COLLISION PREVENTION SYSTEMS REPORT ON LEGACY EQUIPMENT

INDUSTRY ALIGNMENT ON TMM REGULATIONS; SPECIAL PROJECT OF THE MINERALS COUNCIL SOUTH AFRICA

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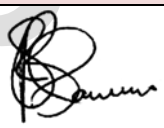
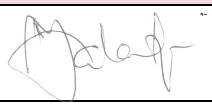
COMPILED BY:

Name	Organisation	Signature	Date
Kobus Blomerus	**SECDI**		**11 October 2025**

APPROVED BY:

Name	Organisation	Signature	Date
Stanford Malatji	**Minerals Council**		20/10/2025

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Definitions and abbreviations

The following definitions and abbreviations will be used to create a common approach for all deliverables.

Table 1: Abbreviations and their definitions appearing in this document

Abbreviation	Definition
Accelerated Development	Developing of CPS products in a coordinated integrated way that will require less time (for the entire SAMI need) than the previous supplier driven CPS product development approach.
Blueprint	Any detailed plan or guide for creating something
CMS	Collision Management System – The overall combination of preventative controls, mitigation, recovery and supporting controls implemented by a mine site to prevent TMM collisions
CPS	Collision Prevention System: A Product System that comprises the functionality and characteristics that comply with the RSA TMM collision prevention regulations. (TMM Regulations 8.10.1 and 8.10.2 and user requirements)
CWAS/(CxD)	Collision Warning and Avoidance System device (CxD) - Device with sensors providing collision warning and avoidance functions to detect objects in the vicinity of the machine, assess the collision risk level, effectively warn the operator of the presence of object(s), and/or provide signals to the machine control system to initiate the appropriate interventional collision avoidance action on the machine to prevent the collision. Note to entry: Proximity Detection System (PDS) is a colloquial industry term for a physical device providing effective warning or collision avoidance functionality.
CxDI	CxD Interface
CxDMI	CxD Machine Interface
Driver or operator reaction time (also known as perception response time)	The time that elapses from the instant that the driver recognises the existence of a hazard in the road, to the instant that the driver takes appropriate action, for instance, applying the brakes. The response time can be broken down into four separate components: detection, identification, decision and response. When a person responds to something s/he hears, sees, or feels, the total reaction time can be decomposed into a sequence of components namely: • Mental processing time (sensation, perception / recognition, situational awareness, response selection and programming) • Movement time, and • Driver response time. Driver reaction time is also affected by several issues such as visibility, operator state of mind (fatigue), direction or position of perceived danger.
DMPR	Department of Minerals and Petroleum Resources.
EW	Effective Warning
Effective Warning (Surface)	The expected outcome of the operator action is that the potential collision is prevented, therefore an effective warning must inform the operators of both TMMs what the appropriate action(s) are to prevent the potential collision.
Effective Warning (Underground)	The expected outcome of the operator and pedestrian action is that the potential collision is prevented, therefore an effective warning must inform the operators of TMMs what the appropriate action(s) are to prevent the potential collision and must alert the pedestrian to potential collisions or interactions with TMMs in the vicinity.
EMC	Electromagnetic Compatibility

EMI	Electromagnetic Interference
EMESRT	Earth Moving Equipment Safety Round Table
Employee	"EMPLOYEE" means any person who is employed or working at a mine.
Functional Specification	Specifications that define the function, duty, or role of the product/system. Functional specifications define the task or desired result by focusing on what is to be achieved rather than how it is to be done.
Homologation	Homologation means to sanction or "allow." Homologation refers to the process taken to certify that a TMM fitted with a CPS is manufactured, certified and tested to meet the standards specified for critical safety related devices fitted to TMMs.
ICASA	*Independent Communications Authority of South Africa*
ICMM	International Council on Mining and Metals.
Independent	Separate from the CPS product developer. Note: Independent does not imply accredited 3rd party, although where required by local or international standards it includes accredited 3rd parties.
Interface	A boundary across which two independent systems meet and act on or communicate with each other. Four highly relevant examples: 1. CxD-machine interface – the interface between a Collision Warning and Avoidance System Device (CxD) and the machine. This interface is described in ISO/DTS21815-2:2021 2. The user interface – Also sometimes referred to as the Graphic User Interface (GUI) if an information display is used. This is the interface between the user (TMM operator or pedestrian) and the CxD or pedestrian warning system, 3. V2X interface – the interface between different CxD devices. V2X is a catch-all term for vehicle-to-everything. It may refer to vehicle-to-vehicle (V-V), vehicle-to-pedestrian (V-P) or vehicle-to-infrastructure (V-E), 4. CxD-peripheral interface – This is an interface between the CxD and other peripheral systems that may be present on the TMM. Examples include a fleet management system, machine condition monitoring system, fatigue management system. Note: An interface implies that two separate parties (independent systems) are interacting with each other, which may present interoperability and/or EMI and EMC challenges.
Legacy Equipment	Equipment (TMMs) that does not have controllers that make it possible to electronically control the equipment. Equipment without CAN BUS control technology.
Loss of control	The uncontrolled movement of a TMM due to operator, machine or environmental reasons. Note: Section 8.10.3 of MHS Act. Loss of control may result in several scenarios: • Machine failure – park brake or service brake, tyre blowout, • Operator disabled – fatigue, medical condition, inattention, distraction, non-compliance with TMP rules (e.g., over speeding on decline, overloading)
MBS	Machine Braking System: The CPS module providing CPS braking functionality.
MC	Machine Controller: The TMM CPS module that provides the control functions to a non-intelligent TMM.
MCxDI	Machine Controller CxD Interface: The TMM CPS Product Module providing integration between the TMM CPS Product and the CxD.
MHS Act	Mine Health and Safety Act No. 29 of 1996 and Regulations. [1]
MHSC	Mine Health and Safety Council.

Minerals Council	Minerals Council South Africa.
MOSH	Mining Industry Occupational Safety and Health.
MRAC	Mining Regulations Advisory Committee.
PDS	Proximity Detection System – see CxD
Pedestrian	A person lying, sitting, or walking rather than travelling in a vehicle.
Project	Industry Alignment on TMM Collision Management Systems Project: CAS READINESS PHASE.
Quality Assurance	Verifying a process, product, or service; usually conducted by a person experienced in the specific field.
Reasonably practicable measure	Reasonably practicable means practicable having regard to:(a) the severity and scope of the hazard or risk concerned, (b) the state of knowledge reasonably available concerning that hazard or risk and of any means of removing or mitigating that hazard or risk, c) the availability and suitability of means to remove or mitigate that hazard or risk, and (d) the costs and the benefits of removing or mitigating that hazard or risk.
Safe speed	The speed that will ensure the controlled stopping of a TMM without any immediate negative impact on the operator or machine. Note: This is a conditional variable value, depending on multiple input variables.
SAMI	South African Mining Industry.
SE	Systems Engineering: Systems engineering is an interdisciplinary field of engineering and engineering management that focuses on how to design, integrate, and manage complex systems over their life cycles.
Significant risk (of collision)	The reasonable possibility of a TMM collision given all the controls that a mine has put in place to prevent a TMM collision.
Slow down	ISO/TS 21815-2:2021[2] defines slow down as: The SLOW_DOWN action is sent by the CxD to reduce the speed of the machine in a controlled / conventional manner as defined by the machine control system. The intent of this command is to slow down the machine when the CxD logic determines that a collision / interaction can be avoided by reducing speed.
Stop	ISO/TS 21815-2:2021 provides for two definitions, an emergency stop, and a controlled stop, both of which are a 'Stop'. The definitions are: 1. The EMERGENCY_STOP action is sent by CxD to instruct the machine to implement the emergency stop sequence defined by the machine control system. The intent of this command is to stop the machine motion as rapidly as possible to reduce the consequence level, if the CxD logic determines that a collision is imminent. The equivalent of an emergency stop is the operator slamming on the brakes in an emergency. 2. The CONTROLLED_STOP action is sent by CxD to instruct the machine to implement the controlled stop sequence defined by the machine control system. The intent of this command is to stop the machine motion in a controlled / conventional manner when the CxD logic determines that a collision / interaction can be avoided by slowing down and stopping. The equivalent of a controlled stop is slowing down and stopping when approaching a red traffic light.
System	A combination of interacting elements organized to achieve one or more stated purposes (ISO/IEC/IEEE 15288:2015).[3])

Technical specification	Specifications that define the technical and physical characteristics and/or measurements of a product, such as physical aspects (e.g., dimensions, colour, and surface finish), design details, material properties, energy requirements, processes, maintenance requirements and operational requirements.
This document	Report on CPS Legacy Equipment.
TMM	Trackless Mobile Machine. (Machine, vehicle, etc.)
TMLP	Traffic Management Leading Practice. The MOSH Traffic Management Leading Practice for Open Cast/Cut mines in South Africa.
TMMP	TMM CPS Product: The product that will make a non-intelligent TMM intelligent and CxD ready.
TMM OEM	Original Equipment Manufacturer of TMMs. Original Equipment Manufacturer of a TMM may be the organisation which originally supplied, or last rebuilt or modified the TMM or the supplier per section 21 of the Mine Health and Safety Act, 1996 (Act No. 29 of 1996). [1])
TMP	Traffic Management Plan. A document that defines the traffic management system that a mine employs to ensure the safe movement of TMMs and pedestrians on the mine.
TMLP	Traffic Management Leading Practice. The MOSH Traffic Management Leading Practice for Open Cast/Cut mines in South Africa.
TRL	Technology Readiness Level. A technology maturity framework for measuring and monitoring technology maturity in 9 increasing levels from TRL 1 to TRL 9.
V2X	Vehicle to Anything.
V2XI	Vehicle to Anything Interface.
VD	Vicinity Detection: The element responsible for detecting TMMs and Pedestrians to prevent TMM collisions as per TMM regulations.
Vicinity (Surface TMMs)	The distance/time of two TMMs from the point of a potential collision, such that if the operators of both machines are instructed to take action to prevent a potential collision, and one or both does not act then the CPS will be able to prevent the potential collision. Note: Vicinity is a conditional, variable value, depending on multiple input variables. It is smaller than any value that is within the range of normal operation
Vicinity (Underground TMM and pedestrians)	The distance/time of a TMM from a pedestrian, such that if the operator of the TMM and the pedestrian do not take action to prevent a potential collision, an emergency slow down and stopping of the TMM can be successfully executed to prevent a potential collision between the TMM and the pedestrian. Note: Vicinity is a conditional, variable value, depending on multiple input variables. It is smaller than any value that is within the range of normal operation.
Walking speed	In the absence of significant external factors, the average human's walking speed is 1.4 meters per second. This is included to help define the crawl speed of vehicles.
V2X	Vehicle to Anything
V-V	Vehicle to Vehicle
V-E	Vehicle to Infrastructure
V-P	Vehicle to Pedestrian
3rd Party	An entity appointed to execute work (testing, witnessing of testing and verifying portfolios of evidence) on behalf of SAMI. Note: The purpose of 3rd party execution is to establish independence and to eliminate duplication

1. Purpose of this document

This document reports on the CPS challenges facing mines using “legacy” TMMs.

2. Background

With the objective of preventing Trackless Mobile Machinery (TMM) collisions, (with each other and with pedestrians), on South African mines, TMM regulations 8.10.1, 8.10.2 and their sub clauses were promulgated in **2015**. Sub clauses 8.10 .1.2 (b) and 8.10.2.1 (b) were suspended due to non-availability of technology to provide the functionality that is required to automatically slow down and stop the TMMs.

The expectation was that CPS product suppliers and in particular TMM OEMs would initiate **fast tracked** product developments that will enable mines to comply with the regulations.

In **2019** the Mining Regulations Advisory Committee (MRAC) of the Mine Health and Safety Council (MHSC) (the committee responsible for facilitation of regulations) assembled a team of experts to advise it on the maturity and readiness of CPS products with a view to uplift the suspended clauses of the TMM regulations at a future date.

The task team determined that the CPS products available at that time were **not** sufficiently developed to support the upliftment of the regulations. The team further identified several **significant** challenges related to the products and the need for further verification. Interoperability and testing were particularly emphasized as key areas of concern. In response to the report from the task team, the Minerals Council South Africa initiated a project to assist its members (mines) by facilitating the development of a CPS blueprint for requirements and technology development of the CPS products and the associated ecosystem (Life Cycle System).

The below extract from the CPS F&TPR specification will be used to explain the challenges

The non-homogenous population of TMMs used in the SAMI necessitates a single set of CPS functions. For a fully functional CPS, all the performance requirements must be met.

The extent to which a specific CPS product needs to be developed are determined by the extent to which a specific TMM (Type, brand and model) is already “intelligent”.

The CPS Functional Breakdown is shown in Figure 1.

The CPS comprises two functional elements(products) namely:

1. TMM CPS Functions (TMMCPS).
2. CxD Functions (CxD).

Each of the functional elements have a number of subgroups of functions. These groups are logically structured and do not imply that a CPS element must have a similar product breakdown structure. Naturally the two elements are products.

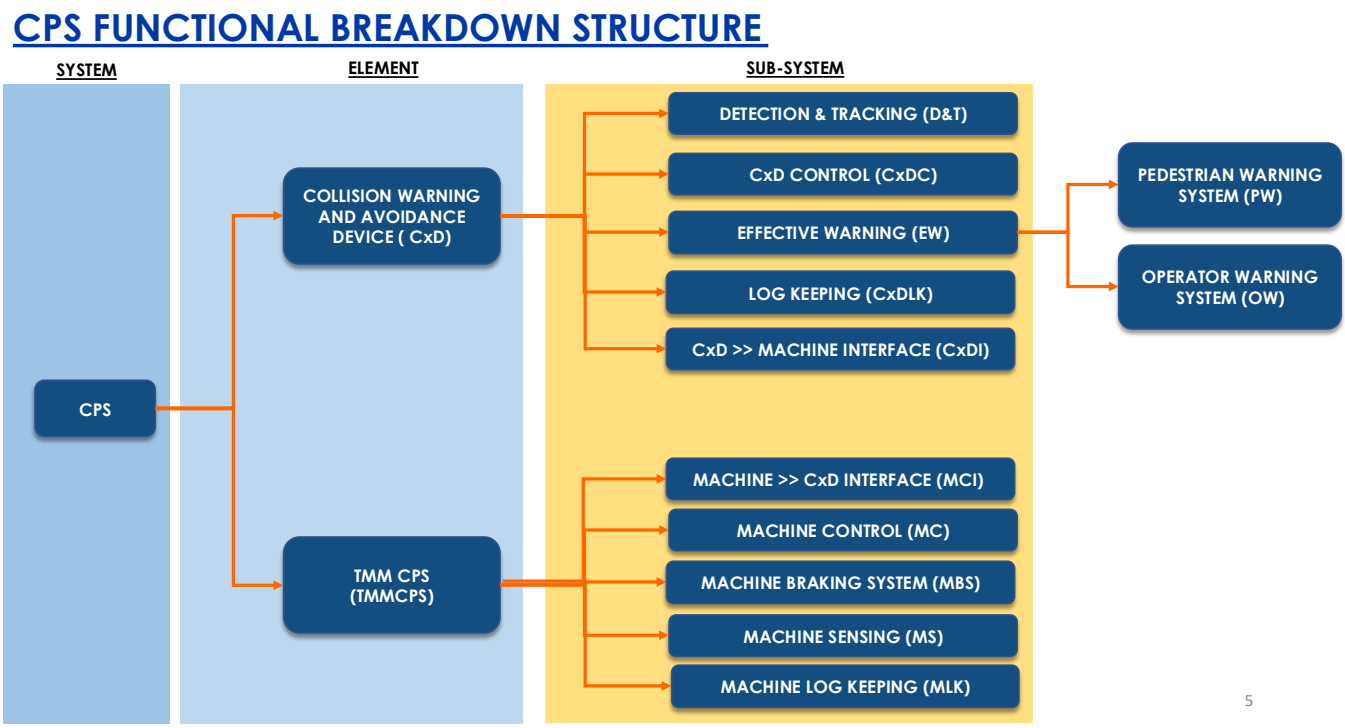

Figure 1: CPS functional breakdown structure.

The CxD Functions are broken down into 5 sub-groups namely:

- Detection and Tracking functions (D&T).
- CxD Controller functions (CxDC).
- Effective Warning functions (EW).
- CxD Log Keeping functions (CxDLK).
- CxD Machine Interface (CxDMI).

NOTE: For underground TMMs the cap-lamp is considered part of the CxD

The TMM CPS Functions are structured in 5 sub-groups namely:

- Machine CxD Interface functions (MCxDI).
- Machine Controller functions (MC).
- Machine Braking System functions (MBS).
- Machine Sensing functions (MS).
- Machine Log Keeping functions (MLK).

3. The challenge that was identified

The depiction in figure 1 and the functions off the TMM CPS listed above, apply equally to “intelligent” (TMMs with CAN BUS) control technology and Legacy TMMs. In order to conform to the CPS requirements TMM information must be sent to the CxD on a continuous basis and TMM functions must be digitally controllable.

With very large numbers of “legacy” equipment in the SAMI, this was considered a significant challenge, especially for members of Aggregate and Sand Producers Association of Southern Africa

(ASPASA), the Clay Brick Association of South Africa, the South African Diamonds Producers Organisation (SADPO) and small mines. Member mines were concerned that the cost of complying to Reg 8.10.2 would force many of them out of business and thus in the process of saving lives the livelihoods of those mine's employees would be lost.

4. The emergence of 3rd Party TMM CPS Suppliers

At the time of the promulgation of the regulations in 2015 the underground Coal industry already had auto slow and stop technology introduced on its electric production equipment. A few local mining equipment parts and services suppliers saw a business opportunity in the Regulations and started to develop 3rd Party TMM CPS products. Since TMM CPS functionality requires physical installation and/or modification of TMM's braking and acceleration/deceleration systems there are warranty and liability issues with such modification. Although not all, but many of the legacy TMMs are long outside of their warranty periods, the liability issue remains. That issue though is beyond the scope of this report.

With most of the SAMI TMM suppliers being international OEMs there were little practical support from TMM OEMs with regards TMM CPS products. Some of them took note of the EMESRT CAS guidelines and entered into exclusive agreements with specific international CXD suppliers. This effectively would lock local CxD suppliers out of the market. By implication it meant that TMM OEMs could establish agreements with specific CxD suppliers of which there were initially only international ones. As reported by the MRAC TMM Regulatory Task Team in 2019 interoperability between CxD products from different suppliers did not exist (and still do not) due to the fact that no international communication standard exists for CxD-to-CxD communication. This was one of the major challenges that had to be overcame for successful introduction of CPS into the SAMI. The MOSH TMM Regulatory Readiness Special Project highlighted this in its first report and the SAMI concluded that the only practical solution is to use one CxD supplier for all TMMs on a mine.

This inevitable decision has a knock-on implication, namely that all TMM OEMs on a specific mine have d to be able to work with a mine's chosen CxD supplier. Practically this means that potentially every TMM OEM must have a solution for every CxD supplier in the SAMI. Since it will be practically impossible for CxD suppliers and TMM OEMs to have unique solutions for every TMM the SAMI had to facilitate interoperability between CxDs and TMM CPS's. The only way to do this was to require that CPS products conform to the ISO 21815-2-2021 communication standard.

The reluctance and inertia of TMM OEMs allowed 3rd Party CPS products to evolve faster than the other CPS products. The 3rd Party suppliers realised the benefit of a standardised interface and therefore were some of the early conformers. As of May 2025, there are seven 3rd Party suppliers that have passed the TRL4 ISO interface independent verification test, five that passed Log Keeping and Self Diagnostics and three that passed Effective Warning.

The 3rd Party products are designed modular, such that a supplier can sell any of the required functions to a mine, based on what is needed to make the TMM CxD ready. This includes physical modifications to braking systems and installation of sensors if needed. A specific CxD supplier are busy developing an integrated CxD and 3rd Party TMM CPS product. These developments have mitigated the risk associated with "legacy TMMs" from a technology aspect. Mines have a variety of 3rd Party TMM CPS products to choose from. The only aspect that a mine must consider is a commercial on. The cost of the 3rd Party products may not be warranted given the remaining life of the TMM.

5. Conclusion

CPS product availability is no longer a challenge for mines with legacy TMMs. The emergence of 3rd Party products did not only address the legacy TMM challenges, but it also enables mines with intelligent TMMs to be made CxD ready i.e. have TMM CPS products installed if TMM OEM are unable to do so.

6. References

The following documents are referenced in this document:

[1] Mine Health and Safety Act No. 29 of 1996 and Regulations

[2] ISO/PRF TS 21815-2:2021 Earth-moving machinery — Collision warning and avoidance — Part 2: On-board J1939 communication interface

[3] ISO/IEC/IEEE 15288:2015, Systems and software engineering — System life cycle processes

[4] MIL-STD-490B:1992 Draft Military Standard Program-Unique Specifications.

[5] ISO/FDIS 16290:2013. Space systems — Definition of the Technology Readiness Levels (TRLs) and their criteria of assessment