CEAL

CHALLENGING ENVIRONMENT ASSESSMENT LABORATORY

"The test of all knowledge is experiment" - Richard Feynmann

This brochure is an introduction to the Toronto Rehabilitation Institute's Challenging Environment Assessment Laboratory, as well as three other unique lab facilities. All of these facilities are open for business to help you test products, develop techniques, and to base these results on real experiments. With real human-in-the-loop evaluation, the development cycle can be closed so that solutions can be evaluated as they will be employed. After several years in the making, these facilities are now ready for the research and development that keeps the healthcare industry on the cutting edge.

We welcome the opportunity to experiment and to test knowledge.

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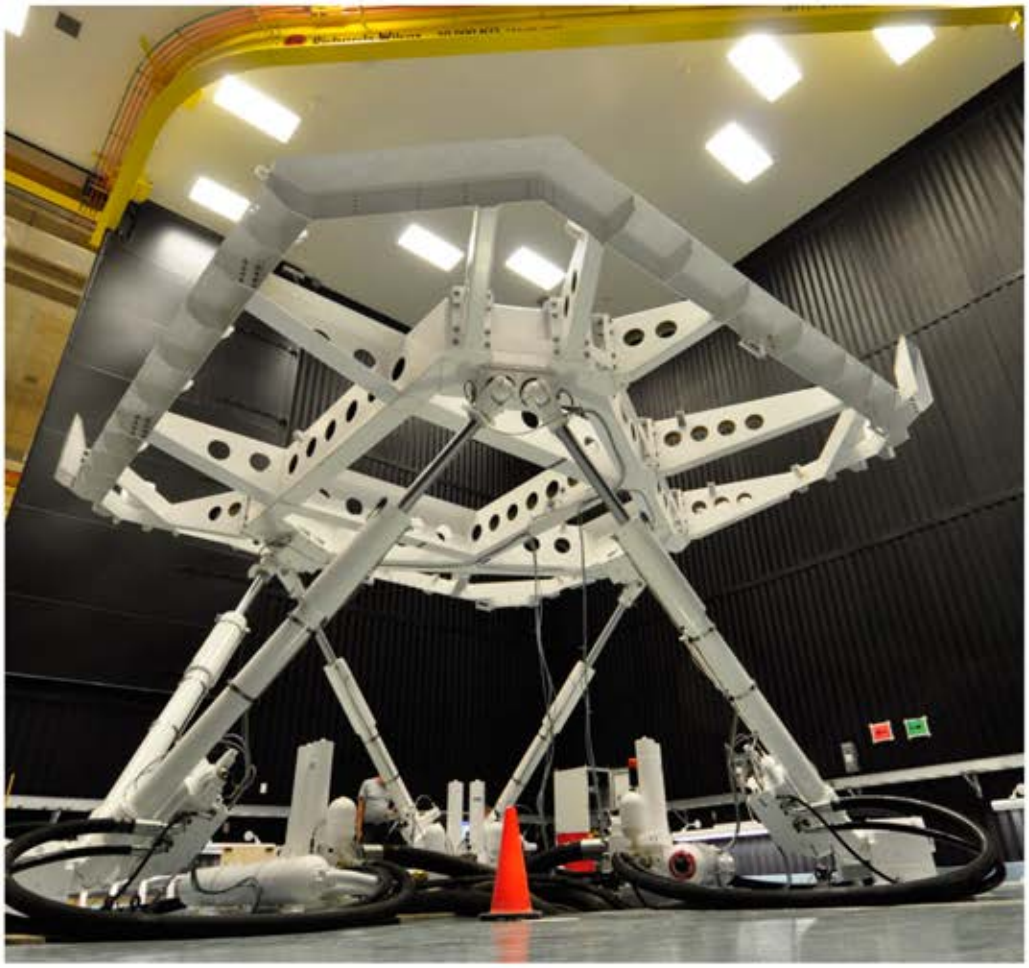
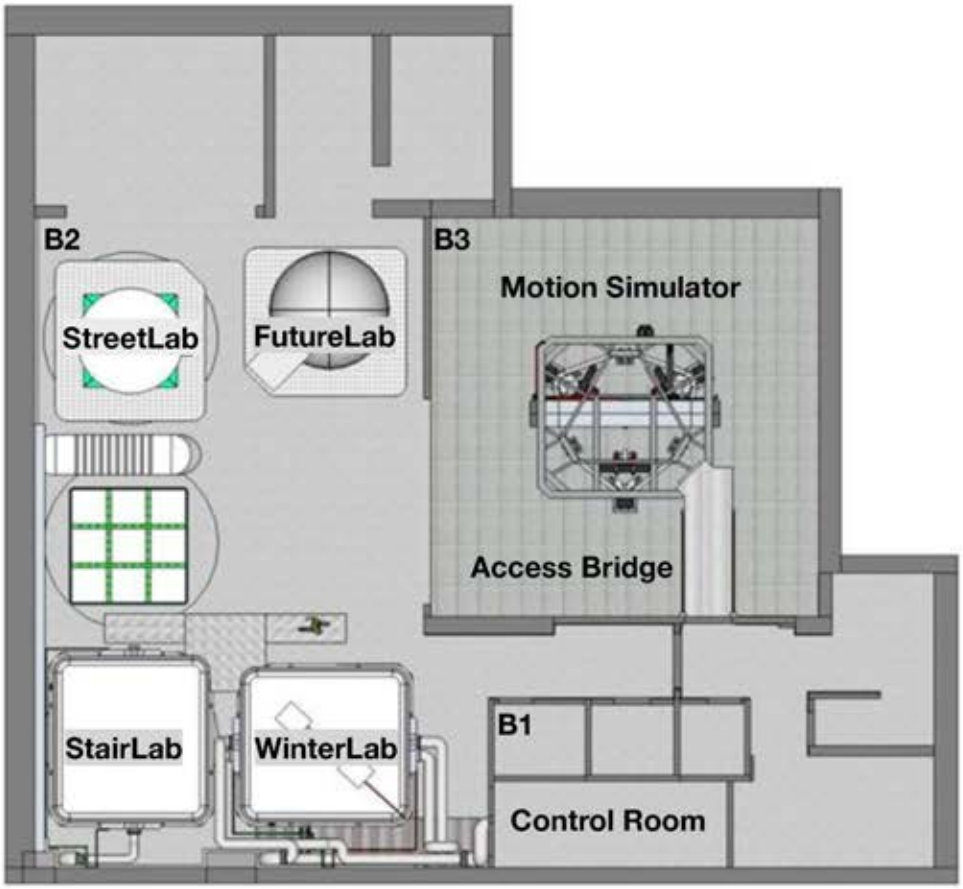


MOTION SIMULATOR

One of the central features of CEAL is a large, 6-degree-of-freedom simulator motion base with a 6m x 6m mounting floor. This mounting floor can host several interchangeable lab spaces that are physically lifted on to the motion base using a large crane. The motion capability enables the simulation of realistic and challenging conditions. In this way, ground surface inclination can be changed, vehicle motion parameters simulated, and balance can be disturbed. The performance of the CEAL motion system exceeds that of most airline training simulators. The higher velocity of this simulator (1.5 m/s as opposed to 0.6 m/s) enables a wider range of challenging motion environments, thus allowing for broader future research opportunities.

Photos Courtesy of Sunjoo Advani, IDT

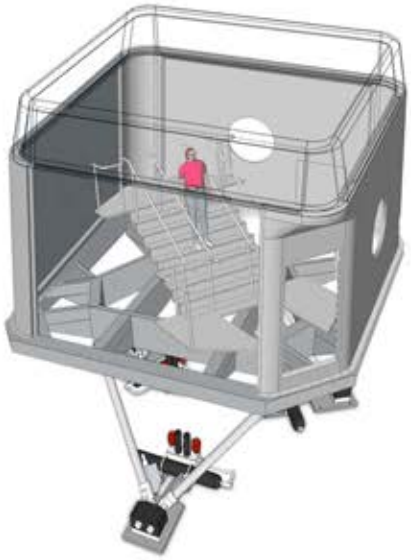


TOP DOWN VIEW

Currently there are three interchangeable lab spaces: StairLab, StreetLab and WinterLab. Each of these labs is portable and can be used on the motion system if research dictates (B3), or when parked in the preparation hall (B2). All labs can be used simultaneously, as they each have a dedicated computing and measurement system.

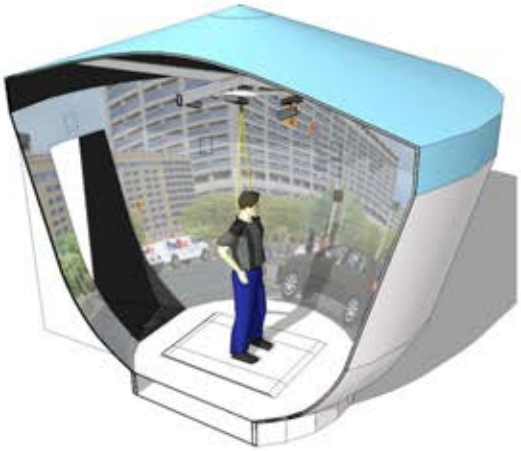
Measurement tools include:

- High-precision motion tracking systems with real-time recalibration
- Large, water-resistant, six-degrees-of-freedom force plates
- Eye tracking
- EEG and EMG



STAIRLAB

StairLab can be outfitted with several different environmental features; most notably, a fully instrumented staircase. This staircase consists of 8 steps with 7" risers and 11" runs. The stair treads are interchangeable to test different surfaces (e.g. materials, markings, colour, etc.), and nosing designs. Force plates are embedded into the steps and load cells are built into the handrails, thus allowing for the measurement of ground forces and hand forces respectively. The stairs can also be removed, revealing a floor with a grid pattern of attachment points; thereby allowing any environment to be built inside this space



STREETLAB

StreetLab contains a high resolution, 240° horizontal, by +15° to -90° vertical field-of-view projection system. Images are continuous and seamlessly blended to create true immersion. This visual system and a high-quality surround sound system can be coupled with various movement interfaces including a linear treadmill and manual and powered wheelchairs. An extremely high resolution, virtual rendering of downtown Toronto has been developed (see image on Page 5). This simulation includes intelligent vehicles and pedestrians and a realistic 3D soundscape.

WINTERLAB

WinterLab can be used to create different atmospheric conditions including subzero temperatures. This lab contains a real, refrigerated ice floor made from lake water. Two industrial fans can produce winds up to 30 km/h at -10°C. There is also the option of introducing snow drifts and blowing snow. Icy curbs and steps can be incorporated into this space as a way of simulating real world winter mobility challenges.

SAFETY FIRST

Safety of operations is our top concern, and has dominated the design, testing and set-up of CEAL. A thorough pre-testing protocol allows experiments to first be evaluated off-line, on-line and without subjects. Human participants are supported by a trained observer on-board the motion environment and both are protected by a sophisticated robotic safety harness system that follows their movements throughout the space. The participant is suspended by a CSA-certified descent controller device, that engages during any descent exceeding its low threshold values.

REAL TIME ENVIRONMENT

The heart of the CEAL simulation capability is the use of dedicated computers in each of the labs. When they are placed in the preparation area, a local station monitors and records the data. When on the motion platform, command and control is switched over to a secure Control Room above the motion platform. This is to ensure safety of operations. In all cases, researchers can configure and modify the measurement systems, feedback loops, and reaction models through an object-oriented environment. Toronto Rehab can provide this capability, however most researchers are able to choose their configurations. The QuaRC™ -based computing system converts this to real-time codes and provides the user-specified feedback and recordings. This allows users to concentrate on efficiently conducting research, instead of learning how to program it.

RESEARCH TOPICS

StairLab

Injuries on stairs are increasing at a rate of 6% every year. Consequently, stairs are one of the biggest concerns for older people living at home and are often what forces them to move. Yet very little is currently known about optimal staircase design from the perspective of safety. Therefore, research in StairLab will be used to evaluate staircase and handrail design to inform standards and increase safety, thus allowing people to stay in their homes for longer.

StreetLab

Multitasking often becomes more difficult after a brain injury. Further, integrating sensory signals from vision, hearing, and balance systems becomes more difficult with age. Therefore, StreetLab provides a realistic, complex environment that can be used to develop multisensory training and diagnostic tools to: optimize gait and balance, improve communication deficits, diagnose mild brain injuries, and assess the use of mobility aids (e.g. wheelchairs).

WinterLab

Strokes and heart attacks increase by up to 60% in colder months. Further, over 21,000 Ontarians visit the ER due to slips and falls on ice and snow each winter. Therefore, WinterLab will be used to study the impact of protective winter clothing on health and mobility, develop and evaluate safer winter footwear, and improve mobility aids for use on icy, snowy and sloped surfaces.

TECHNICAL SPECIFICATIONS

WinterLab	
Dimensions and Mass	Inside 5483 x 5083 mm; Outside 6000 x 5600 mm; Ice Floor Surface, 4539 x 4939 mm; Mass = 6252 kg
Room Temperature	-10 to +35 deg Celsius
Room Humidity	Up to 50% RH at +35 deg Celsius
Wind Speeds	Wind fans inside WinterLab can generate wind speeds up to 50 km/h
Occupants payload (motion)	450 kg (e.g. two persons and one wheelchair)
Safety	Robotic Safety Harness System for active tracking and fall arrest protection of up to 2 occupants; Voluntary stop buttons; Real-time video surveillance; CO2, CO and O2 monitoring; Safety interlock system integrated with motion system and building facilities
Install/remove from platform	Approximately 24 hrs, dependent on ice melting
StairLab	
Dimensions and Mass	Inside 5483 x 5083 mm; Outside 6000 x 5600 mm; Mass = 6192 kg
Generic Attachment Grid	Floor grid with threaded holes providing up to 615 points for attachment of equipment or obstacles
Staircase Configuration	A staircase with 8-steps 7-inch risers/11-inch runs, embedded force plates and load cell equipped handrails
Force Plate Configuration	Up to 9 force plates, each 1200x1200 mm, can be installed
Room Temperature	+13 to +35 deg Celsius
Room Humidity	Up to 50% RH at +35 deg Celsius
Occupants payload (motion)	450 kg (e.g. two persons and one wheelchair)
Safety	Robotic Safety Harness System for active tracking and fall arrest protection of occupants; Voluntary stop buttons; Real-time video surveillance; CO2, CO and O2 monitoring; Safety interlock System integrated with Motion System and building facilities
Install/remove from platform	Approximately 2 to 3 hours
StreetLab	
Room Temperature	+13 to +20 deg Celsius
Safety	Robotic Safety Harness System for active tracking and fall arrest protection of occupants; Voluntary stop buttons; Real-time video surveillance; CO2, CO and O2 monitoring; Safety interlock System integrated with Motion System and building facilities
Projection Field of View	From user viewpoint: -120 to +120 deg horizontal; -90 deg to +20 deg vertical
Screen resolution	Up to 6.5 arcmin/OLP
Projector Type	1920 x 1200 native resolution
Number of Projectors	6 projectors
Calibration System	Automatic
Sound system	Seven individually-addressable spatial speakers plus sub-woofer, to create complete immersion.
Acoustic Lining	Anechoic
Treadmill	Walking surface 1495x711 mm, removable handrails, treadmill running direction and speed are actively controlled
Install/remove from platform	Approximately 2 to 3 hours

Motion System	
Type	Bosch Rexroth HyMotion 11000 Hydraulic 6 Degree-of-Freedom Hexapod Motion System
Maximum Payload	11904 kg
Actuator Stroke	1524 mm (60-inch)
Mounting Platform	6000 x 5600 x 2540 mm
Control Interface	PC Based Host Computer with Quanser QuaRC real-time control software and MATLAB Simulink
Safety	Integrated with E-stop circuit and building Safety interlocks. Watchdog software and communication fault protection
Smoothness	Less than 0.04 g amplitude during turn-around
Linear Translations	From end to end: Surge 2.447 m, Sway 2.210 m, Heave 1.995 m
Rotations	From neutral position: Pitch and Roll 28 deg, Yaw 32 deg
Velocity	Surge and Sway 1.5 m/s, Heave 1.1 m/s, Pitch 35 deg/s, Rol 30 deg/s, Yaw 40 deg/s
Acceleration	Surge, Sway and Heave 8 m/s^2, Pitch, Roll and Yaw 100 deg/s^2
Acceleration onset	Surge and Sway 90 m/s^2/s, Heave 120 m/s^2/s, Pitch, Roll and Yaw 900 deg/s^2/s
On-Board Measurement and Instrumentation	
Motion Capture	Phoenix Technology Inc. VZ4000. Up to 4 tracker bars installed per payload
Force Plates	AMTI BP1200 and BP250500
Load Sensors	ATI Net F/T sensor systems
Acceleration Sensors	Dytran 3041A4
Telemetry EMG	Noraxon TeleMyo 900
Portable Micro EEG	Compumedics, E-Series Portable EEG System
Ambulatory cardiovascular	Vivometrics, Lifeshirt System
Ambulatory Gas Analyzer	Cosmed, K4B2 gas analyzer
Ambulatory EEG/EMG	Compumedics, Safiro Ambulatory EEG System
Gait Analysis	CIR Systems, GaitRite gait analysis system
Eye Tracker	Applied Science Laboratories (ASL), ASL501 Eye Tracker System

OTHER iDAPT LABS

HomeLab

With the emphasis of healthcare shifting towards aging-in-place, research is moving away from institutions and into real-life situations. HomeLab consists of a fully furnished, single-story home with a bedroom, living room and fully functioning bathroom and kitchen. An overhead catwalk allows researchers to observe activities being performed within the home, while an adjustable suspended grid allows for the installation of various types of monitoring systems. HomeLab provides an ideal environment to explore ways to ease the burden on caregivers and to increase the safety and independence of older adults.

CareLab

Directly adjacent to HomeLab is CareLab. Similar in concept, this lab consists of a typical hospital patient room with an en-suite bathroom. This will allow for the testing of new technologies in a real hospital setting.

FallsLab

FallsLab houses a high-velocity (2 m.s), linear X-Y motion platform to study human balance and control. This platform is 7m x 3m and is made up of 8 large force plates. This will allow balance disturbances to be applied in a well-controlled and safe manner. For instance, this lab will be used to study compensatory reactions to unexpected horizontal movement perturbations. Motion capture cameras and other measurement devices are also available in this lab.

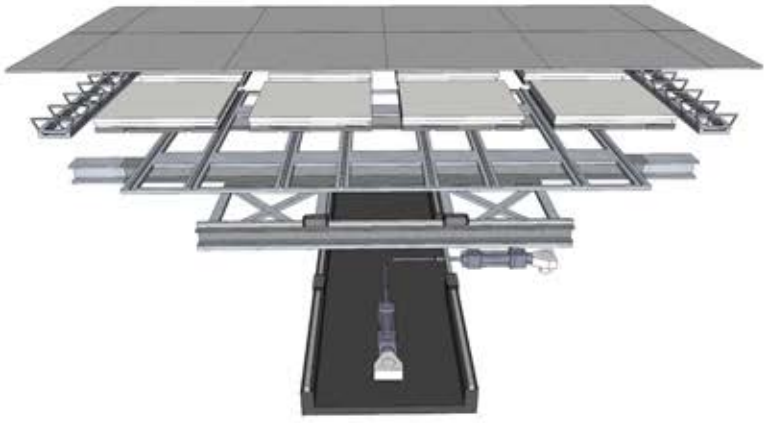


Photo courtesy of Shawn McPherson

We invite you to become a part of this revolutionary research initiative

CONTACT DETAILS

Toronto Rehabilitation Institute
550 University Ave.
Toronto, ON
(416) 597-3422
www.torontorehab.com

DR. GEOFF FERNIE
VP, RESEARCH
fernie.geoff@torontorehab.on.ca

DR. JENNIFER CAMPOS
CHIEF SCIENTIST, CEAL
X 7958
campos.jennifer@torontorehab.on.ca

DAYLE LEVINE
MANAGER, RESEARCH INFRASTRUCTURE AND SPECIAL PROJECTS
X7602
levine.dayle@torontorehab.on.ca

LOIS WARD
MANAGER, RESEARCH SERVICES
X7600
ward.lois@torontorehab.on.ca

DR. SUNJOO ADVANI
PRESIDENT, INTERNATIONAL DEVELOPMENT OF TECHNOLOGY (IDT)
CEAL TECHNOLOGY COORDINATOR
s.advani@idt-engineering.com