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Robotics Tools to Increase Job Quality and Worker Safety

USW/CWA Health and Safety Conference

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Sandia National Laboratories

Exceptional service in the national interest

U.S. DEPARTMENT OF ENERGY

NNSA National Nuclear Security Administration

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Expand Partnering to United Steel Workers

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Stage Right
Nuclear Material Handling

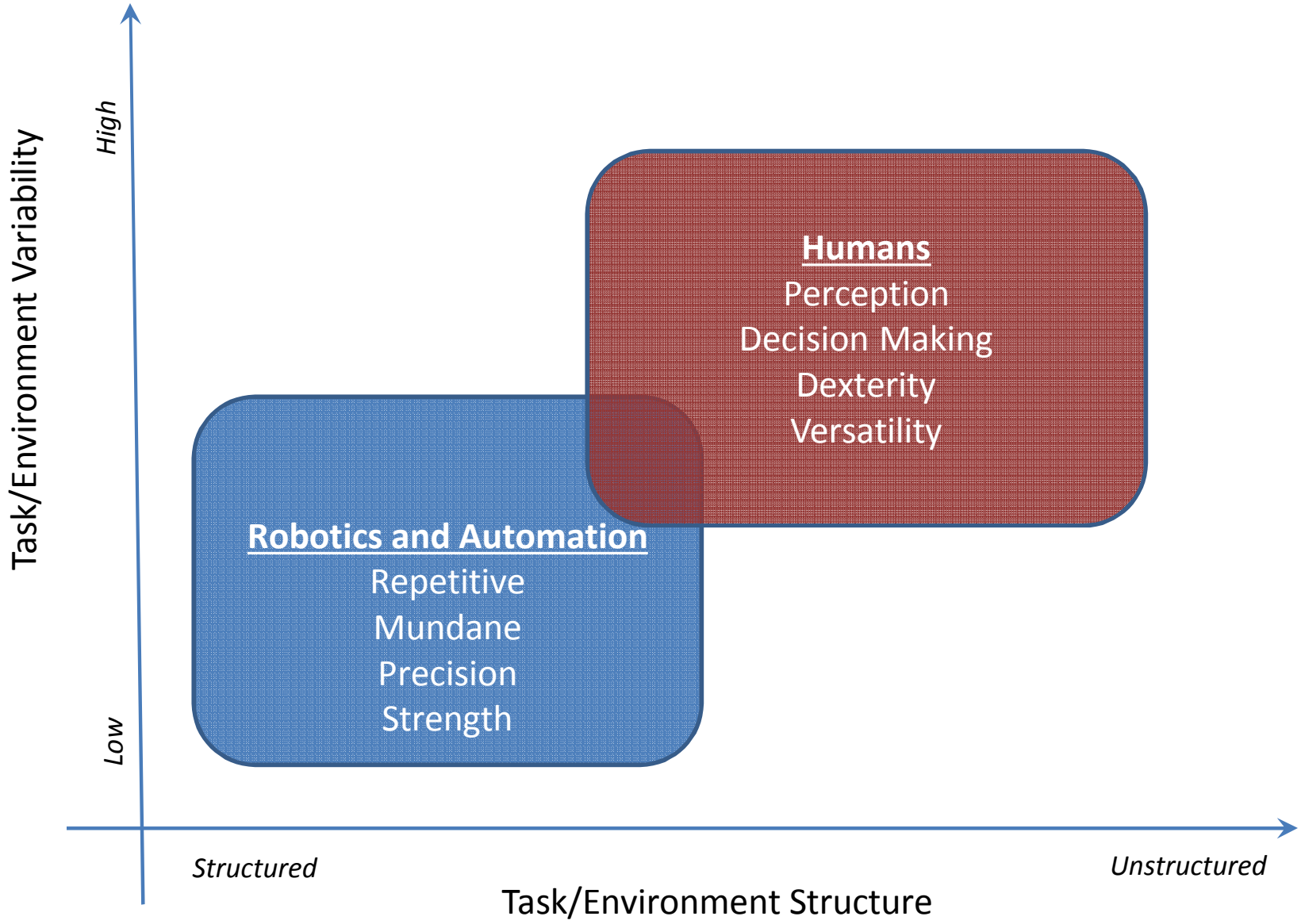
Munitions Disassembly

Improvised Explosive Device disposal for DoD. DOE & State and Local Bomb Squads

Advancing Worker Safety and Job Quality for 15+ years

- Thousands Benefited
- Operation and Maintenance Training Developed
- Technology Transferred to Industry

Why Augment Human Workers?



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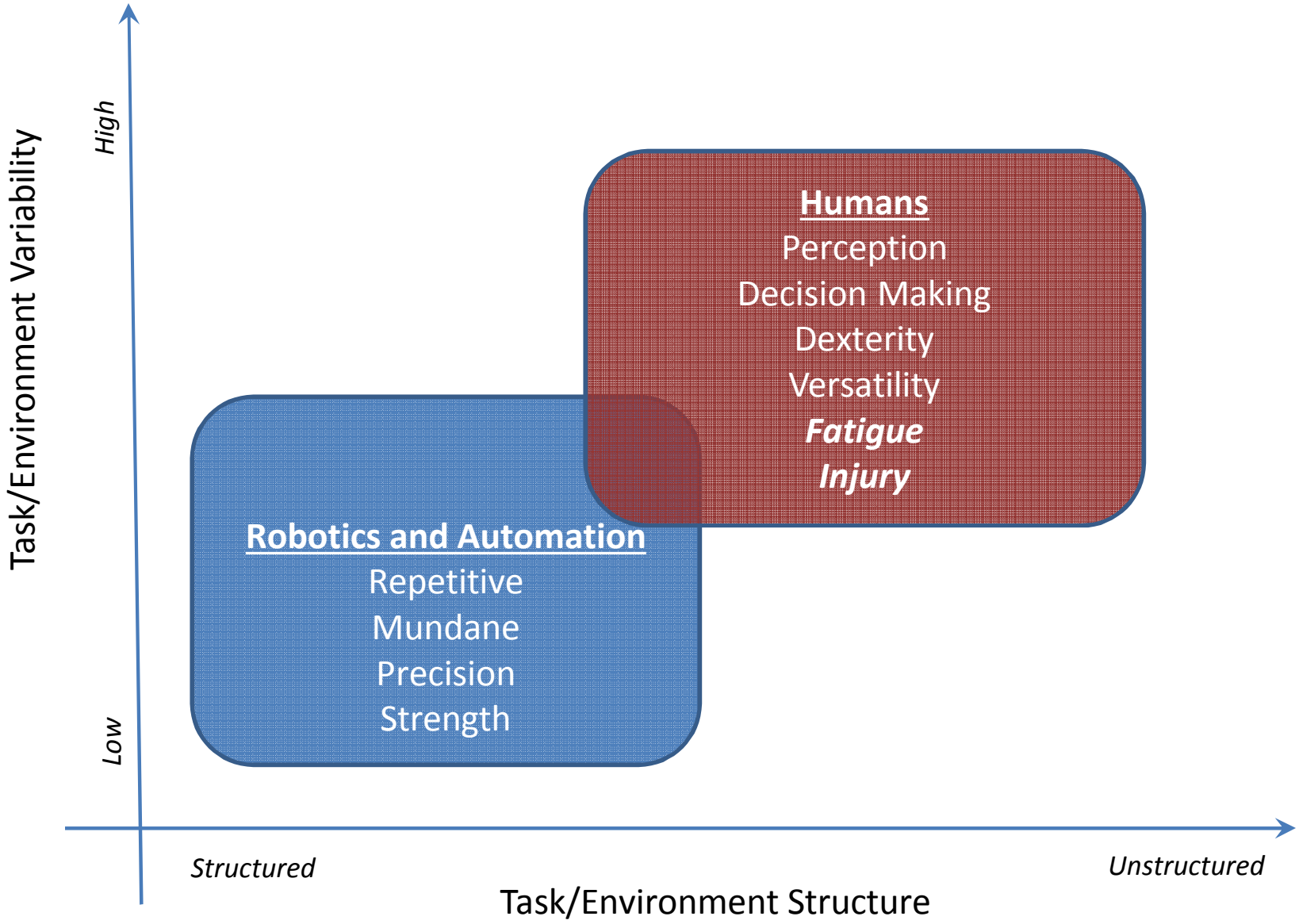

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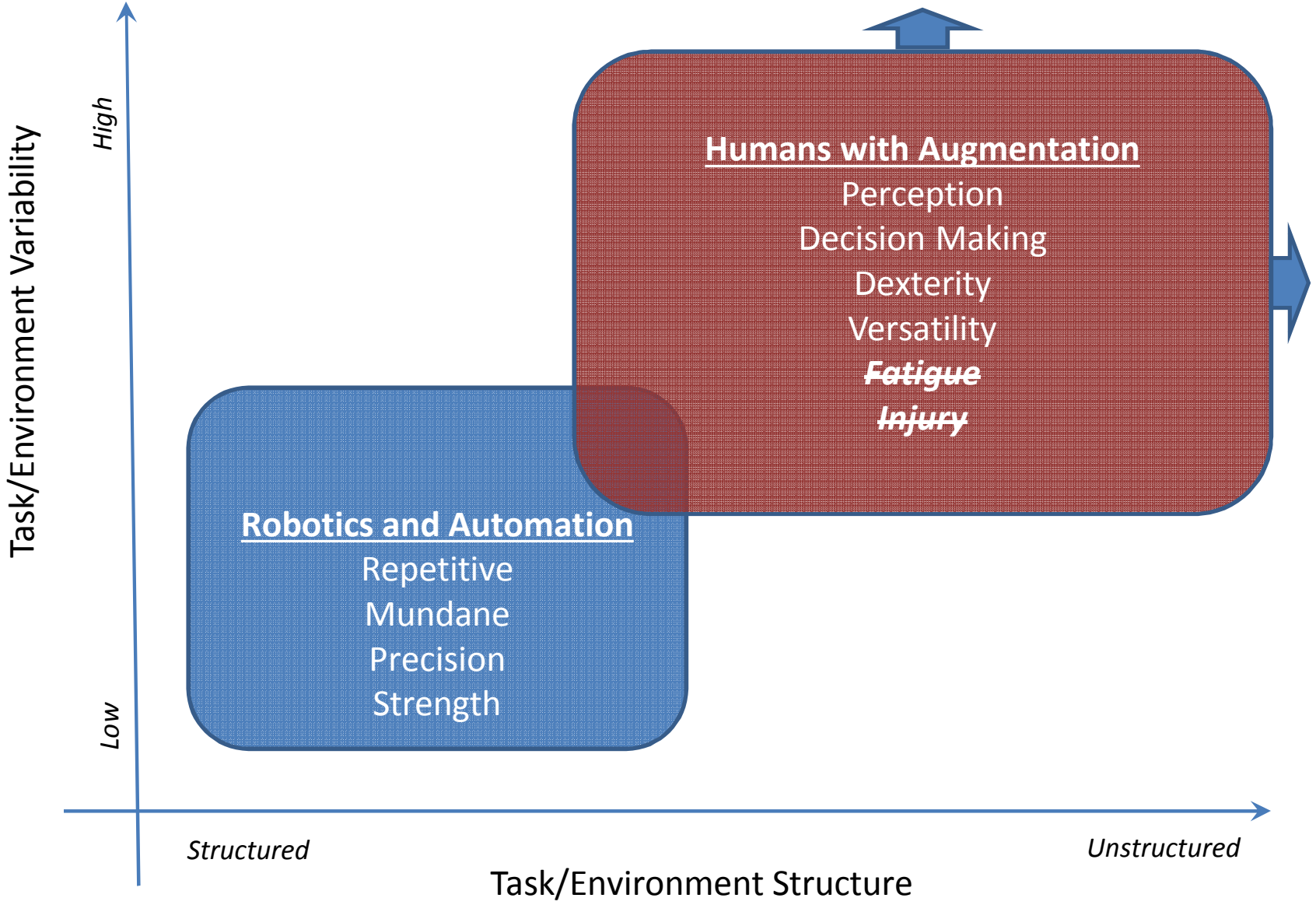

Examples of Tools to Increase Worker Safety and Effectiveness

Teleoperated Robots

Powered exoskeletons

Neural Prosthetics

Power Tools etc.

Quasi-passive exoskeletons

Conventional prosthetics

Active

Complexity

Passive

Level of integration with human

Two Principal Ways Robotic Tools can Assist Workers

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Teleoperation

- Operators control robot remotely from command station
- Provide remote access to dangerous environments
- Can perform sensing and manipulation actions
- Currently in use in several applications
- Examples:
  - Bomb squads
  - Nuclear facilities
  - Disaster response
  - Law enforcement

Wearable

- Device is tightly integrated with worker
- Can augment strength and endurance
- Can allow a wider group of workers to perform physically demanding tasks
- Potential to traumatic and repetitive motion injuries
- Technology and applications still emerging
- Examples:
  - Load carry assist exoskeletons
  - Rehabilitation and assistive devices
  - Strength augmentation

Gemini Scout Mine Rescue Robot

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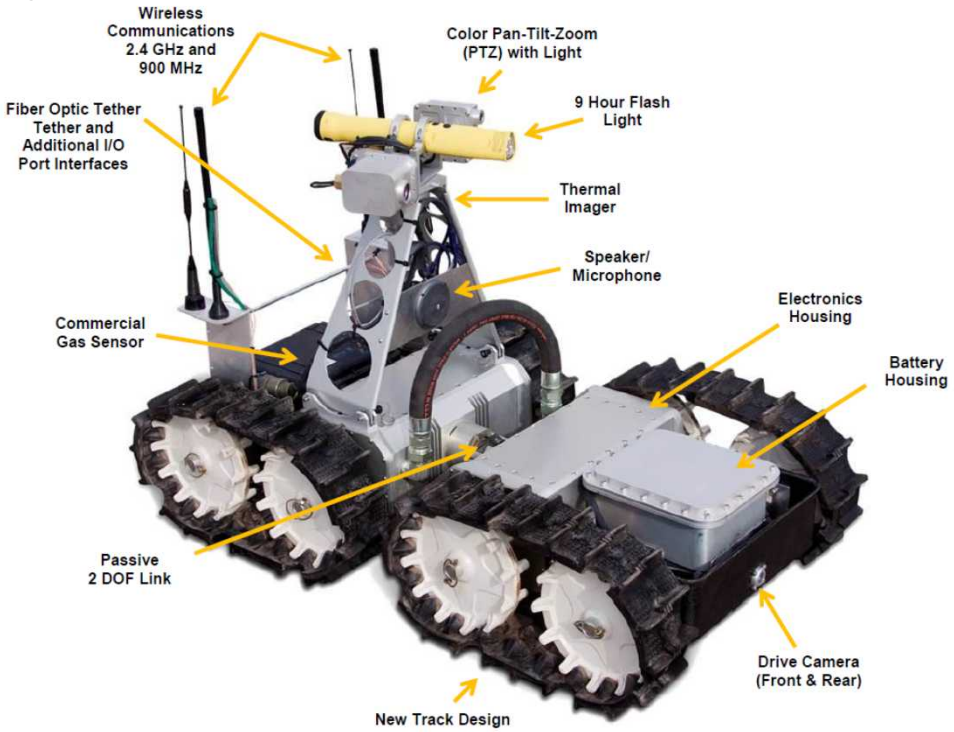
Features

- Extreme mobility
- Fully operational in ~18 in of water
- Explosion-proof housings
- PC-based control interface
- Pan-tilt-zoom color and IR camera
- 2-way radio and lighting
- Gas and temperature sensors
- I/O for adding payload and sensors

Applications

- Search and rescue missions
- Border tunnels
- Payload deployment and delivery
- Intelligence, surveillance and reconnaissance
- Support to first responders in unknown and dangerous situations



Additional Teleoperation Experience

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- Extensive support for law-enforcement and bomb squads
  - We host “Robot Rodeos” regularly for these workers
- X-ray Toolkit for inspection of suspicious packages
- Emergency and disaster response

USW Workers at Portsmouth –Cylinder Inspection

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- Storage cylinders need to inspected regularly
  - Check number
  - Inspect valve
  - Swab surface
- Inspectors receive the highest radiation dose at the plant
- Teleoperated robots allow this task to be done with safe standoff

USW Workers at Portsmouth – Pipe Crawling

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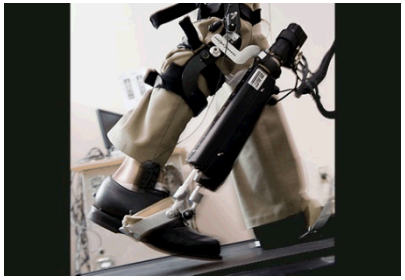
- NDA workers must check MILES of pipe for contamination
- Radiation levels require substantial PPE and spaces are hard to access
- Teleoperated pipe-crawling robots can traverse pipes looking for deposits
- Video feed to operator can be augmented by machine learning to point out potential deposits for further inspection

Classes of Exoskeleton Applications

Rehabilitation/ Mobility

Ekso Bionics

SuitX

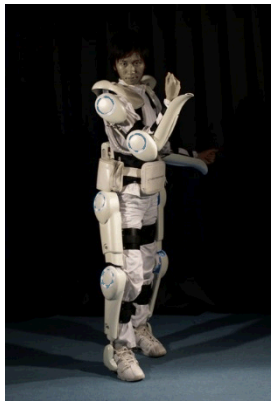


MIT Anklebot

Offloading

Lockheed Martin HULC, FORTIS

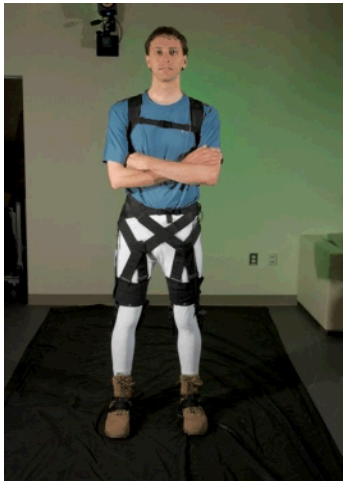
Full Body Augmentation



Cyberdyne HAL

Sarcos XOS

Soft/Conformal

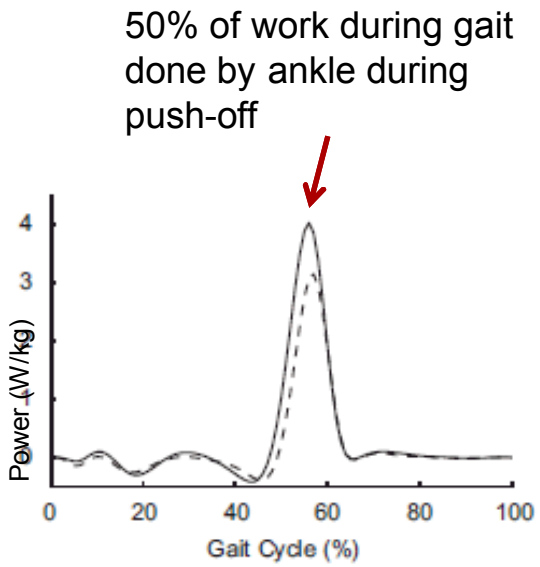


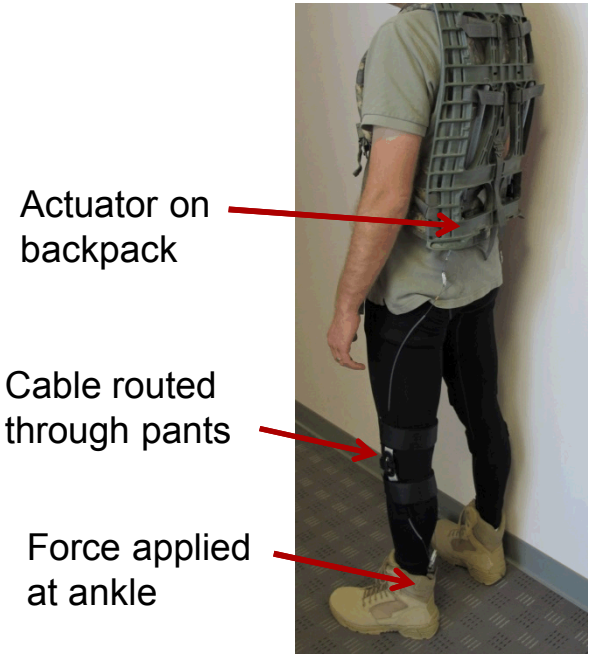
Harvard Soft Exo

SRI Superflex

Human performance augmentation

- Soldiers carrying heavy loads over long distances are prone to injury and impaired mission performance
- In a DARPA-funded effort, we developed soft wearable exoskeletal systems that impart energy to the ankle during push-off to reduce muscle effort and reduce fatigue





Metabolic Testing at Army Research lab

Drop Landing Injury Simulation

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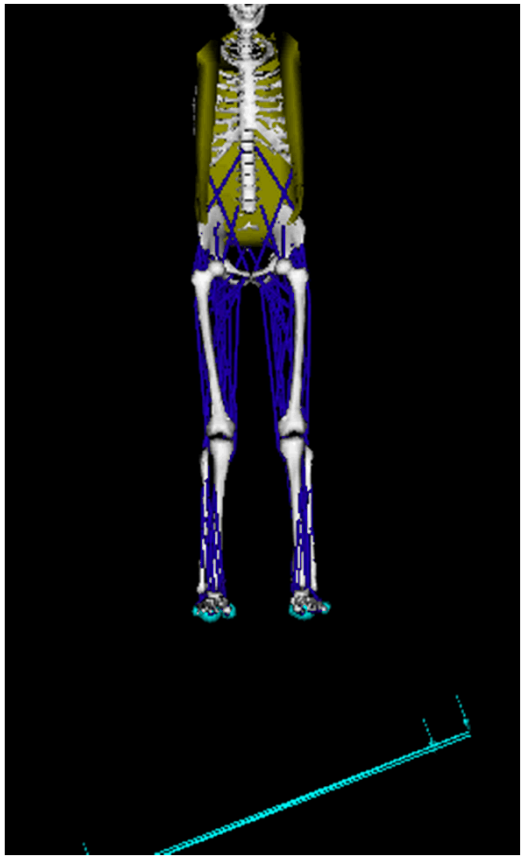
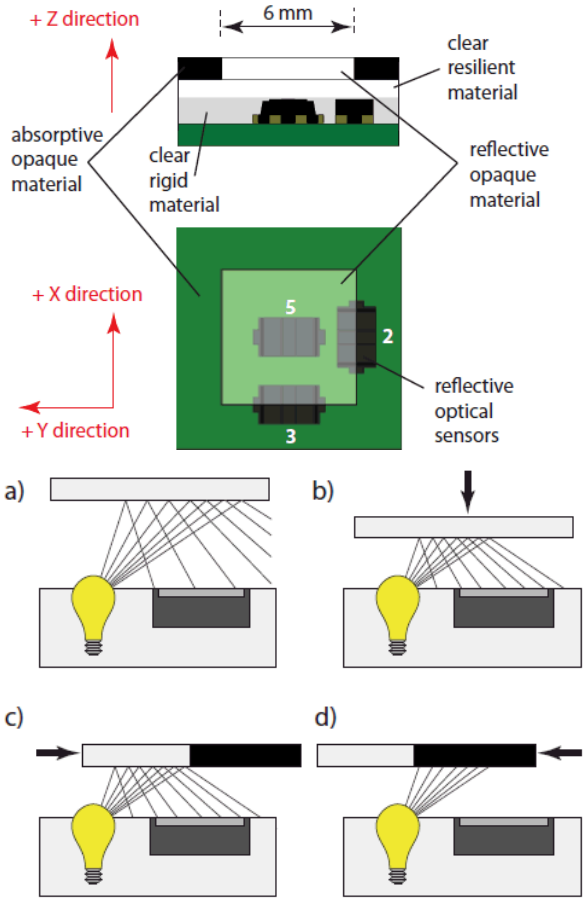
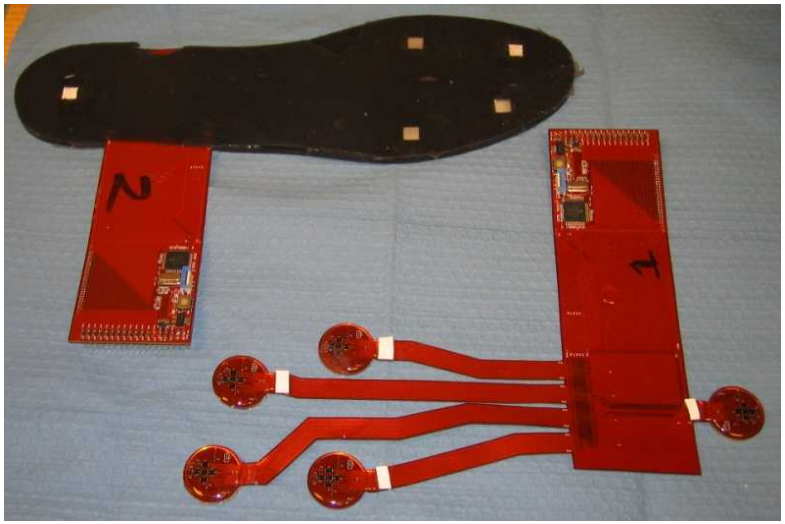
- Difficult to test injury mechanisms in humans
- Forward dynamic simulations can be used to predict how a person may adapt to an assistive device
- In this case, we studied how various ankle braces affected ankle inversion injury risk
- Ankle inversion (subtalar joint) used as a measure if injury risk in 0.5 meter drops onto a 20 degree tilted platform



Human Interface Force Monitoring

- Substantial **pressure and shear** loads can cause discomfort and soft-tissue damage





Advanced Human Input Systems

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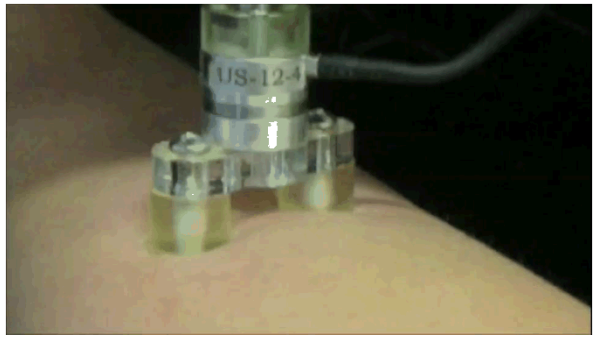
- Increase situational awareness and reduce cognitive burden by:
  - Tailoring input channel to information type
  - Avoid cognitive bottlenecks by using parallel channels:
    - Visual
    - Audio
    - Tactile
      - Vibration (event cues)
      - Contact location and/or skin stretch (motion or analog info)



Ongoing and Future USW Collaborations

- We are developing swing-free crane control methods than can be retrofit to existing cranes to increase worker safety
  - Leveraging previous work for the US Navy
  - **Demo in DOE booth!**

- Other potential USW applications:
  - Industrial exoskeleton development and testing
  - Biometric monitoring for health and safety
  - Ergonomic improvements for NDA workers
  - Advanced PPE
  - Continued teleoperation research and development