

AI Camera Trial on RBE

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SPEED BEACONS

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The PDS Haulage Tag (868 MHz) is designed as a cost-effective approach for an Active RFID solution in haulages.

- The tag operates in the 868 MHz Radio frequency range and could interface with other Epiroc Digital Safety Solutions products with 868 MHz Radio functionality

Applications

When detected by Epiroc's vehicle safety and management systems, the PDS Haulage Tag (868MHz) can be configured to enforce actions and behaviours on the systems.

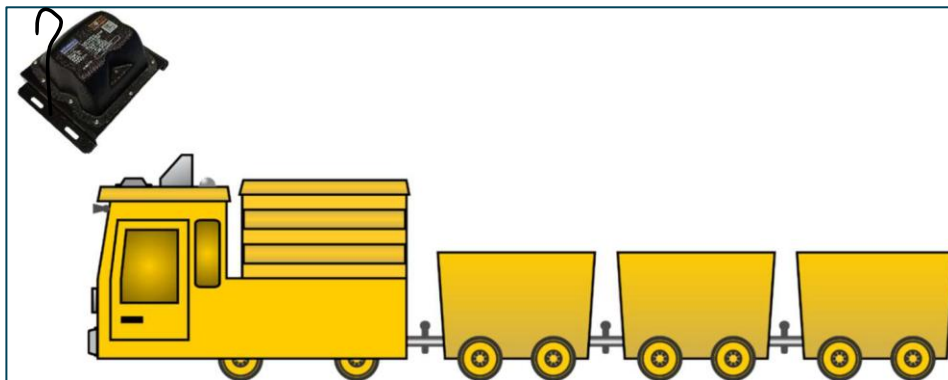
Some of these configurations are:

- Speed zone Management
- Static Hazards
- Development-end Beacons

Functional Overview

The high-level functions of the systems are as follows:

- Battery backup
- Wireless Configuration with the Epiroc Digital Safety Solutions RWM.
- Client specific parameter configuration.
- Wireless communication with Epiroc Digital Safety Solutions devices.
- AC power supply for power grid integration.



The Pulse350 haulage tags have been installed at Impala 20#. The haulage tags can all be configured to enforce various speed zone limits as required. These speed zones can be seen below.

Zone name	Description	Image
Super Slow	Super slow: is the slowest speed awarded to a Locomotive. This speed is usually used in situations where the locomotive is busy with a coupling action or where a very slow speed is required.	
Slow	Slow: is the second slowest speed awarded to a locomotive. This speed is usually applied in circumstances where normal operation is not safe. Typical applications are longer range threat detection, tramming in reverse, operation from the handheld etc.	
Medium	Medium: This speed is used when moderate track conditions are present but there are not any imminent threats in the vicinity of the RBE.	
Normal	Normal: This is the speed that a locomotive should be using most of its' operating time. This is where no unsafe conditions are present.	
Fast	Fast: Speed awarded to a locomotive to achieve its' maximum speed allowed at site. Fast speed zones are typically only used when track conditions are ideal.	

The haulage tags have been set up to indicate various hazards, this allows the locomotive to reduce to a slower speed zone. This can be seen below whereby the locomotive was set to a slow zone due to being in the vicinity of the tip area.



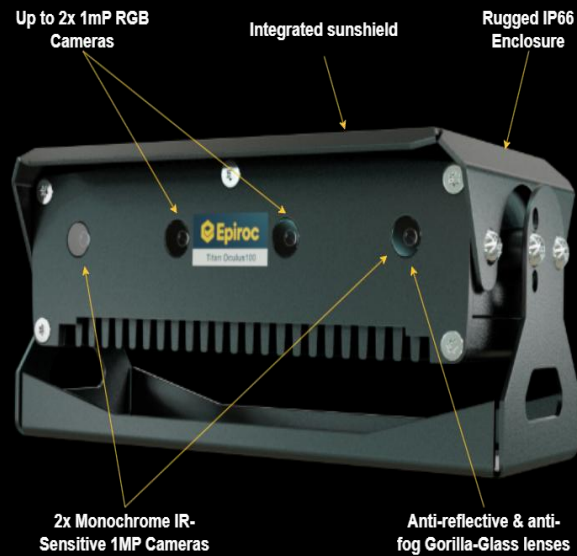
It can be seen that because the locomotive has detected the haulage tag set up at the tipping area, the locomotive is forced to operate in a slow zone. The operator is also required to acknowledge that the tip area has been detected.

AI CAMERA

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Integrated AI acceleration hardware used for object detection, stereo depth estimation and instance segmentation at the edge.



Integrated WiFi for footage extraction, datalog extraction, wireless video streaming, and configuration.

- The Titan Oculus100 is a 1st generation stereoscopic AI camera system that allows for Tagless pedestrian detection and ranging in various environments.
- Combined with the MaxusX system, this provides an additional layer of redundancy, reducing the risk of collisions, accidents and potential loss of life.

During this period, an Oculus100 was installed on both the locomotive and guard side of a locomotive equipped with a MaxusX system, operating in new-era configuration.

Trial Objective

Evaluate the performance of the pedestrian detection algorithm of the Oculus100 and to control the speed of the train based on the detection of pedestrians.

Configuration

- The Oculus100 device has four configurable detection zones.
- When a pedestrian is detected, a box is drawn around pedestrians and overlayed on the footage shown in the preview window of the Oculus100 Dashboard.
- These detection boxes are assigned a specific colour depending in which detection zone the detection was made.

Threshold	Threshold Name	Threshold Colour	Value (m)
1	Super Slow	Red	5
2	Slow	Orange	10
3	Warn	Yellow	15
4	Presence	Green	20

Findings – Stationary loco

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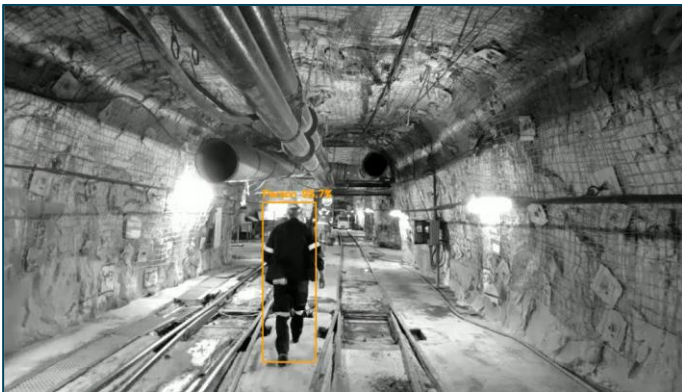
Pedestrian walking away – Entering camera field of view



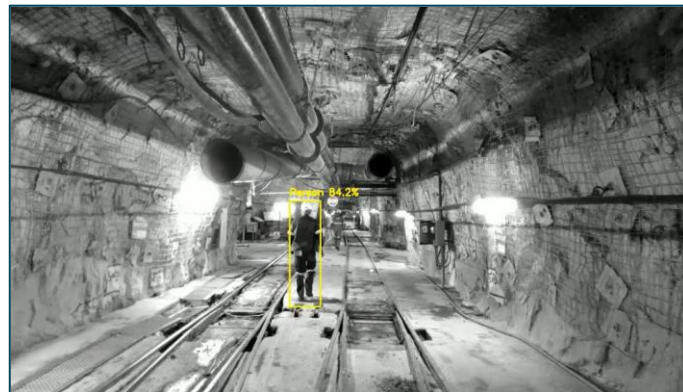
Pedestrian walking away – Detection 0-5 meters



Pedestrian walking away – Detection, presence 15-20 meters



Pedestrian walking away – Detection 5-10 meters



Pedestrian walking away – Detection 10-15 meters

Findings

- The pedestrian is correctly detected and tracked in all the defined zones.
- There are no major breaks in the continuity of detection when the pedestrian transitions between the zones.



Pedestrians walking towards – First pedestrian detected



Pedestrian walking towards – 2nd pedestrian detected



Pedestrian walking towards – Both pedestrians in super slow zone



Both pedestrians in warn zone



Both pedestrians in slow zone

Findings:

- At first the second pedestrian is obscured by the other pedestrian and not detected. As soon as they move out from behind the other pedestrian detection occurs.
- There are no major breaks in the continuity of detection when the pedestrian transitions between the zones.

Findings – Loco in Motion

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Multiple pedestrians – Train moves around a split



Multiple pedestrians – First pedestrian detected



Multiple pedestrians – Detection with multiple pedestrians overlapping



Multiple pedestrians – Second pedestrian detected



Multiple pedestrians – Multiple pedestrians detected

Findings:

- Pedestrians wearing lighter colour overalls are detected easier than pedestrians wearing darker overalls.
- As the locomotive moves closer, more of the pedestrians seated on the bench are detected.
- The system was able to detect multiple people seated closely together and overlapped in the footage

Findings – Cap Lamp Interference

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There's an impact that a cap lamp has on the tracking of a pedestrian in low light conditions.



Pedestrian with cap lamp – Moving in front of stationary train



Pedestrian with cap lamp – First detection made, warning zone



Pedestrian with cap lamp – Tracking lost, warning zone



Pedestrian with cap lamp – Tracking resumes, slow zone



Pedestrian with cap lamp – Tracking lost, slow zone



Pedestrian with cap lamp – Tracking resumes, slow zone



Pedestrian with cap lamp – Tracking continues into super slow zone



Pedestrian with cap lamp – Tracking lost, super slow zone



Pedestrian with cap lamp – Tracking resumes, super slow zone

Findings:

- As the pedestrian walked towards the stationary locomotive with their cap lamp on, they were correctly detected in each of the predefined zones.
- There was a loss in the detection when the pedestrians cap lamp beam was in the direction the Oculus100.
- Even though tracking was lost due to interference from the cap lamp a valid detection was made in each of the zones meaning that the train would have slowed down and the operator would have been made aware of the presence of the pedestrian.

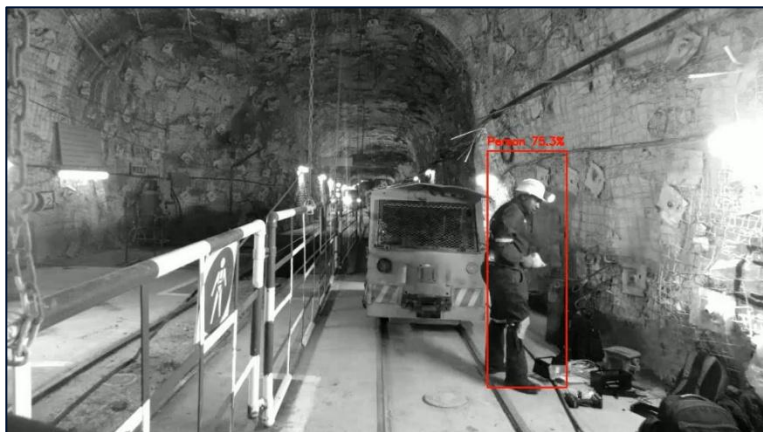
Findings – Pedestrian Posture

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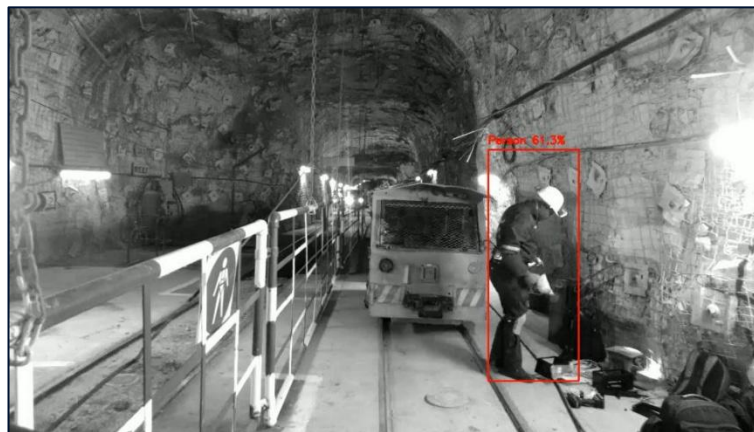
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This section shows the finding observed for the tracking capabilities of pedestrians when they are in non-upright positions.



Pedestrian Posture – Detection when standing upright



Pedestrian Posture – Detection confidence level dropping



Pedestrian Posture – Pedestrian bent over, detection lost

Findings:

- A pedestrian is tracked at first but as the start bending forward to pick something up the detection confidence level drops and ultimately detection/tracking is lost as the pedestrian is fully bent over.

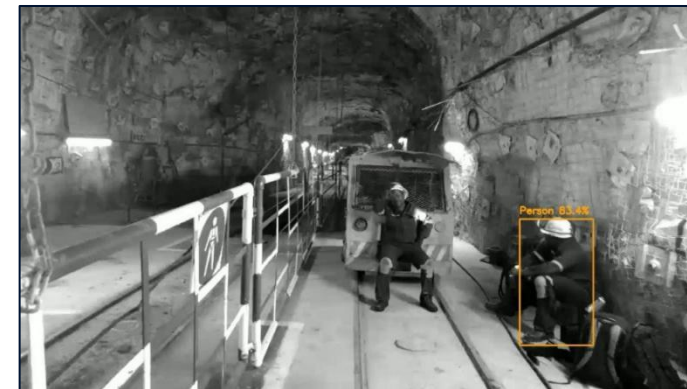
This section shows the finding observed for the tracking capabilities of pedestrians when they are in non-upright positions.



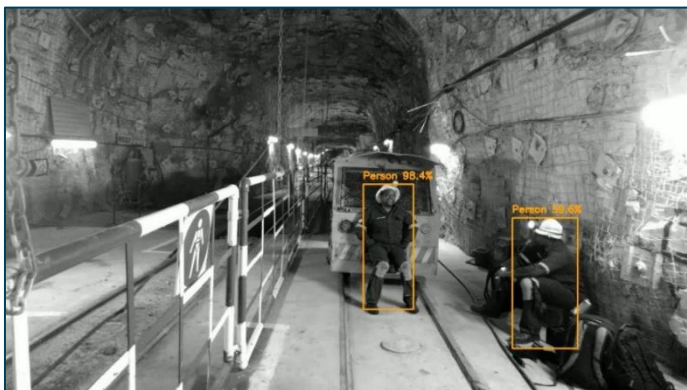
Pedestrian Posture – No detection for leaning and sitting pedestrians



Pedestrian Posture – Detection of leaning pedestrian



Pedestrian Posture – Detection of seated pedestrian 1



Pedestrian Posture – Detection of both seated pedestrians

Findings:

- The current image detection algorithm can recognize pedestrians in different postures including leaning and seated but not as consistently as the upright position.

Detection Improvements

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The second trial focused on evaluating improved pedestrian detection models against the weaknesses identified during the first trial. The updated evaluation showed improved detection robustness, better handling of multiple and non-upright pedestrians, and a reduction in false positive behaviour in selected high dynamic range scenes.

Improvement Area	Result from Second Trial
False Positives	Reduced in selected scenes, especially where previous detections were triggered by high contrast backgrounds or non-pedestrian objects
Detection Consistency	More stable pedestrian detection.
Non-Upright Pedestrians	Improved detection of seated, crouched, leaning, and bent-over pedestrians.
Multiple Pedestrians	Improved ability to detect more than one pedestrian in the same scene.

The evaluation indicates that the weaknesses identified during the original Impala Platinum trial can be reduced through improved trained model selection and targeted dataset expansion.

Plan Forward

Continued model improvement using additional site-specific underground footage, especially colour footage, cap lamp interference, motion blur and high dynamic range scenes. The next step is to further train and validate the selected models.

Model Evaluation outcomes

The second evaluation focused on addressing the detection limitations identified during the initial trial. The detection solution was improved through the evaluation of stronger model architectures, improved model selection and the expansion of underground-specific training data.

Key Improvements:

- Improved model architecture and model selection, providing a better balance between:
- Pedestrian detection accuracy.
- Missed pedestrian detections.
- False-positive detections
- Tracking stability and deployment suitability.
- More consistent pedestrian detection in representative underground conditions.
- Improved detection of multiple pedestrians within the same scene.
- Significant improvement in detecting seated, crouching, leaning and bent-over pedestrians.
- Reduced false-positive detections in selected high-contrast and high dynamic range scenes.
- Improved detection continuity under changing underground lighting conditions.

The report confirms that the principal weaknesses identified during the first trial can be reduced through improved model selection, targeted training data and site-specific validation.

AI Camera + Pedestrian Tags

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The AI camera is limited to line-of-sight pedestrian detection up to a maximum range of 20m. To extend the detection area, VTP tags can be integrated into users' cap lamps, allowing pedestrians to be detected at greater distances before entering the camera's detection zone.

Benefits of VTP Integration:

- Extends pedestrian detection beyond the 20m camera range.
- Allows the locomotive to slow down earlier.
- Supports detection where line of sight is blocked.
- Provides an additional safety layer if the camera does not detect the person.
- Enables more decisive locomotive actions once the pedestrian enters close range.

With the integration of VTP tags, RF detection enables pedestrian detection up to **70 m away**, even when not in line of sight.

This allows the locomotive to slow down earlier and take more decisive safety actions once the pedestrian enters the AI camera's detection range.

