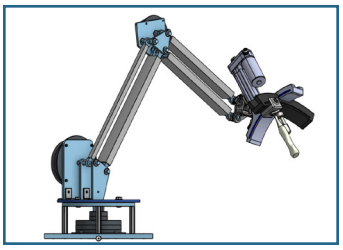
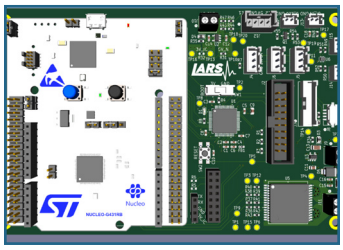
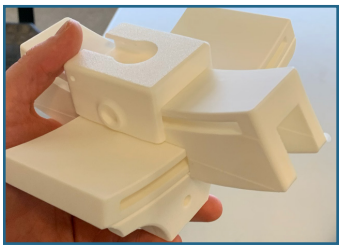
FORCE MEASUREMENT SOLUTIONS

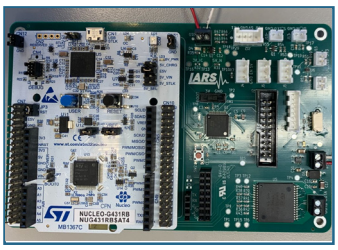
CASE STUDY

University of Waterloo LARS Project Redefines Sonography Application





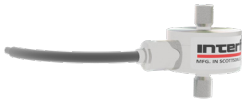




About

Diagnostic medical ultrasound imaging is a hands-on imaging modality that requires sonographers to apply sustained force with an ultrasound probe against a patient while maintaining precise positioning and image quality. Research indicates that this repetitive, physically demanding workflow is associated with nearly 90% of sonographers experiencing work-related pain, with 83% citing force application as a primary contributor.

To address this issue, a capstone engineering team at the University of Waterloo developed LARS (Load Assistance for Reduced-Strain Sonography), a semi-robotic articulated arm designed to assist with applying probe force while allowing the sonographer to remain fully in control. Unlike large, costly robotic systems, LARS integrates directly into existing clinical workflows and provides support without disrupting how sonographers perform scans.



WMC Sealed Stainless Steel Miniature Load Cell

DMA2 DIN Rail Mount Signal Conditioner

Challenge

Sonographers must consistently apply and maintain precise force during imaging, often for extended periods, leading to high rates of physical strain and injury from repetitive motion and sustained pressure. The engineering team's challenge was to design a system that accurately measures and responds to applied force in real time while providing assistive support without removing user control. The system also needed to integrate seamlessly into existing clinical workflows without adding complexity or causing disruption. Achieving both responsive and stable force control while providing a natural user experience was critical.

Solutions

To enable precise and responsive force assistance, the LARS system incorporates two Interface devices. The first is the WMC-110 Sealed Stainless Steel Miniature Load Cell, and the second is the DMA2 DIN Rail Mount Signal Conditioner. The miniature load cell is integrated directly above the ultrasound probe mounting mechanism, enabling real-time measurement of the force applied to the patient.

This force data is continuously processed by a closed-loop control system comprising an outer admittance loop and an inner PID position loop.

The outer loop serves as the force-sensing layer, where an admittance controller processes the error between the sonographer's target force setpoint and the actual force measured by the load cell. This force error is then fed into the inner PID controller, which compares it with real-time feedback from the linear actuator. The PID controller calculates the positional error and adjusts the actuator accordingly. Interface's load cell output is sent to the DMA2 signal conditioner, which converts it into a usable 0–3.3V signal for MCU interfacing.

Results

Interface's WMC load cell enabled LARS to accurately measure applied force and provide a reliable signal for the force control loop. The system achieved a fast response, with a 0.12-second rise time and no overshoot, enabling smooth, stable force application during scanning.

This performance allowed LARS to effectively maintain the desired force set by the sonographer while adapting to movement and patient factors such as breathing or coughing. These results demonstrate that accurate force sensing is critical for enabling effective, safe, and user-friendly assistive technology in medical robotics.

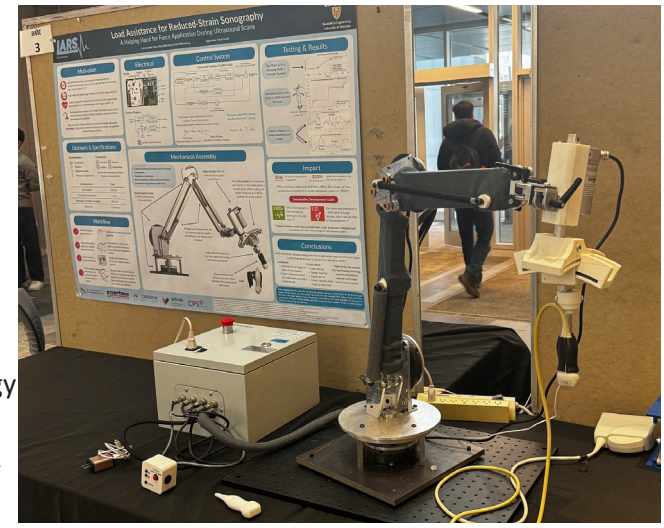


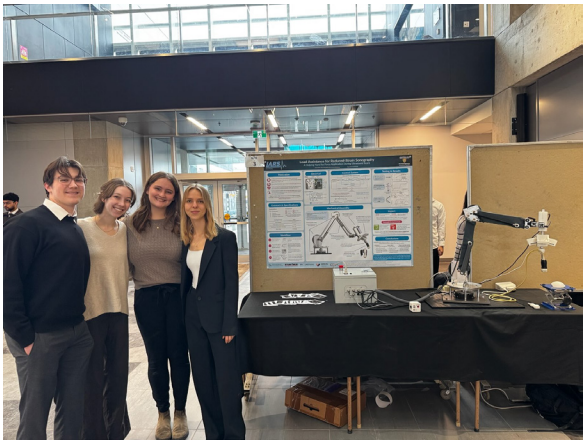
Figure 1. Symposium Setup

The Waterloo University engineering team's capstone project of the LARS system has also been recognized for its innovation and clinical potential:

- **Norman Esch Entrepreneurship Award (2026)** for demonstrating a clear market need and viable commercial path
- **Biomedical Engineering Capstone Best Prototype Winner (2026)**, recognized as the highest fidelity prototype within the departments
- **Baylis Medical Capstone Design Award (2025)** for demonstrating an innovative and technically complex biomedical engineering design

Interface and Education

Interface is honored to provide critical force measurement solutions that support the innovation and advancement of educational projects such as the LARS development. In our commitment to higher education programs and university testing labs, Interface offers a discount for students and faculty. We also carry on our investment legacy in the science of measurement and education through our ForceEDU program, a focused resource hub of materials and references that support learning about metrology, force measurement, and testing.



Contributors: Symposium Team, University of Waterloo
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