USER REQUIREMENT SPECIFICATION FOR SURFACE MINE COLLISION PREVENTION SYSTEMS

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

REV 1

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Table of Contents

Definitions and Abbreviations

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

Table 1: Definitions and abbreviations

Term/Abbreviation	Definition
Accelerated Development	Development of CPS products in a coordinated and integrated way that will require less time (for the entire SAMI need), than the previous individual mine and supplier / OEM driven CPS product development approach.
CAS	Collision Avoidance System
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.)
CPS Start-up	The operator has completed the pre-inspection checks as per the mine's standard operating procedure and removed the chocks or stop blocks from under the TMM's wheels. The operator has entered the cab and is preparing to start operating. During this state, the CPS is undergoing its start-up procedure, e.g. performing system health checks. The CPS is not ready to start normal operation.
CPS Slow	The state when the CxD limits the TMMs speed. The CxD instructs the TMM to slow by sending SLOW_DOWN or APPLY_PROPULSION_SETPOINTS via the ISO/TS 21815-2:2021 CAN-bus interface.
CPS Stop	The state when the CxD intervenes with the intent of stopping or keeping the TMM stationary to avoid a collision or FTSWHI. The CPS has detected a potential collision with a another TMM and is intervening or has intervened to bring the TMM to a safe stop. Once the TMM has stopped, it remains stationary. This state is reached by the CxD instructing the TMM to stop via the ISO/TS 21815-2:2021 CAN-bus interface.
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: **Proximity Detection System (PDS)** is a colloquial industry term for a physical device, providing a warning or collision avoidance functionality.
CxDC	CxD Controller: A sub-system of the CxD, that is typically the computer that contains the decision-making logic.
CxDI	CxD interface: A integration function between the CxD and the Machine Controller.
CxDLK	CxD Log Keeping: The function that receives, and stores CxD data.
Detection	Detection is sensing that an object has entered the detection area.
DMPR	Department of Mineral and Petroleum Resources
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 broken down 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), and direction or position of perceived danger.
DTS	Detect and Track: A functional group of a CxD enabling detection and tracking of TMMs inside the detection area of a surface TMM and an underground TMM respectively.
EMC	Electromagnetic Compatibility

Term/Abbreviation	Definition
Emergency Override	The CPS has intervened and the TMM is in the CPS Stop state. However, there is imminent danger to either the TMM operator and/or nearby pedestrians. The TMM operator engages Emergency Override, as per the mine's standard operating procedure, to move the TMM to a safe place. During Emergency Override, the TMM speed is limited and the TMM is allowed to move for a limited period of time, as determined by the mine's risk assessment. Once this period expires, the TMM returns to the CPS Stop state.
EMESRT	Earth Moving Equipment Safety Round Table
EMI	Electromagnetic Interference
Employee	Employee means any person who is employed or working at a mine.
EW (Surface)	Effective Warning: For Surface TMMs: The expected outcome of the operator action(s) 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, or interactions with TMMs in the vicinity.
F&TPR	Functional and Technical Performance Requirements
FMECA	Failure Modes, Effects and Criticality Analysis
FTSWHI	Fail-to-safe without human intervention The CPS has detected a critical failure that compromises the CPS functionality. The CPS brings the TMM to a safe state within a reasonable time, as defined by the mine's specific risk assessment and standard operating procedure. The CPS can only exit this state if the failure is repaired/resolved, the operator activates Emergency Override, or an authorised technician engages Maintenance Override.
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.
ICMM	International Council on Mining and Metals.
Integrated Testing Regime	A holistic method of testing, optimising existing testing facilities that are currently available irrespective of who owns them. This method ensures specific CPS tests are only done once (CxD and TMM CPS Product combinations) and verification is done as early as possible in the development process.
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. 2. The user interface – Also sometimes referred to as the Graphic User Interface (GUI) when an information display is used. This is the interface between the user (TMM operator) and the CxD. 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, or vehicle-to-infrastructure. 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, or 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.
Maintenance Override	An authorised technician may enable the Maintenance Override state when recovering a TMM to effect CPS repairs. TMM speed is limited as per the mine's standard operating procedure until the Maintenance Override is cancelled by the authorised technician, or the TMM is safe parked. Upon deactivation of Maintenance Override, or start-up from Safe Park, the CPS shall fail-to-safe without human intervention if the critical failure(s) has not been resolved.
MBS	Machine Braking System: The physical components that makes an unintelligent TMM intelligent and enables the CPS auto slow-down and stop functionality.
MC	Machine Controller.
MCI	Machine Control Interface: The interface between the Machine Controller and the CXD interface.
MHSA	Mine Health and Safety Act No. 29 of 1996 and Regulations.
MHSC	Mine Health and Safety Council.
MLK	Machine Log Keeping: The function that receives, and stores TMM CPS data.
MOSH	Mining Industry Occupational Safety and Health Initiative.

Term/Abbreviation	Definition
MRAC	Mining Regulations Advisory Committee.
MS	Machine Sensing: Sensing functionality on a TMM that enable a fully functional CPS.
Normal Operation	The normal state of the TMM while it is operating and there is no significant risk of collision between TMMs. The CPS is functioning as intended and is monitoring for potential collisions.
Operator Stop	The operator has stopped the TMM and signalled their intent to stay stopped. This may happen during the course of the shift. The Operator Stop state is typically characterised by engagement of the Park Brake by the operator. The CPS is functioning normally, but the potential for collisions is limited due to the engagement of the Park Brake.
OWS	Operator Warning System: The system that provides the effective warning and other warnings to the operator of a TMM.
PDS	Proximity Detection System – see CxD.
Pedestrian	A person lying, sitting, or walking rather than travelling in a vehicle.
Phase 2	Phase 2 of the Industry Alignment on TMM Collision Management Systems Special Project of the Minerals Council South Africa.
Reasonably practicable measure	Reasonably practicable means practicable with regards to: (a) The severity and scope of the hazard, or risk concerned. (b) The state of knowledge reasonably available, concerning the hazard or risk, and of any means of removing or mitigating the 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 Park	The TMM is safely parked as per the mine's standard operating procedure, e.g. the operator has engaged the park brake, switched the engine off and exited the cab. The operator has placed chocks or stop blocks under the TMM's wheel(s). This state is typically encountered at the start/end of shifts when the operators are coming on or off duty. The TMM is not operational.
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.
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 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".
Speed Limit Mode	In certain areas, the CPS may enter a Speed Limit Mode. The aim of Speed Limit Mode is to limit the TMM speed to minimize the size of the vicinity. This mode may be utilized in congested areas such as workshops, refuelling bays, waiting areas, etc.
Stop Gap	The shortest distance between the TMMs that have been automatically slowed down and stopped.
System	A combination of interacting elements organized to achieve one or more stated purposes (ISO/IEC/IEEE 2015).
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.
Technician	Competent person with testing experience in the mining / vehicle environment, e.g. testing technician, TMM OEM technician, CxD technician, auto electrician, etc.
TMLP	Traffic Management Leading Practice: The MOSH Traffic Management Leading Practice for Open Cast/Cut mines in South Africa.
TMM	Trackless Mobile Machine as defined in MHSA. (Machine, vehicle, etc.)
TMM CPS	The functional group comprising all TMM CPS related functions.
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).

Term/Abbreviation	Definition
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.
Tracking	Tracking is the monitoring of the progress of the objects in the detection area over time.
UGHR	Underground Hard Rock
URS	User Requirement Specification
UTC	Coordinated Universal Time.
V2X	Vehicle to everything.
Vicinity (Surface TMM)	The distance or time to the point of a potential collision, such that, if the operator(s) receives an effective warning to prevent a potential collision, and one or both (or all) do not take action, the CPS will still be able to prevent the potential collision.
V-V	Vehicle to vehicle.
Walking speed	In the absence of significant external factors, the average human's walking speed is 1.4 m/s. This is included to help define the crawl speed of TMMs.
WP 9	Work Package 9: Testing protocols (including legacy equipment). One of the work packages of the Industry Alignment on TMM Collision Management Systems Project: CAS READINESS PHASE.

1 Context

This document is one of the documents in the Mining Industry Occupational Safety and Health Initiative (MOSH) Collision Prevention Systems (CPS) guideline. During phase 1 of the project a single User Requirements Specification (URS) was developed for Underground and Surface CPS. This document is developed as part of phase 2 of the project and is now a standalone document for surface mining operations, hence it being revision 1. Changes to it is described further on in the document.

Whilst it is developed as a stand-alone document, it is advisable to view it in the context of the other MOSH CPS guideline documents[1].

The South African Mining Industry (SAMI) is the only international region that, at the time of writing, has regulated the installation of TMM safety products that can automatically prevent collisions between Trackless Mobile Machinery (TMMs) in surface operations. This is promulgated in Regulations 8.10.2.1(a) and (b) in the Mine Health and Safety Act No. 29 of 1996 and Regulations (MHSA). Whilst the regulations make provision for managing collision risks with more effective controls that are higher on the hierarchy of risk controls, there is a need to ensure that CPS products are readily available if a mine cannot or does not want to introduce controls that are higher up in the hierarchy of controls to address the significant risk of collision between TMMs.

The availability of CPS products is an unprecedented challenge for the SAMI due to:

- Lack of maturity of the technology being used in collision warning and avoidance device (CxD) products.
- Complexity of CPS products.
- Interoperability challenges with CPS products.
- The number of operations being classified as mines in South Africa.
- Most TMMs being designed and manufactured outside of South Africa.
- The many types of TMMS, brands, models and configurations in the industry.
- The large number of older TMMs in use on mines in South Africa that do not have electronic gearboxes and CAN-bus networks (referred to as legacy TMMs).
- The diversity of TMM fleets on mines.
- All mines having to ensure that on a specific date TMMs (where there is a significant risk of collision between those TMMs and other TMMs on surface operations or between TMMs and pedestrians in underground operations) are fitted with such products.
- Limited engineering and development resources and capacity in South Africa.

Under the MHSA, a **mine** has the legal duty to comply with the law by introducing reasonably practicable measures to prevent persons from being injured while doing their work on the mine. One of the aspects that a mine must **ensure** is that equipment, structures and services procured for use on the mine complies with the general requirements of the MHSA, namely: it will not injure persons working on the mine when such equipment, structures or services are used as intended. Another aspect is that equipment, structures or services must comply with the specific requirements of the MHSA.

In the case of Reg 8.10.2.1(a) and (b) the mine must ensure that CPS products comply with the specifics of the relevant sub-clauses. The Section 2.13.1 legal appointee (in terms of the Regulations which remain in force and in effect in terms of Schedule 4 of the MHSA) on the mine has the responsibility and accountability to **ensure such**. Since the MHSA is not a detailed, prescriptive act that lists every

[1] Available at https://www.mosh.co.za/transport-and-machinery/documents

single requirement and design detail of each piece of equipment, structure or service, the accountability for establishing such supplementary information is that of the 2.13.1 legal appointee on a mine.

Although the TMM regulations have been promulgated in 2015, the two clauses requiring automatic slowdown and stopping of TMMs were suspended due to the unavailability of CPS products at the time.

Since 2015 the SAMI made concerted efforts to facilitate the development of CPS products that would comply with the TMM regulations. The significant challenges that had to be overcome only became apparent during the initial years of the effort. Some of the challenges include:

- The industry wide TMM population, its types, brands, models and configurations must be known to enable a risk-informed and logical development initiative.
- A representative definition of relevant mining processes that involve TMMs on the different types of mines.
- Full visibility of key TMM characteristics such as deceleration rates, stopping distances and the impact of sudden stopping on operators, such as whole-body vibration.
- A fully integrated development effort between all role-players to expedite the development, maturity and availability of CPS products, including:
    - Maximum collaboration between role players
    - A single set of requirements
    - A single accelerated development program
    - A single integrated test regime

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

The MRAC task team identified a number of challenges that still need to be addressed and resolved. The Minerals Council South Africa took heed of the report issued by the task team and initiated a multi-million-rand project namely: Industry Alignment on TMM Regulations: Special Project of The Minerals Council South Africa to facilitate the integrated development of, not only CPS products, but the required ecosystem that would enable the upliftment of the suspended clauses of the TMM regulations as soon as possible. The key pillars of the project were:

- Collaboration
- Centralised requirements definition
- Single integrated testing regime
- Defined development maturity criteria
- Shared verification and validation (testing)
- Ecosystem focus

The Minerals Council South Africa's investment to assist its members with regulatory readiness, demonstrates the SAMIs commitment to compliance. The MOSH CPS guideline established by the Minerals Council CPS project enables mines to comply with their duty to ensure compliance to Reg 8.10.2.1(a) and (b). This naturally only applies to those mines that adopted the MOSH CPS guideline as its requirements for CPS.

At a first glance, the most appropriate CPS product approach would be that a TMM OEM develops a CPS product for its own TMM range. This would ensure that the technical challenge for CPS products would be within the full control of TMM OEMs, and a single point of liability would exist. For that approach to work, an international standard for communication between CPS products (Collision Warning and Avoidance Devices, or CxDs, from different OEMs) is a prerequisite. Such an international standard did not exist then, and still does not exist in 2025. This reality induced significant complexity to the regulatory compliance challenge and drove the functional structure and requirements of the two CPS products, namely the CxD and the TMM CPS.

This document was initially developed as one part of Work Package 9 (WP 9) deliverable of the INDUSTRY ALIGNMENT ON TMM COLLISION MANAGEMENT SYSTEMS PROJECT: CAS READINESS PHASE[2]. The document has been revised and updated to reflect lessons learnt and experience gained since its original publication and extensive interaction with the key role players in the SAMI. Revision 1 (this revision) is a significant update that includes a restructuring of the User Requirements Specification (URS) into separate documents for Underground TMMs and Surface TMMs. The URS must be read in the context of:

- Data collected and collated by the Minerals Council South Africa and provided to the project (as referenced before).
- Learnings and experience gained from SAMI where PDS/Collision Management Systems (CMS) has been implemented.
- Accident and incident statistics in SAMI and other parts of the world, made available from the Minerals Council South Africa and Department of Mineral and Petroleum Resources (DMPR),
- Knowledge gained from experienced mining specialists about mining processes and the Vehicle to Vehicle (V-V) and Vehicle to Person (V-P) interactions that occur in those processes,
- Global CMS initiatives emanating from Earth Moving Equipment Safety Round Table (EMESRT[3]) and the International Council on Mining and Metals (ICMM).
- Extensive CMS and CPS testing conducted by the University of Pretoria.
- Engagements with the Northern Cape Mine Managers Association Engineering Work Stream and their interactions with CPS suppliers, TMM OEMs and the Northern Cape Mine Health and Safety Inspectorate.

2 Purpose of this document

The purpose of this document is to:

- Serve as a template for 2.13.1 legal appointees for adoption or adaption as evidence of the **reasonable steps** taken to ensure compliance with Regulation 8.10.2.1.
- Serve as a SAMI requirement guideline for surface CPS product suppliers.
- Assist the SAMI with accelerated development of surface CPS products by having a single requirement set for all surface CPS products.
- Save CPS suppliers time and money to develop conformant CPS products based on:
    - A common interpretation of the direct and indirect (implied) requirements of Reg 8.10.2 and in particular 8.10.2.1.
    - A common set of User Requirements, based on actual production processes to be executed in mines as a comprehensive basis that:

[2] Available from https://www.mosh.co.za/transport-and-machinery/documents
[3] Available from https://emesrt.org/wp-content/uploads/2019/09/EMESRT-PR-5A-Vehicle-Interactions_v2_20190902-1.pdf

        - Meets the MHSA TMM collision prevention regulatory requirements.
        - Meets the needs of the SAMI mine types and mine working environments,
        - Informs the CPS **functional specification,** thereby ensuring that any CPS developed according to the CPS functional specification and tested in accordance with the CPS test regime is suitable for use in the SAMI, and
        - Meets the purpose of CPS.
    - Common requirements for CPS development processes that informs the Functional Readiness Criteria and will ensure that the information contained in the technical file required by Section 21 of the MHSA is produced as a natural outcome of the development process.

It is <u>not</u> the purpose of this URS:

- To be the functional specification defining performance criteria (refer to CPS Functional Specification[4]).
- To be the functional readiness criteria for CPS products (refer to Functional Readiness Criteria for CPS[4]).
- To define the life cycle requirements of the CPS.
- To define any SAMI CPS needs other than the MHSA regulatory **direct and implied** CPS requirements.

The Minerals Council South Africa's approach to the regulatory challenge its members faced, was to focus on ensuring that CPS products that are offered to the SAMI conform to requirements that will allow mines to comply with the local TMM regulations. The approach is not to specify any specific technology and limit competition in the market. It does not limit any CPS product definition; it only defines the **minimum** requirements to ensure regulatory compliance. CPS product suppliers have full freedom to supply products with additional functionality and features to both the local and global markets in order to differentiate its product(s). It is acknowledged that CPS is not regulated in any other mining jurisdiction and therefore CPS product suppliers can supply any CAS product to those markets. Naturally where CPS requirements are more stringent and challenging than CAS products, CAS product suppliers may find it challenging to offer CPS products to such a small market.

Figure 1 depicts the relative position of SAMI CPS requirements within the local and global markets. Any CPS supplier that offers a CPS product that it claims to comply with the local TMM regulations will have to demonstrate that such CPS product has achieved the product requirements as set out in MOSH CPS requirements documents.

The role and impact of EMESRT and the ICMM is dealt with in detail in the CMS Specification Guideline Review Report Rev 7[5]. For the purposes of the CPS URS it is important to note that (see Figure 1 for a graphical representation):

- A Collision Avoidance System (CAS) is an international term defining automatic slowdown and stop functions for mine vehicles in **general** terms.
- CAS products do not necessarily comply with the MHSA and if it does, it is best described as a Collision Prevention System (CPS). CPS is thus a subset of CAS.

[4] Available from https://www.mosh.co.za/transport-and-machinery/documents
[5] Available from https://www.mosh.co.za/transport-and-machinery/documents

Figure 1: CPS requirements in relation to Supplier offerings

The CPS URS aligns with both EMESRT and ICMM Vehicle (TMM) interaction initiatives where possible and not in conflict with the requirements of the MHSA. EMESRT PR-5A Vehicle interaction systems dated August 2019, and the Vehicle Interaction improvement Guide dated October 2020 were used to support the development of this URS.

The URS also aligns with the input provided by previous guidelines most notably: "Collision Management Systems Technical Specification Guidelines for Underground Mining Operations (Rev A.6)"

The documents include a mixture of user, functional and technical specifications and where appropriate the user requirements of this document have been aligned with those in the abovementioned documents.

3 Background

The technology required to develop fit for purpose and regulatory compliant CPS products is complex. A key aspect of any systems engineering based system or product development process is the establishment and approval of the URS. As indicated in the CMS Technical Specification Guideline Review Report, a formal and approved set of CPS user requirements did not exist in 2020. The absence of an URS almost always leads to a lengthy product development cycle, uncovering user requirements as the product is starting to be used. Such an approach for a safety system in a regulated environment is highly undesirable, as it may expose legally responsible persons. This document defines the Surface TMM CPS URS after extensive engagement with industry experts, facilitated by the Minerals Council South Africa MOSH Transport and Machinery (T&M) Adoption Team.

A specific emphasis of the URS is the definition of the **CPS regulatory requirements,** namely: to prevent injuries arising from collisions involving TMMs in surface operations. The regulatory requirements and the justification thereof are provided with specific attention given to the key aspects of vicinity, effective warning, automatic slowdown and stop, and fail-to-safe without human intervention (FTSWHI).

Technical performance aspects such as reliability, accuracy, electromagnetic compatibility (EMC), maintenance and support are also included in the URS as general requirements.

The URS defines the baseline CPS Product Breakdown Structure. Key operational scenarios are depicted, defining specific requirements that the CPS products must conform to. The operational scenarios represent typical use cases within which CPS products will operate.

It is reasonably foreseeable that the CPS will have significant implications on a mine's existing day-to-day operations, because the CPS can be classified as:

- A critical safety related system
- A maintenance significant system
- An operations significant system

The above classification means:

- Safety: Any fault with the system is a "NO-GO", it must fail-to-safe and be tamperproof. Continuing operations in the presence of safety faults may expose the mine's legal appointee to liability if an injury were to occur.
- Maintenance: Since the CPS is a safety related system, proper, diligent maintenance of the CPS is required. Only skilled and competent employees are allowed to work on a CPS. The CPS must support accurate fault detection and root cause analysis. Critical spares must be readily available.
- Operations: Only skilled and competent employees are allowed to operate a TMM fitted with a CPS. The CPS must not receive false positives and zone sizes must be limited to lower any negative impact on production. The CPS must be accurate, reliable and repeatable.

4 Scope

For the purpose of the scope of this document the USER is defined as **the mine** that has the legal duty to prevent persons from being injured as a result of TMM collisions.

The Surface CPS URS applies to:

- The SAMI for TMM surface mines that adopted the MOSH CPS guideline .
- All surface mining types and processes.

The scope of this URS does not:

- Include all interaction scenarios that may be found in a specific mine's mining processes. These interaction scenarios must be determined through performing a traffic flow analysis, a risk analysis. Flowing from that work, additional/mine specific interaction scenarios may be identified.
- Explicitly consider the capability of currently available CPS products, but rather defines what the end user (the mine) requires from a CPS in order to comply with the MHSA.

5 Approach Used to Develop the URS

The overall approach used to develop this document is described in the report titled: REVIEW REPORT: Collision Management Systems, Technical Specification Guideline, SME and UME, REV 6 OF THE INDUSTRY ALIGNMENT ON TMM REGULATIONS; SPECIAL PROJECT OF THE MINERALS COUNCIL SOUTH AFRICA[6].

Figure 2 shows the CPS requirements structure. It is based on classic systems engineering practice and standards. The structure enables mines and CPS suppliers to identify the CPS products, their elements, modules and components in a holistic way, that will enable traceability from the CPS level down to a specific product/element component.

[6] Available from https://www.mosh.co.za/transport-and-machinery/documents

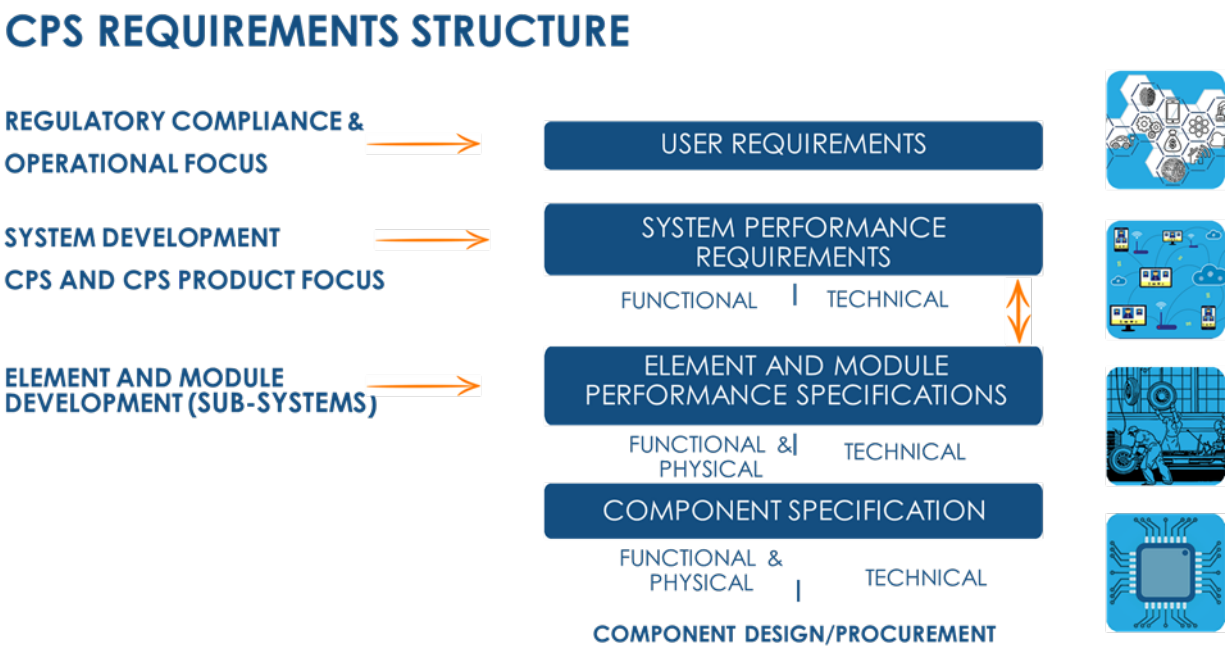


Figure 2: CPS requirements structure

6 Regulatory Requirements

The first step in classical systems engineering is to define all requirements **external** to the system's operational environment. The URS will therefore focus on the TMM regulatory requirements. It will address the **direct as well as implied** requirements.

6.1 CPS Legal Liability

Automatically slowing down and stopping a TMM, seconds before a potential collision, under the legal objective to prevent injury as a result of such collisions, bears a significant legal duty for a mine. The duty of a mine is to **ensure compliance with the TMM regulations.** CPS falls within the accountability of the 2.13.1 legal appointee and as such he/she must be clear on the objective of the regulations, the direct requirements as well as the indirect requirements that will **ensure** compliance with the regulations. It is significant that the requirements address the CPS as a whole and not sub-systems or products (CxD & TMM CPS) supplied by different suppliers.

The lack of an international standardised communication protocol between different CPS products, implies that a mine must standardise on the CxD to be deployed on the mine. This reality has significant legal implications for the 2.13.1 appointee. If the 2.13.1 appointee is unable to bound the liability of any sub-element of the CPS, he/she will not be able to keep the suppliers of the sub-elements legally accountable for their products and hence will be significantly exposed legally.

For a 2.13.1 appointee it is therefore very important to define the CPS such that the requirements of the elements (products) can be unambiguously bound, so as to contract the products such that the product supplier bears the legal liability for the product(s) supplied.

To effectively demonstrate the reasonable measures taken to ensure compliance the 2.13.1 appointee must:

- Structure the CPS in logical elements that can be contracted with clear legal boundaries.
- Specify the Functional and Technical requirements for each of the elements.

- Specify the requirements for each of the elements' suppliers to demonstrate conformance with the requirements.
- Specify the evidence to be provided or be available (Section 21 Technical File Content).
- Ensure conformance with the requirements.

Being an injury prevention safety system, comprising multiple products, implies specific functional and technical requirements that would otherwise not be needed. These implied requirements are as valid as are the direct requirements. The fact that it is not directly stated in the texts does not make them optional or guidance only. These are:

- The TMM to slow down and stop without operator action when the CxD or any of the TMM CPS functions failed. This in turn implies that:
  - The CPS must have self-diagnostic capabilities
  - Automatic deceleration (retardation), service brake, as well as park brake application capabilities. This in turn implies that:
    - The deceleration must be such that it does not have any negative health impact on the operator.
    - The TMM must remain stable and controllable during such automatic slowdown.
    - The TMM must not lock wheels during such automatic slowdown. This in turn implies that the speed, load status and inclination at the time of a slowdown and stop must be considered.
- The CPS products to be able to give evidence of its functionality and communication with the other CPS products. This implies accurate and frequent logging of data and communication between the different CPS products.

The above implied requirements are within the context of the MHSA not being prescriptive and detailed. The onus is placed on the mine to ensure compliance and adherence to the stipulations of the MHSA. The legal duty of the mine therefore includes development of detail CPS requirements that will ensure that the mine complies with Reg 8.10.

6.2 Collisions between diesel powered TMM

The specific regulations defined in the MHSA are included here for ease of reference. It is important to read Regulation 8.10.2 in its entirety, as the requirements build on the foundation laid by preceding clauses. Contextual reading is key to understanding the requirements derived from the Regulations.

Since the mine has the legal duty to prevent operator injuries as a result of TMM collisions, and the act says that all TMMs must be under legal duty of the engineer, it follows that it is the legal duty of the 2.13.1 appointee to **ensure compliance** with the TMM regulations. Since the regulations are not prescriptive and not specific the first critical aspect is to interpret the high-level regulatory requirements.

8.10.2	*The employer must take reasonably practicable measures to ensure that persons are prevented from being injured as a result of collisions between diesel powered trackless mobile machines.*

The clause explicitly requires that **all** mines take reasonably practicable measures to **prevent injuries** due to collisions between diesel powered TMMs. The clause provides the fundamental **objective** of the regulation. It is not limited to specific mining types (surface or underground) and does not differentiate between types of TMMs, there is no reference to a specific type of TMM and there is also no reference to the significance of a TMM collision. A mine therefore must determine the hazards on

the mine that can result in an injury due to a collision between all types of TMMs in all TMM related operations and introduce reasonably practicable measures to prevent persons from being injured as a result of such collisions.

A critical implication of Clause 8.10. is that the regulation does not require technology products (CPS) as the **only** measure to achieve the objective. The implication is that, as long as **reasonably practicable measures** are in place to prevent injuries due to diesel powered TMMs collisions, a mine does not need to revert to technology to prevent such collisions. The measures that are to be in place however must be **effective** in preventing persons from being injured.

Paragraph 8.10.2 then states:

8.10.2(cont.)	*At any opencast or open pit mine where there is a significant risk of such collisions, such measures must include:*

This introduction has two key requirements, firstly what follows is only applicable where there is a significant risk of such collisions (where persons can be injured). The second requirement implies that a mine must have a methodology to determine where there is a significant risk between TMMs to collide and have such places explicitly identified.

Clause 8.10.2 and its sub-clauses therefore are only applicable to a mine where a significant risk of these collisions **remain**, after applying the reasonably practicable measures regulated in clause 8.10.2.

8.10.2.1	*Every diesel powered trackless mobile machine must be provided with means to automatically detect the presence of any other diesel powered trackless mobile machine within its vicinity; and*
8.10.2.1(a)	*upon detecting the presence of another diesel powered trackless mobile machine, the operators of both diesel powered trackless mobile machines shall be warned of each other's presence by means of an effective warning; and*

8.10.2.1 requires that, where significant risk of collision exists, **all** TMMs (every) is to be fitted with a CPS. Detection is required within each other's vicinity.

Vicinity is not defined here; however, it can be assumed that the choice of the word implies something specific. The second direct requirement is that all the TMM operators involved must be warned of each other's presence. The regulation uses a specific type of warning, an effective warning. Again, no further explanation or detail requirements are provided, but once more it must be assumed that the choice of words is deliberate, having a specific meaning. The clause then ends with an 'and…' This is significant in the context of the detection functionality since clause 1b indirectly defines some requirements of the detection functions.

8.10.2.1(a) defines the requirements for what must happen when the TMMs detect each other automatically. The direct functionality requirements derived from 8.10.2.1(a) are:

- Detection must be performed automatically for both/all the TMMs.
- Detection when within each other's **vicinity**
- **Both the TMM** operators must warned
- Warnings to be **effective warnings**

Whilst bullet 1 and 3 is self-explanatory, bullets 2 and 4 require further interpretation in order to be unambiguous. Section 8.10.2.1(b) provides additional key information:

*8.10.1.2 (b) in the event where **no** action is taken to prevent potential collision, further means shall be provided to **retard** the diesel powered trackless mobile machine to a **safe speed** where after the **brakes** of the diesel powered trackless mobile machine are **automatically** applied. The prevent potential collision system on the diesel powered trackless mobile machine must **'fail to safe'** without human intervention.*

The requirements stemming from Paragraph 8.10.2.1(b) are:

- All the TMM operators are expected to take action to prevent the potential collision.

- Only after the operator(s) fail to take action as instructed by the effective warning, must the TMM(s) start the **automatic slowdown and stop**.
- The operator(s) are to be given time to take action.
- If the TMM that is to stop automatically is travelling at a speed at which it is **unsafe** to apply the service brakes, the TMM must first **automatically slow down** to a speed at which it is **safe** to apply the **service brakes automatically**.
- Once the safe speed is reached, the **service brakes** must be applied **automatically**.
- If any of the aforementioned functionalities fail, the CPS must **fail to safe without human intervention**.

The terms **vicinity, effective warning**, **safe speed** and **fail-to-safe without human intervention** require further interpretation.

6.2.1 Defining Vicinity

Since Regulation 8.10 expects the operator(s) to only **take action** to **prevent** a potential collision 'when within each other's **vicinity**', vicinity can be interpreted as follows:

*The **distance** or **time to** the point of a potential collision, such that, if the operators receive an effective warning to prevent a potential collision, and one or both (or all) do not take action, the CPS will still be able to prevent the potential collision.*

This requirement is implied. Vicinity therefore **cannot** be a fixed value; it is scenario dependent. It dynamically changes, based on variables such as the speed of each TMM, the direction it is travelling in, its payload, the road gradient, and importantly the rate of deceleration of each TMM, given all the other variables.

Vicinity thus depends on specific circumstances and operational scenarios. The URS (this document) therefore defines typical scenarios that may be encountered on typical South African surface mines.

It is noteworthy that the regulation only requires warning when a potential collision is imminent. Again, this is implied, however it is a critical requirement since it excludes what is called "L7" "Awareness" warnings as defined in the EMESRT approach. Lessons learned since introduction of "L7" highlights how TMM operators get conditioned to ignore "alarms" and are frustrated by the constant noise and distractions in the TMM cab.

6.2.2 Defining Effective Warning

The definition of **effective warning** can be derived from paragraphs 8.10.2.1 and 8.10.2.1(a) in conjunction with 8.10.2.1(b).

Paragraph 8.10.2.1(a) states that the operator(s) of the TMM(s) is to receive an effective warning. Paragraph 8.10.2.1(b) implies that the operator(s) **must** take action to avoid the potential collision.

The MHSA requires that an operator of a TMM must always stay in control of his/her TMM. This requirement is fundamental to safe operation of a TMM and must be upheld even when there is a potential collision. The intention of the TMM regulation is clearly to uphold this principle.

The TMM regulations are specifying technology to enable automatic stopping of TMMs to prevent collisions, but it **upholds** the obligation of the operator to remain in control of the TMM under **normal operating conditions**. This is an important consideration as this requirement implies the provision of a delay of the time to trigger the automatic stopping of the TMM in order to give an operator an opportunity to prevent a potential collision. This requirement ensures that control is never taken away from an operator during normal operating conditions, however if an operator is incapacitated/unable to operate the TMM safely, there is a safety system to prevent the operator(s) from being injured.

In order to facilitate this requirement a CPS should not give a **general warning** or an **awareness warning**. It calls for an **effective warning,** and only at the vicinity boundary.

Considering that the expected outcome of the operator action is that the potential collision is prevented, therefore an effective warning must inform the TMM operator(s) what the appropriate action(s) are to prevent the potential collision.

An effective warning is conditional, depending on speed, relative position, road design, road condition, etc.

If the **operator** is expected to take action to avoid a potential collision, she/he must be granted a reasonable opportunity to take such action. An effective warning therefore must consider the **time** that an operator is given to respond to the effective warning to avoid a potential collision. An effective warning is therefore:

- Not general or an awareness mechanism
- Is only given at the vicinity boundary
- Specific, i.e. ‘Stop’ or ‘Slow’
- Considerate of a reasonable operator response time
- Anticipating an operator action

6.2.3 Defining Safe Speed

A **safe speed** is a speed below which the automatic stopping intervention can be initiated without increasing the risk of a collision or causing other unintended consequences that may lead to operator injury.

Various factors influence the value of the **safe speed**. Examples of these factors include the TMM type, TMM payload, road gradient, friction limit between the TMM tyre and the road, brake wear, tyre wear, etc. (note that this is not a complete list). The **safe speed** thus depends on the operational scenario and is influenced by factors the CPS designer cannot control (e.g. road surface condition). It is critical that the **safe speed** of a particular TMM is **clearly defined**, and that the **assumptions** informing that definition are clearly **documented** and **made available** to all parties involved. This include the mine and the CxD suppliers.

6.2.4 Defining Fail to Safe Without Human Intervention (FTSWHI)

Subsection 8.10.2.1 (b) states: The prevent potential collision system on the diesel powered trackless mobile machine must fail to safe without human intervention. In simple terms it means the CPS must do what it has been designed to do automatically – without relying on the operator. The only safe

condition for a TMM with a failed CPS is a stationary TMM that does not pose a risk to the operators of other TMMs. This is a fundamental and direct regulatory requirement for a CPS. FTSWHI has significant design implications for CPS. By implication a TMM that was busy with normal operations and with failed CPS will be stationary in the operational area of the mine. The implied availability, reliability and maintainability requirements are obvious, however the self-diagnostic requirements at subassembly level must be stressed, as is the communication of the failed subassembly, correct critical sub-assemblies and repair tools. Self-diagnostic requirements for FTSWHI must not be confused with that to ensure CPS availability. This is a fundamental and direct regulatory requirement for a CPS.

A CPS that complies with the above requirements is as unique to the South African mining industry as is the terminology for a TMM. Subsection 8.10.2.1 (b) states … The prevent potential collision system... This is the origin of the term Collision Prevention System (CPS).

7 CPS Product Definition

To enable the above, the CPS Product definition is important. The functional breakdown structure is briefly mentioned below for contextual purposes.

A key aspect of a CPS is that it will, for the foreseeable future, consist of two separate products, supplied by separate suppliers. Every TMM brand, type, model and sometimes serial number combination with a specific CxD is a unique CPS product. This is due to the diverse population of TMMs used in the SAMI. Some TMMs are electronic controlled, with CAN-bus systems and some are not. Product configurations are determined by the different CPS product providers. Products however must conform to the functional requirements for a CPS. Functional requirements are structured in a logical functional breakdown, shown graphically below.

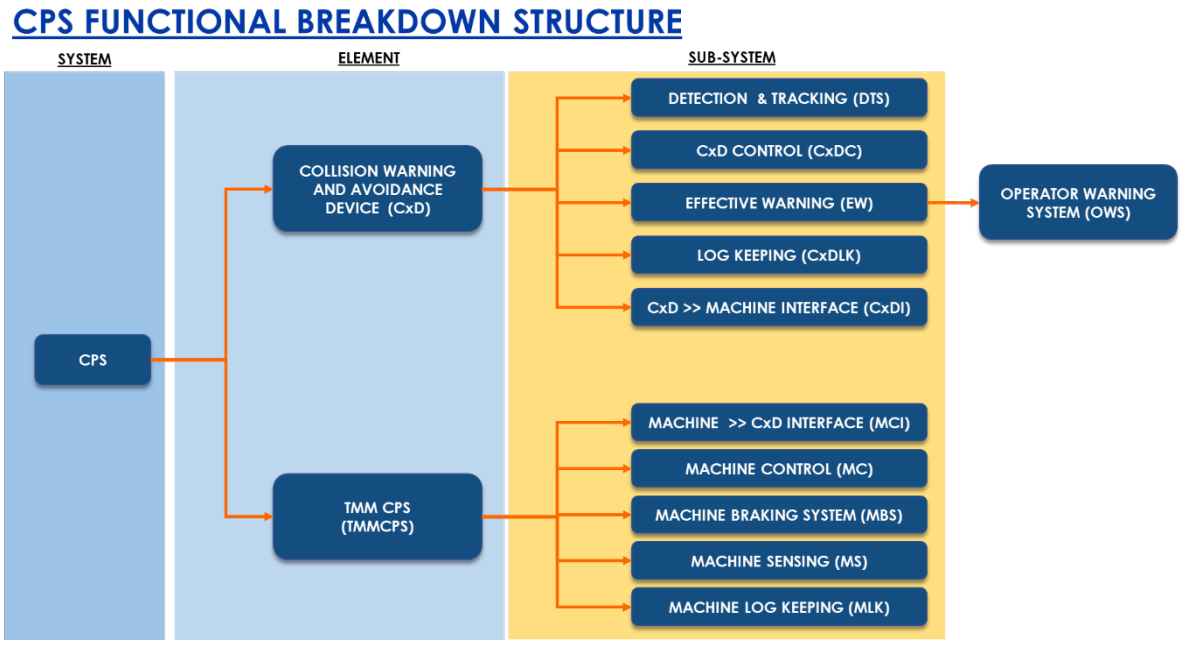


Figure 3: CPS functional breakdown structure.

The TMM CPS functions are structured in five sub-groups, namely:

1. Machine >> CxD Interface functions (MCI).
2. Machine Controller functions (MC).
3. Machine Braking System functions (MBS).

4. Machine Sensing functions (MS).
5. Machine Log Keeping functions (MLK).

The CxD functions are broken down into five sub-groups namely:

1. Detection and Tracking functions (DTS).
2. CxD Control functions (CxDC).
3. Effective Warning functions (EW).
4. CxD Log Keeping functions (CxDLK).
5. CxD Machine Interface functions (CxDI).

8 User Requirements Structure

The approach to define the user requirements is as follows:

- General requirements
- Surface Mining specific requirements

The Minerals Council South Africa facilitated the definition of basic mining process descriptions for different mining types, also indicating equipment types involved with each type of process, the basic types of interactions, the minimum number of exposed persons and the minimum number of equipment types. The work further includes equipment population information. The URS are informed by the information provided by the Minerals Council South Africa.

9 General Requirements

The nature, complexity and associated liability of CPS necessitates a number of requirements that might otherwise be insignificant.

The user requirements that are applicable to all surface CPS products, irrespective of the mining types and processes that they are involved in, are defined below.

General requirements include requirements related to the MHSA, the development process, design analysis and conformance verification. These requirements are the reasonable actions taken by the 2.13.1 appointee to ensure that CPS products conform to requirements that will enable the mine to comply with the regulations. Table 2 lists the general requirements.

Table 2: CPS General Requirements

Group	URS No.	Requirement
Prevent collisions	SM.G01	CPS products must prevent collisions by: • Detecting the movement of other TMMs within a detection range around the TMM. • Track the movement of the detected TMMs. • Determine the vicinity boundary for every TMM as they move. • Trigger an effective warning to the applicable TMM operators, providing all operators sufficient time to respond. • Where one or both parties do not respond appropriately, the TMM must be automatically slowed down to a safe speed, then automatically stopped and held stationary.

Group	URS No.	Requirement
Conform to functional and technical requirements that will ensure mine regulatory compliance.	SM.G02	The CPS must have functional and technical performance requirements that will ensure general requirement SM.G01, as documented in the MOSH CPS guideline, that include but are not limited to: • Physical installation drawings • Operating manuals • Inspection and maintenance manuals • Post maintenance inspection test instructions
Conform to functional and technical requirements that will ensure mine operation	SM.G03	The CPS must have functional and technical performance requirements that will ensure general requirement SM.G01 as documented in the MOSH CPS guideline.
Demonstrate conformance	SM.G04	CPS conformance to user functional and technical requirements must be demonstrated by formal supplier verification as well as independent verification as defined in the CPS Requirements Verification Regime as well as the CPS Independent Verification Test Specification as documented in the MOSH CPS guideline.
Comply with MHSA Section 21	SM.G05	Must comply in as far as: • Legal liability is unambiguously defined • Intended operation is defined • Conformance is demonstrated and traceable as per the CPS Section 21 Technical Information Framework. (produce a Section 21 Technical File)
Have unambiguous legal boundaries	SM.G06	If the CPS is not supplied by a single supplier (as was indicated) the CPS must have clear physical and functional boundaries, as is set out in the CPS Functional and Technical Performance Requirement Specification.
Have unambiguous formal legal agreements	SM.G07	For every mine, CPS integration supplier, CxD supplier and TMM OEM/3rd Party CPS supplier a formal signed legal agreement shall exist unambiguously defining the legal boundaries and agreements between the parties.
Prevent collisions	SM.G07.1	CPS products must prevent collisions between TMMs without compromising employees' health and safety due to the use of CPS.
Automatically slow down and stop	SM.G07.1.1	The TMM may not become unstable or uncontrollable due to the use of CPS,
Automatically slow down and stop	SM.G07.1.2	Limit the number of false warnings, slow down or stopping,
Automatically slow down and stop	SM.G07.1.3	CPS to limit TMM functionality to ensure that the CPS remains within its design limits (e.g. limit TMM speed to ensure there is sufficient time and/or distance to detect other TMMs, warn the operator and slow down and stop the TMM without causing a collision or resulting in TMM loss of control).
Automatically slow down and stop	SM.G07.2	Have a 100% effective detection of potential collisions
Automatically slow down and stop	SM.G07.3	Must allow normal operation of the TMM when TMMs are outside of the vicinity boundary
Prevent collisions: Operational scenarios	SM.G07.4	Prevent collisions for all operations defined in this document.
Prevent collisions: Operational scenarios	SM.G07.4.1	Prevent TMM collisions for all reasonably foreseeable operational scenarios, including:

Group	URS No.	Requirement
Prevent collisions: Operational scenarios	SM.G07.4.1.01	Machine maintenance and service support,
Prevent collisions: Operational scenarios	SM.G07.4.1.02	TMM Washing,
Prevent collisions: Operational scenarios	SM.G07.4.1.03	Brake testing,
Prevent collisions: Operational scenarios	SM.G07.4.1.04	Lubrication,
Prevent collisions: Operational scenarios	SM.G07.4.1.05	Component replacement and maintenance,
Prevent collisions: Operational scenarios	SM.G07.4.1.06	Refuelling,
Prevent collisions: Operational scenarios	SM.G07.4.1.07	Wheel changing,
Prevent collisions: Operational scenarios	SM.G07.4.1.08	Condition/health monitoring etc.,
Prevent collisions: Operational scenarios	SM.G07.4.1.09	Shift change,
Prevent collisions: Operational scenarios	SM.G07.4.1.10	Supervision/Inspection visits during operation.
Prevent collisions: TMM conditions	SM.G07.4.2	Prevent collisions for all reasonably foreseeable TMM conditions and states, including:
Prevent collisions: TMM conditions	SM.G07.4.2.1	TMM accommodate current state braking system performance that may deteriorate due to wear and tear,
Prevent collisions: TMM conditions	SM.G07.4.2.2	Normal TMM operating conditions including bucket raised, TMM articulated, boom extended, as applicable to each TMM type,
Prevent collisions: TMM conditions	SM.G07.4.2.3	All normal operating speeds per TMM type,
Prevent collisions: TMM conditions	SM.G07.4.2.4	Breakdowns and recovery scenarios,
Prevent collisions: TMM conditions	SM.G07.4.2.5	Vehicle towing and pushing,
Prevent collisions: TMM conditions	SM.G07.4.2.6	Emergency conditions (fires, ambulances, etc.).
Prevent collisions: Environment	SM.G07.4.3	All reasonably foreseeable environmental conditions, including:
Prevent collisions: Environment	SM.G07.4.3.1	Various road design and construction,
Prevent collisions: Environment	SM.G07.4.3.2	Inclines and declines,
Prevent collisions: Environment	SM.G07.4.3.3	Road surface conditions,
Prevent collisions: Environment	SM.G07.4.3.4	Weather conditions,
Prevent collisions: Environment	SM.G07.4.3.5	Day and night operation,
Prevent collisions: Environment	SM.G07.4.3.6	Poor visibility.
Prevent collisions: Vicinity	SM.G07.5.	Predict potential collisions dynamically as TMMs move by continuously determining where the vicinity boundaries are.
Prevent collisions: Effective warning	SM.G07.5.1	Ensure that operators of all TMMs within the vicinity (see definition) receive an effective warning (see definition) of actions to be taken to prevent a potential collision. Such warnings shall:

Group	URS No.	Requirement
Prevent collisions: Effective warning	SM.G07.5.2.1	Give the operators sufficient time to react to the warning and take evasive action to avoid a potential collision (operator reaction time - fatigued operator, distracted operator, limited visibility, etc.),
Prevent collisions: Effective warning	SM.G07.5.2.2	Be provided in a way that a TMM operator(s) can clearly understand it in preferred languages,
Prevent collisions: Effective warning	SM.G07.5.2.3	Consider all other associated attention drawing devices such as: screens, lighting or sound, if used,
Prevent collisions: Effective warning	SM.G07.5.2.4	Be proven by human factors engineering standards and requirements to not have any distractive effect on the TMM operator or health impact and is agreed to by a representative sample of specific TMM operators,
Prevent collisions: Effective warning	SM.G07.5.2.5	Be the outcome of the application of a credible Human Factors and ergonomics analysis and design process,
Prevent collisions: Effective warning	SM.G07.5.2.6	Only alert to the potential collision with the highest probability, if multiple interactors are involved,
Prevent collisions: Effective warning	SM.G07.5.2.7	Ensure that any devices installed in the TMM cab is positioned such that it does not impede on any visibility aspects of the design of the TMM,
Prevent collisions: Effective warning	SM.G07.5.2.8	Have a standardized TMM type cab layout with regards CPS displays or have the CPS display integrated into other existing displays,
Prevent collisions: Effective warning	SM.G07.5.2.9	If the effective warning functionality is compromised, the CPS shall FTSWHI.
Interoperability	SM.G08.1	CPS products must be interoperable:
Interoperability	SM.G08.1.1	For all different types of TMMs including LDVs used in mining operations. (Mine bakkies),
Interoperability	SM.G08.1.2	For all different brands of TMMs,
Interoperability	SM.G08.1.3	For all different models of TMMs,
Interoperability	SM.G08.1.4	For all unique serialised models of TMMs.
EMC	SM.G09.1	The CPS must be EMC with all other radio frequency-based systems used on the mine.
EMC	SM.G09.1.1	Other CPS products and electronic devices fitted to TMMs,
EMC	SM.G09.1.2	Other mine infrastructure and EMI sources,
EMC	SM.G09.1.3	The composition of the minerals mined,
EMC	SM.G09.1.4	Electronic detonation items.
Fail-to-safe	SM.G10.1	Be self-diagnostic to ensure 100% CPS functionality before start up, during normal and emergency operation of all elements/subsystems, individually.
Fail-to-safe	SM.G10.2	Be of a fail to safe design that does not rely on any operator action, i.e. automatic. The CPS will immediately **inform** the operator and either:
Fail-to-safe	SM.G10.2.1	not start/propel the TMM if it was stationary or
Fail-to-safe	SM.G10.2.2	bring the TMM(s) to a safe stop.
Fail-to-safe	SM.G10.2.2.1	without any negative health or safety impact on the TMM operator(s) and/or passengers,
Fail-to-safe	SM.G10.2.2.2	be the outcome of the application of a credible Human Factors analysis and design process, including but not limited to the effects of:
Fail-to-safe	SM.G10.2.2.2.1	EMI,
Fail-to-safe	SM.G10.2.2.2.2	Whole body vibration.
Fail-to safe	SM.G10.3	Have a motion enabler functionality for dealing with emergency as well as recovery/repair situations

Group	URS No.	Requirement
Log-keeping	SM.G11.1	Have a supervisory monitoring data collection, storage and reporting capacity that provides reports: • For analysis of interactions that are a safety concern and require urgent attention (including: test failures, trends, and heat maps of hazardous locations), • For analysis of interactions that are a production concern and require urgent attention (including trends and heat maps of production locations where interactions occur), • For summary reports of the above interactions and operating/maintenance compliance (safety, production, availability, reliability and mean time to repair (MTTR)), • For incident detail reporting when required, • The reporting system must have an up-time of 24/7 x 98% and be configurable for each mine site and must be able to run in the cloud and on typical SAMI mining local area networks, • The reporting system must be secure.
Log-keeping	SM.G11.1.1	The data/log keeping system must maintain logs when an effective warning or an automatic slowdown and stop event (the event) occurred. Such logs shall:
Log-keeping	SM.G11.1.1.1	Be based on the UTC time or synchronized with an easily accessible reference time,
Log-keeping	SM.G11.1.1.2	Include all machine data communicated to the CxD leading up to, during and immediately after the event,
Log-keeping	SM.G11.1.1.3	Include any actions (such as effective warning, slowdown and stop) issued by the CxD to the operator or machine,
Log-keeping	SM.G11.1.1.4	Be easily accessible to management for oversight purposes.
Log-keeping	SM.G11.1.2	With a real-time date and time stamp synchronisation of all identified system elements requiring such.
Log-keeping	SM.G11.1.3	The log keeping system shall fail to safe
Log-keeping	SM.G11.1.4	The log keeping system must retain data logs for a minimum period of seven days on TMM.
Log-keeping	SM.G11.1.5	Log any element/sub-system faults.
Installation, Maintenance and Repair (IMR)	SM.G12.1	The CPS shall have a modular design that shall ensure replacement of critical components/subassemblies in reasonable times.
IMR	SM.G12.2	The CPS shall have an authorized override (maintenance/recovery override) capability.
IMR	SM.G12.2.1	The CPS shall provide a means for an authorised supervisor or person to temporarily suspend an automatic intervention for maintenance and recovery reasons (To be specifically defined by the responsible person),
IMR	SM.G12.2.2	Authorised override mode to limit TMM speed (limp mode) while active,
IMR	SM.G12.2.3	Limp mode speed to be configurable as per site specific and TMM OEM requirements,
IMR	SM.G12.2.4	CPS to return to Normal Operation from Authorised Override mode as described in ISO 21815-1:2022.
IMR	SM.G12.3	Be easy to fault-find
IMR	SM.G12.4	Provide easy access for maintenance purposes by authorized and competent personnel
IMR	SM.G12.5	Provide for quick calibration
Reliability	SM.G13.1	Be 99% available for times required to operate

Group	URS No.	Requirement
Reliability	SM.G13.1	Have identified safety critical sub-assemblies and components with operating/maintenance tactics required
Reliability	SM.G13.1.1	Have cables, sensors and antennas positioned, secured and protected against physical damage under normal operation conditions, such as stepping on, falling materials, bumping against side walls and infrastructure, etc.
Reliability	SM.G13.1.2	Vibration-induced failure to components (e.g. mounting brackets, cables passing through enclosures/panels, etc.)
Reliability	SM.G13.1.3	In harsh mining conditions of 50 °C temp and 80 % relative humidity.
Reliability	SM.G13.1.4	Withstand the forces and conditions of normal vehicle high pressure washing.
Design Process	SM.G14.1	Be based on ISO 9001 or similar standard, ensure formal reviews, record keeping and independent verification
Design Process	UG.G14.1.1	Documented in a formal design quality plan,
Design Process	SM.G14.1.2	Follow an acknowledged Technology Readiness maturity process,
Design Process	SM.G14.1.3	Include independent verification by an acknowledged CPS testing entity,
Design Process	SM.G14.1.4	Keep records of evidence for the purpose of demonstrating conformance.

10 Surface Mining Specific User Requirements

The CPS requirements from individual user groups within the mine are defined in the table below. Although there are some duplications with other sections it provides further details to be considered during the functional analysis.

Table 3: Specific Requirements

URS No.	User requirement	Objective
SM.R1	**User**: Operator **Requirement**: Sufficient time to react Effective warning must allow for sufficient time for the operator to give action to the effective warning. Each operator will react differently and in different times depending on a variety of factors that confront the operator at the time (see Section 6.2.2): Driver or Operator reaction times). For the purposes of the URS, this reaction time must allow for the worst-case scenario with the operator in the worst state. This reaction time is expected to be between 1.5 seconds to 2.5 seconds.	To give the operator sufficient time to react to TMMs in the vicinity to prevent TMM collisions.

URS No.	User requirement	Objective
SM.R2	**User:** Operator **Requirement:** Effective warning An operator must receive an effective warning when other TMM(s) enter the vicinity of her/his TMM. Effective warning must be the result of a human factors engineering process and consider a combination of visual, audible and or haptic warning, including the following: • An audible warning in an operator language of choice • Screen brightness auto adjustment to brightness of the interior of the cab. • Screen or operator display indicating the alert, alarm, or advisory message with the highest priority when multiple warnings are received. Haptic warning may be a vibrating element drawing the human's attention to the warning on the screen.	To give the operator both an audible and visual warning of a TMM's location and movement in the vicinity of the TMM.
SM.R3	**User**: Operator **Requirement**: No false positives or false warnings The number of false positives or false warnings must be limited to ensure that operators do not become complacent and ignore warnings of potential collisions in their vicinity.	To limit the number of false warnings, auto retards or auto stops.
SM.R4	**User:** Operator **Requirement:** Automatic slowdown and stop final state is CPS Stop Once automatic stop has been activated by the CPS and the TMM comes to a stop, the TMM must enter a state of CPS Stop. The operator cannot put the TMM into motion until the other TMM has moved out of its vicinity.	TMM to remain in CPS Stop while the other TMM is in its vicinity.

URS No.	User requirement	Objective
SM.R5	**User**: Operator **Requirement:** Visibility The operator's visibility should not be obstructed or restricted due to improper positioning of equipment: • Operation of the CPS solution controls should be evaluated through design risk assessments (by the CxD supplier and by the OEM) to ensure unintended risks or consequences are not introduced, • Ergonomics of the operator cabin should not be compromised due to improper positioning of components, • Warning or diagnostic display units should be positioned so that the operator is always made aware of an alarm regardless of direction of travel or driving position. • Display units should be positioned in the operator's field of vision to allow alarms or advisory messages to be seen by the operator without unnecessary distraction and confirmed by design and operational risk assessments, • Display units should function effectively independent of the number of vehicles or personnel around the machine, • Display units should indicate the standby battery power availability (if an independent battery power supply has been specified), • Display units should show the current date and time if an internal real-time clock is used for time stamping of data, • Display units should clearly indicate the operating status of any radio communication or positioning links (e.g. V-P, V-V or vehicle-to-fixed infrastructure communications links); Colours used by display units should be different to other existing warnings on the machine to avoid operator confusion, if possible.	Operator visibility not to be impeded by CPS location in cab.
SM.R6	**User**: Engineering and maintenance, OEMs **Requirement**: TMM braking systems must not deteriorate due to CPS interventions. Braking systems (service braking, retarder, regenerative braking, hydrostatic braking, emergency braking, park brake) must be used to ensure the best proportional braking option to minimise any negative impact on operator and machine life cycle and maintenance costs. Machine braking performance must not deteriorate the braking system to such an extent that it cannot meet the compliance testing acceptance criteria.	CPS initiated brake performance must comply with national and international braking system in-service compliance testing.
SM.R7	**User:** Operators **Requirement:** No false positives or false warnings The number of false positives or false warnings must be limited to ensure that employees do not become complacent and ignore warnings of potential collisions in their vicinity.	To limit the number of false warnings, auto retards or auto stops for all employees
SM.R8	**User:** Operator **Requirement:** TMM safe speed When the TMM is slowing down to a safe speed, such speed must consider the stability of the TMM.	CPS intervention must not make the TMM unstable during the intervention.

URS No.	User requirement	Objective
SM.R9	**User**: Operator **Requirement:** Automatic slow down and stop final state is stationary TMM Once automatic slow down and stop has been activated by the CPS and the TMM comes to a stop, the TMM must remain stationary. The operator cannot engage any gear to put the TMM into motion.	TMM to remain stationary until no TMMs in the vicinity (see 6.2.1).

11 Surface Mining Interaction Scenarios

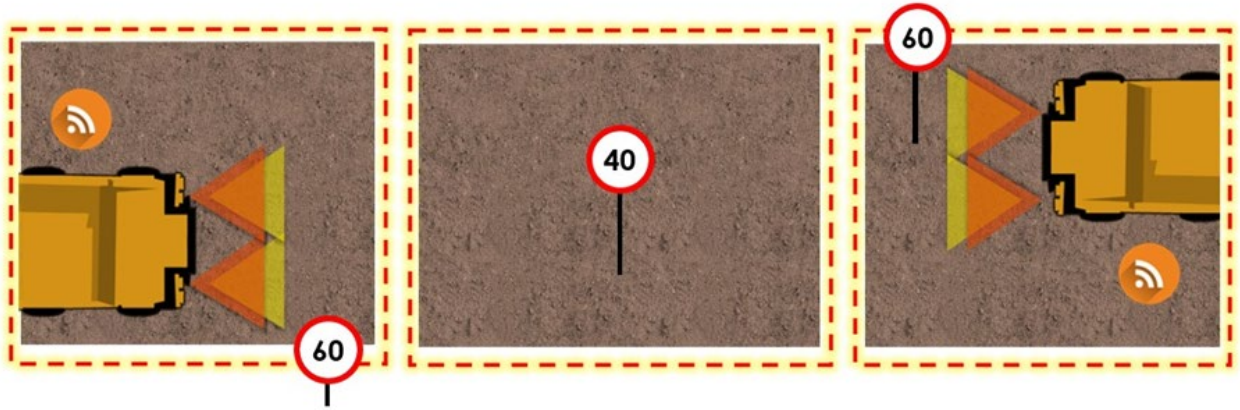
This Section defines typical interaction scenarios between surface TMMs in surface mines in South Africa. The intent of this Section is to guide the mine's legal appointees and developers of CPS products when specifying the CPS requirements. It is not an exhaustive list of all possible interaction scenarios in surface mine operations and should be used in conjunction with a site-specific risk assessment.

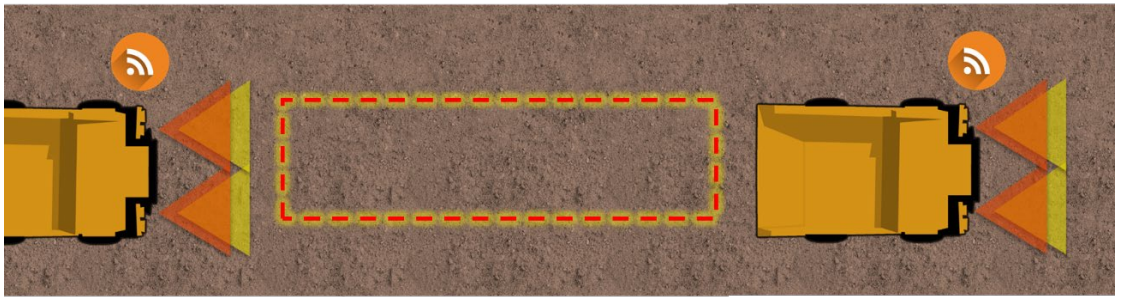
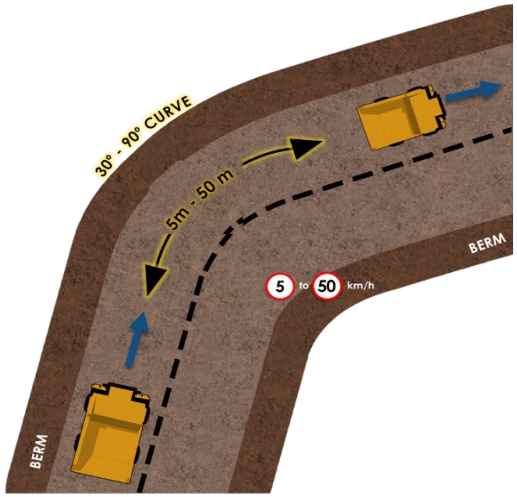
Table 4 defines various terms to describe the state of a TMM. These states are referenced in the interaction scenarios that follow.

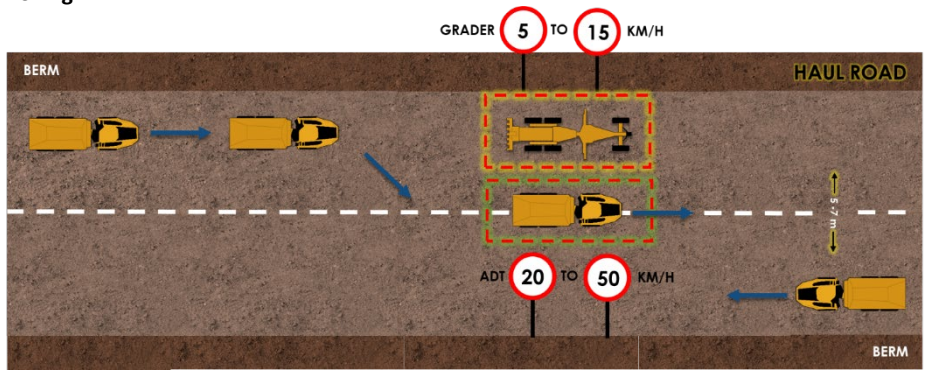
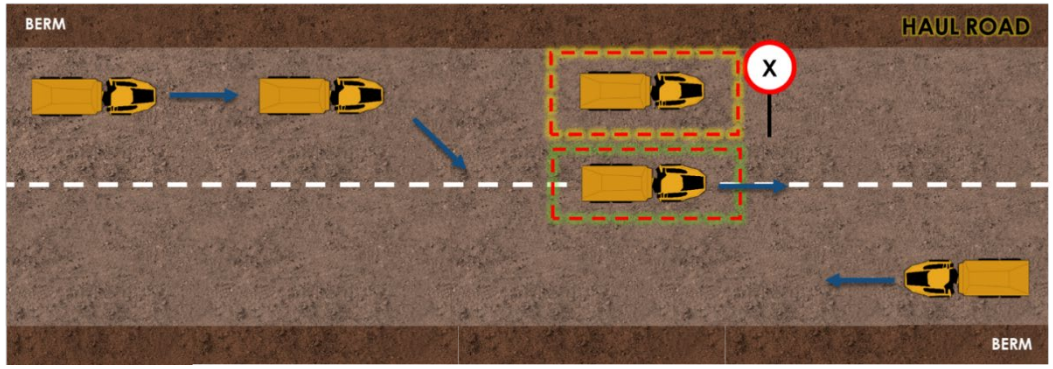
Table 4: TMM CPS states

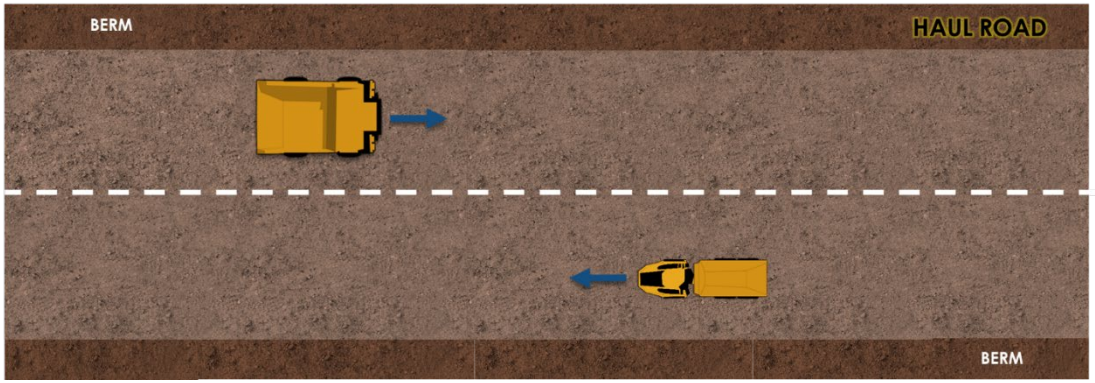
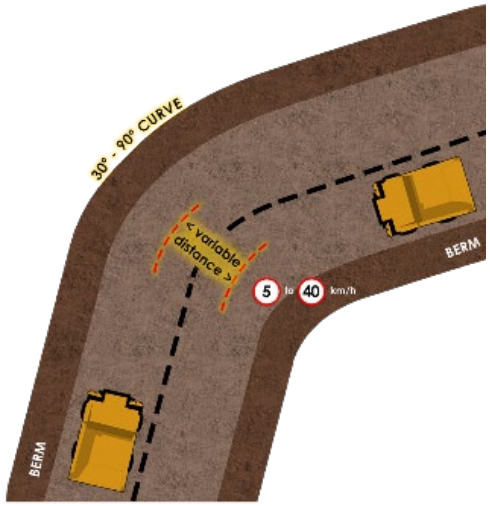
TMM state	Description
Safe Park	The TMM is safely parked as per the mine's standard operating procedure, e.g. the operator has engaged the park brake, switched the engine off and exited the cab. The operator has placed chocks or stop blocks under the TMM's wheel(s). This state is typically encountered at the start/end of shifts when the operators are coming on or off duty. The TMM is not operational.
CPS Start-up	The operator has completed the pre-inspection checks as per the mine's standard operating procedure and removed the chocks or stop blocks from under the TMM's wheels. The operator has entered the cab and is preparing to start operating. During this state, the CPS is undergoing its start-up procedure, e.g. performing system health checks. The CPS is not ready to start normal operation.
Normal Operation	The normal state of the TMM while it is operating and there is no significant risk of collision between TMMs. The CPS is functioning as intended and is monitoring for potential collisions.
Operator Stop	The operator has stopped the TMM and signalled their intent to stay stopped. This may happen during the course of the shift. The Operator Stop state is typically characterised by engagement of the Park Brake by the operator. The CPS is functioning normally, but the potential for collisions is limited due to the engagement of the Park Brake.
CPS Slow	The state when the CxD limits the TMMs speed. The CxD instructs the TMM to slow by sending SLOW_DOWN or APPLY_PROPULSION_SETPOINTS via the ISO/TS 21815-2:2021 CAN-bus interface.
CPS Stop	The state when the CxD intervenes with the intent of stopping or keeping the TMM stationary to avoid a collision or FTSWHI. The CPS has detected a potential collision with a another TMM and is intervening or has intervened to bring the TMM to a safe stop. Once the TMM has stopped, it remains stationary. This state is reached by the CxD instructing the TMM to stop via the ISO/TS 21815-2:2021 CAN-bus interface.
Emergency Override	The CPS has intervened and the TMM is in the CPS Stop state. However, there is imminent danger to either the TMM operator and/or nearby pedestrians. The TMM operator engages Emergency Override, as per the mine's standard operating procedure, to move the TMM to a safe place. During Emergency Override, the TMM speed is limited and the TMM is allowed to move for a limited period of time, as determined by the mine's risk assessment. Once this period expires, the TMM returns to the CPS Stop state.

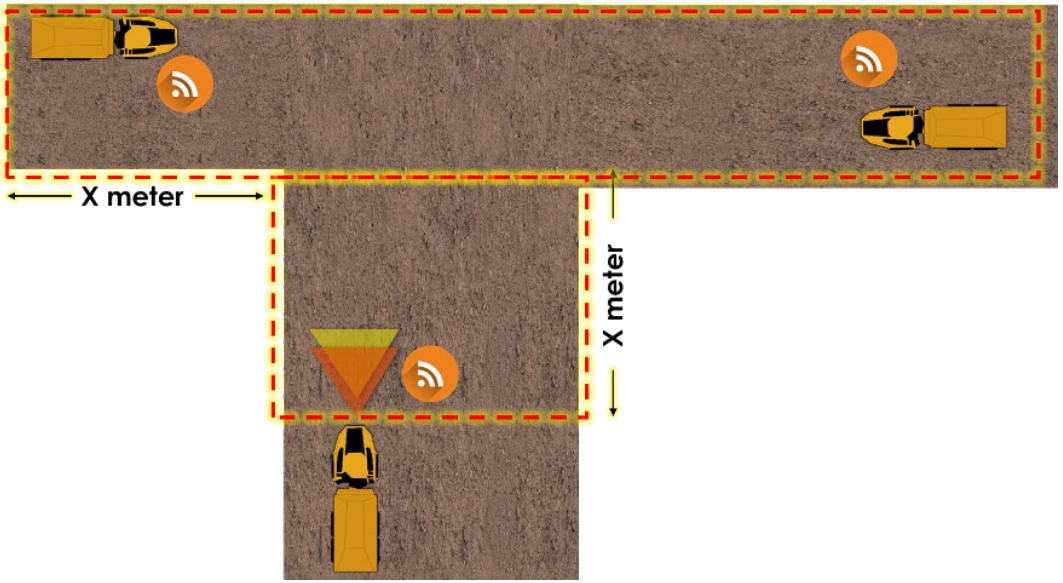
TMM state	Description
Fail-to-safe without human intervention	The CPS has detected a critical failure that compromises the CPS functionality. The CPS brings the TMM to a safe state within a reasonable time, as defined by the mine's specific risk assessment and standard operating procedure. The CPS can only exit this state if the failure is repaired/resolved, the operator activates Emergency Override, or an authorised technician engages Maintenance Override.
Maintenance Override	An authorised technician may enable the Maintenance Override state when recovering a TMM to effect CPS repairs. TMM speed is limited as per the mine's standard operating procedure until the Maintenance Override is cancelled by the authorised technician, or the TMM is safe parked. Upon deactivation of Maintenance Override, or start-up from Safe Park, the CPS shall fail-to-safe without human intervention if the critical failure(s) has not been resolved.
Speed Limit Mode	In certain areas, the CPS may enter a Speed Limit Mode. The aim of Speed Limit Mode is to limit the TMM speed to minimize the size of the vicinity. This mode may be utilized in congested areas such as workshops, refuelling bays, waiting areas, etc.

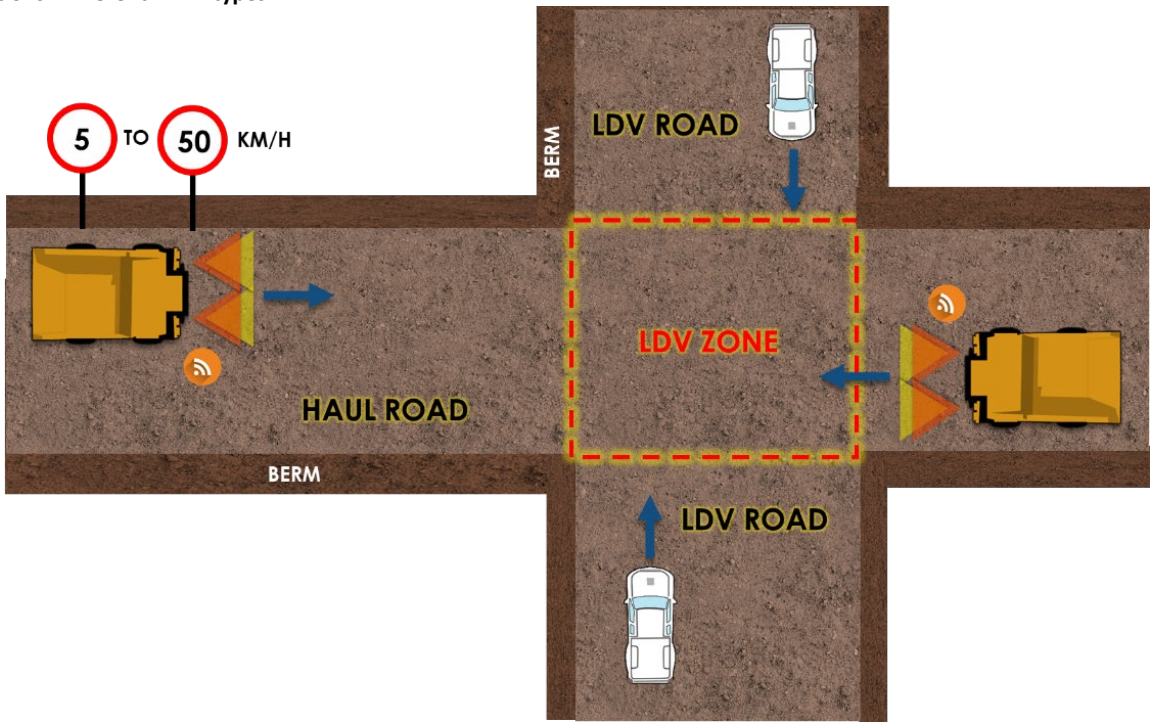
Scenario number	Scenario description	Objective
SM.S1	**Different types of TMMs: Designated roads/areas**  It is reasonably foreseeable that LDVs will interact with HMEs as part of their daily activities. This may be due to maintenance/breakdowns, shift change, inspections, etc. The CPS must prevent collisions between different types of TMMs if there is a significant risk of collision.	• The CPS shall prevent potential collisions between HMEs (including FELs, Shovels, etc.) and LDVs in all operational areas. • The CPS shall allow the LDV to approach the HME if the HME is in Safe Park or Operator Stop. • The CPS shall only allow the HME to move once the LDV is out of the vicinity. • No use of operator override/bypass/acknowledge is permitted when operators are following the Traffic Management Plan
SM.S2	**Speed limited area**  A mine's Traffic Management Plan will typically include speed limited areas. Similarly, the CPS is designed to a specific maximum speed (e.g. to ensure sufficient detection range). The CPS must ensure that TMMs operate at or below the speed limit, as defined by the Traffic Management Plan and the CPS design speed limit.	• The CPS must prevent potential collisions by ensuring that the speed restrictions on different areas on the mine are maintained. Examples of such areas are dumps, stockpiles, hard parks, workshop areas, etc. Similar for specific sections of roads such as ramps, curves, intersections, proximity to infrastructure and the like. • The CPS must remain within its design limits.

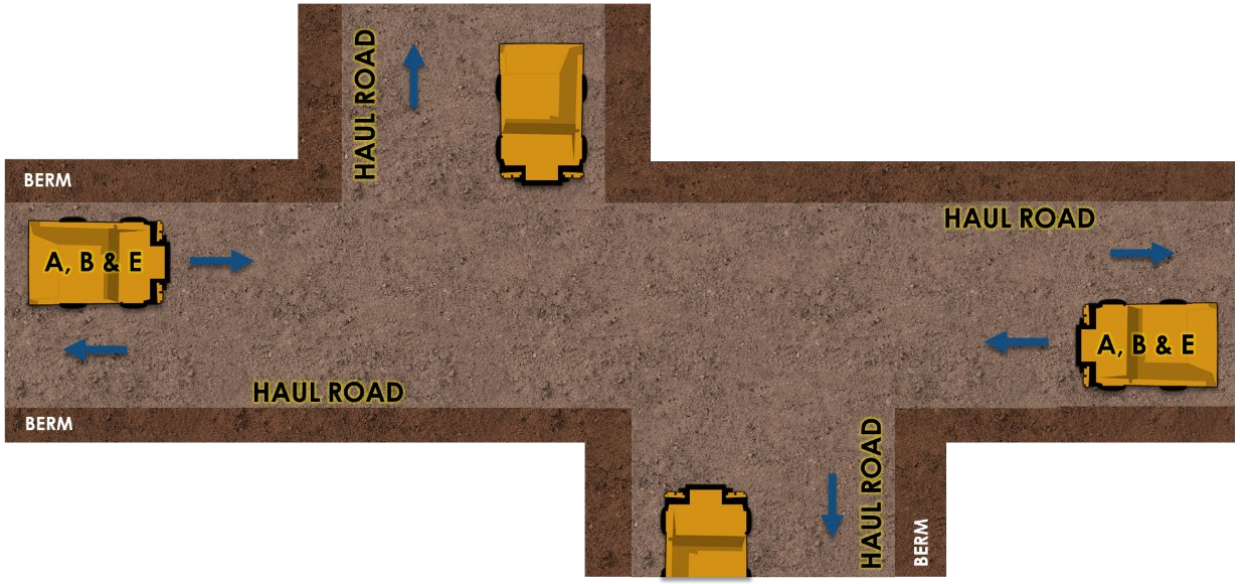
Scenario number	Scenario description	Objective
SM.S3.1	**Dovetail: Straight-line**  TMMs regularly follow each other from one area (e.g. the pit) to another (e.g. the dump). It is reasonably foreseeable that TMMs will interact with each other (e.g. not keeping a safe following distance or stopping at an intersection). The CPS must prevent collisions when TMMs are following each other.	• The CPS must prevent potential TMM collisions when TMMs are following each other. • The lead TMM may be moving or stationary (e.g. stopped at an intersection). • The CPS must be able to adjust following distances based on weather and road conditions. • No use of operator override/bypass/acknowledge is permitted when operators are following the Traffic Management Plan
SM.S3.2	**Dovetail: Curves**  TMMs regularly follow each other from one area (e.g. the pit) to another (e.g. the dump). It is reasonably foreseeable that TMMs will interact with each other (e.g. not keeping a safe following distance or stopping at an intersection). The CPS must prevent collisions when TMMs are following each other, including when they are following each other around a curve or bend in the road.	• The CPS must prevent potential TMM collisions when TMMs are following each other. • The lead TMM may be moving or stationary (e.g. stopped at an intersection). • The CPS must ensure detection of a TMM by another TMM on curves/bends or when the TMMs are not in line-of-sight when there is a significant risk of collision. • No use of operator override/bypass/acknowledge is permitted when operators are following the Traffic Management Plan

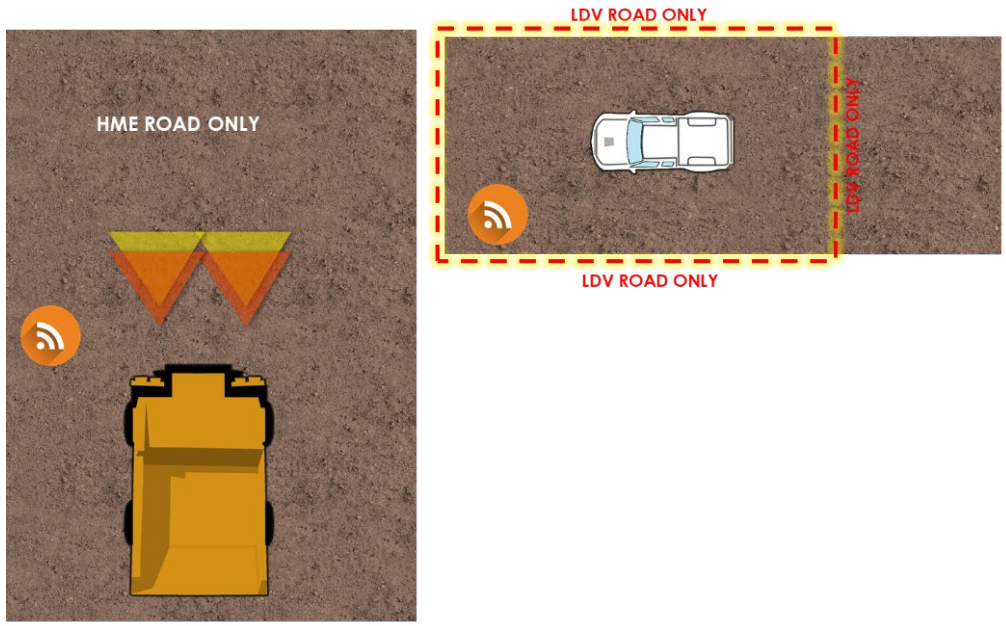
Scenario number	Scenario description	Objective
SM.S4.1	**Overtaking: Slow-moving TMM**  The CPS must prevent collisions between slow moving TMMs and faster TMMs approaching from the rear (similar to SM.S3.1 and SMS.3.2). Operators of the approaching TMM should be allowed to overtake the slow-moving TMM if it is safe to do so. The CPS must prevent near misses due to the passing gap being too small. The CPS must prevent the overtaking TMM from collisions with oncoming traffic (TMMs travelling in the opposite direction).	• The CPS shall prevent TMM collisions when faster moving TMMs must overtake a slower moving TMM. • The CPS must prevent near misses when the passing gap between the slow TMM and the fast TMM is too small. • The CPS must prevent collisions between the overtaking TMM and oncoming traffic. • No use of operator override/bypass/acknowledge is permitted when operators are following the Traffic Management Plan
SM.S4.2	**Overtaking: Broken-down TMM**  It is reasonably foreseeable that a TMM will break down in an area where other TMMs are operating. This may be anywhere on the mine where TMMs operate, including on a haul road, queuing at a pit or dump, at a hard park, etc. A collision between a moving TMM and broken-down TMM may result in siginficant injuries to the occupants. The CPS must prevent collisions between moving TMMs and broken-down TMMs. The CPS must take reasonable measures to ensure that a broken-down TMM is still visible to other TMMs with CPS. The CPS must allow a TMM to pass a broken-down TMM if it is safe to do so. The CPS must prevent near misses if the overtaking TMM passes too close to the broken-down TMM. The CPS must prevent collisions between the overtaking TMM and oncoming traffic.	• The CPS shall take reasonable measures to prevent collisions between moving TMMs and broken-down TMMs. • The CPS shall prevent TMM collisions when a moving TMM overtakes a broken-down TMM. • The CPS must prevent near misses when the passing gap between the moving TMM and the broken-down TMM is too small. • The CPS must prevent collisions between the overtaking TMM and oncoming traffic. • No use of operator override/bypass/acknowledge is permitted when operators are following the Traffic Management Plan

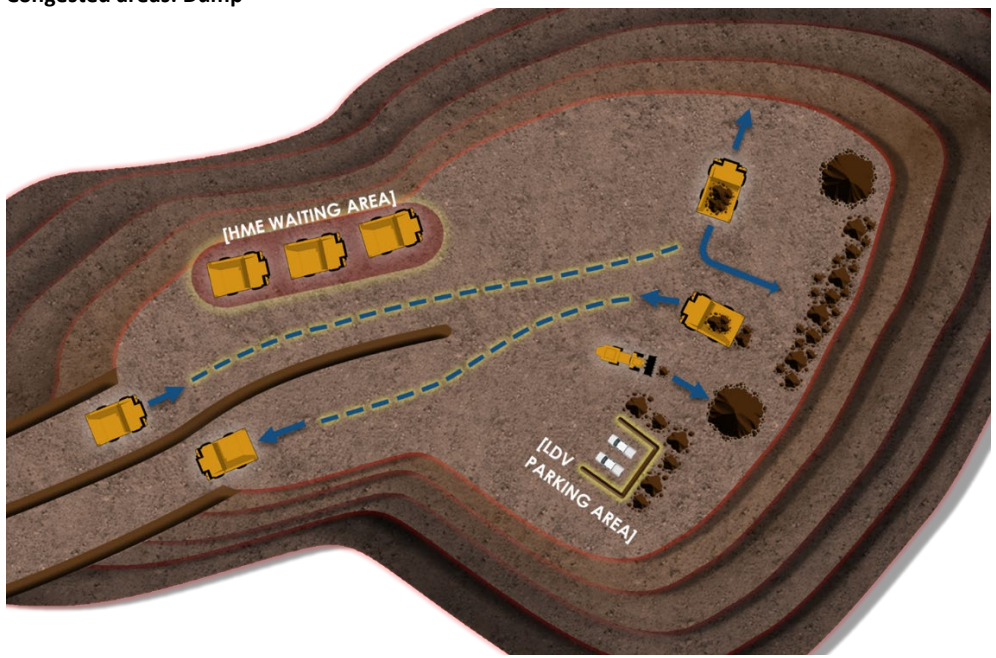
Scenario number	Scenario description	Objective
SM.S5.1	**Head-on: Straight**  TMMs regularly pass each other when driving in opposite directions. The CPS must prevent head-on collisions between TMMs. The CPS must allow TMMs to safely pass each other when there is no significant risk of collision. Mine haul road designs vary, and the CPS should be configurable to the mine specific design.	• The CPS shall prevent potential head-on collisions between approaching TMMs on straight roads • Safe passing distance between passing TMMs must be variable depending on size and speed of TMMs and mine haul road design • No use of operator override/bypass/acknowledge is permitted when operators are following the Traffic Management Plan
SM.S5.2	**Head-on: Curves**  TMMs regularly pass each other when driving in opposite directions. The CPS must prevent head-on collisions between TMMs. The CPS must allow TMMs to safely pass each other when there is no significant risk of collision. Mine haul road designs vary, and the CPS should be configurable to the mine specific design.	• The CPS shall prevent potential head-on collisions between approaching TMMs on curved roads • Safe passing distance between passing TMMs must be variable depending on size and speed of TMMs and mine haul road design • No use of operator override/bypass/acknowledge is permitted when operators are following the Traffic Management Plan

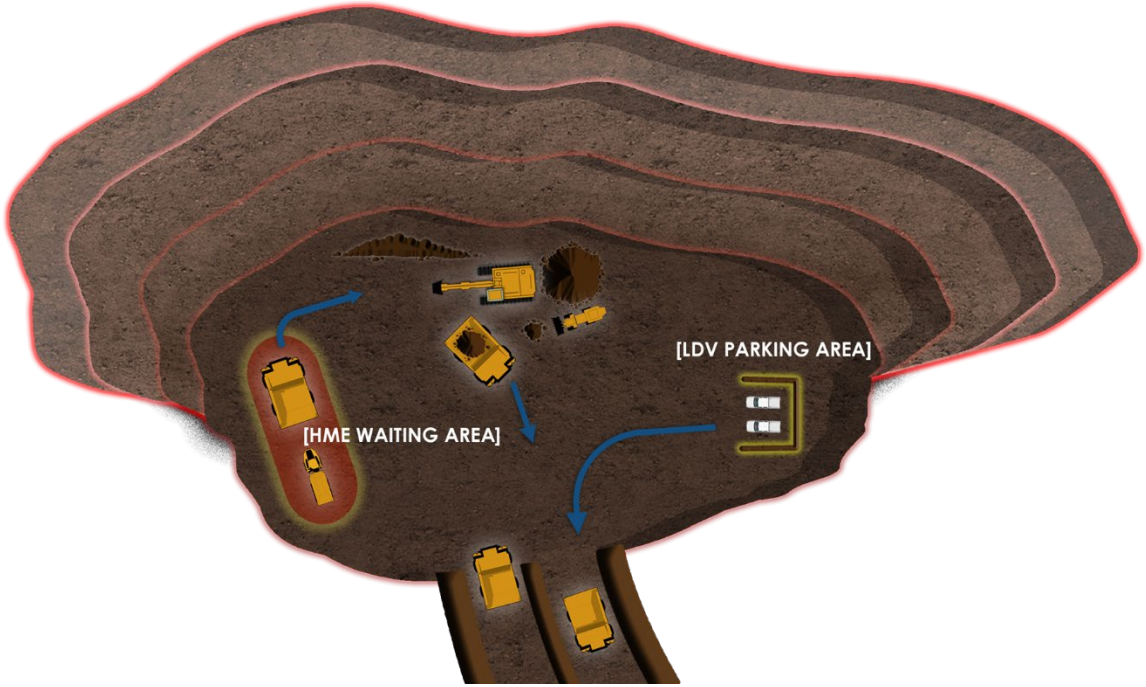
Scenario number	Scenario description	Objective
SM.S6.1	**Intersections: T-junctions**  Intersections typically present areas where TMMs will often interact with each other, frequently with limited line-of-sight due to the presence of berms and other infrastructure. The CPS must prevent collisions at intersections, including preventing a TMM that has stopped at a T-junction from entering a road in front of an approaching TMM.	• The CPS must prevent potential collisions at intersections. • The CPS must provide correct functioning despite the presence of berms and other obstructions limiting line-of-sight. • No use of operator override/bypass/acknowledge is permitted when operators are following the Traffic Management Plan

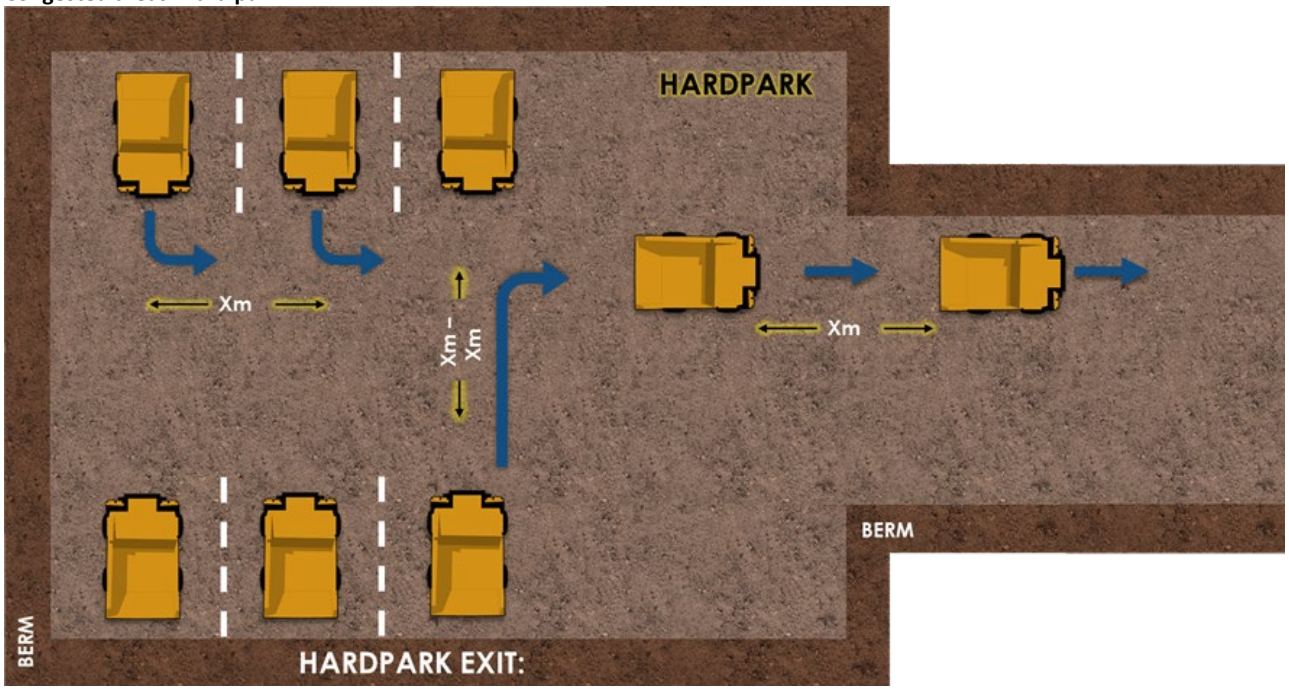
Scenario number	Scenario description	Objective
SM.S6.2	**Intersections: Different TMM types**  Intersections typically present areas where TMMs will often interact with each other, frequently with limited line-of-sight due to the presence of berms and other infrastructure. The CPS must prevent collisions at intersections, including preventing collisions between different types of TMMs (e.g. HMEs and LDVs) when designated roads cross.	• The CPS must prevent potential collisions at intersections, including crossings where different TMM types may interact. • The CPS must provide correct functioning despite the presence of berms and other obstructions limiting line-of-sight. • No use of operator override/bypass/acknowledge is permitted when operators are following the Traffic Management Plan

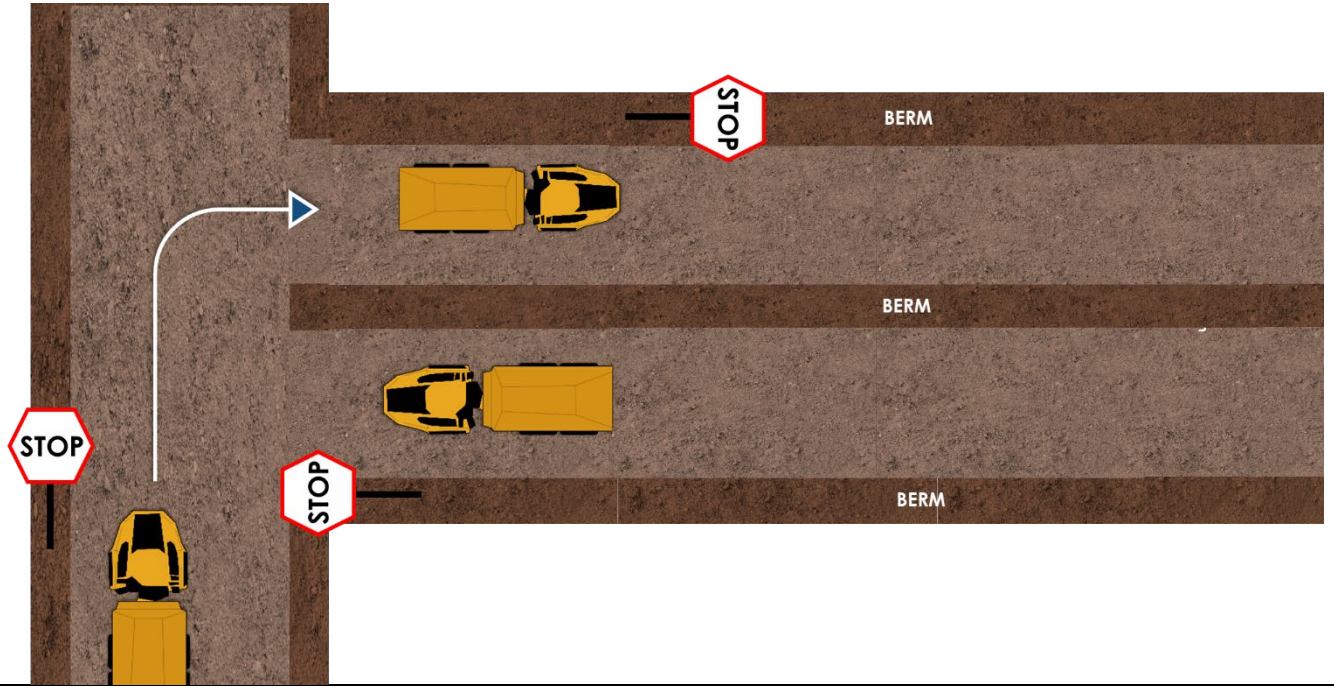
Scenario number	Scenario description	Objective
SM.S6.3	**Intersections: Multiple interactors**  Mine road layouts often necessitate complex intersections or junctions with multiple roads from various directions. Operator sight lines may often be limited or obstructed in these areas. The CPS must prevent collisions at intersections, even in the presence of multiple TMMs arriving at the intersection from various directions.	• The CPS must prevent potential collisions at intersections, including crossings where multiple TMMs from different directions may interact. • The CPS must provide correct functioning despite the presence of berms and other obstructions limiting line-of-sight. • No use of operator override/bypass/acknowledge is permitted when operators are following the Traffic Management Plan

Scenario number	Scenario description	Objective
SM.S6.4	**Intersections: Designated roads/areas**  It is reasonably foreseeable that a surface mining operation will have roads/areas designated for different types of TMMs (e.g. HME roads and LDV roads). There may be areas where designated roads cross each other. The CPS must prevent collisions between all types of TMMs where there is a significant risk of collision at crossings. Operators of all TMMs involved in the potential collision must be effectively warned. If they do not take action as instructed, the CPS must automatically slow down and stop the TMM(s), as applicable, to prevent the collision. Once automatically stopped, the TMMs must enter CPS Stop. TMMs may only move if there is no significant risk of collision (e.g. the TMM at risk has moved out of the vicinity by reversing).	• The CPS must prevent collisions between different types of TMM if there is a significant risk of collision. • All operators involved in the potential collision must receive an effective warning. • The applicable TMM(s) must automatically slow down and stop if the operator(s) do not heed the warning. • No use of operator override/bypass/acknowledge is permitted when operators are following the Traffic Management Plan

Scenario number	Scenario description	Objective
SM.S7.1	**Congested areas: Dump**  The CPS must ensure that normal mining processes can continue without relying on manual override by the TMM operator. The CPS must ensure that significant risk of injury due to collisions between TMMs in congested working areas is prevented. A dump area will typically involve multiple haul trucks, a bulldozer, several LDVs and other support TMMs such as a water bowser, maintenance truck, etc. The CPS design must take the mine Traffic Management Plan into consideration to ensure that normal operation can continue as intended when there is no significant risk of collision. The CPS shall consider reasonably foreseeable scenarios within the dump area, such as: • TMMs queueing at the entrance • TMMs manoeuvering into position • A break-down ocurring in the dump area • LDVs entering and departing the dump area • Maintenance and support TMMs entering the area (e.g. dust supression unit, refuelling bowser, etc.). • Bulldozer moving dumped material into stockpiles • Front End Loaders loading smaller TMMs with material • Smaller TMMs (such as ADTs) transporting material for further processing (e.g. to the crusher/conveyor)	• The CPS must ensure the maximum speed limit inside the dumping area is adhered to. • The CPS shall prevent potential TMM collisions during dumping operations • The CPS shall prevent collisions between different types of TMMs in congested areas. • CPS shall allow normal operations to continue if there is no significant risk of collision that may lead to injuries. • No use of operator override/bypass/acknowledge is permitted when operators are following the Traffic Management Plan

Scenario number	Scenario description	Objective
SM.S7.2	**Congested areas: Pit**  The CPS must ensure that normal mining processes can continue without relying on manual override by the TMM operator. The CPS must ensure that significant risk of injury due to collisions between TMMs in congested working areas is prevented. A pit/loading area will typically involve multiple haul trucks, a bulldozer, several LDVs and other support TMMs such as a water bowser, maintenance truck, etc. The CPS design must take the mine Traffic Management Plan into consideration to ensure that normal operation can continue as intended when there is no significant risk of collision. No use of operator override/bypass/acknowledge is permitted when operators are following the Traffic Management Plan as intended. The CPS shall consider reasonably foreseeable scenarios within the loading area, such as: • TMMs queueing at the entrance • TMMs manoeuvering into position in close proximity to a shovel or front end loader • A break-down ocurring in the pit/loading area • LDVs entering and departing the pit/loading area • Maintenance and support TMMs entering the area (e.g. dust supression unit, refuelling bowser, etc.). • Bulldozer moving cleaning spillage	• The CPS must ensure the maximum speed limit inside the pit/loading area is adhered to. • The CPS shall prevent potential TMM collisions during loading operations • The CPS shall prevent collisions between different types of TMMs in congested areas. • CPS shall allow normal operations to continue if there is no significant risk of collision that may lead to injuries. • The CPS shall not require operator override/bypass/ acknowledge to perform normal mining activities. • No use of operator override/bypass/acknowledge is permitted when operators are following the Traffic Management Plan

Scenario number	Scenario description	Objective
SM.S7.3	**Congested areas: Hard park**  The CPS must ensure that normal mining processes can continue without relying on manual override by the TMM operator. The CPS must ensure that significant risk of injury due to collisions between TMMs in congested working areas is prevented. A hard park will typically involve multiple TMMs in close proximity. The CPS design must take the mine Traffic Management Plan into consideration to ensure that normal operation can continue as intended when there is no significant risk of collision. No use of operator override/bypass/acknowledge is permitted when operators are following the Traffic Management Plan as intended. The CPS shall consider reasonably foreseeable scenarios within the hard park, such as: • TMMs queueing at the entrance • TMMs manoeuvering into position (reverse parking) • Multiple TMMs departing at the same time (e.g. at shift change) • A break-down ocurring in the hard park • Maintenance and support TMMs entering the area (e.g. LDV, dust supression unit, refuelling bowser, etc.).	• The CPS must ensure the maximum speed limit inside the hard park is adhered to. • CPS will allow for orderly TMM entrance and departure, including when multiple TMMs want to enter and exit (such as at start and end of shift). No false positives. • Collisions will be prevented between all types of TMMs at significant risk of collision within the hard park • No use of operator override/bypass/acknowledge is permitted when operators are following the Traffic Management Plan

Scenario number	Scenario description	Objective
SM.S7.4	**Congested areas: Ramp** 	• The CPS must ensure the maximum speed limit on the ramp is adhered to. • The CPS shall prevent potential TMM collisions on a ramp, going up or down the ramp. • The CPS shall prevent collisions between different types of TMMs in congested areas. • CPS shall allow normal operations to continue if there is no significant risk of collision that may lead to injuries. • The CPS shall not require operator override/bypass/ acknowledge to perform normal mining activities. • No use of operator override/bypass/acknowledge is permitted when operators are following the Traffic Management Plan
SM.S7.5	**Congested areas: General** The CPS must ensure that normal mining processes can continue without relying on manual override by the TMM operator. The CPS must ensure that significant risk of injury due to collisions between TMMs in congested working areas is prevented. No use of operator override/bypass/acknowledge is permitted when operators are following the Traffic Management Plan as intended.	• The CPS shall prevent collisions in TMM congested areas • No use of operator override/bypass/acknowledge is permitted when operators are following the Traffic Management Plan