# Haul Truck Safety Research

Image credit: Komatsu 930E Haul Truck | 3D CAD Model Library | GrabCAD


Joseph Bickson

Mining Engineer


*2022 Meeting of the Automation and Emerging Technologies Partnership*

Sept 14, 2022 — Sept 15, 2022

# NIOSH has two projects on haul truck safety research

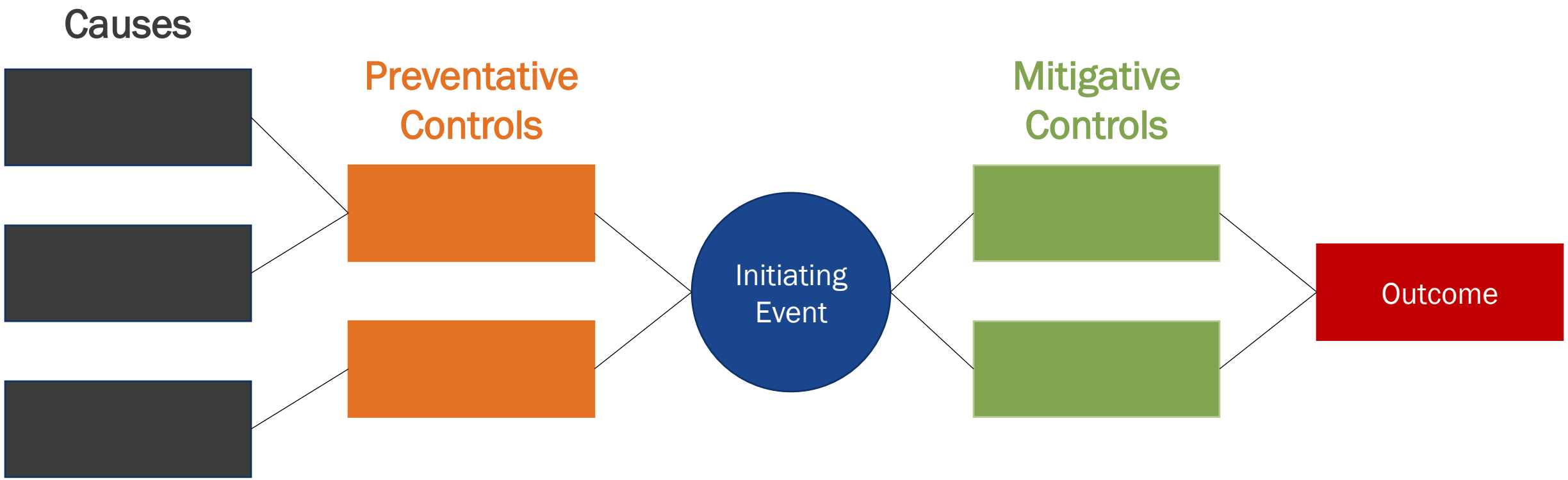
## Characterization of Haul Truck Health and Safety Issues

*Project team*
Jennica Bellanca (**PI**), Jacob Carr, Brendan Demich, William Helfrich, Cassie Hoebbel, John Homer, Jon Hrica, Brendan Macdonald, Jason Navoyski, Tim Orr

## Validating Collision Warning and Avoidance System Detection Performance for Surface Mining Haul Trucks

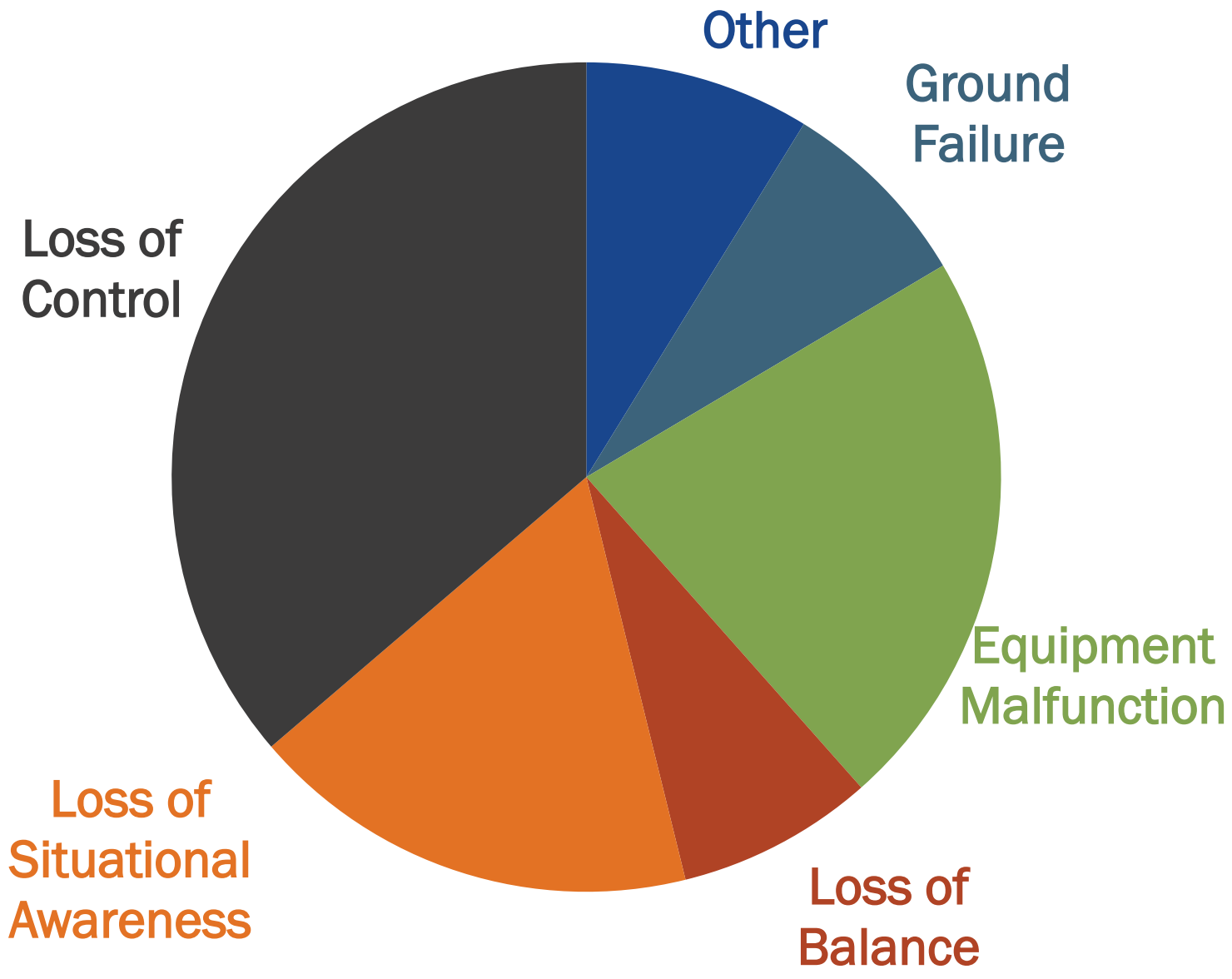
*Project team*
Joseph Bickson (**PI**), John Homer (PI), Jacob Carr, Cory DeGennaro, Matt Girman, Chris Jobes, Brandin Lambie, Justin Srednicki, Lincan Yan, Dave Yantek, Jeff Yonkey, Yongjun (Alan) Zhang, Chenming (Jim) Zhou


# Researchers created bowtie representations for haul-truck-related fatal accidents in the U.S. from 2005 – 2018

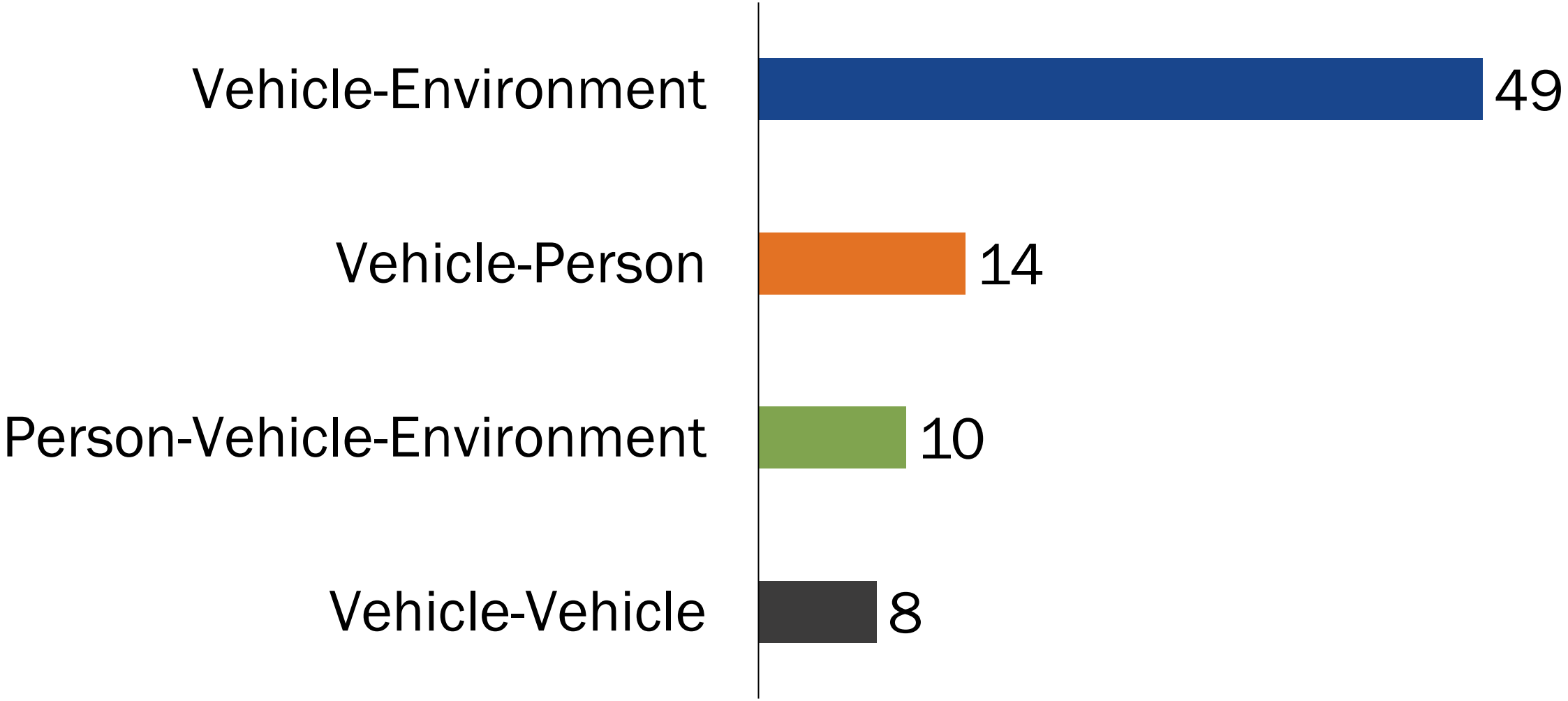



91 accidents that happened to or because of a mineworker operating a haul truck

# 61% of the fatal accidents are initiated by the operator

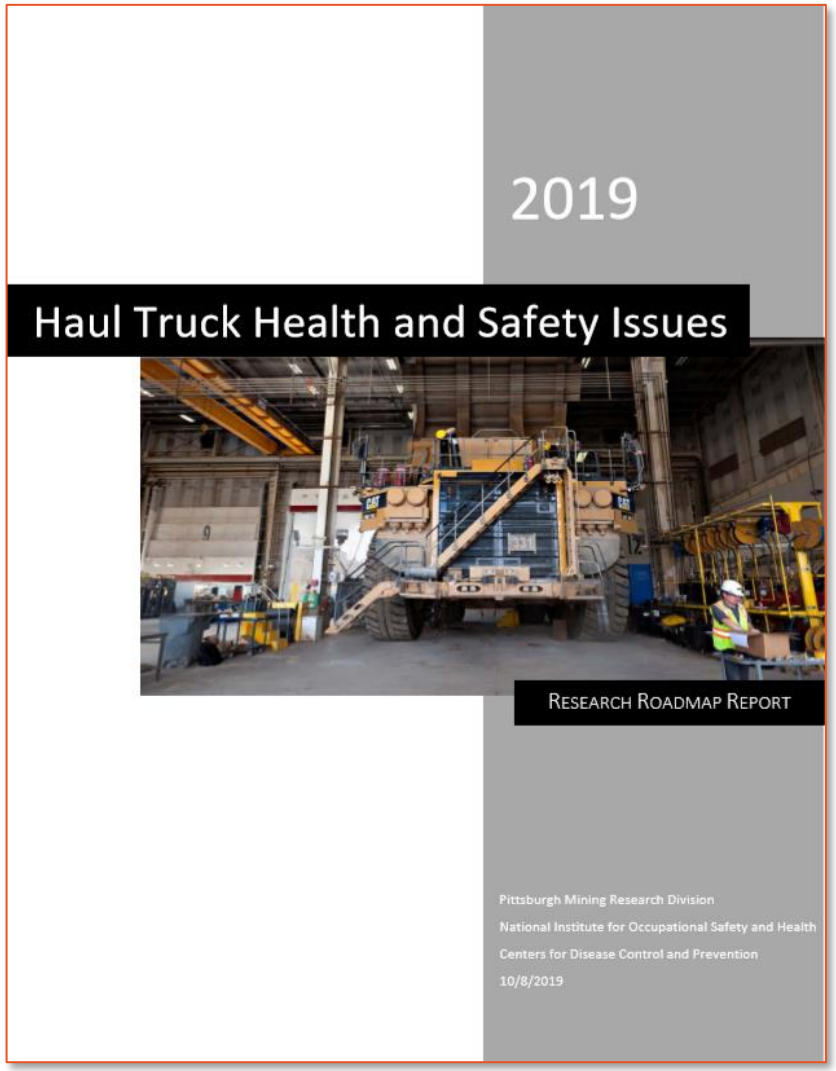


# The majority of fatal accidented were vehicle-environment interactions from 2005 -2018

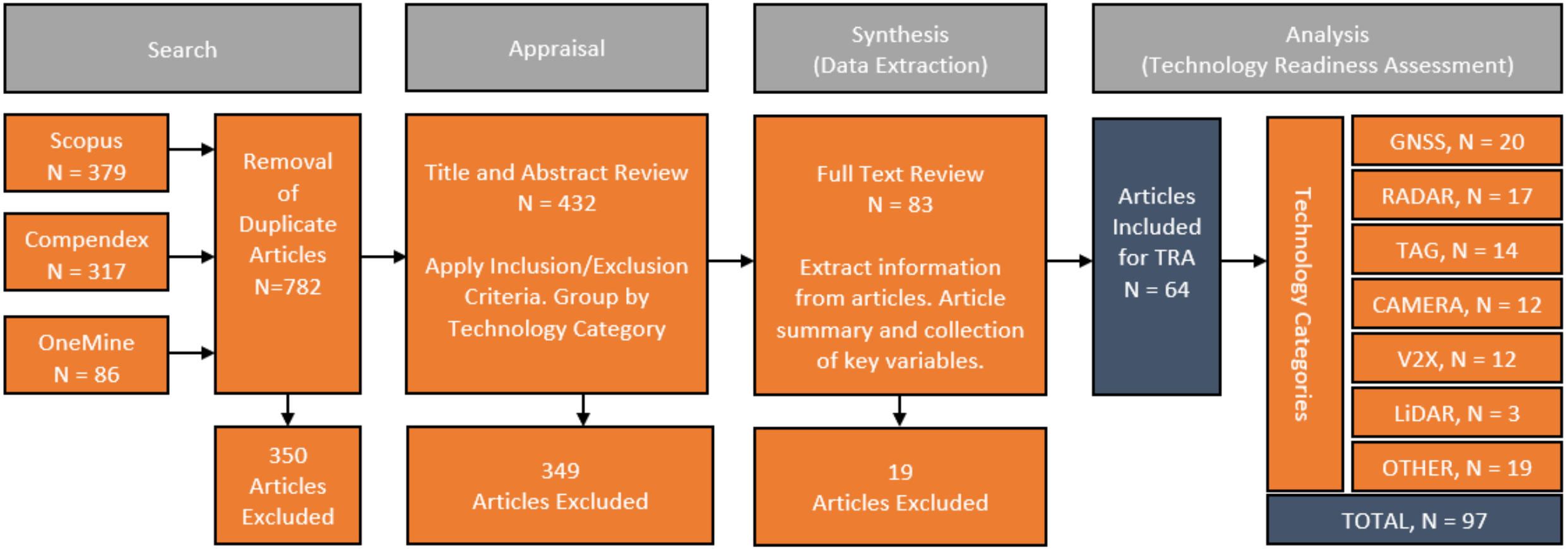


# Haul Truck Health and Safety Issues Research Roadmap Report

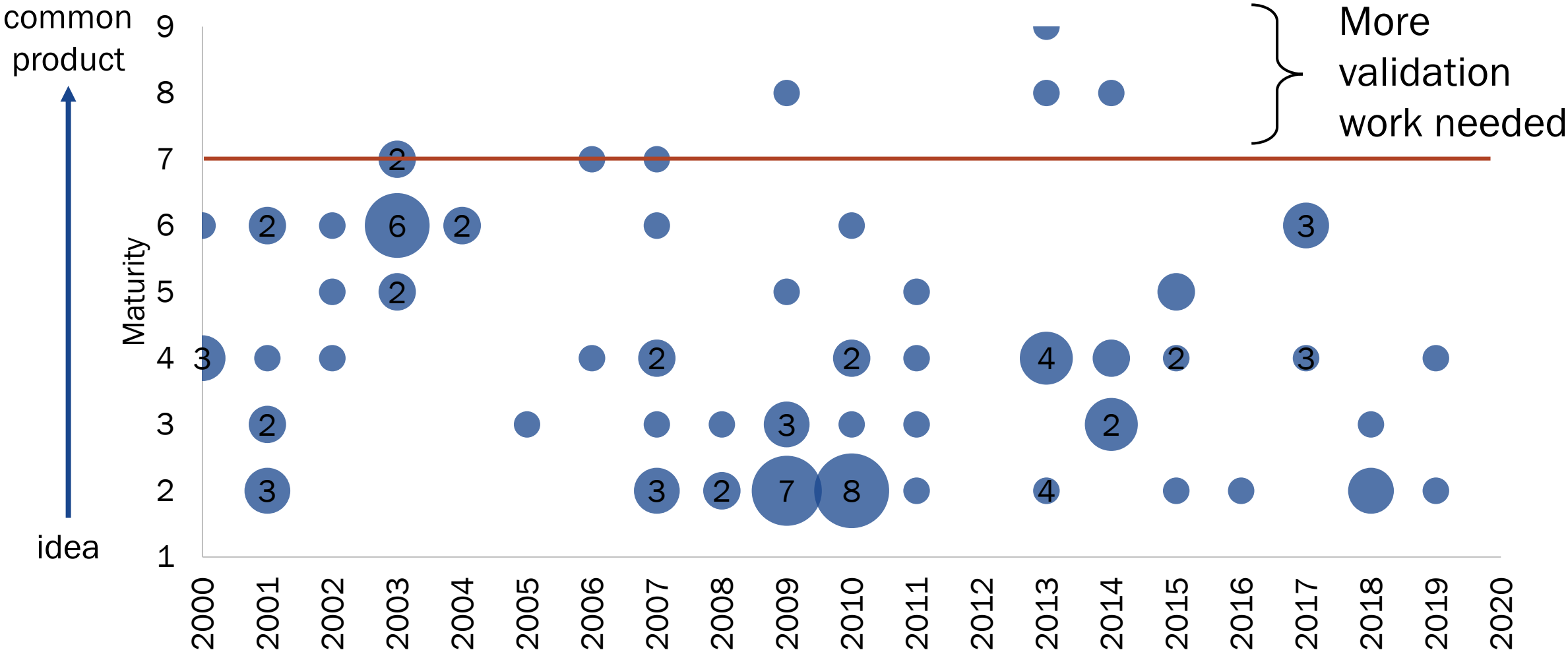
There is a systemic lack of **development**, **implementation**, and **integration** of haul-truck-related health and safety interventions.
A **systems approach** should be taken to fully integrate interventions.



# Systematic literature search of peer reviewed articles on CXSs between 2000 – 2020 resulted in 97 articles

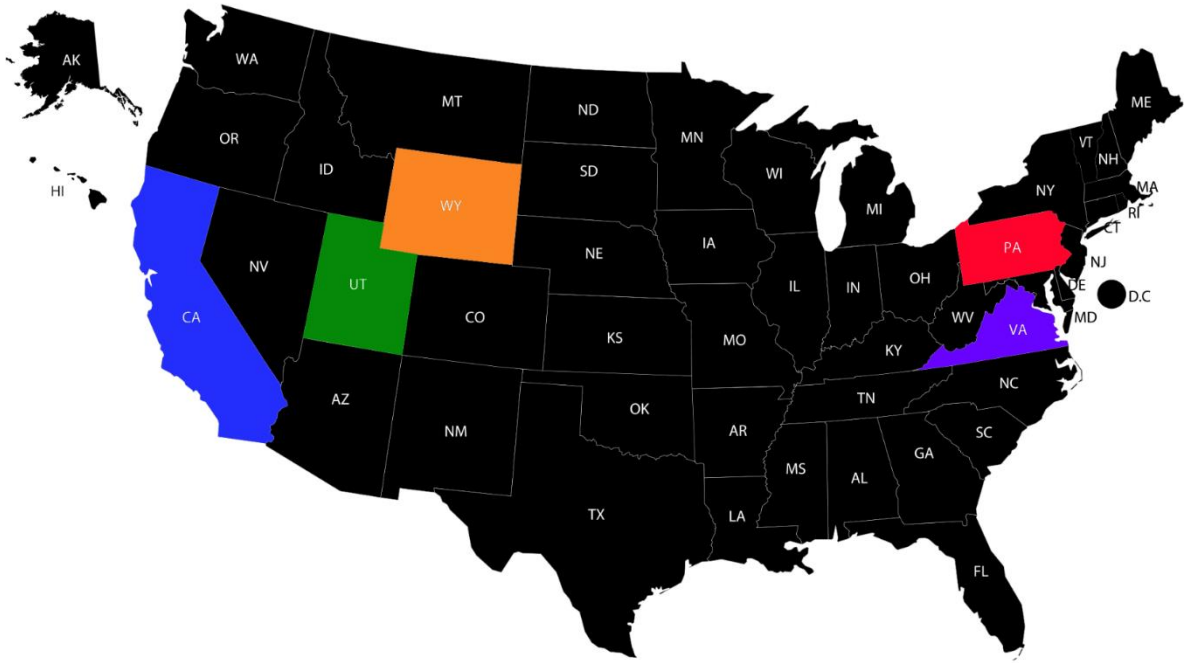


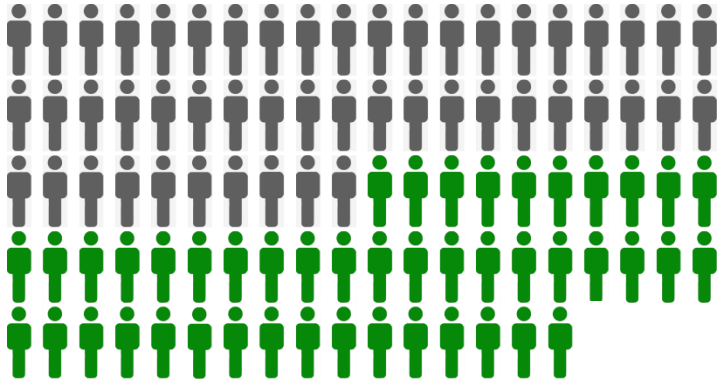
# Technology Readiness of Collision Avoidance/Warning Systems identified the need for more collaboration between industry, academia, and government.



# Interviewed mineworkers were sampled across region, commodity, and role to identify concerns, differing expectations, and opportunities for improvement

- Mine Companies
  - Surface Coal
    - 1 Small
    - 1 Large (2 locations)
  - Surface Stone, Sand, Gravel
    - 3 Small
    - 1 Medium (4 locations)
  - Surface Metal
    - 1 Large
- Personnel (N = 96)
  - Haul Truck Operators
  - Managers
  - Health & Safety Professionals
  - Trainers
  - Maintenance Personnel






# Providing industry with lessons learned, safety solutions, and heuristics


# “Don’t make Assumptions”

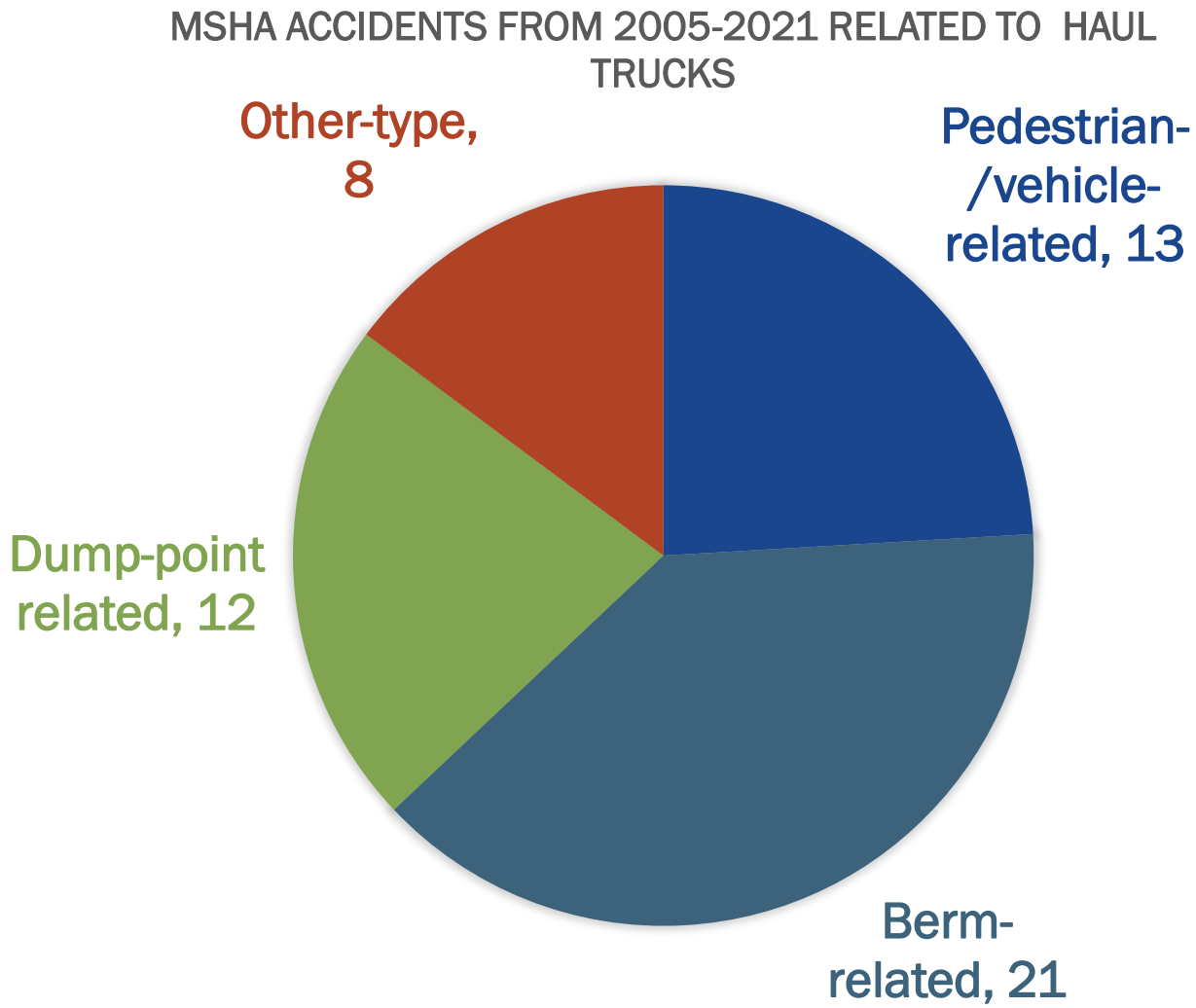
# Why do haul truck fatal accidents keep occurring?

- Take a systems approach
- Re-focus on low-level controls (EMESRT's levels 1-6)
- Develop shared hazard perceptions
- Provide engaging hazard training
- Promote proactive communication

Jennica Bellanca |Jbellanca@cdc.gov | 412.386.6445

NIOSH Mining Program
www.cdc.gov/niosh/mining

# Between 2005 and 2021, haul trucks were involved in 54 fatal incidents at surface mines in the United States




**13 pedestrian-/vehicle-related incidents**

| Haul Truck Motion | Victim(s) Position | CXS-relevant | Incidents |
|---|---|---|---|
| Forward Travel | Parked LV – Occupant | Yes | 2 |
| | Operator Cab | Yes | 1 |
| | Head-On Traveling LV – Occupant | Yes | 1 |
| | Pedestrian | Yes | 1 |
| | Railroad Car – Dropper | Yes | 1 |
| Forward Start | Parked LV – Occupant(s) | Yes | 2 |
| | Portable Toilet – Occupant | Yes | 1 |
| Reverse Start | Parked Haul Truck – Behind Cab | Yes | 1 |
| Loss of Control | Stopped Haul Truck – Occupant | Potentially | 1 |
| Forward Roll/Drift | Pedestrian | No | 2 |

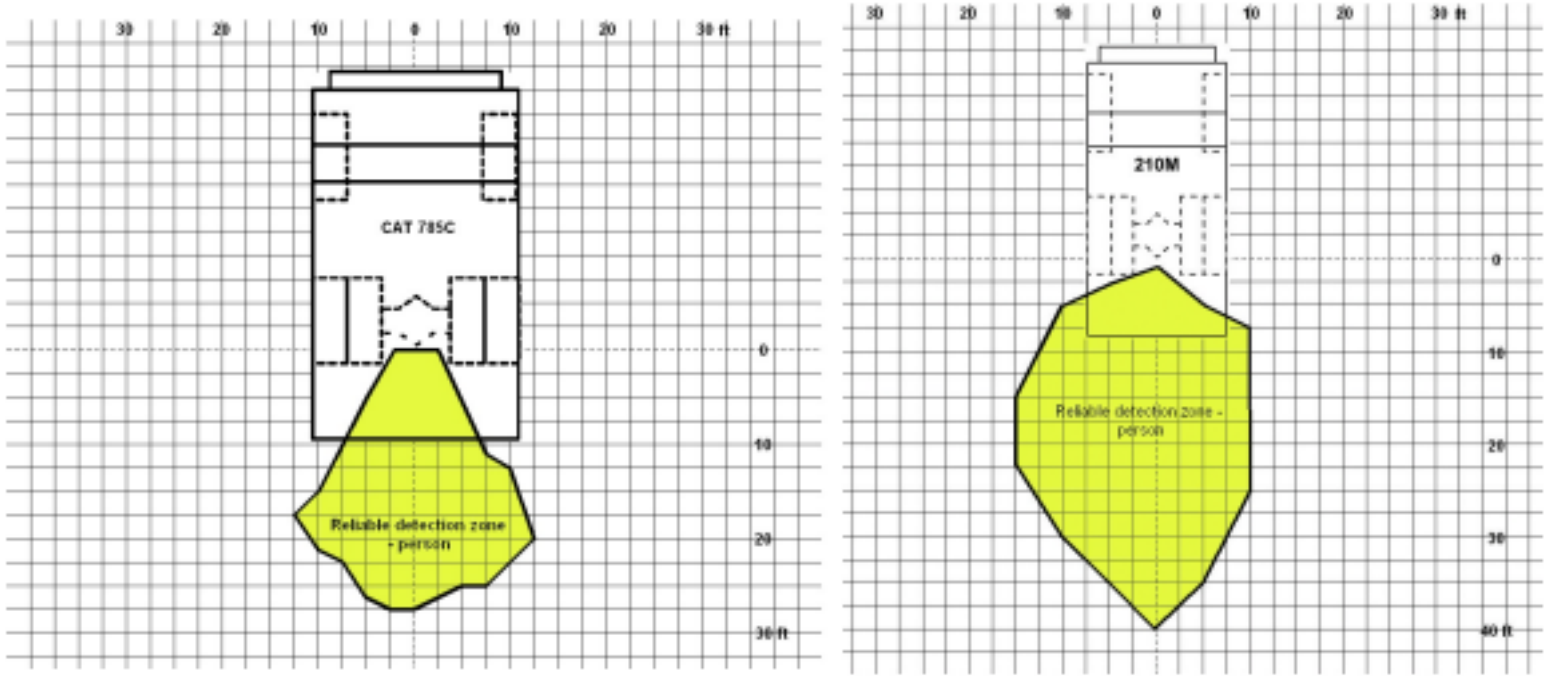
Homer J, Bickson J, DeGennaro C, Girman M [2022]. Analysis of U.S. Surface Mining Haul-Truck-Related Fatalities. In: Proceedings of the SME Annual Meeting. Society for Mining, Metallurgy, and Exploration, Inc., Preprint 21-085, February 27 - March 2.

# NIOSH researchers reviewed CXS related documents (1) to identify methods and parameters used to evaluate detection performance and (2) to identify gaps in CXS test methods and in detection performance.

Approaches:

- Static/Dynamic
- Scenario-specific
- Computer modeling

Author: Ruff, Todd
Title: MONITORING BLIND SPOTS: A MAJOR CONCERN FOR HAUL TRUCKS

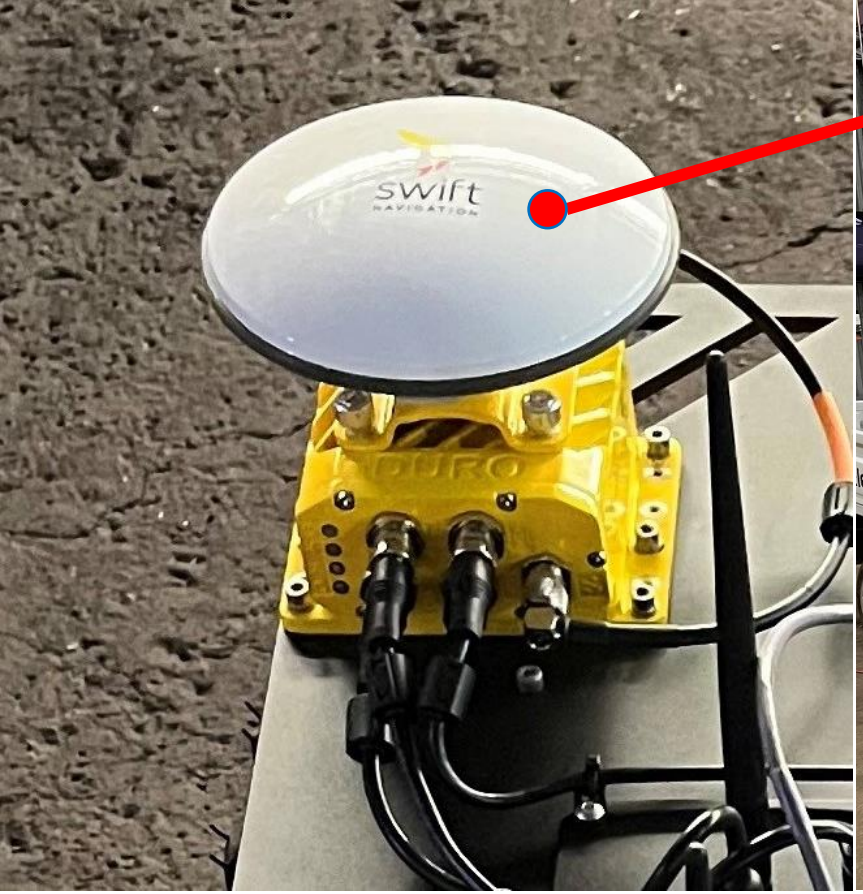



Bickson J, Homer J, DeGennaro C, Girman M, Jobes C [2022]. An Overview of Methods and Parameters to Evaluate Detection Performance and Validation of Collision Warning and Avoidance Systems. In: Proceedings of the SME Annual Meeting. Society for Mining, Metallurgy, and Exploration, Inc., Preprint 21-087, February 27 - March 2.

# The second part of our objective was to identify gaps in CXS test methods and in actual CXS detection performance (real-world)

**Research gaps included:**

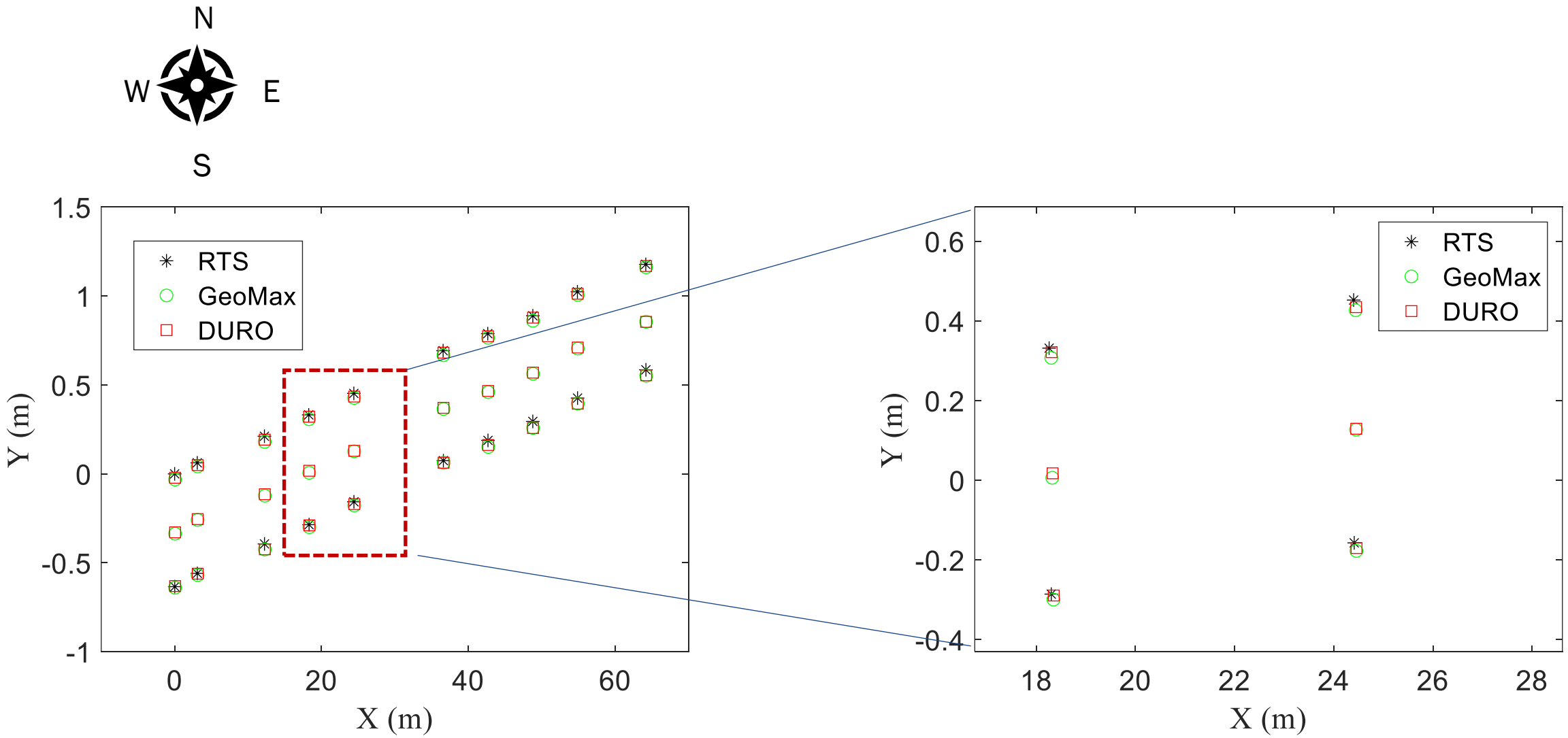
- Test methods for false positive detections
- Extensive assessment of CXS limitations and capabilities
- Lack of standard test/simulation methods and procedures
- Design of experiments testing to assess the effect of environmental factors
- Documented performance of CXS at dump points or drop-off hazards
- Lack of test methods and procedures for target recognition-based systems





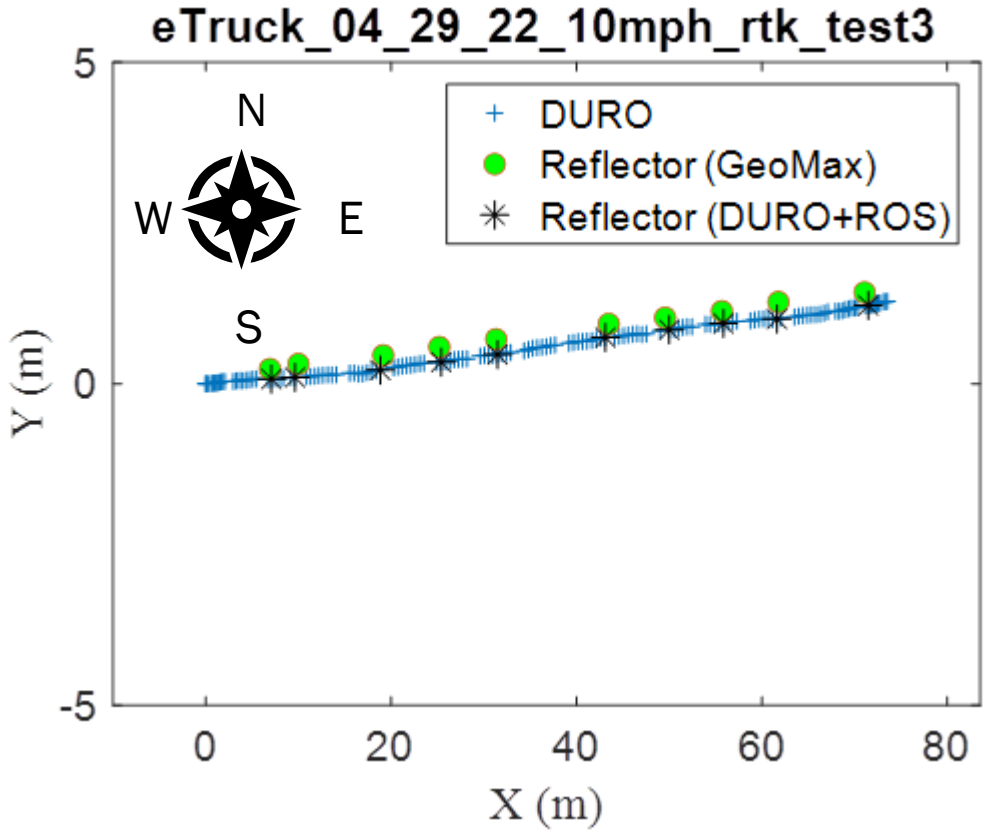
**We conducted ground truth validation tests to establish the accuracy of the ground truth data collection systems (DURO GNSS) using an unmanned ground vehicle (UGV) and a reduced-scale vehicle (RSV)**

# The results of static showed agreement between the surveying instruments and the DURO GNSS

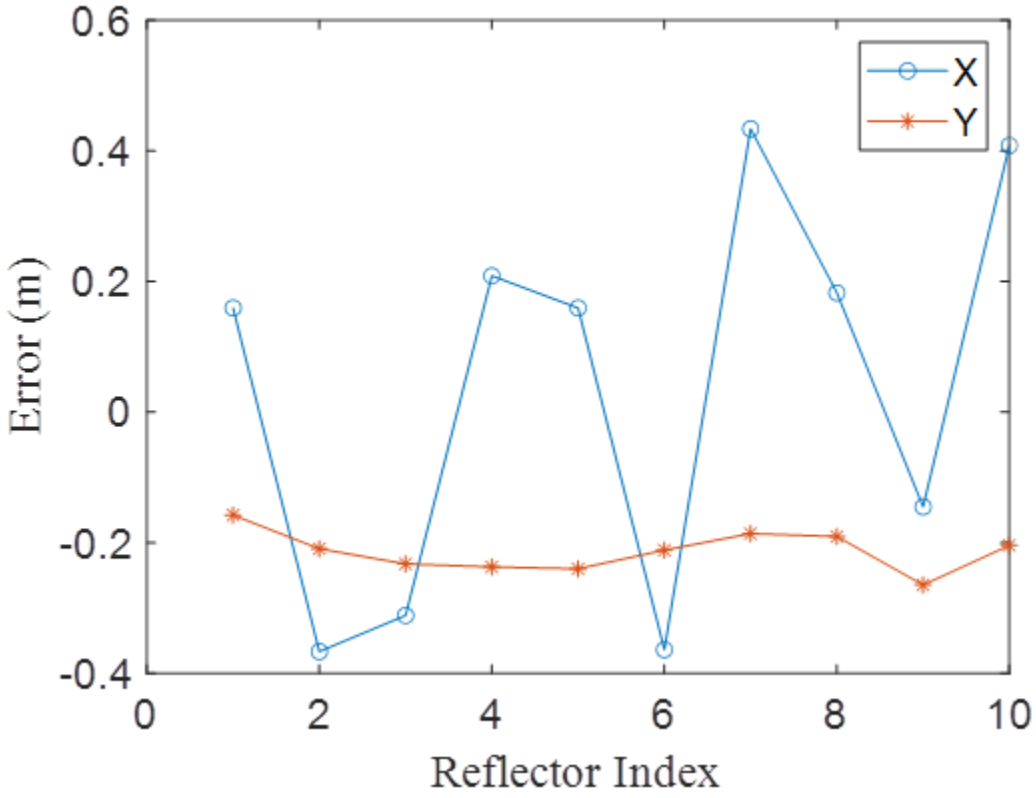


# The results of the dynamic test results showed a consistent offset with the surveyed points

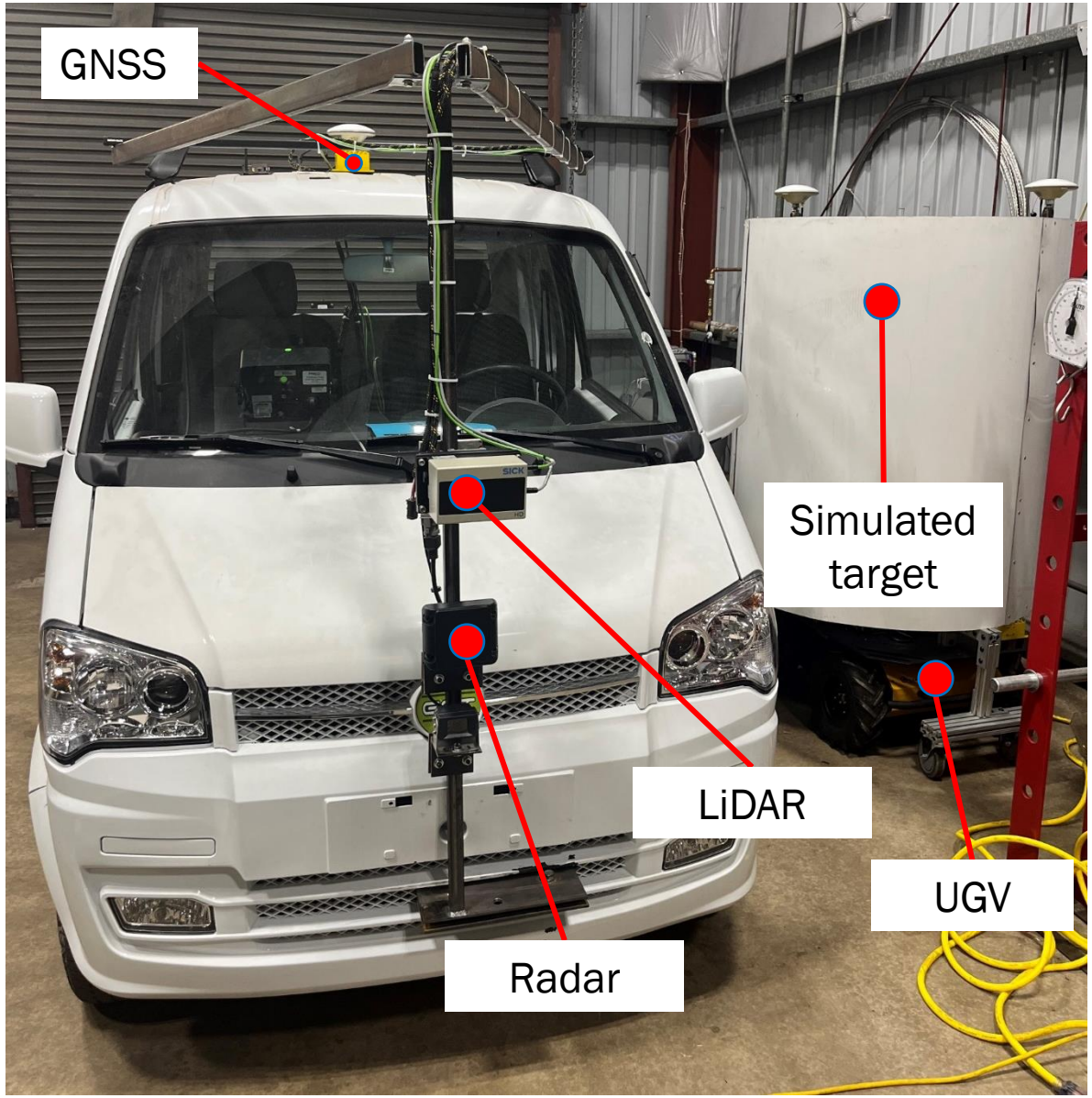
Points on the North




Average errors in X and Y coordinates

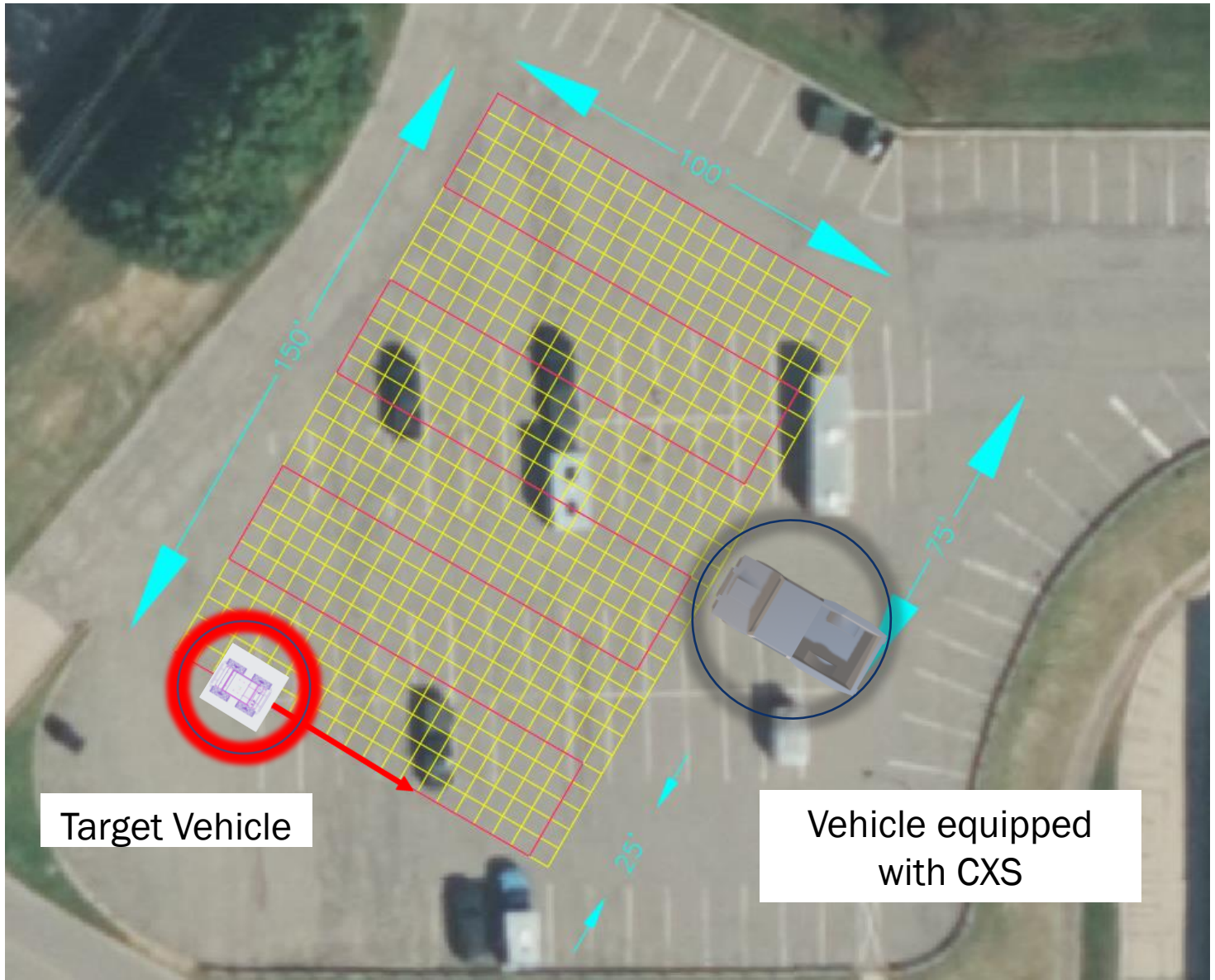


# NIOSH researchers are prepared for CXS reduced vehicle testing using an RSV and an unmanned ground vehicle (UGV)

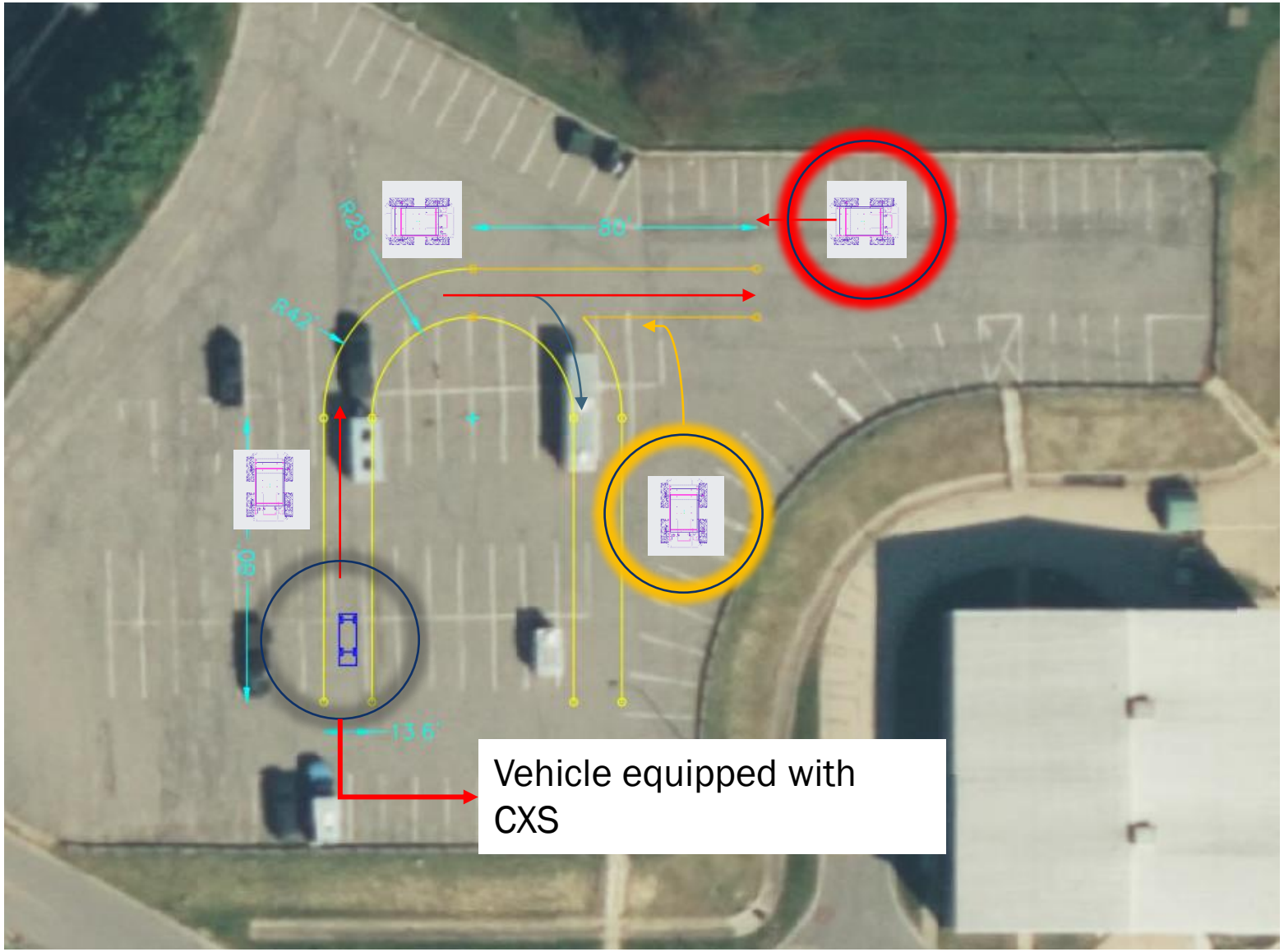


# We plan on maneuvering the UGV in and out of the detection zone autonomously to ensure efficiency and repeatability for RSV tests

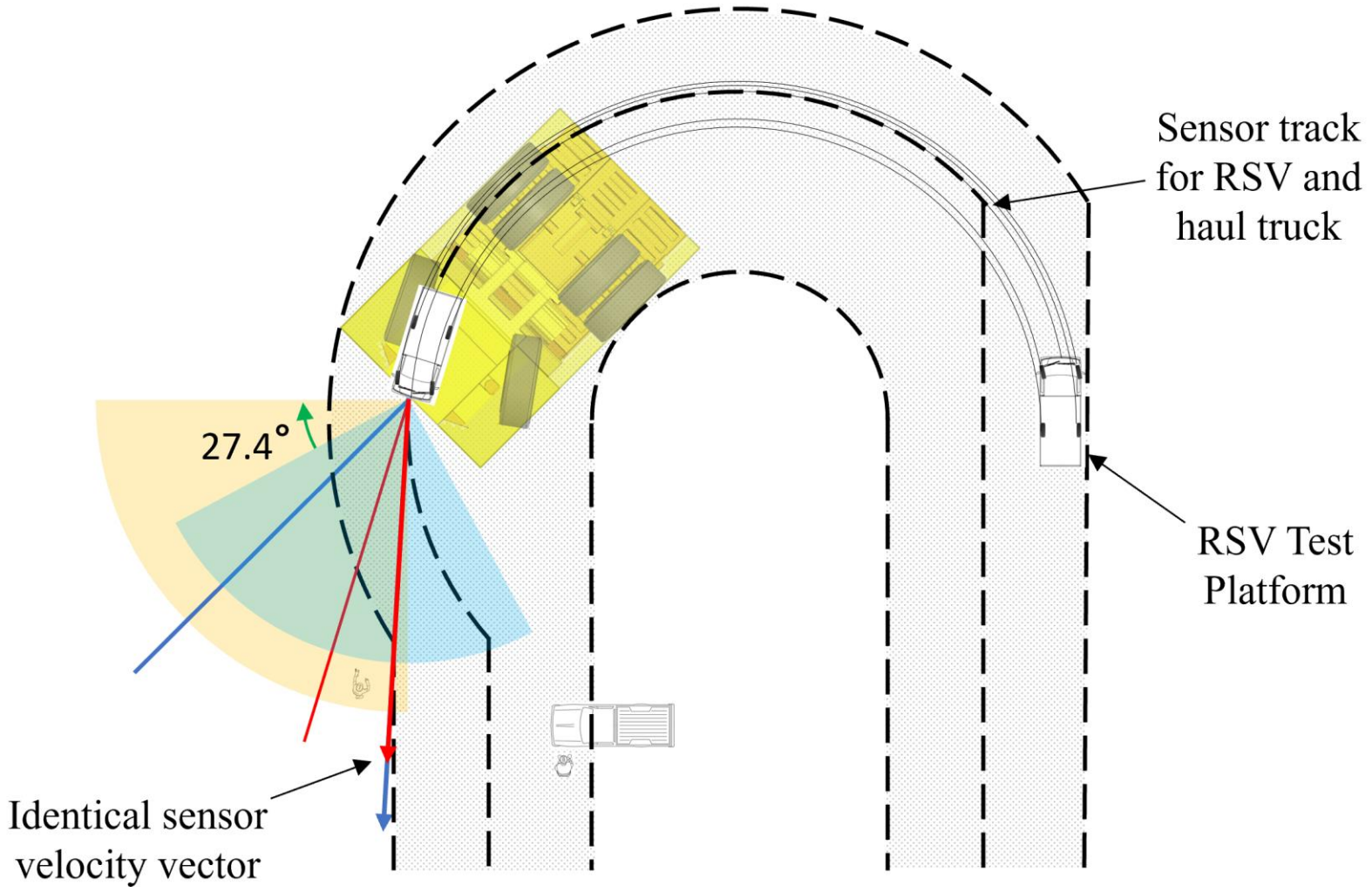
# NIOSH researchers plan to on conducting static tests with RSV



# We also plan to on conducting dynamic tests: straight and curved paths using RSV



# Kinematic calculation showed that using our RSV to model the equivalent sensor track of a CAT 793C would require the sensor be offset 27.4° towards



# We intend to simulate vehicle interaction in MATLAB and validate the results in the field

1). Sensor index

2). Detection time

3). Detection target

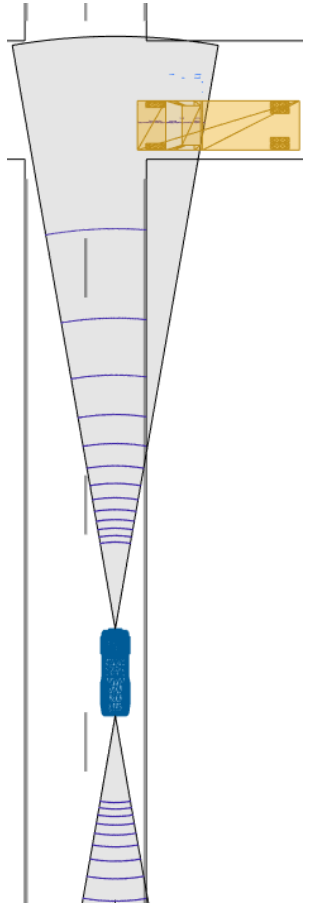
4). Actor position at detection

5). Actor velocity at detection

5). Actor acceleration rate at detection

6). Relative distance at detection (collision)

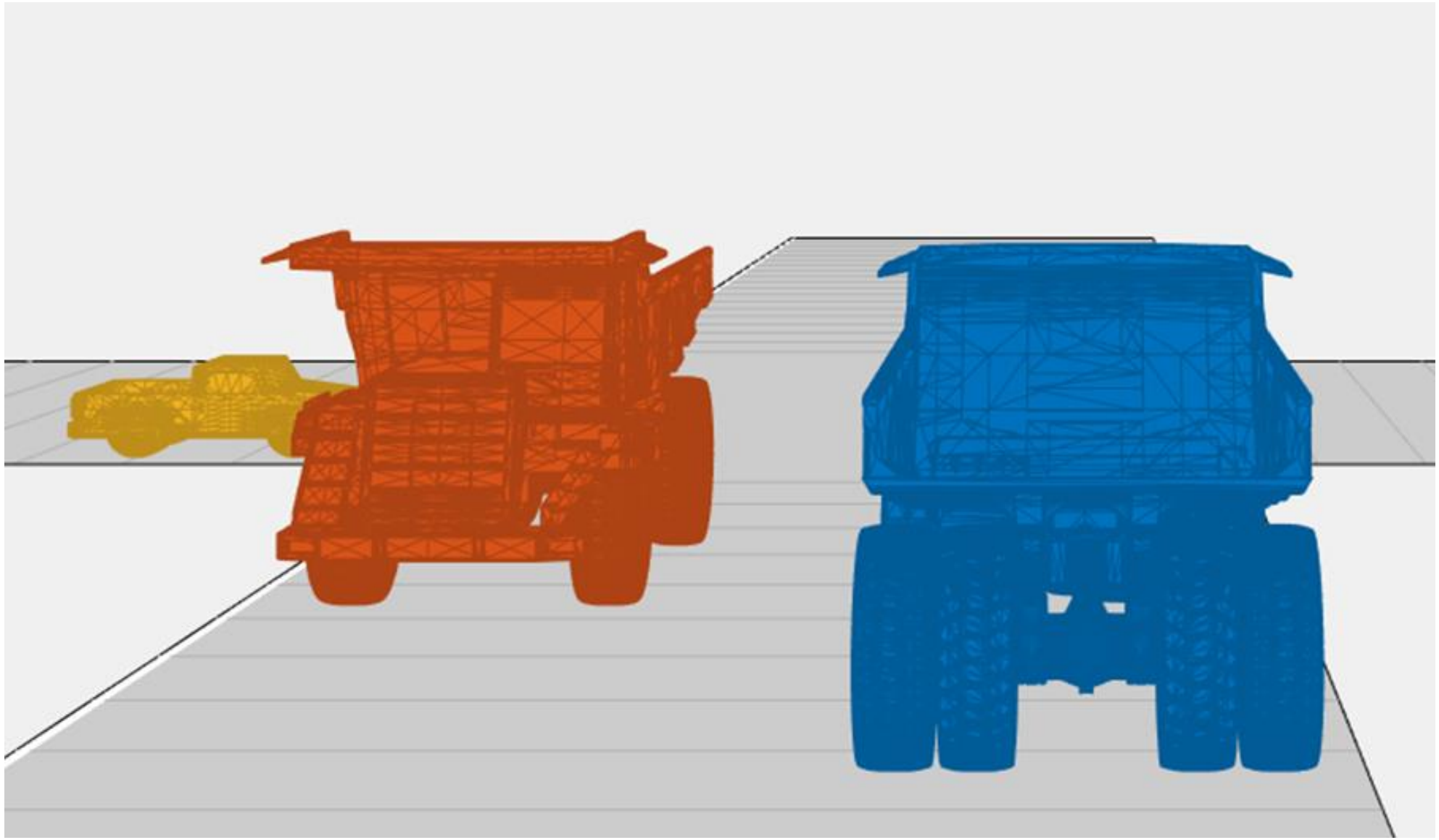
7). Time of collision



LiDAR detection

# Thank you!

Joseph Bickson
JBickson@cdc.gov
412.386.5935



NIOSH Mining Program
www.cdc.gov/niosh/mining