Wearable Robotics and Exoskeletons to Improve Worker Safety

Sandia National Laboratories

DOE-EM Technology Development Office
Federal Remediation Technology Roundtable
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DOE-EM Wearable Robotics Program Overview

- Workers at EM sites are well protected from external hazards thorough various controls such as PPE
- Internal injuries due to acute overexertion or chronic overuse remain common, and PPE can increase risks
- The Technology Development office of DOE-EM is exploring whether emerging exoskeleton devices can support workers and reduce the risk of musculoskeletal injury
- Sandia National Laboratories is leading a consortium of other labs and universities who are working with EM sites to address this challenge

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SAVANNAH RIVER NATIONAL LABORATORY
OPERATED BY SAVANNAH RIVER NUCLEAR SOLUTIONS

FIU FLORIDA INTERNATIONAL UNIVERSITY

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Georgia Tech

ihmc
FLORIDA INSTITUTE FOR HUMAN & MACHINE COGNITION

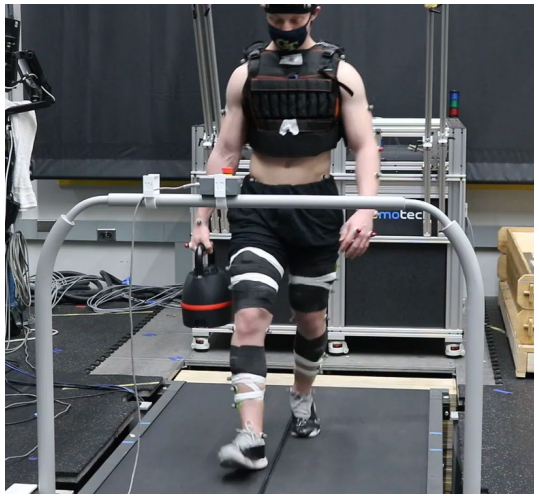
Los Alamos
NATIONAL LABORATORY
EST. 1943

Examples of Challenging EM Tasks

- The team has been working with several sites, including Hanford, Savannah River, and WIPP to understand challenging work that may benefit from wearable technology
  - Tank farm workers carry SCBA tanks while doing maintenance and other work
  - Workers must lift and move 45-90 lb. lead blankets used for equipment shielding
  - Warehouse and other operations require lifting heavy and odd-shaped objects
  - Glove box and hot cell operations can be ergonomically challenging

Device testing capabilities

- Sandia has established a DOE-EM Exoskeleton Testbed
  - EM site tasks can be emulated and participants evaluated with and without devices
  - Metabolic and biomechanical test equipment
- Georgia Tech has extensive human testing capabilities that are being leveraged
- Florida International has mock-ups of Glove Boxes
- PPE compatibility is also being considered



Wearable device examples

- Several devices are currently commercially available and are being considered for various industrial applications
- We have procured many of these for evaluation in EM situations

Bioservo Ironhand

Lockheed Martin ONYX

Noonee Chairless Chair

Herowear APEX

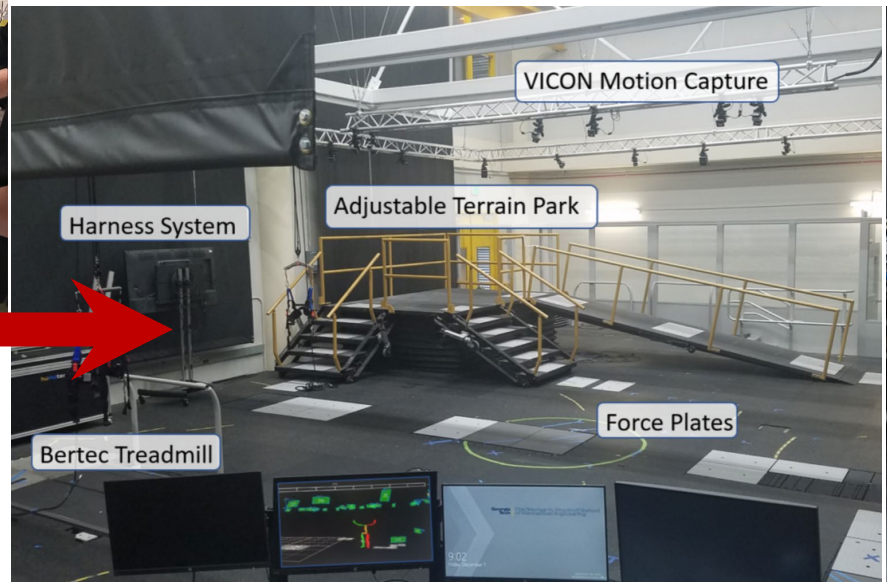
Suit-X MAX

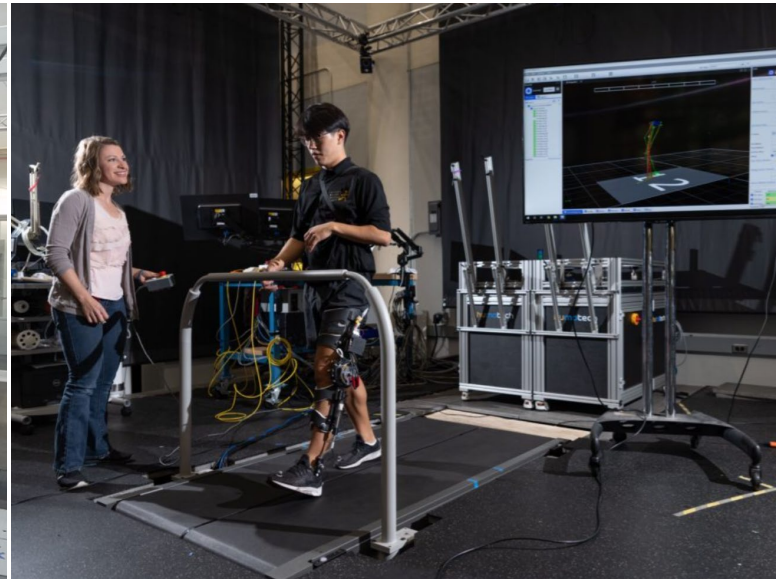
DEPHY Exoboot

Georgia Tech ---> Re-create DOE-EM Tasks in-lab

GOALS:

1. **Replicate DOE-related industrial tasks in controlled laboratory setting for neuromechanical analyses**
2. **Examine ability of assistive devices and/or biofeedback to reduce the potential for work-related injuries**

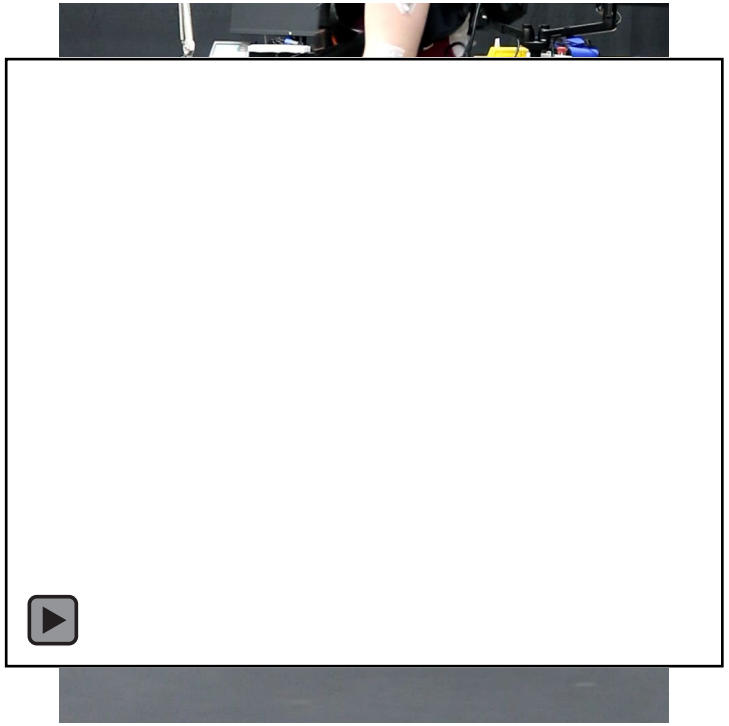




Georgia Tech

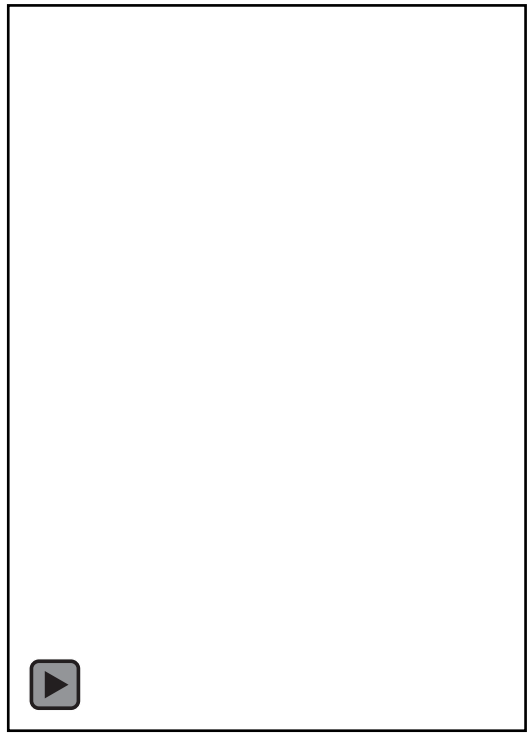
Exoskeleton-focused protocol -- 3 Devices (n=10)

Dephy Exoboots



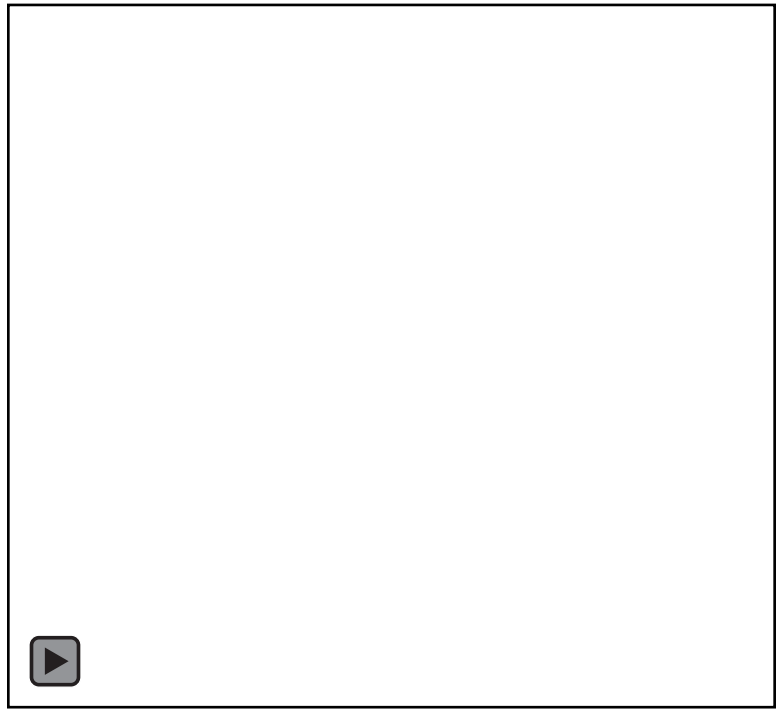
Stock walking controller

HeroWear Apex



Passive elastic assistance

GaTech V3 Knee Exo



Custom walking and lifting impedance controllers

Exoskeleton-focused protocol

Session 1: Training & Metabolic measures

Baseline (no exo)

- 3 mins
  - Standing
  - Standing w/ Weighted Vest (25lbs)

Lifting

- 6 mins, 1 lift/10 seconds
  - No exo, knee exo, back exo

Walking

- 6 mins
  - No exo, knee exo, ankle exo

Session 2: Neuromechanics measures

Lifting

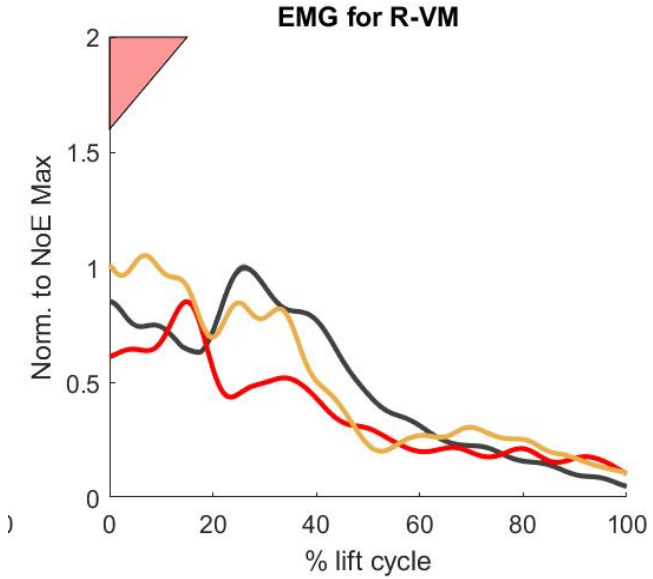
- 0, 90, 180 degrees
- KW, WK
- Time limit = 6 sec to complete lift
- 10 trials/lift type
  - No exo, knee exo, back exo

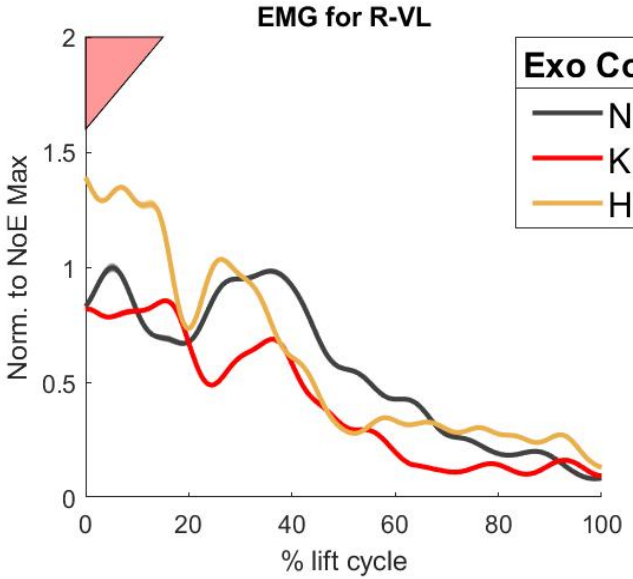
Walking

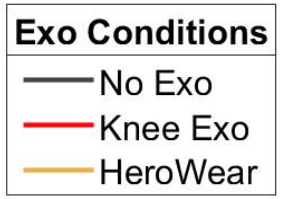
- 2 mins
  - No exo, knee exo, ankle exo

Preliminary Exo Results: Muscle Activations (n=1)

Symmetric Knee-to-Waist Lift







Quadriceps Muscle Activity reduced by *both* knee and back devices.

Exoskeleton Development --Tank Farm Workers

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Exoskeleton Hardware

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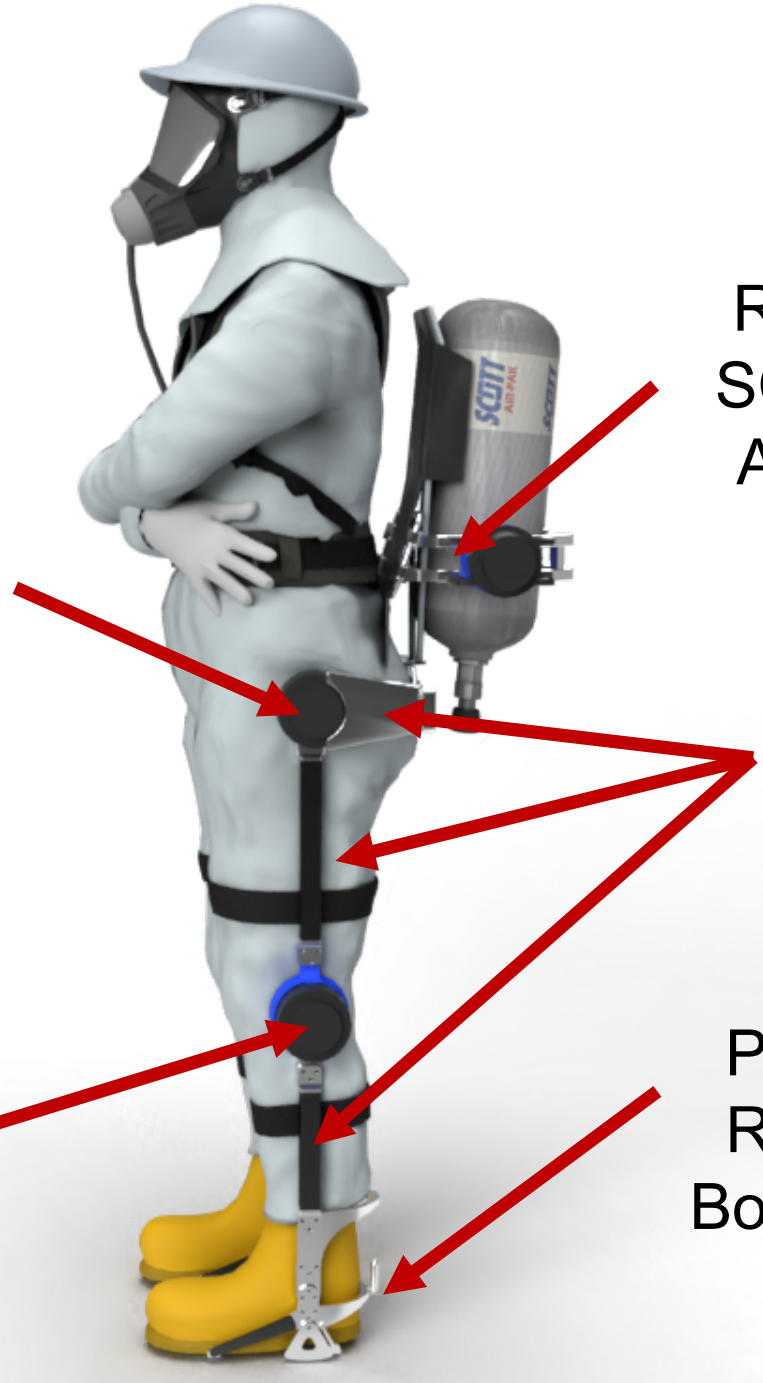
Hardware Design

Hip:
Active flexion/extension
Assistance through direct drive
Passive ab/adduction
Compliant internal/external rotation

Knee:
Active flexion/extension
Assistance through direct drive
No passive DoFs
Simple pin joint



Backpack:
Rigid attachment to user
SCBA slots into backpack
Ankle actuators external
Electronics internal

Modular linkages

Ankle:
Plantarflexion assistance
Rigid attachment to shoe
Bowden cable transmission

Questions?