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Introduction

Every year in the construction industry, people are killed or injured due to being struck by moving plant. Site personnel, site visitors and the public can all be at risk if the plant and pedestrian interface is not properly managed and controlled.

Data suggests that plant person interface injuries are relatively uncommon. However, due to the power, weight and hardness of plant, compared with the fragility of the human body, when they do occur the consequences are often serious. Increasing investment in roads, standardisation of products and methods, improved collaboration between organisations and developments in technology all offer opportunities to increase the Health and Safety at Work benefits we can derive from the use of plant as well as opportunities to eliminate harm caused by plant.

Forward

This document is intended to generate collaboration with all stakeholders (OEM's, Supply Partners, Sub-Contractors, Clients, Main Contractors, etc.) to develop a common specification for Human Form Recognition (HFR) camera systems when installed on plant equipment.

A common specification will ensure consistency for operators and the workforce working around plant fitted with these camera systems across the construction industry.

In addition to this, it will also provide the basis for OEM's to develop these systems as a common standard for use throughout the construction industry.

Scope

A multi camera, modular type camera system which is capable of being installed on mobile plant that detects the human form. Detections should be communicated visually and audibly to the operator of the mobile plant and, where appropriate, audibly to the pedestrian that has been detected.

The camera system must be able to collect data of all detections so that these can be easily displayed on a web-based portal for review (subject to the relevant GDPR compliance) by the end user and interested parties.

Fail safe controls must also be in place and a warning to the operator on the in cab display as well as an alert on the portal in the event of any component failure or tampering i.e., broken wires, camera failure, obstructed camera view, etc.

Camera systems should be configured so the human form detection zones, as shown in appendix 1, can be achieved with zero blind spot areas and camera systems should be configured so the human form detection zones, as shown in appendix 1, can be achieved with zero blind spot areas.

Scope of machine inclusion –

- Excavators 13t and above
- FT Dumpers 6t and above
- Articulated Dump Truck 9t and above
- Roller 13t and above
- Telehandler all sizes
- Dozers
- Wheeled Loaders
- Graders

Standards

Several standards come into action for this type of technology. Although there is no one individual standard the encompasses everything that is required.

Below is the list of standards that were discussed as suggested minimum requirements: -

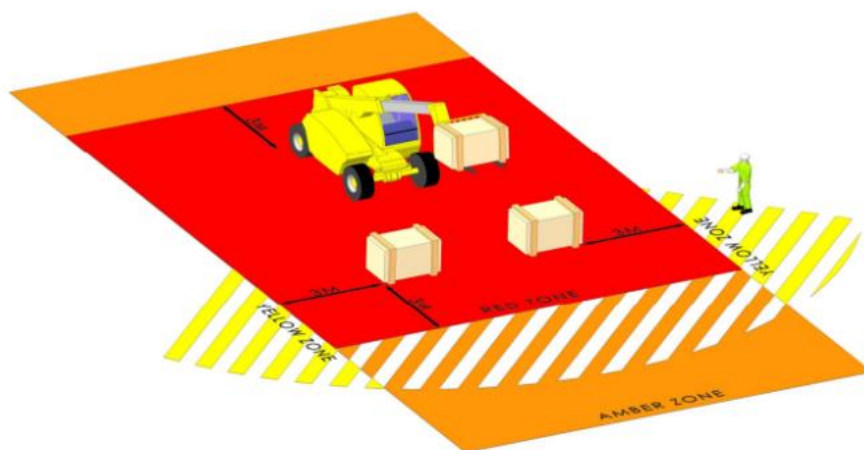
- EC Reg 10 Automotive Electromagnetic compatibility and / or ISO 13766 - Electromagnetic Compatibility for Earth-Moving Machinery
- ISO 13849 - Safety of machinery. Safety-related parts of control systems
- CE and / or UKCA Certification

Minimum Camera Specification

- 720p HD
- Colour
- 25 Frames per second
- Detection achievable in low level light (Min 0.1 Lux)
- IP68 protection
- 8-15v DC power range
- Operating temperature between -20 ~+60°C
- Relative humidity up to 90%
- Vertical and horizontal adjustable mountings
- Camera fault alarm

Accuracy levels for detection of the whole system must be above 95%. This will need to be verified via data captured during testing of the system as laid out in Appendix 2 – HFR Accuracy Test criteria.

Red Zones & Hierarchy of Controls



Red zones are commonly used in the construction industry to inform personnel of the dangers of working within the vicinity of plant and vehicles on site. Red zones are also linked to company hierarchy of controls and form a basis for training material.

Individual company policies and procedures must be considered when using this technology to ensure compliance.

This Human Form Recognition technology has been developed to provide assurance that red zone training is being complied with. The system's primary function is to advise the plant operator that a person has, or is about to, enter the danger zone (red zone) of the plant.

It remains the responsibility of the pedestrian to never enter the red zone unless the plant operator has made it safe to do so and confirmed this to the pedestrian.

Functionality

Audible Alarms – when pedestrian detected: -

Internal

HFR Outer Zone – Subtle audible alert (such as beeps) when a pedestrian enters the detection zone.

HFR Inner Zone – Repeating spoken alarm “**Person Detected**” whilst a pedestrian remains in the detection zone.

External

HFR Outer and Inner Zones – Repeating spoken alarm – for example, “**Danger - Move away**”, “**Caution. Machine in operation**”

External alarms to have a supervisor level deactivation system when working in noise sensitive areas so these can be turned off - i.e., during night works or close proximity to housing.

Portal notification or indication when external alarms are turned off.

Visual Alarms – when pedestrian detected: -

Internal: -

- Visual zonal alert that stays illuminated (Amber HFR Outer Zone or Red – HFR Inner Zone) while person remains present within the zones.
- CCTV Display screen – optional.

Managing False Alerts – HFR must always be active when the ignition is on, and the operator must continue to be notified visually of any pedestrians in the outer and inner zones even if the machine is in a “safe” state. Audible notifications must be minimised whilst machine is in a “safe” state. Video clips of detection must only be active when machine is in work mode i.e., Deadman lever engaged, or handbrake is released (for machine without Deadman levers).

Zone changes

Occasionally, changes to the default detection zones will be identified following specific risk assessments of the activities. Changes to the zones need to be actionable in a timely and easy to do manner, either over the air or via a connected device.

Data & Recording

Any personal data that is captured by this camera system must be in line with current GDPR regulations and each company employing this technology must carry out their own Data Protection Impact Assessment (DPIA).

Whilst the majority of data captured is numerical and location data, the video capture data is classed as personal data as identification can be made to an individual.

In certain circumstances, data and video capture may not be authorised or allowed by the client, for example military installations and certain parts of the power generation industry. It is advisable to check with the client before any such technology is deployed on these sites.

Data Points – (non-video)

Below is a list of minimum data points required from the HFR camera system: -

- **Company name** – refers to the company name where the data is being collected.
- **Incident ID** – Unique detection id number
- **License / Registration Plate** – Plant asset ID Number
- **Alert Tag (Outer/Inner Detection Zone)** – Classification of detection
- **Latitude** – for location of the detection
- **Longitude** – for location of the detection
- **Date** (of alert) – in dd/mm/yyyy format
- **Time** (of alert) – in 24hr format
- **Supplier of Asset** (Plant) – Company name of the owner of the HFR System

- **HFR Outer Zone**
 - All Outer Zone detection videos will be stored locally on the internal hard disc storage device on the item of plant and numerical data of detections will be visible in the Management reporting system.

- **HFR Inner Zone**
 - All Inner Zone detection videos (10 sec clip) will be “thumb nailed” on the internal hard disc storage device. These clips can be downloaded upon request and stored on Cloud based portal for ease of review by interested parties. All numerical data of detections will be visible in the Management reporting system.

On board data storage min 250hrs

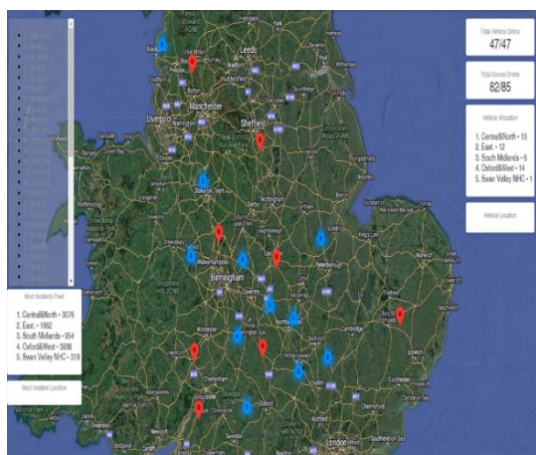
All machine with 270 degree zone also require forward facing recording cameras. These need to be in accordance with GDPR legislation and have a 250 hour storage capacity.

Event, numerical and video data must be API (Application Programming Interface) capable.

Dashboard & Reports

All systems must be installed ready to connect and transmit data to a cloud-based data portal so that the data collected by the HFR camera system can be easily accessed and reviewed.

Included in the reporting system, there needs to be a Google Earth (other mapping systems can be used) image of the site, overlaid with Heatmaps summarising the number of detections and amalgamating these, as shown in the examples shown below. The Heatmaps allow rapid identification of problem areas so that the data can be reviewed, and the causes of the problems resolved.



The data portal must be capable of providing data reports at intervals as required by the end user. The information required will be the detection data, together with the ability to interrogate the data to identify details of the detections.

Each end user will have their bespoke requirements and the format of this data will be specific to individual companies.

Appendix 1 - Default Detection Zones

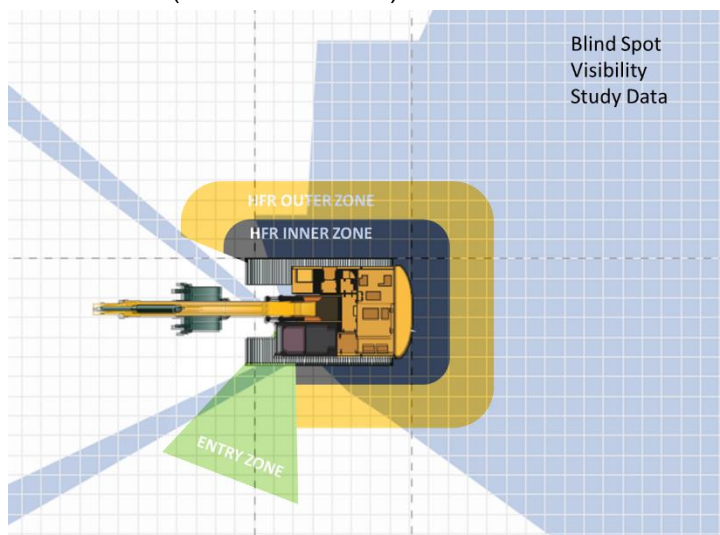


Excavators 13t and above

270° Detection Coverage + forward facing recording.

5m Detection Zone

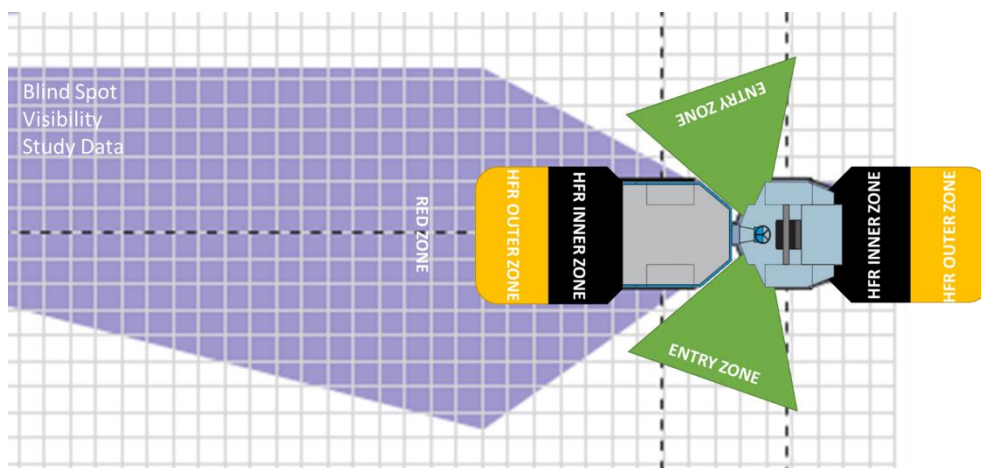
- 2m – 5m Zone (HFR Outer Zone)
- 0m – 2m Zone (HFR Inner Zone)



FT Dumper 6t and above

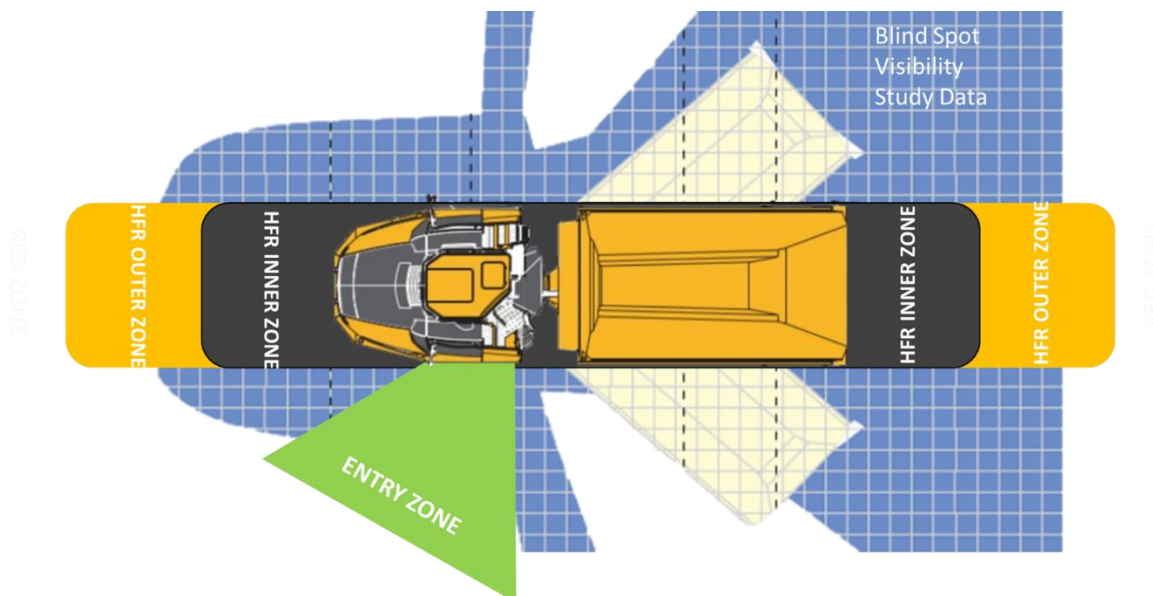
5m Front & Rear Detection Zone

- 2m – 5m Zone (HFR Outer Zone)
- 0m – 2m Zone (HFR Inner Zone)



Articulated Dump Truck 9t and above 10m Front & Rear Detection Zone

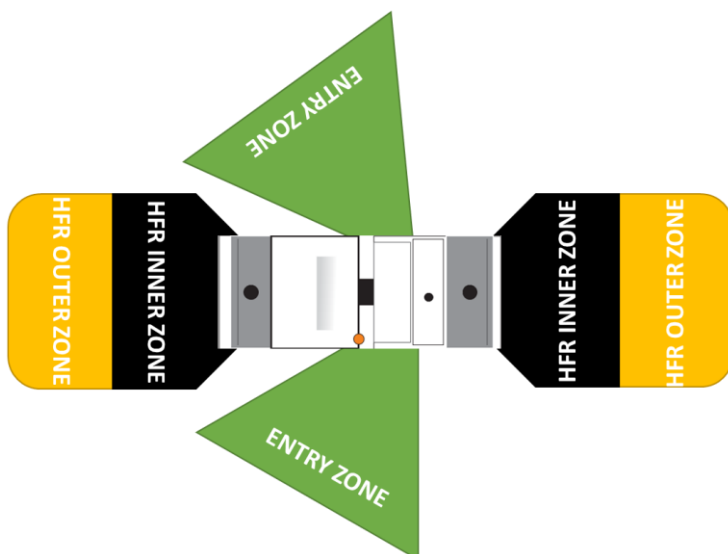
- 5m – 10m Zone (HFR Outer Zone)
- 0m – 5m Zone (HFR Inner Zone)



Roller 13t and above

5m Front & Rear Detection Zone

- 2m – 5m Zone (HFR Outer Zone)
- 0m – 2m Zone (HFR Inner Zone)



Telehandler all sizes

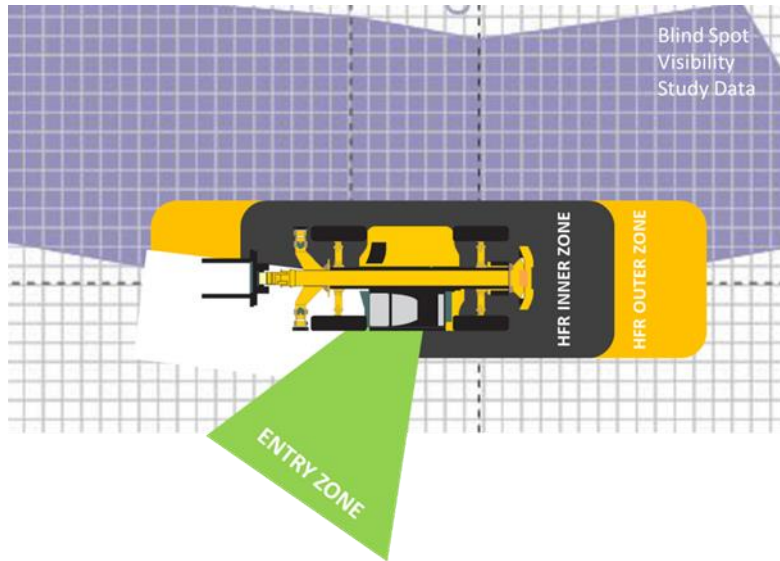
270-degree Detection Coverage + forward facing recording

5m Front & Rear Detection Zone

- 2m – 5m Zone (HFR Outer Zone)
- 0m – 2m Zone (HFR Inner Zone)

Body Sides Detection Zone

- 0m – 1.5m Zone (HFR Inner Zone)



Dozers

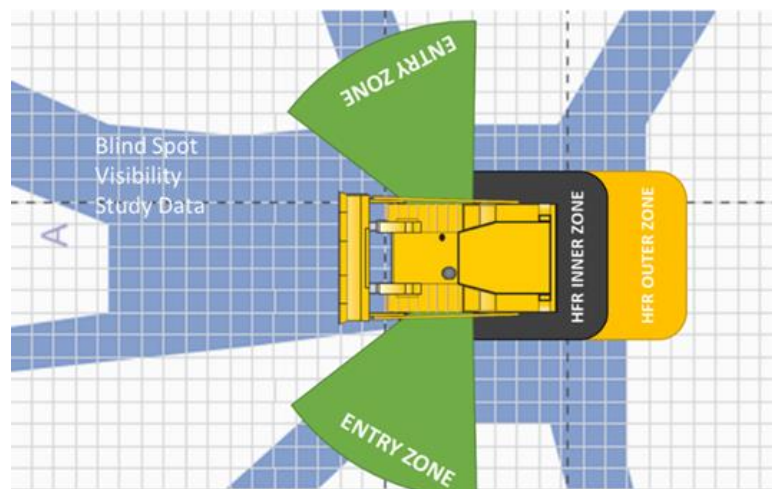
180-degree Detection Coverage

Rear Detection Zone

- 2m – 5m Zone (HFR Outer Zone)
- 0m – 2m Zone (HFR Inner Zone)

Body Sides Detection Zone

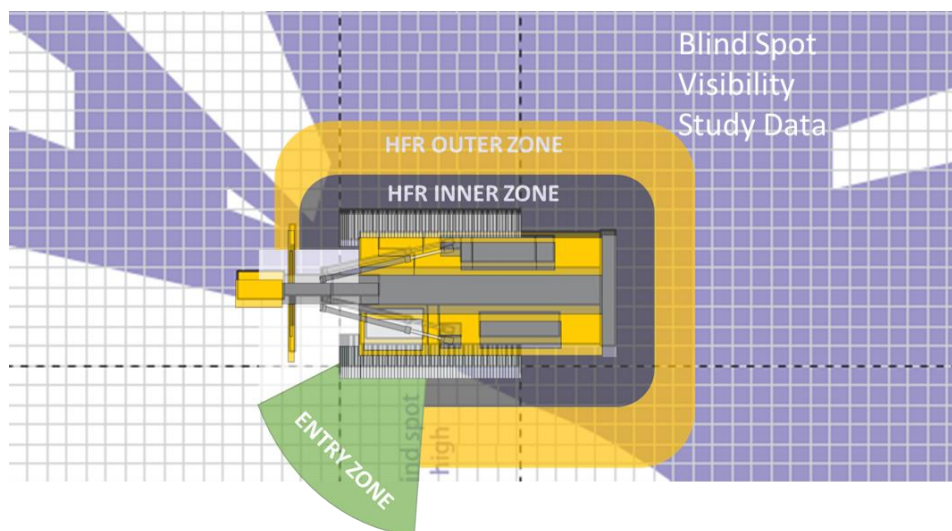
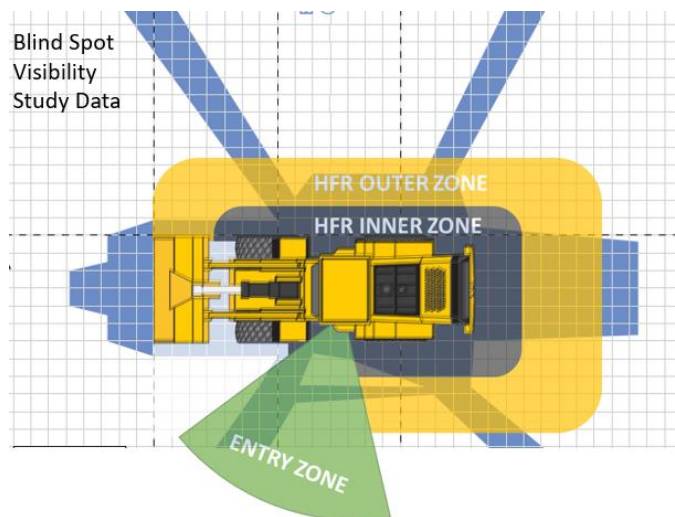
- 0m – 1.5m Zone (HFR Inner Zone)



Wheeled Loaders

270-degree Detection Coverage

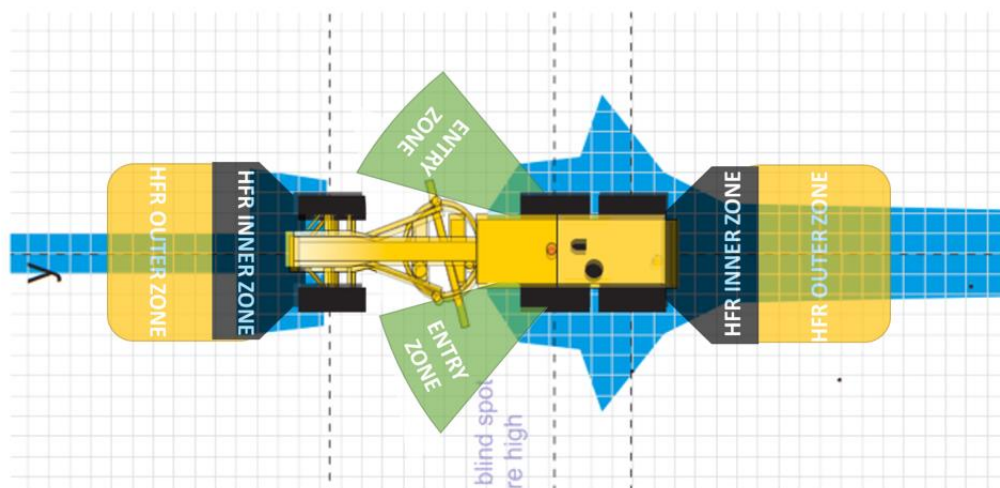
- **5m Detection Zone**
 - 2m – 5m Zone (HFR Outer Zone)
 - 0m – 2m Zone (HFR Inner Zone)



Graders

5m Front & Rear Detection Zone

- 2m – 5m Zone (HFR Outer Zone)
- 0m – 2m Zone (HFR Inner Zone)



Appendix 2 – HFR Accuracy Test Criteria



Accuracy testing is an important function when using human form recognition cameras on construction plant as poor performance could result in incidents and potentially fatalities occurring.

The requirement for accuracy testing demonstrates the reliability of detecting pedestrians within the detections zones as shown in appendix 1 – Default Detection Zones.

The following Test Criteria will need to be carried out and verified by Balfour Beatty's Product Manager for any Human Form Recognition system solutions so that approval can be obtained from Balfour Beatty.

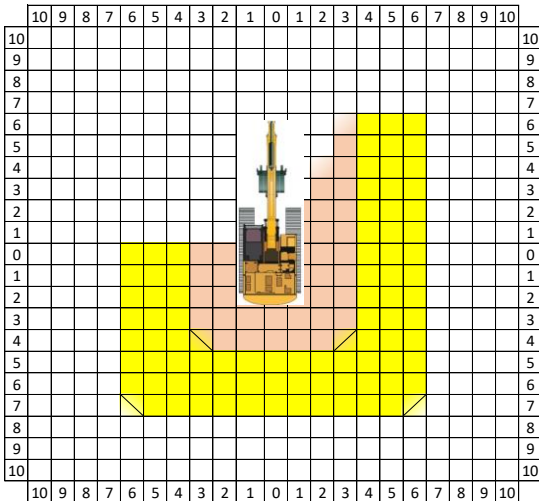
Human Form Recognition Camera System Test Criteria

The following information needs to be captured for all test scenarios

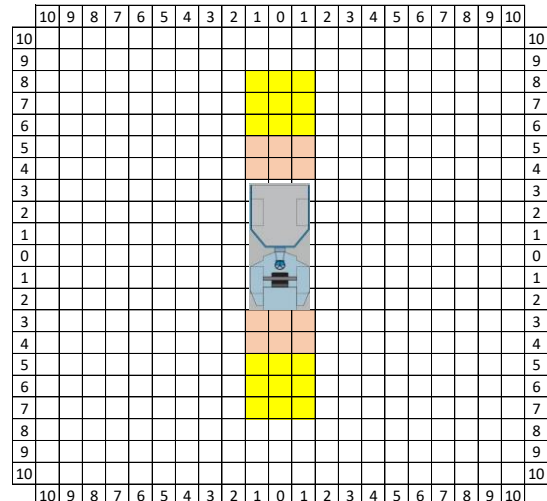
Date:		Time:		Location:		
Machine Type:	Excavator / Dumper / ADT / Roller / Telehandler / Dozer / Wheeled Loader / Grader			Make & Model:		
Camera OEM:		Detection Configuration:	360° / 270° / 180° / Front & Rear / Front only / Rear only			
Weather Conditions:						
Clothing / PPE Colour:	Yellow	Orange	Blue	Black	Grey	White
Pedestrian Position:	Standing	Crouching	Walking	Running	Kneeling	
	Lower Body Obscured		Upper Body Obscured		Other	

The grids below are the templates to be used showing 1 x 1 meter squares around the plant which should be marked on the ground. Repeat this exercise for each type of clothing in each different position.

Excavator



Dumper



Use the key below to record the outcome of the test.

KEY	
✓	Successful detection
X	Unsuccessful Detection
⊕	HFR Camera locations
→	Direction pedestrian facing
■	Outer Detection Zone
■	Inner Detection Zone
☀	Area of concern

Example of Accuracy Test carried out: -

Date:	12/08/23	Time:	11:00 am	Location:	BB Yard, Thurnscoe, Barnsley.	
Machine Type:	Excavator / Dumper / ADT / Roller / Telenandier / Dozer / Wheeled Loader / Grader			Make & Model:	CAT 320GC	
Camera OEM:	ACME HFR SYSTEMS	Detection Configuration:	360° / 270° / 180° / Front & Rear / Front only / Rear only			
Weather Conditions:	Sunny, warm					
Clothing / PPE Colour:	Yellow	Orange	Blue	Black	Grey	White
Pedestrian Position:	Standing	Crouching	Walking	Running	Kneeling	
	Lower Body Obscured		Upper Body Obscured		Other	

