Test Results of a GPS-based Collision Avoidance System at Line Creek Operations

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Haulage & Loading 2013, Phoenix, AZ

Teck ART - Project Charter

- Evaluate proximity detection technologies and suppliers to select a Teck technology standard
- Reduce the number and severity of equipment accidents
- Key issues:
  - Understand Mine Ops environment and SOP's
  - Solution must support – not replace – existing safety measures
  - Minimize operator overload and nuisance alarms
  - Potential for technology integration

Trial Objectives

- Show effectiveness of SAFEmine in increasing operator awareness of nearby equipment and potential collisions
- On/Off study to show changes in operator behavior
- Show adaptability to meet mine's specific requirements
- Two key scenarios:
  - Light vehicle and heavy vehicle interactions
  - Vehicles and equipment near the shovel

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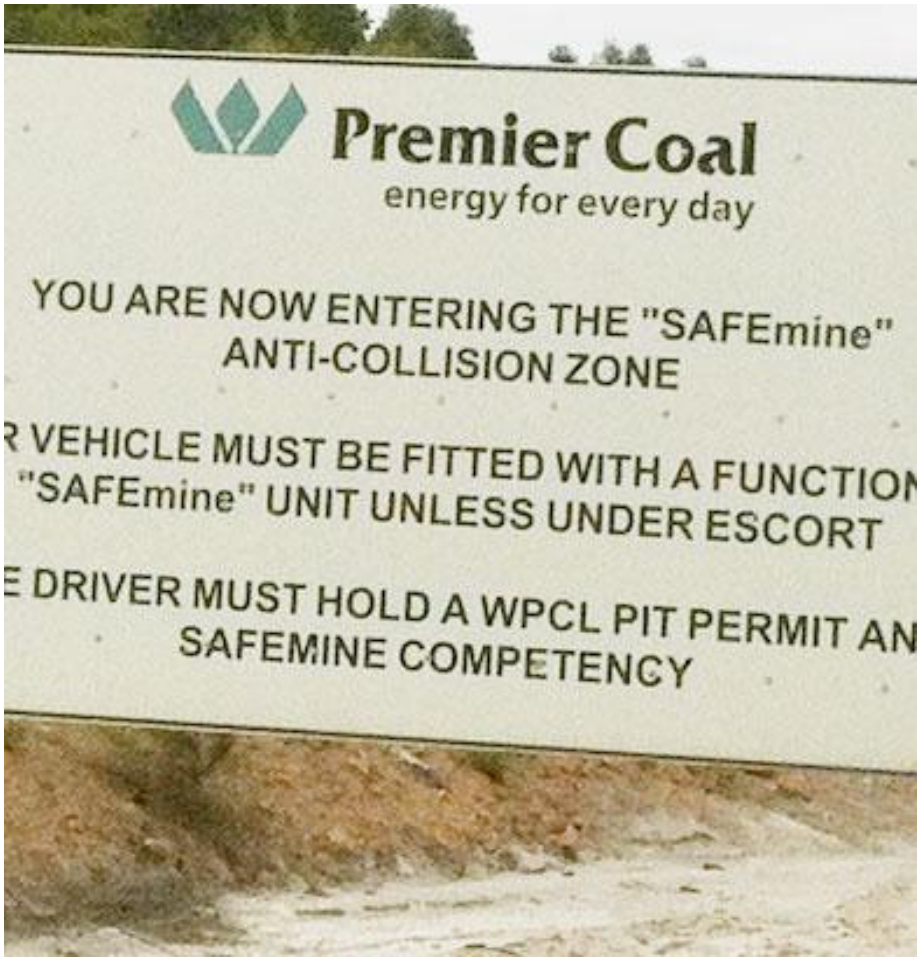
SAFEmine - The Company

- 35 mines on four continents operating with SAFEmine
- More than 14,000 vehicles protected by SAFEmine Collision Avoidance Systems (CAS)
- More than 1,000 with live tracking & reporting
- World standard for CAS in aviation
- Developed for surface mining with Anglo American



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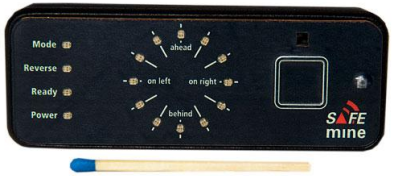
SAFEmine CAS

- GPS-based collision avoidance with peer-to-peer radio communication
- Traffic awareness and collision avoidance functions based on position, speed, heading, and vehicle type
- Simple and rugged design
- Optional radar, camera integration (not part of this trial)

GPS/RF antenna

Receiver/ Processing unit



Display

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SAFEmine CAS - Awareness and Avoidance

Level 1: Traffic Awareness

- visual info = anticipate danger
- based on: proximity, position

Level 2: Collision Avoidance

- audible alarm = call to action
- based on: Dynamic Safety Zones
  (pat. pending)

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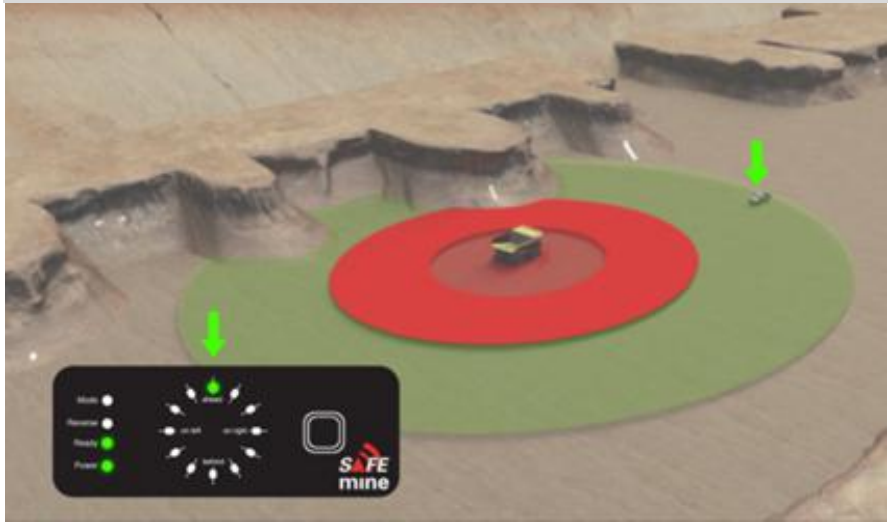
SAFEmine CAS - Awareness and Avoidance

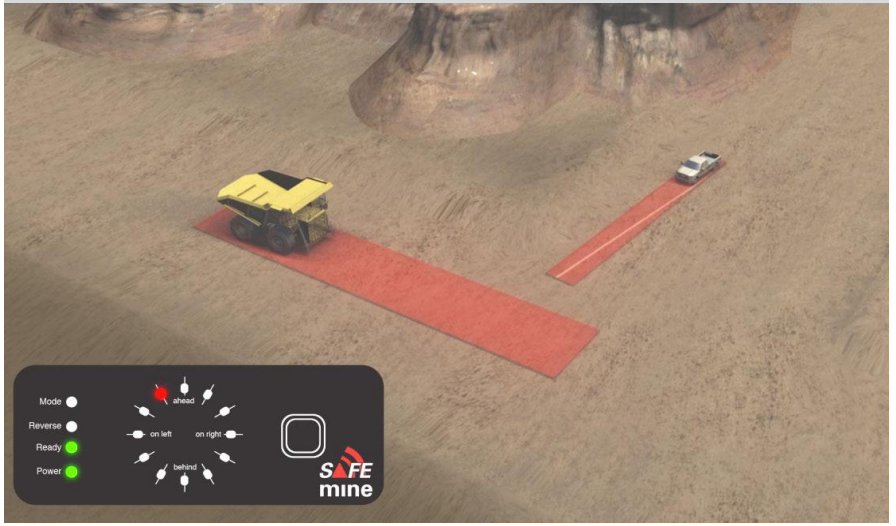
Level 1: Traffic Awareness

- display indicates surrounding vehicles (360º), no blind spots
- several vehicles displayed simultaneously



Level 2: Collision Avoidance

- intelligent warnings alert the driver
- based on: Dynamic Safety Zones



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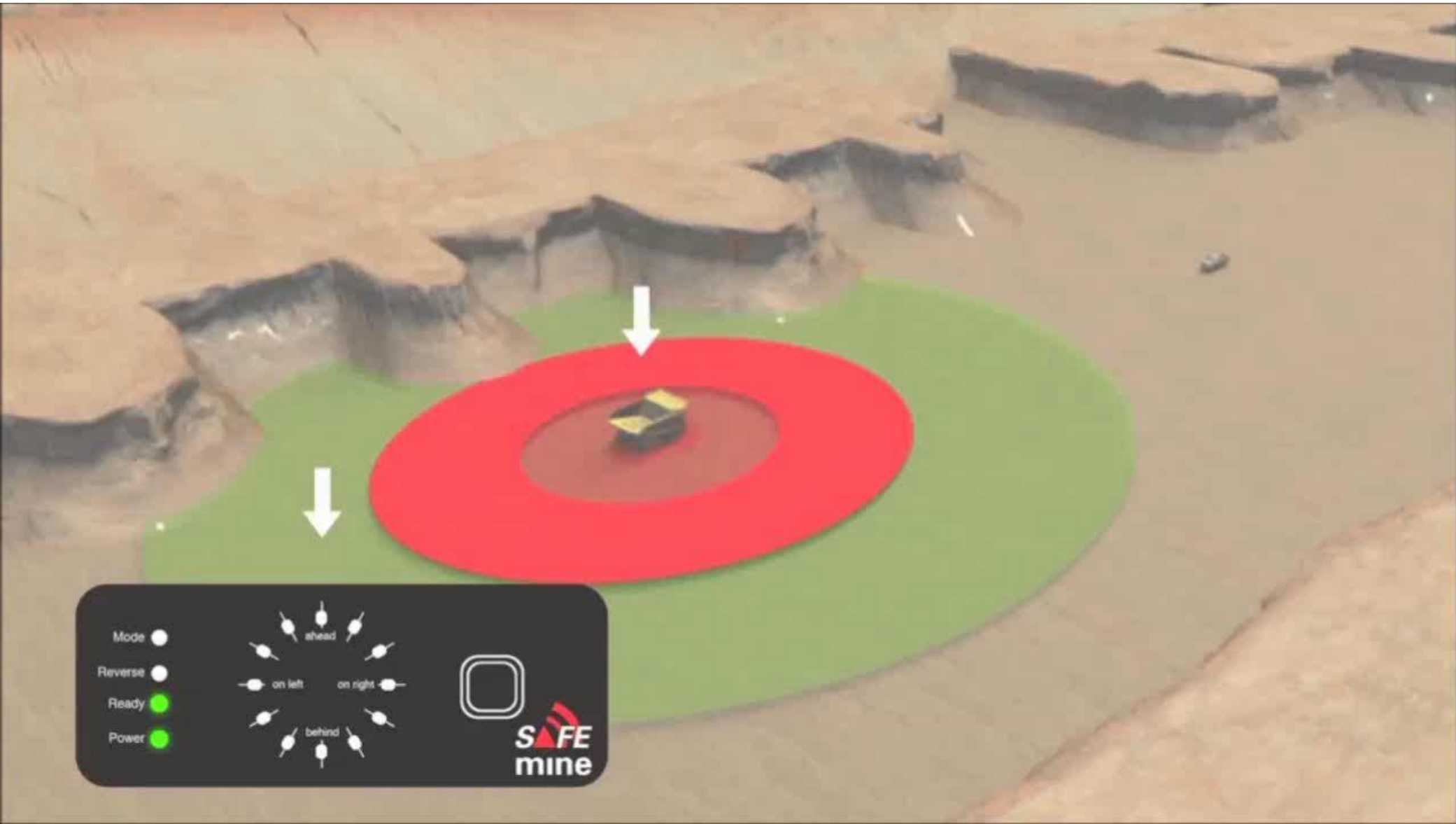
SAFEmine CAS - Traffic Awareness



SAFEmine CAS - Collision Avoidance

SAFEmine CAS - Functions

Function	Detail
Traffic Awareness & Collision Avoidance	▪ 360 deg. awareness, simple display ▪ No blind spots
Black Box Recording	▪ Continuous recording of vehicle parameters ▪ Analysis of incidents & near misses (logfiles)
Fixed Hazard Mapping	▪ Geofencing ▪ Fixed hazards: stop signs, overhead power lines
Speeding	▪ Vehicle specific speed limit ▪ Geographical speeding
SyncStation	▪ Auto update of firmware and configuration
Real-time Tracking/Reports	▪ Web-based tracking and vehicle status ▪ WiFi or GSM connectivity

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Trial Design

- Teck's Line Creek Operations in BC, Canada
- 8-week study on 12 machines and vehicles:
  - OFF phase: 3 weeks system running, but no alarms or traffic indicators to operators (baseline)
  - ON phase: 5 weeks with alarms and indicators on
- Equipment outfitted:
  - 4 haul trucks (250 ton)
  - 1 shovel (electric)
  - 1 rubber tire dozer
  - 1 front-end loader
  - 5 light vehicles (lube truck and pickups)

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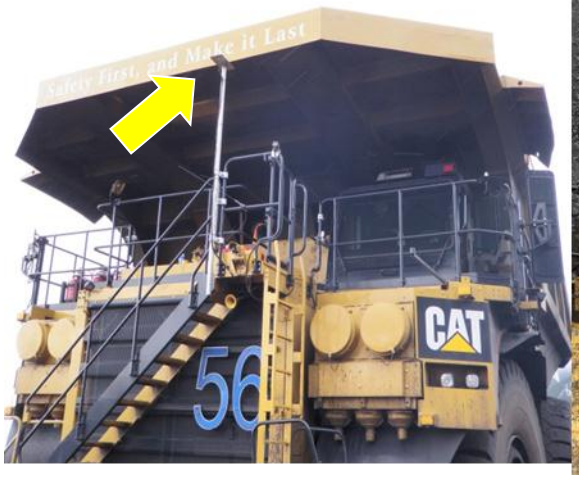
System Installation Examples



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Data Collected

- Main unit stores 2-3 days of system data:
  - Vehicle position, speed, heading, GPS status, alarm information, nearby vehicles, etc., recorded every second
  - Downloaded from vehicle's unit via WiFi remote link (from our HQ in Switzerland!)
  - Analyzed over 50 million data entries
- Operator and manager feedback
  - Interviews
  - Feedback forms

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Evaluation Criteria from Teck

- System Accuracy
- System Reliability
- System Usability
- Overall Site Safety Improvement

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Results (from Teck)

	Evaluation Criteria	Test Result	Testing Methodology
System Accuracy	Does system alarm when it is meant to	**Success**	Closed Environment testing and operator feedback
System Accuracy	GPS Precision <2m 85% of the time	• 77% of time within 2m • 92% of time within 3m • 98% of time within 4m	Stationary GPS test
System Reliability	Greater than 95% GPS coverage in the pit	**Success**	% Time signal lost on system for all units
System Reliability	Greater than 95% Peer to Peer communication availability	**Success (99.9%)**	Stationary communication test
System Reliability	System uptime of 99%	**Success**	Downtime due to system issues
System Usability	Operator input regarding the system is positive	**Success**	Operator interviews
System Usability	Administration of mobile units takes less than 5 minutes to install	**Success**	Installation of a quick mount unit
Overall Site Improvement	An overall reduction of proximity events (per operating hour) based on pre-trial baseline data obtained Reduction in speeding events	Limited conclusions due to inconsistency of data and traffic patterns **Success**	Off and On phase alarm comparison

Results – Speeding Events (from Teck)

Data comparison over 4 days in the "Off" and "On" phases - mine helper truck		
Number of overspeeds during OFF phase	123	
Number of overspeeds during ON phase	57	
Maximum speed over 65km/hr OFF	25	(15 mph)
Maximum speed over 65 km/hr ON	1	
Number of overspeeds 5km/hr over limit OFF	18	
Number of overspeeds 5km/hr over limit ON	0	
Number of overspeeds 10km/hr over limit OFF	11	
Number of overspeeds 10km/hr over limit ON	0	

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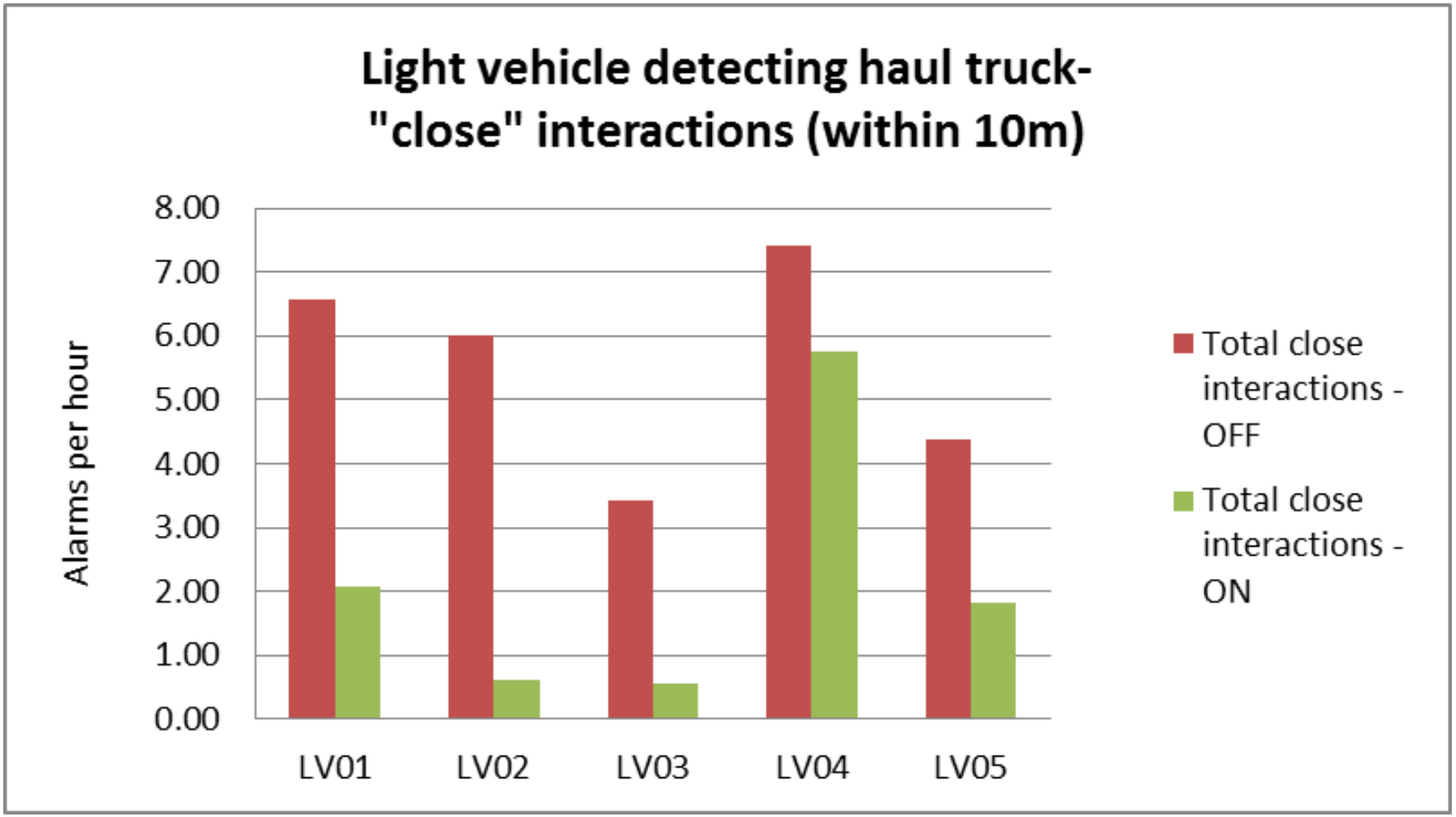
Results – Close Interactions



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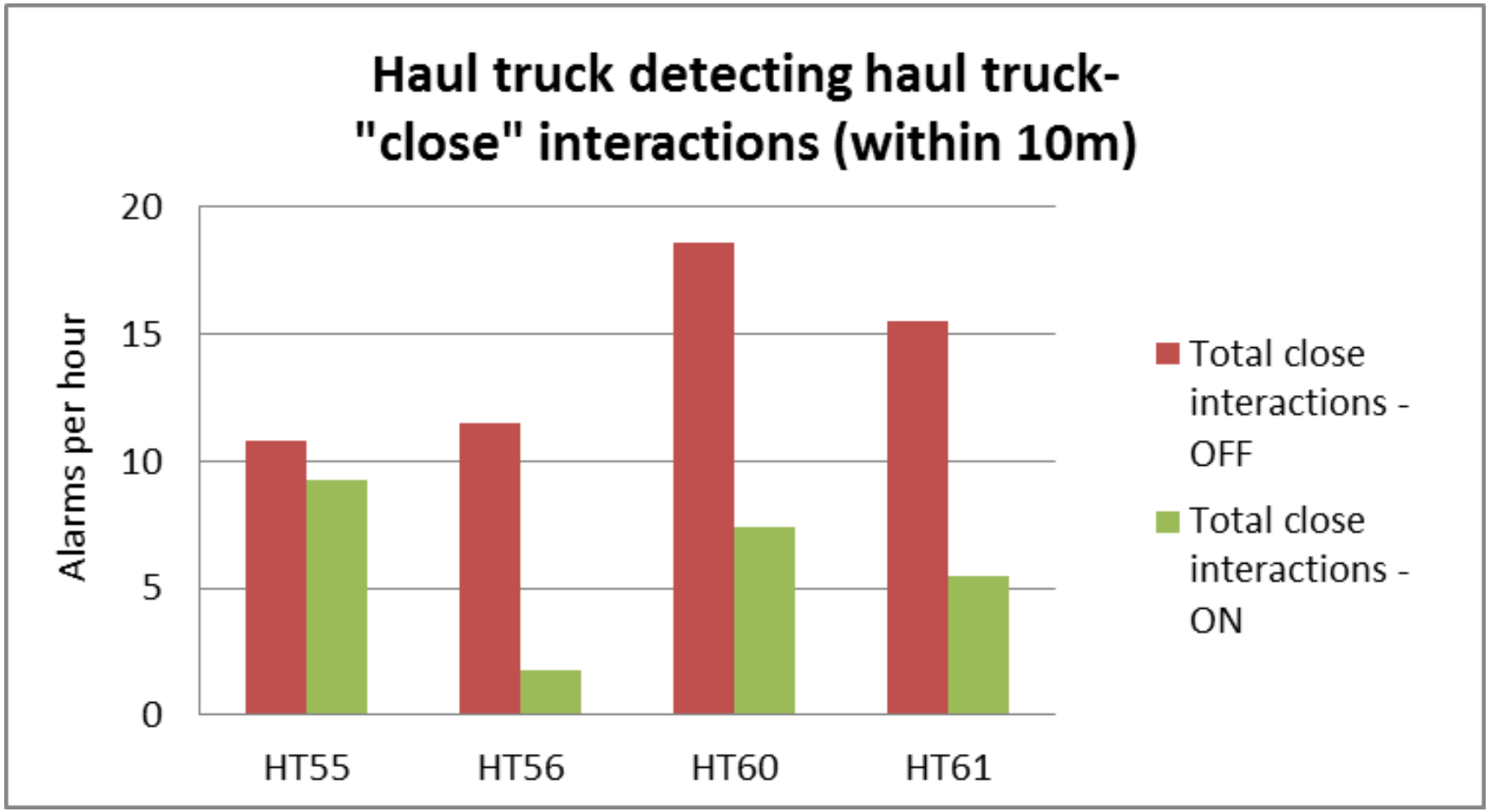
Results – Close Interactions



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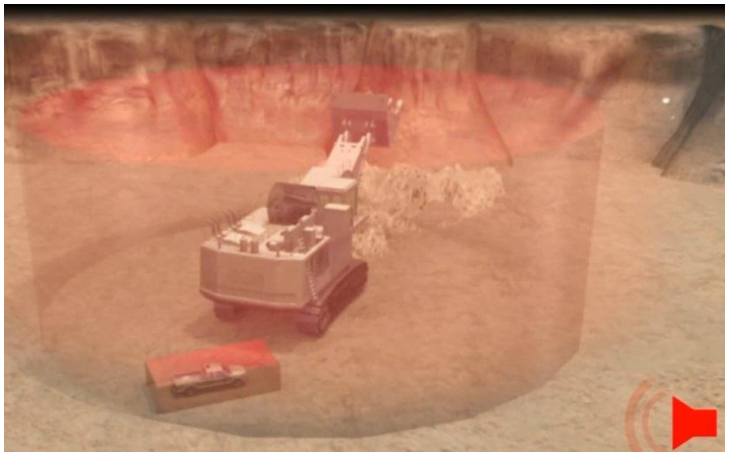
Results – Special Cases

Shovel - normal operation:

- Shovel system will alarm when dozer or other vehicle is within boom swing radius



- Shovel system does not alarm when truck is loading

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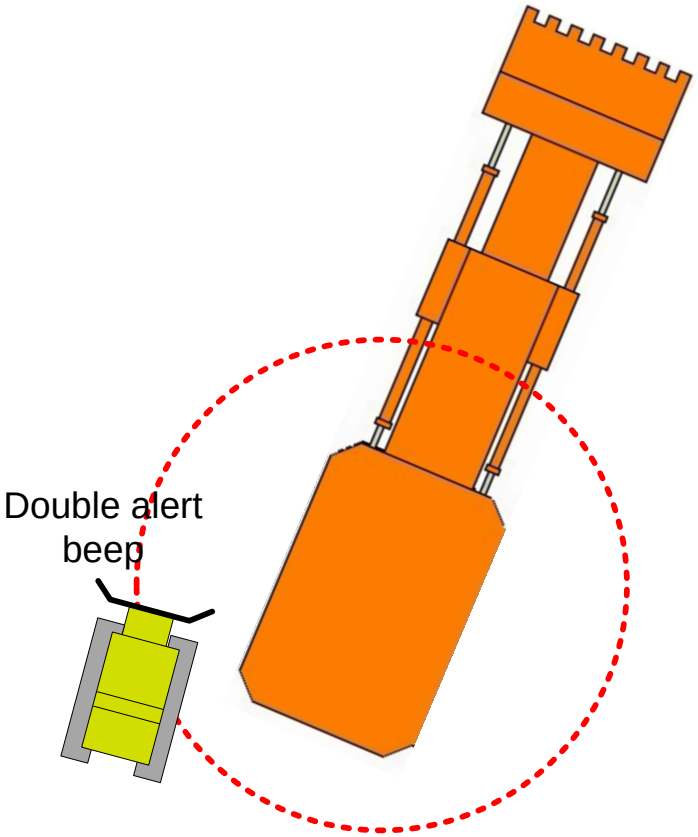
Results – Special Cases

Shovel:

- SAFEmine system knows what type of vehicle is nearby
- Need to allow dozer to clean up next to shovel
- Provide reminder to both shovel operator and dozer operator that they are close, but not full collision alarm
- Full collision alarms remain for light vehicles within boom swing



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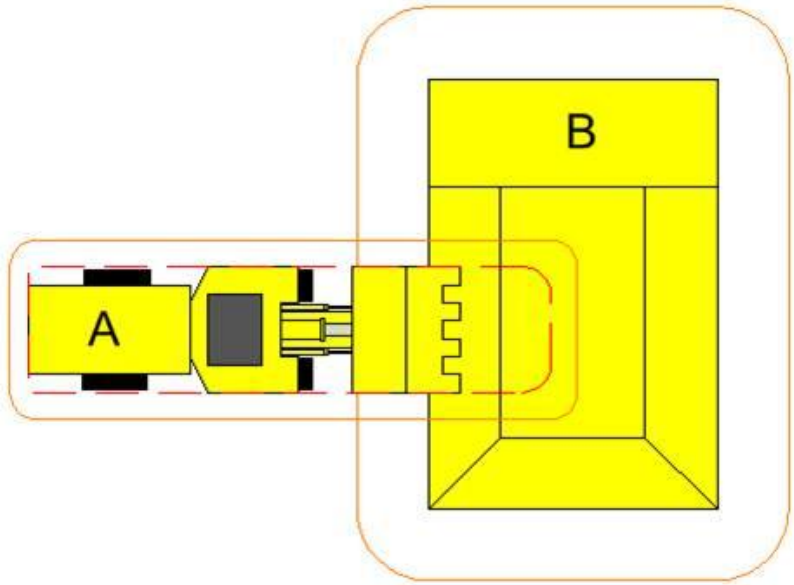
Results – Special Cases

Loader and Haul Truck:

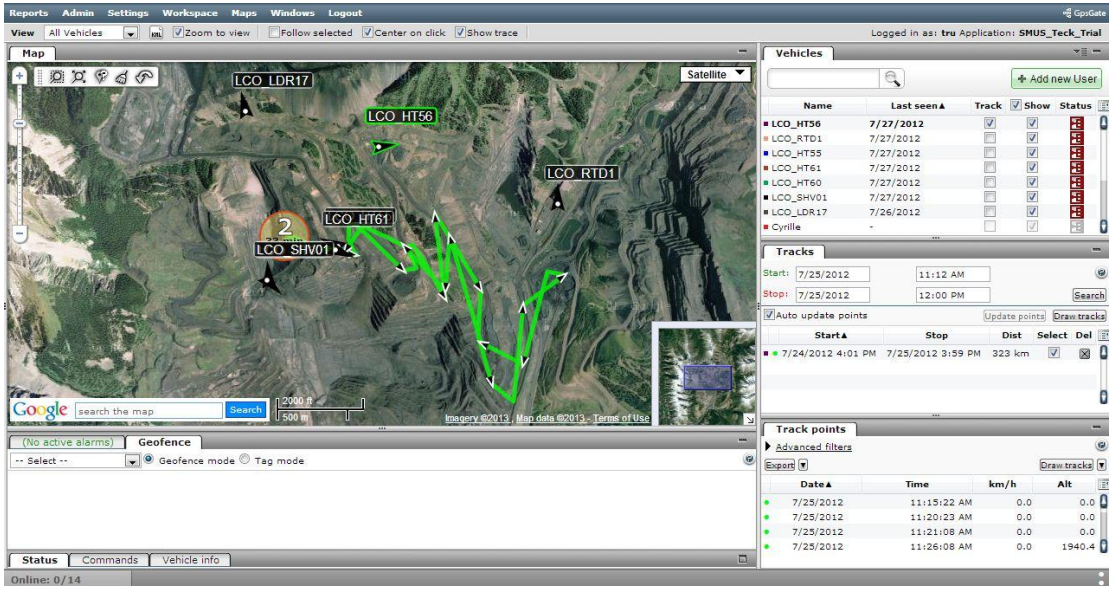
- Need to allow loader to approach truck with no alarms
- Truck is stationary – no alarms
- Provide detection when loader reverses



SAFEmine TRACK

Real-time tracking and remote connectivity:

- Locate equipment quickly
- Monitor equipment status
- Speed and area alerts
- Reports for maintenance and training
- Remote connectivity for offsite support



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Summary

Teck's feedback:

- Useful tool to increase operator awareness in poor weather, at night, or in the fog
- Operators found SAFEmine was very helpful in keeping track of light vehicles around heavy equipment
- Speeding events were drastically reduced due to SAFEmine speeding alarms
- Early training and operator involvement is essential
- Strong site commitment needed

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Summary

SAFEmine's experience:

- Extremely important to minimize nuisance alarms – intelligent alarming based on context and risk is critical
- Dynamic safety zones based on vehicle speed and type further limit alarms to just those that require action
- Operators will change their driving behavior to avoid dangerous situations
- Real-time tracking and reporting increases value
- Trial was successful and additional trial in progress at Teck's Carmen de Andacollo mine in Chile

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One Screen for Traffic Safety

- Integrate safety technologies
  - Collision avoidance
  - Cameras
  - Fatigue monitoring
- Reduce clutter in the cab
- One display for safety systems

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Questions?

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Thank you for your attention!