

Hazards Associated with Mobile Equipment Operation

Line-of-Sight & Situational Awareness; Vibration & Posture; Fatigue

Tammy Eger, Research Chair

Alison Godwin, Associate Director

Sandra Dorman, Director





Line of Sight and
Situational Awareness

Vibration and Posture

Fatigue

Line of Sight & Situational Awareness

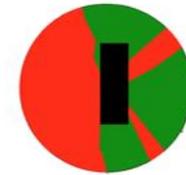
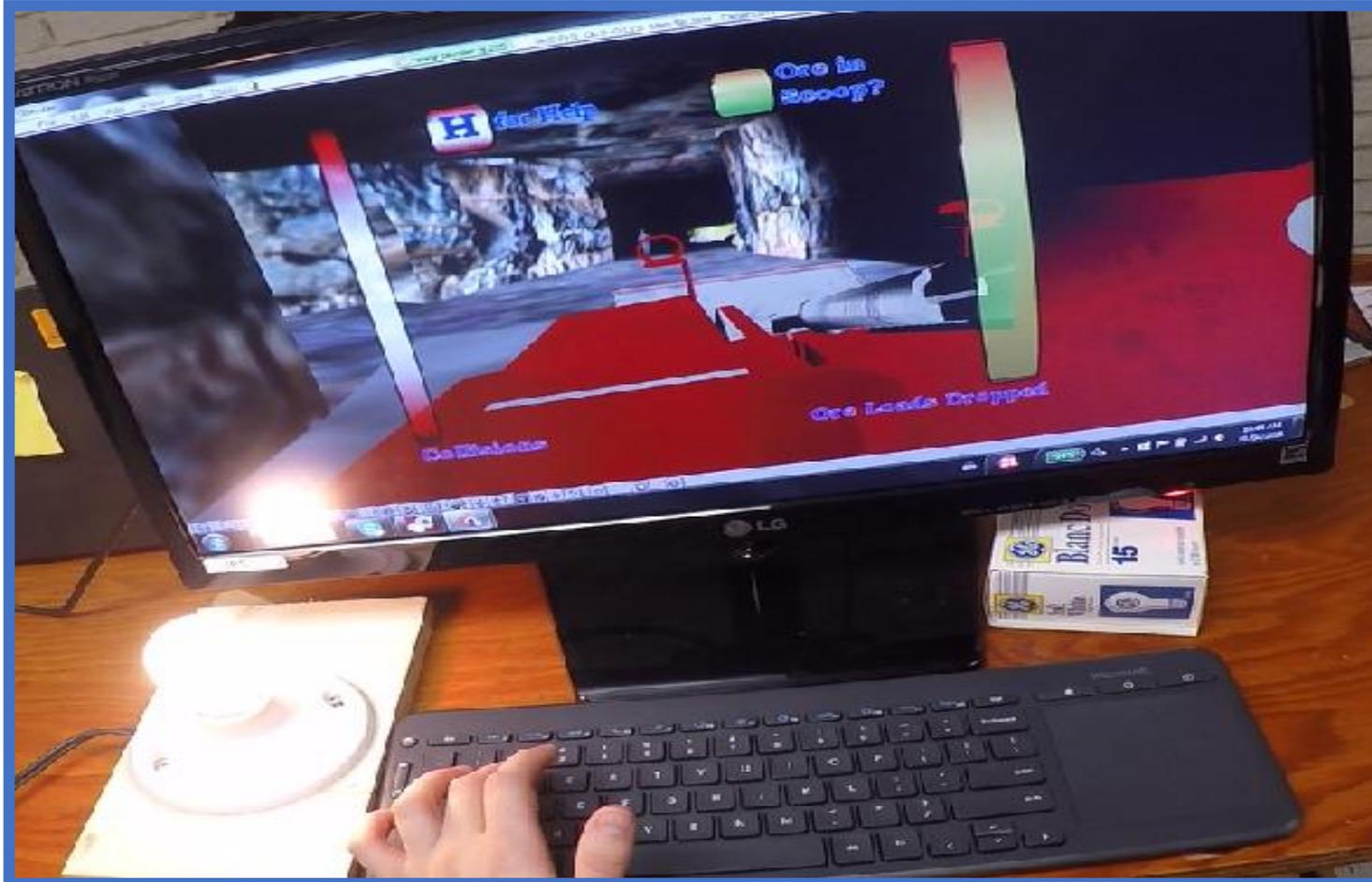


Alison Godwin, PhD

Associate Director, CROSH

Associate Professor, School of Human Kinetics

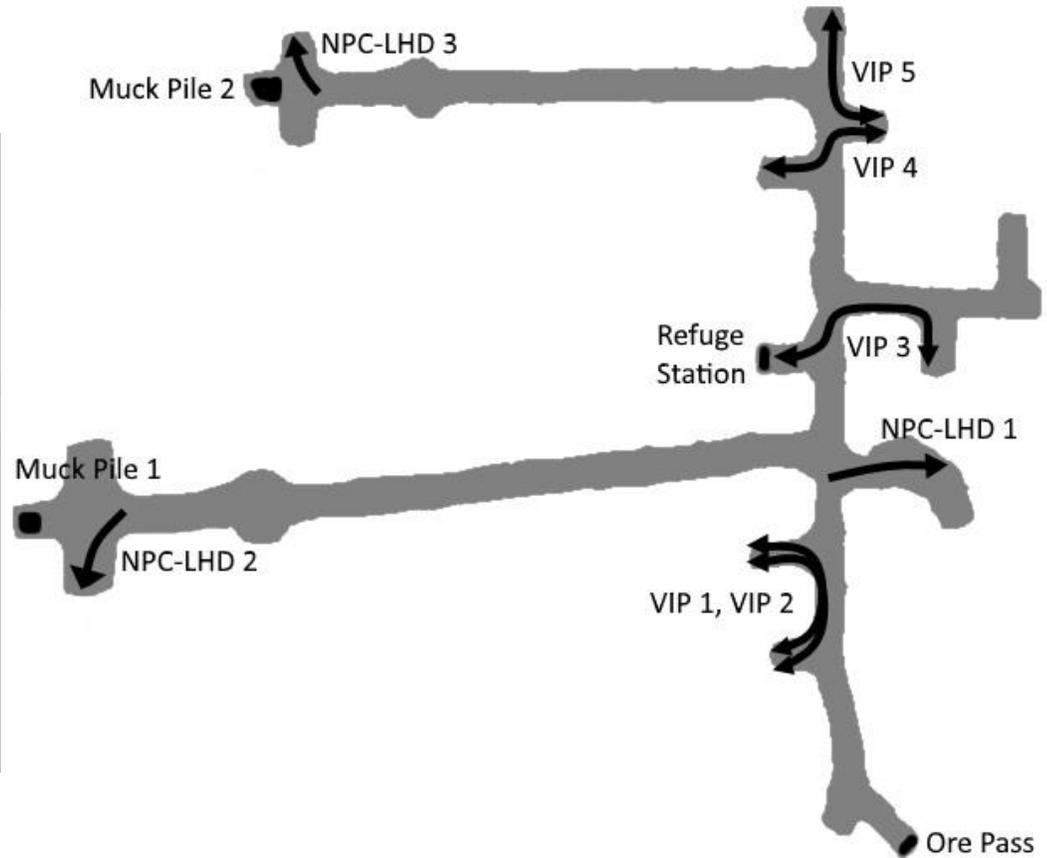
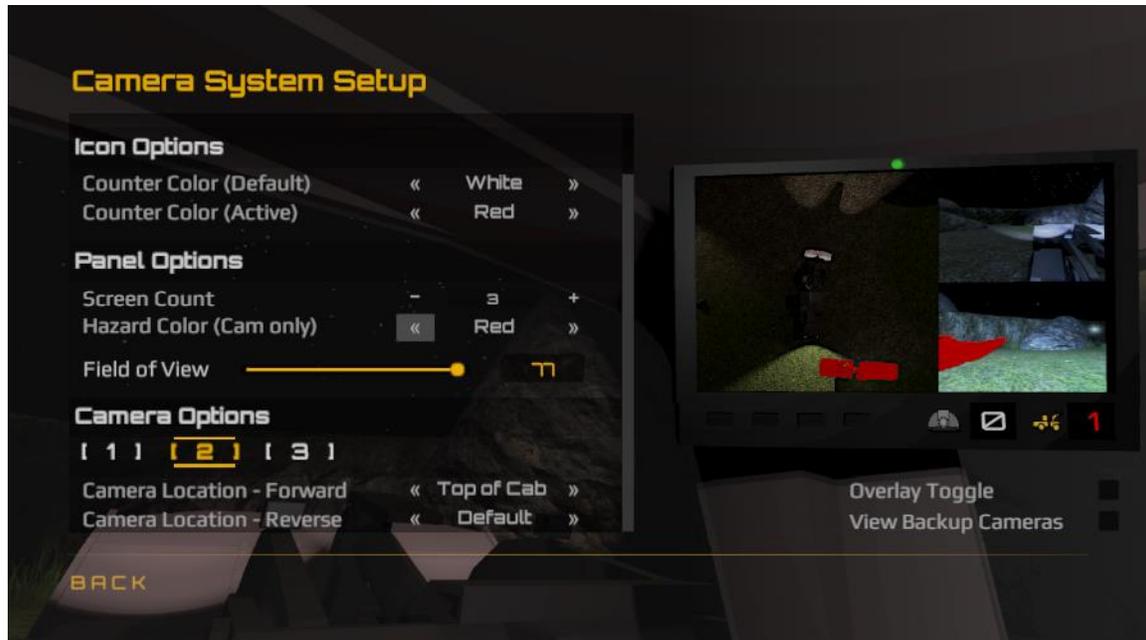
Serious Games for Workplace Learning



Development of Virtual Reality Mine



Custom Options in Simulation



Testing Situational Awareness

Back **Mission Setup**

Player: Default ▾

Max Collisions: Visible: ▾

Ore Loads: Visible: ▾

Vehicle Type: Small Red ▾

Reaction Time Reset:

Screen: Forward ▾

Sanctuary Door Colour: Blue ▾

Mine Depth: 5200 ▾

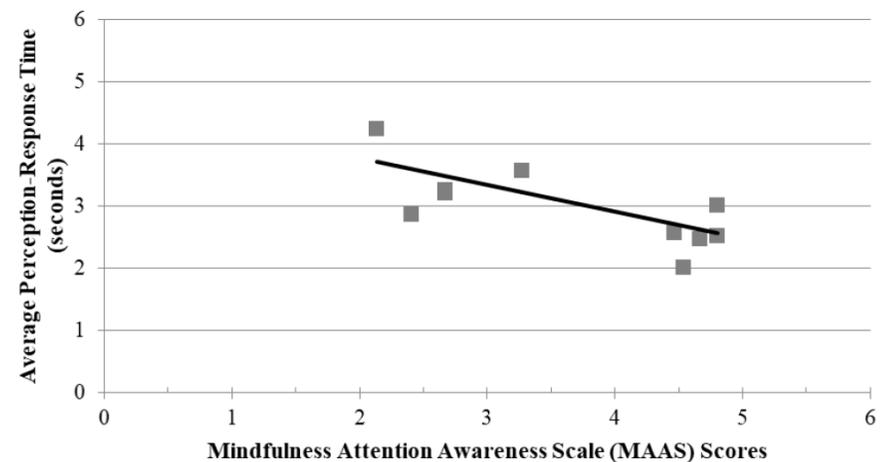
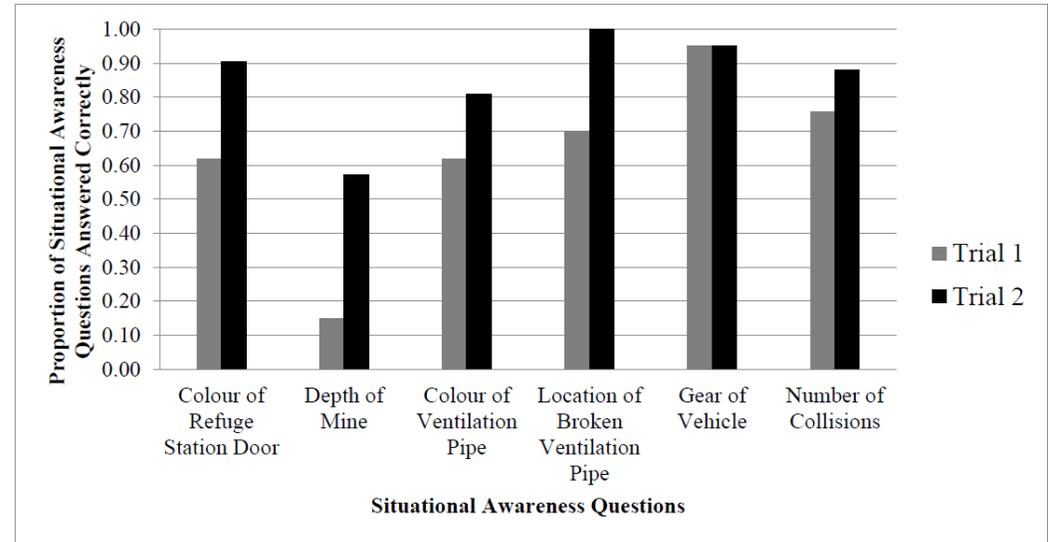
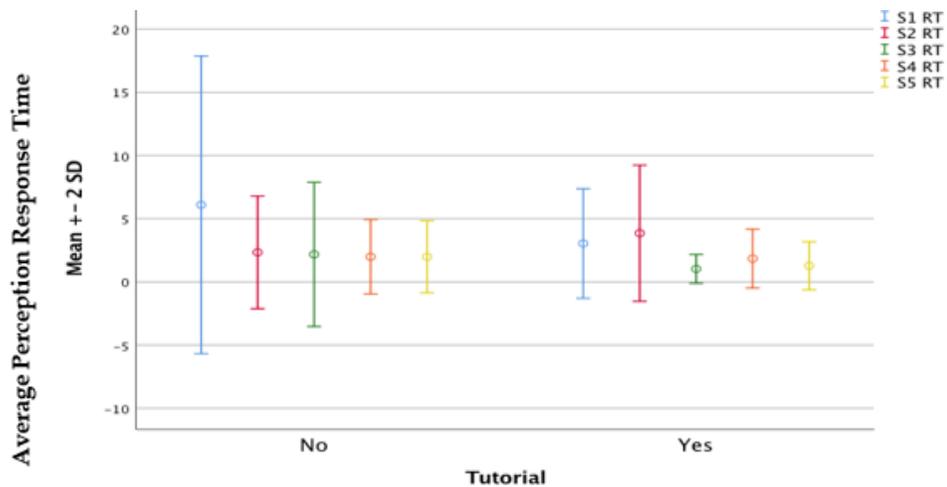
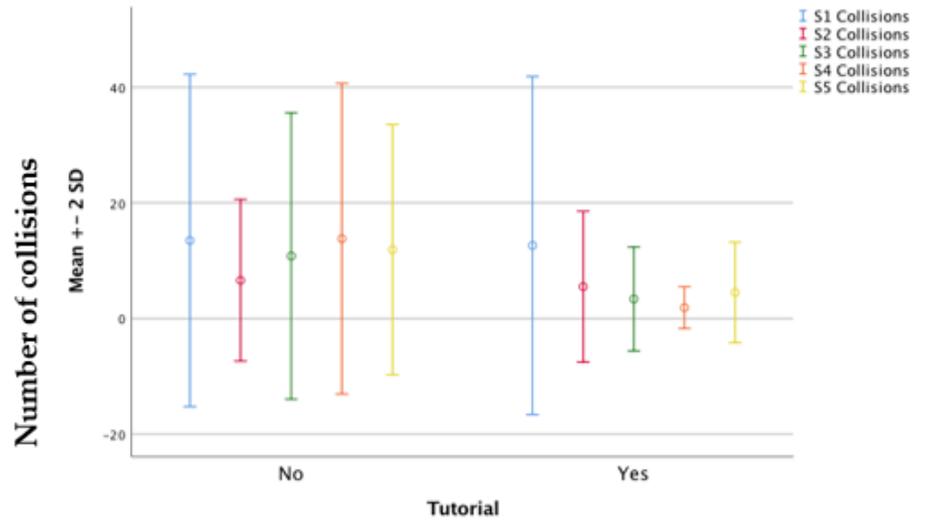
Bonus Mining: Efficient Mining

Time: 20 Min ▲ ▼

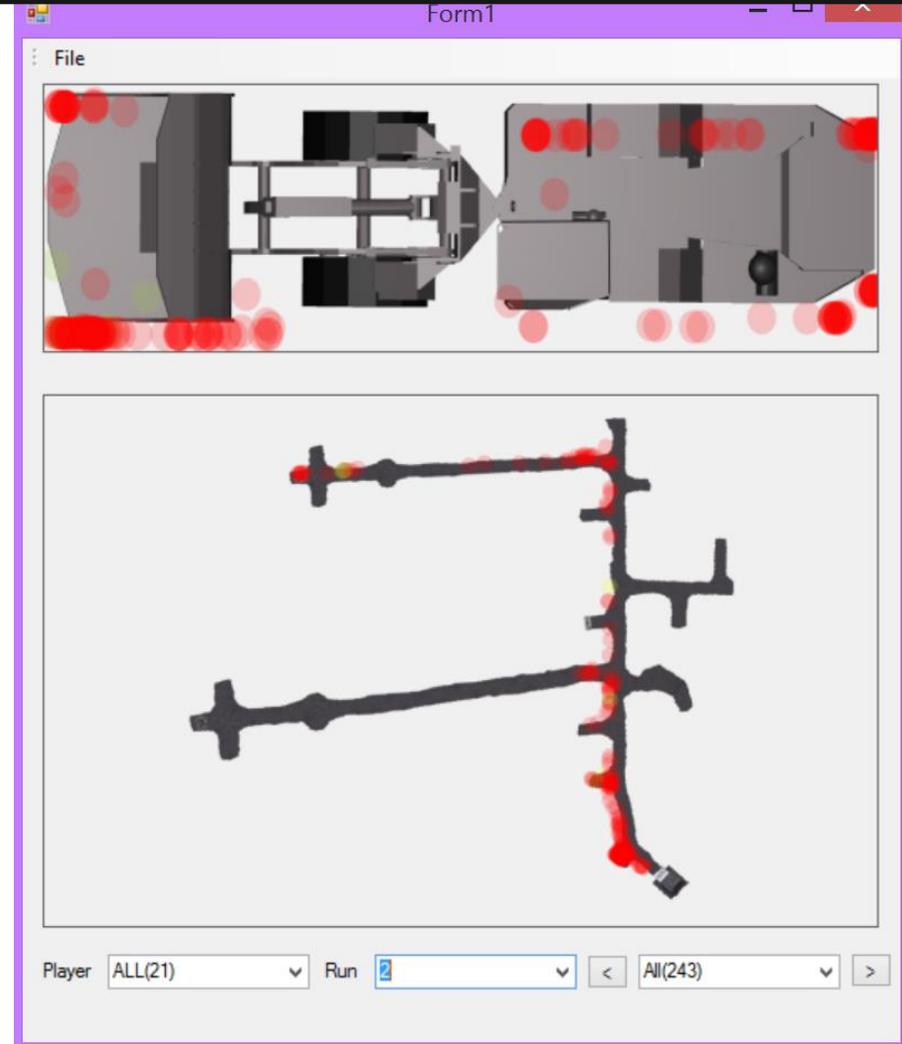
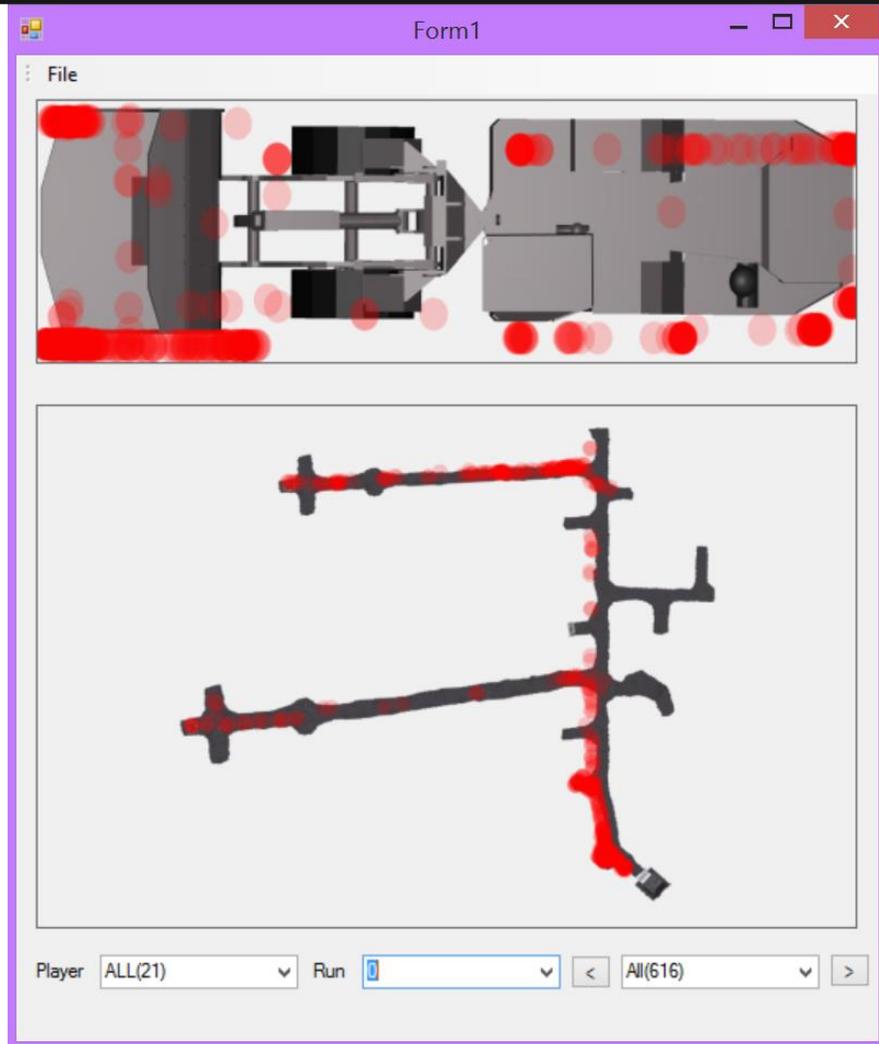
Start

Randomize
Presets
1 2 3 A B Save

Simulator Performance Results



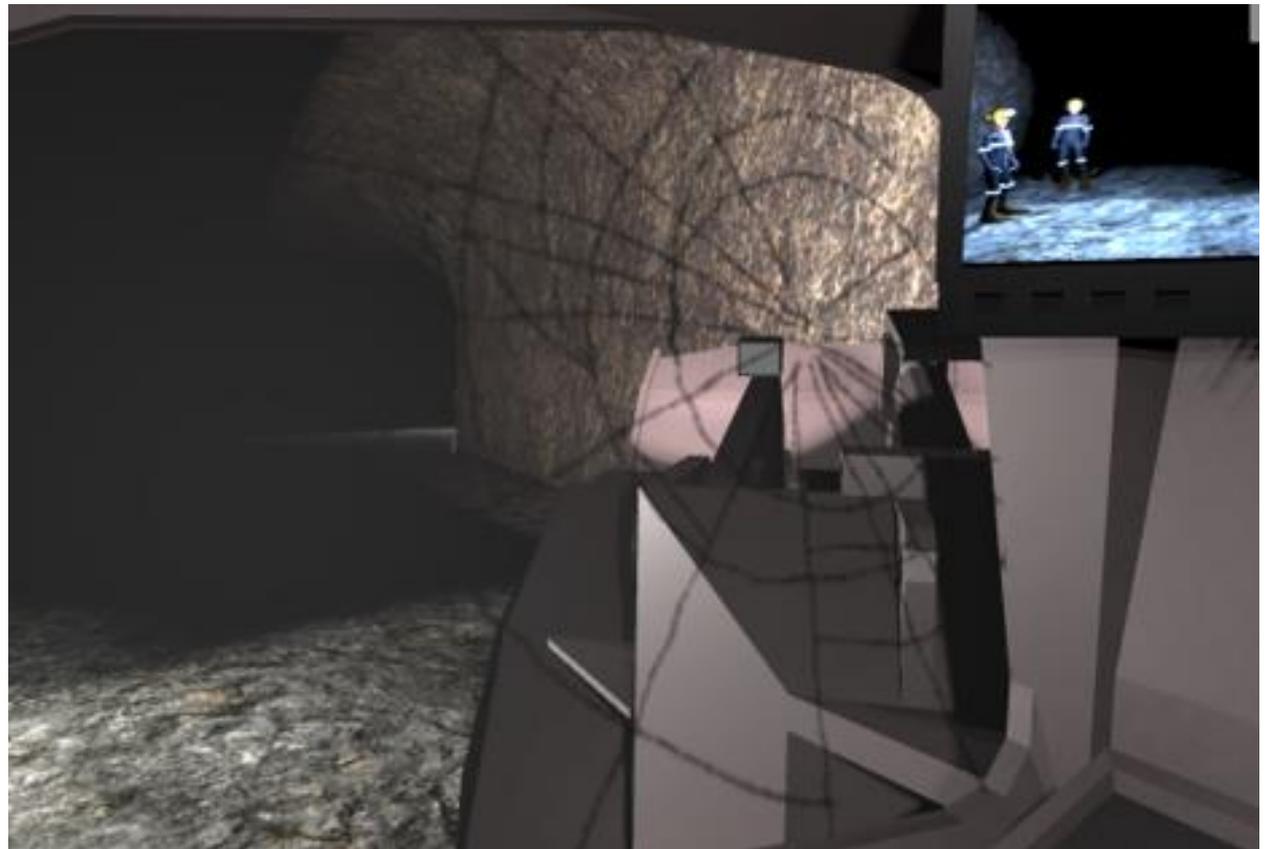
Big Data from Simulation



Testing Technology in VR



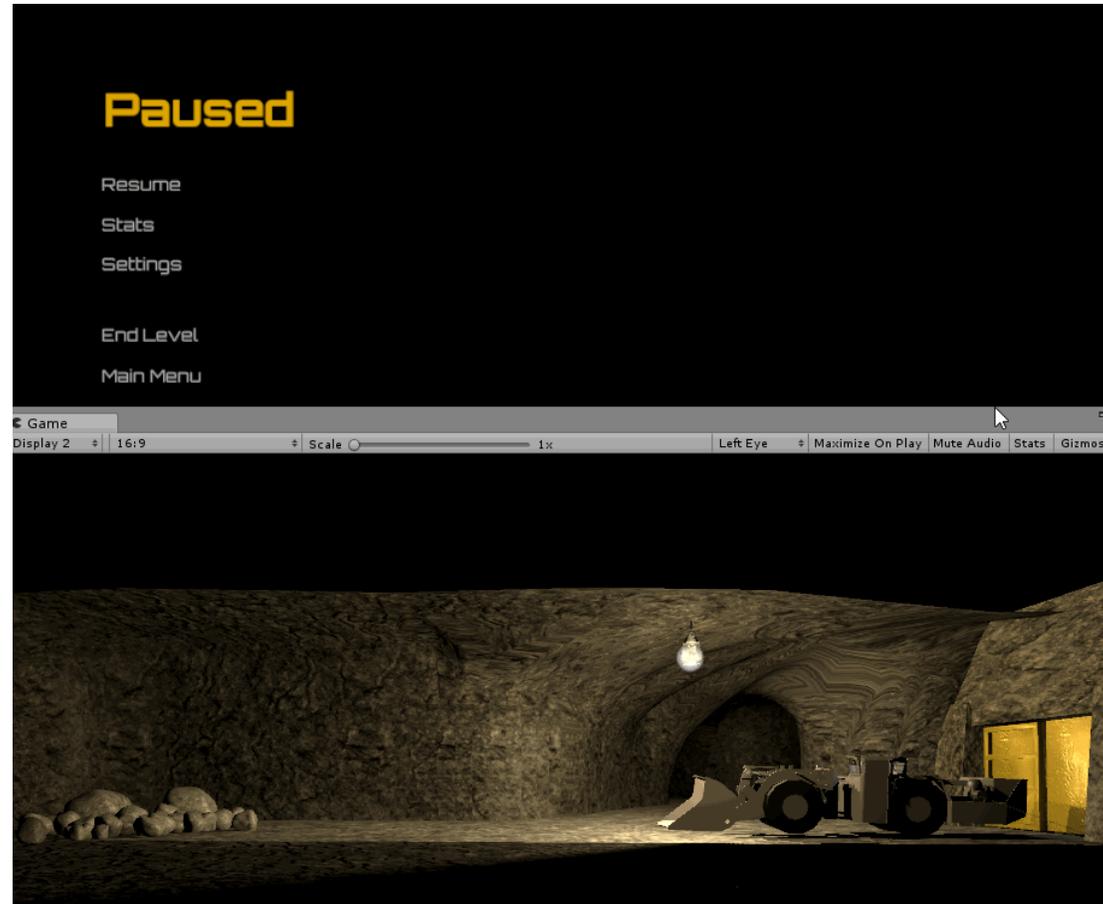
Further Development



Artificial Intelligence in the Mine



Game Demo



Vibration and Posture



Tammy Eger, PhD

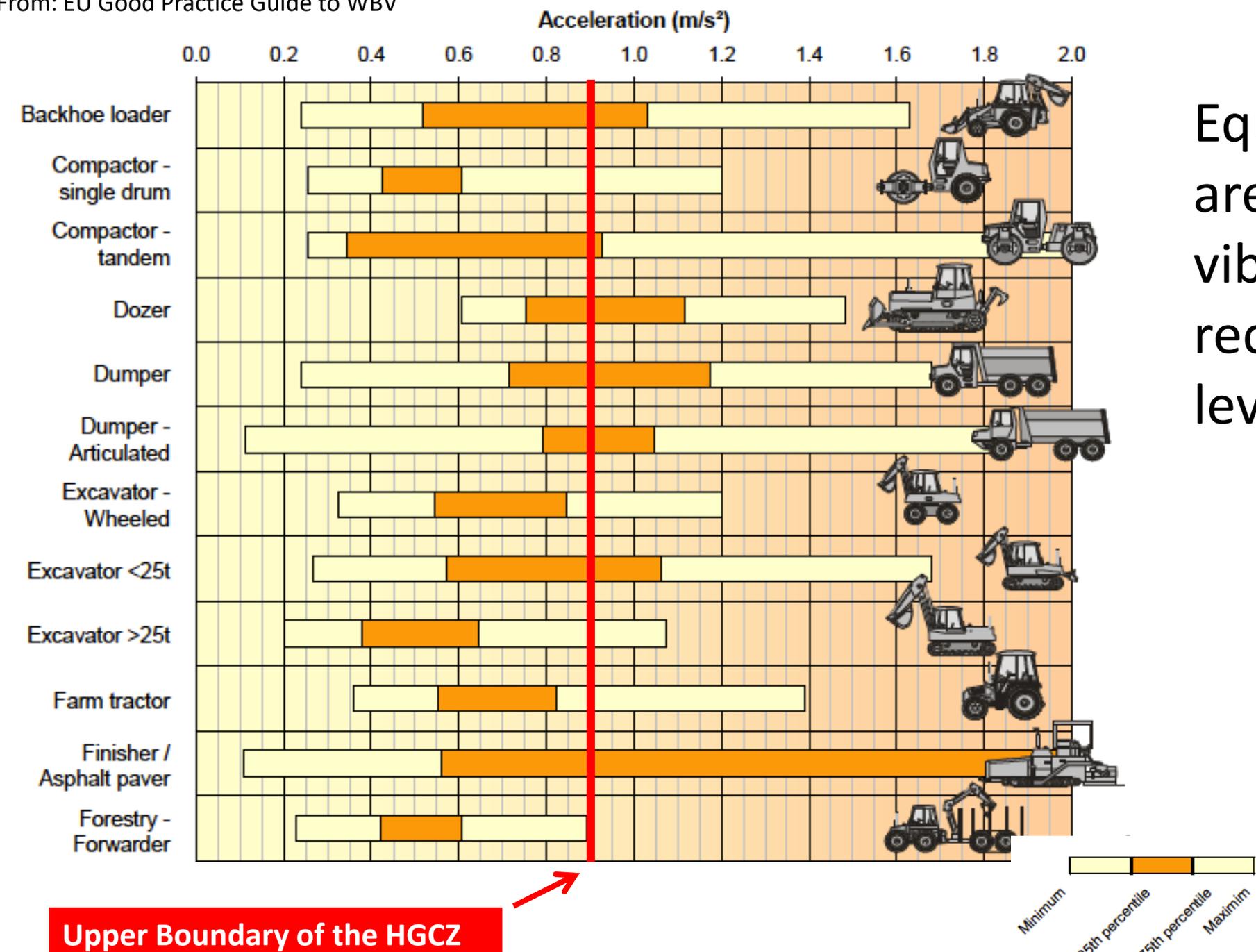
Research Chair, CROSH

Full Professor, School of Human Kinetics

Whole-Body Vibration

Vibration travels into your entire body through your hips/thighs while seated and driving equipment and vehicles.

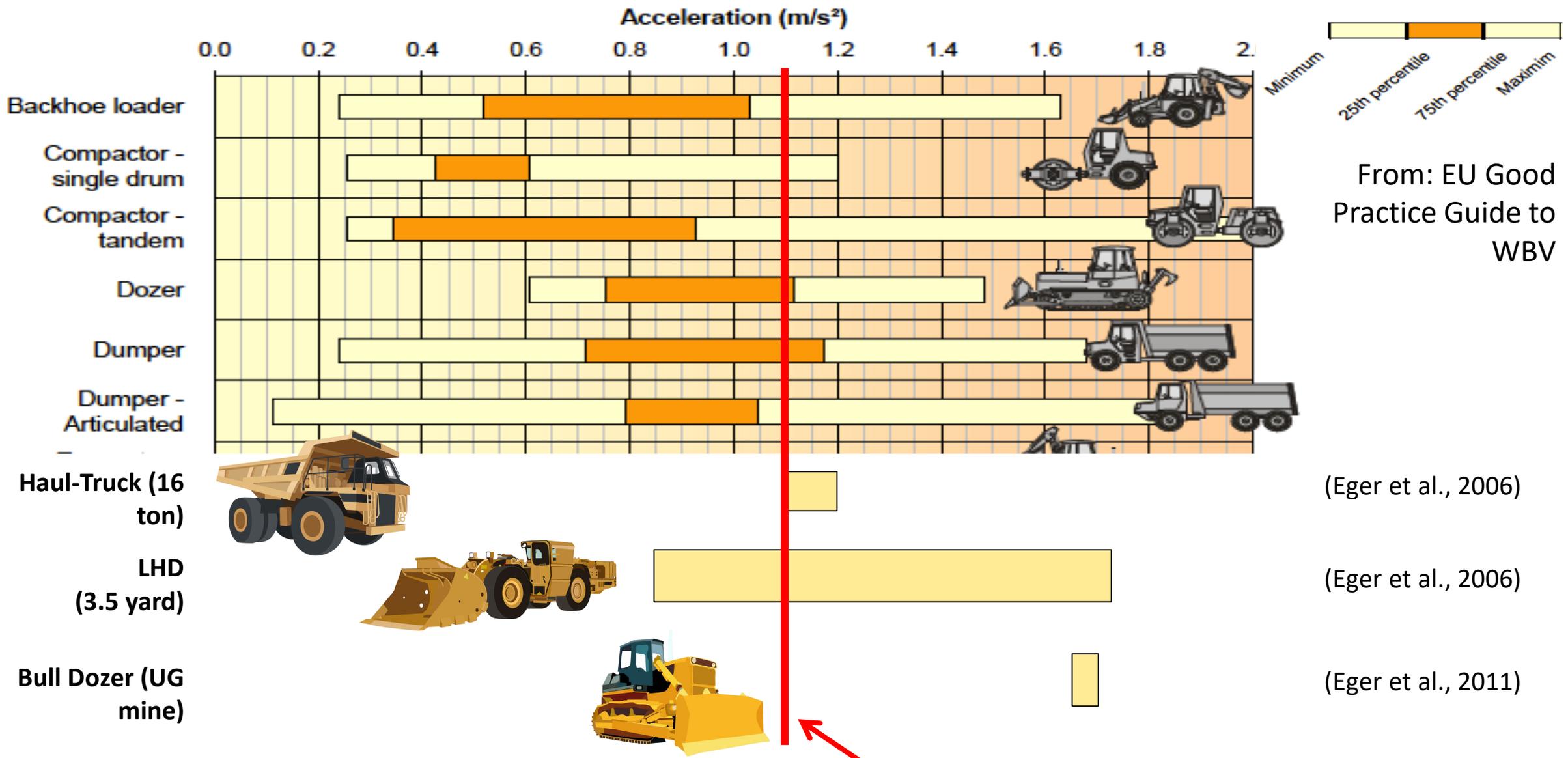




Equipment operators are exposed to vibration above recommended levels.

Upper Boundary of the HGCZ

Minimum
25th percentile
75th percentile
Maximum



EU Directive Exposure Limit Value

WBV Exposure Health Risks

Low-back pain

Neck pain

Muscle fatigue

Reproductive Health

Hearing Loss

GI tract problems

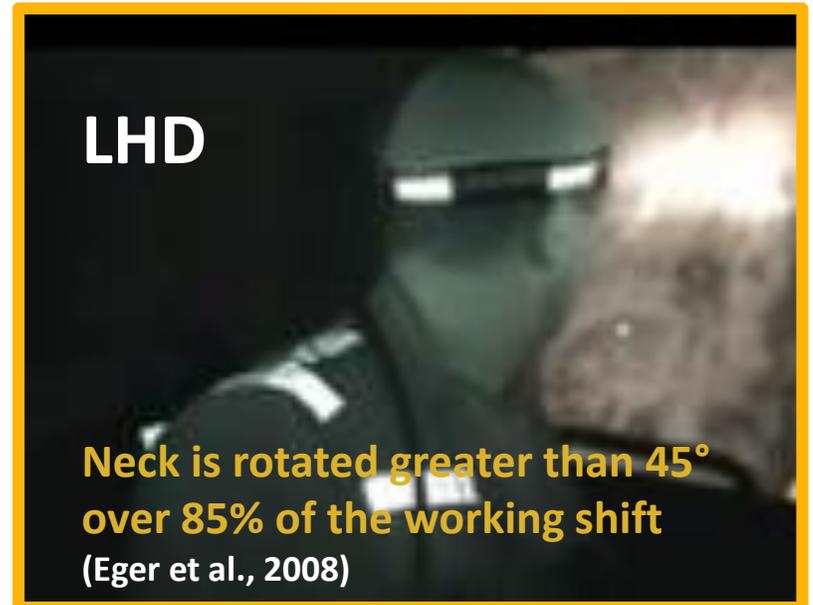


Whole-Body Vibration and Rotated Postures



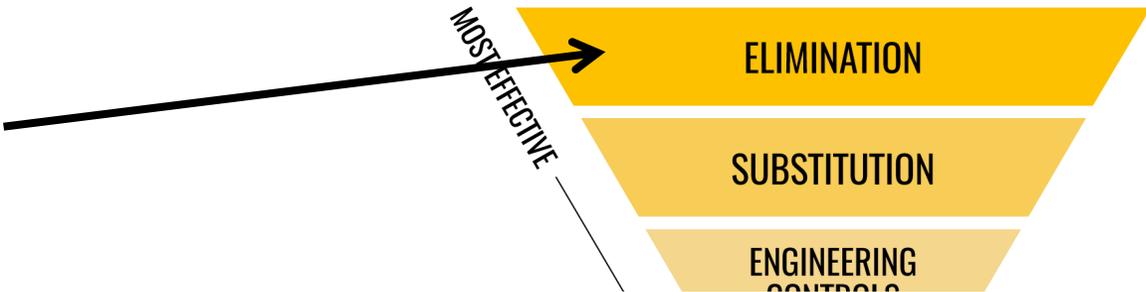
Increased low-back injury risk when WBV exposure is combined with bent and twisted postures

Port workers – cranes & lift trucks
Farm workers – tractors
Construction – excavators, pavers
Locomotive operators
LHD operators



Remove Worker from the Source

HIERARCHY OF CONTROLS



Sandvik AutoMine Tele-Remote an entry level automation option for LHDs

Posted by Paul Moore on 18th September 2017

Tele-Remote And Co-Piloting System Makes Waves Underground



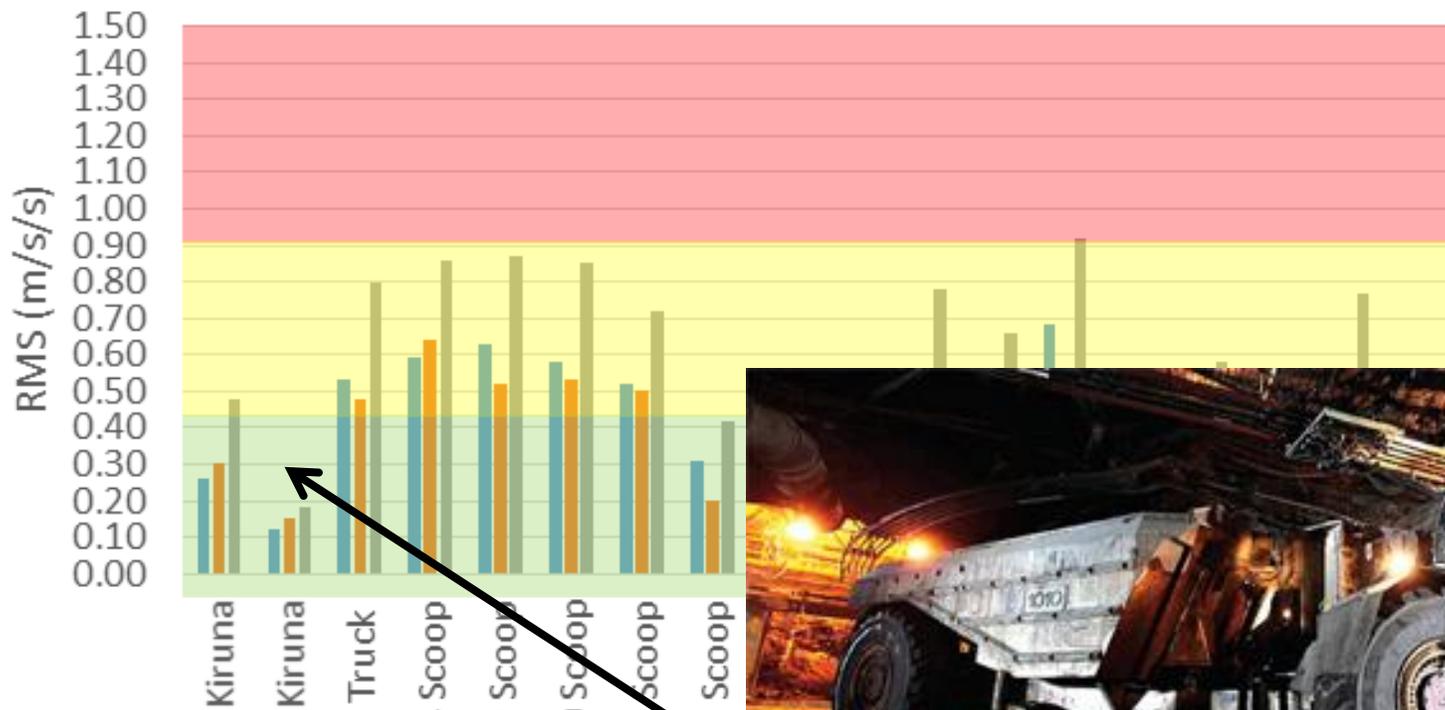
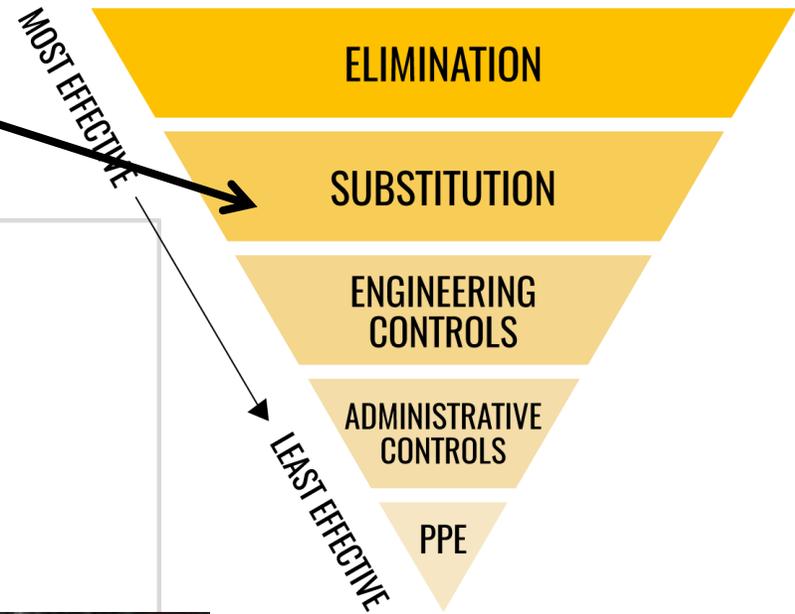
APRIL 13, 2017

The underground tele-remote system being piloted on a couple of loading vehicles at Barrick's Cortez Hills Underground mine in Nevada recently scooped the first of many ore buckets—operated by a miner in a specialized chair from the surface. The project is part of Barrick's digital transformation, and these scoops were part of the commissioning process for the first automated loader on site.



Purchase equipment with lower vibration emissions

HIERARCHY OF CONTROLS



Equipment

Lower WBV exposure: Kiruna Truck (Electric)

(Killen et al., 2016)

New Technology: Electric & Battery Operated Equipment

ENVIRONMENT JUNE 21, 2018 / 11:56 AM / 10 MONTHS AGO

First new all-electric mine dumps diesel; cuts costs, pollution

Susan Taylor, Barbara Lewis



A battery electric boom truck, manufactured by MacLean Engineering CREDIT: MACLEAN ENGINEERING

The effort to create a single, integrated team at Borden is all part of Goldcorp's approach to encourage collaboration and make sure its ambitious project – which will be the first-ever modern, all-electric underground mine when it enters commercial production later this year – is successful.

From the start, the company knew that success at Borden would rest on finding partners as invested in its vision for an all-electric mine as Goldcorp itself.

That's because some of the equipment needed to electrify Borden did not exist when the miner made the commitment in November 2016. Sandvik and MacLean Engineering, both leaders in electric equipment for underground mining, were brought on as official partners

Revolutionizing Canada's mining industry with electric vehicles

March 09, 2016 — Saskatoon, Saskatchewan

Working underground in mining often means breathing air that can be less than fresh.

Miners in Canada typically rely on heavy machinery – diesel-powered and emission-generating – that leave the air thick with pollutants. But thanks to

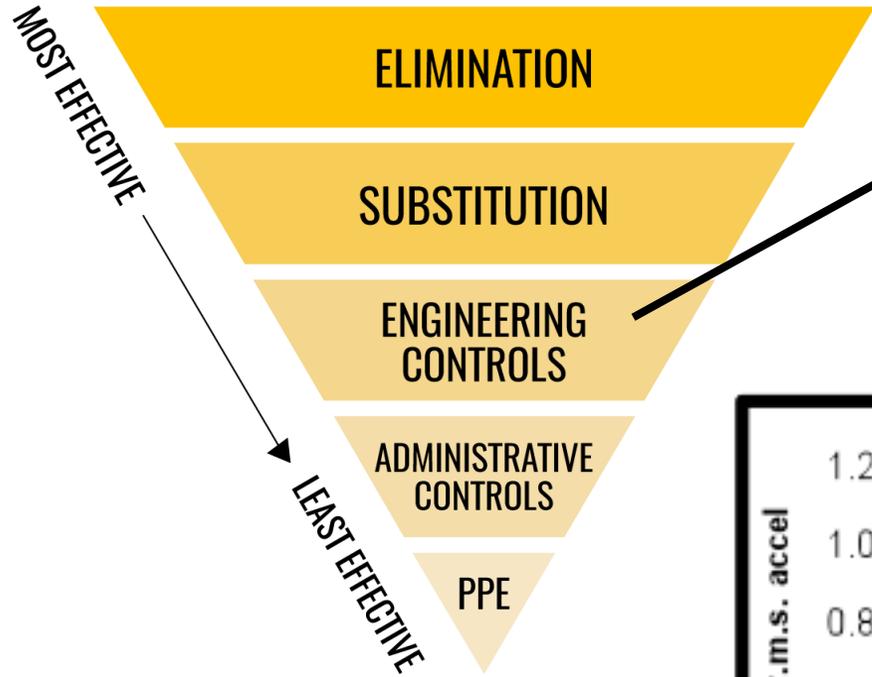
innovations and its rechargeable, batteries, workers across the industry find a collective sigh of relief.

PapaBravo (since purchased by Prairie Paper) was the force behind an array of rechargeable electric-battery technologies. PapaBravo's cutting-edge technologies, in particular, are especially popular among miners because, unlike gas or diesel, there are no toxic emissions.



Thanks to NRC-IRAP support, Saskatoon's PapaBravo Innovations developed a line of rechargeable electric vehicles for the mining sector to replace the diesel-guzzling trucks currently in use – eliminating noxious fumes in the process.

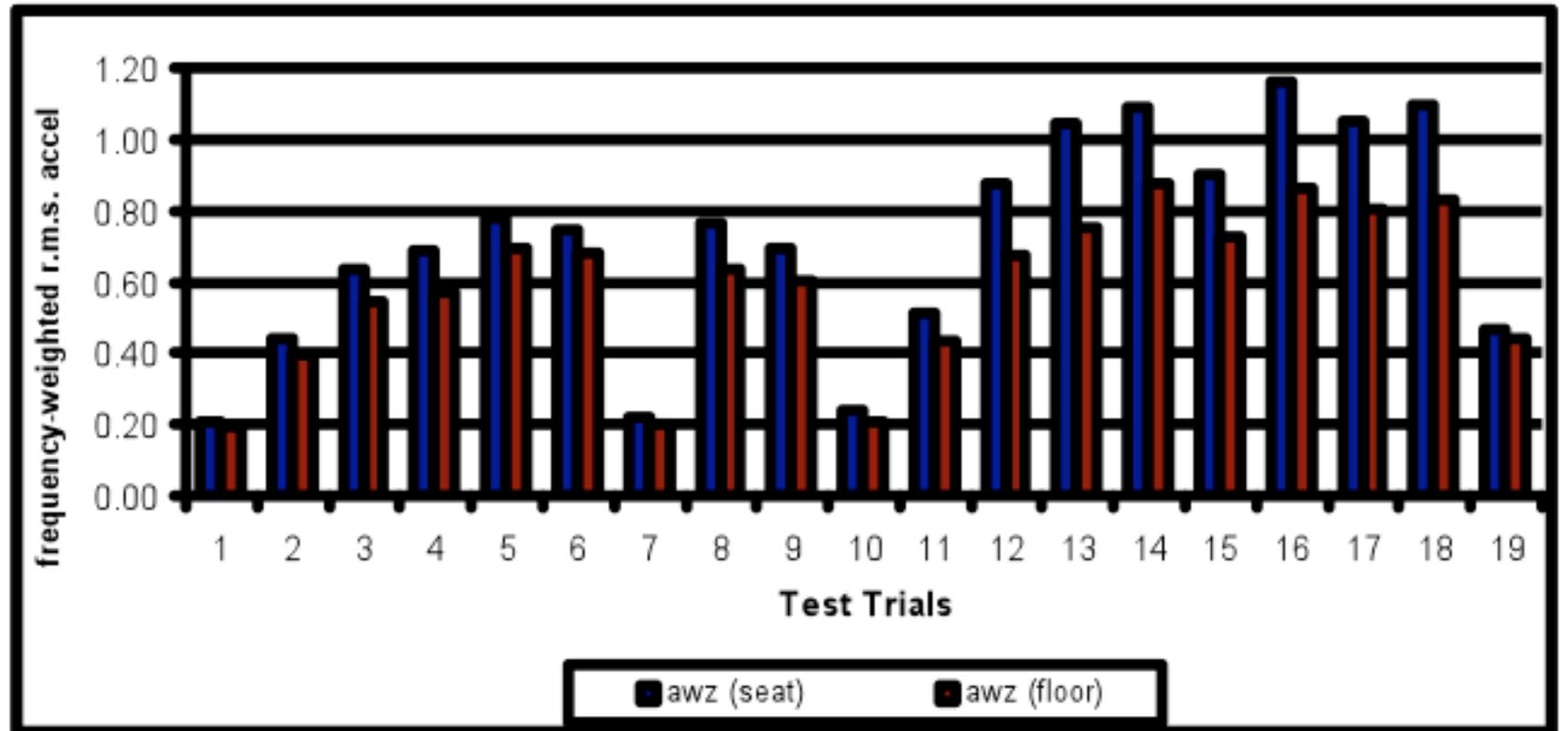
HIERARCHY OF CONTROLS



Seat Selection

BLUE = seat

RED=floor



Seat Testing



Vibration Rotopod

- We can replicate vibration associated with mobile equipment operation

Seat Testing:

- We can collaborate with seat manufacturers to identify the “best” seat for vibration reduction for specific mobile equipment types

Key: Less vibration will be transmitted to the operator if a seats that attenuate vibration is installed in the vehicle.

New Technology: Active Suspension Seat

<https://www.clearmotion.com/active-suspension-seat>

How it Works

Advanced suspension technology that protects drivers from the unwanted shaking and jarring they experience in their trucks.

1 Sensors detect unwanted motion

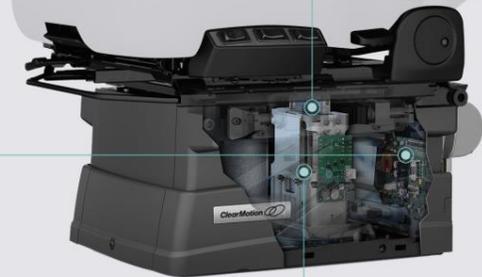
High precision sensors on the seat detect cab motion thousands of times per second.

2 Computer calculates optimal response

The optimal position of the seat is instantly calculated and commanded via state-of-the-art power electronics.

3 Motor counteracts unwanted motion

An electromagnetic motor adjusts the position of the seat to minimize impact to the driver.



Semi Trucks

Available Now

[Learn More](#)

For truck drivers facing the most strenuous environment.



Off-Highway

Coming Soon

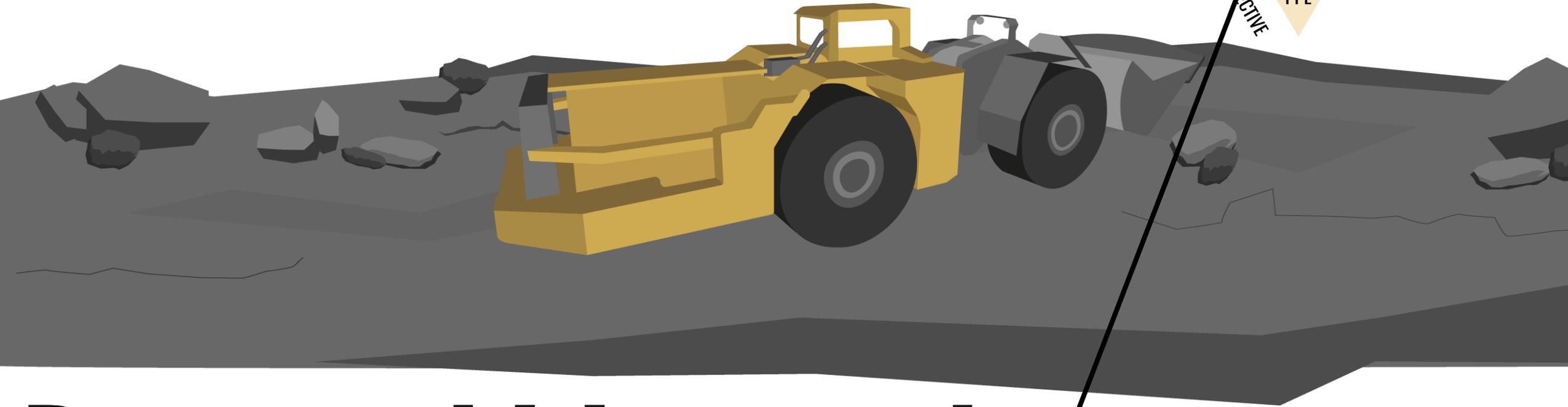
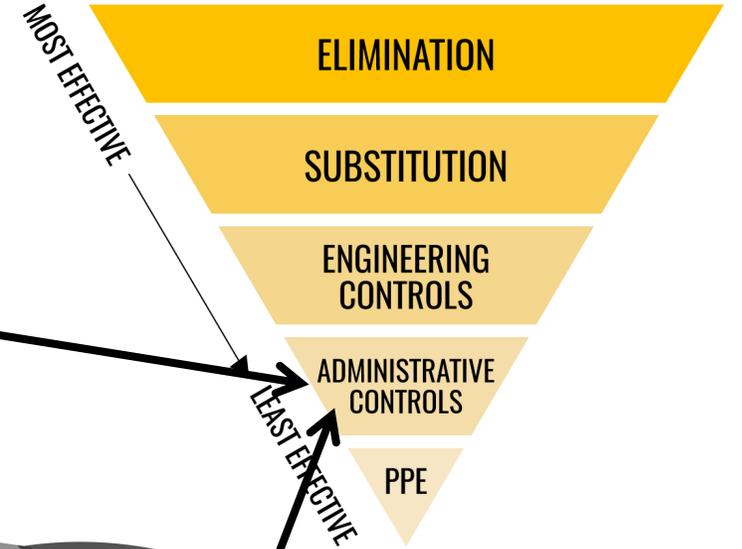
For demanding agricultural and construction applications.

CLEARMOTION.COM

ClearMotion 

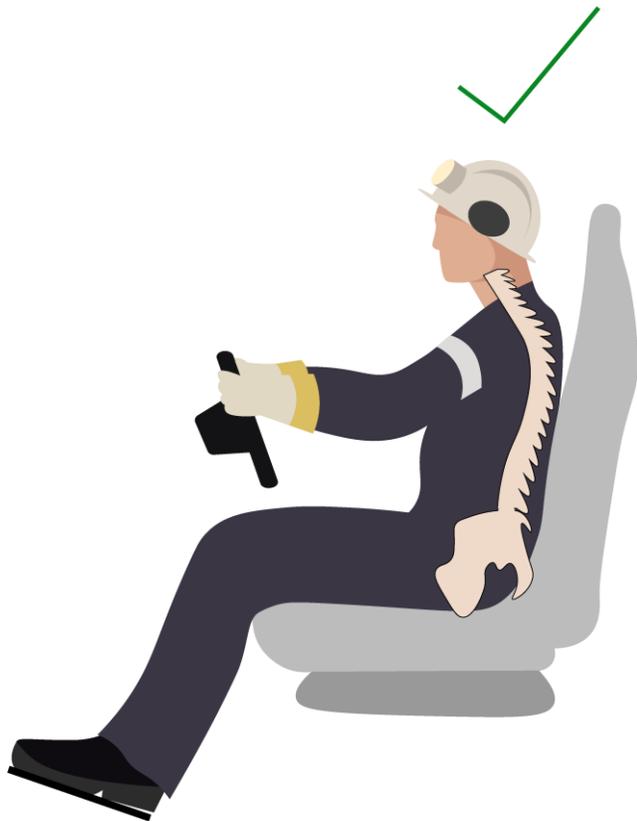
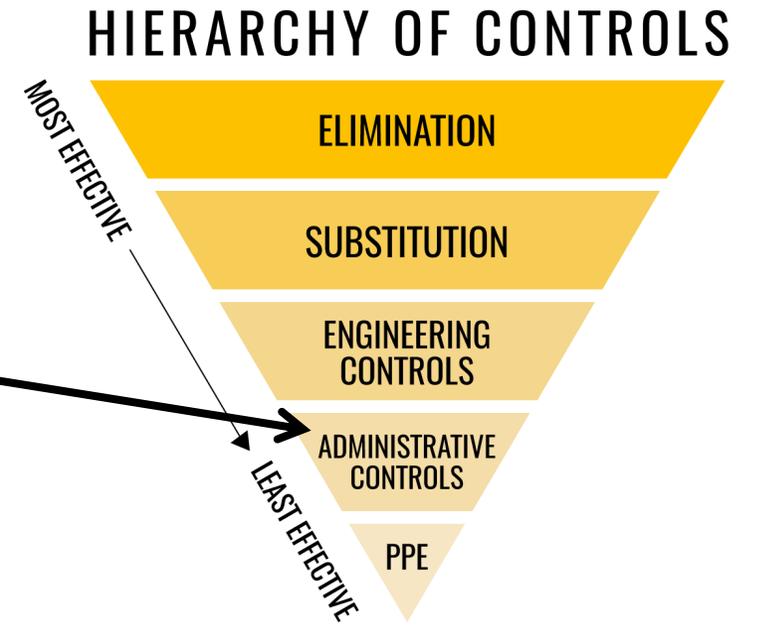
Maintain roadways and equipment

HIERARCHY OF CONTROLS



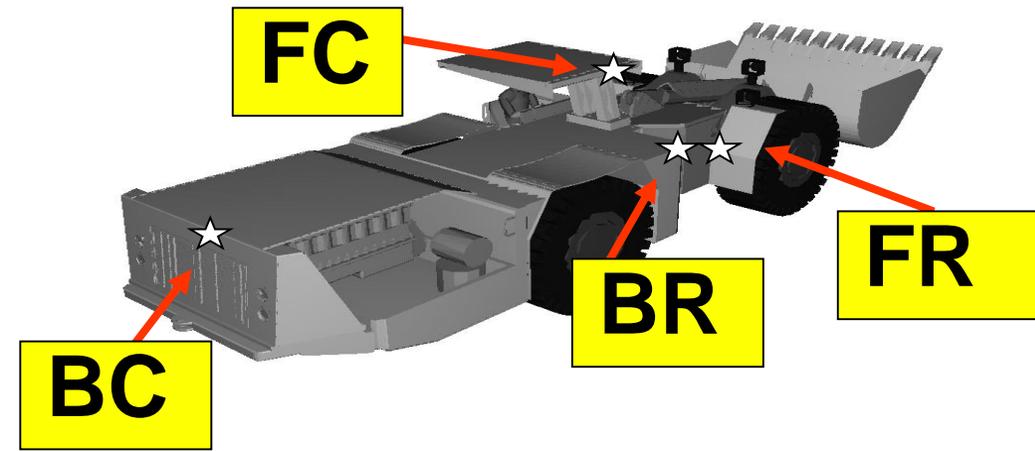
Decrease driving speeds

Maintain a neutral supported driving position whenever possible



Posture Improvement

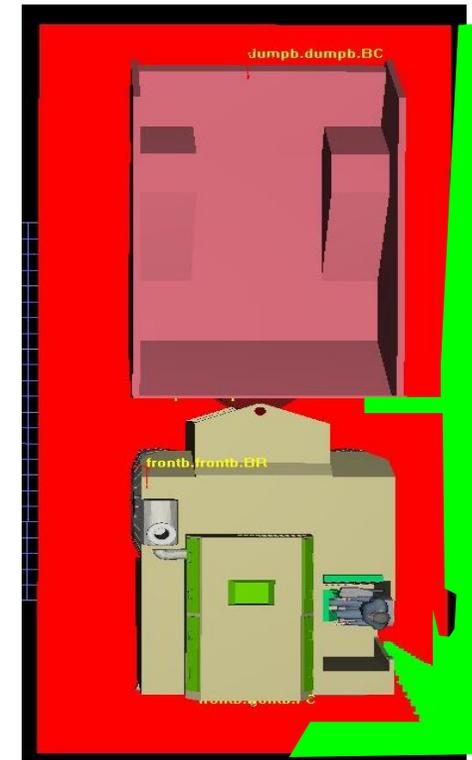
- Operator posture improved with improved line-of-sight
- Operator line-of-sight is improved with the installation of cameras



LOS

(no cameras)

4 Cameras

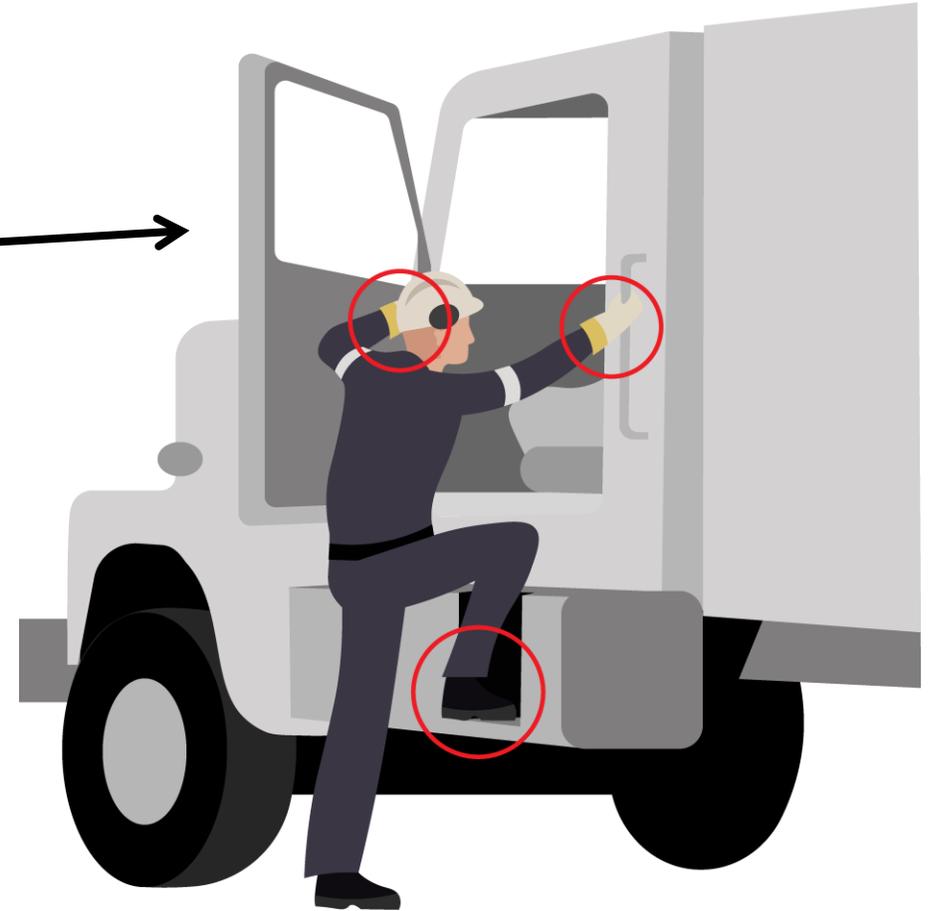


(Godwin, & Eger, 2009)

HIERARCHY OF CONTROLS

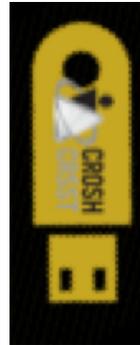
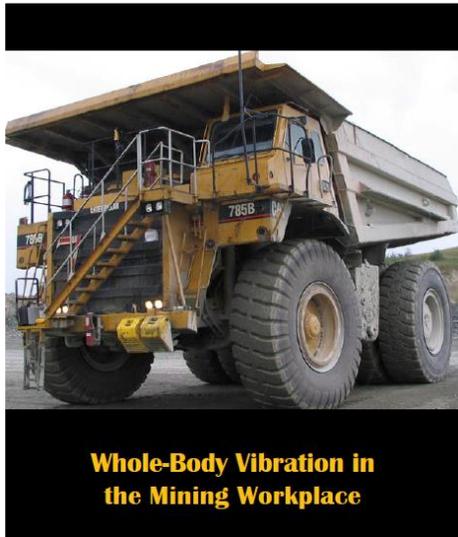


Use 3-point contact when getting in and out of equipment



Education, Training and Exposure Management

A comprehensive evidence-based program to raise awareness around hazards and control strategies for whole-body vibration exposure associated with mobile equipment operation.

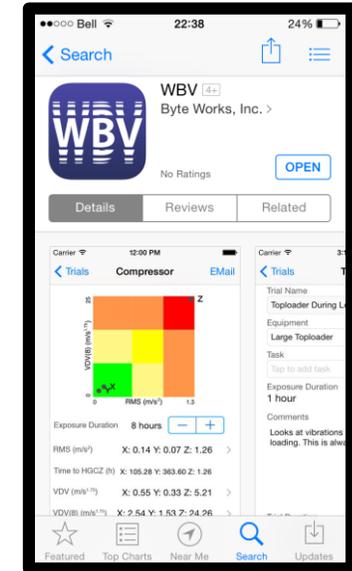
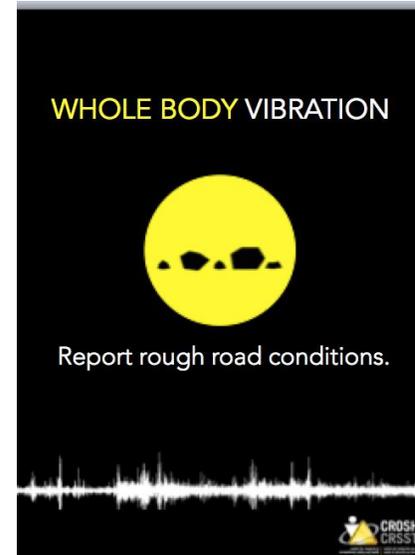


SAFETY CHECK
WHOLE BODY VIBRATION

| | YES | NO |
|---|-----------------------|-----------------------|
| Are the roadways maintained for a smooth ride? | <input type="radio"/> | <input type="radio"/> |
| Are you aware of your driving speed? | <input type="radio"/> | <input type="radio"/> |
| Has the vehicle undergone routine maintenance recently? | <input type="radio"/> | <input type="radio"/> |
| Do you have your seat adjusted according to your body dimensions? | <input type="radio"/> | <input type="radio"/> |
| Are you able to sit with a neutral posture while driving? | <input type="radio"/> | <input type="radio"/> |

If you have answered NO to any of these questions, please discuss vibration control strategies with your supervisor.

CROSH CRST



EDUCATE

ENGAGE

REINFORCE

EVALUATE

CONTROL

Fatigue



Sandra Dorman, PhD

Director, CROSH

Full Professor, School of Human Kinetics

Fatigue

Fatigue can include physical and mental fatigue, can be task dependent and is not necessarily commensurate with sleepiness

General Definition: a decreased capacity to perform.

Fatigue has many possible causes and is associated with many different condition



Fatigue and Accidents

Human errors: 80% of industrial accidents

First cause: attention lapses & fatigue

Fatigue: 31% of fatal to the driver truck accidents



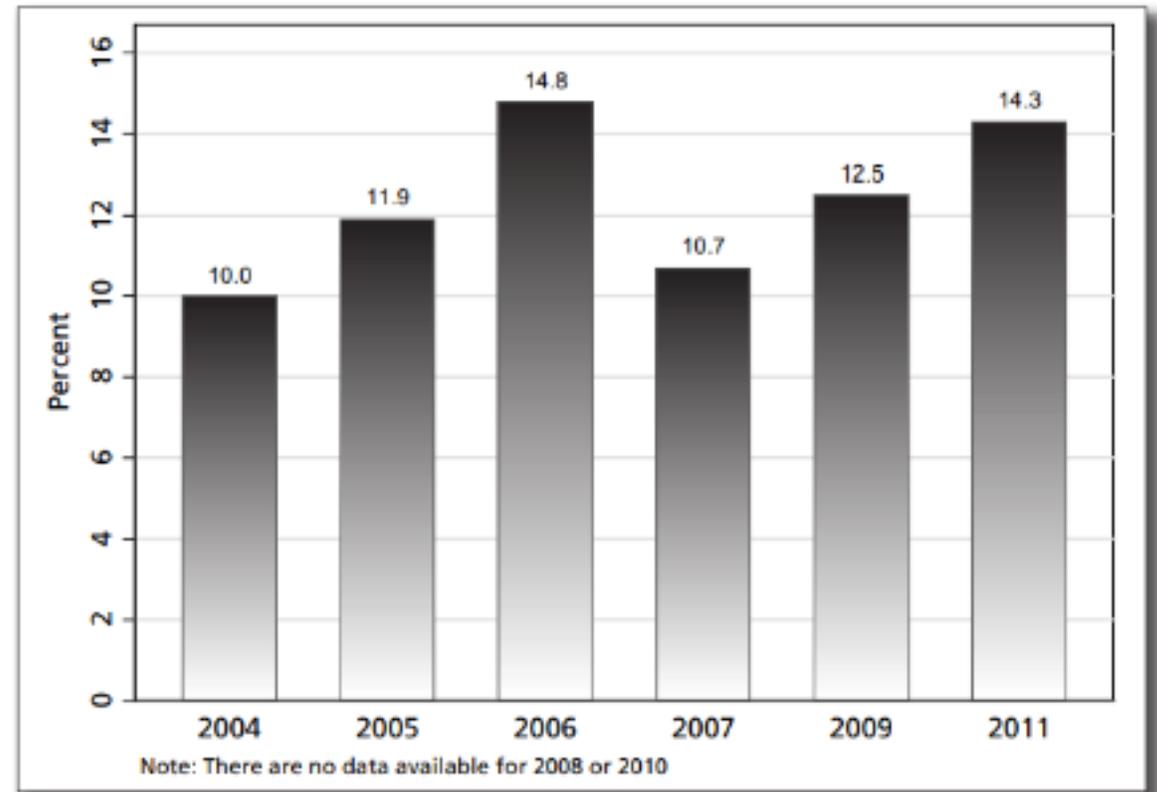
Driving in Canada

20% of drivers have fallen asleep or nodded off while driving in the past year

- 33% had been driving for less than an hour
- 30% between 9pm and 6am

61% of drivers rated drowsy driving as ‘a very or extremely serious problem’

Self-report fatigued driving



Mobile Equipment and Fatigue

- Impaired cognitive and motor performance
- Reduced alertness
- Longer reaction time
- Ability to respond to emergencies is reduced
- Impaired concentration
- Decreased task motivation
- Memory problems
- Poor judgment



Factors Contributing to Fatigue

- Personal Factors
 - Sleep (quality and quantity)
 - Fitness
 - Nutrition
 - Hydration
 - Psychosocial factors
 - Smoking (environmental exposures)
- Workplace Factors
 - Physical demands of the job (workload; vibration)
 - Environmental factors (light; noise; temperature; humidity)
 - Mental demands of the job (psychosocial factors)
 - Respiratory factors (particulate matter exposure)



Consensus Statement

Major causes of fatigue are:

- Time of day of the vehicle operation (e.g. night/early morning)
- A long duration of wakefulness
- Inadequate sleep
- Pathological sleepiness (e.g. Sleep apnea)
- Prolonged work hours (not necessarily operating the vehicle)

***ALL ASSOCIATED WITH NONSTANDARD SHIFTS**

Hydration

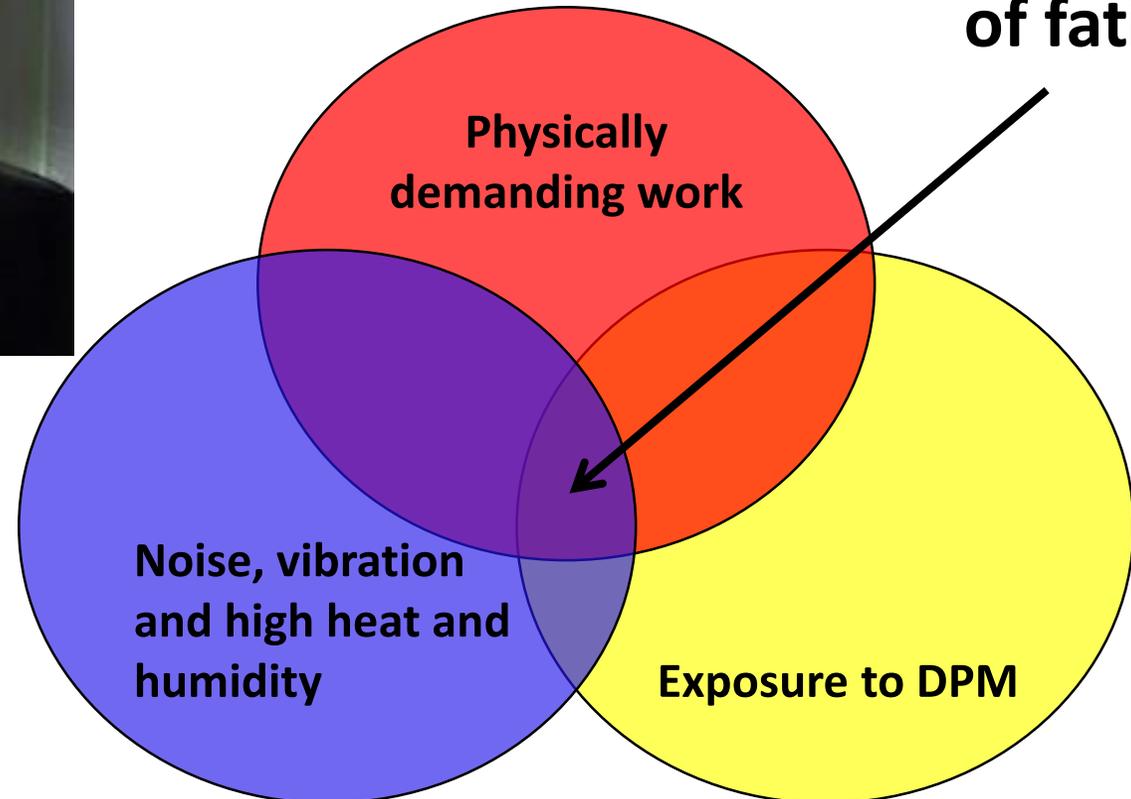
- Fluid intake is important when working in hot and humid environments
- Mild dehydration is a common and often overlooked cause of fatigue
- Dehydration can reduce blood flow to organs and slow down brain function



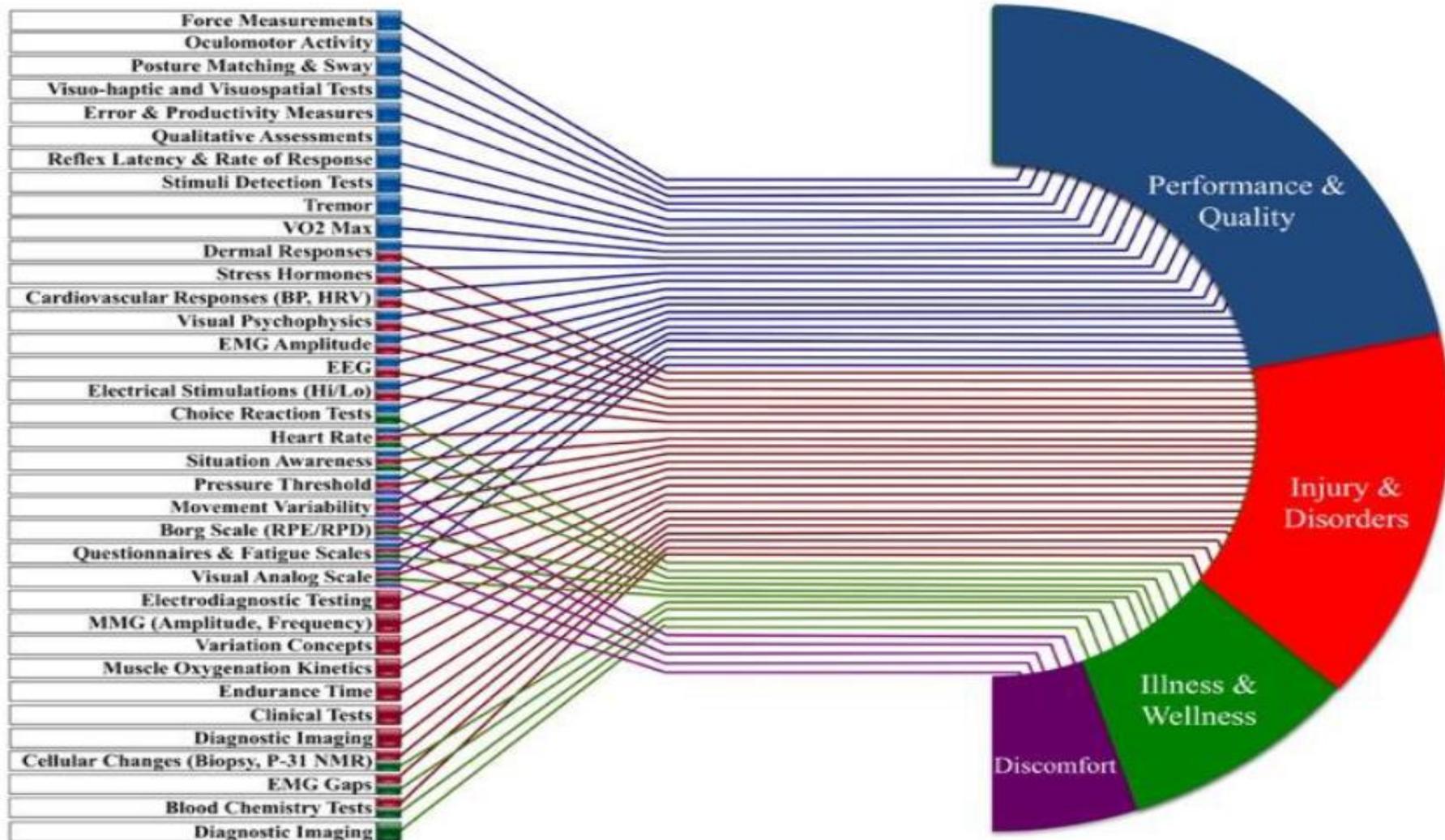
Consider Cumulative Risks:



Interaction
leading to
increased risk
of fatigue?



How do we Measure Fatigue?



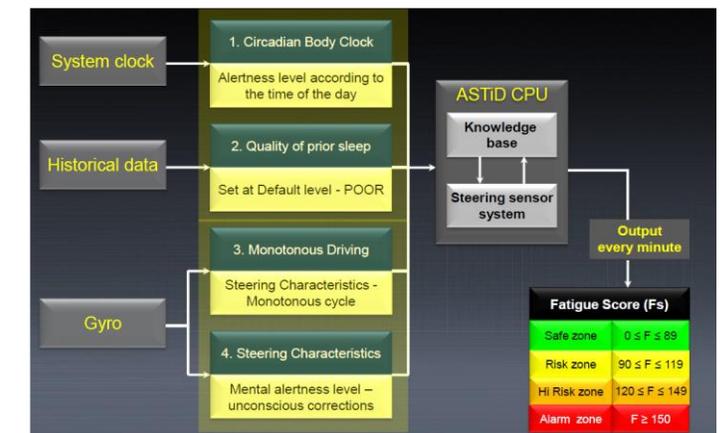
Currently there is no single measure that is sufficient to capture all aspects of fatigue.

“Fatigue Detection” Technologies

- Fitness-for-duty tests
- Continuous operator monitoring
 - Real-time observation and analysis of operator behavior and/or physiology
 - Ex. eye closure, head position, brain wave
- Performance-based monitoring
 - Monitor tasks
 - Ex. lane tracking, vehicle speed



Source: www.seeingmachines.com



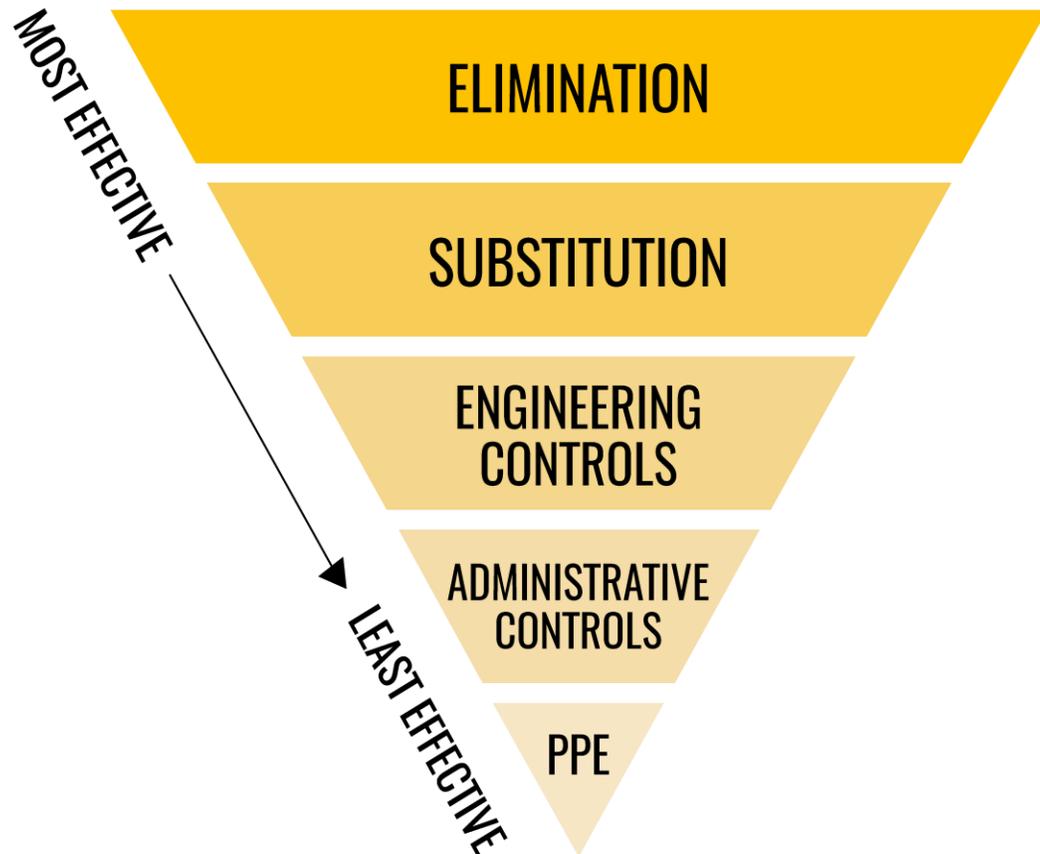
<https://fmilt.co.uk/assets/summary-of-operation-.pdf>

Technology Limitations

- If you are considering a “fatigue monitoring” technology you are advised to conduct your own review to determine if independent research has been conducted
 - there is currently little systematic evidence regarding their scientific reliability or validity
 - Researchers have reported: detection technology cannot prevent fatigue from occurring or mitigate it

Technology Limitations

HIERARCHY OF CONTROLS



- Fatigue Monitoring CANNOT be substituted for a Fatigue Management System
- They do not protect you legally (in absence of a FMS)
- How these technologies contribute to an effective fatigue risk management system is still unclear

Consideration: Commuting

Dram Law – a business/host who serves alcohol to an obviously intoxicated person is liable for injuries sustained by third party as a result of the intoxicated person.

? Does



=



Conclusions

- Employees require education and awareness training
- Employers / Operators need a Fatigue Management Response System, specific to the individual risks within their operations
- This System may include technology that assesses contributors to fatigue or physiological indicators of fatigue.



PREVENTION THROUGH RESEARCH

Current: Knowledge Transfer Project

CROSH

Centre for Research in Occupational Safety and Health

/ KNOWLEDGE TRANSFER KITS



VIBRATION
EXPOSURE



LINE OF SIGHT
ISSUES



FATIGUE
MANAGEMENT

CROSH

EACH KNOWLEDGE TRANSFER KIT INCLUDES:



Safety meeting presentations and discussion questions



Leaders' guide to help with instruction



Posters to display to reinforce the safety message



Interactive technology for hands-on learning

CONTACT US FOR MORE INFORMATION



crosh@laurentian.ca



www.crosh.ca



[@CROSH_CRSSST](https://twitter.com/CROSH_CRSSST)



Questions

www.CROSH.ca

CROSH@laurentian.ca

[@CROSH_CRSST](https://twitter.com/CROSH_CRSST)



CROSH
CRSST

centre for research in
occupational safety and health
at Laurentian University

centre de recherche sur la
santé et sécurité au travail
à l'Université Laurentienne

Sandra Dorman

Director, CROSH

Tel: 705-675-1151 ext. 1015

E-mail: sdorman@laurentian.ca

Tammy Eger, Ph.D.

Research Chair, CROSH

Tel: 705-675-1151 ext. 1005

E-mail: teger@laurentian.ca

Alison Godwin, Ph.D.

Associate Director, CROSH

Tel: 705-675-1151

E-mail: agodwin@laurentian.ca