ADVANCED MINING TECHNOLOGIES PTY LTD

COLLISION AVOIDANCE SYSTEM CAS-CAM/RF®
Product Overview

1 November 2007

Issue E

This page is intentionally left blank.

Table of Contents

List of Figures

1 SYSTEM OVERVIEW

1.1 Introduction

Since the advent of large mining trucks there has been an ongoing problem with collisions resulting from poor external vision and limited manoeuvrability. This has resulted in a very high incidence of accidents where large mining trucks collide with other vehicles, items of plant and occasionally people. Over the last 10 years in Australian open cut coal mines in the states of New South Wales and Queensland, 147 collisions have been reported involving large mining equipment. Of these, a large proportion has been the result of poor visibility (see Figure 1). Remarkably there have been few fatalities but property damage and lost productivity has been significant.

The only protection against collisions in the blind areas of a truck at the moment are procedural or "soft" barriers, such as no-go zones for Light Vehicles, standard parking and start-up procedures, and audible reversing alarms. Even with these procedural controls and noisy reversing alarms in place, the problem of Heavy Vehicle collisions has not been eliminated. In addition to the requirement for an improved collision avoidance system, the noise from these smart reversing alarms have recently come under review in mines operating in close proximity to residential areas.

Even if the Heavy Vehicle driver could be provided with 360 degree unlimited vision around the Heavy Vehicle, this would still not be adequate because of the vehicle size. The driver would only be able to ‘look’ in a limited number of directions at once with the potential for also creating distractions from safe driving.

An improved approach is to provide enhanced driver vision supplemented by an automatic detection system that looks in all high risk directions at once, identifies potential problems and attracts the driver’s attention to those areas where potential collisions could occur. In addition, a further level of effectiveness is to provide warning information to both the Heavy Vehicle driver and the objects at risk, as any hazardous situation involving two parties, in which one party does not have the ability to take action, is inherently unsafe.

As part of the ongoing commitment to improving safety and productivity through the application of innovative technology, Advanced Mining Technologies (AMT) in conjunction with CSIRO Exploration and Mining has developed such a Collision Avoidance System (CAS) aimed at greatly improving Heavy Vehicle safety and eliminating the need for audible reversing alarms.

The CAS technology utilises state of the art colour video cameras with an LCD video Display Unit as a vision aid (CAS-CAM®) and Radio Frequency (RF) transmitters and receivers for automatic object detection and classification (CAS-RF®). The combined video camera and RF technologies form the CAS-CAM/RF® System.

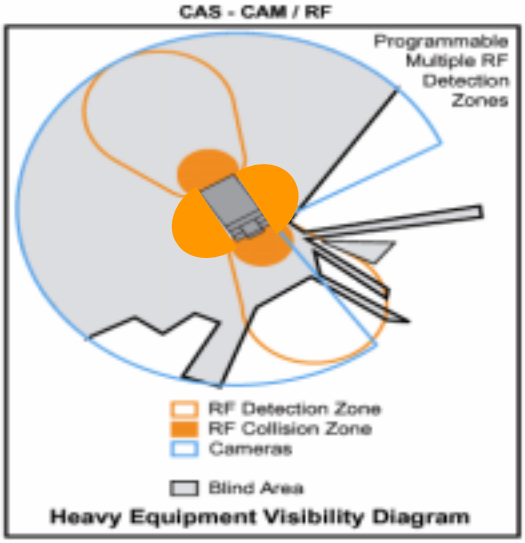


Figure 1: Typical Visibility Map for a Large Haul Truck

1.2 Performance Capabilities

The key performance capabilities of the CAS-CAM/RF® System are as follows:

- Warning to the driver of the Heavy Vehicle when a vehicle or stationary object is in the Heavy Vehicle's path (visual and audible warning when an object is detected within a programmed detection range)
- Warning to the "AT-RISK" vehicles in the case of an imminent collision when the Heavy Vehicle is detected within a programmed detection range (visual and/or audible warning)
- Programmable multiple detection ranges from 0 – 80 m (accuracy of +/-20%)
- Improved vision for the driver (i.e. video cameras)
- Mechanism for driver acknowledgment of alarms
- Rugged construction for reliability in mining environments
- Reliable operation in adverse environmental conditions (e.g. Dust, fog, smoke, hot, cold and darkness)
- System aids and doesn't inhibit current mine operations
- Coded identification of objects within programmed detection ranges displayed at all times
- Data logging capability on all Heavy Vehicles and Light Vehicles for monitoring/recording system operational performance & reliability (optional)
- Easy integration with existing Mine Fleet Management Systems (via RS-232, RS-485 or CAN interfaces).

1.3 Features and Benefits

Features	Benefits
• Combined vision system (CAS-CAM®) & automatic object detection (CAS-RF®) technologies (CAS-CAM/RF®)	• Comprehensive Heavy Vehicle safety package utilising both vision aids (cameras) and automated object proximity detection (using active RF tags) for safe interactions between Heavy Vehicles, Light Vehicles and Stationary Objects. • Single compact video display / alarm unit alerts Heavy Vehicle operator when objects are in the vehicle's path. • Automatic alarming alleviates need to monitor video display whilst driving thus reducing distractions. Alarms attract the driver's attention to areas of potential collisions. • Improved driver vision using high-resolution colour video cameras. • Multiple levels of collision detection redundancy (i.e. two-way RF tagging, Video Cameras, reversing alarms and side mirrors). • Seamless integration of CAS-CAM® and CAS-RF® components into CAS-CAM/RF®.
• Two-way alarming	• Heavy Vehicle driver receives alarm when a Heavy Vehicle, Light Vehicle or Stationary Object is in the vehicle's path and can take appropriate action. Driver can also confirm presence of 'AT-RISK' objects using unique object Identification Codes for specific radio confirmation and can also check location using video cameras. • Individual warning to the "AT-RISK" vehicles of the approaching Heavy Vehicle so that appropriate action can be taken. • Avoids the hazardous situation involving two parties, in which one party does not have the ability to take action, as this is inherently unsafe.

Features	Benefits
• Coded object classes (i.e. Heavy Vehicle (HV), Light Vehicle (LV), Stationary Object (SO), Test Station (TS)) • Client specified object Identification (I.D.) code (e.g. TRUCK1, CAR3, DOZER4)	• Heavy Vehicle driver receives real time indication of the objects Identification codes and can confirm the location of the objects using video cameras. • Object Identification (I.D.) provides positive confirmation and enables specific radio contact to be established with the 'AT-RISK' objects. • Alarms generated when object status changes within the programmed detection range(s). • Multi-RF tag operation. • RF tag could also be used for access control purposes when integrated with a security access control system.
• Specific Heavy Vehicle (HV) types (e.g. Truck, Dozer, Grader, Scraper, Loader, Medium Vehicle, Drill, Shovel / Dragline)	• Programmable HV-HV alarm scenarios to reduce level of unnecessary alarms (e.g. Truck to Truck, Truck to Dozer, Truck to Loader, Shovel / Dragline to Dozer)
• Programmable multiple detection ranges from 0 – 80 m (accuracy of +/- 20%). • Option for long range operation (typically 200-300m) for haul road crossing warning light activation by approaching Heavy Vehicle.	• Flexibility to adjust detection ranges to suit specific applications. • Programmable detection ranges available on Heavy Vehicle for different object types (e.g. HV, LV, SO, TS), HV detection location (i.e. front, rear or sides), HV direction of travel (forward or reverse) and speed. • Single detection range on Light Vehicle, Stationary Object & Test Station tags. • Heavy Vehicle detection ranges can be dynamically changed according to vehicle speed for high speed and low speed collision warning ranges.
• Cameras can be programmed to automatically switch to front, rear or side cameras either on gear changes and / or automatic object detections	• Provides driver with visual confirmation of the presence of new object (s) without having to manually switch cameras.
• High performance Heavy Vehicle & RF communications backbone	• Allows flexibility for custom operation and future expansion. • Easy integration with other Heavy Vehicle collision sensing technologies (e.g. radar, ultra-sonics). • Easy integration with existing mine data telemetry networks (e.g. fleet management systems).

Features	Benefits
• Heavy Vehicle and Light Vehicle data logging capability for all detections	• Able to monitor system performance and all collision detections as a safety audit trail. • Data recoverable via laptop PC or in real-time using Fleet Management System.
• Localised System compared with Distributed Wide Area Network	• Not reliant on existing mine infrastructure for reliable operation (i.e. good risk management practice). • High level of redundancy. • Fast detection response time (typically under 300 msec for 10 units operating within the detection range).

2 SYSTEM DESCRIPTION

2.1 Overview

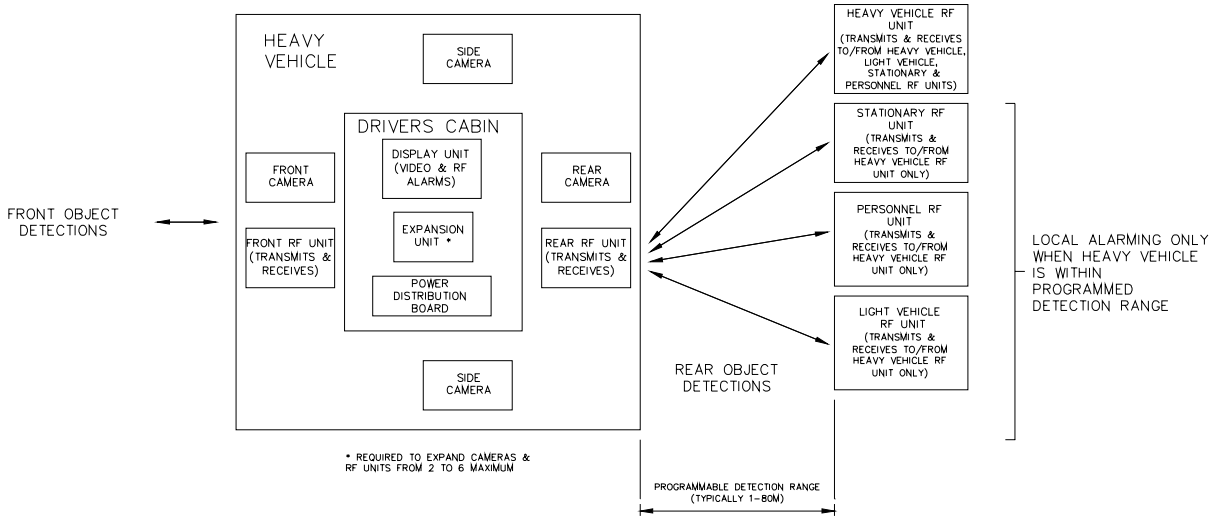


Figure 2: System Function Diagram

The CAS-CAM/RF® system consists of Radio Frequency (RF) Tags for each Light Vehicle, Heavy Vehicle and other items of value. The Heavy Vehicle also has high quality video cameras and a high definition LCD video Display Unit. The camera video images and RF tagging alarms, in text format, are simultaneously displayed on the Display Unit inside the Heavy Vehicle driver's cabin.

The video camera is housed in a ruggedised enclosure and produces full colour vision down to 0.03 lux illumination. Camera settings such as brightness and colour can be set for each individual camera at the time of installation. Up to six (6) cameras can be attached to the Display Unit (2 directly, 4 via an Expansion Unit). User programmable camera functions include: DIM (brightness settings) and manual camera switching. Additional programmable camera settings fixed at the time of installation include: Camera titles (8 characters maximum), mirror / normal mode, auto switching to reverse / forward / side cameras when vehicle either engages reverse / forward gear or when RF detections are recorded at the rear / front / side, camera cycling at variable rates. All settings are saved during power down.

The Radio Frequency system transmits digitally coded data such as tag identification number, tag type, vehicle status and tag status. This is crucial to the system's ability to discriminate when multiple tags are detected of various object classes.

A high quality, license exempt, digital RF link is used with full error control.

The system can be purchased with the following options:

- Video Only system for enhanced vision applications: CAS-CAM®
- RF Only system for automatic object detection: CAS-RF®

- Video & RF systems (vision & object detection): CAS-CAM/RF®

A Video only system (CAS-CAM®) or RF only system (CAS-RF®) can be easily upgraded for full Collision Avoidance System capability (CAS-CAM/RF®) as both technologies can be seamlessly integrated with each other.

2.2 Heavy Vehicle System

The Heavy Vehicle System comprises of the following components:

- Camera Unit (up to 6 units)
- Display Unit
- Expansion Unit (required if more than 2 cameras / RF units are used)
- Front and / or Rear RF Unit and / or Side RF Units

Details on these components are as follows:

2.2.1 Camera Unit (PROD0118)

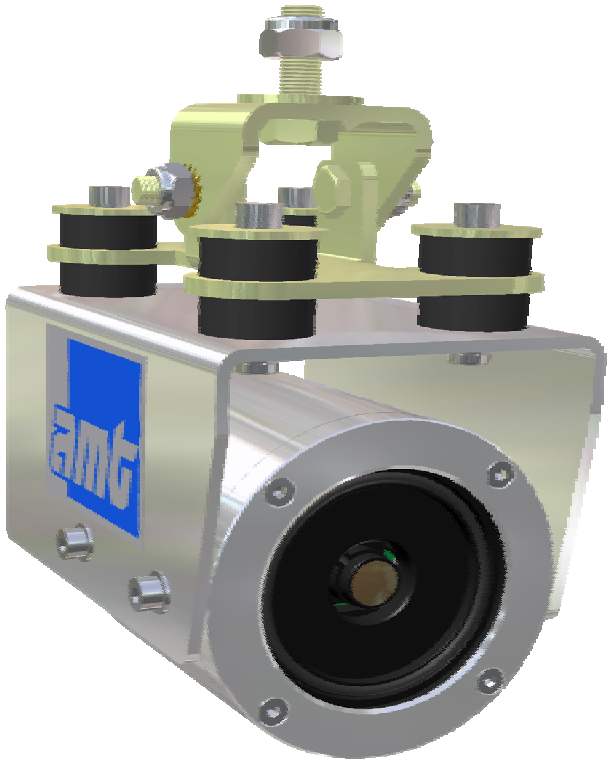


Figure 3: Camera Unit (PROD0118)

The Camera Units are water and dust resistant and designed to withstand the high-pressure water sprays commonly used to clean Heavy Vehicles.

Features:

- IP 66 rated enclosure
- High resolution colour 1/3” CCD image sensor
- Resolution: 380 TV lines
- Viewing angle: 123 degrees horizontal and 91 degrees vertical (153 degrees diagonal) (narrower viewing angles are available on request)

- Minimum illumination: 0.03 lux / F1.2 using day/night camera
- Waterproof connection system
- Shock proof mounting
- Small contemporary design
- Solid aluminium construction
- Highly adjustable mounting hardware

2.2.2 Display Unit (PROD0119)

Figure 4: Heavy Vehicle Display Unit (PROD0119)

The Heavy Vehicle Display Unit consists of an active matrix 6.4” colour LCD screen. It displays images from the cameras, text information received from the RF system, and driver controls for camera selection adjustment and alarm acknowledgement. The Display Unit also contains an RS-232 interface for system configuration and recovering logged detection data via a laptop PC.

Features:

- IP 32 rated enclosure
- Full colour display (6.4” colour TFT LCD)
- High resolution (960W x 234H) anti-glare screen
- User programmable camera functions include: DIM (brightness)
- Installer mode functions programmable via a Laptop PC using RS-232 interface include: Channel Settings (6 camera channels maximum), Camera Titles (8 characters maximum), Camera Brightness (1-5), Camera Colour (1-5), Camera Mirror (on/off), Camera enabled (yes/no), Camera Auto Cycling (off, 2s, 4s, 6s, 8s, 10s), Keypad Tone (yes/no), Auto Switch to Reverse / Forward Camera on Reverse / Forward Gear Selection and / or Rear / Front RF Unit detections, Display power down settings (sleep time: off, 5mins, 10mins, 15mins, 20mins, 25mins, 30mins), Camera Wake Settings (on forward gear and / or reverse gear), RF Detection Settings (programmable range, visual & audible alarms for various object types and direction of travel), Clock Settings.
- Wide operating power supply range (10–30 VDC, 25W max)
  (Note: The Display Unit, Expansion Unit, Camera Units and RF Units can be permanently powered from the Heavy Vehicle battery with the Display Unit screen powering down after a preset timeout period when the vehicle is not in forward or reverse gear (if enabled). This function conserves battery life and enables the RF tagging to still be active when the vehicle is unattended for the benefit of other vehicles. Camera only installations (CAS-CAM®) are powered from the vehicle auxiliary / ignition circuit.
- 4 function membrane keypad
- On-screen display function (text overlaid on video)
- Real time clock
- Audible alarm
- Menu settings saved during power down
- Two camera inputs (expandable up to 6 cameras using Expansion Unit) - can connect RF Units to Camera inputs for upgrade to RF tagging capability (CAS-CAM/RF®)
- Video output – PAL (for connection to VCR)
- RS-232 & RS-485 interfaces
- Rugged aluminium construction
- Sun visor

2.2.3 Expansion Unit (PROD0161)

Figure 5: Heavy Vehicle Expansion Unit (PROD0161)

The Heavy Vehicle Expansion Unit provides the ability to easily expand the number of cameras and RF Units from the standard 2 channels supported by the Display Unit up to a maximum of 6 channels.

Features:

- IP 54 rated enclosure
- Provides Camera Unit & RF Unit expansion up to 6 units maximum with the Display Unit
- 4 local camera inputs (in addition to 2 camera inputs on Display Unit) – can connect RF Units to Camera inputs for upgrade to RF tagging capability (CAS-CAM/RF®)
- 4 auxiliary inputs (opto isolated) (e.g. reverse & forward signals)
- 2 switched contact outputs (voltage free) (e.g. reverse alarm circuit)
- RS-232, RS-485 & CAN interfaces
- Wide operating power supply range (10–30 VDC, 50W max) – also powers Display Unit (Note: The Display Unit, Expansion Unit, Camera Units and RF Units can be permanently powered from the Heavy Vehicle battery with the Display Unit screen powering down after a preset timeout period when the vehicle is not in forward or reverse gear (if enabled). This function conserves battery life and enables the RF tagging to still be active when the vehicle is unattended for the benefit of other vehicles. Camera only installations (CAS-CAM®) are powered from the vehicle auxiliary / ignition circuit.
- Input power provided from vehicle electrical distribution board (10–30 VDC, 50W max)
- Rugged aluminium construction
- Typically located within 10 metres of Display Unit

2.2.4 Front / Rear / Right / Left RF Units (PROD0239 / PROD0169 / PROD0307 / PROD0308)

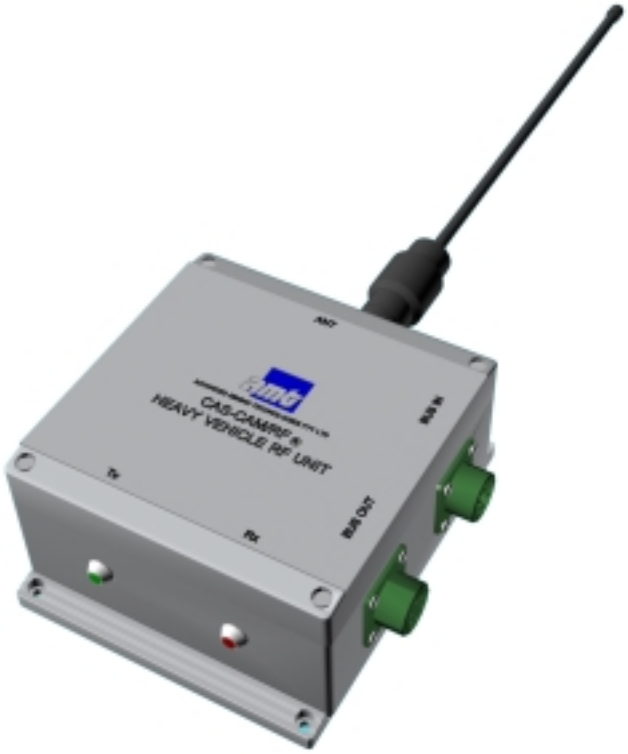


Figure 6: Heavy Vehicle (HV) RF Unit (Front – PROD0239 / Rear – PROD0169 / Right – PROD0307 / Left – PROD0308)

The Heavy Vehicle (HV) RF Unit is available in Front and Rear models for mounting at the front and rear of the vehicle respectively. Rear mounted versions are typically located above the rear axle of rear dump trucks; front mounted versions are typically located in front of the grill on the driver access ladder.

Optional Side RF Units (Left RF Unit, Right RF Unit) are available for effective 360 degree close-range start-up object detection, whereas Front & Rear RF Units only provide partial blind-spot object detection at the expense of long range detection directly in front or behind. Side RF Units are typically located on the front top deck side-rear handrails of rear dump trucks.

The RF units receive the transmitted signal from other RF units and also continuously transmit a signal for triggering alarms on the remote tags when located within the programmed detection range.

Features:
- IP 56 rated enclosure
- Low power RF transceiver operates in LIPD class license for unlicensed bands
- Digital RF data transmission with full error control
- Detection angles typically in range 90 – 120 degrees at rear (including detection in rear tyre path) and 180 degrees at front and sides
- Power supply 12VDC, 100mA maximum

(Note: The Display Unit, Expansion Unit, Camera Units and RF Units can be permanently powered from the Heavy Vehicle battery with the Display Unit screen powering down after a preset timeout period when the vehicle is not in forward or reverse gear (if enabled). This function conserves battery life and enables the RF tagging to still be active when the vehicle is unattended for the benefit of other vehicles.

- Input power provided from Display Unit or Expansion Unit
- Up to two units can be connected directly to Display Unit camera channels or additional 4 units connected via the Expansion Unit. Can multi-drop RF Units with camera connected directly to RF Unit (e.g. Front + Left Side RF Units, Rear + Right Side RF Units).
- External Tx and Rx activity indicators (green / red LED's)
- Rugged aluminium construction

2.3 Light Vehicle (LV) System (with external beacon option) (PROD0294)

The Light Vehicle (LV) System (with external beacon option) comprises of an RF unit (Figure 7) which is normally fitted to the roof of a Light Vehicle. A driver dash-mounted Alarm Unit (Figure 8) is situated inside the vehicle cabin to provide both an audible and visual warning to the driver when a Heavy Vehicle (HV) or Test Station (TS) is detected within the programmed detection range. The Alarm Unit also contains a RS-232 interface for system configuration and recovering logged detection data via a Laptop PC.

Features:

- IP 54 rated enclosure
- RF transceiver
- Optional external beacon interface (12VDC@5A maximum)
- Dash mounted Alarm Unit containing audible alarm buzzer, flashing alarm indicator, power indicator and RS-232 interface
- Optional External Beacon & dash mounted Alarm Unit activated when Heavy Vehicle (HV) (in gear) or Test Station (TS) is detected within the pre-programmed range
- Low power RF transceiver operates in LIPD class license for unlicensed bands
- Digital RF data transmission with full error control
- Object detection angle of 360 degree
- Operating power supply: nominal 12VDC, 5A maximum (0.1A without external beacon)
- Input power provided from vehicle electrical distribution board (via battery) for permanent installation.
  (Note: The Light Vehicle Unit is normally permanently powered from the vehicle battery which enables the RF tagging to still be active when the vehicle is unattended for the benefit of other vehicles)
- External Tx and Rx activity indicators (green / red LED's)
- Rugged aluminium construction

Figure 7: Light Vehicle (LV) System – Light Vehicle RF Unit (with external beacon option) (PROD0295)

Figure 8: Light Vehicle (LV) System – Dash Alarm Unit (PROD0211)

2.4 Stationary Object (SO) System (PROD0605)

The Stationary Object (SO) System is an identical design to the Light Vehicle (LV) System (refer to section 2.3), however, is coded as a Stationary Object (SO). The unit would normally be mounted on fixed plant / equipment / obstacles that are prone to being damaged by Heavy Vehicles. The unit can be powered by either battery packs with solar panel charging capability or powered directly from mains powered 12VDC supply.

2.5 Test Station (TS) System (PROD0606)

The Test Station (TS) System is an identical design to the Light Vehicle (LV) System (refer to section 2.3), however, is coded as a Test Station (TS).

Test Stations are used for in-field testing of all mobile RF tagged object types (e.g. Heavy Vehicle, Light Vehicle, Stationary Object) and are designed to be alarmed by and trigger alarms on all object types.

Test Stations would normally be installed in locations frequently passed by RF tagged objects (e.g. maintenance workshop, GO-LINE, refuelling station etc) and serve to provide regular functional two-way testing of all RF tagged objects. Solar power versions are available for remote locations.

3 SYSTEM OPERATION

3.1 General

The Heavy Vehicle (HV) will detect any tagged object within a pre-designated Detection Zone that can be programmed at the time of installation. The RF tags transmit an identification code that is deciphered by the Heavy Vehicle RF unit(s) and is classified into various object classes, i.e. Light Vehicle (LV), Stationary Object (SO), other Heavy Vehicle (HV) or Test Station (TS). HV's can be programmed for specific types including: Truck, Dozer, Grader, Scraper, Loader, Medium Vehicle, Drill, Shovel / Dragline.

The Identification Codes of all RF tags detected are displayed on the video monitor for both front, rear, left and right detections (refer to Figure 4). The Heavy Vehicle unit also conducts initial and continuous self-checks to detect equipment malfunctions, which are reported to the driver on the Display Unit.

The Heavy Vehicle is continually receiving and transmitting signals that are detected by a Light Vehicle (LV), Heavy Vehicle (HV), Stationary Object (SO) or Test Station (TS) RF tags. When in the Heavy Vehicle Detection Zone (and HV in gear), the Light Vehicle tags can flash lights (if fitted) and sound an audible alarm in the cab. Tagged Stationary Objects and Test Stations can also flash lights (if fitted) for driver identification.

The driver is provided with the Identification codes of each object within the Heavy Vehicle's Detection Zones on the Display Unit. Only when the Heavy Vehicle is in gear will the audible alarm in the Display Unit sound when any objects have been detected within the Heavy Vehicle Detection Zones. Heavy Vehicle visual and audible alarms are fully programmable in the Display Unit for each object class (HV, LV, SO, TS), based on range, HV detection location (front / rear / sides), direction of travel (forward / park / reverse) and speed.

All RF tags have a unique ID code that is logged when detected by either a Heavy Vehicle, Light Vehicle, Stationary Object or Test Station unit. Collision detection data can be retrieved by either a Fleet Management System or Laptop PC for safety audit trail purposes.

The system has been designed to enable the installation of the CAS in it's entirety (CAS-CAM/RF®) or the high-resolution colour video system (CAS-CAM®) as a stand-alone product, with the necessary in-built smarts to install the RF interface (CAS-RF®) at a later stage, should the user so desire.

3.2 Programmable Detection Zones

Each tagged object has programmable Detection Zones as follows:

3.2.1 Heavy Vehicle Detection Zones

Fully programmable detection zones and audible alarms for different object types (e.g. HV, LV, SO, TS) based on range (0-80m), vehicle gear status (i.e. forward, reverse, park), detection location (i.e. front or rear or sides) and vehicle speed.

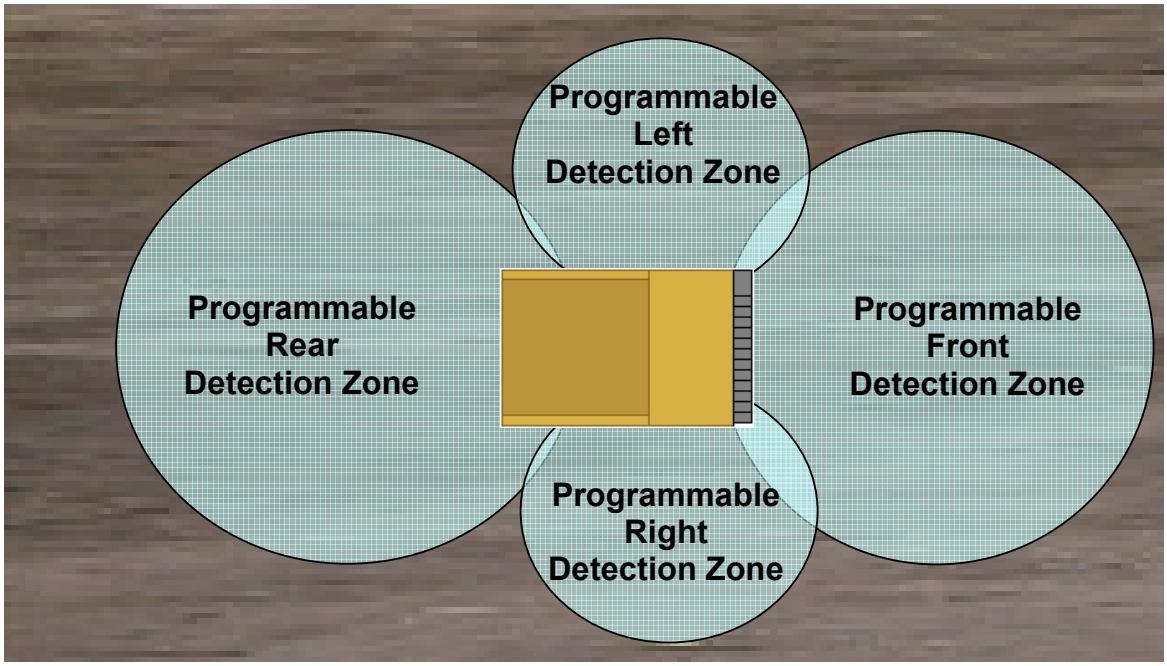


Figure 9: Heavy Vehicle Detection Zones (Front, Rear and Side RF units)

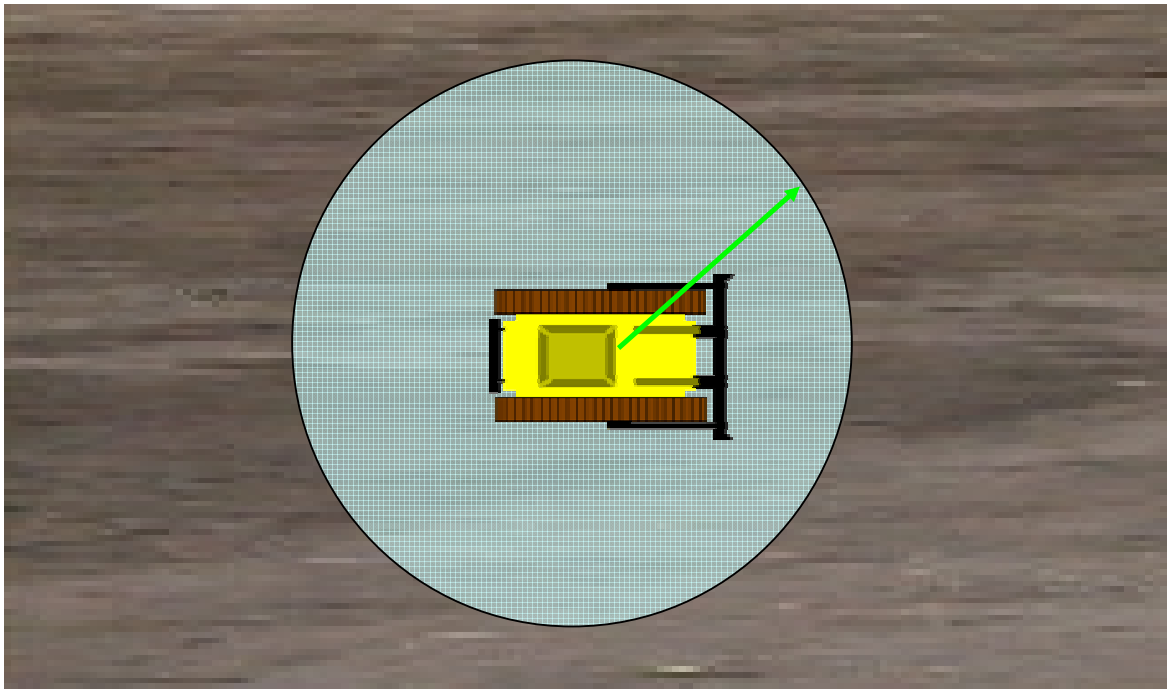


Figure 10: Heavy Vehicle Detection Zone (Central RF unit)

3.2.2 Light Vehicle Detection Zone

Single Programmable Detection Zone
Radius programmable from 0- 80 m

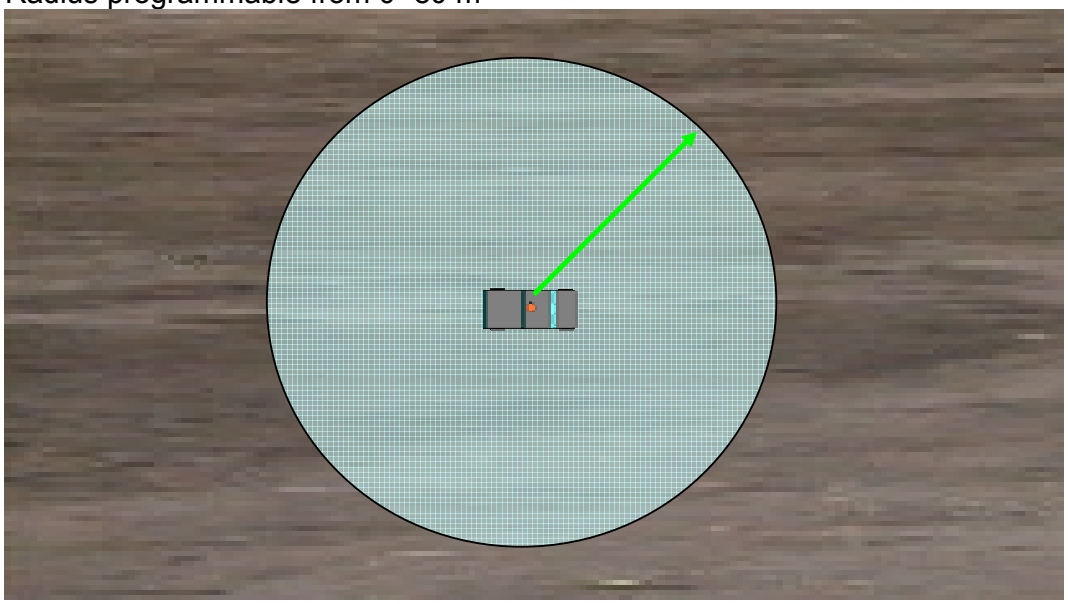


Figure 11: Light Vehicle Object Detection Zone

3.2.3 Stationary Object / Test Station Detection Zone

Single Programmable Detection Zone
Radius programmable from 0- 80 m

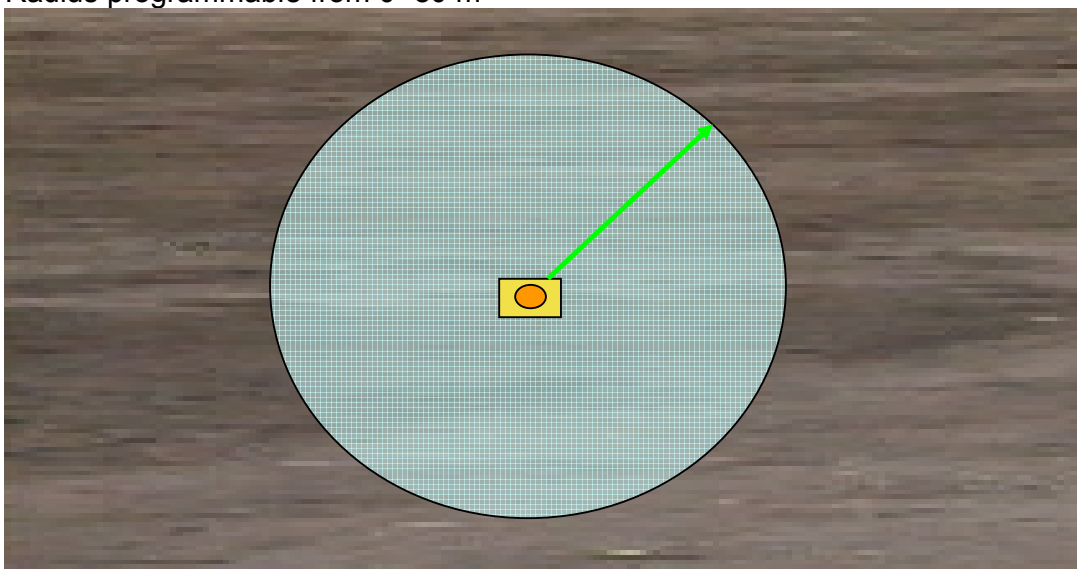


Figure 12 – Stationary Object / Test Station Detection Zone

4 TYPICAL COLLISION AVOIDANCE SCENARIOS

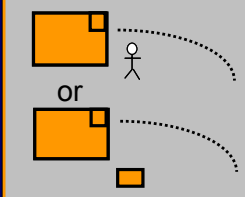
4.1 General

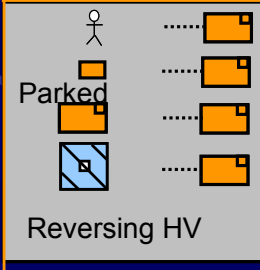
Typical collision avoidance scenarios for an open-cut mine site include operation between moving vehicles on haul roads, loading and dump sites, around high-wall and various bench levels and around other mine site obstacles such as buildings, plant and equipment etc.

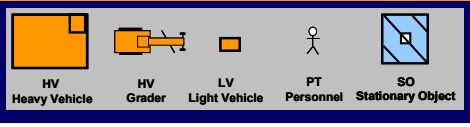
A typical CAS-CAM/RF® system would be configured for front and rear and optional left & right detection zones on all Heavy Vehicles, with fully programmable alarming for each object type (based on distance, detection location, direction of travel and speed), and a single detection zone on all Light Vehicles, Stationary Objects and Test Stations.

The system operation covers the following Heavy Vehicle – Light Vehicle and Heavy Vehicle – Heavy Vehicle interaction scenarios (ranked from highest to lowest risk):

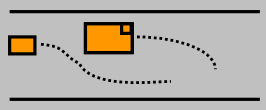
4.2 Collision Scenarios and Solutions

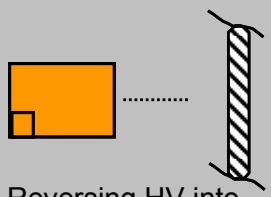
Scenario 1	AMT CAS Solutions	Comments
	HV driving forward receives audible & visual alarm when within 'AT-RISK' object programmed detection range. HV automatically switches to Front Camera for blind spot vision on both forward gear or when 'AT-RISK' objects are detected at the front. 'AT-RISK' objects also receive audible and visual alarms when the HV is in gear.	HV to 'AT-RISK' objects alarming is two-way. Different HV alarm ranges for different 'AT-RISK' object types (e.g. HV, LV, SO, TS). HV RF units located on front / rear / right & left sides for close range start-up object detection. Note: Personnel protection under development.

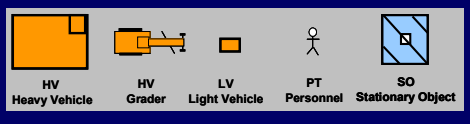
Scenario 2	AMT CAS Solutions	Comments
	Reversing HV receives audible & visual alarm when within 'AT-RISK' object programmed detection range. HV automatically switches to Rear Camera for blind spot vision on both reverse gear or when 'AT-RISK' objects are detected at the rear. 'AT-RISK' objects also receive audible and visual alarms (no audible alarm on parked HV).	HV to 'AT-RISK' objects alarming is two-way. Different HV alarm ranges for different 'AT-RISK' object types (e.g. HV, LV, SO, TS). Note: Personnel protection under development.



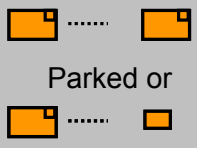
CAS Scenario Solutions 2007

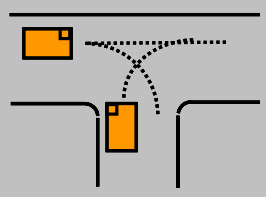
Scenario 3	AMT CAS Solutions	Comments
 LV Overtaking HV	Procedure for LV to call HV on radio for permission to overtake. HV receives LV Identification Code on Display Unit for positive confirmation before granting approval for LV to overtake.	Provides Positive Identification (ID) for radio confirmation.

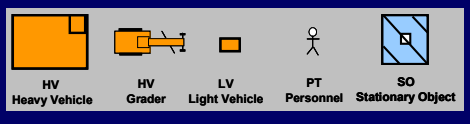
Scenario 4	AMT CAS Solutions	Comments
 Reversing HV into dump	Rear camera assists HV operator in: 1) reversing square to berm, 2) avoid sharp rocks that could result in tyre damage, 3) verification of tray empty before driving forward.	



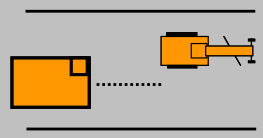
CAS Scenario Solutions 2007

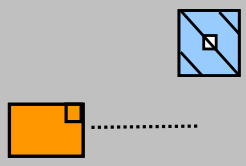
Scenario 5	AMT CAS Solutions	Comments
 Parked or Approaching parked vehicle	Approaching HV receives audible & visual alarm when within programmed range of another HV rear or approaching a LV when in gear. LV only alarms when HV is in gear and within programmed range. No alarming on parked HV.	HV to HV alarming is two-way. Different HV alarm ranges possible for different object types (e.g. HV, LV, SO, TS) and HV location (front/rear/sides).

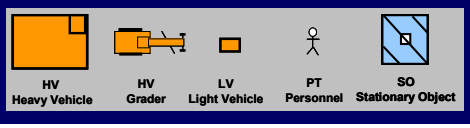
Scenario 6	AMT CAS Solutions	Comments
 Intersection	HV on straight haul road approaching road junction would trigger Haul Road Crossing Warning lights at 200-300m distance prior to road intersection. No HV - HV front audible alarms enabled. Assume stop sign is in place at entry to 'T' junction.	HV to HV alarming is two-way. Different HV alarm ranges possible for different object types (e.g. HV, LV, SO, TS) and HV location (front/rear/sides).



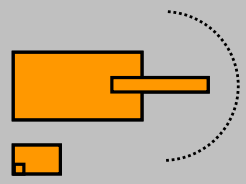
CAS Scenario Solutions 2007

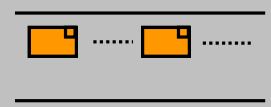
Scenario 7	AMT CAS Solutions	Comments
 HV approaching roadwork	Approaching HV receives audible & visual alarm when within programmed range of Grader in gear. Grader would receive audible and visual alarm when approaching HV in gear is detected within the programmed detection range. Grader automatically switches to Rear Camera for blind spot vision when 'AT-RISK' objects are detected within the programmed detection range.	HV to HV alarming is two-way. Different HV alarm ranges possible for different object types (e.g. HV, LV, SO, TS) and HV location (front/rear/sides).

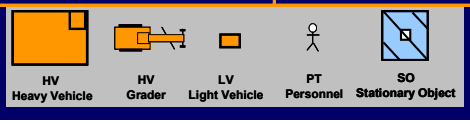
Scenario 8	AMT CAS Solutions	Comments
 HV Approaching / passing structure	Approaching HV receives audible & visual alarm when within programmed range of a RF tagged Stationary Object (SO). SO can provide visual alarm when HV is in gear and within programmed range. No alarming on parked HV.	HV to SO alarming is two-way. Different HV alarm ranges possible for different object types (e.g. HV, LV, SO, TS) and HV location (front/rear/sides).



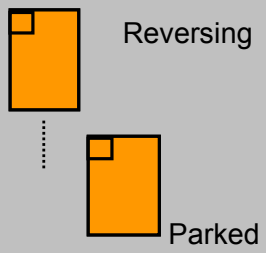
CAS Scenario Solutions 2007

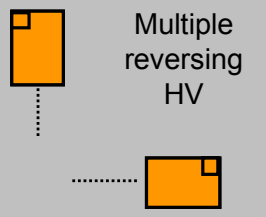
Scenario 9	AMT CAS Solutions	Comments
 Shovel rotating / swinging	HV blind side camera used to assist operator in aligning with Shovel bucket. Shovel blind spot cameras fitted with automatic switching on swing direction.	Side RF units can be fitted to Shovel for alarming HV when within swing radius of Shovel Housing. HV's normally programmed to receive audible alarms from Shovel typically include Clean-up Dozer and Cable Handling Vehicle as Rear Dump Trucks may receive a high level of nuisance alarms when reversing to Shovel at different approach angles.

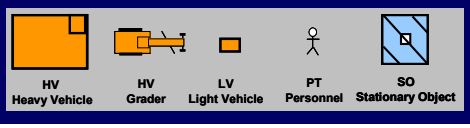
Scenario 10	AMT CAS Solutions	Comments
 Following Same lanes	HV getting too close to HV in front would receive an audible & visual alarm based on distance. Different Alarms can be programmed based on speed & distance to cover both the 'Queuing' and 'Haul Road At Speed' scenarios.	HV to HV alarming is two-way. Different HV alarm ranges possible for different object types (e.g. HV, LV, SO, TS) and HV location (front/rear/sides).



CAS Scenario Solutions 2007

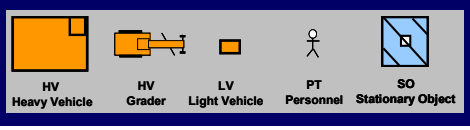
Scenario 11	AMT CAS Solutions	Comments
	Reversing HV receives audible & visual alarm when within programmed detection range of another HV. HV automatically switches to Rear Camera for blind spot vision on both reverse gear or when 'AT-RISK' objects are detected at the rear. No alarming on parked HV.	HV to HV alarming is two-way. Different HV alarm ranges possible for different object types (e.g. HV, LV, SO, TS) and HV location (front/rear/sides).

Scenario 12	AMT CAS Solutions	Comments
	Reversing HV's receive audible & visual alarm when within programmed detection range of another reversing or stationary HV. HV's automatically switch to Rear Camera for blind spot vision on both reverse gear or when 'AT-RISK' objects are detected at the rear.	HV to HV alarming is two-way. Different HV alarm ranges possible for different object types (e.g. HV, LV, SO, TS) and HV location (front/rear/sides).



CAS Scenario Solutions 2007

CAS settings shown are AMT suggested settings only. All settings are fully programmable and final settings are best decided upon completion of site Risk Assessment.



CAS Scenario Solutions 2007

4.3 Additional Benefits from Camera Only installations (CAS-CAM®)

Heavy Vehicle Reversing Operations – side view cameras provide a wider field of view than existing side view mirrors, offering greatly improved visibility and awareness of surroundings. Rear View camera eliminates known rear blind spots that have directly attributed to fatalities in the surface mining industry.

Heavy Vehicle Forward Operations – front view camera eliminates known front blind spots (typically out to 5-10m on larger rear dump trucks) that have directly attributed to fatalities in the surface mining industry.

Dozer reversing operations – operator experiences neck & back strain due to repetitive turning / twisting during reversing operations. Can be alleviated using rear view camera system.

Load Placement - Rear Dump Truck leading tyre breaks through berm during reversing operations for load dumping, placing vehicle at risk of flipping over edge when bed is raised during dumping. Can be prevented using wide angle rear camera showing the location of the rear tyres in relation to the berm in order to square the truck. The rear & blind-side cameras are also helpful in lining up the truck with a Shovel during loading operations.

Backing to Berms - Rear Dump Truck reverses over rock causing tyre and / or vehicle damage. This can be prevented by using rear and blind side-view cameras to detect the presence of rocks before reversing.

Confirming Load Completion – rear camera can be used to determine when the bed is empty during dumping as the driver can see when the material stops falling from the bed so they can determine when they can start off again. Without a rear view camera, drivers would allow the bed to stay raised longer because they could not tell if the bed was completely empty. Confirming Load Completion reduces turn-around time and increases productivity as well as reducing the time the truck is backed up.

Keeping the Berm Intact – using the rear camera, the truck driver can partially raise the bed of the truck during dumping so the bed doesn't damage the berm.

Automatic Switching of Cameras on gearing – system automatically switches to front or rear camera on gearing assisting the operator in assessing objects 'AT-RISK' before vehicle motion. The system can also automatically switch to front, rear or side cameras on RF tagged object detections at either the front, rear or sides of the vehicle. Where objects are detected by multiple RF units, the camera switches to the direction of vehicle travel.

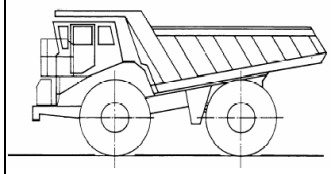
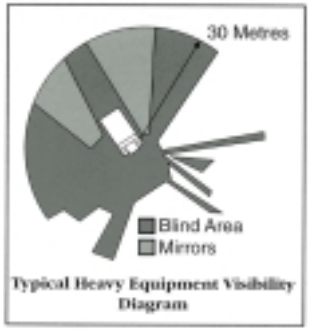
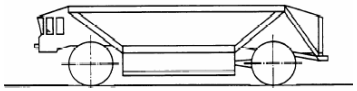
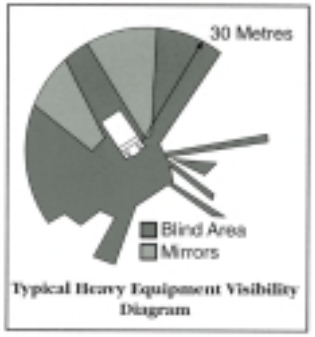
Note:

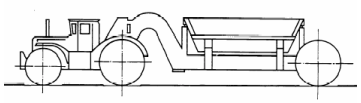
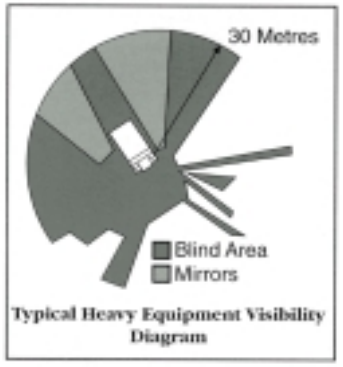
- Elimination of Heavy Vehicle blind spots using camera systems (CAS-CAM®) significantly reduces the risk of collision with other vehicles, mobile and fixed plant & equipment and objects. However, the Heavy Vehicle operator cannot always be watching the camera Display Unit whilst focusing on the task of machine operation. Hence, the risk of collision is further reduced using the Automatic Object Detection

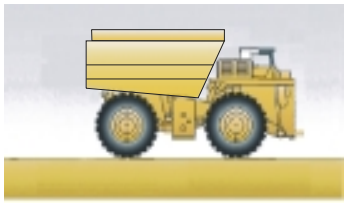
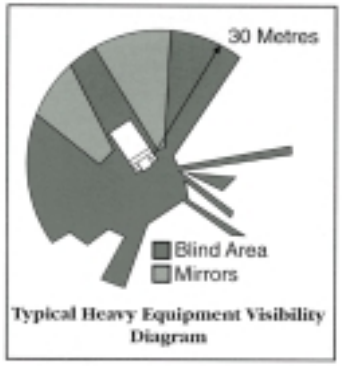
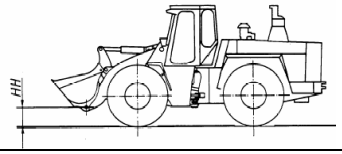
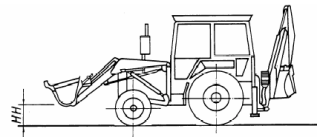
capability of the RF tagging (CAS-RF®), thereby offering a high level of protection and redundancy in a complete standalone package.

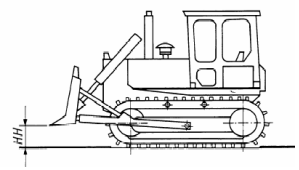
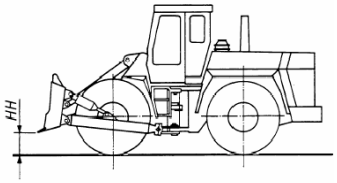
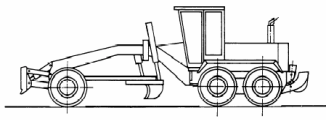
- The CAS-CAM/RF® System is a safety aid in providing the drivers of Heavy Vehicles and Light Vehicles with additional information to make informed decisions in order to reduce the incidence of collisions. The system is not designed to be a stand-alone safety interlocking system that can give a false sense of protection and security, but still requires that all vehicle drivers still take every manual precaution to avoid the incidence of collisions and to comply with existing work place procedures. The system is designed as an aid to supplement and enhance existing safe work practices and procedures.

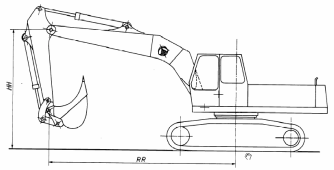
5 MINE EQUIPMENT TYPICAL CAS-CAM/RF® HARDWARE CONFIGURATIONS

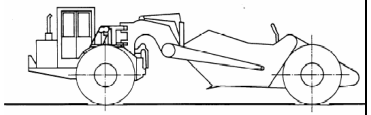
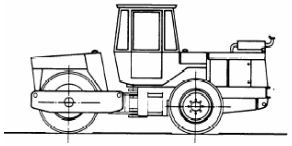
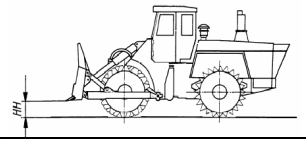
Equipment (to be fitted with CAS)	High Risk Blind Spots	Camera Locations	RF Locations
REAR DUMP TRUCK 	Rear Front Off-Side Driver Side 	• Rear • Front • Off-Side • Driver Side	• Rear • Front • Off-Side • Driver Side
BOTTOM DUMP TRUCK (HAULER) 	Rear Front Off-Side Driver Side 	• Rear • Front • Off-Side • Driver Side	• Rear • Front • Off-Side • Driver Side

Equipment (to be fitted with CAS)	High Risk Blind Spots	Camera Locations	RF Locations
SIDE DUMP TRUCK (Includes Articulated Bottom Dump Truck) 	Rear Front Off-Side Driver Side  Typical Heavy Equipment Visibility Diagram	• Rear • Front • Off-Side (located at rear pointing forward) • Driver Side (located at rear pointing forward)	• Rear • Front • Off-Side • Driver Side

Equipment (to be fitted with CAS)	High Risk Blind Spots	Camera Locations	RF Locations
WATER TRUCK 	Rear Front Off-Side Driver Side  Typical Heavy Equipment Visibility Diagram	• Rear • Front • Off-Side • Driver Side	• Rear • Front • Off-Side • Driver Side
LOADER – WHEELED 	Rear	• Rear	• Central RF (roof)
LOADER – BACKHOE / EXCAVATOR 	Rear	• Rear	• Central RF (roof)

Equipment (to be fitted with CAS)	High Risk Blind Spots	Camera Locations	RF Locations
DOZER – TRACKED 	Rear	• Rear	• Central RF (roof)
DOZER – WHEELED 	Rear	• Rear	• Central RF (roof)
GRADER 	Rear	• Rear Note: additional cameras can be added for operational purposes, up to 6 cameras maximum (e.g. Front camera on CAT 24H grader).	• Central RF (roof)

Equipment (to be fitted with CAS)	High Risk Blind Spots	Camera Locations	RF Locations
SHOVEL / Excavator 	Rear (counterweight) Off-Side Driver Side (4 cameras on electric shovels (rear (Qty 2: left and right), off-side, driver side), 3 cameras on large hydraulic excavator (200T+) (rear, off-side, driver side), 2 cameras on other excavators (rear and off side))	• Rear • Off-Side • Driver Side Note: additional cameras can be added for operational purposes, up to 6 cameras maximum (e.g. Hoist Winch & Cable Reeler cameras on Electric Shovel).	• Driver Side Rear • Off-Side Rear Challenge to manage frequency of alarms when swinging and loading Trucks, in particular, during tandem loading.
DRAGLINE 	Rear (counterweight) Off-Side Driver Side	• Rear (Qty 2: left and right) • Off-Side • Driver Side Note: additional cameras can be added for operational purposes, up to 6 cameras maximum (e.g. Hoist Winch & Cable Reeler cameras).	• Driver Side Rear • Off-Side Rear RF alarm range set at swing radius + safety margin. Alarming beneficial to clean-up Dozer and Trailing Cable Vehicle. No audible alarming recommended on Dragline.

Equipment (to be fitted with CAS)	High Risk Blind Spots	Camera Locations	RF Locations
SERVICE TRUCK (Maintenance)	Rear Off-Side (for CAT 777 size and above)	• Rear • Off-Side (for CAT 777+)	• Rear • Off-Side (for CAT 777+)
SCRAPER 	Rear	• Rear	• Central RF (roof)
ROLLER / COMPACTOR  	Rear	• Rear	• Central RF (roof)

Equipment (to be fitted with CAS)	High Risk Blind Spots	Camera Locations	RF Locations
DRILL RIGS (Blast Hole)	Rear Off-side Front Driver Side	• Rear • Off-side • Front • Driver Side Note: additional cameras can be added for operational purposes, up to 6 cameras maximum (e.g. Rod in hole & mast drive head cameras).	• Rear • Off-side • Front • Driver Side
OTHER:			
Float	Rear Front Off-Side	• Rear • Front • Off-Side	• Rear • Front • Off-Side
Cable Truck + Cable Reeler	Rear	• Rear	• Central RF (roof)
Explosive Truck	Rear	• Rear	• Central RF (roof)
Cranes	Rear	• Rear	• Central RF (roof)
Tyre Handlers	Rear	• Rear	• Central RF (roof)

Equipment (to be fitted with CAS)	High Risk Blind Spots	Camera Locations	RF Locations
Light Vehicles	• N/A	• N/A	• Central RF (roof) – fixed or Portable RF Unit (refer below)
Medium Vehicles	• N/A	• N/A	• Central RF (roof) – fixed or Portable RF Unit
Stationary Objects Options for protecting: • Portable lighting Towers • Other fixed plant & equipment (e.g. pumps, stockpile pillars)	• N/A	• N/A	• Central RF (fixed or Portable RF Unit)
Test Station (provides full system functional test of RF tagged objects during drive-by)	• N/A	• N/A	• Central RF (permanent or solar trailer installations)
Portable RF Unit	• N/A	• N/A	• Central RF (magnetic base with internal battery and cigarette lighter / external power)
Security Gate RF Interface	• N/A	• N/A	• Manned or unmanned versions

6 APPLICATIONS

The superior quality video imaging, RF tagging capability and rugged construction make the CAS-CAM/RF® system an ideal package in assisting the prevention of collisions with plant and mobile equipment for a variety of Heavy Vehicles.

Typical application areas include:

- Quarry, Mining and Construction Industry
- Refuse Industry
- Transport Industry (Road Haulage and Buses)
- Forklift / Handling / Storage
- Fire Fighting / Emergency Services Industry
- Agricultural Industry
- Recreational Vehicles
- Any other poor visibility application in hostile environments

For Information or Technical Support on AMT's Collision Avoidance System (CAS-CAM/RF®), contact: support@advminingtech.com.au

For Sales inquiries, contact: sales@advminingtech.com.au

Or visit our web site at: www.advminingtech.com.au

Advanced Mining Technologies Pty Ltd
A.B.N. 76 060 418 859

Head Office
3 Co-Wyn Close Fountaindale NSW 2258 Australia
PO Box 5107 Chittaway Bay NSW 2261 Australia
Phone: (+61) 2 4389 2344 Fax: (+61) 2 4389 2355

industrea Part of the Industrea Group **www.industrea.com.au**