Collision Avoidance Systems and Seatbelt Training

Reducing Surface Mobile Equipment Accidents and Fatalities Through Technology

MSHA Powered Haulage Initiative

National Mine Health & Safety Academy

Collision Avoidance Systems Training

Mobile Equipment at Surface Mines

- Equipment Collisions with Other Equipment
- Equipment Collisions with Pedestrians

Collision Avoidance Systems Training

Mobile Equipment at Surface Mines

- 2017 Accidents
  - Nearly 40% of Fatalities Involved Mobile Equipment
  - Over 30% of Injuries Involved Mobile Equipment
- Since 2007 - 61 Mining Fatalities Involving Mobile Equipment
- 2018 - of the 24 fatalities recorded so far this year, 7 have involved a collision between a worker and a vehicle or piece of machinery (29%).

Collision Avoidance Systems Training

Blind Areas

- Mobile equipment size and shape and the operator's cab location each create unique blind areas

- Blind areas have contributed to mobile equipment operators driving over highwalls or dump points, colliding with other equipment, and striking miners

Fatality #15, 2018

METAL/NONMETAL MINE FATALITY – On November 3, 2018, a 44-year old shift supervisor with 3 years of experience was killed when a loaded Caterpillar 785B haul truck ran over her pickup truck at the crusher site.

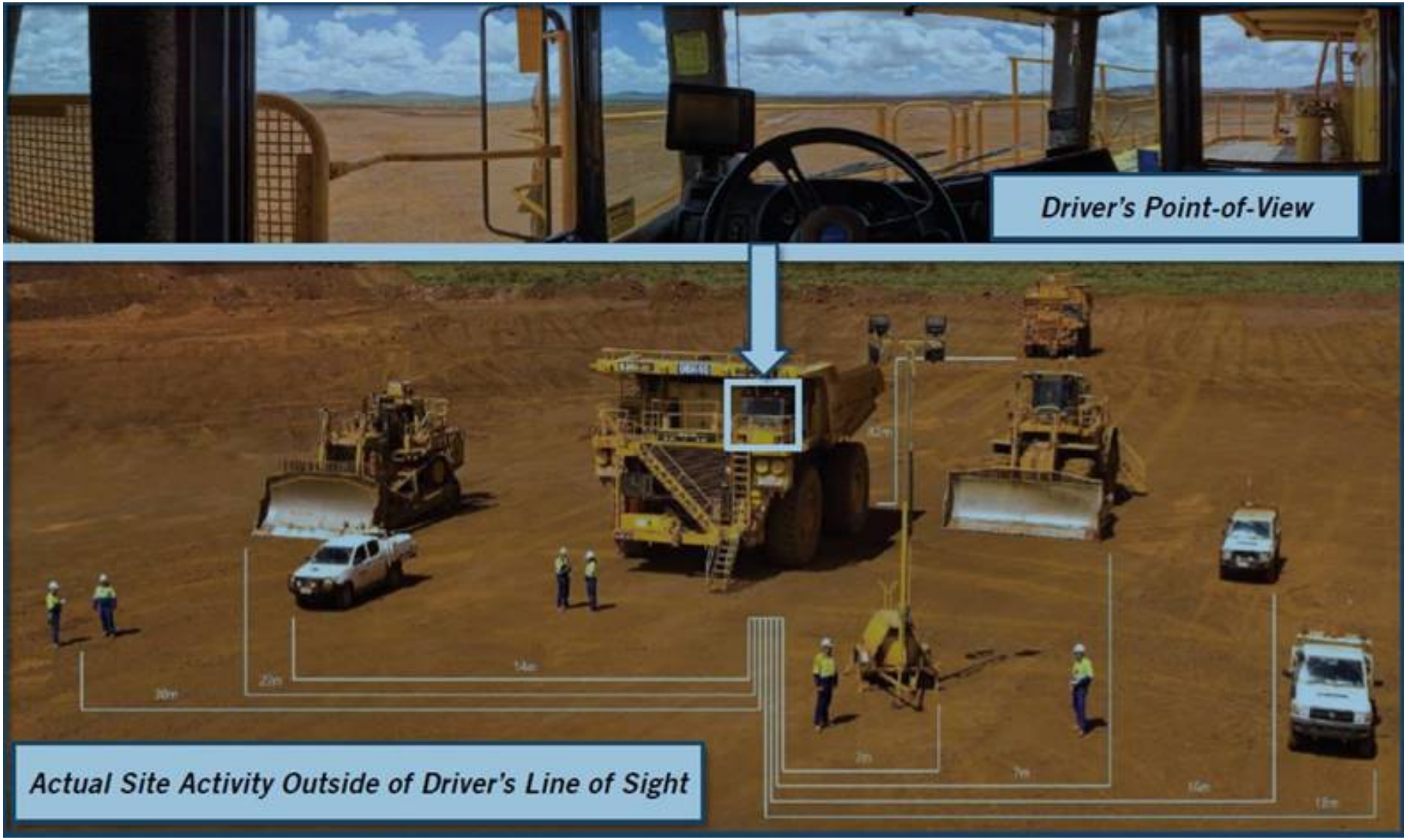
Blind Areas

- NIOSH has Developed a Manual Method of Evaluating Mobile Equipment Blind Areas

- Simplified Version of ISO Method Used by OEMs to Enable End Users to Perform Evaluations

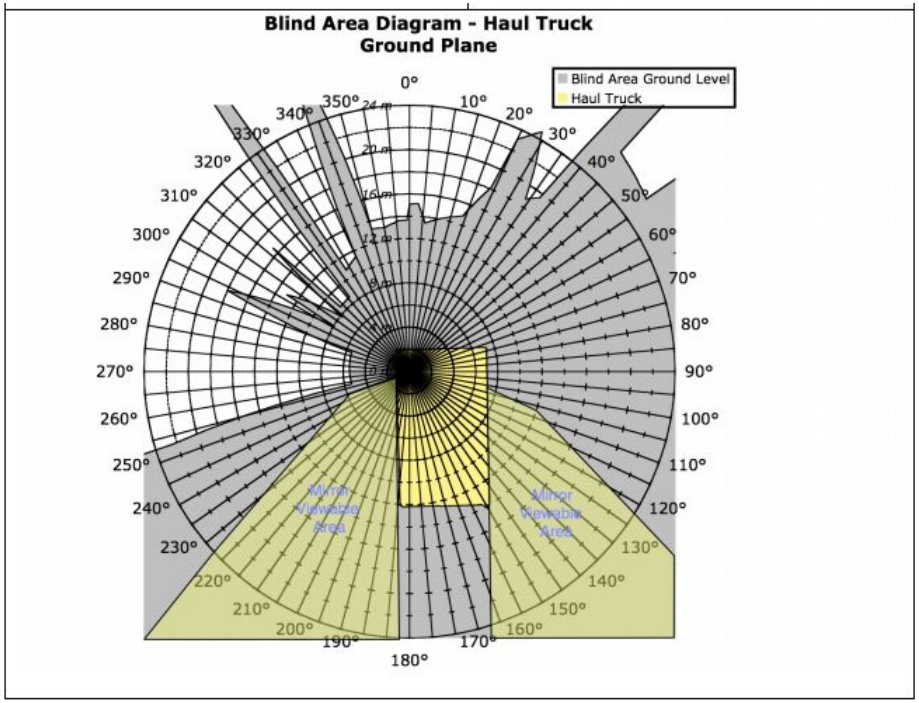
https://www.cdc.gov/niosh/topics/highwayworkzones/bad/manualmethod.html

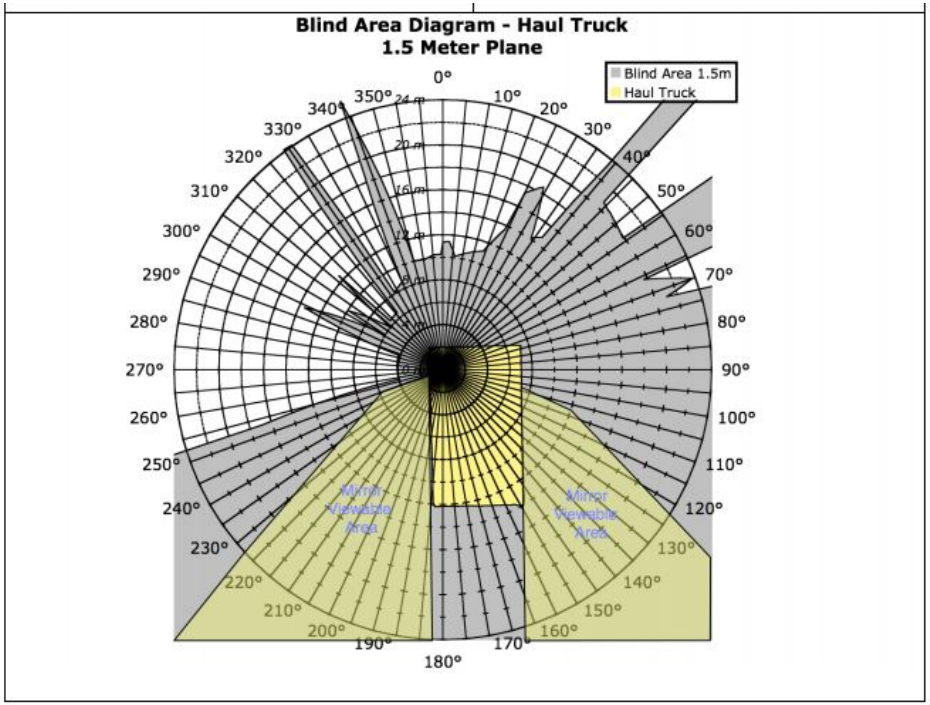
Blind Areas


Driver's Point-of-View
Actual Site Activity Outside of Driver's Line of Sight

Blind Areas

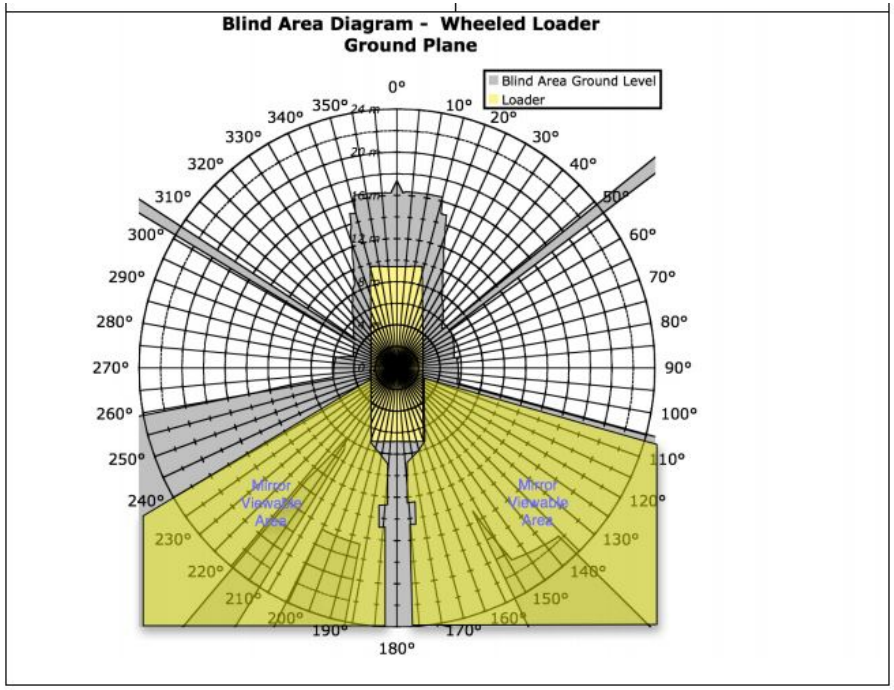
Haul Truck (NIOSH Example)

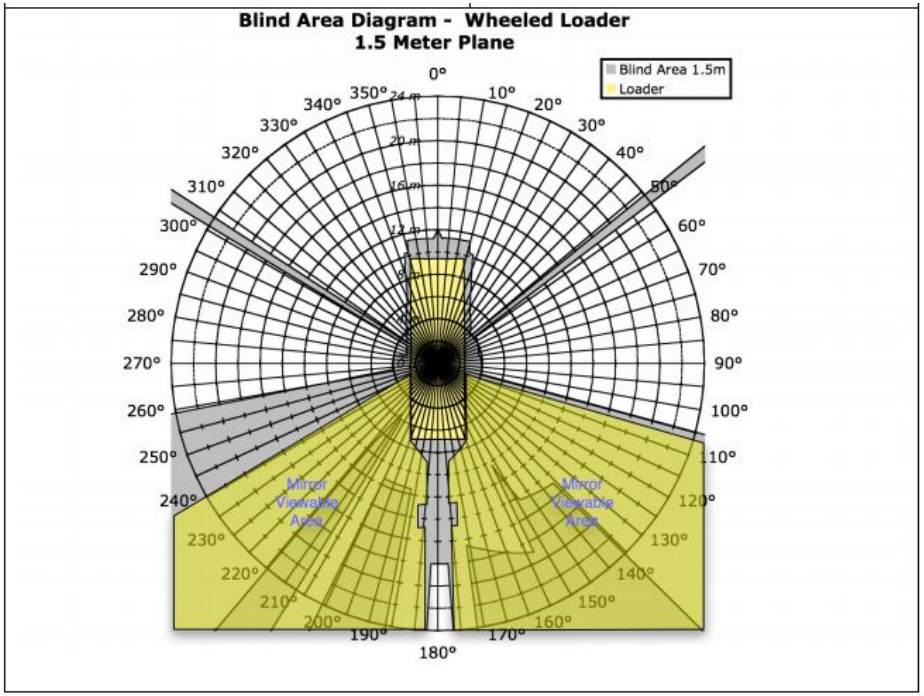




Blind Areas

Front End Loader (NIOSH Example)

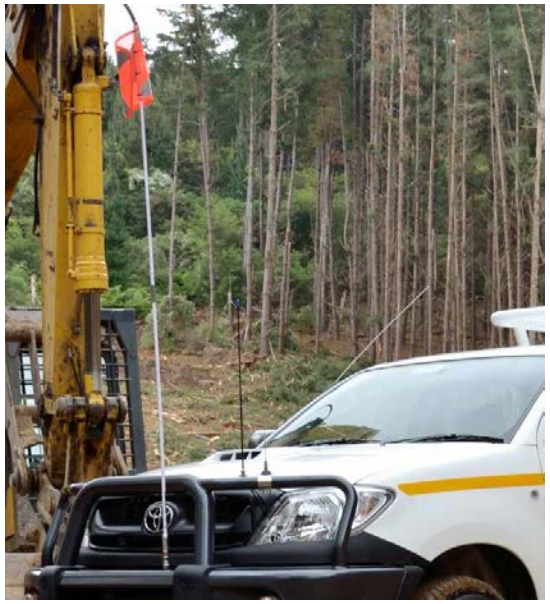




Blind Areas

Blind Areas

Low Tech Technology Solutions



Everyone needs to Communicate

On February 21, 2017, a bulldozer trammed over a parked, government-owned vehicle with an MSHA health specialist inside. Fortunately, the specialist received only minor injuries. The accident did require the specialist to be extracted from the vehicle after being trapped. This alert applies to vehicle operation around mobile equipment.

Collision Warning / Collision Avoidance

Collision Warning System (CWS)

- Provide Equipment Operators with an Awareness of the Location of Nearby Personnel, Light Vehicles, Stationary Structures, and Other Pieces of Equipment through Display Screen in the Operator's Compartment and through Audible and Visible Alarms

Collision Avoidance System (CAS)

- Operates the Same as CWS Except that CAS can take Control of the Mobile Equipment to Slow Down or Stop it Before an Accident can Occur

Collision Warning / Avoidance Technology

- Global Navigational Satellite System (GNSS)
- GPS in United States
- Systems Track Equipment in Relation to One Another
- Ability to “Geo-Fence” Areas to Restrict Equipment to Set Boundaries

Collision Warning / Avoidance Technology

- RADAR
- LIDAR
- Ultrasound
    - Units Installed on Mobile Equipment to Detect Other Equipment and Objects, including Pedestrians Using Time of Flight Measurements

Collision Warning / Avoidance Technology

- Electromagnetic
- Radio Frequency Identification (RFID)
  - Units Installed on Mobile Equipment to Detect Sensors Mounted on Other Equipment and Objects, Including Pedestrians
- Cameras
  - Video Screens Display Camera Feeds from Blind Spots Around the Equipment

CWS Preventable Fatal Accident Analyses

- United States Surface Mining Operations Since 2003
  - Using CWS could have Prevented 21 Accidents that Resulted in 23 Fatalities

CWS Preventable Fatal Accident Analyses

EXAMPLE #1

- Front End Loader Backs into Pickup Truck that had Parked Behind it

Potential of Save by Available CWS Technologies

GNSS	Radar/Lidar	Electromagnetic	RFID	Cameras
Yes	Yes	Yes	Yes	Possibly

CWS Preventable Fatal Accident Analyses

EXAMPLE #2

- Van Pulled Up with 9 Miners along side Haul Truck
- 2 miners were killed

Potential of Save by Available CWS Technologies

GNSS	Radar/Lidar	Electromagnetic	RFID	Cameras
Yes	Yes	Yes	Yes	Possibly

CWS Preventable Fatal Accident Analyses

EXAMPLE #3

- Pickup Truck Parked in the Haul Truck Traffic Path

Potential of Save by Available CWS Technologies

GNSS	Radar/Lidar	Electromagnetic	RFID	Cameras
Yes	Yes	Yes	Yes	Possibly

CWS Preventable Fatal Accident Analyses

EXAMPLE #4

- Truck Driver Ran over Portable Toilet

Potential of Save by Available CWS Technologies

GNSS	Radar/Lidar	Electromagnetic	RFID	Cameras
Possibly	Yes	Yes	Yes	Possibly

CWS Preventable Fatal Accident Analyses

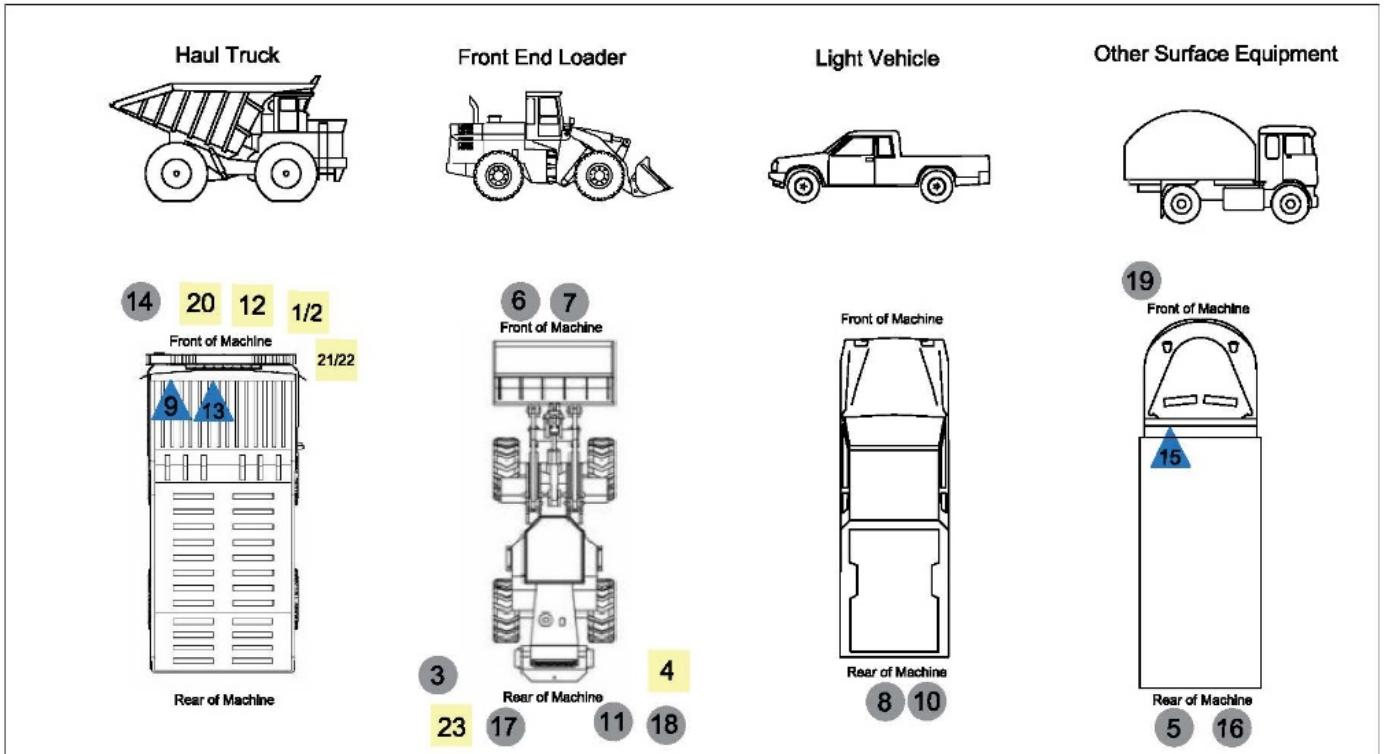
EXAMPLE #5

- Scraper and Fuel/Grease Truck Collided on Haul Road

Potential of Save by Available CWS Technologies

GNSS	Radar/Lidar	Electromagnetic	RFID	Cameras
Yes	Yes	Yes	Yes	Possibly

CWS Preventable Fatal Accident Analyses



CWS Preventable Fatals 2003 - 2017	
Pedestrians	12
Light Vehicle Occupant	8
Equipment Operator (Machine-Machine Contact)	3

CWS Preventable Fatal Accidents 2003 - 2017

Fatals by Equipment Type	COAL	MNM
Haul Truck	4	5
Front End Loader	0	8
Light Vehicle	1	1
Other Equipment	1	3

FIGURE 1

Victim's Physical Location
In Relation to Surface Equipment

- Pedestrians
- Light Vehicle Occupant
- Surface Equipment Operator

CWS Preventable Fatal Accident Analyses

- Victims Located in Front of Haul Trucks on 5 of 7 Haul Truck Accidents
- Victims Located Behind Front End Loaders in 6 of 8 Front End Loader Accidents
- 14 of 21 Surface Equipment Accidents Occurred while Equipment was at Low Speed and Initiating a Forward or Reverse Movement

What to Expect?

- CWS/CAS Systems to become more prevalent in the industry
  - Reduction in accidents and fatalities
- Possibility of CWS/CAS Systems being installed as a means to prevent reoccurrence of an accident at mining operations?
- Standards?
- Scenarios?

Seat Belt Safety

- Three fatalities in 2017 and 2018, and 38 fatalities since 2007, involved miners <u>not wearing seat belts</u>

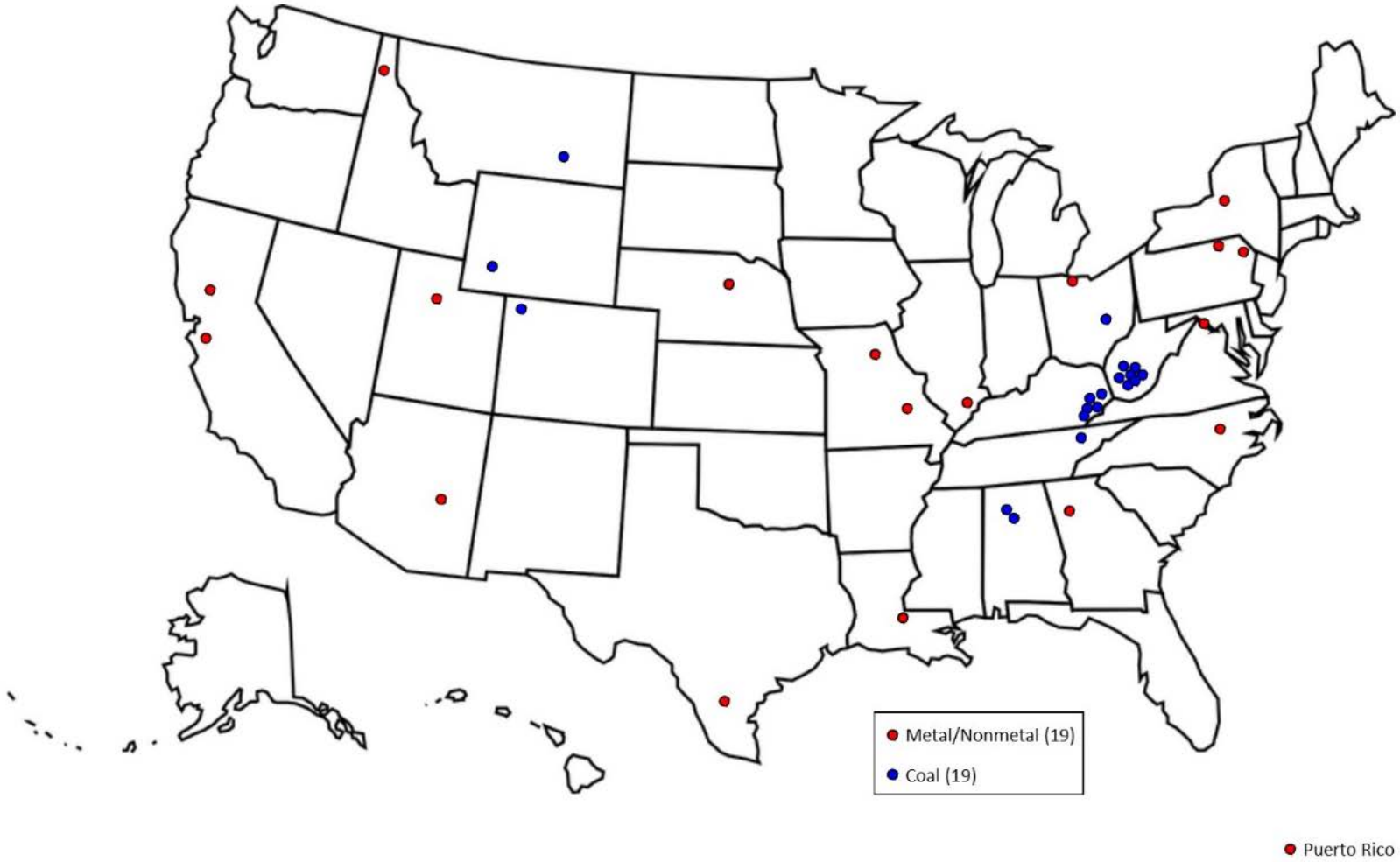
- 6000+ MSHA citations issued for failure to wear seatbelts since 2007 (most in MNM mines)

Coal Fatality #11 for 2012

2007 - 2017 Mobile Equipment Fatalities

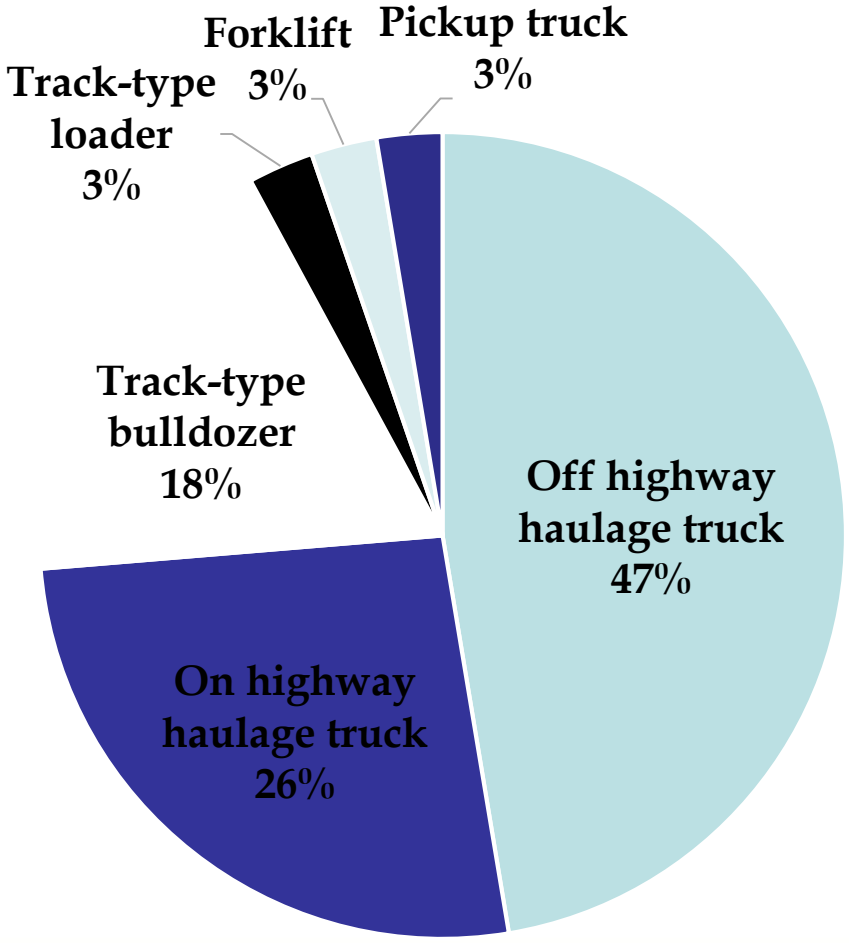
- 38 fatal accidents involving the victim not wearing a seat belt (NSB) while operating mobile equipment.
- With few exceptions, victims had a greater chance of survival had they been wearing an adequate seat belt.
- 34 had an adequate seat belt provided, 2 were defective, and 2 were not provided.

2007 - 2017 NSB Fatalities Map



2007 - 2017 NSB Fatalities by Equipment Type

Equipment Type	Fatalities
Off highway haulage truck	18
On highway haulage truck	10
Track-type bulldozer	7
Track-type loader	1
Forklift	1
Pickup truck	1
Total	**38**

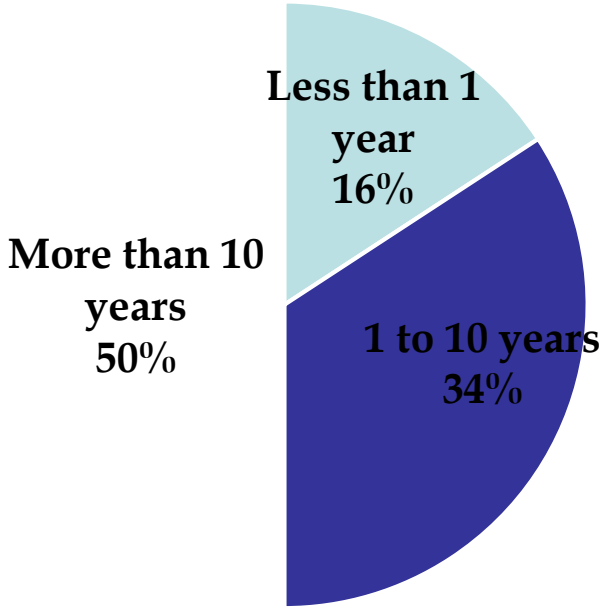


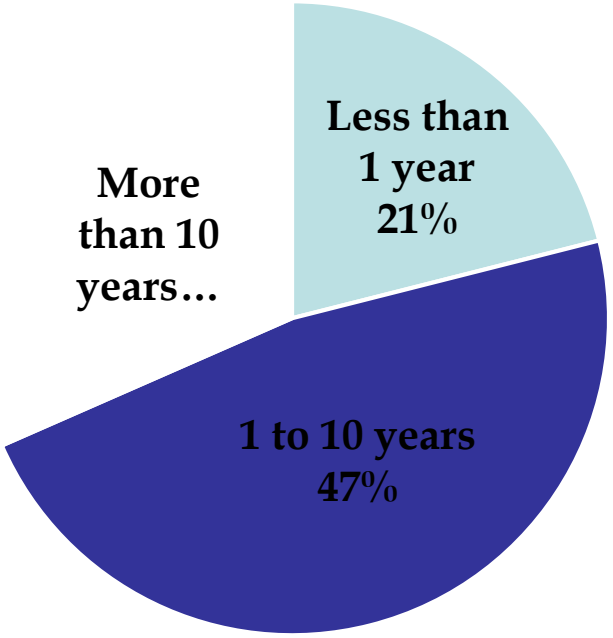
MNM Fatality #8 for 2014

2007 - 2017 NSB Fatalities by Experience

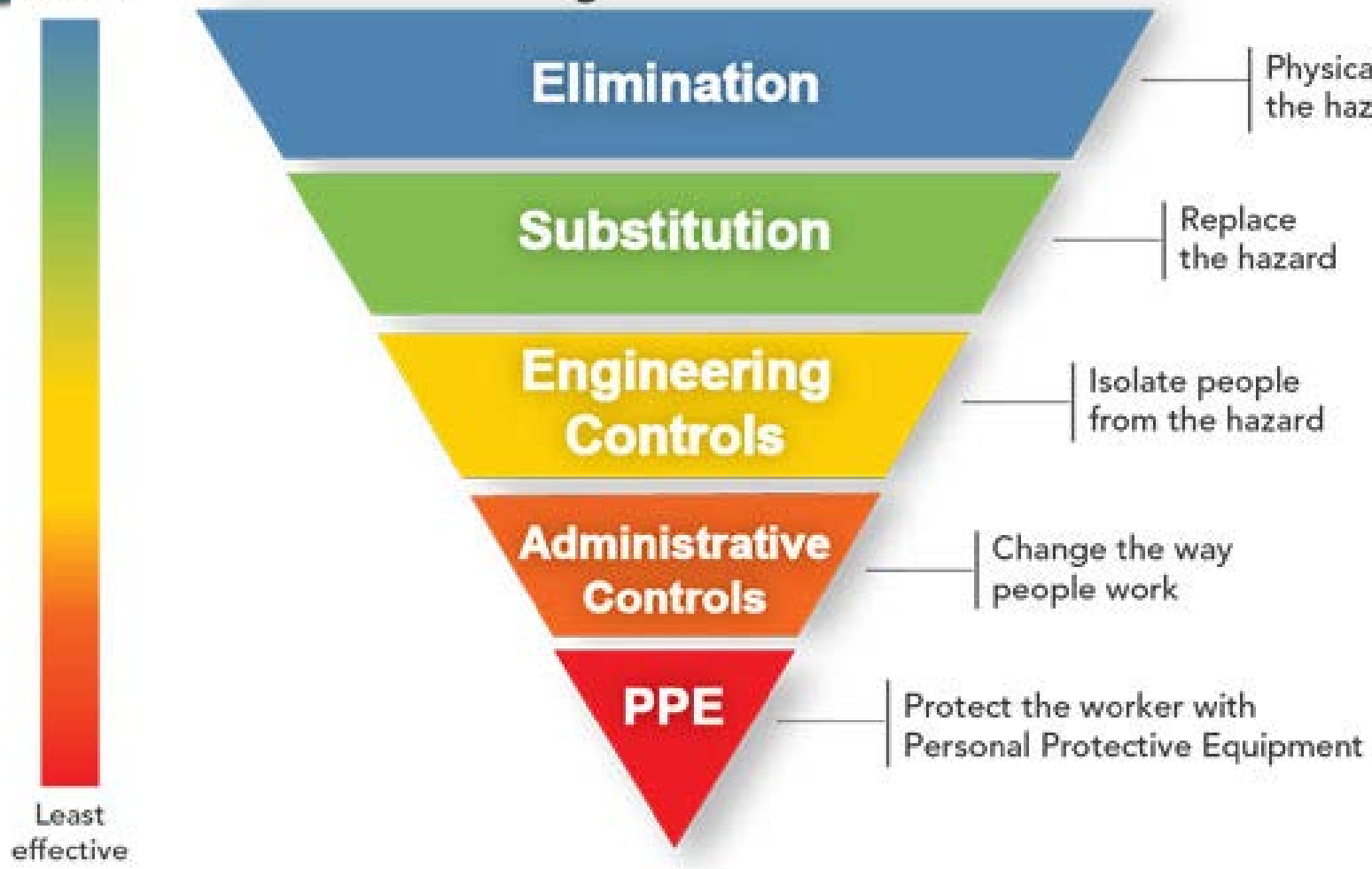
Mining Experience	Fatalities
Less than 1 year	6
1 to 10 years	13
More than 10 years	19
Total	**38**

Job Experience	Fatalities
Less than 1 year	8
1 to 10 years	18
More than 10 years	12
Total	**38**





Hierarchy of Controls



Source: NIOSH

Seat Belt Tampering Alert

https://www.msha.gov/sites/default/files/Alerts%20and%20Hazards/seat-belt-tampering-alert-oct-2016.pdf

Administrative Control Solutions

- Passive warning devices
  - Nuisance alarm, warning lights
- High visibility and rigid seat belts
- Remote telematics
- Training and education
- Regulations, policies, procedures
- *Advantages*
  - Ease of implementation and training
  - Requires minimal resources and cos
- *Disadvantages*
  - Ineffective for equipment operators who refuse to wear seat belts

Engineering Control Solutions

- Active control interlocks
  - Seat switch
  - Ignition switch
- *Advantages*
  - Difficult to defeat
  - Requires seat belt usage to operate machine
  - Minimal management oversight
- *Disadvantages*
  - Possible unintended consequences
  - Design complexity may increase cost

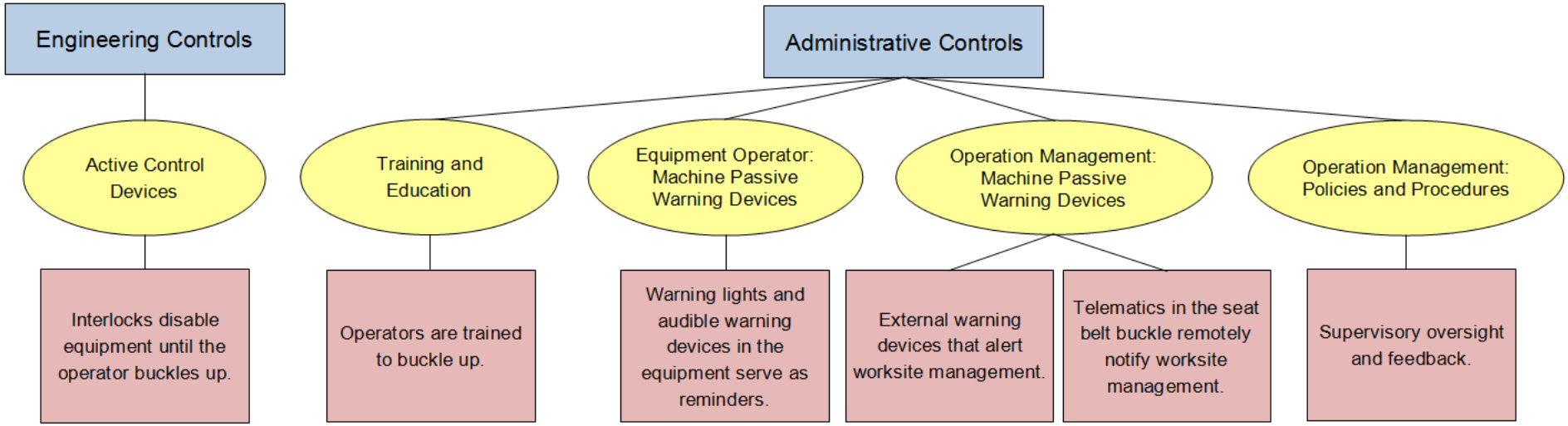
Articulated Haul Truck
September 19, 2016

https://arlweb.msha.gov/Alerts/Seat%20Belt%20Save.pdf

Front End Loader
March 13, 2018

https://dol-msha-peir-mshagov-prod.s3.amazonaws.com/s3fs-public/Alerts%20and%20Hazards/Surface-Seat%20Belt%20Save_0.pdf

Seat Belt Safety Alert



https://arlweb.msha.gov/alerts/Seat%20Belt%20Alert%20Oct%202016.pdf

Best Practices for Trainers

- Suggest implementation of a “condition of employment” seat belt policy
  - Zero tolerance for nonuse or misuse
- Provide effective training
  - Orientation programs that set expectations of seat belt use
  - Personal stories to engage the miners
  - Stickers, handouts, best practice cards
  - Meaningful incentives
- Ensure miners understand that seat belts are proven to save lives and they are ultimately responsible for buckling up

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