

## Background

As TDS looks to expand the capabilities of its flagship RE3 Exoscope product by extending the lengths of its ITD and Robot Arms at the front of the system, the system must become much heavier to prevent the arms from tipping it over while fully extended. To prevent the RE3 System from becoming too heavy, TDS has tasked us with designing a testing platform with a new counterweight system that reduces the systems total weight while maintaining stability.

## Overview / Design Specs

To accomplish our primary goal of designing a lighter counterweight for the RE3 System, we used a **linearly actuated counterweight stack** that automatically responds to changes in the systems global center of mass as the arms are moved. To achieve this, we use the readings of **four imbedded load cells** in the subframe in combination with a **P.I. Velocity Controller for motor actuation**. We were also given the following design specs to consider:

System must be stable on 5° and 10° inclines in transport or non-transport modes

Weight distribution must be within ±10% of evenly distributed among all corners

Must remain stable while a 150N side load is applied during operation

Table 1: Design Specs

## Functional Flow Diagram

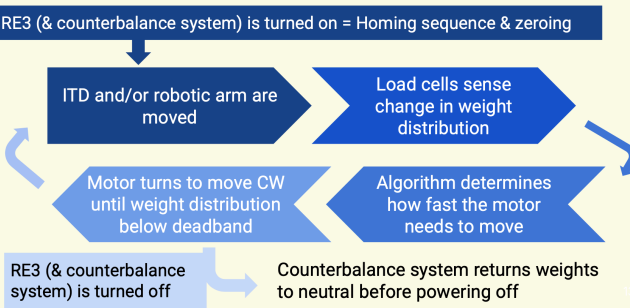


Figure 2: Functional Flow Diagram

## Final Design

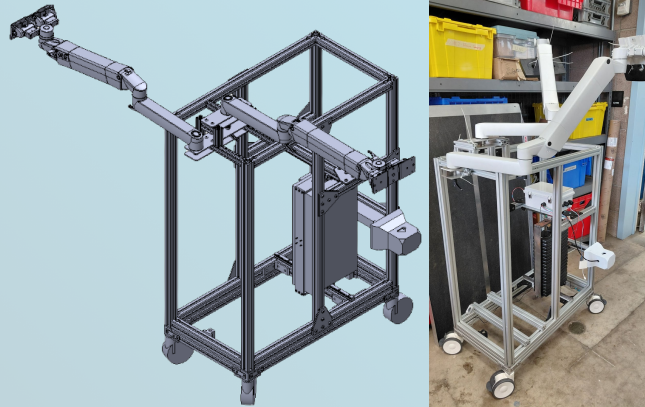


Figure 1: Full assembly of the four subassemblies that make up the dynamic counterweight system

## Hardware / Key Components



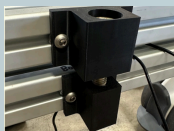
### Electrical Box

The electrical box houses all four load cell amplifiers, the stepper driver, and the Arduino microcontroller with cable glands for neat routing.



### Linear Ball Screw Module

The stepper motor easily provides the required **0.58 N\*m** of torque to actuate the counterweight



### Lateral Supports

The main body frame and subframe are connected via a 3D printed lateral support joint. An M8 bolt provides support in the lateral directions, but does not bear any load in the vertical direction



### Linear Guide Rails

The counterweight stack is supported on the top and bottom by low friction linear guide rails, drastically reducing the required torque from the motor.

## Key Result: Weight Reduction

The total weight of TDS's current RE3 product is **293 kg**. By implementing a dynamic counterweight instead of a static one, our team was able to reduce the total weight of the system to **232 kg**, which resulted in a **21.3% reduction in total system mass**, and a **51% lighter counterweight**.

When the arms are in their neutral configuration, the system's weight is distributed as follows:

**Back Corners (Counterweight Side): 17%**  
**Front Corners (Arms Side): 33%**

With these results, we have accomplished our main goal of reducing the systems total weight while remaining within the design specs for even weight distribution.

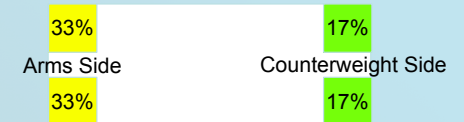


Figure 4: Weight Distribution Diagram

## Key Result: Stability on Incline

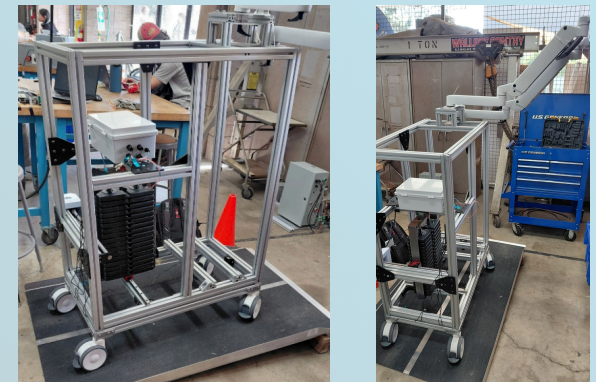


Figure 3: Incline Stability Tests

Through testing various arm configurations we were able to prove that the system remains stable and safe from tipping over at the 5° and 10° incline specs that TDS provided.