

# Why do haul truck fatal accidents keep occurring?



Tim Orr, Jennica Bellanca, Jon Hrica  
Pittsburgh Mining Research Division





# Haul truck fatal accidents continue to be a significant health and safety concern in the mining industry

- Powered haulage accounts for 50% of fatal accidents each year

(MSHA, 2018a)

- Haul trucks are the largest contributor

(MSHA, 2018b)

- 6 of 28 in 2017
- 6 of 27 in 2018

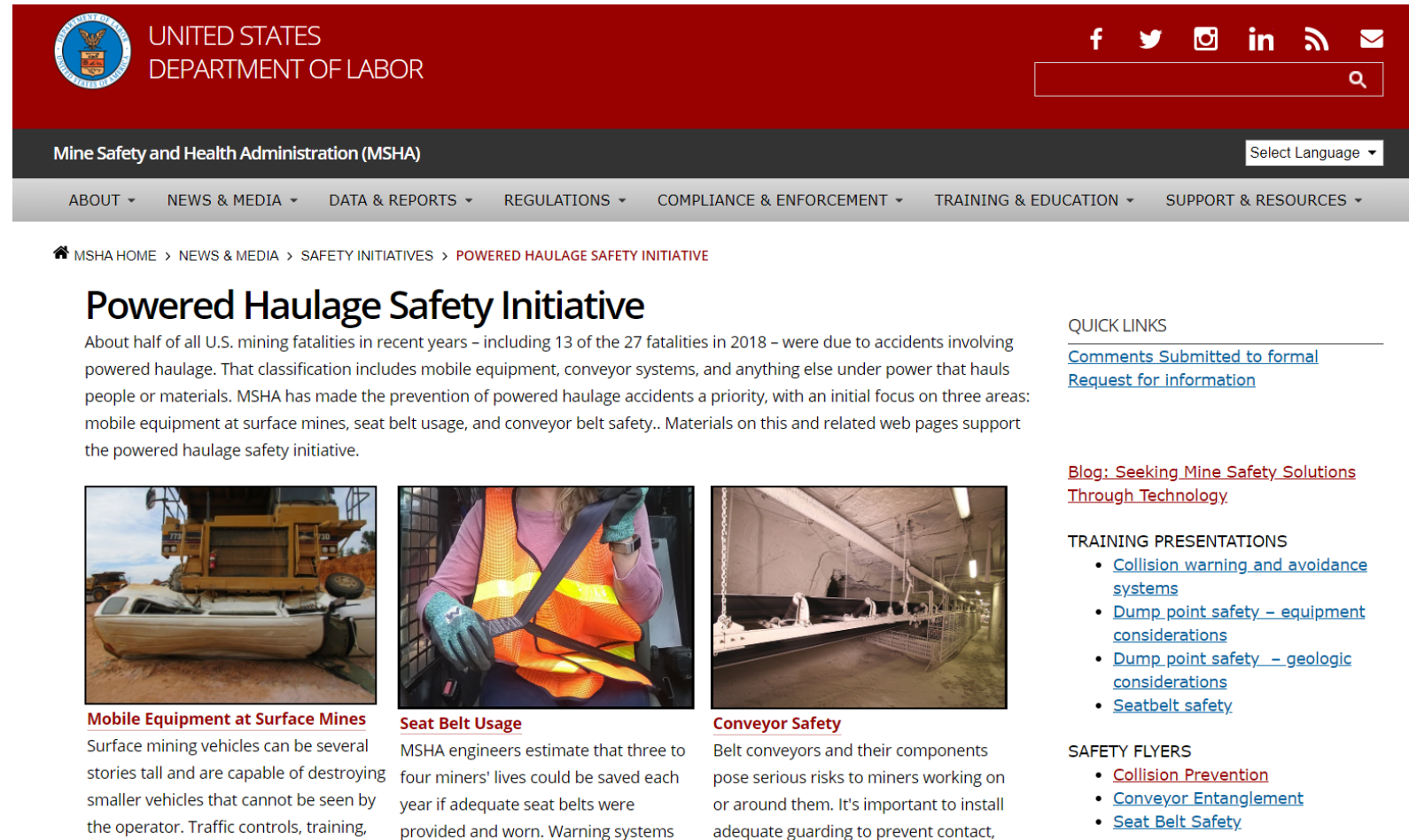
- Haul trucks account for 45% of mining equipment

(PR Newswire, 2015)



# MSHA recently began a powered haulage safety initiative

- Request for Information
- Safety Flyers
  - Collision Prevention
  - Conveyor Entanglement
  - Seat Belt Safety
- Training Presentations



The screenshot shows the MSHA website header with the United States Department of Labor logo and navigation menu. The main content area features the title "Powered Haulage Safety Initiative" and a paragraph explaining the initiative's focus on mobile equipment, conveyor systems, and seat belt usage. Three images illustrate these areas: mobile equipment at surface mines, seat belt usage, and conveyor safety. A sidebar on the right contains quick links, training presentations, and safety flyers.

**United States Department of Labor**

**Mine Safety and Health Administration (MSHA)**

ABOUT ▾ NEWS & MEDIA ▾ DATA & REPORTS ▾ REGULATIONS ▾ COMPLIANCE & ENFORCEMENT ▾ TRAINING & EDUCATION ▾ SUPPORT & RESOURCES ▾

MSHA HOME > NEWS & MEDIA > SAFETY INITIATIVES > **POWERED HAULAGE SAFETY INITIATIVE**

## Powered Haulage Safety Initiative

About half of all U.S. mining fatalities in recent years – including 13 of the 27 fatalities in 2018 – were due to accidents involving powered haulage. That classification includes mobile equipment, conveyor systems, and anything else under power that hauls people or materials. MSHA has made the prevention of powered haulage accidents a priority, with an initial focus on three areas: mobile equipment at surface mines, seat belt usage, and conveyor belt safety.. Materials on this and related web pages support the powered haulage safety initiative.

**Mobile Equipment at Surface Mines**  
Surface mining vehicles can be several stories tall and are capable of destroying smaller vehicles that cannot be seen by the operator. Traffic controls, training,

**Seat Belt Usage**  
MSHA engineers estimate that three to four miners' lives could be saved each year if adequate seat belts were provided and worn. Warning systems

**Conveyor Safety**  
Belt conveyors and their components pose serious risks to miners working on or around them. It's important to install adequate guarding to prevent contact,

**QUICK LINKS**

- [Comments Submitted to formal Request for information](#)

**Blog: Seeking Mine Safety Solutions Through Technology**

**TRAINING PRESENTATIONS**

- [Collision warning and avoidance systems](#)
- [Dump point safety – equipment considerations](#)
- [Dump point safety – geologic considerations](#)
- [Seatbelt safety](#)

**SAFETY FLYERS**

- [Collision Prevention](#)
- [Conveyor Entanglement](#)
- [Seat Belt Safety](#)

<https://www.msha.gov/news-media/special-initiatives/2018/05/31/powered-haulage-safety-initiative>



## Previous Research

What has already been done?

## Accident Analysis

Where do we need more information for the mineworker?

## Report, Site Visits & Discussions

Where does the Industry need/want help?

## Workers Perspectives

What motivates policy violations? How good are current policies and procedures?

## Technology Maturity

Where are the technology gaps?

## Research & Technology Gaps

Where are the research questions?



A large yellow CAT haul truck is the central focus, parked in a spacious industrial facility. The truck is viewed from a rear-quarter perspective, showing its massive tires and the operator's cab. A worker in a yellow hard hat is visible on the truck's platform. In the foreground, another worker wearing a white hard hat and a high-visibility vest is standing at a workbench, handling a cardboard box. The background features the complex steel structure of the factory, including overhead cranes and various equipment.

# Haul Truck Fatal Accidents



Monotonous Driving

Rough Roads

Changing Conditions

Congested Areas

- Previous analysis identified contributing factors

(Porter, 2016; Santos et al., 2010; Randolph & Boldt, 1997)

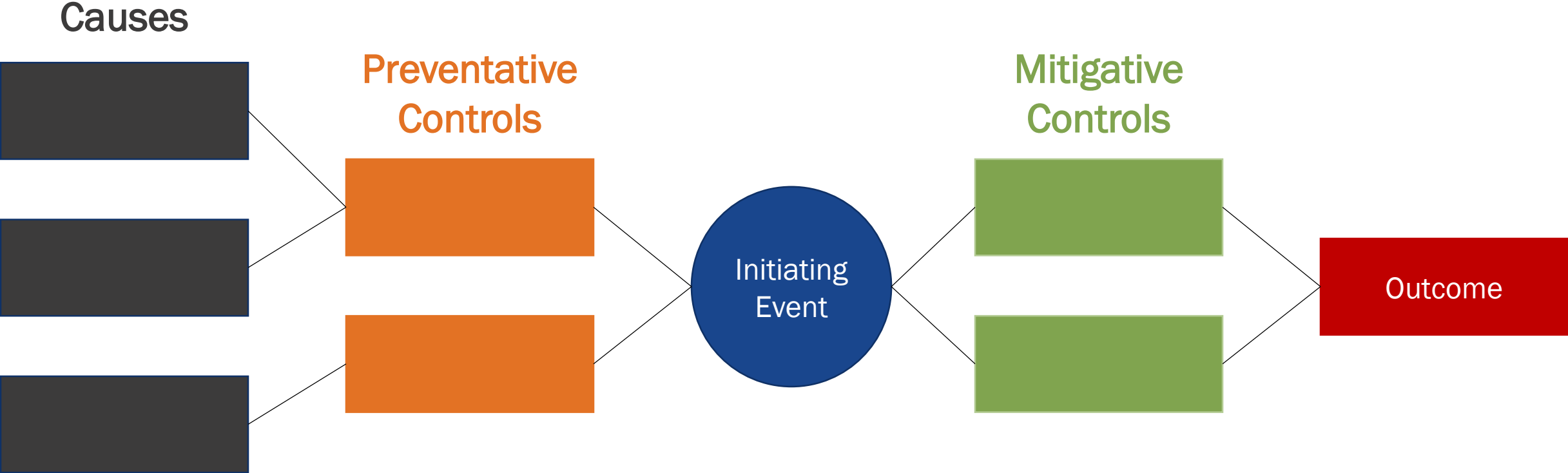
- Vehicle control
- Hazard recognition
- Human performance

Low Responsiveness

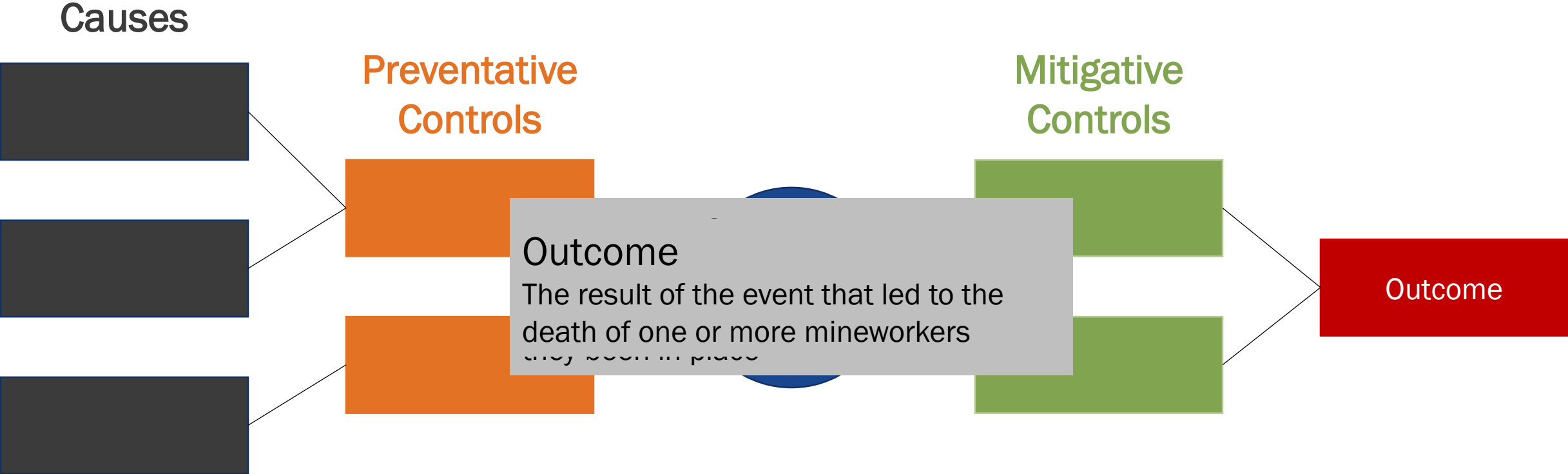
Limited Visibility



# Bowtie representations can give a more nuanced and holistic picture of the accident



# 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



# Fatal accident initiating events

Initiating Event	Definition
Equipment Malfunction	some aspect of the vehicle or equipment failed (e.g., brake failures)
Ground Failure	the ground or surface became unstable or failed (e.g., highwall failures)
Loss of Balance	a person or persons lost their balance (e.g., fall from height)
Loss of Control	the operator lost control of a vehicle due to the presence of performance-reducing factors (e.g., inclement weather, poor road conditions)
Loss of Situational Awareness	all aspects of the incident were under control, but the operator's awareness of the situation was inaccurate in some critical respect (e.g., location of other mineworkers, position of self)
Other	not otherwise categorized (e.g., falling material from a suspended load)



# Fatal accident outcomes

Outcome Type	Definition
Vehicle-Environment Interaction	operator loses control or otherwise drives vehicle into an environmental hazard (e.g., over berm, into pond, tips over)
Vehicle-Pedestrian Interaction	vehicle has a collision with a pedestrian
Vehicle-Vehicle Interaction	vehicle has a collision with another vehicle
Material-Person Interaction	uncontrolled material contacts or engulfs mineworker (e.g., pipe, mined ore)
Material-Vehicle Interaction	uncontrolled material contacts or engulfs vehicle (e.g., highwall failure, flying rock)
Person-Vehicle-Environment Interaction	mineworker falls to the ground from a vehicle or comes in contact with an environmental hazard that was created or exacerbated by the vehicle (e.g., falls off stairs, catches on fire from vehicle)
Other	not otherwise categorized (e.g., person bumps head)



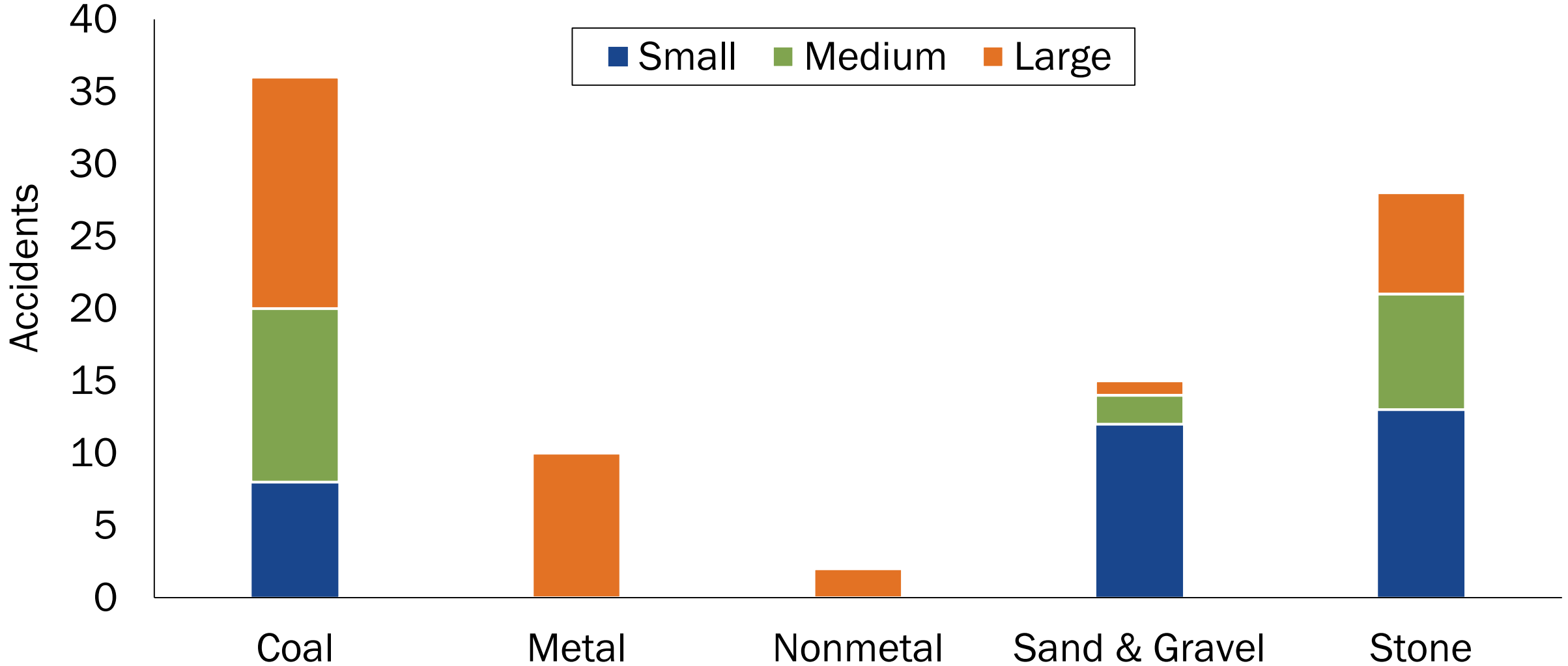
# Many industry partners are using a critical controls framework for risk management



(EMESRT, 2019)

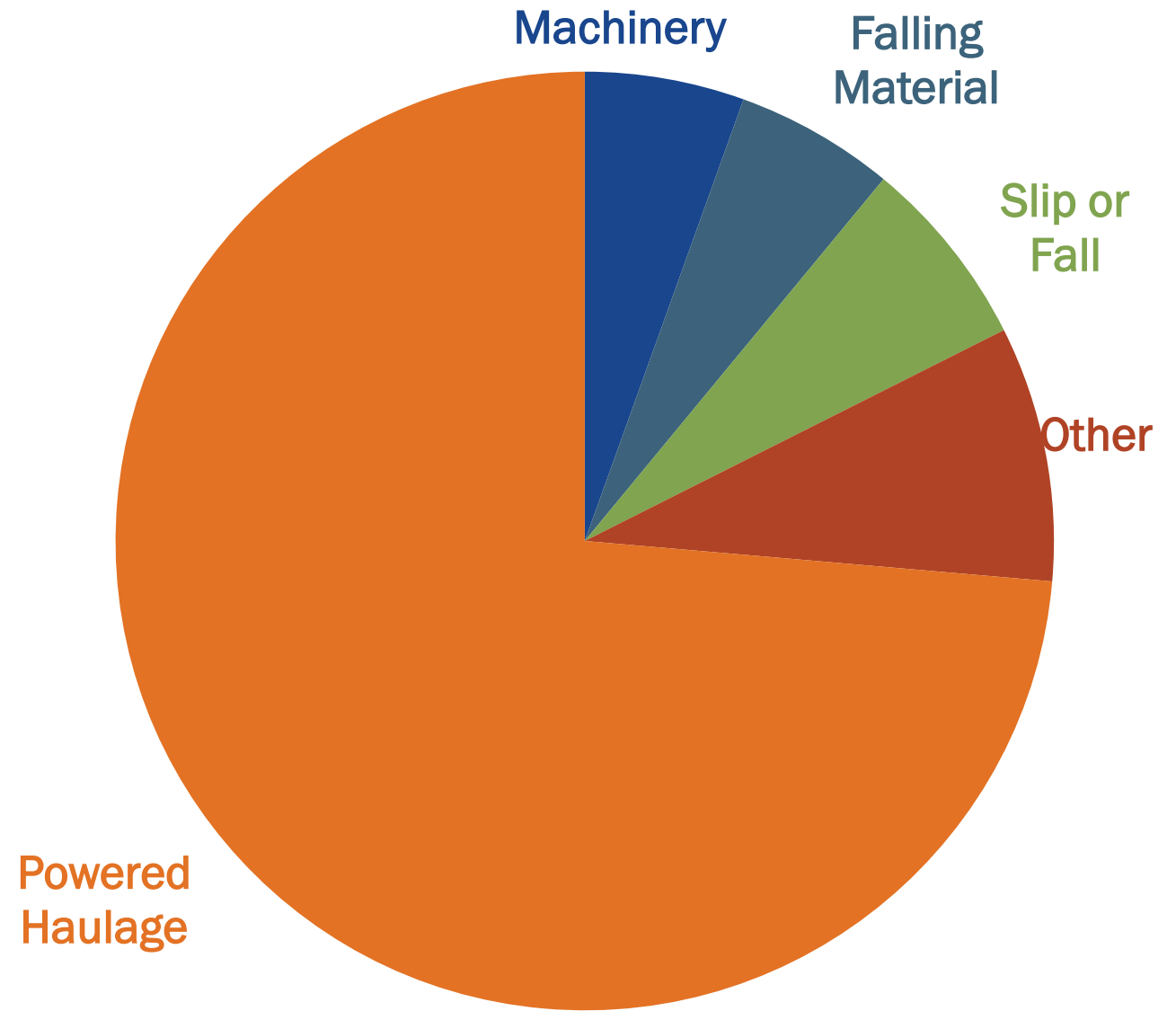


# Haul truck fatal accidents disproportionately affect large coal and metal/nonmetal mines and mostly occur at coal and stone mines



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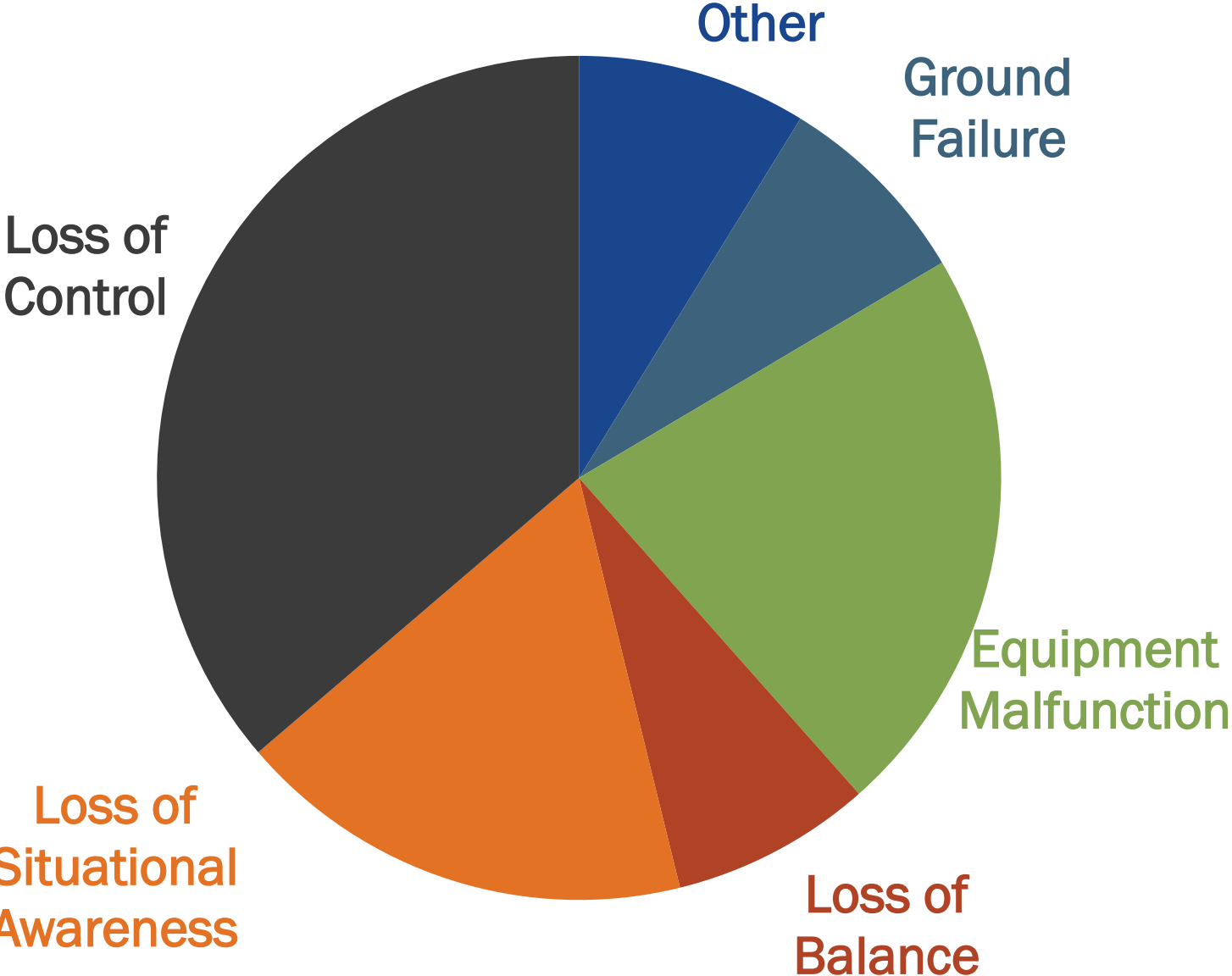
# Haul-truck-related fatal accidents are not just powered haulage



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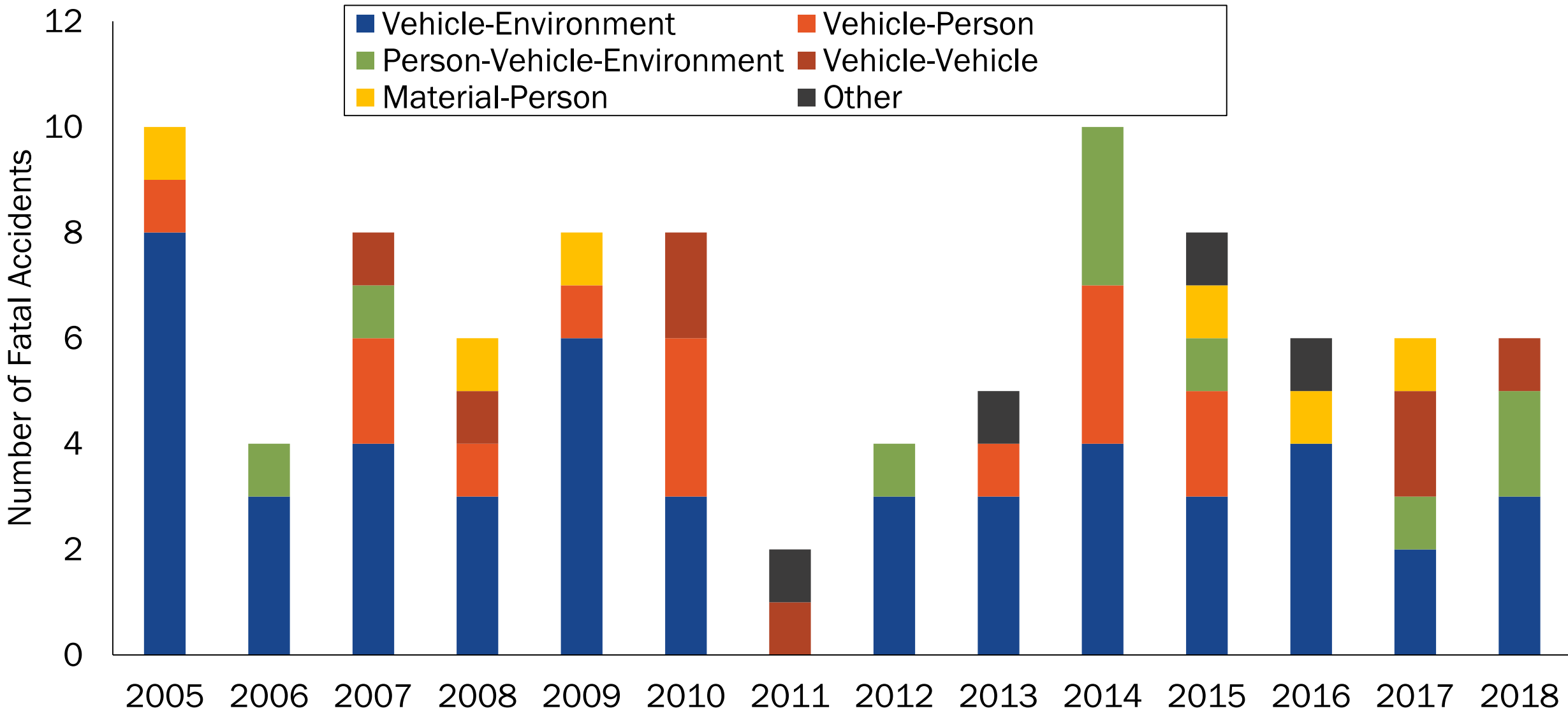


**61% of the fatal accidents are initiated by the operator**



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# Haul truck accidents are continually occurring and the majority are the vehicle-environment interactions

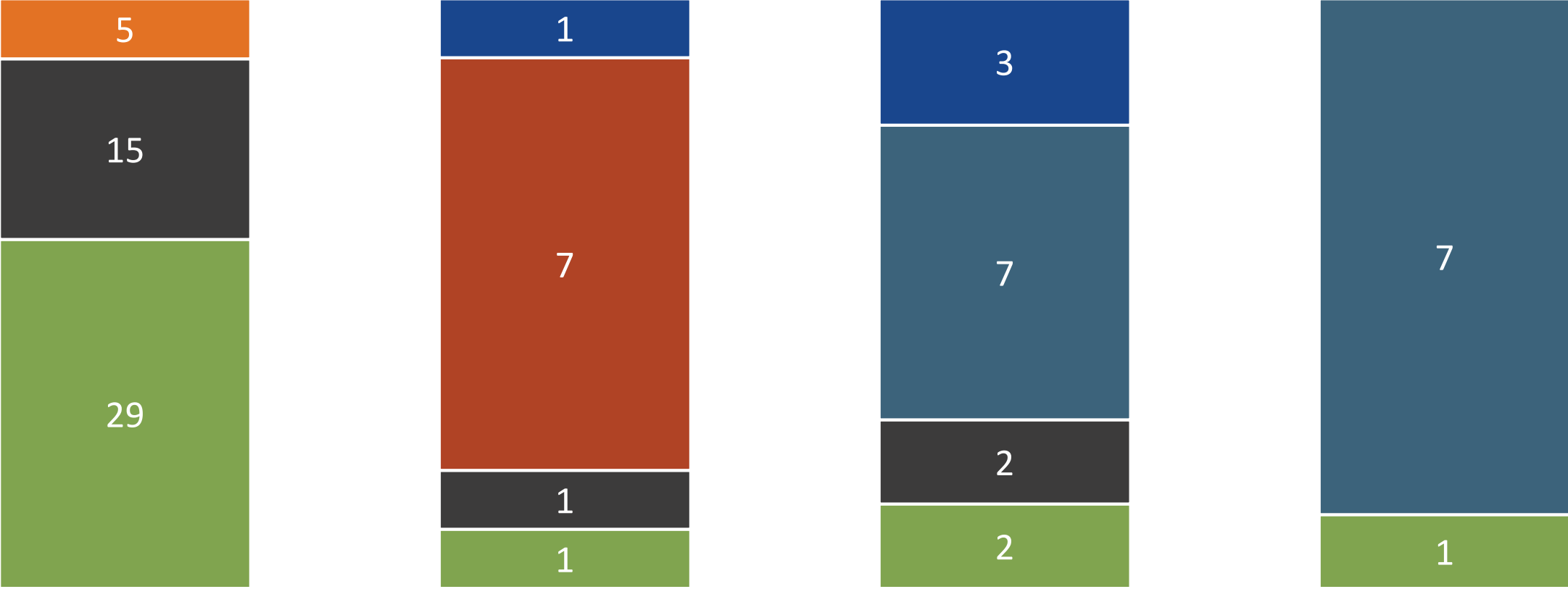


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# Environmental hazard fatalities were mostly initiated by loss of control and equipment malfunction

Loss of Control | Loss of Situational Awareness | Loss of Balance  
Ground Failure | Equipment Malfunction | Other



Vehicle-Environment

Person-Vehicle-Environment

Vehicle-Person

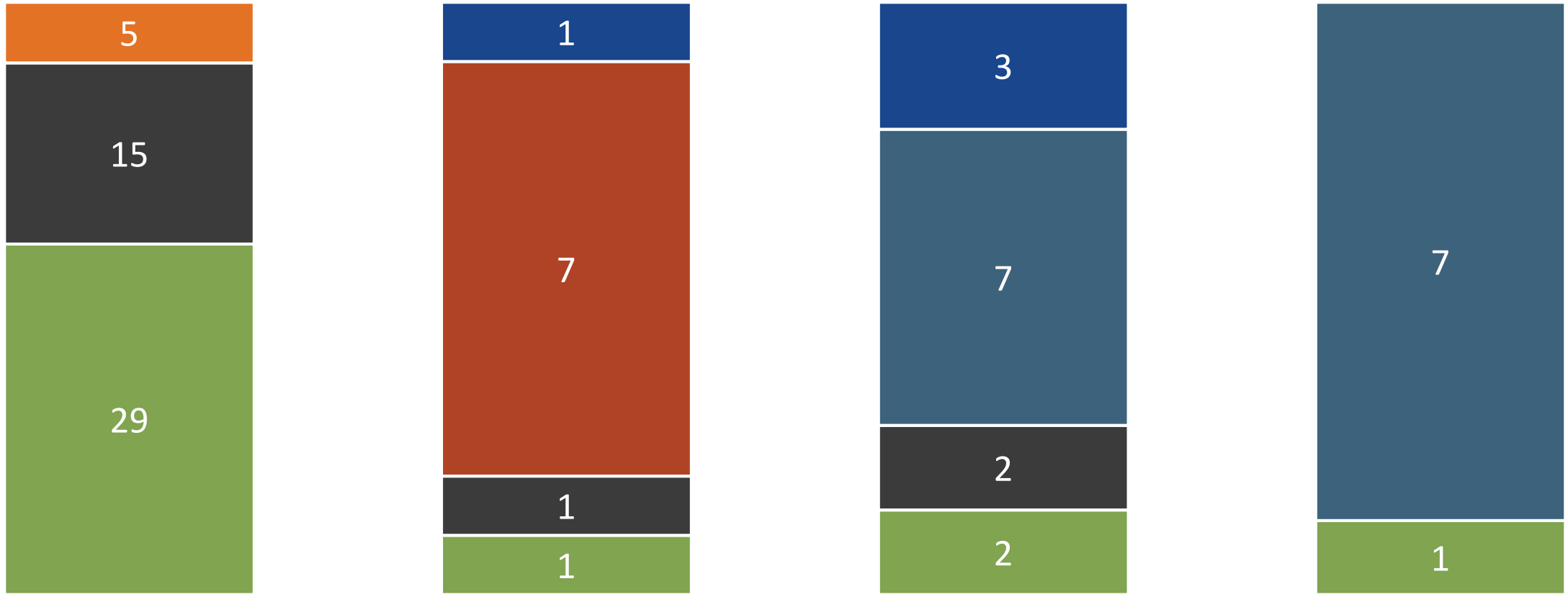
Vehicle-Vehicle

N = 81

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# Vehicle and pedestrian collisions fatalities were mostly initiated by loss of situational awareness

Loss of Control | Loss of Situational Awareness | Loss of Balance  
Ground Failure | Equipment Malfunction | Other



Vehicle-Environment

Person-Vehicle-Environment

Vehicle-Person

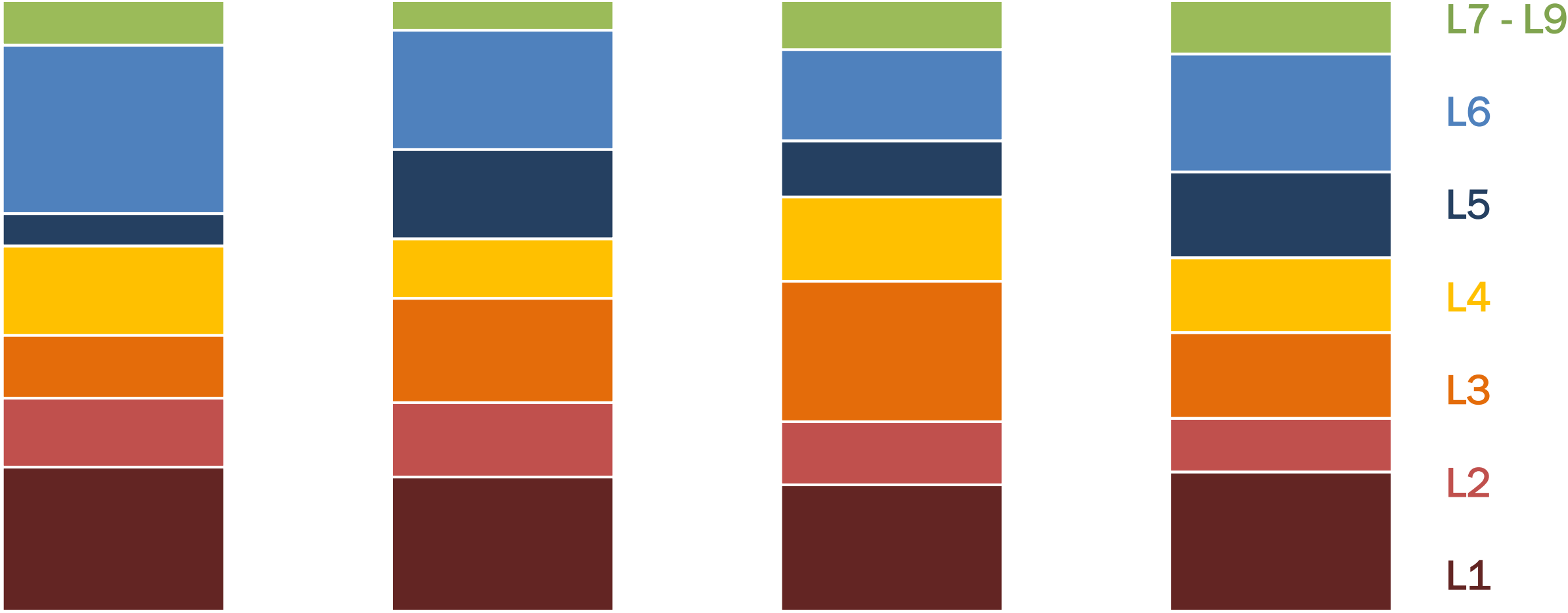
Vehicle-Vehicle

N = 81

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# Causes were predominantly low-level control failures (L1 – L6), specifically “failure to follow policies and procedures”



Vehicle-Environment

Person-Vehicle-Environment

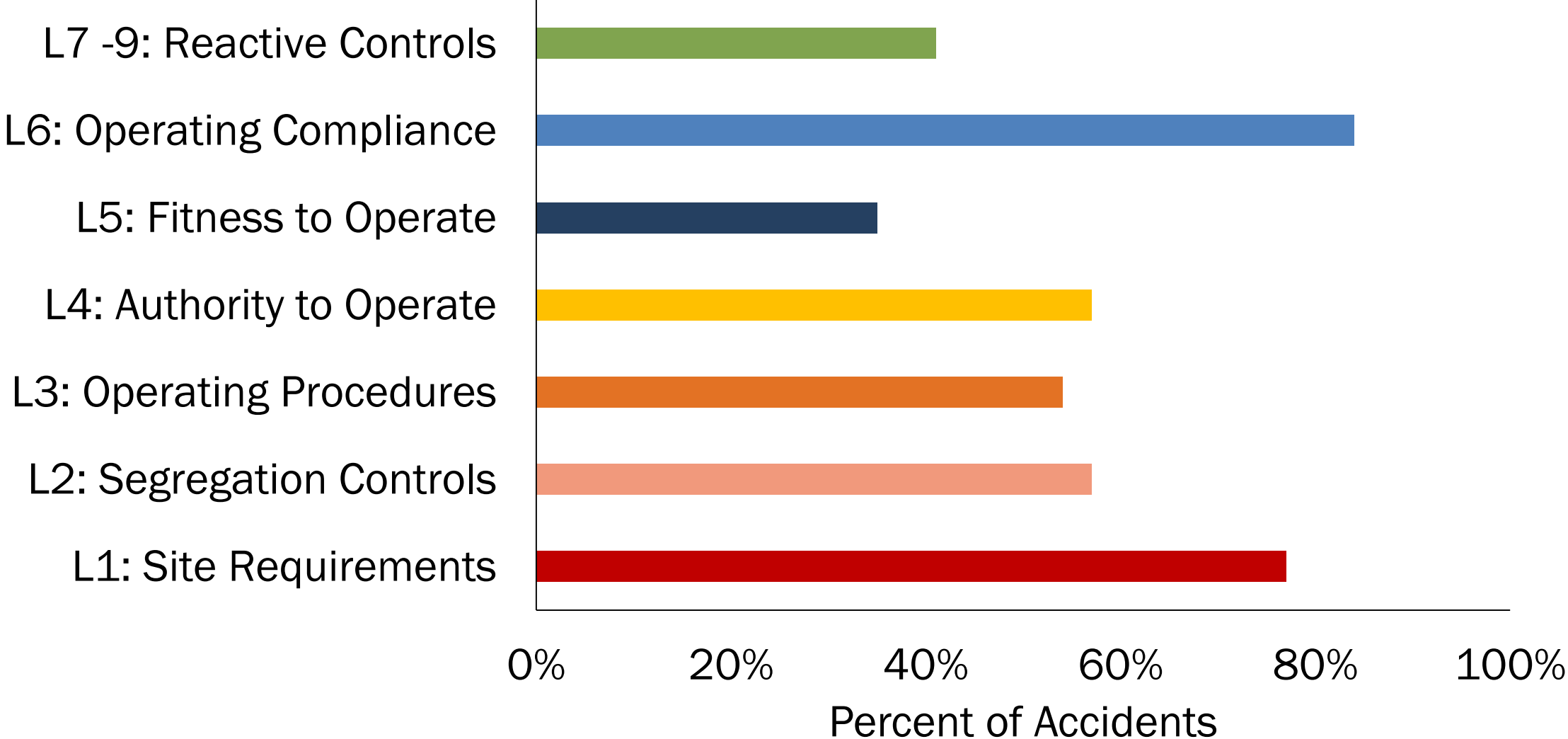
Vehicle-Person

Vehicle-Vehicle

N = 81

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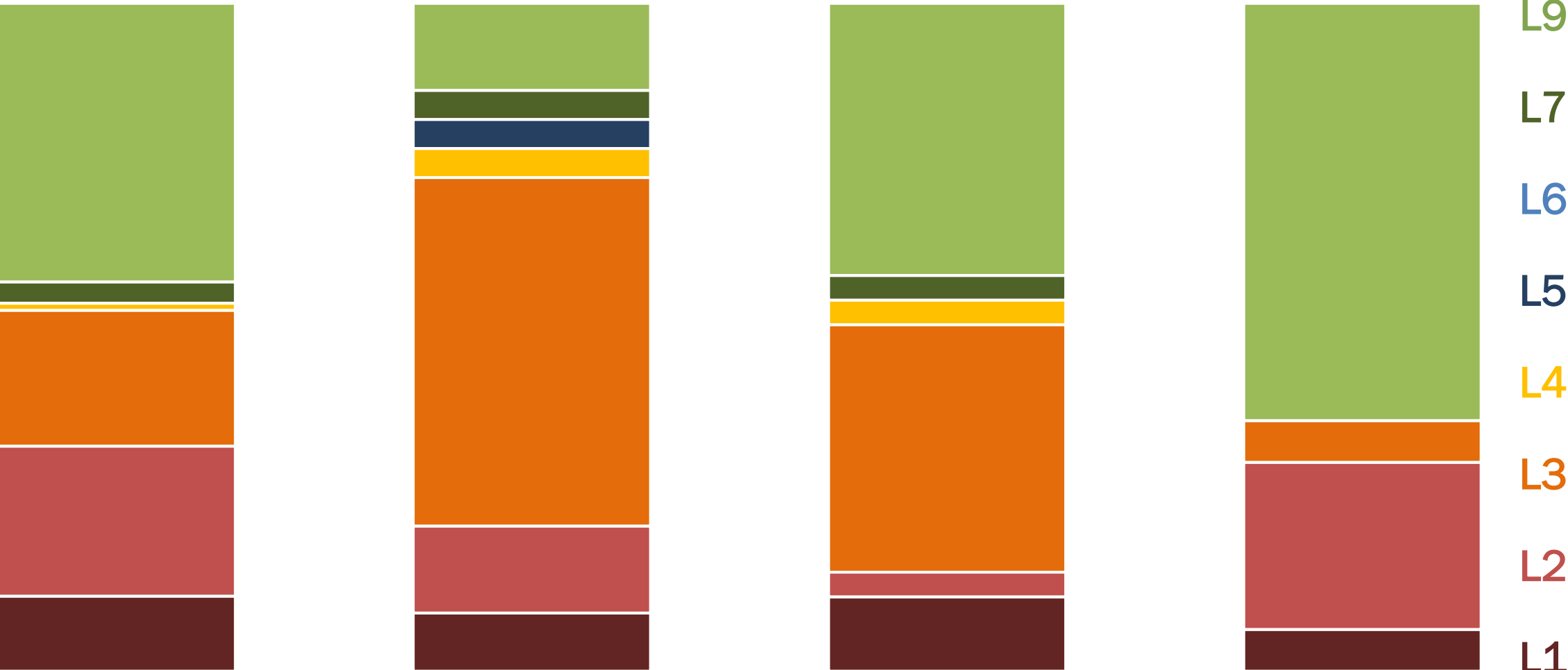
# Operating compliance and site requirements control failures were identified in almost all the accidents



N = 91

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# Mitigative controls varied more by outcome and included more reactive controls (L7 - L9)



Vehicle-Environment

Person-Vehicle-Environment

Vehicle-Person

Vehicle-Vehicle

N = 81

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# Vehicle operation remains a core issue for haul-truck-related health and safety

- Inability to control haul truck is most common
  - 3 of top 4 outcomes
  - 78% of accidents
- May be used differently at different operations



- Causes and preventative controls
  - Maintenance and inspections
  - Traffic control
  - Berms
  - Dumping
  - Communication
  - Weather
  - Drugs and alcohol

- Mitigative controls
  - Driver assist
  - Seat belt interlocks
  - Collision avoidance
  - Remote operation systems
  - Monitoring and reporting
  - Working alone
  - Emergency response



## There is a high rate of operators failing to follow established site policies and procedures

- Unclear what motivations risk-taking behavior
- Limited information about time of the accident
- Identified factors
  - Inexperience
  - Training
  - Lack of enforcement
  - Inadequate policies and procedures
  - Lack of information





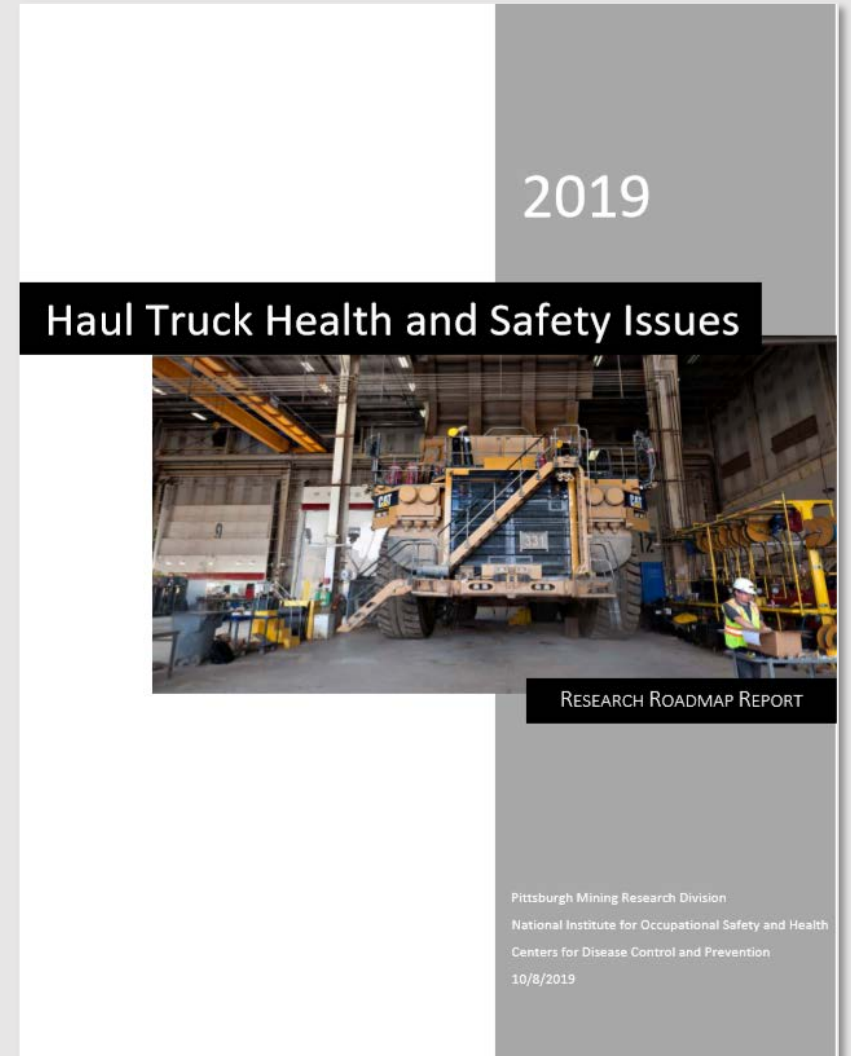


# Haul Truck Health and Safety Issues



# Key Findings

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.



# Development, implementation, and integration gaps exist at every level of the system

<b>External</b>	<b>Organizational</b>	<b>Workers</b>	<b>Environment &amp; Technology</b>
<p><b>Regulation</b> Instances where regulation does not align with the current state of the industry</p>	<p><b>Policies and Procedures</b> Instances where policies and procedures are not appropriate, effective, or communicated</p>	<p><b>Human-Centered Design</b> Human-machine-environment interactions where human-task mismatches exist</p>	<p><b>Infrastructure</b> Systems, networks, or installations where support, maintenance, or investment gaps exist</p>
<p><b>Standards and Guidelines</b> Instances where there are insufficient or multiple standards or guidelines</p>	<p><b>Communication</b> Instances where information or expectations are not transferred</p>	<p><b>Situational Awareness</b> Processes or interventions that limit or do not provide sufficient information or understanding</p>	<p><b>Interoperability</b> Systems, networks, or installations where communication and compatibility gaps exist</p>
<p><b>Industry Forum</b> Lack of a cohesive group, venue, or openness to facilitate sharing of information and exploration</p>	<p><b>Workforce</b> Aspects of the workforce composition that lead to gaps in communication, expectations, or inclusion</p>	<p><b>Trust</b> Instances where lack of trust (e.g., between people, technology, organization) leads to increased risk</p>	<p><b>Analytics</b> Systems, databases, or processes where gaps in processing, application, or consideration exist</p>

# External

*Industry-wide forces that influence the adoption of safety and health interventions*

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- Regulation
  - Powered Haulage Initiative
  - Automation Regulation
- Standards and Guidelines
  - ISO/ASTM
  - Vehicle Interaction and Automation Guidelines
- Industry Forum
  - EMESRT
  - ICMM
  - GMG
  - NMA





# Organizational

*Attributes of a mining company that make decisions or create policies and procedures that can affect the health and safety of workers*

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- Policies and Procedures
  - Effectiveness
  - Applicability and Consistency
  - Alignment and Integration
- Communication
  - Change Management
  - Interdepartmental Communication
- Workforce
  - Contractors
  - Remote Operation





# Workers

*Individual workers at a mine site that make decisions or take actions that can affect their own or the safety and health of others*

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- Human Centered Design
  - Communication and Intent
  - Task Incompatibilities
  - End User Implementation
- Situational Awareness
  - Collision Warning Systems
  - Fleet Management
  - Illumination
- Trust
  - Automation
  - Failure to Follow Policies and Procedures

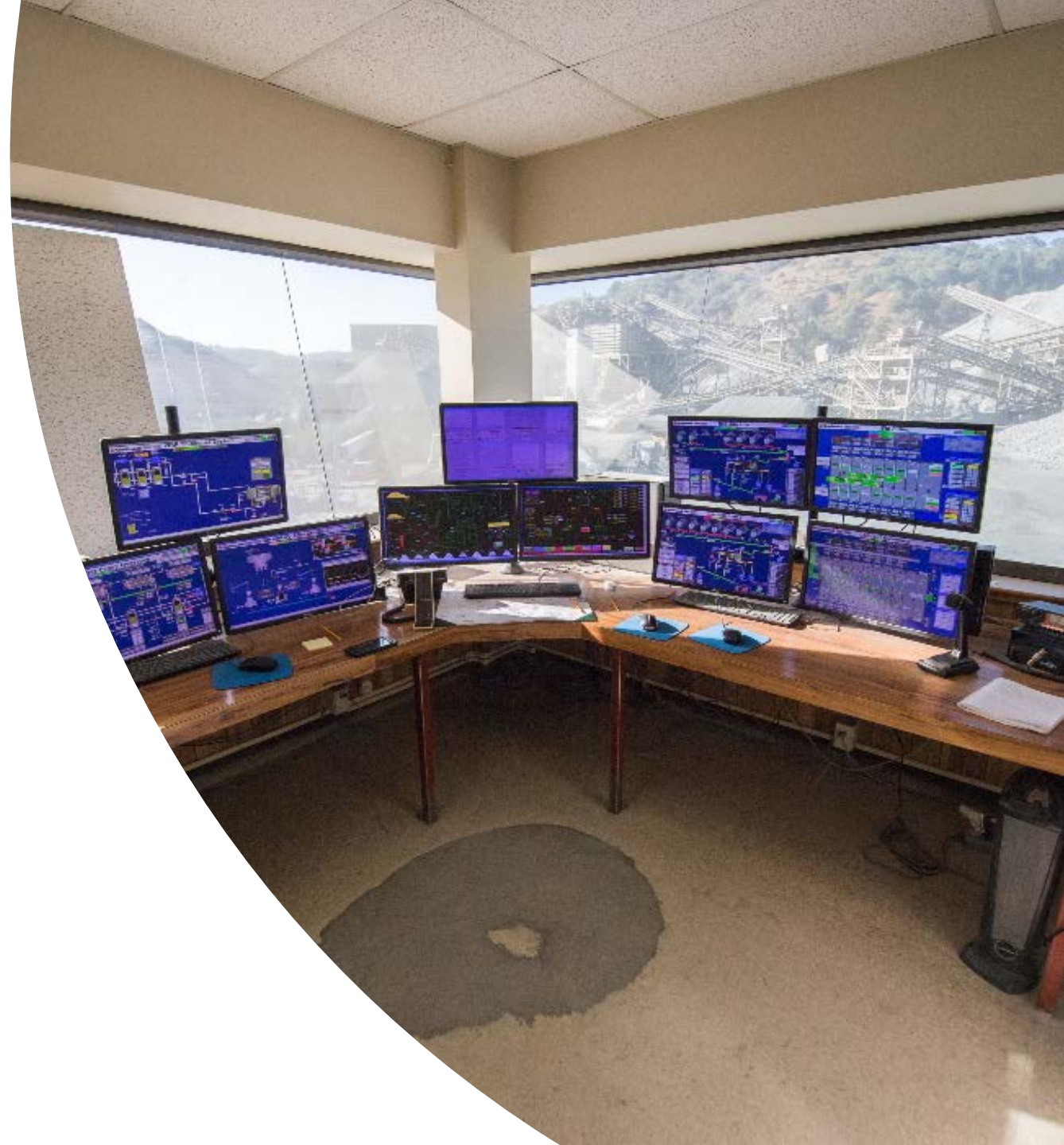


# Environment & Technology

*Conditions, systems, solutions, and interventions at a mine site that affect the safety and health of workers*

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- Infrastructure
  - Roadway Infrastructure
  - Communication Infrastructure
  - Maintenance
- Interoperability
  - Sensor Integration
  - Data Reporting and Monitoring
  - Data Sharing
- Analytics
  - Performance Monitoring
  - Operations Data Review
  - Big Data and Predictive Analytics





What's Next?

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# Surface VR Mine



# What drives haul truck operators?



We are looking for mine sites to participate



# Why do haul truck fatal accidents keep occurring?

- Take a systems approach
- Re-focus on low-level controls (EMESRT's levels 1-6)
- Develop reactive controls to address loss of control and SA

Jennica Bellanca | [Jbellanca@cdc.gov](mailto:Jbellanca@cdc.gov) | 412.386.6445



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