Workplace Safety North™

LoopX

2025 Mining Health and Safety Conference

Technical Session Speaker

Advancements in Collision Avoidance Technologies for Underground Mining Safety

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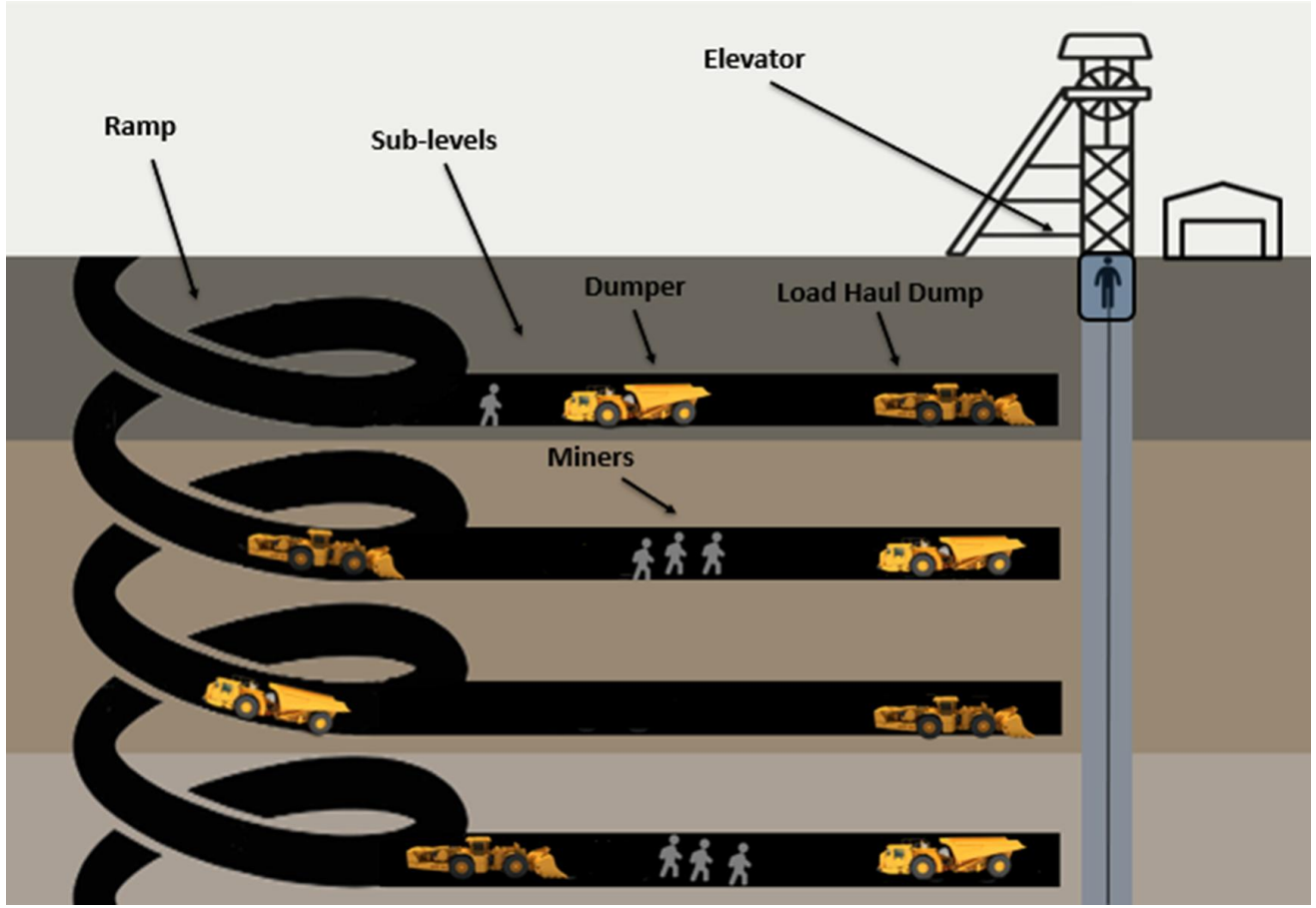
Presentation Overview

- Increasing Safety Challenges Underground
- Safety Solutions - EMESRT Framework
- Current Collision Avoidance Technologies
- Future Trends
- Conclusion

Increasing Safety Challenges Underground

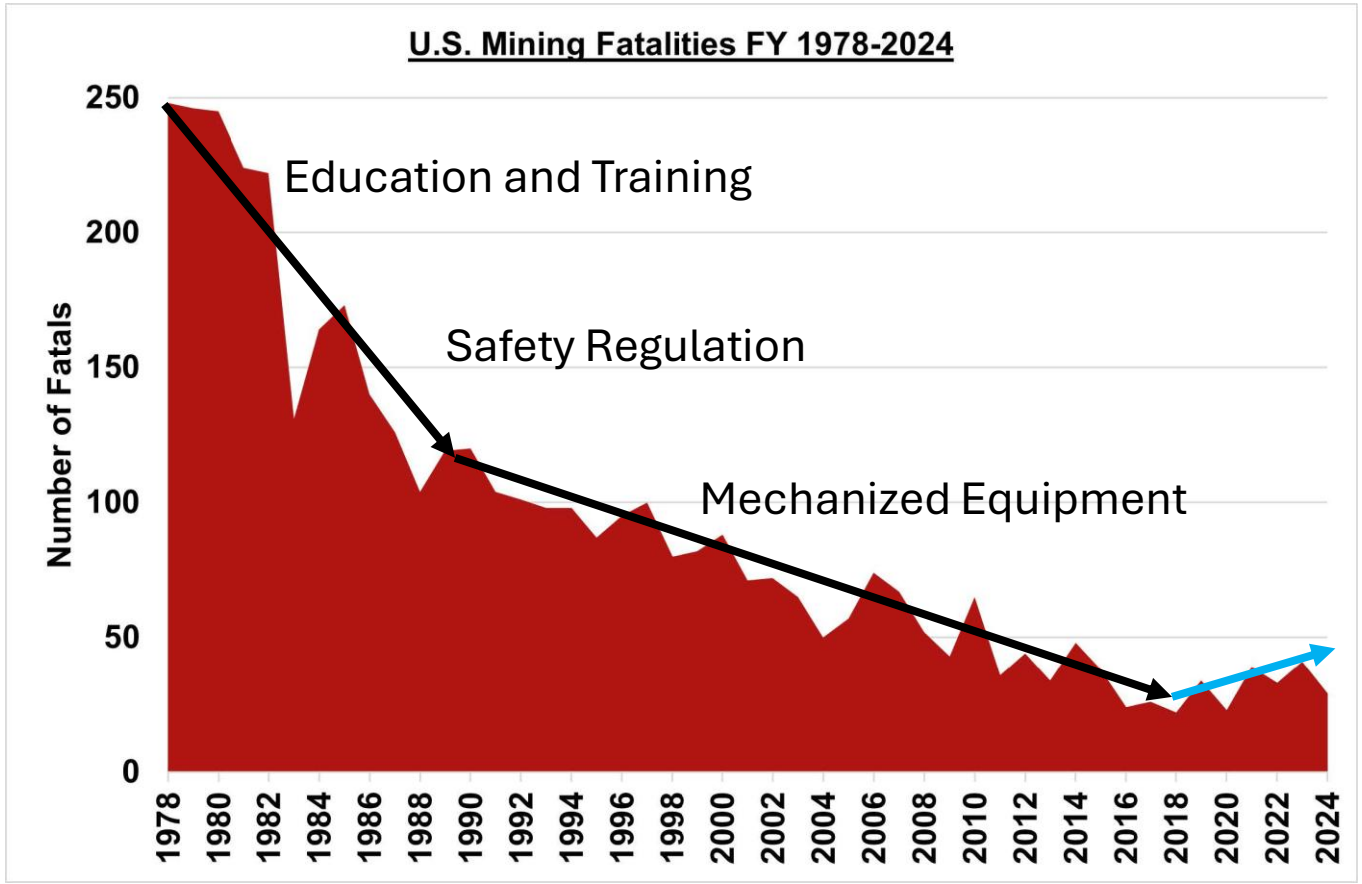


- Increasing safety risks as more and more mines move deeper underground.
- Poor visibility, dust, noise, confined space create blind spots.

Source: Mohamed Iman, et al. (2023), The Future of Mine Safety. *Sensors*. https://doi.org/10.3390/s23094294

Increasing Safety Challenges Underground

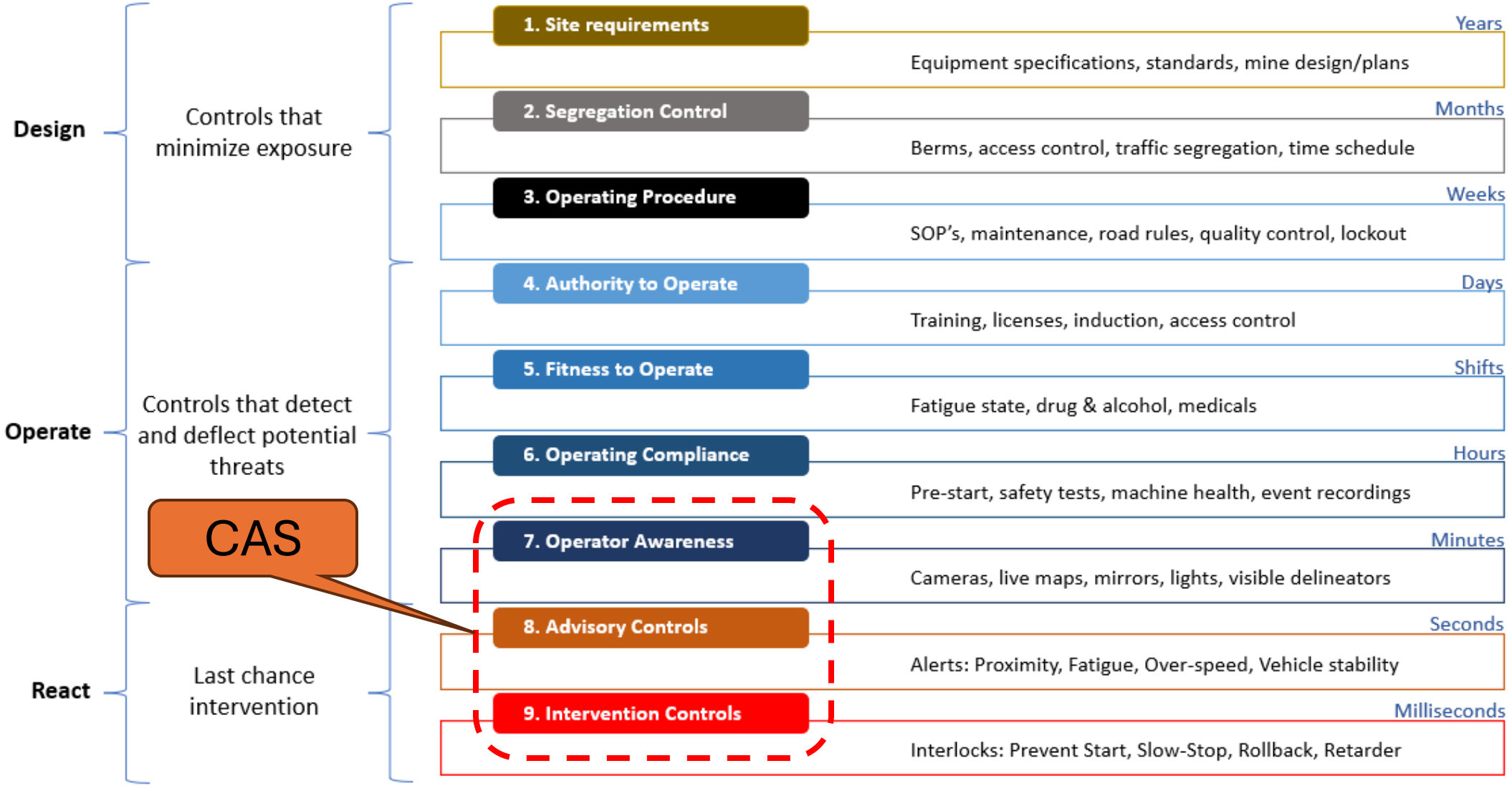
- Fatality rates have slightly increased over the past five years, indicating that current solutions are no longer sufficient to achieve zero-fatality goals.
- Interaction with mobile equipment have emerged as a leading risk in underground mining.



https://www.msha.gov/mine-safety-and-health-glance-fiscal-year

https://www.workplacesafetynorth.ca/

Safety Solutions – EMESRT Framework



The EMESRT Nine Layer Model for Improving Vehicle Interaction Controls

Current CAS Solutions – RF-Based

- Radio Frequency (RF) - based technologies

(Tag-to-Antenna Proximity Detection)

Technology	Range	Cost	Pros & Cons
BLE (Bluetooth Low Energy)	1 m - 10 m	Very Low	✓ Low power consumption, less maintenance × Unstable signal strength (RSSI) × Not reliable for mobile equipment or L9 CAS
EM (Electromagnetic)	2 m - 5 m	Med	✓ Reliable for short-range zone control × Cannot detect through corners or obstructions × Not reliable for mobile equipment or L9 CAS
RFID	5 m - 30 m	Low	✓ Balanced in cost and detection range × No exact distance or direction × Not reliable for L9 CAS
UWB (Ultra-Wide Band)	10 m - 50 m	High	✓ High accuracy in distance and direction within line of sight × Requires multiple anchors on vehicles or infrastructure × More complex calibration
Wi-Fi	20 m - 100 m	Med	✓ Leverage existing Wi-Fi networks (local access points) × Poor distance and direction accuracy based on RSSI × Not reliable for L9 CAS

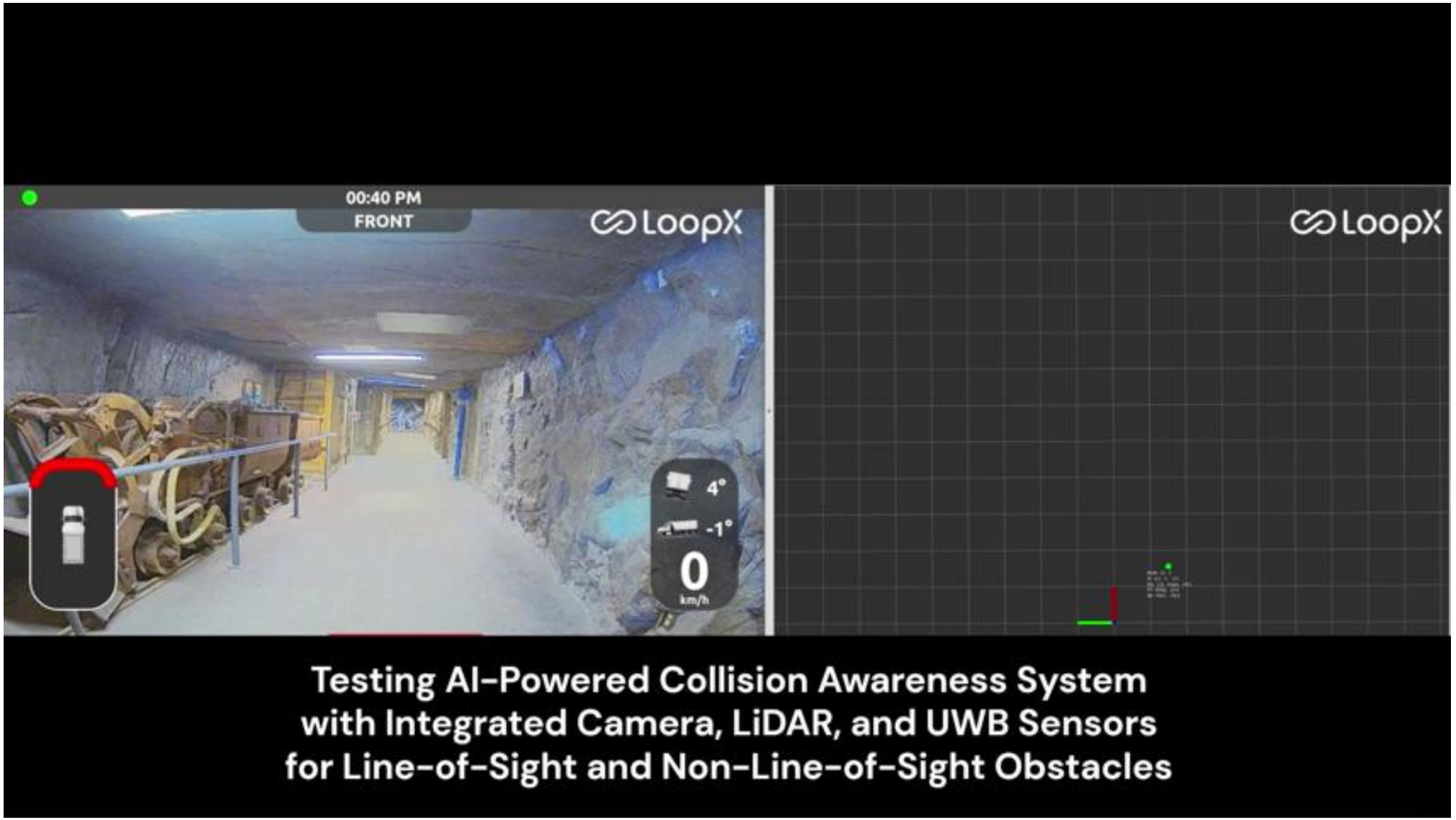
Current CAS Solutions – Sensor-Based

- Vehicle Sensor - based technologies

(Sensor Line-of-Sight Object Detection)

Technology	Range	Cost	Pros & Cons
RGB Camera	30 m	Low	✓ Easy to apply AI for object detection × Prone to environmental factors like light, glare, and dust
Infrared Camera	10 m	Med	✓ Easy to apply AI for object detection ▪ Less prone to environmental factors like light and glare
Thermal Camera	30 m	High	✓ Resistant to environmental factors like light, glare, and dust ▪ Moderate compatibility with AI for object detection × No color or less texture
Radar	100 m	Med	✓ Resistant to environmental factors like light, glare, and dust × Lower resolution; can't identify objects (e. g., HDV, LDV) × Limited ability to detect stationary pedestrian
LiDAR	50 m	Med	✓ High accuracy on distance measurement ✓ Resistant to light and glare × Prone to dust

CAS Testing – RF-Based



https://youtu.be/Vy3AT-2CiZc

CAS Testing – Sensor-Based

https://youtu.be/ilD4QVh2vCQ

Future Trends: Electrification Enables CAS L9

New Collision-Related Risks with Electric Vehicles

- **Silent Operation**

  EVs produce little to no noise, increasing risk of collisions

  Workers may not hear the approach of a vehicle near blind corners or intersections

- **Instant Torque & Acceleration**

  Electric drivetrains deliver torque immediately, making unintended acceleration more dangerous

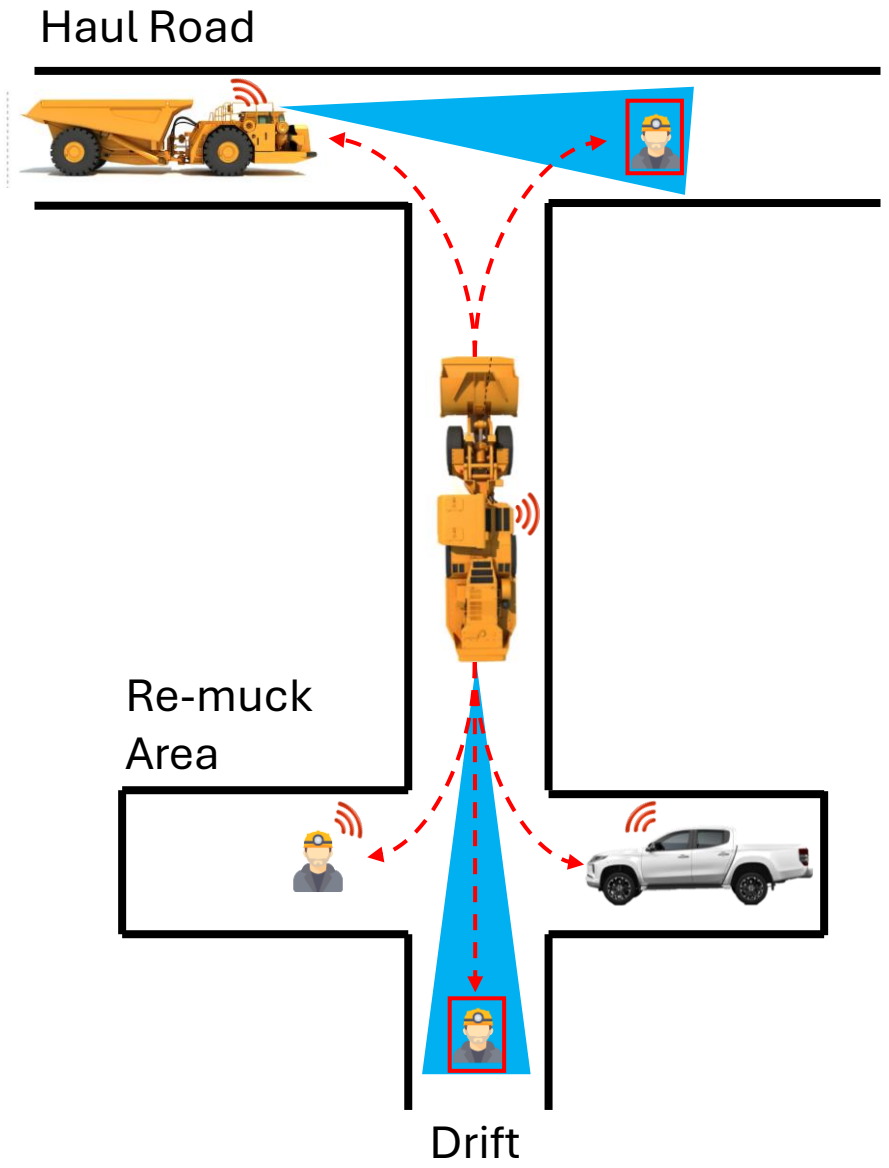
Electrification: A Catalyst for CAS L9 and Autonomy

- Electric mining vehicles are more computerized and software-driven
- Easier to interface with Level 9 CAS for automated intervention (e.g., slow-down, stop)
- Provides a strong foundation for semi / fully-autonomous control, supporting future-ready mining operations

Future Trends: Hybrid CAS (Radio + Sensor)

Combines radio-based (UWB, Wi-Fi) with sensor-based (camera, LiDAR) technologies

- **Radio-based systems:** Reliable detection in non-line-of-sight conditions but prone to false alarm and lack contextual awareness
- **Sensor-based systems:** Enable object recognition and AI-powered perception but affected by dust and lighting, not effective for NLOS
- **Fusion approach:** Provides redundancy and compensates for individual tech limitations
- **Future-proof:** Supports EMESRT Level 9 CAS compliance and prepares for future autonomy integration



Future Trends: From CAS to SAS

CAS (Collision Avoidance System)

- Focused on detection and reactive alerts (e.g., stop or warn)
- Limited to proximity-based triggers, without understanding context

SAS (Situational Awareness System)

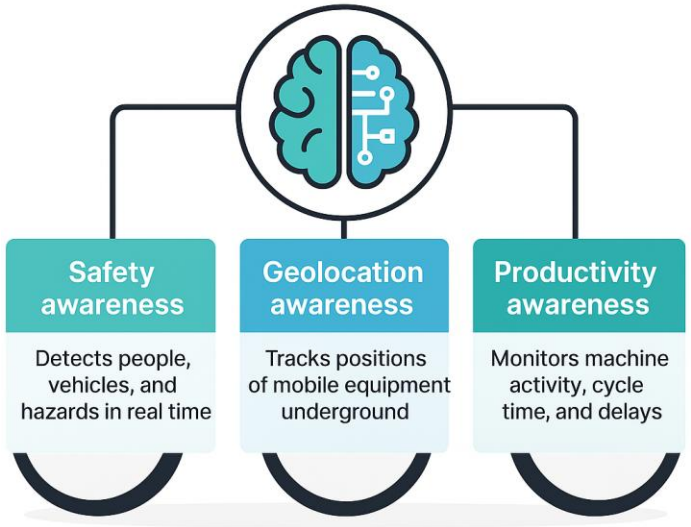
- Adds perception, understanding, and prediction capabilities
- Integrates multiple types of awareness into one intelligent platform:

  Safety awareness – Detects people, vehicles, and hazards in real time

  Geolocation awareness – Tracks positions of mobile equipment underground

  Productivity awareness – Monitors machine activity, cycle time, and delays

  And More - Incorporate maintenance, environmental, and operational insights



Conclusion

Existing CAS Technologies Review

- Radio Frequency – based (e.g., RFID, EM, UWB, BLE)
- Vehicle Sensor – based (e.g., Camera, LiDAR, Radar)

Future Technologies Forecast

- CAS L7 for Diesel-based Vehicles → CAS L9 for Electric Vehicles
- RF-only / Sensor-only CAS → Hybrid CAS
- Single-function collision avoidance → Comprehensive situational awareness

Let's Build the Future of Mining Together – Safely and Smartly

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