# Load Sensing Device for Speed Climbing Hand Holds

THE UNIVERSITY OF UTAH
Department of Mechanical Engineering

Gannon Brady, Tren Hirschi, Daisy Quach, Lingbai Ren, Clarissa Seebohm, Julian Torres
Advisor: Stephen Mascaro

## INTRODUCTION

Our project aims to address the inability of United States Olympic Climbing (USOC) to measure the force a speed climber exerts on a hand hold. We have developed two independent methods to collect multi-axial force data — **instrumented bolt** and **behind-the-wall**. Ultimately, USOC should be able to collect data required to optimize athlete training regimens.

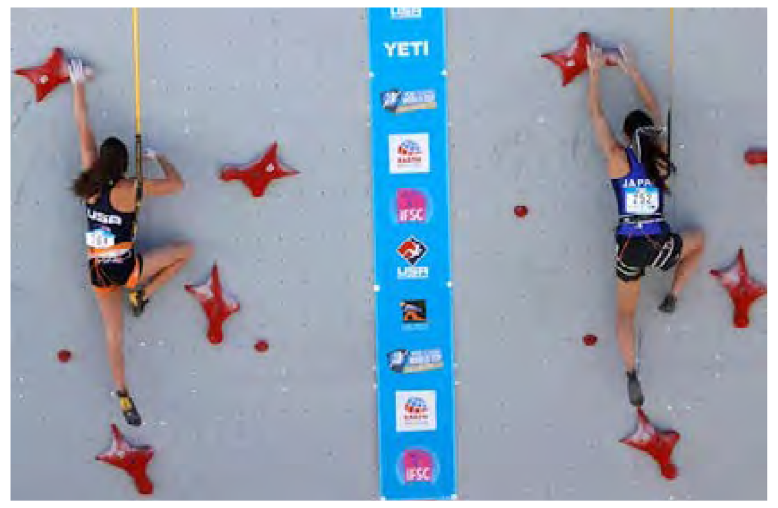


*Figure 1: Two athletes speed climbing.*

*Figure 2: Testing on mock wall.*

## PROBLEM

USOC is unable to measure speed climber's start kinematics. Our objective is to develop instrumented speed holds for International Federation of Sport Climbing (IFSC) climbing walls that will record the multi-axial force data. The device ideally shall not obstruct the wall nor training of the athlete.

## METHODS

We have developed two independent methods to collect multi-axial force data from a speed climbing hold. The instrumented bolt offers non-invasive data collection with less accuracy. While the behind-the-wall design uses a six-axis force-torque sensor for greater precision but requires a more invasive installation.

## METRICS

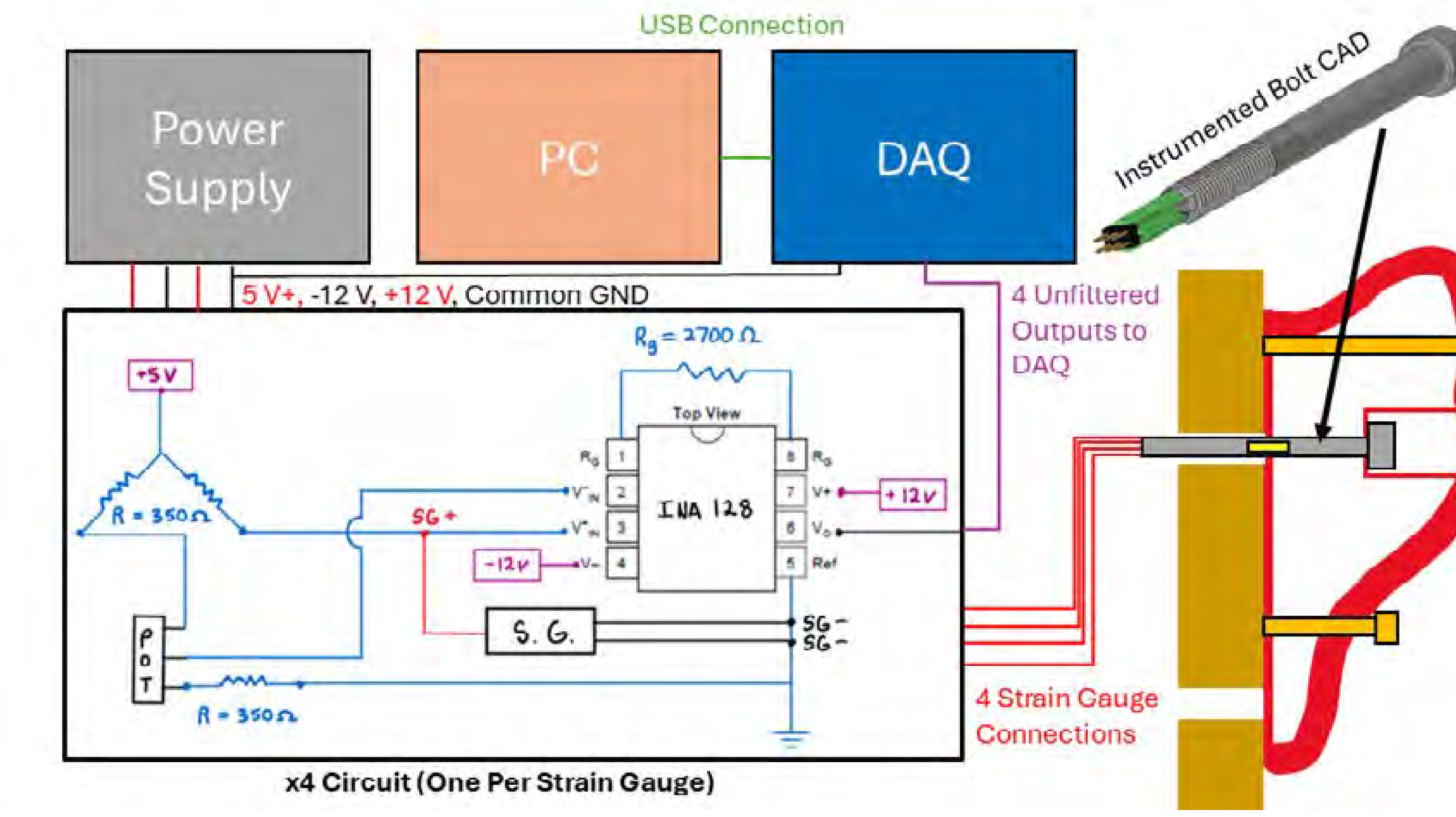
Shown below is a comprehensive table presenting key performance metrics for both systems. The systems shall be accurate, deployable within a reasonable time frame, and imperceptible to athletes when they climb. In addition, the wall shall not be modified in any way.

*Table 1: Metrics table showing the target, achieved for behind-the-wall, and achieved for instrumented bolt.*

| Metrics | Target | Achieved (BtW) | Achieved (IB) |
|---|---|---|---|
| Accuracy | +/- 5% | 10% | 25% |
| Deployability | Easy-to-install with no modifications to the wall | Yes, but tedious and time consuming | Yes |
| Perceptibility | Imperceptible to athletes | Not yet | Yes |

## INSTRUMENTED BOLT (IB)

The instrumented bolt design uses four strain gauges on a machined 3/8" bolt. The strain gauge wires are routed through the hollow center of the bolt. Behind the wall, a pin connector allows the strain gauges to be easily connected to an amplification/data-collection circuit. The recorded strains are then calibrated into three-axis force data.



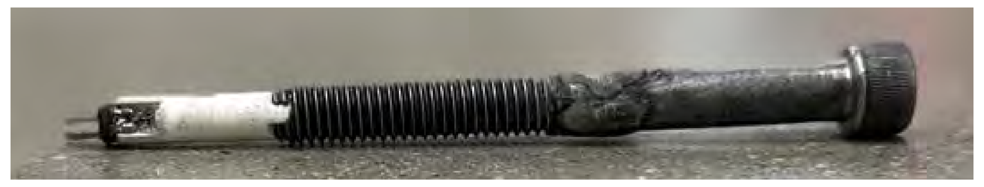



*Figure 3 (above): Diagram of the IB subsystems.*

*Figure 4 (left): Photo of the IB.*

## IB RESULTS

Currently, the instrumented bolt can be accurately calibrated to report applied force only when a variety of outside variables are controlled (bolt torque, bolt orientation, hold orientation, additional screw placement, and several others). Because of this, the instrumented bolt has not yet been validated as a standalone system that will be accurate enough for training purposes. Strain data was collected while several athletes climbed at a commercial climbing gym, which proves that the mechanical and electrical design is robust and non-invasive enough for the application.

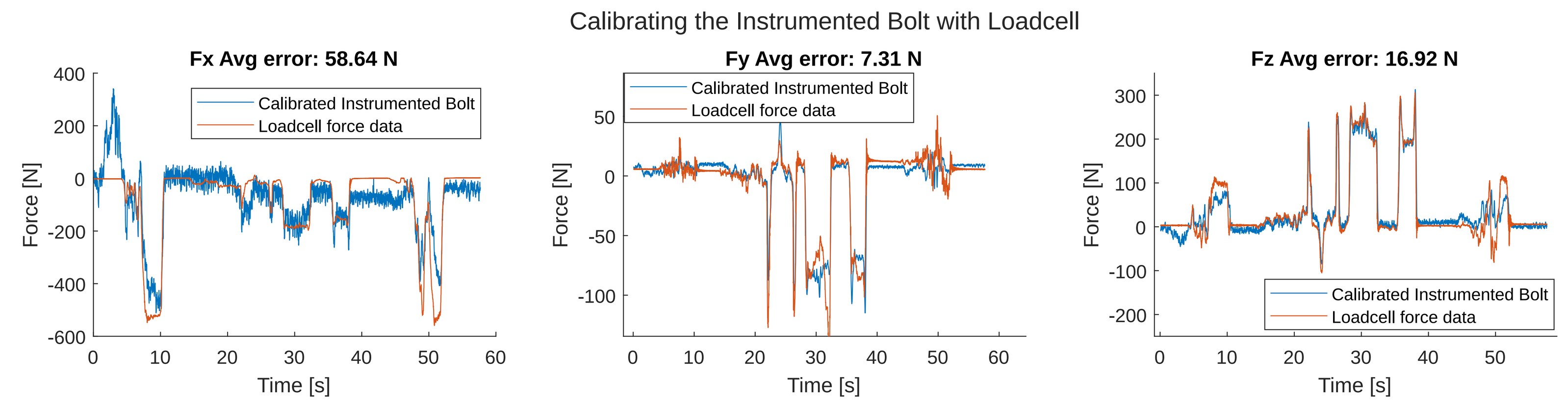
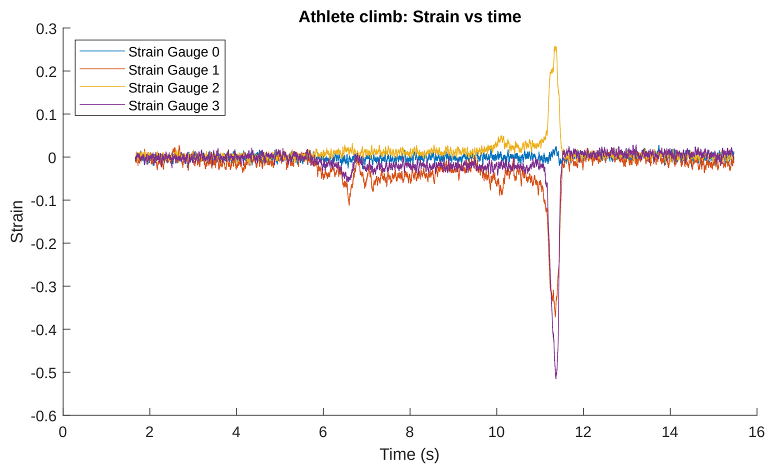



*Figure 5 (above): Force as a function of time plots that show the calibration of the instrumented bolt using the load cell.*

*Figure 6 (right): Strain on all four strain gauges as a function of time for an athlete test.*




## BEHIND-THE-WALL (BtW)

The behind-the-wall design uses a commercial force transducer to collect the data. As the name suggests, the transducer is mounted behind the wall. An internal plate is set within the hand hold and is used to connect to another plate mounted to the transducer. The transducer is connected rigidly to the wall using the sheet metal housing.

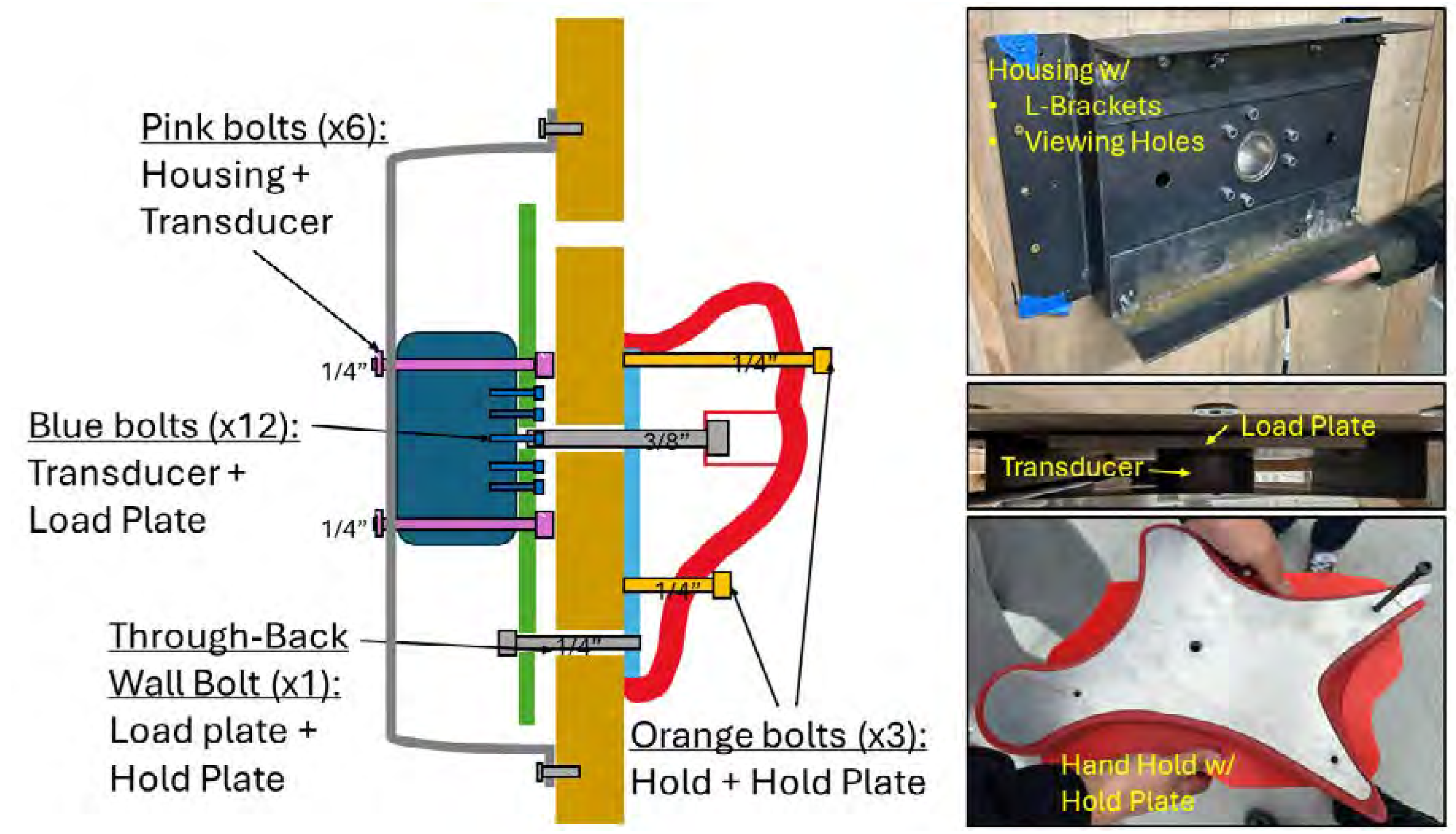



*Figure 7: Diagram and photos of the BtW design.*

## BtW RESULTS

When properly installed, the behind-the-wall design can measure loads applied to the hand hold with a margin of error within 10%. However, the behind-the-wall design requires an intense and precise setup procedure which makes it infeasible to set up anywhere but semi-permanently at a dedicated training wall.

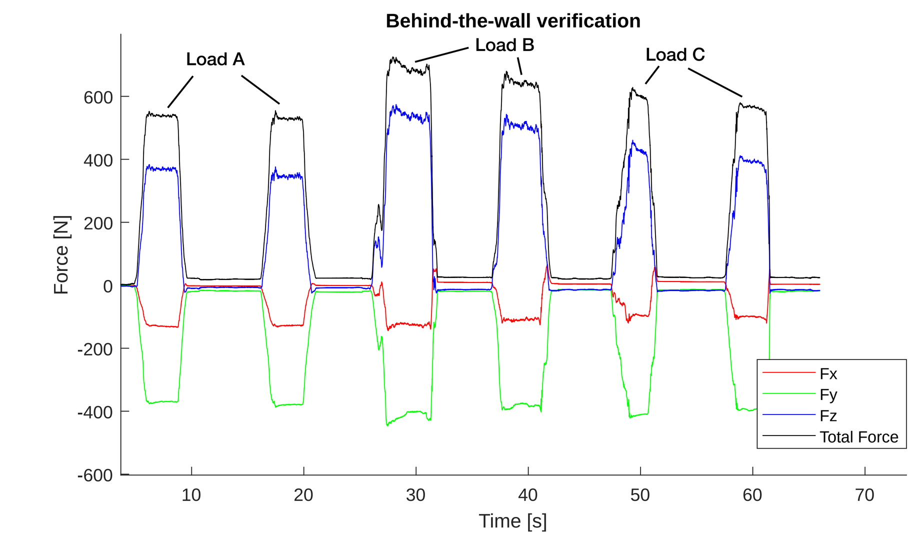



*Figure 8 (left): Body weight force collected as a function of time for verification of the BtW system.*

*Load XX: Actual, Measured, Error*
*Load A: 540 N, 520 N, 3.62%*
*Load B: 649 N, 668 N, 7.25 %*
*Load C: 720 N, 585 N, 9.91%*

## CONCLUSION

Both systems have shown success as a proof-of-concept. The data collected from the behind-the-wall design is nearly accurate enough to be used in training, but could be improved. It is extremely difficult to install and not applicable to commercial gyms. While we have been able to obtain high quality strain data from the instrumented bolt, our calibration methods are not yet consistent enough for training purposes. An updated version of the instrumented bolt could provide the necessary accuracy in a package that is more deployable than the behind-the-wall design.