Validating Collision Warning/Avoidance System Detection Performance

John Homer
JHomer@cdc.gov
412-386-5289

NIOSH – Pittsburgh Mining Research Division

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Justification for collision warning/avoidance system validation research

- 2018 MSHA Powered Haulage Safety Initiative Request For Information

  "MSHA is also seeking suggestions from stakeholders on... information they may have to improve safety in and around mobile equipment..."

- 2019 NIOSH Mining Program Review

  "Identify and study the gaps in sensing and situational awareness... continue to expand and build upon work in proximity detection..."

- NIOSH Mining Project: Characterization of Haul Truck Health and Safety Issues – Haul Truck Research Roadmap

- NIOSH Automation and Emerging Technologies Partnership

Justification for collision warning/avoidance system validation research

- Surface operations using technology
  - Limited and varying degrees of success
  - Implementation depends on site-specific parameters
  - Near misses still occur and false/nuisance alarms are a challenge
  - No matter the technology/system, there is no single solution; redundant measures are needed
- Objectives
  - Determining system effectiveness
  - Investigating system validation and performance limitations
  - Developing recommendations for effective implementation

Research objectives

- *Develop procedures for validating system detection performance*

  Investigate methods and parameters for determining system efficacy

  - Collision scenarios – Harmful interactions and unwanted events

    System acts when expected

  - Non-collision scenarios – Safe operations

    System refrains from taking actions

	Condition Absent	Condition Present
Negative Result	True Negative	False Negative
Positive Result	False Positive	True Positive

- *Develop guidance for validating system detection performance*

  Conduct reduced- and full-scale testing to assess the methods and their translation to the field

Project overview (FY 2021 - 2023)

1. Determine critical parameters and relevant methods
   - Conducting background research on testing
   - Examining mining-specific requirements
   - Investigating haul truck collision accidents
   - Researching technology and solutions
2. Evaluate methods and parameters
   - Developing laboratory evaluations
   - Modeling interaction scenarios
3. Exchange information via partnership
   - Holding stakeholder discussions
   - Identifying opportunities for collaboration
4. Conduct field evaluations
   - Assessing the value of validation methods

MSHA Fatality Alert – October 14, 2020

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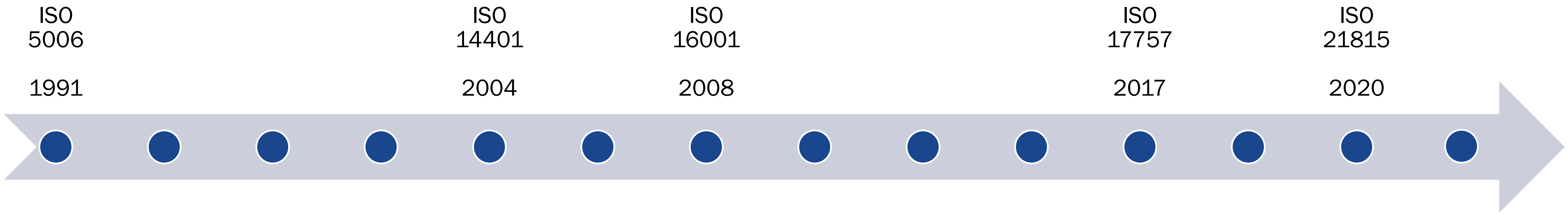
Determining critical parameters and methods relevant to validating system detection performance



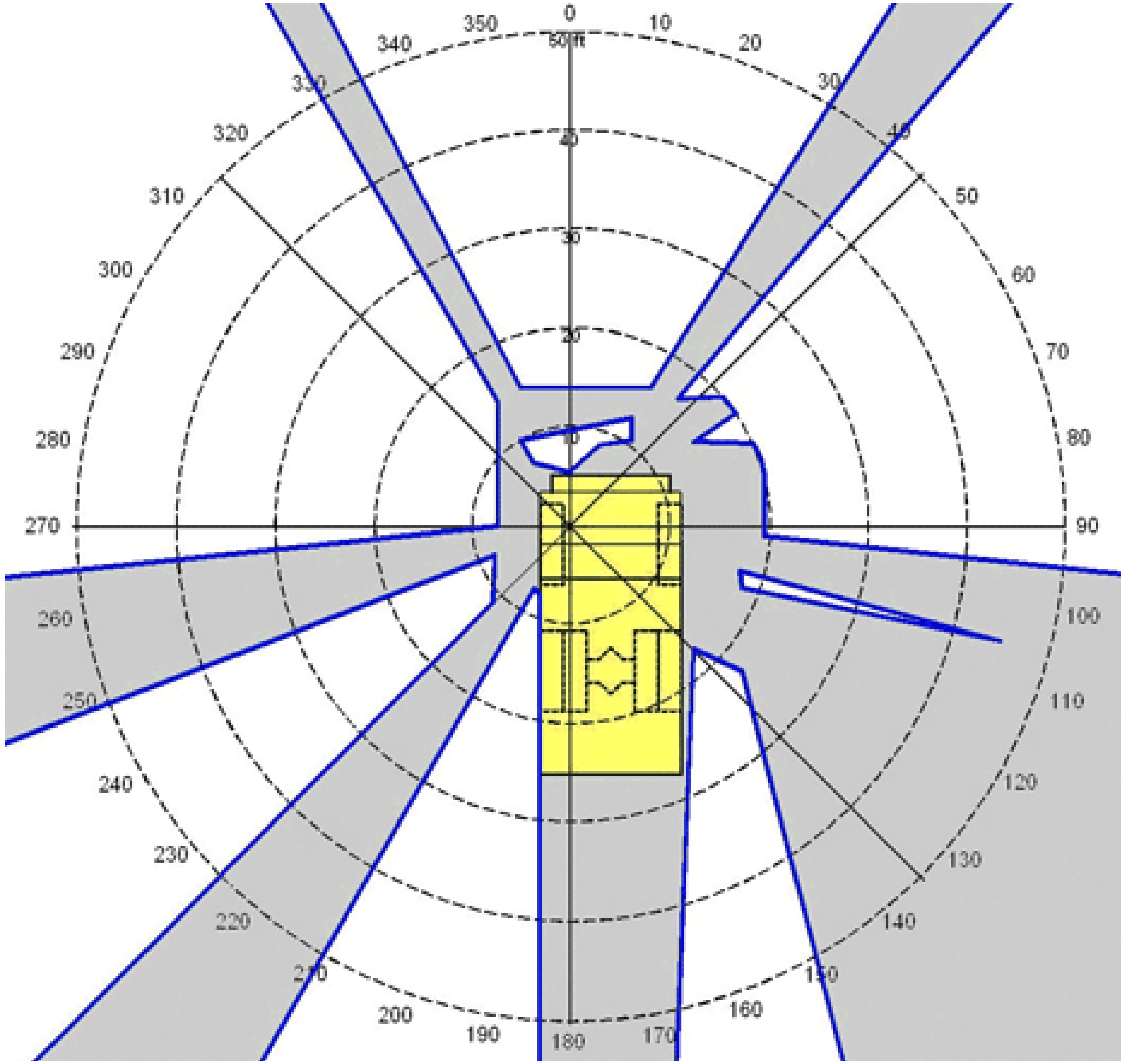
- Identified and reviewed mining-related standards
  - Lay the groundwork for testing
  - Gaps in terms of validating system performance
  - Validation methods/frameworks afford insight, but significant work is still needed
- Included standards and achievements from other industries

Determining critical parameters and methods relevant to validating system detection performance

- Parameters

  e.g., time-to-collision, onset timing, field-of-detection, relative distance/velocity…

- Examine for developing lab/field test methods and simulations for evaluating detection performance



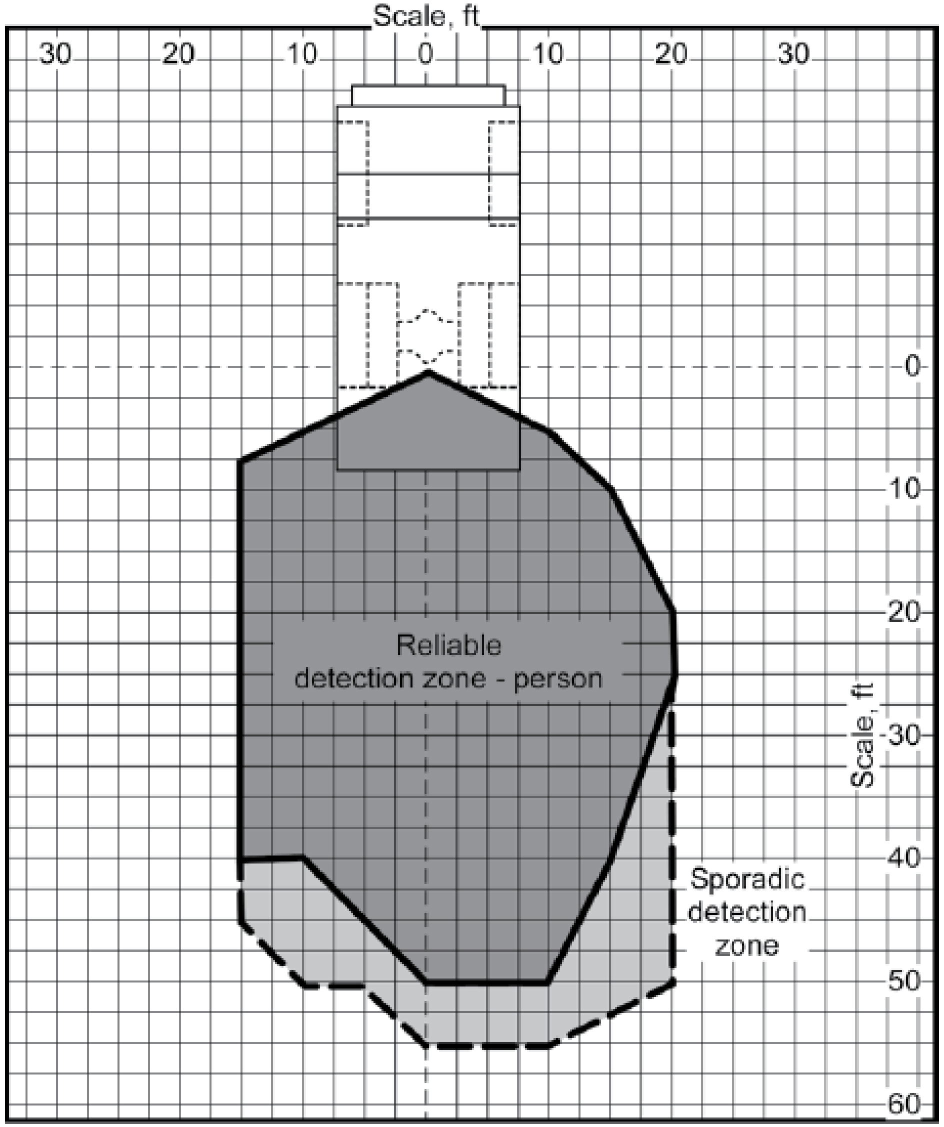
NIOSH image depicting blind-zones around a typical haul truck

Establishing test methods and critical parameters to address prevalent interaction scenarios

- Detection
  - Classification
    (true and false +/-)
  - Accuracy and repeatability
    (reliable vs. sporadic/edge cases)

- System
  - Field-of-detection/configuration
  - Capabilities:
    timing/latency, tracking/discrimination
  - Limitations

- Performance considerations
  - Environmental/asset variations
  - Stability

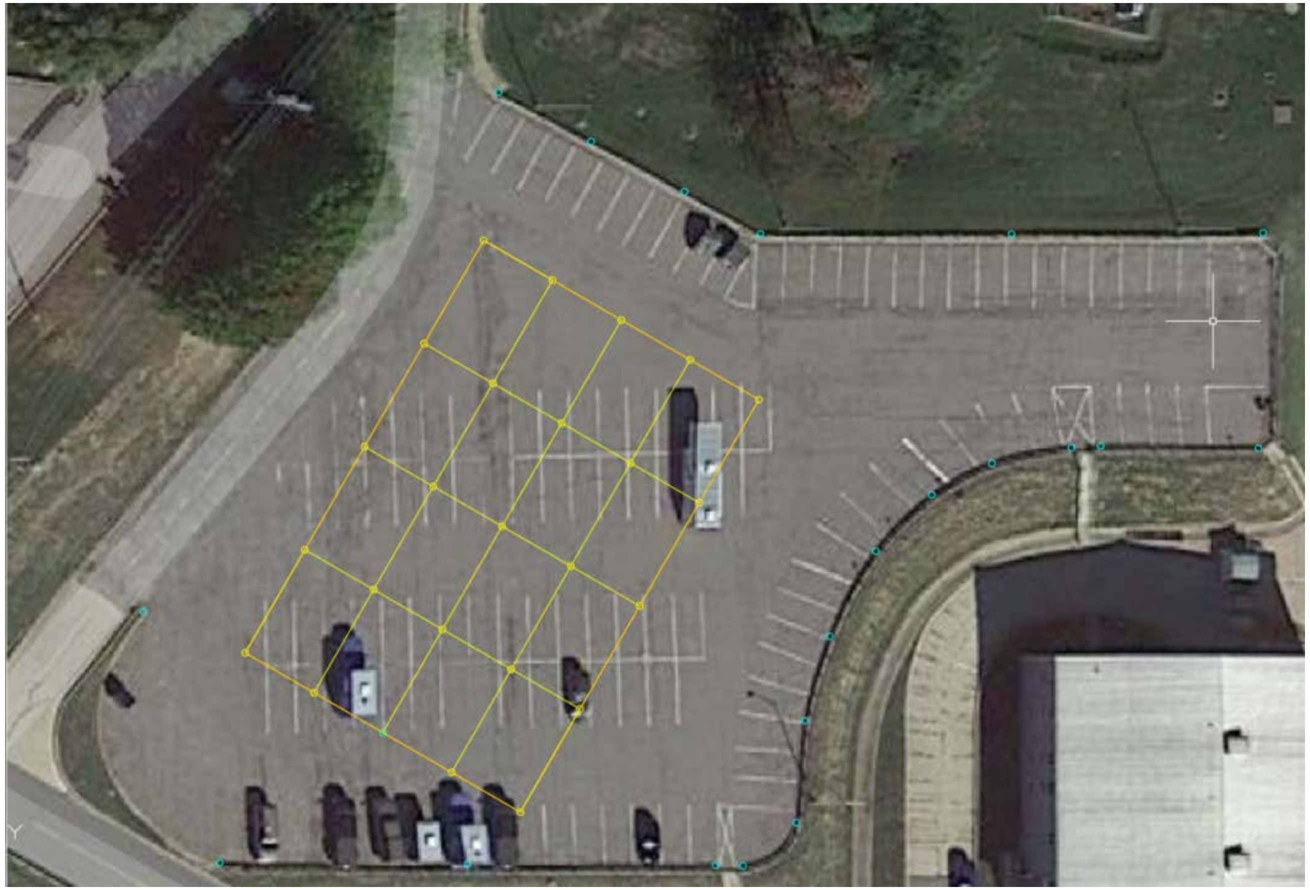


NIOSH Ruff, 2007

Developing methods and procedures to validate data acquisition system and sensor reliability and limitations

- Establish data collection
  - System monitoring
  - Ground truth data

    GPS, survey points, video, optical/laser sensors
- UGV automated waypoint navigation
- UAV video surveillance



NIOSH Pittsburgh Research Facility – UAV video surveillance concept

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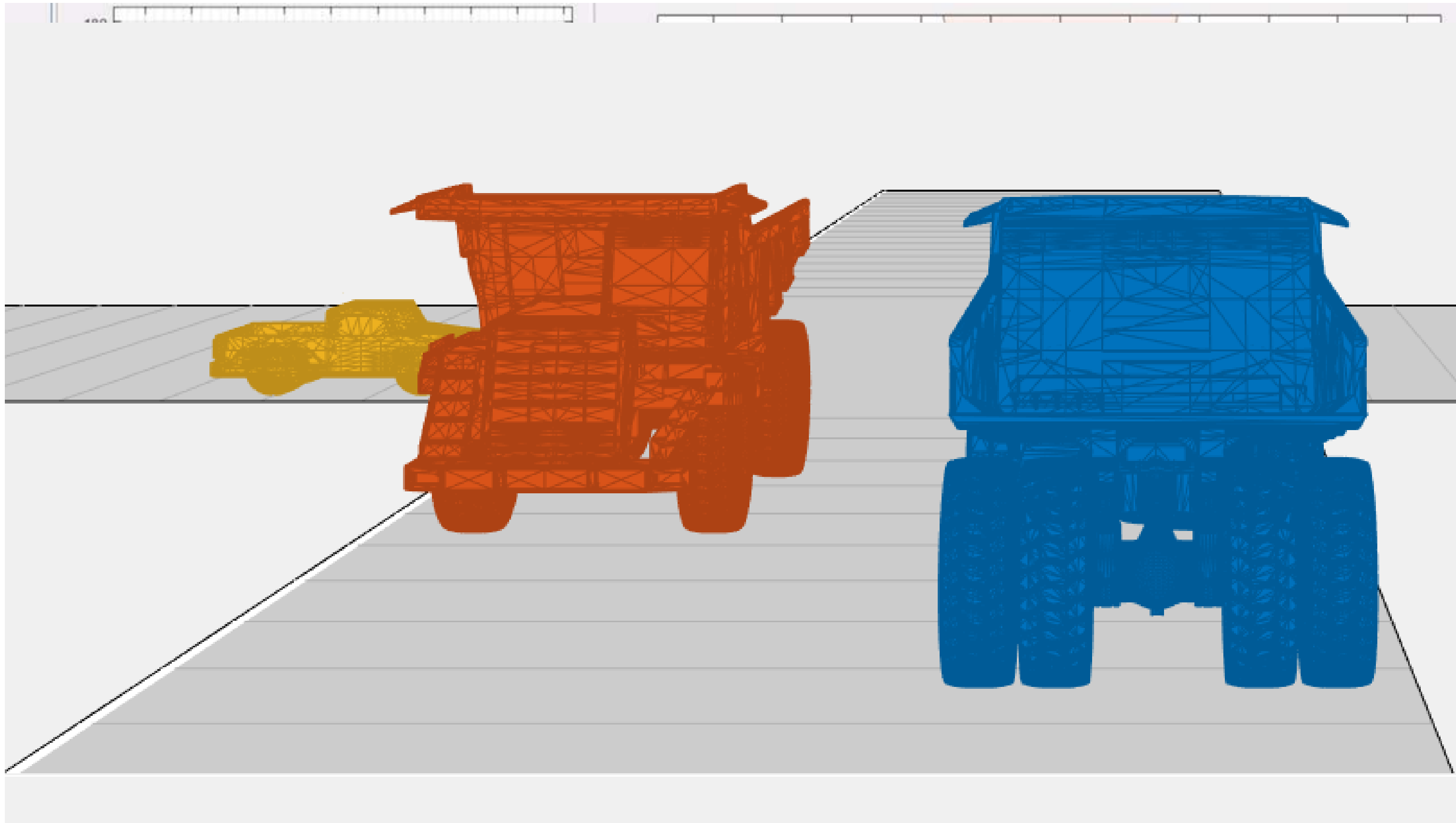
Modeling vehicle interaction scenarios to facilitate focused and efficient field testing

- Vehicle interactions
  - Prevalent scenarios
  - Based on U.S. fatality reports
- Kinematic analysis
  - Input parameters
  - Sensor/configuration data
- Explore relevant parameters
- Visualize detection data



NIOSH simulation model
Vehicle interaction scenario
Left: 2D/grid view of the two haul trucks and a LD vehicle;
Right: bird-eye, 2D simulation showing system field-of-vision

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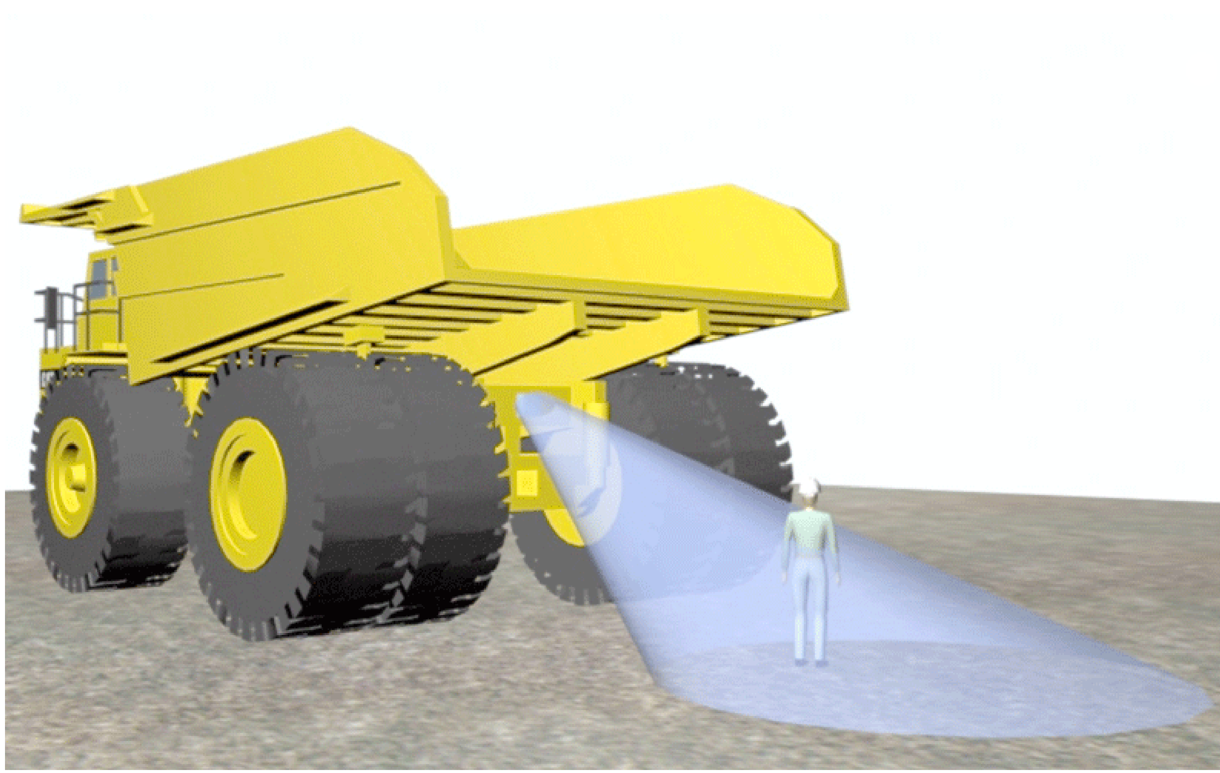
Conducting field evaluations to examine real-world performance

- Determine in situ system performance
  - Examining the value of methods in terms of real-world performance
  - Determining the value of assessments system efficacy
- Instrumentation
  - Camera monitoring – 360° exterior, UAV surveillance
  - Interior camera(s) and/or microphone to detect system warnings
  - GPS for location and speed
  - Additional sensors as determined



NIOSH image depicting sensing zone behind a haul truck

Questions?

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