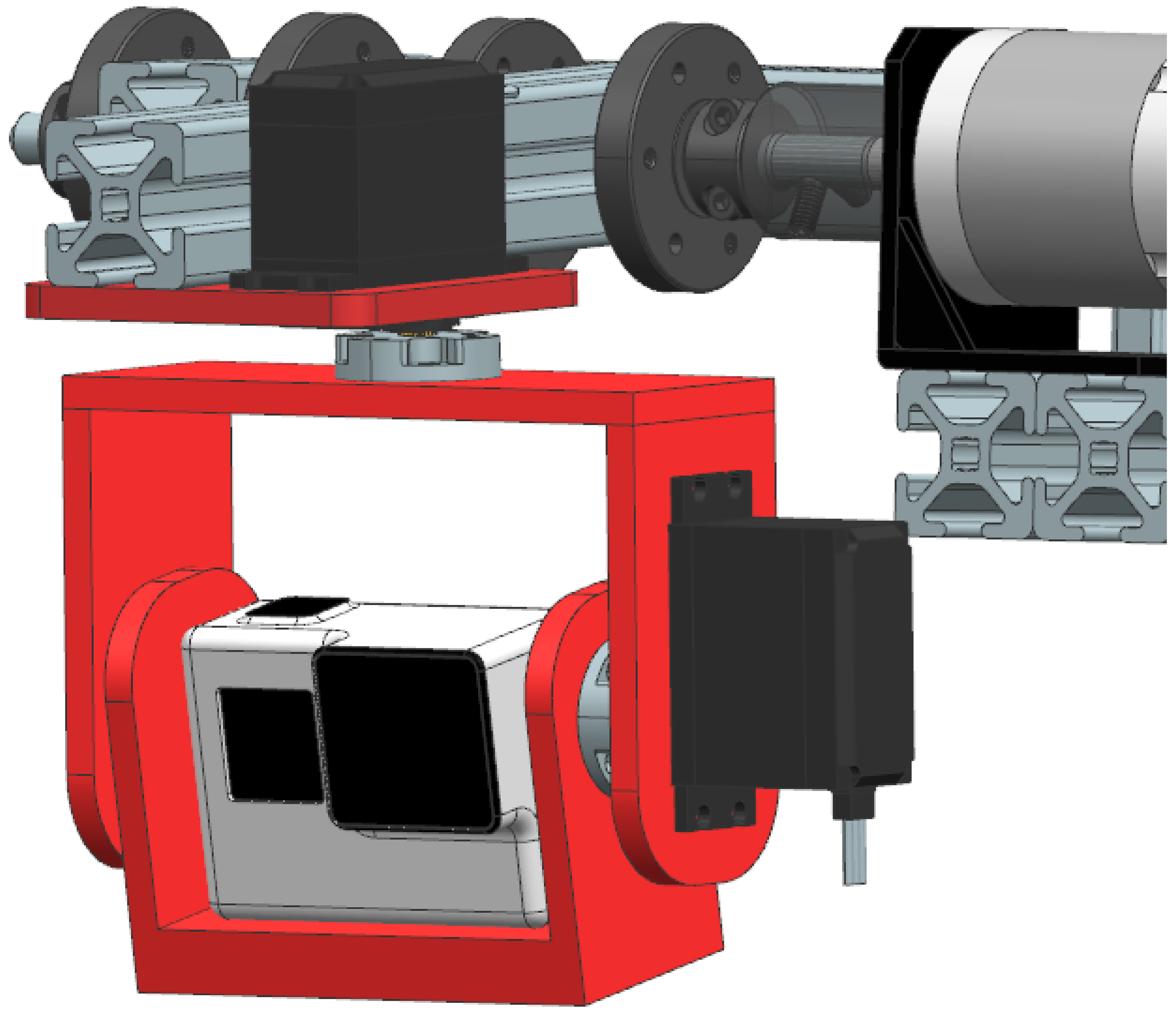
$$T[Nm] = M \times g \times L + I \times \alpha$$

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

Max. dynamic torque equation

The other worst-case scenario that was accounted for was complete vertical extension of the arm linkages. Radial load is the maximum force exerted to the shaft perpendicular to the axial direction.

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



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

This manuscript has been authored by Fermi Research Alliance, LLC under Contract No. DE-AC02-07CH11359 with the U.S. Department of Energy, Office of Science, Office of High Energy Physics.