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Title:	â€˜Falling Manâ€™ Study
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Intended for:	JOWOG-44, 2012-07-12 (Los Alamos, New Mexico, United States)

‘Falling Man’ Study

Design of Experiments

JOWOG – 44
Methodologies for Nuclear Weapon Safety Assurance
July, 2012

Walter E. Gilmore
LANL/W-10:
Weapon Surety and Military Liaison

Scope of Falling Man Study

- Risk of violent response if the worker falls onto the energetic material.
- Mechanisms not well understood.
- investigate the biomechanical properties.
- provide a rationale for reviewing the conservatisms currently in use.
- Decide if a less conservative model can be empirically substantiated.

Project Team

Los Alamos NATIONAL LABORATORY

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Overview - Experiments

Walking to Item of Interest
Forces and velocity profiles of worker approaching a work stand.

Tether Release
Posture (lean forward angle) and mechanisms for balance recovery.

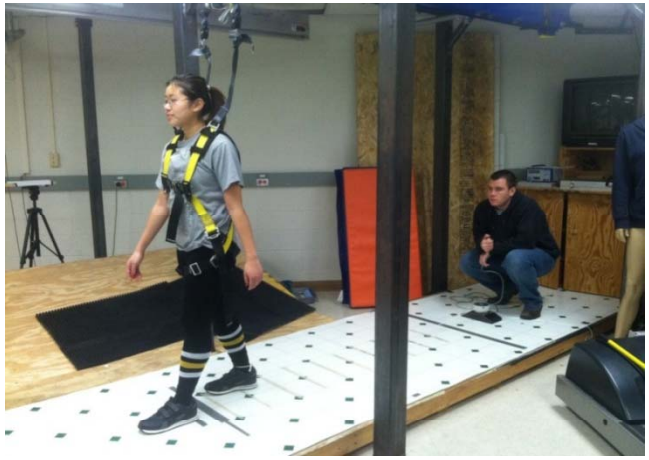
Strip Strength
dynamic "strip force“ to jerk a screwdriver out of a worker’s hand

Maximum Striking Force
Worker striking the surface of a force plate with a screw driver.

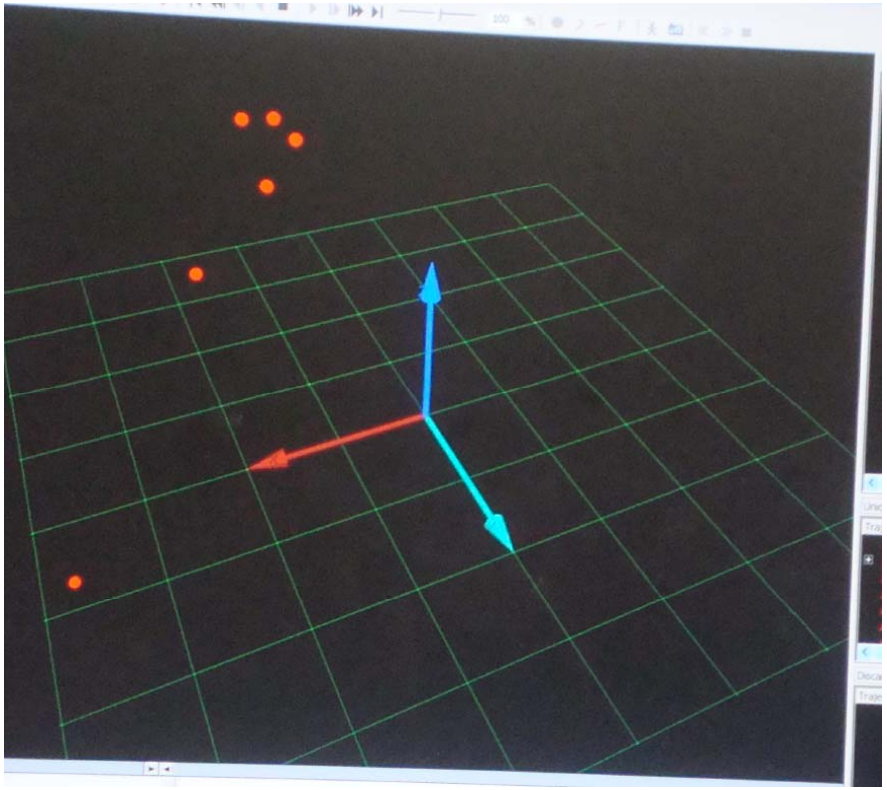
Crash Test Dummy
Acceleration and reaction forces falling onto a load cell/impact plate.

Walking to Item of Interest

- human subjects traverse a test track that's designed to simulate a fall event.
- Walk along the 25x4 foot walkway and be tripped directly in front of a simulated workstation.
- Load / No load condition

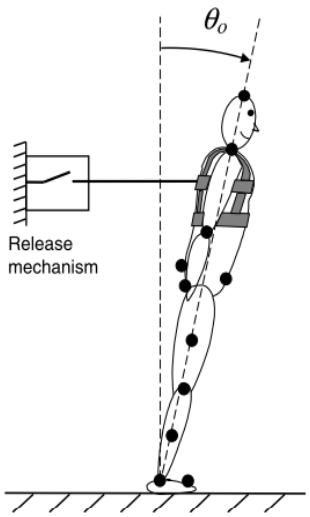


Walking to Item of Interest: Motion Capture (Sensor nodes)



Tether Release

- **An experiment designed to evaluate the posture (lean forward angle) and balance recovery.**

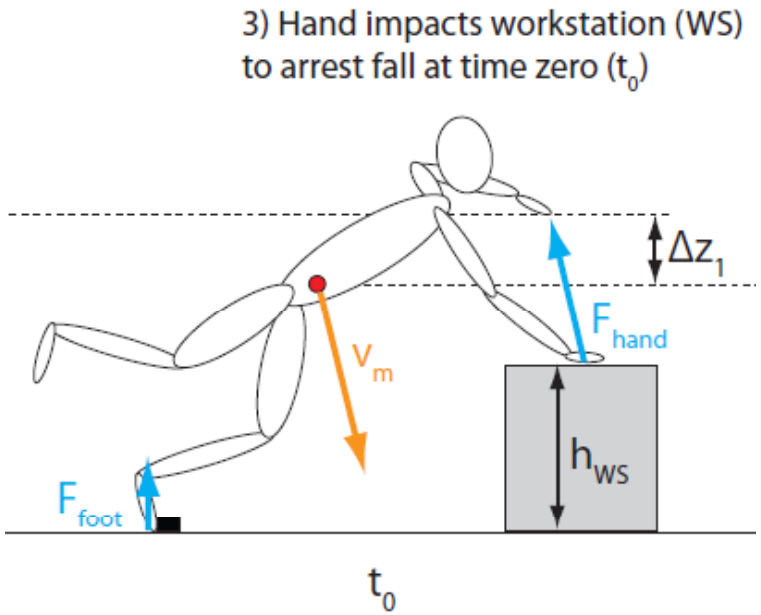


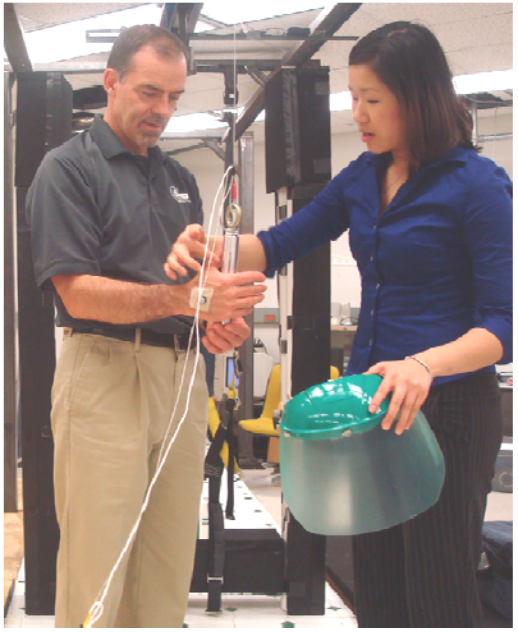
Hsiao-Wecksler, E. T. (2008). Biomechanical and age-related differences in balance recovery using the tether-release method. *Journal of electromyography and kinesiology : official journal of the International Society of Electrophysiological Kinesiology*, *18*(2), 179-87. doi:10.1016/j.jelekin.2007.06.007

Tether Release

Strip Strength

- **Investigate the dynamic "strip force“ required to jerk a screwdriver handle out of a worker’s hand. (Glove and no glove conditions.)**





Source: Gary Parker (2011), Los Alamos National Laboratory.

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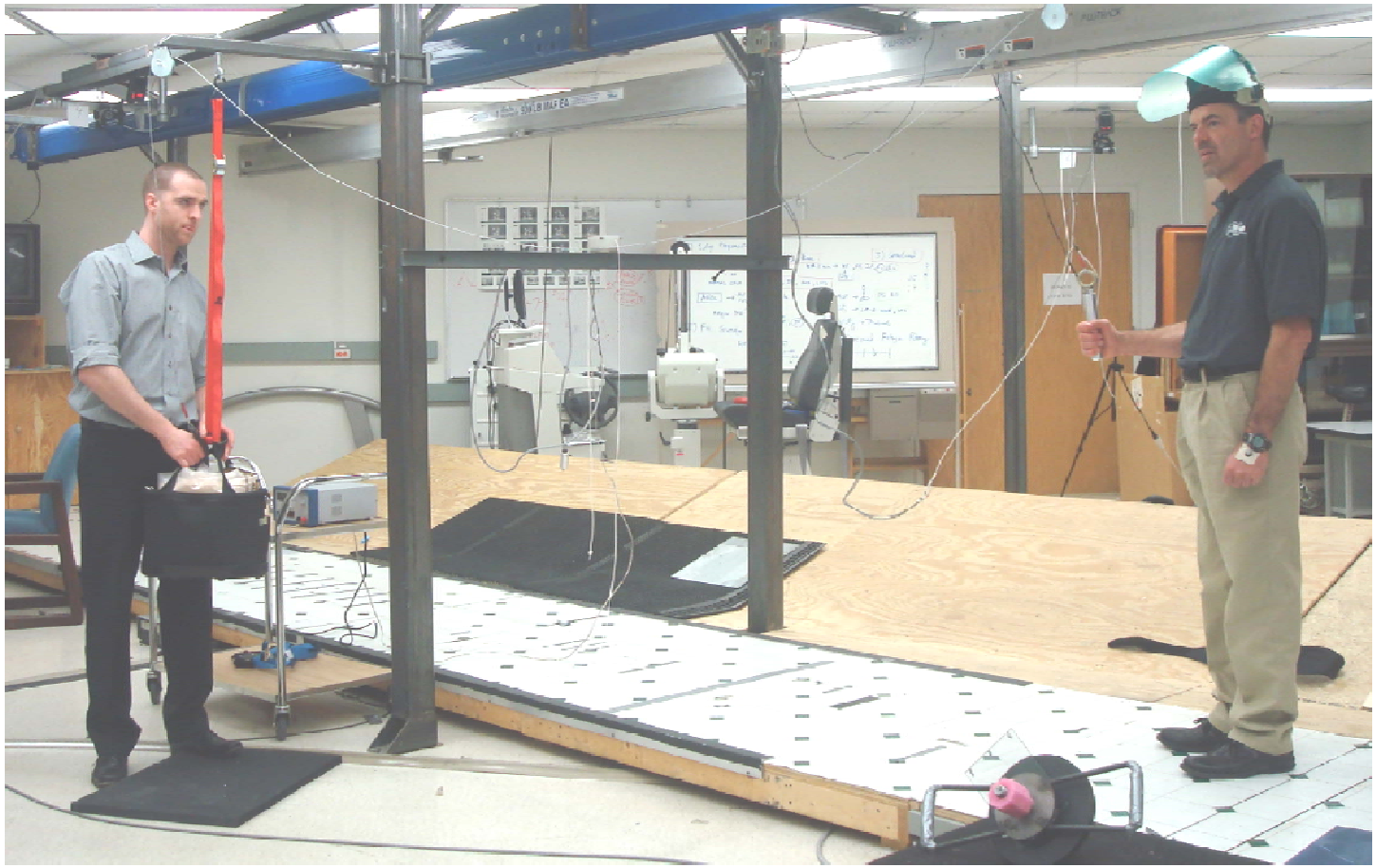
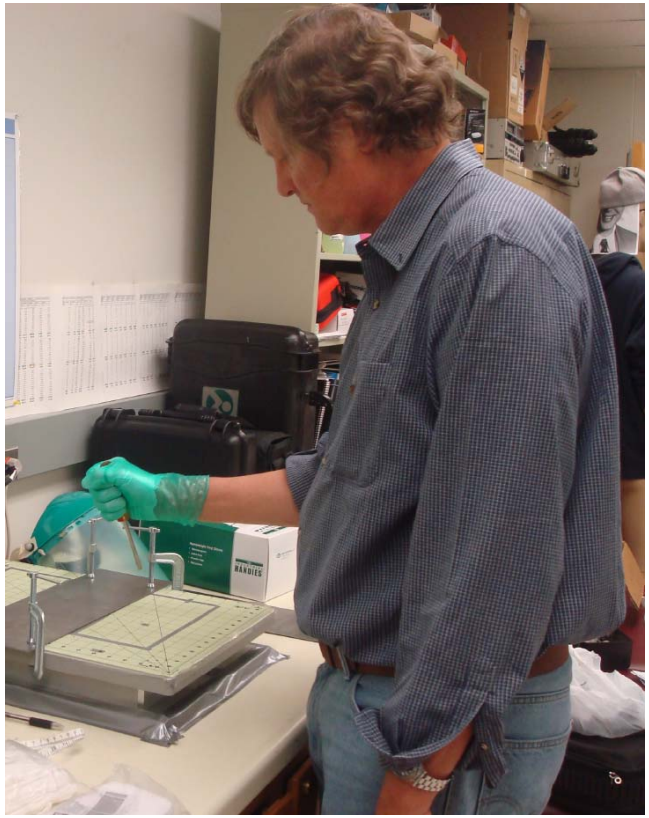
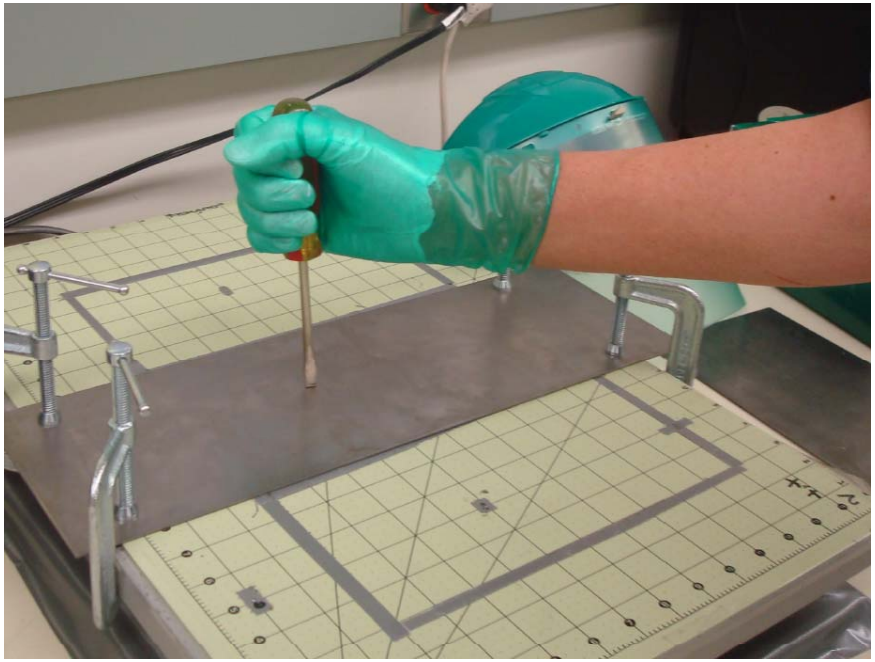
Strip Strength – Experimental Setup



Maximum Striking Force

- **Forces striking the surface of a force plate with a screw driver. (Glove and no glove conditions.)**



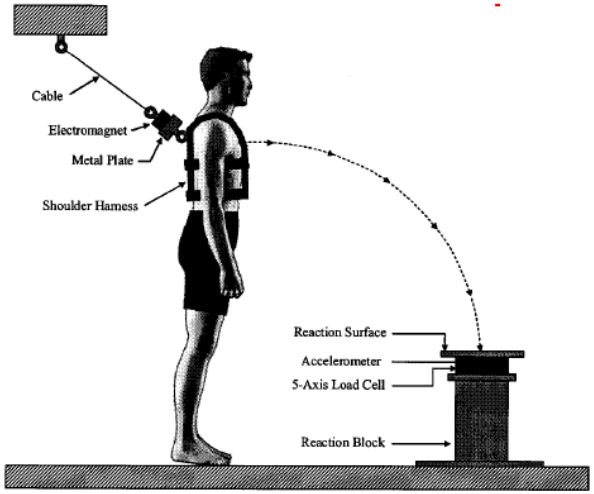


Crash Test Dummy

- High fidelity, 50th percentile male, frontal-impact, crash test dummy.
- Fall forward onto a load cell/impact plate configuration.
- Measure acceleration parameters and reaction force profiles.
- Conditions:

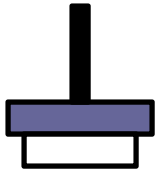
  (1) Mid-sternum - screwdriver handle anchored onto the impact plate.

  (2) Thoracic section onto the flat impact plate (no screwdriver handle).



Source: Andrew Kemper (2011), Center for Injury Biomechanics, Virginia Tech.

Crash Test Dummy – Treatment Conditions

Load Cell	Description
	• Thoracic Impact onto screwdriver handle. • Experimental Treatment
	• Thoracic Impact onto pressure plate (6 in. diameter). • Reference Treatment (Compare results with pendulum impact data, 6 in. diameter impact surface.)
	• Thoracic Impact onto pressure plate (> 6 in. diameter. Plate size should take as much of the chest as possible without affecting supporting strategies.) • Control Treatment (Compare results with screwdriver handle.)

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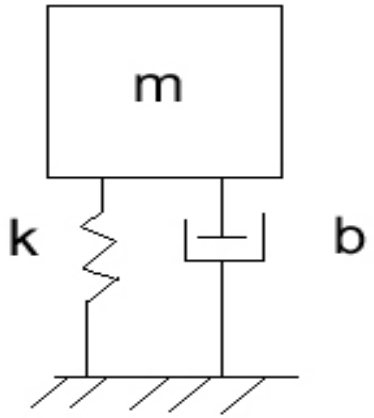
Crash Test Dummy

Future Plans: FY 2012

- Complete and finalize data collection activities
- Technical and Administrative Exchange Visits (Technical Progress Meeting # 1: Los Alamos, NM)
- Technical and Administrative Exchange Visits (Technical Progress Meeting # 2: Amarillo, TX)

Parameterization of the "Falling Man" Scenario

Parameters derived from the Human subjects/cadaver experiments

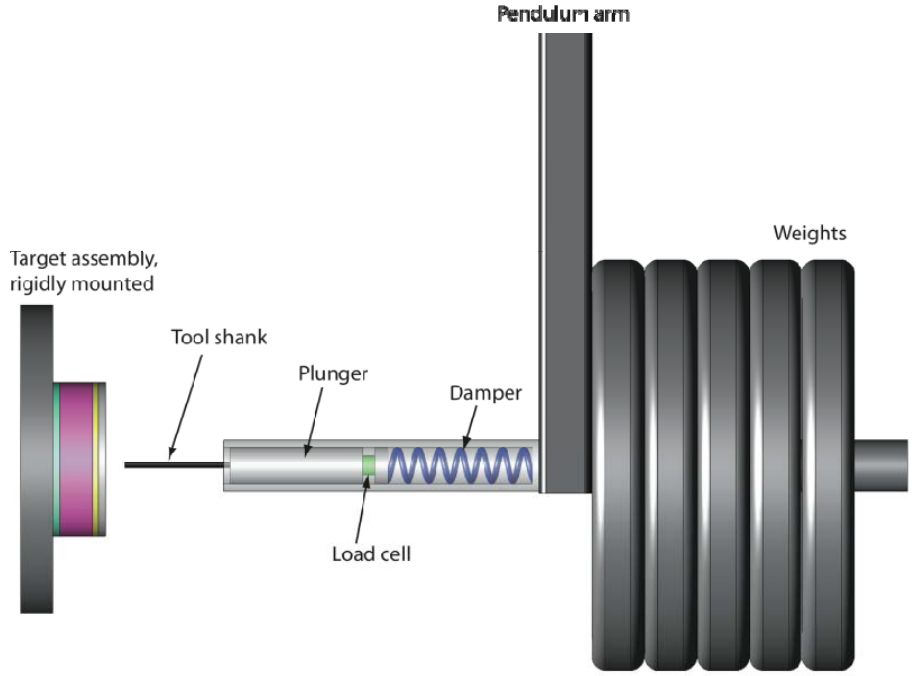


K = stiffness

b = damping coefficient

Lockhart, T. E., Research Design and Methods, *Personal Communication*, May 25, 2011.

LANL Rigid-Arm Pendulum / Impactor test apparatus



Parker, G., Dickson, P., Rae, P. and Novak, A. *Proposal to Study Low-Velocity Impact of U6Nb-Clad HE Mock: Addressing the Worst-Case "Falling Man" Insult Scenario*, LANL/WX-6, High Explosives Physics Team, 2011.

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