

Intelligent Proximity Detection Technology for Underground Coal Mines

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NIOSH - OMSHR

The mission of the Office of Mine Safety and Health Research (OMSHR) is to **eliminate mining fatalities, injuries, and illnesses through research and prevention.**

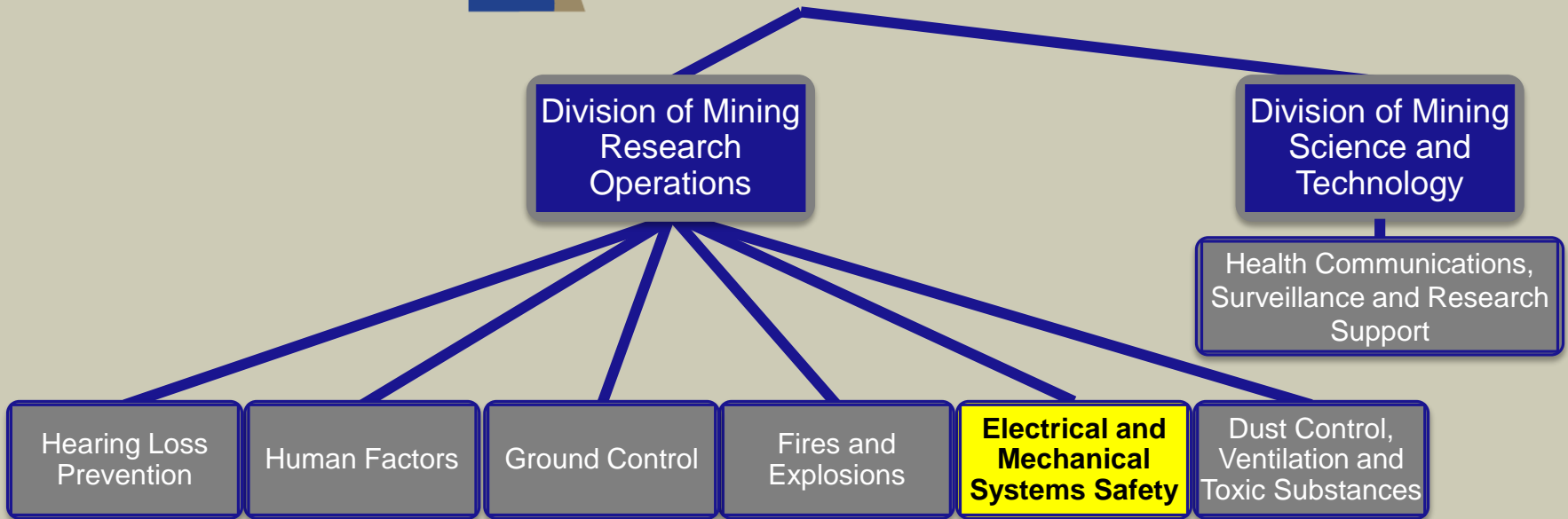


OMSHR Organization



Office of Mine Safety
and Health Research

improving the health and safety of mine workers



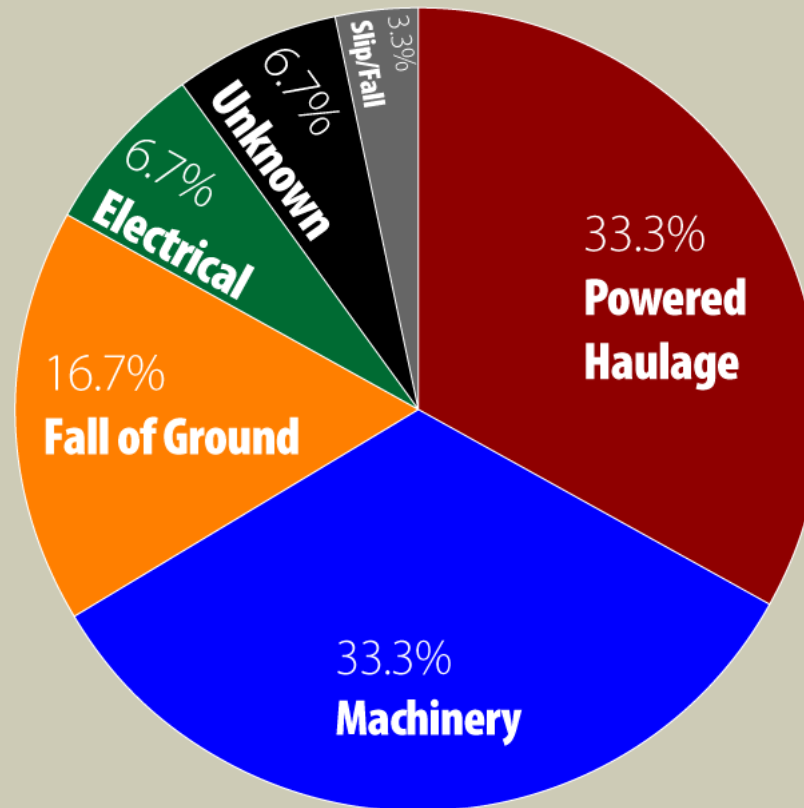
Electrical & Mechanical Systems Safety Branch

Current Research Activities

- Development of an intelligent Proximity Detection (iPD) system for Continuous Mining Machines
- Intelligent Lock out/Tag out (iLOTO)
- Battery Safety
- Mine communication and tracking



Coal Mining Occupational Fatalities by Accident Classification



Data source: MSHA 2008
Excludes office workers



Injuries/Fatalities Proximity systems may prevent



- 37 crushing/pinning fatalities involving continuous mining machines (CMM) since 1984
 - 2/13/2013: A miner was pinned between the tail of the CMM and the rib
- 12 crushing/pinning fatalities involving shuttle cars since 1995
- Typical CMM pivot rate can exceed 6 fps at head and tail



Proximity Detection Systems: engineering controls solution

- Underground proximity systems detect the presence of personnel nearby using electromagnetic technology
- Provides warnings and shut down of the equipment
- MSHA plans to publish a final rule in 2013 that would require proximity detection systems on all continuous mining machines except full-face machines. (DOL Unified Agenda, RIN 1219-AB65)



OMSHR Research Efforts in proximity detection

- Hazardous Area Signaling And Ranging Device (HASARD) concept proposed by NIOSH researchers and conducted tests in the late 1990s
 - Formal development started in 1998
 - NIOSH awarded patents in 1999 (Patents 5,939,986 & 6,810,35)
- Escapability research with computer simulations
- CMM Operator positioning and visual cues
- NIOSH intelligent proximity detection technology development including posture ID and Visual Warning



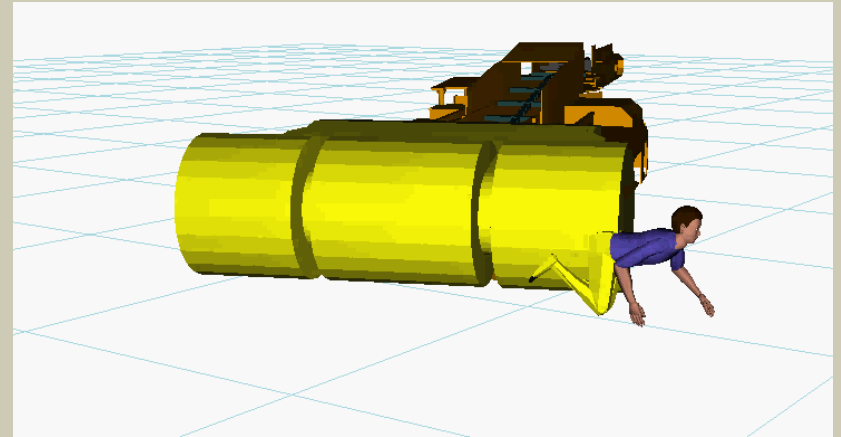
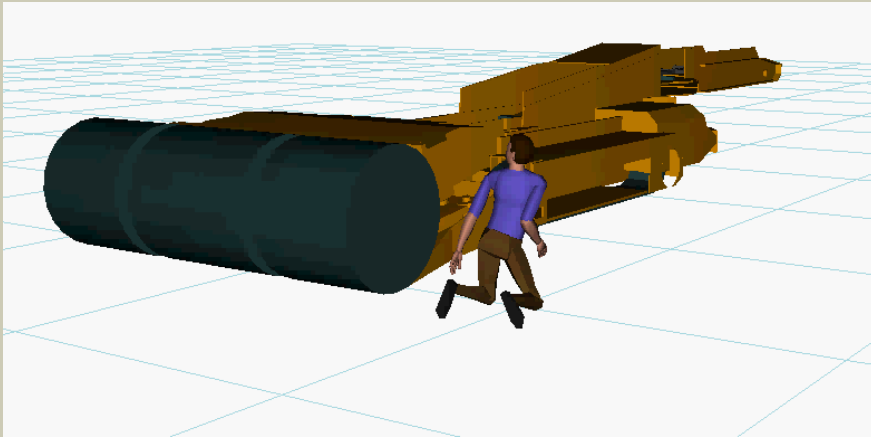
Escapability Studies

- Motion capture data was recorded using experienced miners
 - 3 postures
 - 3 facing directions
 - 8 escape directions



Escapability Studies

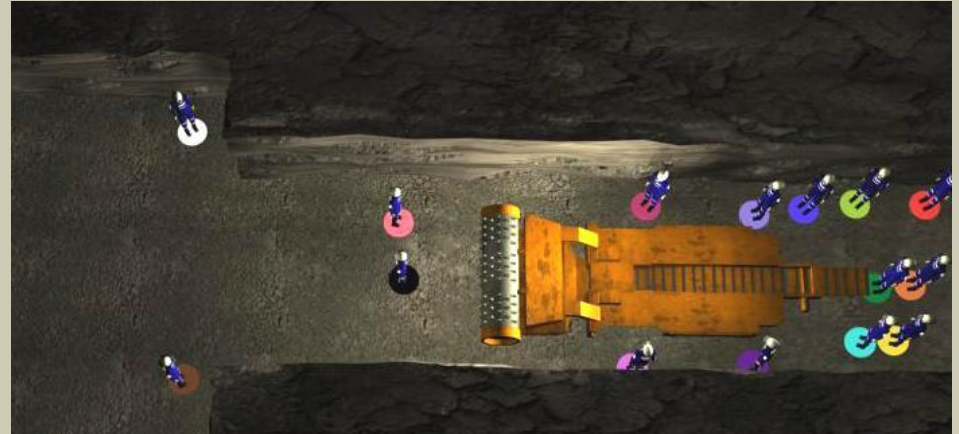
- The motion data was fed into a simulation that included a digital human model and a moving continuous mining machine
- Results showed that a position farther than 3 feet from a moving machine could significantly reduce the likelihood of an operator being struck by the CM



Work Position and Visual Cues

Continuous mining machine operators were interviewed about:

- Work positions
- Work postures
- Visual attention locations



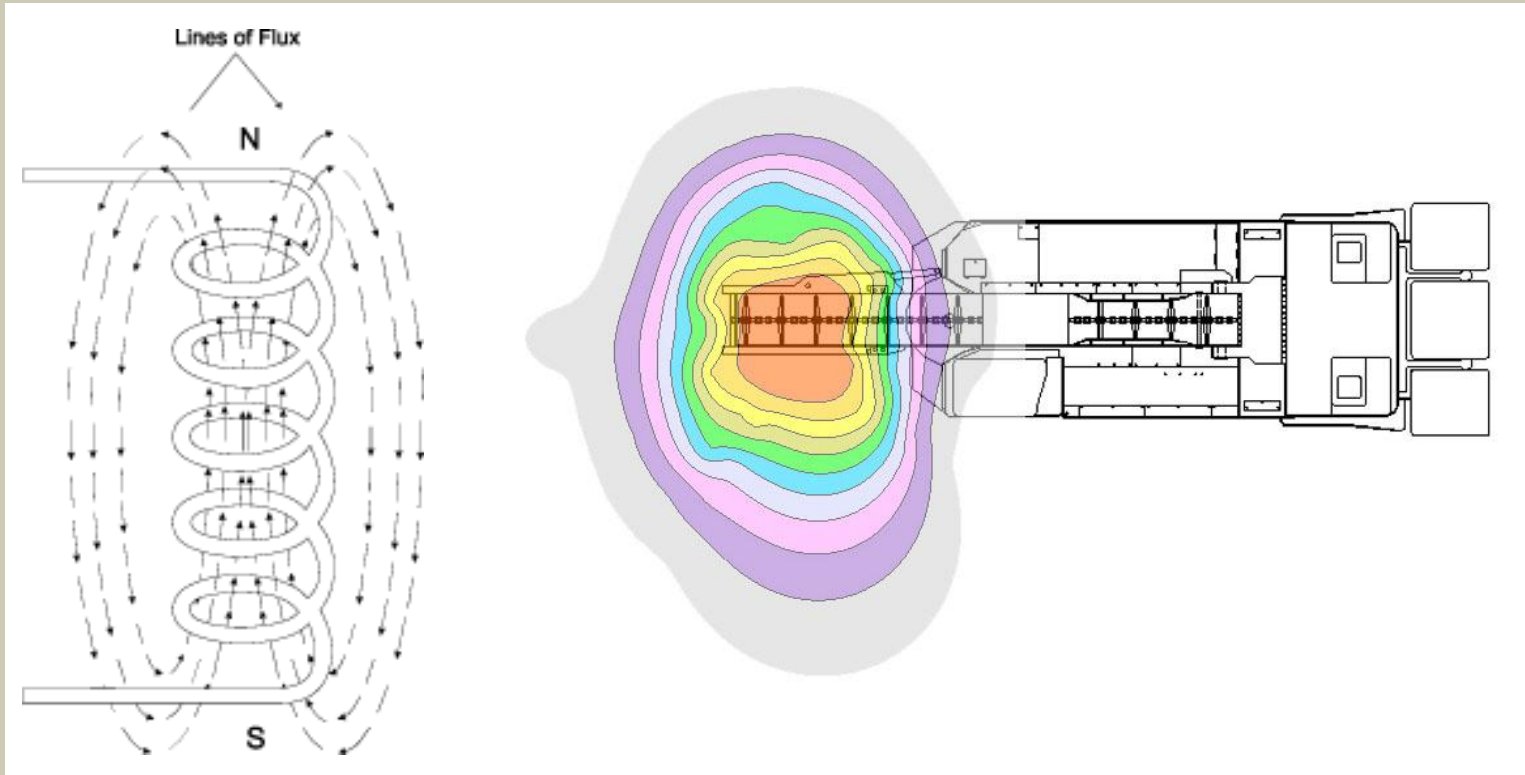
Conclusions:

- Operators work from a variety of positions and postures around the machine
- All areas around the machine need to be protected
- Some visual cues may require the operator to be very close to the machine

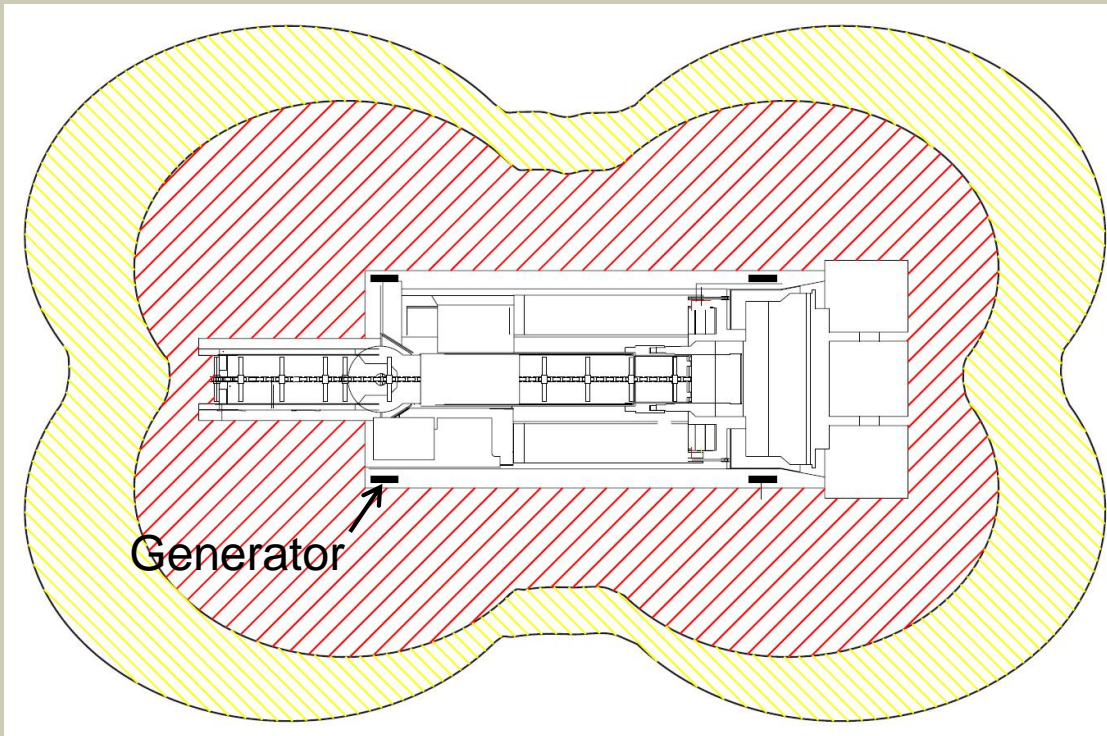


Electromagnetic Proximity Detection

- Magnetic fields generated by copper wound ferrite core



Current Proximity Detection Technology



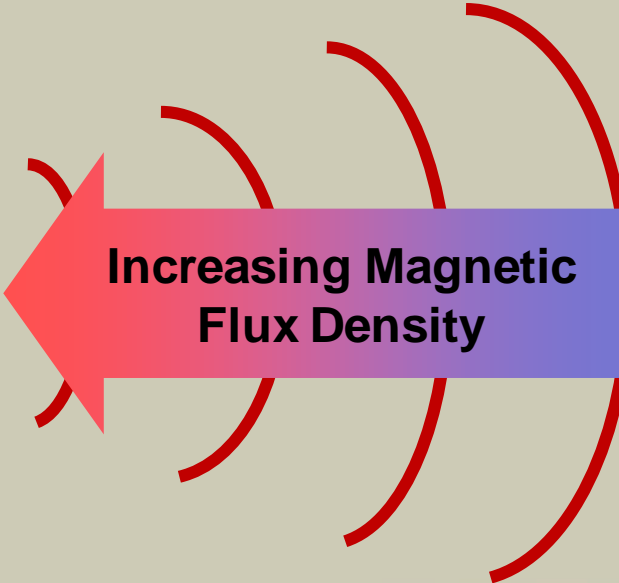
- Various generators are used to provide desired coverage.
- System does not know where the person is, only whether they are in a zone.



Electromagnetic Proximity Detection



Ferrite-Cored
Magnetic Field
Generator



Personal
Alarm Device
(PAD)



NIOSH Intelligent Proximity Detection

- The NIOSH intelligent proximity detection system does not disable all machine motions
- It uses triangulation to determine an operator's position, not just their presence
- Instead, it makes decisions based on operator position and only disables those machine motions that could cause harm
- Safe machine motion is allowed to continue uninterrupted



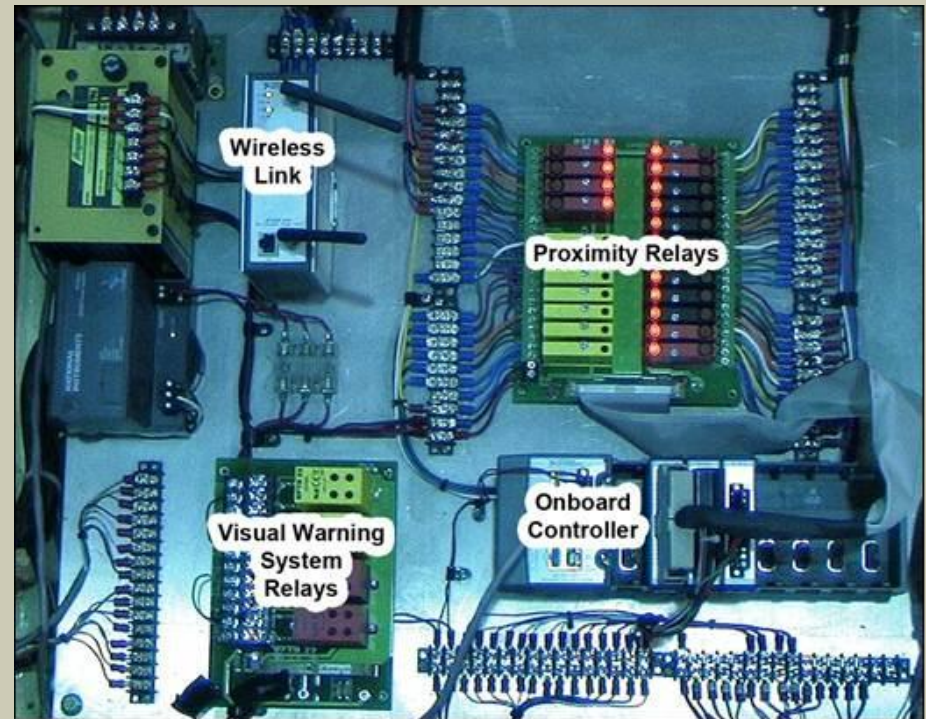
NIOSH Intelligent Proximity Detection

- The intelligent system allows the operators freedom to select where they will stand without disabling all machine motion
 - The operator can select a position that provides best protection from other hazards such as unsupported roof and ribs
 - The operator will be able to have better visibility allowing for safer operation of the machine
 - Operator frustration will be minimized – operator acceptance is critical to the success of any safety device

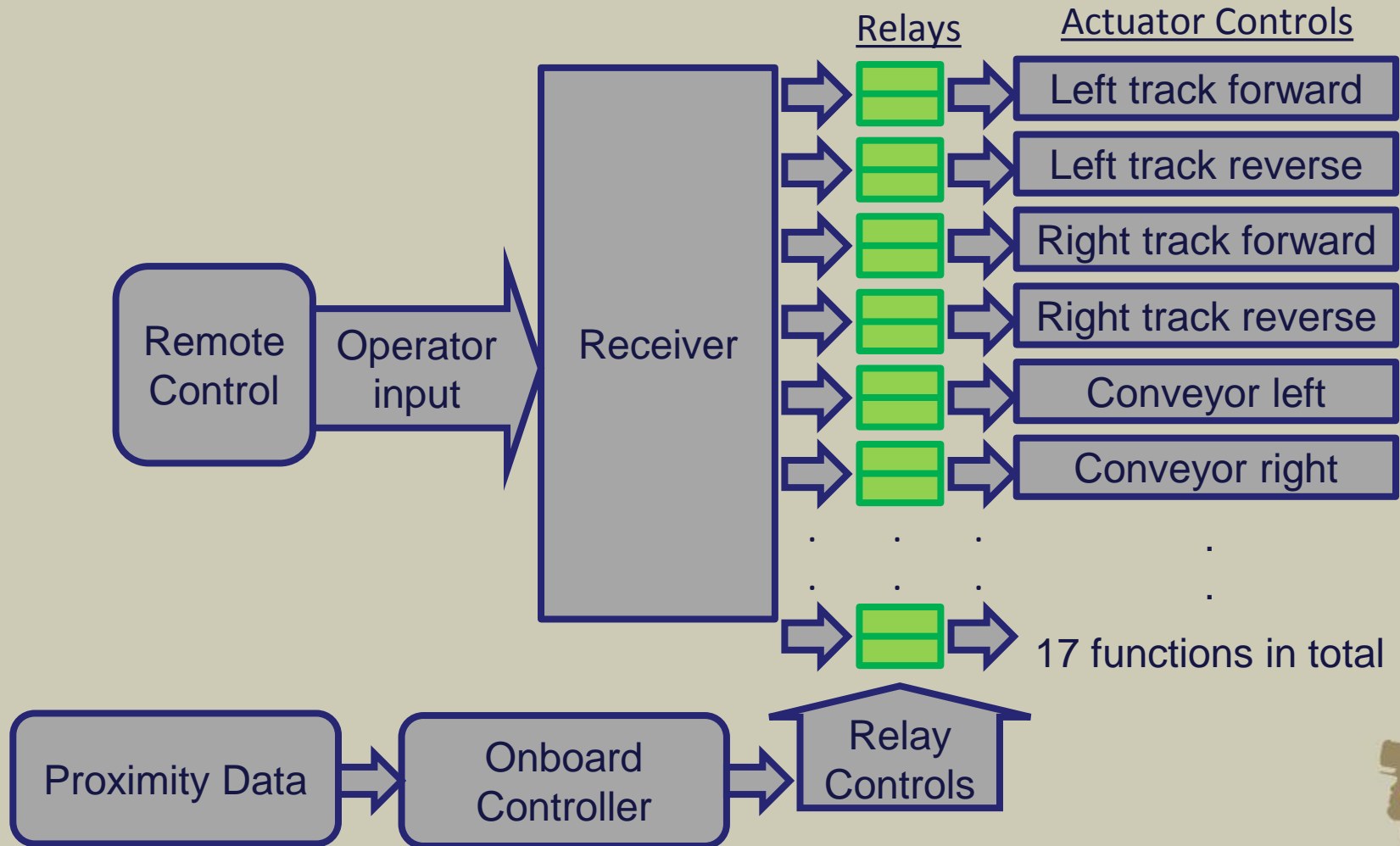


NIOSH development of Intelligent Proximity Detection

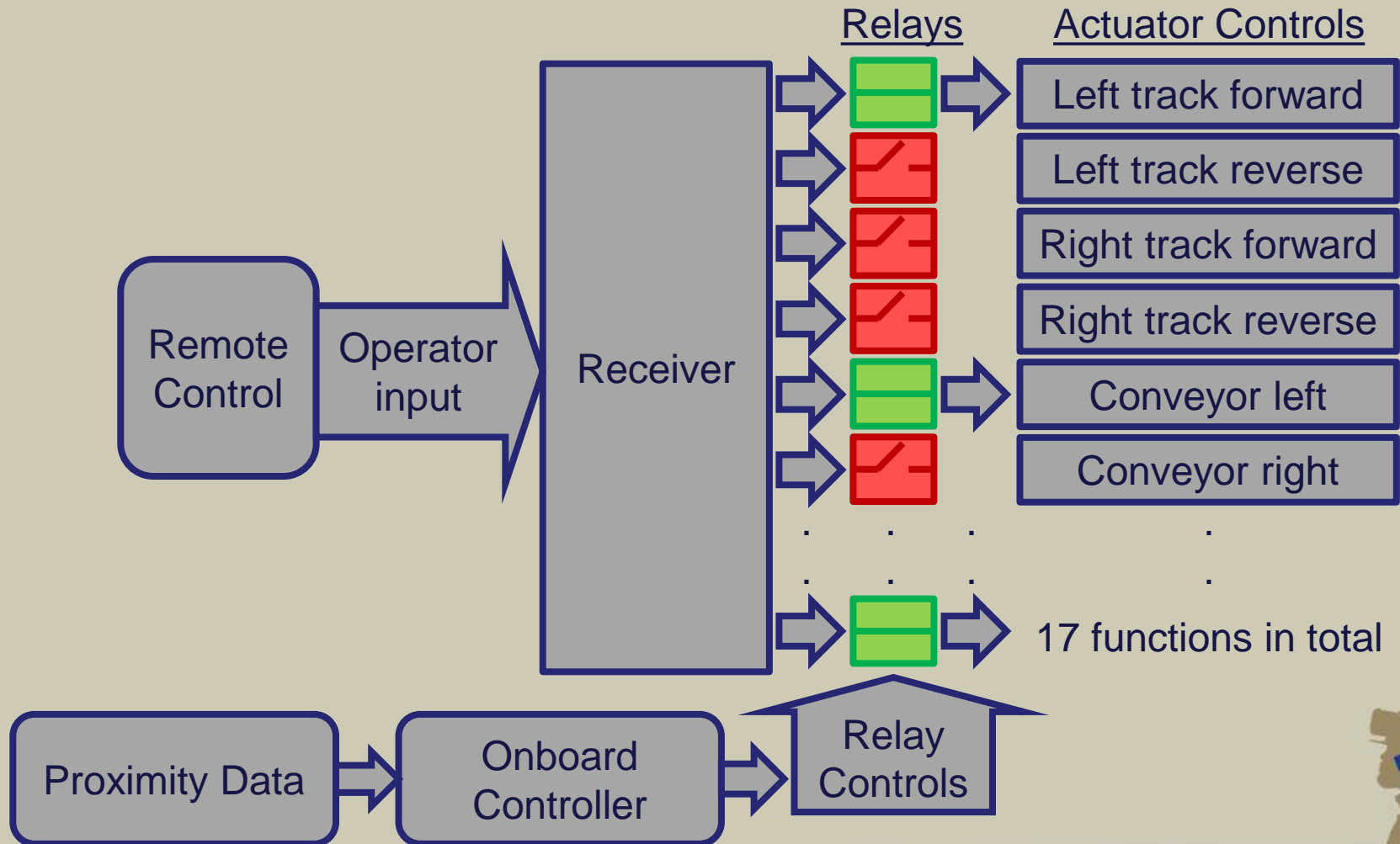
- Installed on a Joy 14CM continuous mining machine at the OMSHR
- Uses commercially available proximity detection hardware
- Utilizes NIOSH-developed technology and software



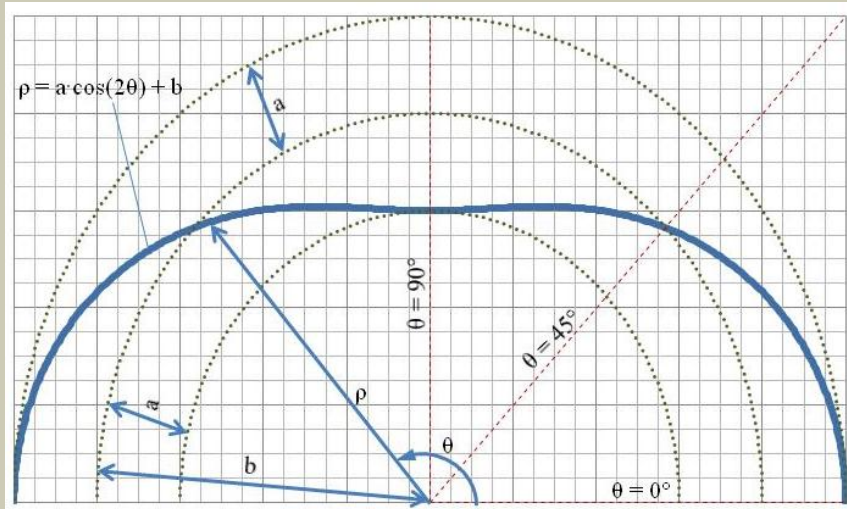
Machine Control Interface: Intelligent Proximity Detection



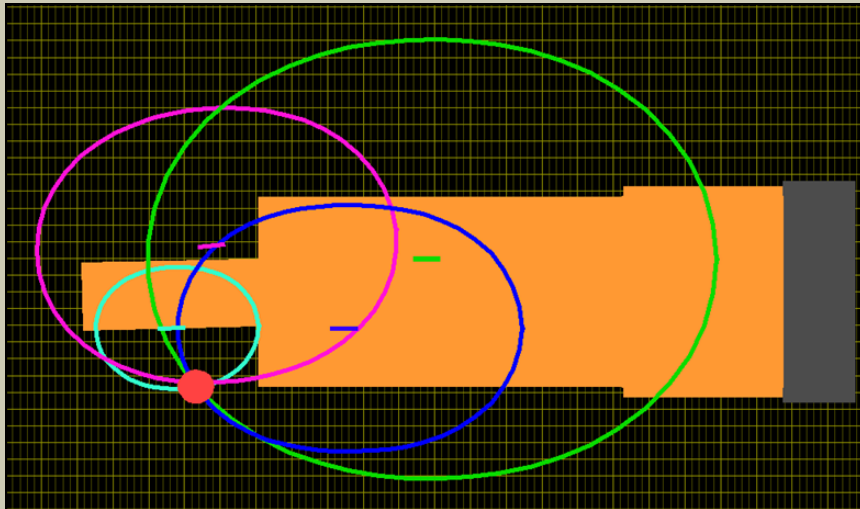
Machine Control Interface: Intelligent Proximity Detection



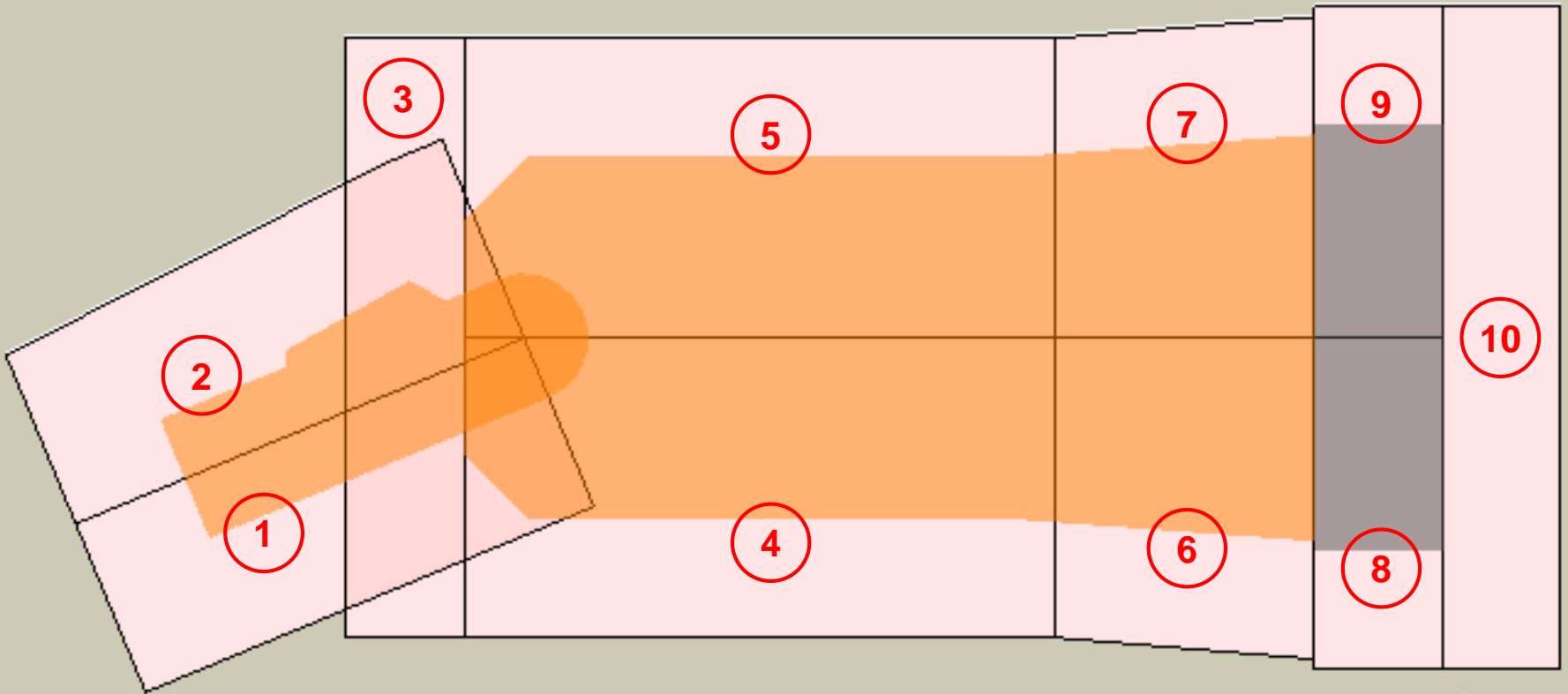
Real-Time Position Tracking



By mathematically modeling the magnetic fields and applying triangulation techniques using multiple generators, the operator's position relative to the machine can be determined

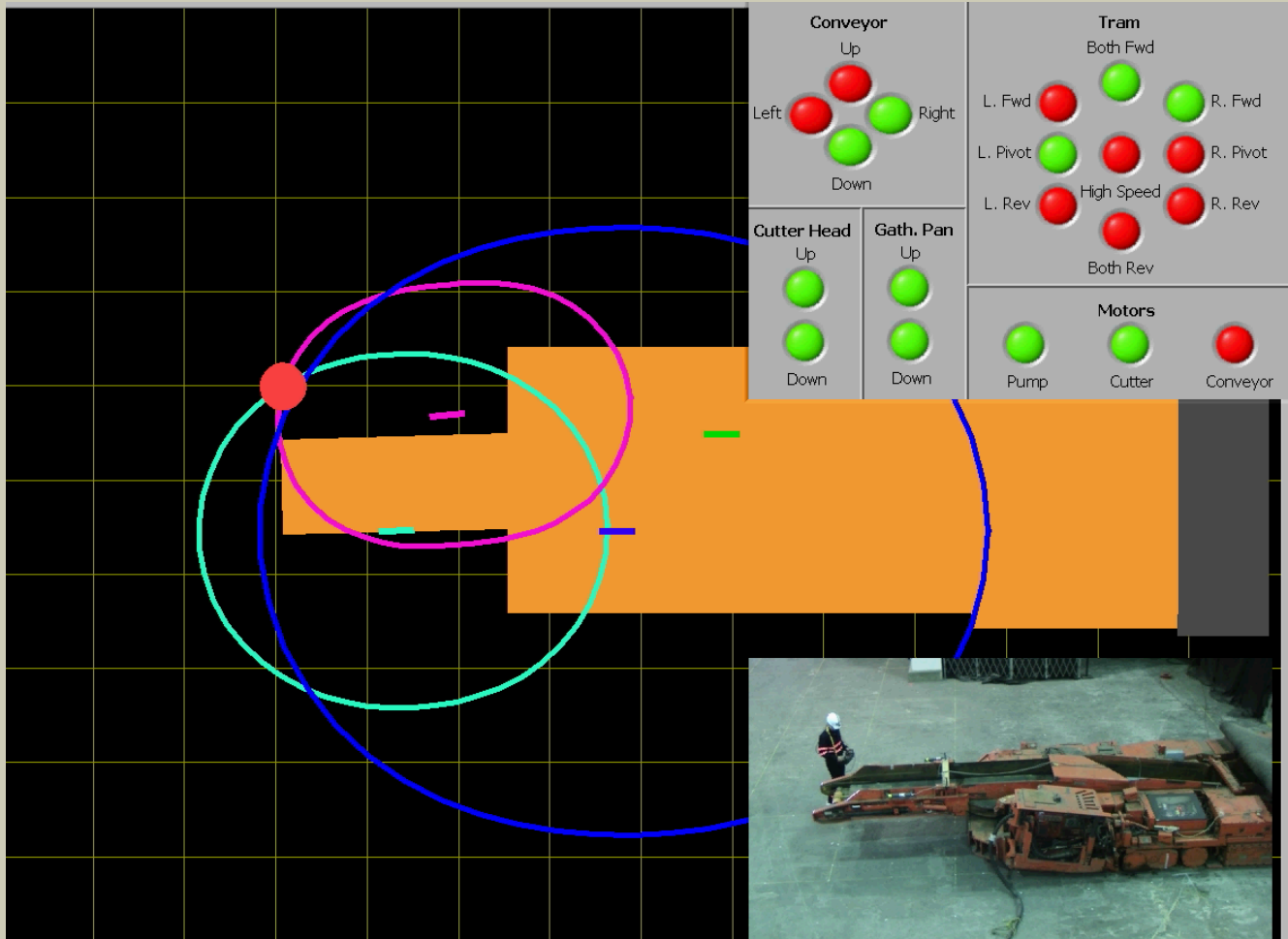


Dynamic Programmable Safety Zones



Intelligent Proximity Detection

Example of operation

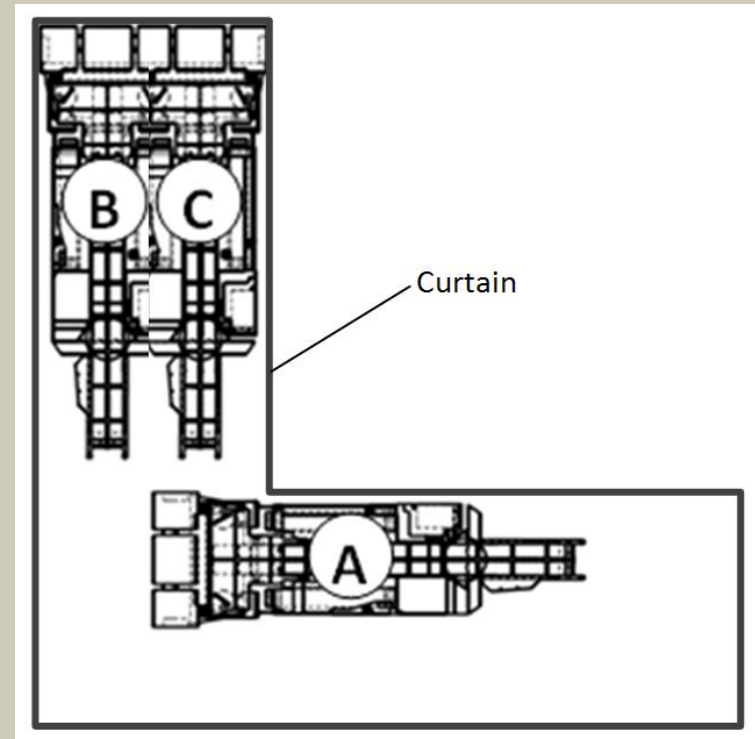


NIOSH Current Research

- Human subjects tests to quantify safety and performance
- Integration of Visual Warning System
- Adding posture ID capability



Human Subjects Tests: Simulated mining experiments



- Three modes of operation
 - No Proximity
 - Standard Proximity (+12%)
 - Intelligent Proximity (+2%)

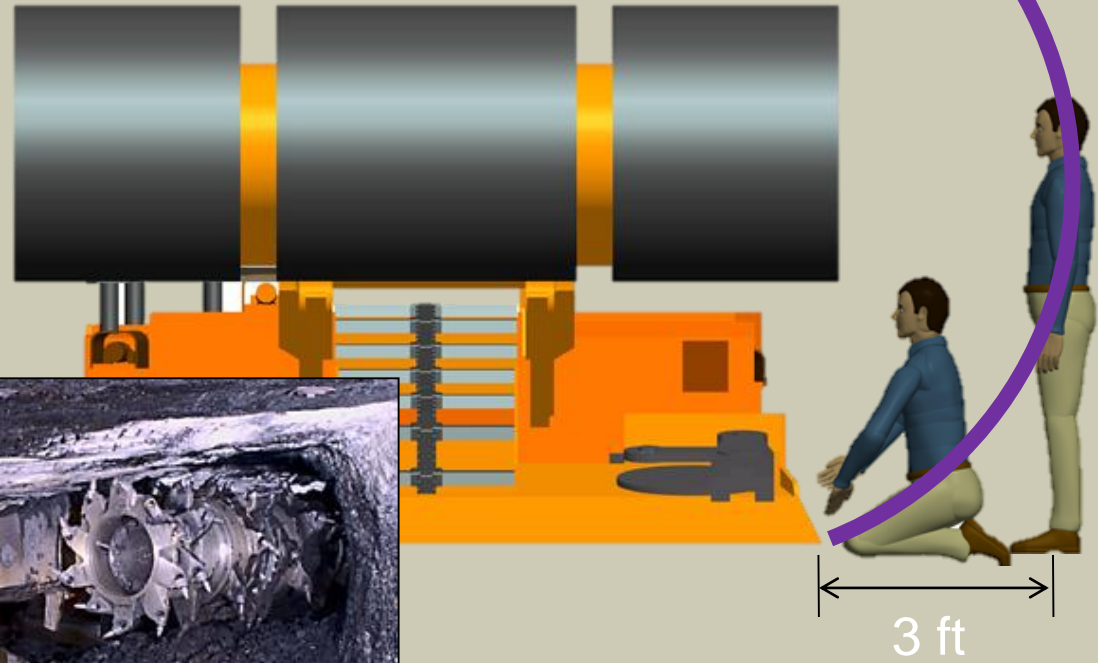


Visual Warning System

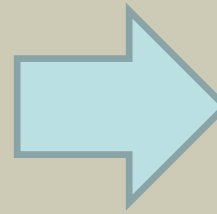
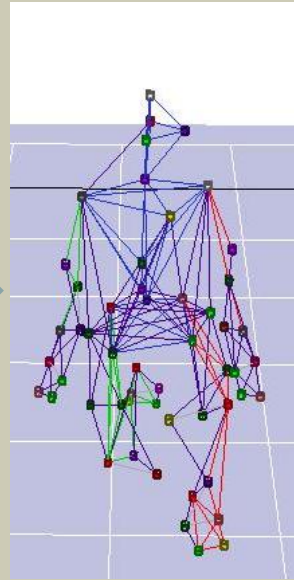
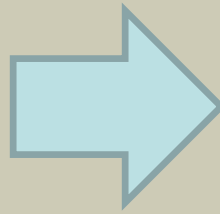
- Indicates machine motions
- Provides feedback to operator when they are detected in zone AND commanding unsafe machine motion
- Expected to improve operator acceptance of proximity detection systems



Posture Identification



Posture Identification



Motion capture of human subjects is used in digital human analysis



Posture Identification



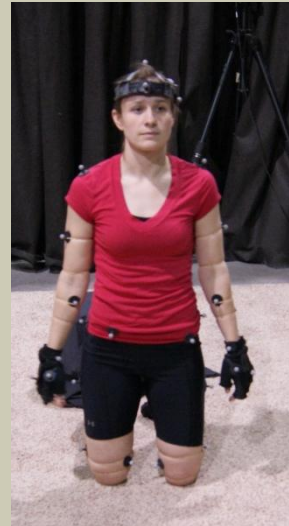
Walking/
Standing



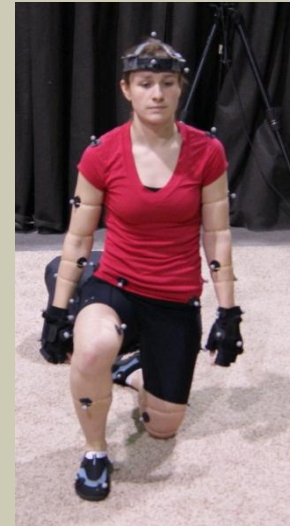
Sitting,
legs bent



Sitting,
legs
extended



Kneeling,
both
knees



Kneeling,
one knee



Lying
down



Summary

- Proximity systems can prevent striking and pinning accidents
- Pioneered with HASARD (73 khz)
- Studies developed the 3 foot recommendations
- Developed maps of fields and triangulation techniques
- Future work will optimize iPD technology
 - Prove system performance with Human subject testing
 - VWS will provide operator feedback
 - Posture ID will improve system performance and enhance safety



For more information

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OFFICE OF MINE SAFETY AND HEALTH RESEARCH



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