National Aeronautics and Space Administration

Exercise Countermeasures Lab (ECL)

Human Research Program – NASA Glenn Research Center

The human research conducted at the Glenn Research Center focuses on exercise, physiology, exploration medical capability, and other related issues.

Capabilities

The eZLS (enhanced Zero-gravity Locomotion Simulator) provides a high-fidelity ground-based simulation of in-flight (0g) and lunar and martian surface simulations and compliant interfaces. It supports development and validation of exploration exercise countermeasure devices, requirements, and exercise prescriptions for exploration missions, as well as kick load assessments, sensorimotor challenges, and lower and upper body kinematics assessments.

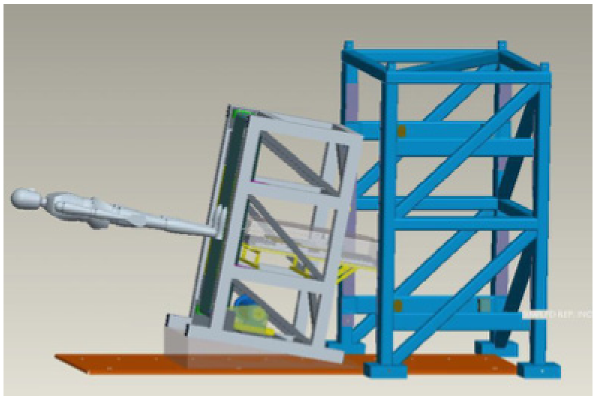
Data options include accelerometry, video, ground reaction forces, in-line subject load device (SLD) forces, displacements, accelerations, motion capture analysis, ground reaction forces, and wireless electromyography data for a full suite of biomechanical analysis and operational volume capability.

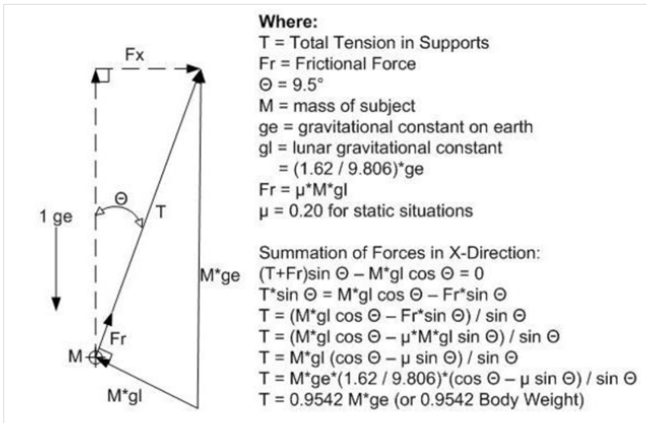
The laboratory uses a Vicon Vero v2.2 motion capture system to analyze human movement, either while in the eZLS or on the ground.

Test protocols are conducted under approval of the NASA JSC institutional review board (IRB), and the principal investigator's host institution IRB.

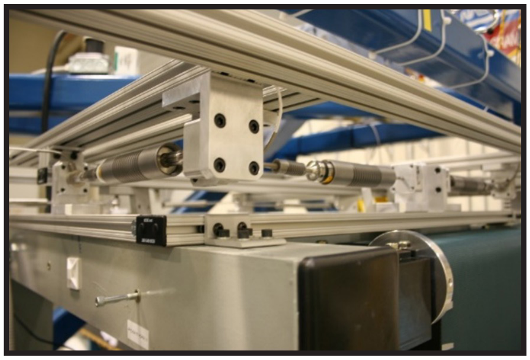
The eZLS simulates lunar (1/6 g), martian (3/8 g), and other reduced gravitational loads via a pneumatic SLD that also provides compliance in the Z-direction.

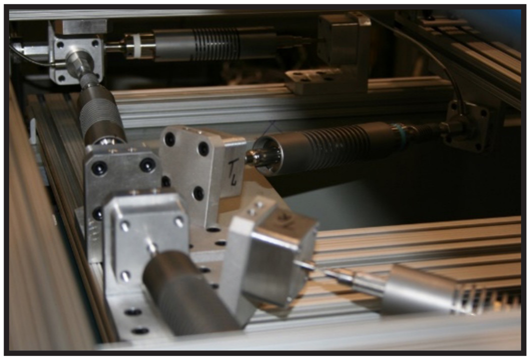
The air bearing table provides 3 degrees of freedom during locomotion, which allows frictionless translation and rotation, including pitch, sway, and yaw.



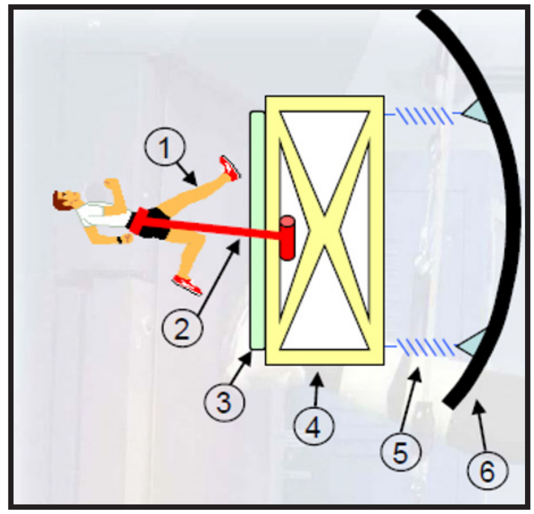


When the surface that holds the treadmill is tilted to a specific angle, it provides an analog of lunar loads without the use of a subject load device.





The VIS system dynamics testing captures some of the interplay between the variables illustrated here, which will directly affect reaction force loads on the human musculoskeletal system:



1. Biomechanics
2. Subject Load Device (SLD)
3. Treadmill Dynamics
4. Rack Dynamics
5. Isolation Elements
6. Vehicle Structural Dynamics

The eZLS provides an analog of the spacecraft vibration isolation system (VIS) that was used by JSC and Boeing to test their T2 treadmill VIS. The VIS has also been used for sensorimotor studies including balance challenges and simulation of activities on the lunar surface including lifting, carrying, locomotion, and falling.

Past human-in-the-loop test protocols included medical station analysis for a habitat design; operational volume analysis of a compact exercise device; development of an ISS T2 Treadmill harness; evaluation of the T2 treadmill vibration isolation system with NASA JSC and Boeing; a kinematic and electromyographic study comparing gait parameters and muscle-activation patterns during treadmill running in the eZLS, 1g upright, and in parabolic flight; lunar-gravity locomotion studies and Daily Load Stimulus characterizations during various lunar tasks; evaluations of compact advanced exercise equipment, SLDs, and sensorimotor balance challenge countermeasures; and development of wireless biometric sensors that were evaluated in parabolic flight.

The ECL boasts a cadre of talented and dedicated engineers and scientists who collaborate to take maximum advantage of their knowledge of spaceflight payloads, flight analog and ground research, and technology development.