Speed Skate

A project journey

CANADIAN SPORT INSTITUTE CALGARY
INSTITUT CANADIEN DU SPORT

For more info, visit us at motusdesign.ca

motus DESIGN GROUP

2016

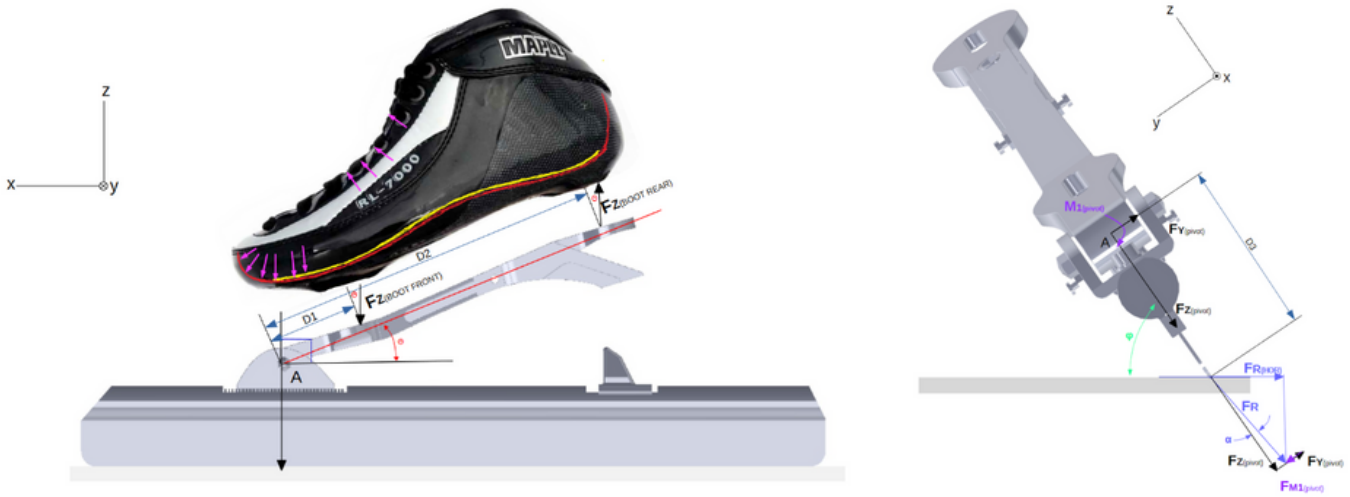
The Need for Speed Skating Canada

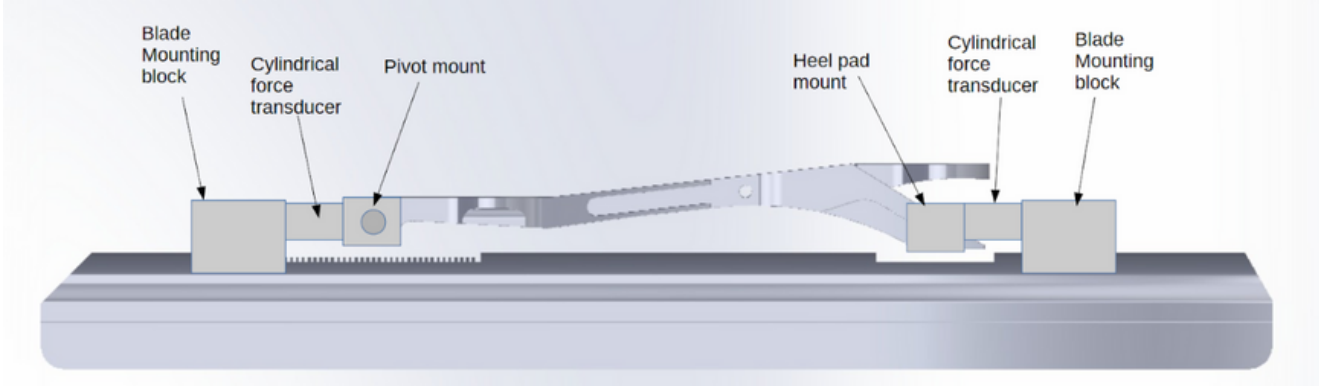
Speed Skating Canada first approached us in 2016, they needed a tool for measuring and recording real-time force output by long track speed skaters. The measurement had to be done under regular skating conditions and minimally affect the feel or ergonomics of skating.

A force measurement clap skate had been created in the Netherlands in 2016, however the set up was heavy, bulky, and changed the height of the skating platform. A significant difference in the feel of the skates would change how an athlete applies force while skating, as well as limit the usage to specific testing sessions.

Preliminary Analysis

A detailed analysis of the mechanics of existing clap skates and the dynamics of skating forces needed to be completed leading up to a proposed design concept that would meet the measurement needs of Speed Skating Canada. It was determined that a convenient place to measure force in a clap skate system would be at the pivot point, where the frame that attaches to the boot connects to the blade assembly. Strain gauges located at the front and rear mounting points would theoretically be able to determine the propulsive force generated by the skater.





motus DESIGN GROUP

Motus Technology

As project budget was a consideration, we sought to maximize value and leverage some existing Motus Sport Measurement technology Motus had previously developed for other Canadian Olympic sports. This included Motus Review (software for video and data sync and playback), Motus Podia (hardware for high frequency data collection), as well as some core force transducer and analog instrumentation technologies Motus had designed for other applications. Incorporating existing Motus video capture software provided a high value overall solution, where coaches and athletes would be able to review force data with video to better understand how technique affects performance.

Past Motus projects showcasing rowing foot plate & force transducer

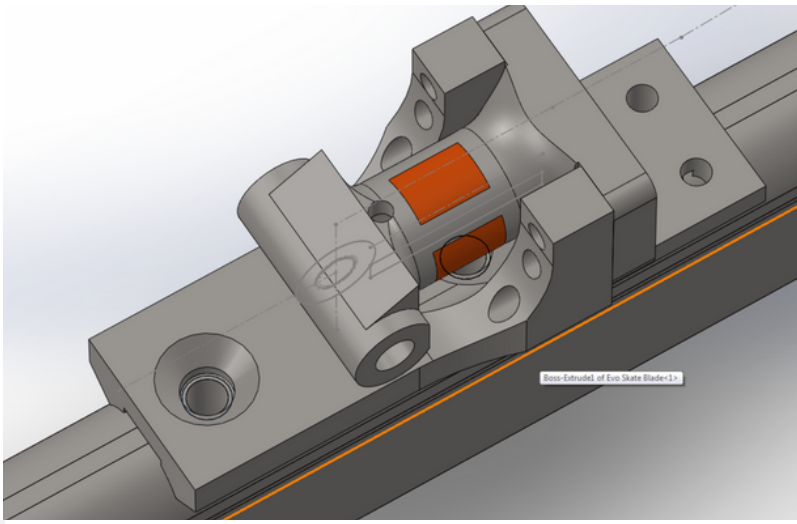
Proposed Solution

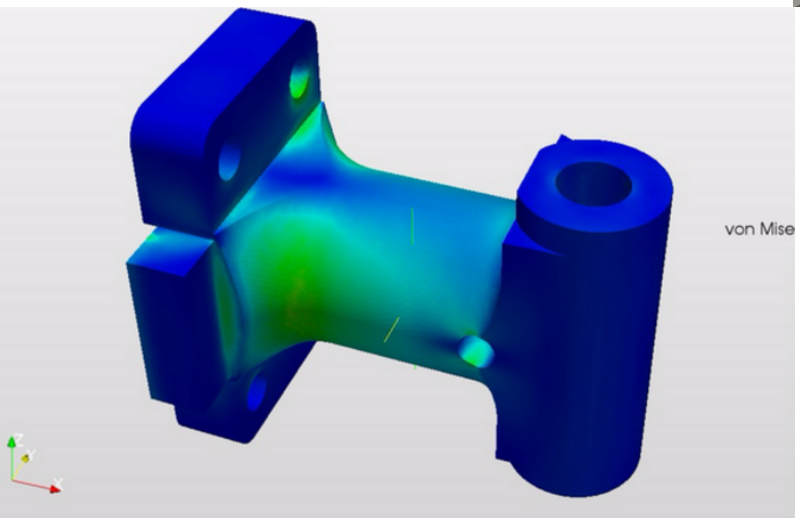
Motus set out to design a new clap skate that was as close in weight, height, and feel to a generic clap skate as possible. Transducers at the front and rear mounting points would be fitted to an existing skate blade. The Evo Blade was chosen over more popular blade manufacturers because it allowed for the best mechanism attachment locations. In keeping with the project goals, the solution would utilize existing sports performance technologies at Motus and package video review software for data analysis.

Prototyping

The stack height of the skates became a significant challenge. We used a custom force transducer design so we could optimize the stack height, with front and rear transducers each having their own unique designs. Tight space tolerances necessitated measuring multiple axis of forces and torsion on a single set of strain gauges on a single transducer. A novel analog instrumentation solution derived from NASA sensor systems solved this problem. Iterations of 3D printed concepts allowed us to quickly verify stack height, assembly issues and feasibility, while finite element analysis of transducers allowed us to hone in on the right combination of design and material choice.

CAD concept of front transducer on Evo Blade



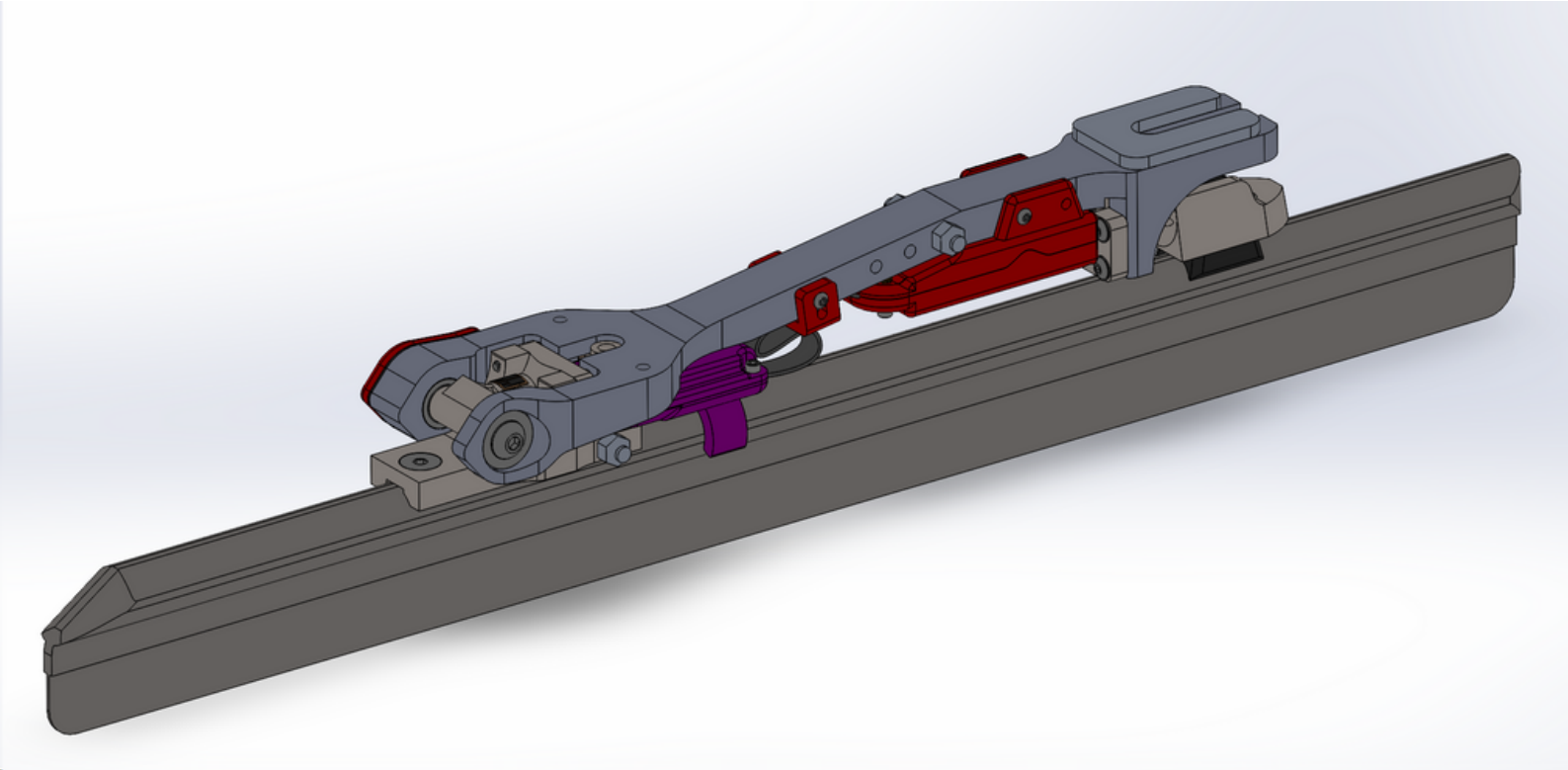


FEA of front transducer during maximum loading

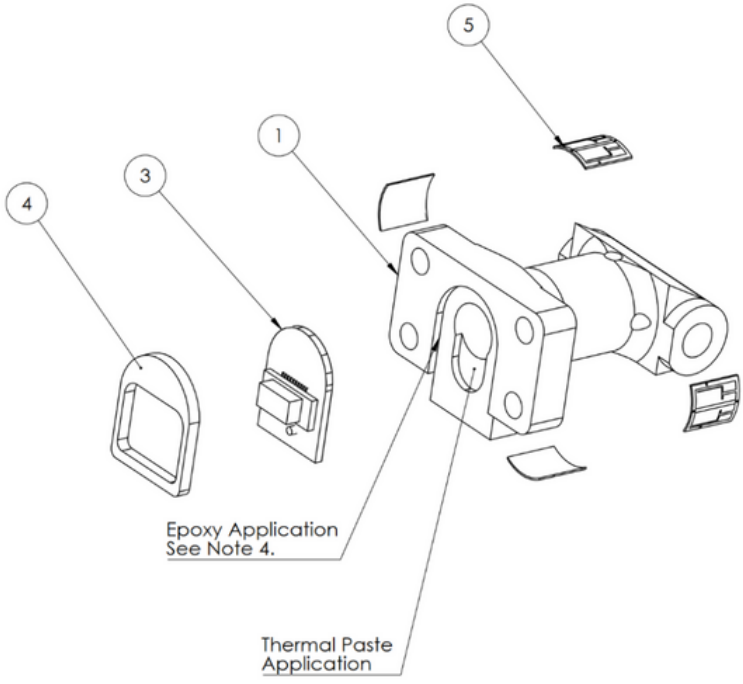
motus DESIGN GROUP

Design

Limitations to weight and strength meant we chose titanium transducers, paired with an aluminum skate bridge. Digitally controlled analog instrumentation on custom circuit boards with custom firmware were designed to fit within the tight physical constraints of the skate. The result was a skate mechanism that was the exact same stack height as the original mechanism. The system was designed to withstand twice the peak force of the strongest Olympic speed skaters with material selection kept as light as possible.



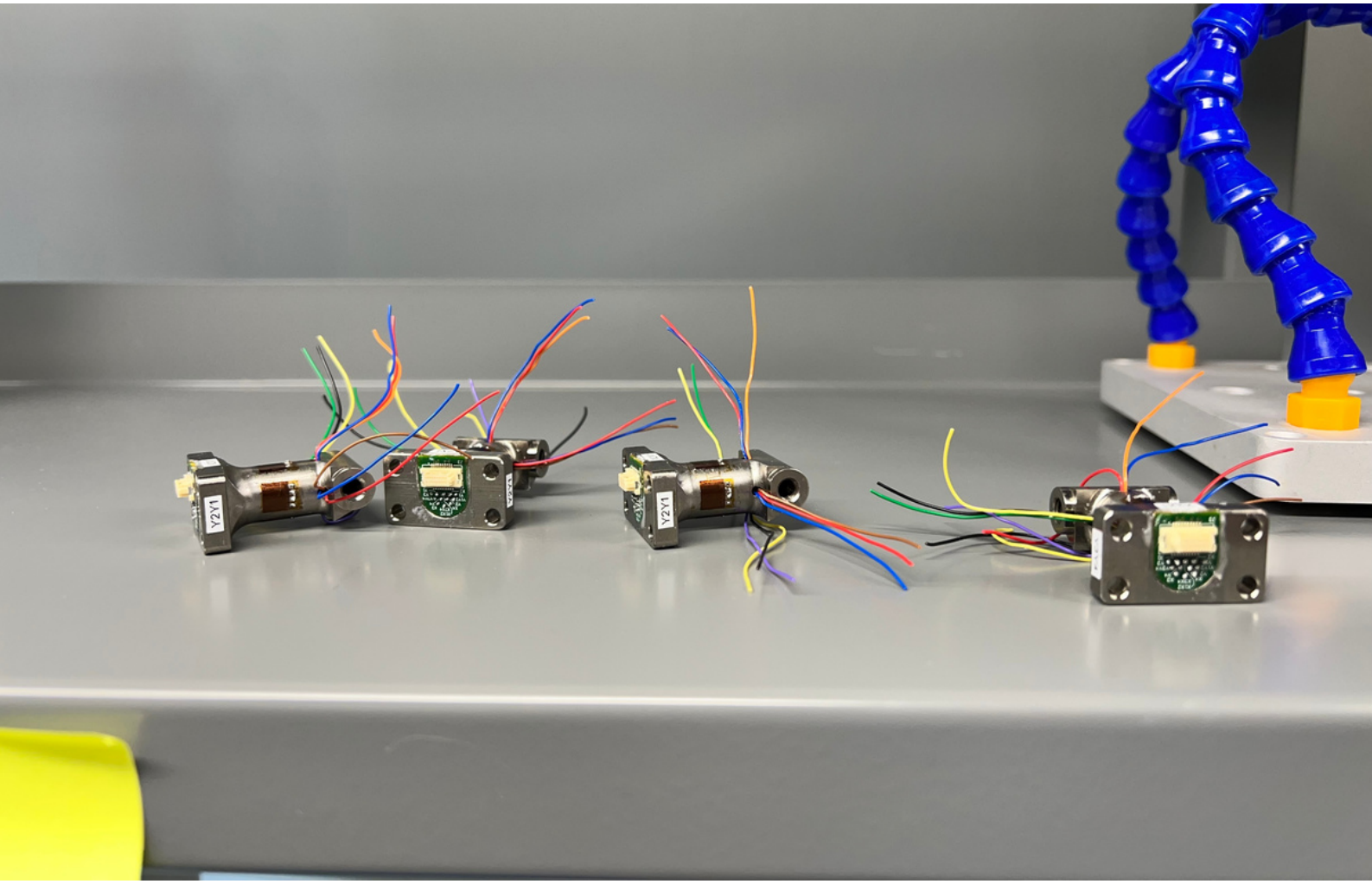
Custom digitally controlled instrumentation amplifier PCB



Blade transducer assembly

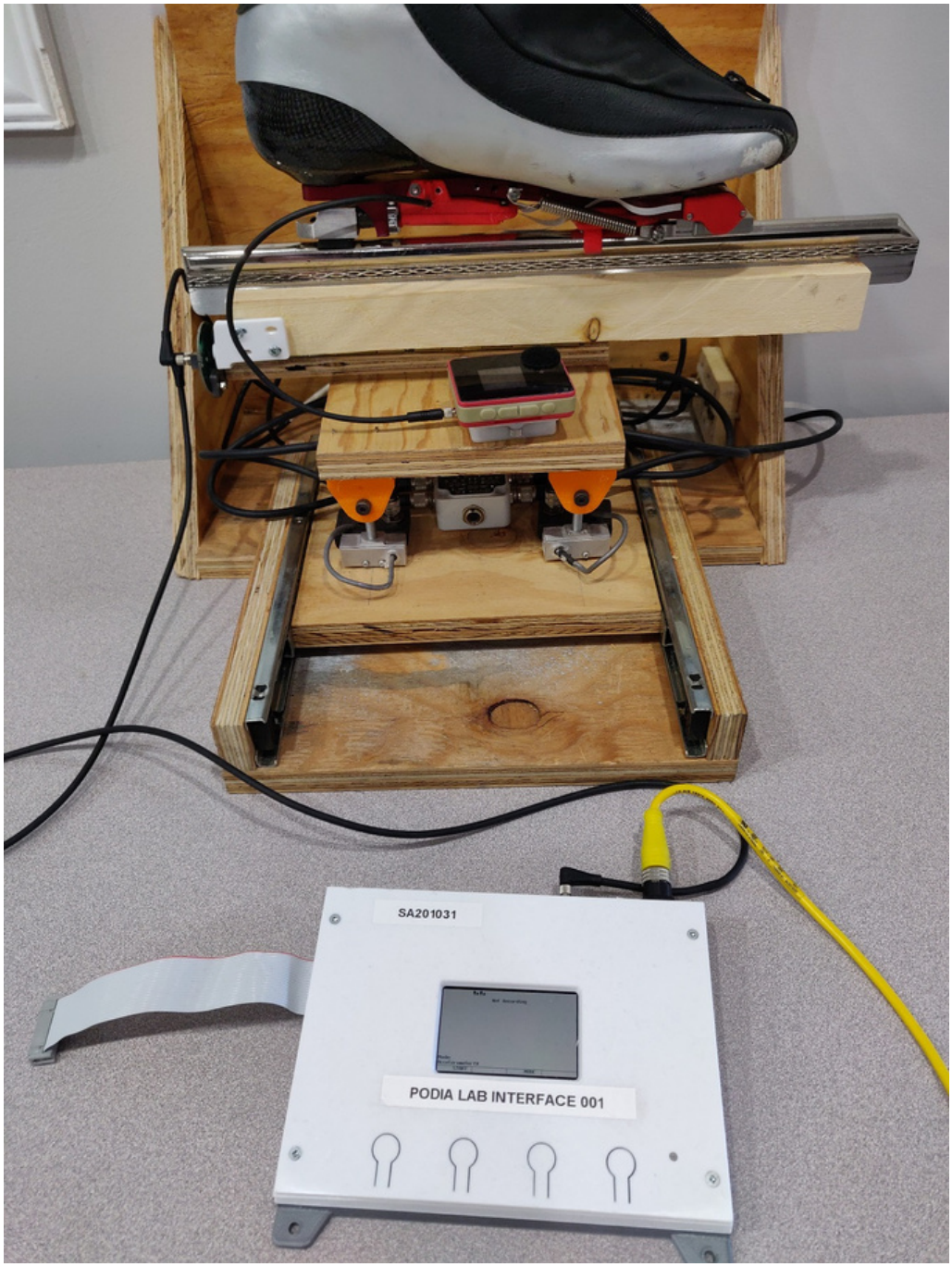
Build

Machining was done by Rainhouse Manufacturing in Victoria BC, and the rest of the build was completed in-house by Motus. Finding a local manufacturer that was willing to take on such detailed components in titanium was challenging, but Rainhouse was up to the challenge! Eight strain Gauges had to be applied to each transducer, soldered by hand, and epoxied in place. This required the design of custom assembly jigs and a custom heat curing process to ensure quality and consistency. The configuration of these strain gauges allow us to measure bending force in x and y directions, as well as the rotational torsion applied to the skate.



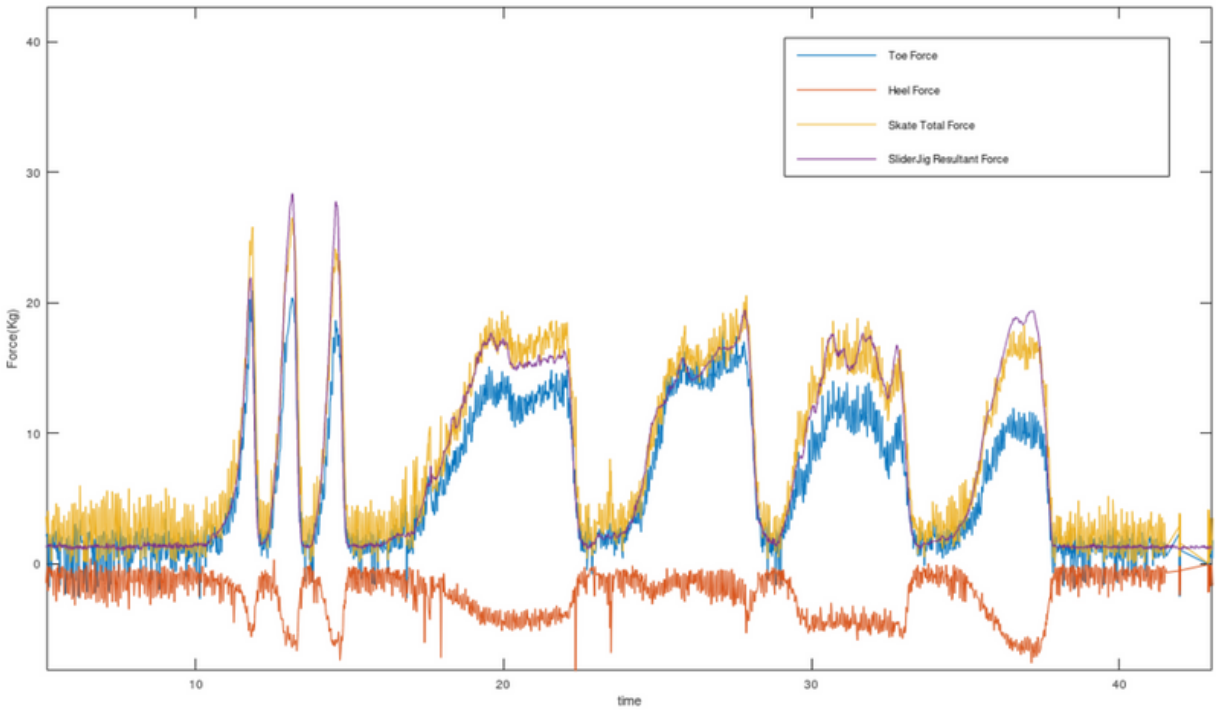
In-Lab Verification

We designed and built custom load cell measurement jigs that would allow us to measure and compare horizontal and vertical forces that the skate was reporting. If the skate recorded the same value that the jig was measuring, we would know everything was working as expected.



motus DESIGN GROUP

Slider-jig testing session



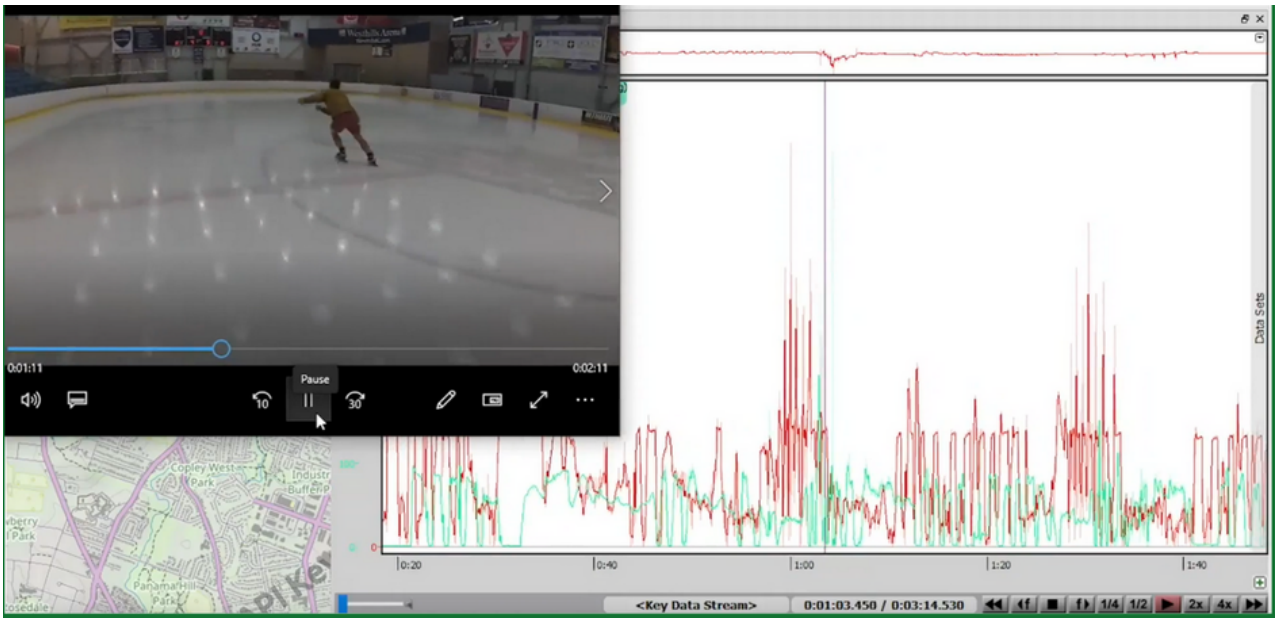
Force: Slider Jig Measured (purple) matching Skate Reported (yellow)

On-Ice Validation

After confirming the skate force response in the lab, the final step was to validate the design in the field. We brought in our friend and former professional short track speed skater, Isaac Leblanc, to perform on-ice testing with the skates. Testing was carried out in multiple sessions, with the latter being delayed due to the Covid-19 pandemic in spring of 2020.

Testing fell into two categories. The first involved maximum effort intervals to stress test components and see how the skates felt under full load. The second aimed to replicate more typical long track paced efforts around the rink, with the focus being to check time synchronization, accuracy, and data collection.

On-site review of test data



Motus Review session of on-ice skate testing

Delivery

Skates were delivered March 2020

The first pair of instrumented clap skates were delivered to the Canadian Sport Institute. Motus continues to support the team in Calgary with mechanical assembly and data analysis.

At the 2022 Winter Olympic Games in Beijing, Team Canada won 5 medals in speed skating - tied for the second most. Speed Skating Canada continues to offer one of the strongest programs in the sport, exemplified by their world-class performances and technological achievements.

2023 Updates

New blade base & more skates!

In 2023, Speed Skating Canada approached us with a new request. Evo, the provider of the base blades for the skates, was going out of business. Speed Skating Canada needed the skates to be redesigned to a blade made by Viking that would be around for many years to come.

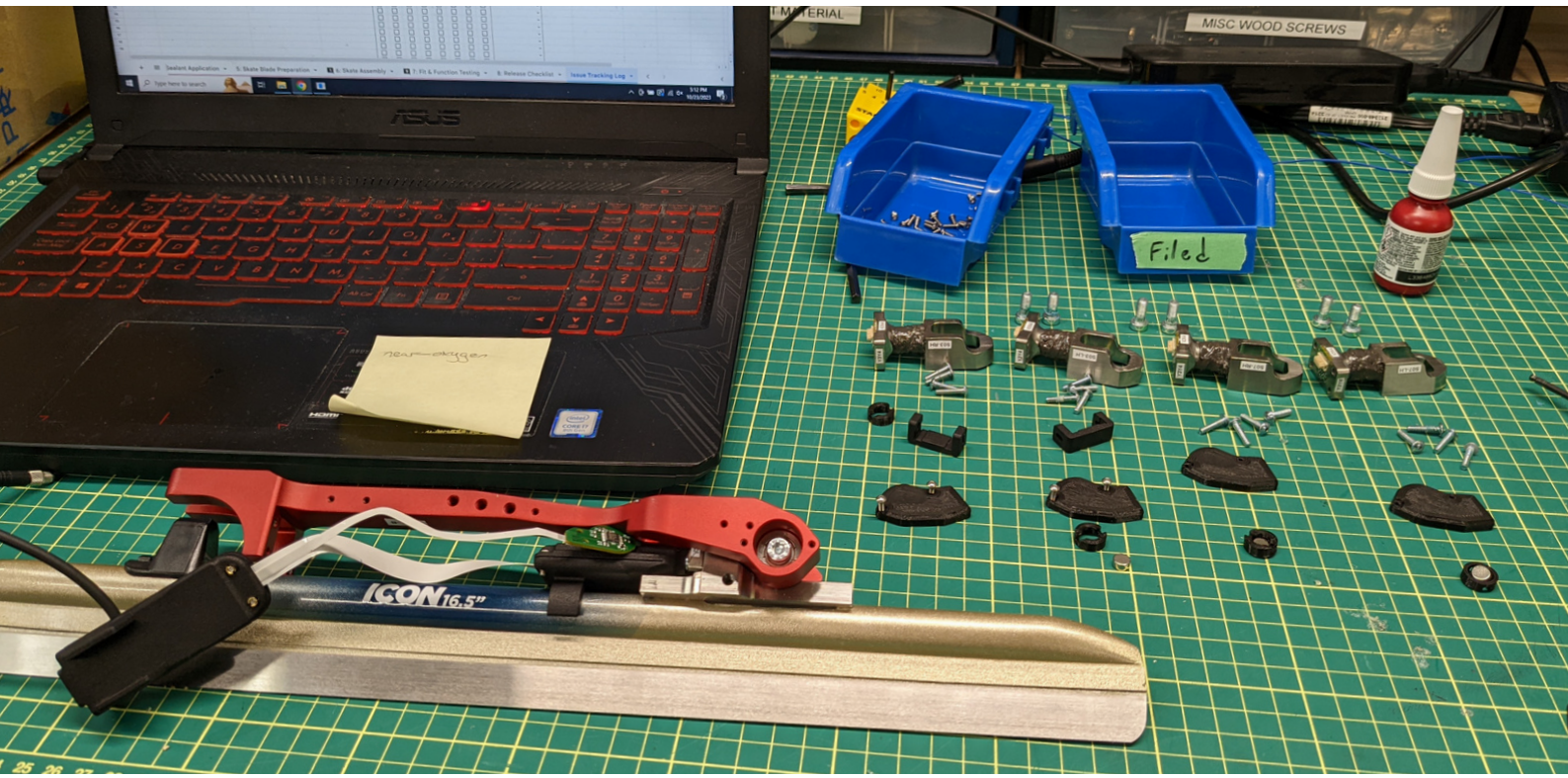
After discussing the goals of the instrumented skate program, we determined these modifications were a good opportunity to manufacture four skates of varying sizes. This would allow Olympic athletes of any boot size the opportunity to test on the skates, as well as enabling a full team pursuit squad of 4 athletes to be instrumented in a single test - this would allow the team to explore the effects of drafting.

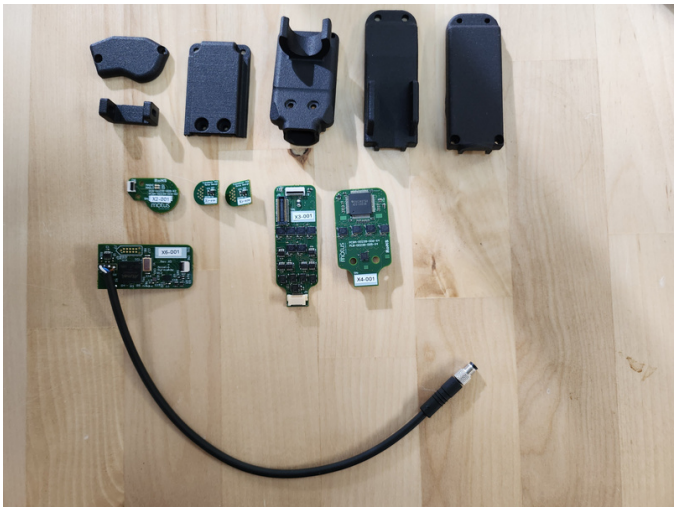
motus DESIGN GROUP

Fabrication

Fabrication and testing of the units was done in assembly line fashion to complete the skates as time efficiently as possible. The process included:

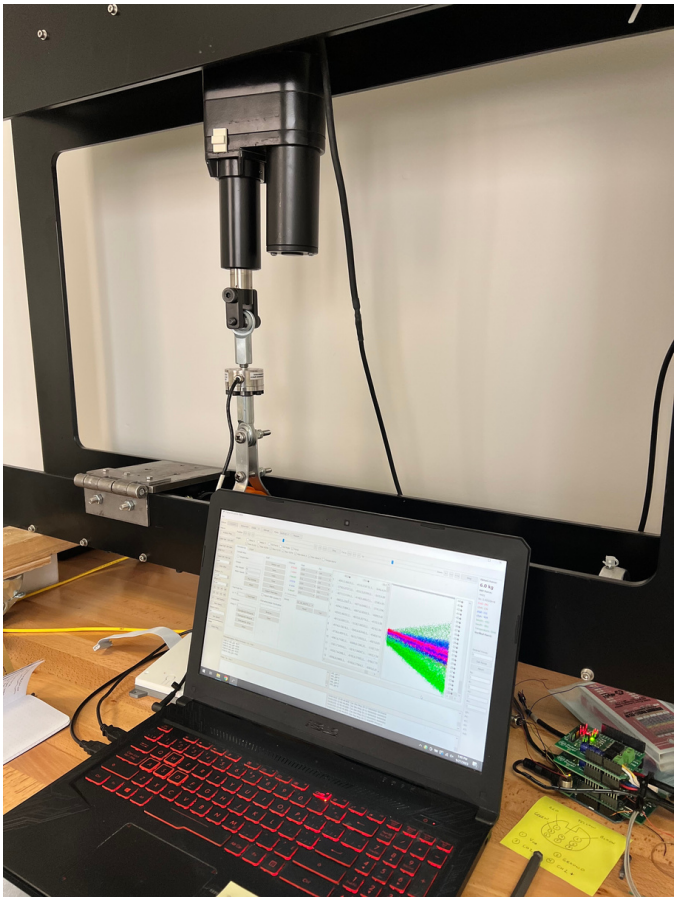
1. Quality inspection of all parts received
2. Transducer strain gauge application
    a. Surface preparation
    b. Strain gauge glueing
    c. Heat curing
    d. Soldering of connections
3. Characterization
4. Apply protective coating to strain gauge
5. Build and test complete assembly
6. Perform on-ice testing



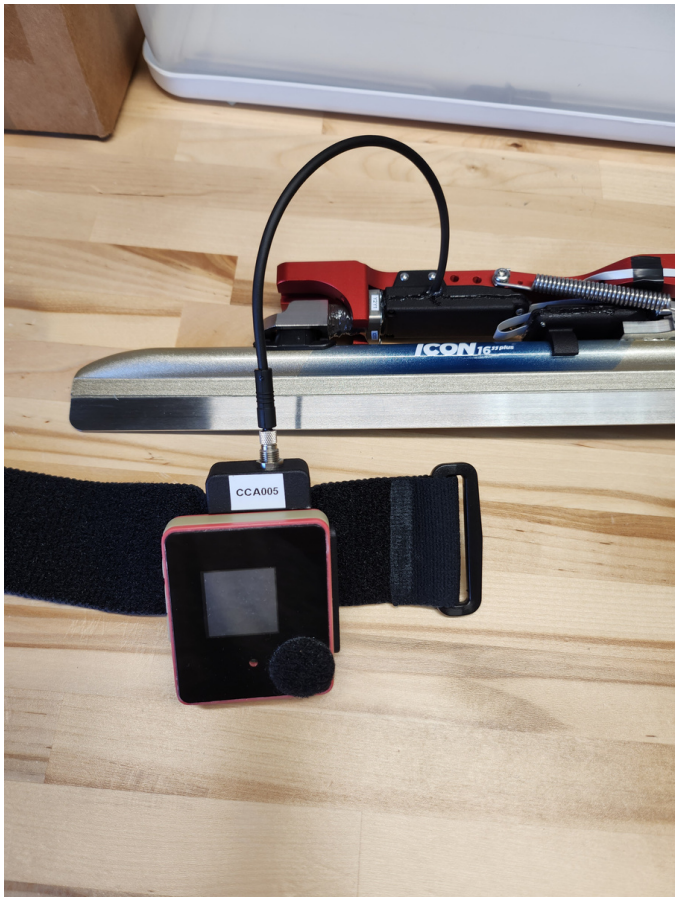


Inspection & testing of PCBs

Strain gauge application



Transducer characterization



Complete assembly

motus DESIGN GROUP

Testing

With the help of Isaac Leblanc, we were able to test all four new skate mechanical assemblies, on ice, in a single test session. Testing followed the same protocol as the original skate projects. Each skate was put through a “max force” scenario, typically a maximum effort acceleration. Skates were also given longer tests to ensure good time synchronization, recording stability, and connectivity.

Isaac Leblanc preparing for on-ice testing

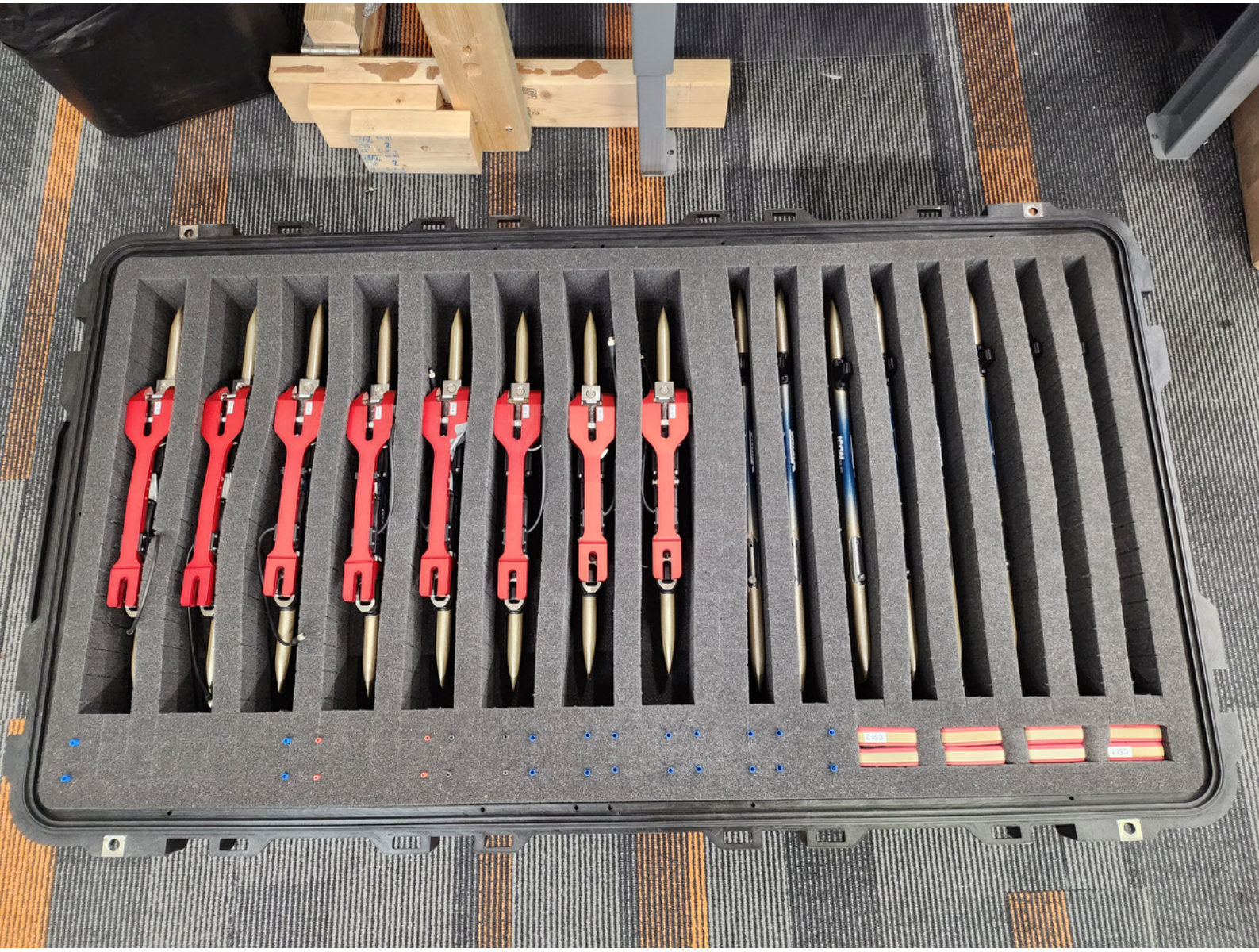

VIKING


ESQUIMALT

Delivery

Skates were delivered October 2023

The updated skates were delivered just four months after the project kicked off! All four units were fully functional and rigorously tested.



motus DESIGN GROUP

The Team

We at Motus appreciate the opportunity to explore innovative solutions in this sports performance study.

Thank you.

Cheyenne Heenan | Geoff Shera | Jeff Doyle | Matthew Fournier | Derrick Ushko
(not shown) Josh Erickson, Simon Pearson, Andrew Gillan, Alex Kolodinsky

motus DESIGN GROUP

motus
DESIGN GROUP