Proximity Detection System:

Latest Developments on Training

and

Technology Demonstration

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Project Title

Enhanced Mobile Equipment Experiential Learning and Safety Technology Demonstration Project

Project Sponsor and Disclaimer

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Why are we doing this work?

Between 2000 and 2010 nearly 800 miners were injured and 16 killed in accidents involving shuttle cars and scoops in underground coal mines. Some examples of recent fatal accidents include:

- In February 2013, a shuttle car operator was fatally injured while shoveling ribs when a scoop struck him.
- In November 2012, a miner was killed when a scoop pinned him.
- In July 2010, a section electrician was fatally injured when he was run over by a shuttle car. The miner was walking in an entry toward the face when he was struck by the shuttle car.
- In February 2008, a surveyor with eight years of mining experience was fatally injured while surveying in an active underground mining section. The victim was struck by a loaded shuttle car as it traveled through a run-through check curtain.
- In May 2008, a general inside laborer with four weeks experience was fatally injured when a battery-powered scoop struck him.

Some common factors

- Most of these accidents occur because the equipment operator is not aware of the presence of personnel near the mining equipment.

- Visibility is often low due to the design of the equipment, low lighting, and dust in the air; ambient noise is such that individuals may not be heard.

- The confined space typical of underground coal mines leaves little room to maneuver or respond once personnel in the critical path are recognized.

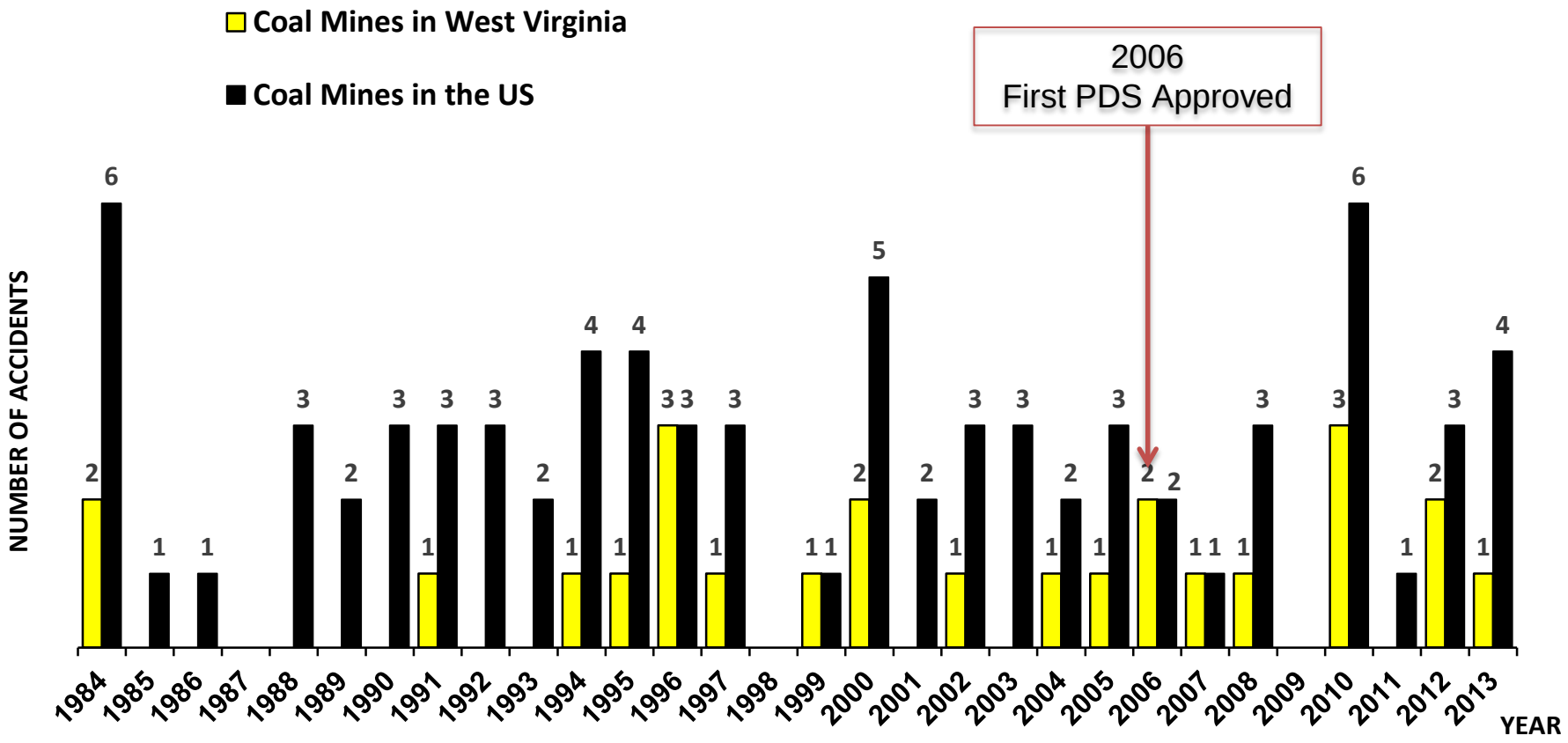
Can Proximity Detection and Camera Systems help?

- Further investigation of the accidents, determined that proximity detection systems could have prevented these accidents.

- Recent evaluations made MSHA of accident reports involving coal hauling machines and scoops indicated that the implementation of proximity detection systems (PDS) could have prevented 42 fatalities and 179 injuries between 1984 and 2014.

FATAL ACCIDENTS THAT MIGHT HAVE BEEN PREVENTED BY USING A PDS IN DIFFERENT EQUIPMENT TYPICALLY USED IN COAL MINES

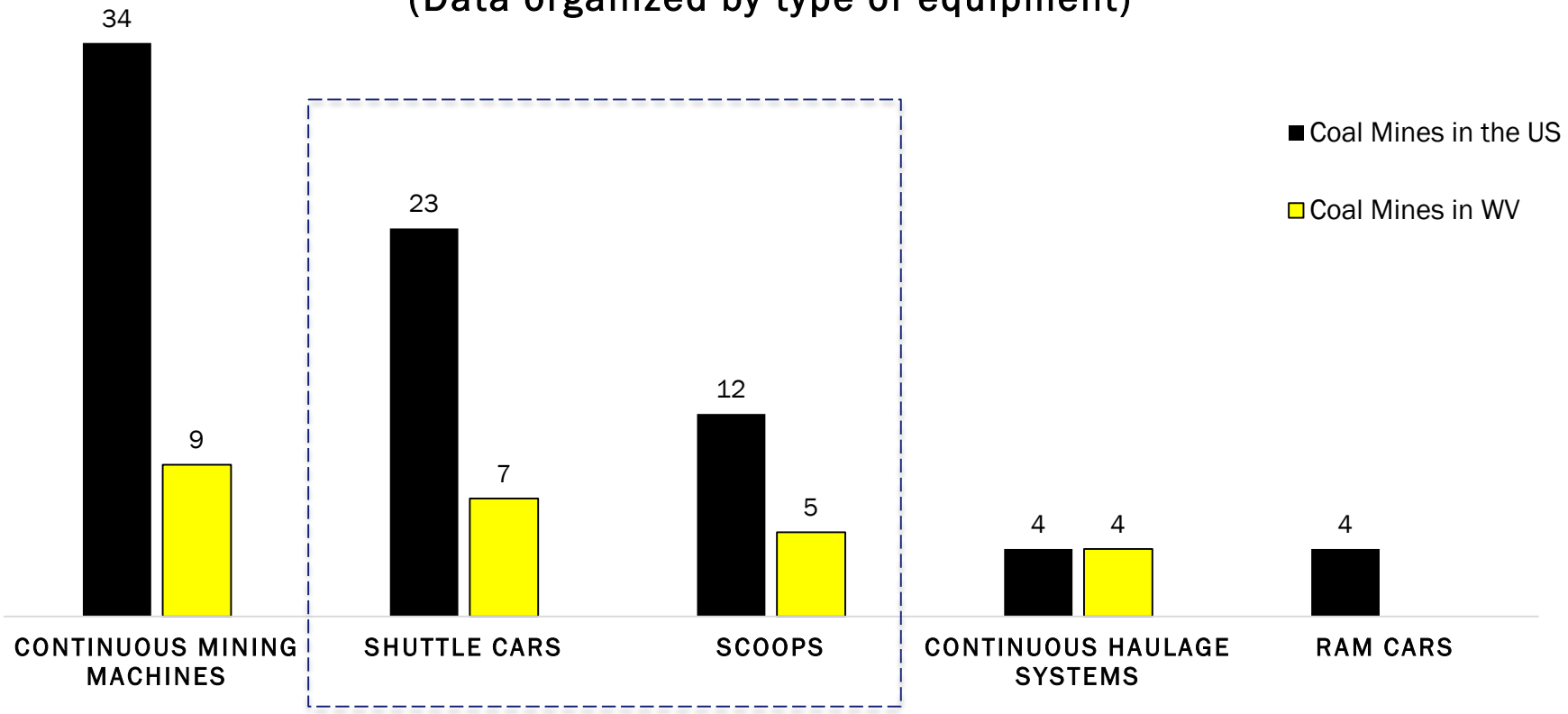
(Data organized by year)



Source: MSHA Analysis by Chirdon, et al. (2014)

FATAL ACCIDENTS THAT MIGHT HAVE BEEN PREVENTED BY USING A PDS IN COAL MINES IN THE PERIOD OF 1984-2013.

(Data organized by type of equipment)



Source: MSHA Analysis by Chirdon, et al. (2014)

PDS Currently Installed in the US

January, 2014

Manufacturer	CMs	Shuttle Cars	Haulers	Scoops	Loaders	MBCs	Roof Bolting Machines	Feeder / Breaker	Misc.	Total
Matrix Design Group M3-1000 at Alliance Coal Company	76									76
Matrix Design Group Intellizone at Alliance Coal Company	2									2
Matrix Design Group M3-1000	7									7
Joy Smartzone Gen 1	135									135
Joy Smartzone Gen 2	2		1							3
Strata HazardAvert	72	34	12	33	19	0	1	1	4	176
Total	**294**	**34**	**13**	**33**	**19**	**0**	**1**	**1**	**4**	**399**

September, 2014

Manufacturer	CMs	Shuttle Cars	Haulers	Scoops	Loaders	MBCs	Roof Bolting Machines	Feeder / Breaker	Misc.	Total
Matrix Design Group M3-1000 at Alliance Coal Company	66									66
Matrix Design Group Intellizone at Alliance Coal Company	34	4								38
Matrix Design Group M3-1000	9									9
Matrix Design Group Intellizone	8									8
Joy Smartzone Gen 1	146									146
Joy Smartzone Gen 2	49	1	2							52
Strata HazardAvert	82	45	13	42	22	0	1	1	4	210
Total	**394**	**50**	**15**	**42**	**22**	**0**	**1**	**1**	**4**	**529**

Source: MSHA Analysis by Chirdon, et al. (2014), as reported by system manufacturer to MSHA

What is needed?

- Experience demonstrated that machine mounted cameras and PDSs can improve the ability of equipment operators to know when individuals may be in harm's way.

- However, without proper training, there may be a tendency for operators to rely too much on this technology and neither represents a failsafe system.

- Therefore, realistic experiential training is needed to fully impart the dangers presented by mobile equipment, the limitations of any technological aids, and best safety practices by everyone to reduce significantly the number of accidents involving mobile equipment.

Project Main Objective

Create and provide the research based experiential training necessary to improve the safe operation of shuttle cars and scoops in underground coal mines.

Specific Aims

1. Development of Training Curriculum. Create key components of a training curriculum based on experience and limitations observed by equipment operators and management of currently operating mines.

2. Conduct Training Program. Execute the training curriculum which includes training exercises at the simulated mine facility, and demonstrations of mine safety technology (PDS).

3. Assess Impact and Effectiveness of Training Effort. Provide evidence that the training conducted as part of this effort has been effective.

Research Strategy

- The Training Intervention Effectiveness Research (TIER) model proposed by NIOSH is implemented in this effort.
- TIER stages:
  - Stage 1 – Formative Research
  - Stage 2 – Process Research
  - Stage 3 – Outcome Research
  - Stage 4 – Impact Research
- Training curriculum developed according to the Analysis, Design, Development, Implementation, and Evaluation (ADDIE) instructional design model.
- Evaluation levels:
  - Level 1, Participant reaction: Contributes to gain immediate feedback about participants' experience of being in the training.
  - Level 2, Participant Learning: Evaluates immediate changes in knowledge, skills, or attitude-behavior based on exposure to the training materials.

PROPOSED TRAINING CURRICULUM

Learning Objective:

Enhance miner training by having a scoop equipped with the most current safety technology that will provide students with the opportunity to experience the limited visibility of the equipment operator in a simulated mine environment.

Learning Outcomes:

Upon completion of the proposed training, the trainee should be able to:

1. Recognize the challenges of the operation of scoops in confined spaces and poor visibility typical in a working mine.
2. Understand the basics of the operation of a haulage equipment equipped with proximity detection and camera systems.
3. Understand the advantages and limitations of proximity detection or camera systems.
4. Experiment the challenges of the operation of scoops in confined spaces and poor visibility typical in a working mine.

Target Audience:

Apprentice miner or mine foreman student with or without scoop operation experience.

Overview of Contents:

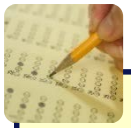
The training sessions will be divided in three main modules:

MODULE 1: Classroom Session

- Introduction to MSHA Recommendations “Safety Practices around Shuttle Cars and Scoops in Underground Coal Mines”.
- General characteristics of a battery scoop machine.
- Basics of PDS and Camera Systems.
- Review of Federal and WV Regulations on PDS

MODULE 2: Hands-on Session

- Simulated mine located at the WVU Mine Academy will be used as main training place.
- **Training topics**: Reduced visibility exercises combined with use of proximity detection system and cameras installed on a battery scoop.
- **Experiencing scenarios**: Four levels of difficulty with decreasing levels of visibility.



Evaluation

- At the end of the training sessions:
  - Level 1. Participant Reaction of the proposed training.
  - Level 2. Perceived Learning of the trainee.

Training Scenarios and Training Tools

VISUAL OBSTACLES ⇩ / ⇨	Scoop without simulated operator guard	Scoop with simulated operator guard
Bucket unloaded	X	X
Bucket loaded	X	X

REDUCTION OF VISIBILITY (LOWEST TO HIGHEST)			
LEVEL 1	**LEVEL 2**	**LEVEL 3**	**LEVEL 4**
Scoop unloaded without simulated operator guard	Scoop loaded without simulated operator guard	Scoop unloaded with simulated operator guard	Scoop loaded with simulated operator guard

Battery Scoop

Scoop without protective guard

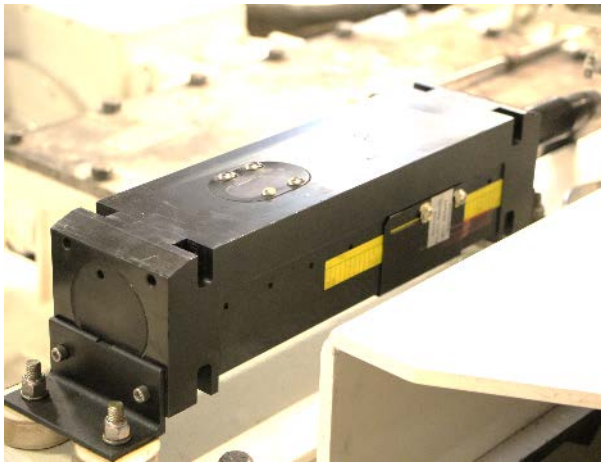
Scoop with Proximity Detection System and Cameras

Scoop with protective guard

Proximity Detection and Camera Systems Installed on Scoop

Proximity Detection System

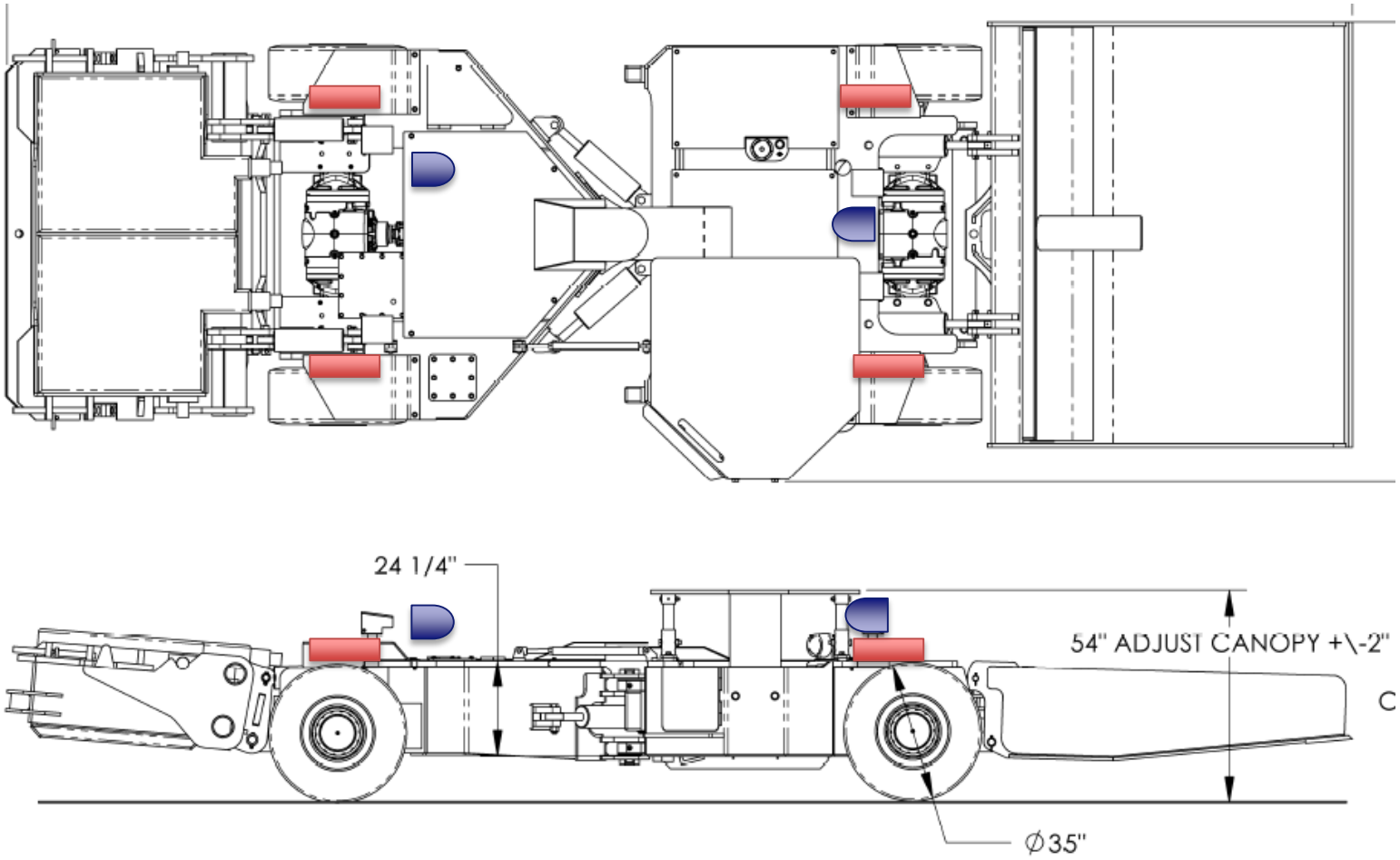
- Strata HazardAvert
- Four field generators
- Six wearable pads
- Checkout box



Camera System

- Two low light cameras
- Front and back
- Two monitors in operator's compartment
- Repositionable
- Angles of vision:
  H = 78.6 deg.
  V = 59.3 deg.

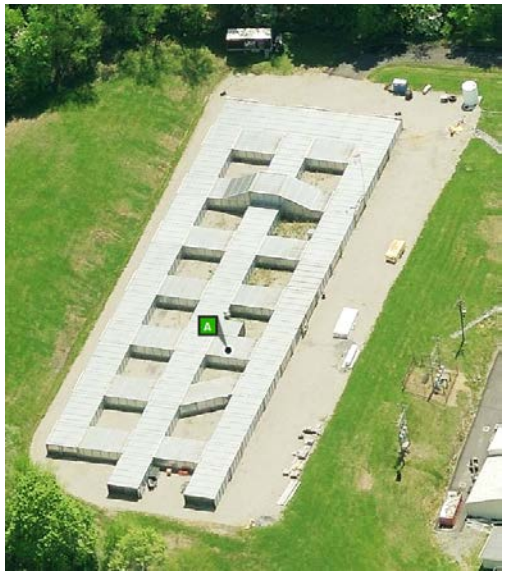
Battery-Powered Scoop



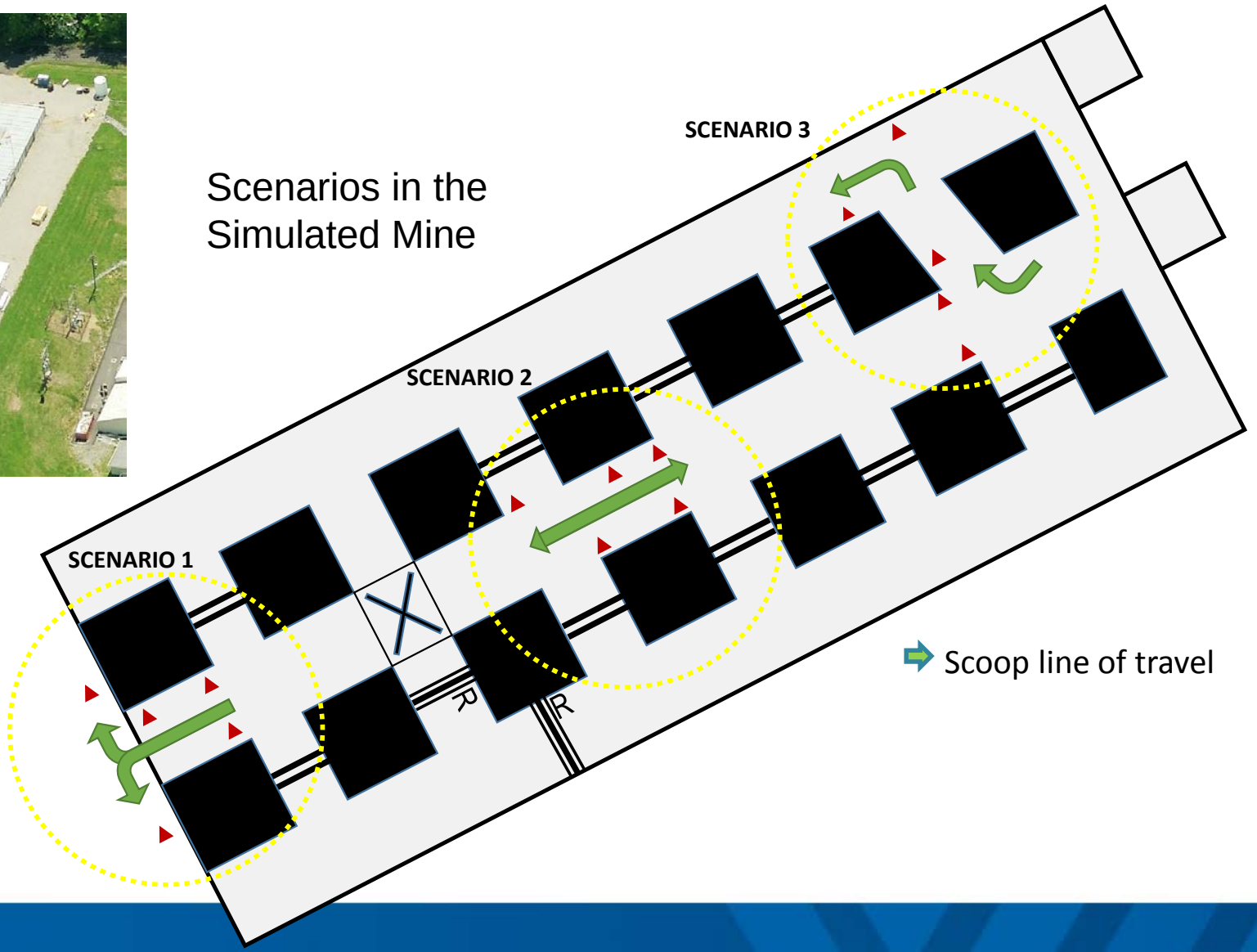
Cameras

PDS Magnetic Field Generators

Training Place: Simulated Mine at WVU



Scenarios in the Simulated Mine

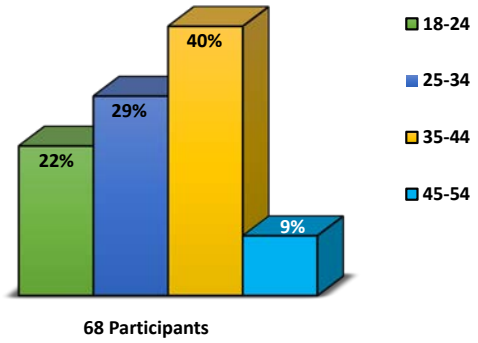


Scoop in Simulated Mine at WVU

Participants and demographics

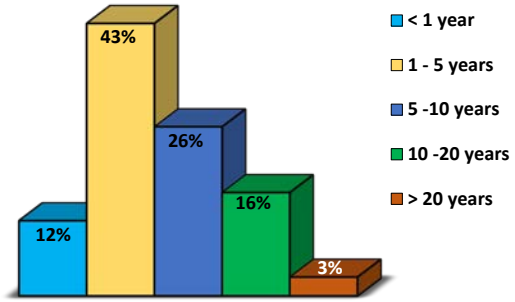
Group #	Number of Participants	Type of Audience	Employment Status	Employment Location
1	13	Mine Foreman/Fireboss Certification Class	Full Time Employee	WV
2	10	Mine Foreman/Fireboss Certification Class	Full Time Employee	WV
3	8	Mine Foreman/Fireboss Certification Class	Full Time Employee	WV
4	14	Mine Foreman/Fireboss Certification Class	Full Time Employee	WV
5	9	WVU Mining Engineering Students	Student	WV
6	14	Mine Foreman/Fireboss Certification Class	Full Time Employee	WV, PA, KY, VA
Total	68			

Age Distribution



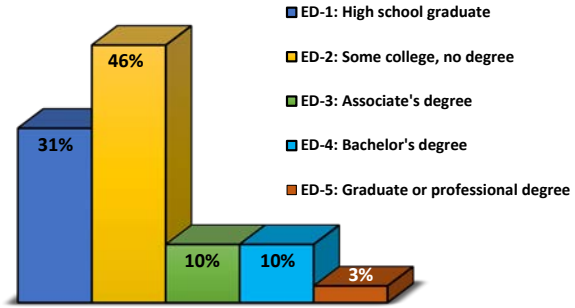
68 Participants

Years of Experience in Mining Industry



68 Participants

Highest Level of Education



68 Participants

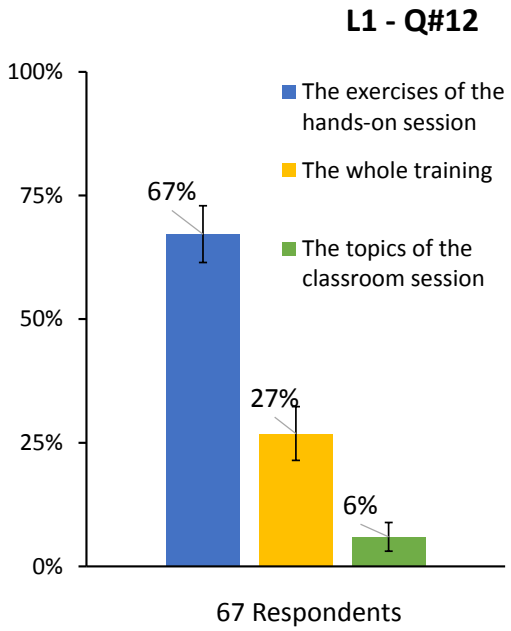
Evaluation Levels

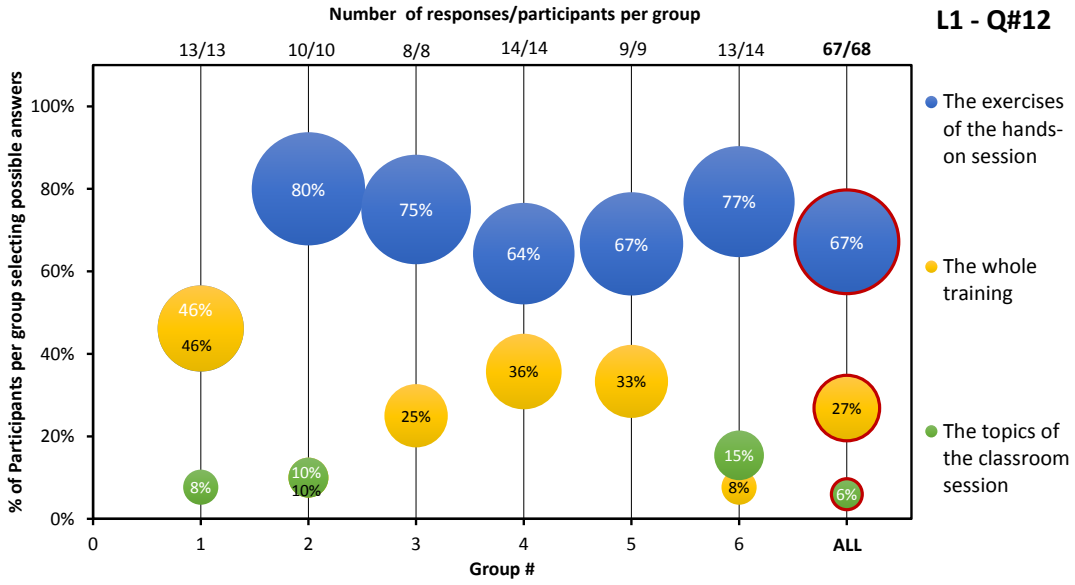
Level	Outcome	Addressed by Questions #
Level 1: Participant Reaction	Aspects of the Module 1 (Classroom session)	1 – 4
	Aspects of the Module 2 (Hands-on session)	5 – 8
	Preparedness/Training organization	9 – 11
	Participant satisfaction	12, 13, 16
	Future topics	14 – 15
Level 2: Perceived Learning	Changes in knowledge	1 – 2
	Changes in attitude, behavioral intent	3, 4, 10
	Demonstrated skills and abilities	5 – 9
	Demonstrated understanding	11 – 12

Global Results per Question and per Group (example)

Level 1. Participant Reaction

Q12. What did you like best about this pilot training?

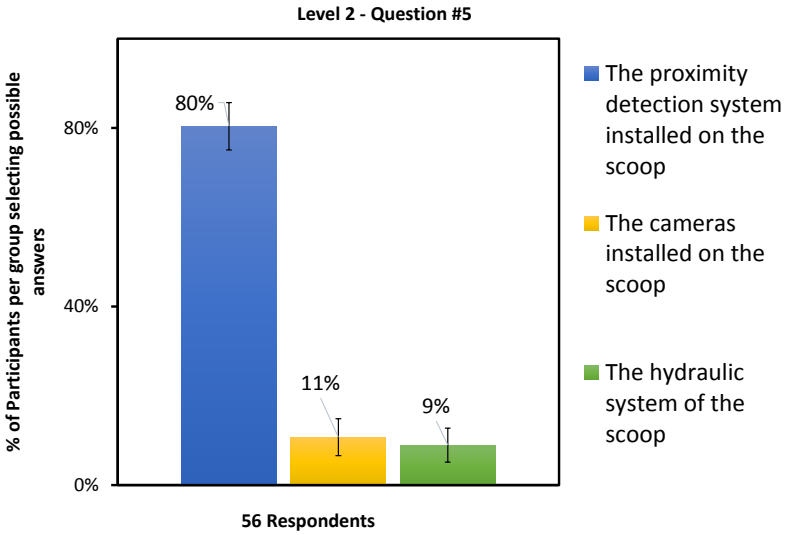


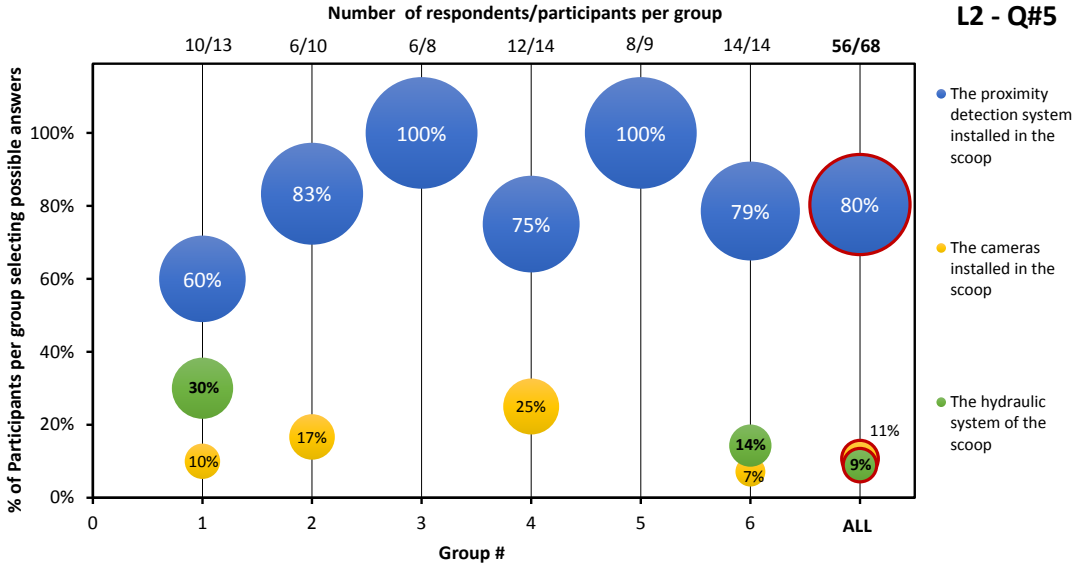


Global Results per Question and per Group (example)

Level 2. Perceived Learning

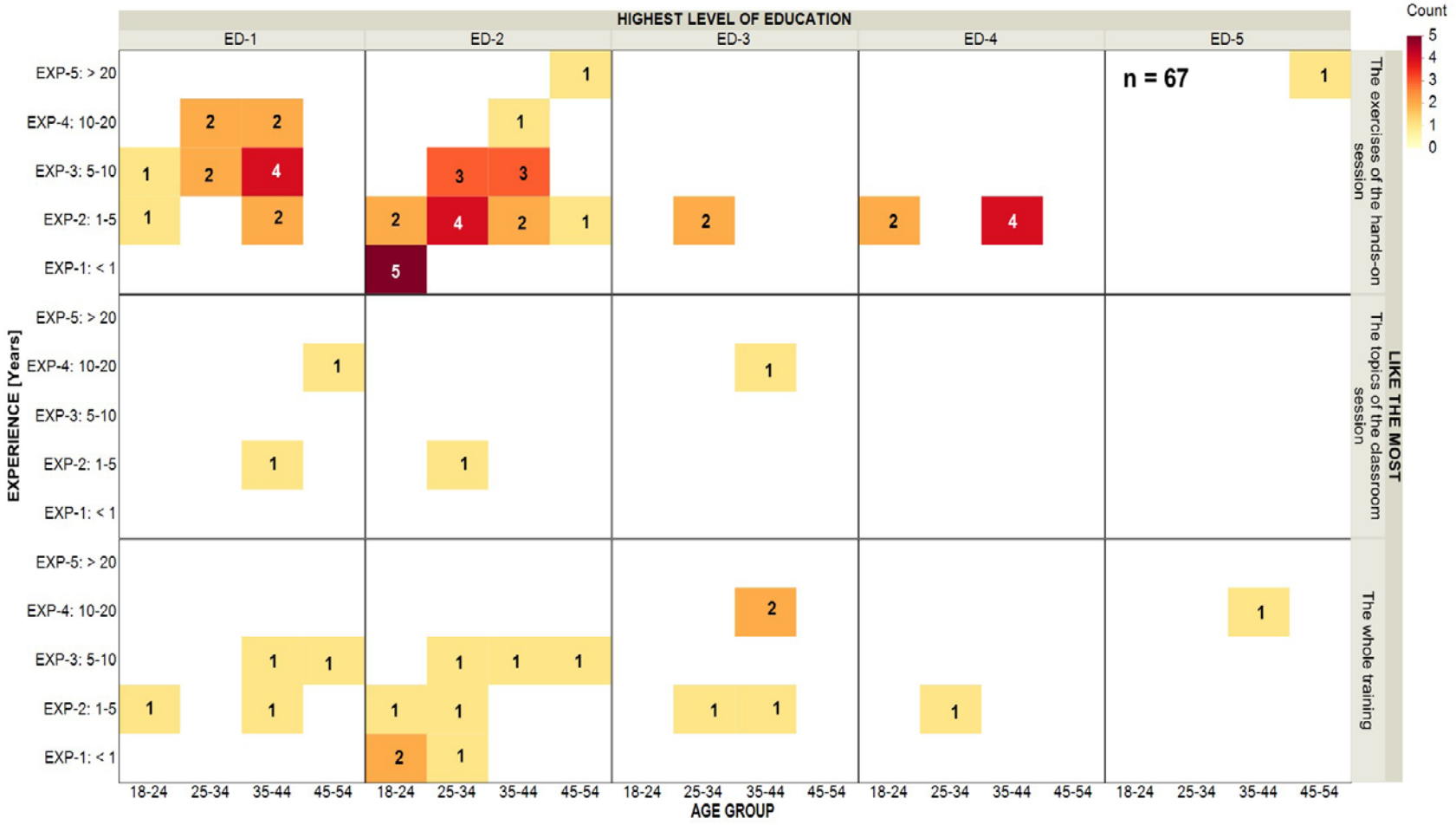
Q5. The warning and danger zones are created by the following technology:





Responses as function of demographics (example)

Level 1. Participant Reaction Q12.What did you like best about this pilot training?



Main Conclusions

Considering the reaction of trainees to the proposed training materials:

1. The volunteers exposed to the materials developed as part of this research project manifested a positive reaction to the proposed training approach consisting of a combination of classroom and hands-on sessions.

2. Despite valuing the specifics of the classroom session positively, the most preferred portion of the training was the hands-on session with the exercises executed in the simulated mine.

Main Conclusions

Considering the perceived learning of trainees:

1. Nearly 90% of the participants manifested intentions of implementing changes in their current activities as a result of the new knowledge or were willing to share the new knowledge with their peers.

2. Overall, 70% to 90% of participants, and depending on the questions, responded correctly when asked about basic functionality and particularities of proximity detection and camera systems.

3. These results indicate that there is room for improvement to increase the effectiveness of the proposed training.

Main Conclusions

Considering the preference of trainees regarding training settings:

1. Trainees clearly preferred experiential training that included hands-on activities instead of learning through the classical classroom setting.

2. This result is in line with previous observations reported in the literature that pointed out that adults respond best to learning that is active and experience-based, especially within the miner's community.

Thanks for your attention.