INDEPENDENT VERIFICATION TEST SPECIFICATION FOR UNDERGROUND COLLISION PREVENTION SYSTEMS (CPS): TRL7 STAGE GATE

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

REV 1

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Definitions and abbreviations

Table 1 defines terms and abbreviations used in this document.

Table 1: Abbreviations and their definitions appearing in this document

Abbreviation	Definition
CAN bus	Controller Area Network bus
CDI	CxD Interface
CLK	CxD Log keeping
CoC	Certificate of Compliance
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 Developer	The organisation selected for each CPS to act as the single entity to coordinate the development and testing of the specific CPS.
CPS Stop	The state when the CxD intervenes with the intent of stopping or keeping the TMM stationary to avoid a collision or FTSWHI. This is the end state after a CPS intervention, reached by the CxD instructing the TMM to stop via the ISO/TS 21815-2:2021 CAN-bus interface.
CPS Slow	The state when the CxD intervenes with the intent of stopping or keeping the TMM stationary to avoid a collision or FTSWHI. This is the end state after a CPS intervention, reached by the CxD instructing the TMM to stop via the ISO/TS 21815-2:2021 CAN-bus interface, or by the TMM slowing and stopping due to FTSWHI.
CSD	CxD Self-diagnostics
CxD	Collision Warning and Avoidance System device (CxD): Device with sensors providing collision warning and avoidance functions, to detect objects in the vicinity of the machine, assess the collision risk level, effectively warn the operator of the presence of object(s) and/or provide signals to the machine control system, to initiate the appropriate interventional collision avoidance action on the machine, to prevent the collision. Note to entry: Proximity Detection System (PDS) is a colloquial industry term for a physical device, providing a warning or collision avoidance functionality.
CxDC	CxD Controller
CxDI	CxD interface: A integration function between the CxD and the Machine Controller.
CLK	CxD Log keeping
DAQ	Real time computer with data acquisition and control capabilities. Has ISO21815 interface. Example: dSPACE MABX III.
DTS	Detection and Tracking System
EMC	Electromagnetic compatibility
EW	Effective Warning
F&TPR	Functional and Technical Performance Requirements
FTSWHI	Fail to Safe Without Human Intervention
HME	Heavy Mining Equipment
HP INSS	High Precision Inertial Navigation Satellite System, capable of measuring position, with an absolute accuracy of 0.1m and velocity to within 0.2km/h with an update rate of 100Hz. Example Racelogic VBOX 3i.
ID	Identifier.
Interface	A boundary across which two independent systems meet and act on or communicate with each other. Two examples are: 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 or pedestrian) and the CxD or pedestrian warning 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.
LDV	Light duty vehicle
MBS	Machine Braking System: The physical components that makes an unintelligent TMM intelligent and enables the CPS auto slow-down and stop functionality.

Abbreviation	Definition
MCI	Machine Control Interface: The interface between the Machine Controller and the CXD interface.
MHSACT	Mine Health and Safety Act No. 29 of 1996 and Regulations.
MOSH	Mining Industry Occupational Safety and Health Initiative
MSDS	Material Safety Data Sheet
OWS	Operator warning subsystem the device in the vehicle that warns the operator of potential collisions
PWS	Pedestrian Warning System the device that provides a warning to a pedestrian
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 prevented from moving. The TMM is not operational.
SAMI	South African Mining Industry.
Stage gate	A step in the testing regime / process where the CPS product system is tested against acceptance criteria, the failure of which would limit the CPS product system from moving to the next step in the regime / process.
System	A combination of interacting elements organized to achieve one or more stated purposes (ISO/IEC/IEEE 2015).
TMM	Trackless Mobile Machine. (Machine, vehicle, etc.) as defined in MHSAct
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 Emulator	A TMM emulator is system that behaves like a real TMM, enabling the TMM emulator to integrate with a CxD without compromising the performance of the CxD.
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).
TV	Test Vehicle: A vehicle used to conduct the verification scenarios specified in DTS, EW and CxDC test protocols
UG	Underground: Indicating that a specific aspect is applicable to underground TMMs/operations.

1 Introduction

This document is intended for Underground (UG) Collision Prevention Systems (CPS) to be used in the South African Mining Industry (SAMI).

The document is one of the documents in the Mining Industry Occupational Safety and Health Initiative (MOSH) Collision Prevention Systems (CPS) guideline. 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]. This document must be read in conjunction with the CPS Requirements Verification Regime. The CPS Requirements Verification Regime sets out the rationale for requirements verification, independent verification Stage Gates and describes the end-to-end verification steps. Figure 1 depicts the CPS Requirements Verification Regime.

This document covers the Independent Verification Test for UG CPS (TRL7 Stage Gate), shown in purple in Figure 1.

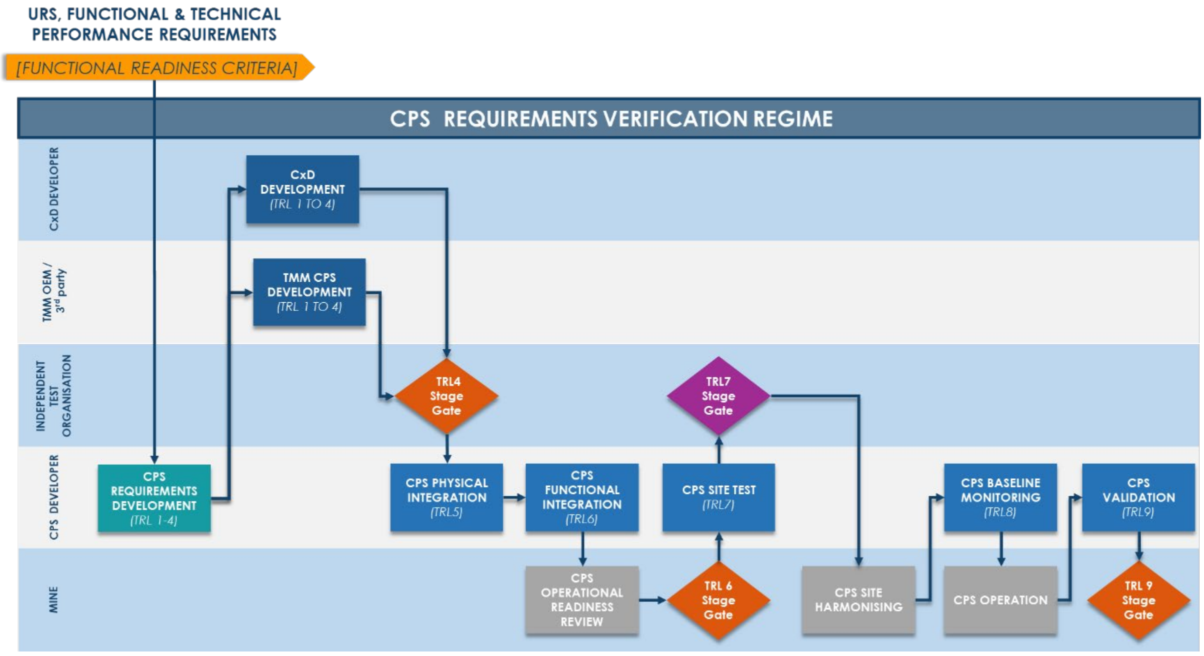

Figure 1: CPS requirements verification regime

This document is an update of the original CPS Test Specification published in November 2022. The original document contained all the Surface and Underground CPS tests and was based on the test regime as initially planned. For user convenience, the independent verification test specifications are now structured as independent documents for surface and underground. Refer to the CPS Requirements Verification Regime Section 9 for the CPS documentations containing requirements to be verified.

Figure 2 shows the UG CPS verification test regime. The UG CPS product verification tests (Stage Gates) as shown in Figure 2 are:

1. CPS product independent verification Testing (CxD and TMM CPS) in a controlled environment (e.g., a laboratory or a proving ground), referred to as Technology Readiness Level 4 (TRL4) tests.

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

2. CPS testing in a representative, but controlled environment (e.g., in a test mine or a cordoned off section of an active mine), referred to as TRL7 tests.
3. CPS validation testing in the operational environment (e.g. monitoring the performance of a CPS over a period of time at an active mine), referred to as TRL9 tests.

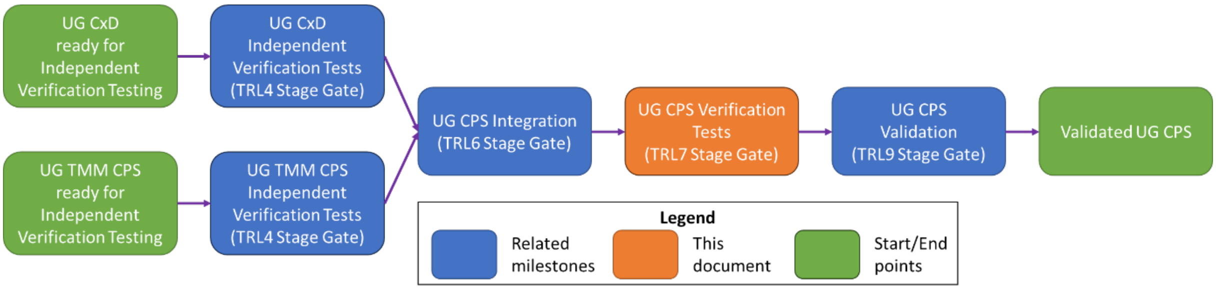

Figure 2: UG CPS requirements verification regime

2 Context

As part of the MOSH CPS guideline, extensive documentation has been prepared to describe the user requirements, functional and technical performance requirements and independent test specifications for UG CPS products. Figure 3 shows the document structure defining the MOSH guideline towards conformant UG CPS products.

User Requirements Specification
- UG CPS

Functional and Technical Performance Requirements
- UG CxD
- UG TMM CPS

Readiness Criteria
- Readiness Criteria For Collision Prevention System Development And Deployement

Requirements Verification Regime
- CPS Requirements Verification Regime

Independent Verification Specifications
- UG CxD TRL4 Stage Gate
- UG TMM CPS TRL4 Stage Gate
- **UG CPS Verification TRL7 Stage Gate (this document)**

Figure 3: UG CPS functional testing related documentation

This document is the UG CPS Independent Verification Test specification (TRL7 Stage Gate) and builds on the User Requirement Specification (URS) for UG CPS, the Functional and Technical Performance Requirements (F&TPR) for UG CxDs, and the F&TPR for Trackless Mobile Machine Collision Prevention Systems (TMM CPS). The purpose of this document is to provide a single test specification to assess the functionality of UG CPS in accordance with the applicable URS and F&TPRS. Tests documented herein are verification tests and are intended for representative test environments, such as a cordoned off test area on a UG mine. The intent of these tests is to verify that the integrated CPS, consisting of both the CxD and TMM CPS, performs as required in a representative environment. The tests are appropriate for TRL 7 and the TRL 7 Stage Gate.

This specification must be considered in conjunction with[2]:

- The URS for UG CPS
- The CPS F&TPR Specification for UG CxDs
- The CPS F&TPR Specification for UG TMM CPS
- CPS Requirements Verification Regime
- CPS Readiness Criteria
- The Independent Verification Test Specification for UG CxD.
- The Independent Verification Test Specification for UG TMM CPS.

Despite the importance of these tests, successful completion of the tests described in this document neither guarantees that a CPS will prevent all collisions under all circumstances, nor does it guarantee that a CPS will be deemed compliant with the Mine Health and Safety Act and Regulations. Successfully completing the tests in this document independently confirms conformance to the set requirements and provide confidence that a CPS is ready for site harmonisation and baseline on-site monitoring.

3 CPS Independent Verification Testing

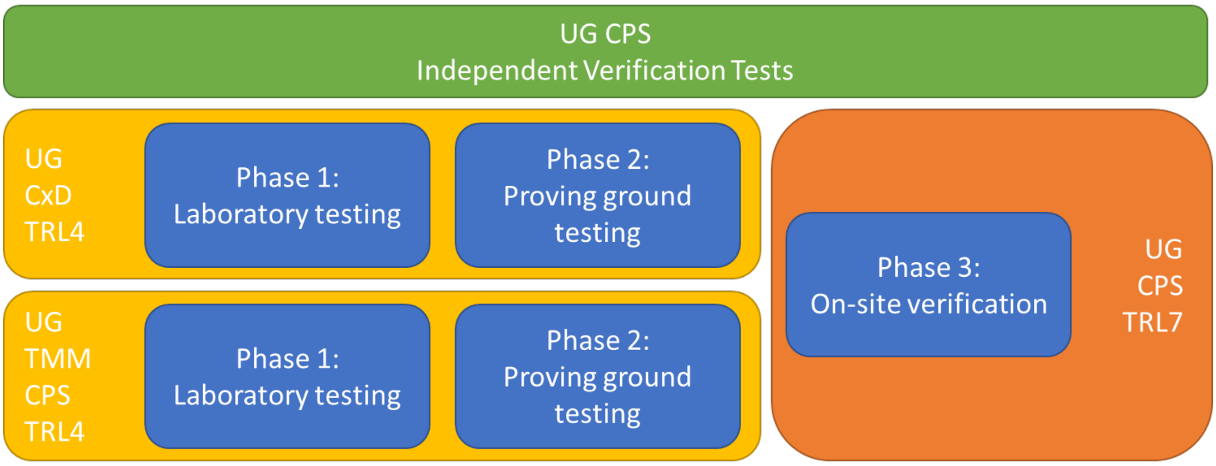

Figure 4: UG CPS independent verification test regime

CPS independent verification testing is done in three stages, **laboratory, proving ground** and **on-site**:

- **Phase 1:** Laboratory testing (independent 3rd Party laboratory) and
- **Phase 2:** Proving ground testing (independent 3rd party tests at a proving ground)
- **Phase 3:** On-site verification (independent 3rd party goes to a suitable area, such as a mine site, where the integrated CPS is ready for testing)

The following tests are done for **Phase 1: Laboratory tests (TRL4)**

- UG CxD Interface Test - the ISO/TS 21815-2: 2021 test
- UG CxD Log Keeping Test
- UG CxD Self-Diagnostic Test
- UG TMM CPS Machine Controller Interface Test - the ISO/TS 21815-2: 2021 test
- UG TMM CPS Machine Log Keeping Test

2 Available at https://www.mosh.co.za/transport-and-machinery/documents

Phase 1 tests are bench-top tests, typically conducted in a laboratory environment with suitable emulators.

The following tests are done for **Phase 2: Proving Ground tests (TRL4)**

- ICASA Type Approval demonstration. All relevant suppliers submit their ICASA certificates.
- EMC demonstration, as applicable (consult with an accredited EMC test laboratory). All relevant suppliers submit their EMC certificates.
- UG CxD Detection and Tracking Test
- UG CxD Effective Warning Test
- UG CxD Controller Test
- UG TMM CPS Machine Self-Diagnostic Test
- UG TMM CPS Machine Sensing Test
- UG TMM CPS Machine Controller Test

Phase 2 tests are done at a proving ground, typically at Gerotek Test Facilities. The Phase 2 tests are done with light vehicles, allowing for safe and repeatable testing within a short timeframe.

The following tests are done for **Phase 3: On-site UG CPS tests (TRL7)**

- UG CPS Integration Test
- UG CPS Representative Environment Test

Phase 3 tests are done with a fully integrated CPS in a **representative** environment, such as a cordoned-off area of a mine. This document describes the test procedures for Phase 3 tests.

4 TRL7 Stage Gate

TRL 7 Stage Gate testing is done with actual TMMs in a representative environment. The tests are therefore riskier than the TRL4 tests. It is a prerequisite that the TRL4 Stage Gate independent verification was passed. The UG CPS Independent Verification Test (TRL7 Stage Gate) consists of two functional test protocols, each with a specific purpose, test prerequisites, test instrumentation, preparation, test method and acceptance criteria. Ideally, a CPS will be submitted for testing against both the CPS verification tests in one go with no changes/adjustments required between tests. However, to enable flexibility, the test regime makes provision for conducting the two functional tests at separate locations and different times.

Figure 5 shows the TRL7 Stage Gate process. Each test is preceded by a pre-test check. The intent of the pre-test check is to confirm if any significant changes to the CxD or TMM CPS have affected previous test results. Here, the responsibility is placed on the CPS Developer to clearly indicate any changes made since the previous test. It is left to the discretion of the test engineer responsible for the verification test to decide if a CxD or TMM CPS passes the pre-test check and that it may proceed with the subsequent TRL7 test.

After completing a test, two results are possible: Accept, and Reject.

- Accept: An Accept result indicates that, on the day of testing, the CPS under test conformed to all the requirements of that specific test.
- Reject: A Reject result indicates that there are significant shortcomings that need to be rectified before testing can proceed.

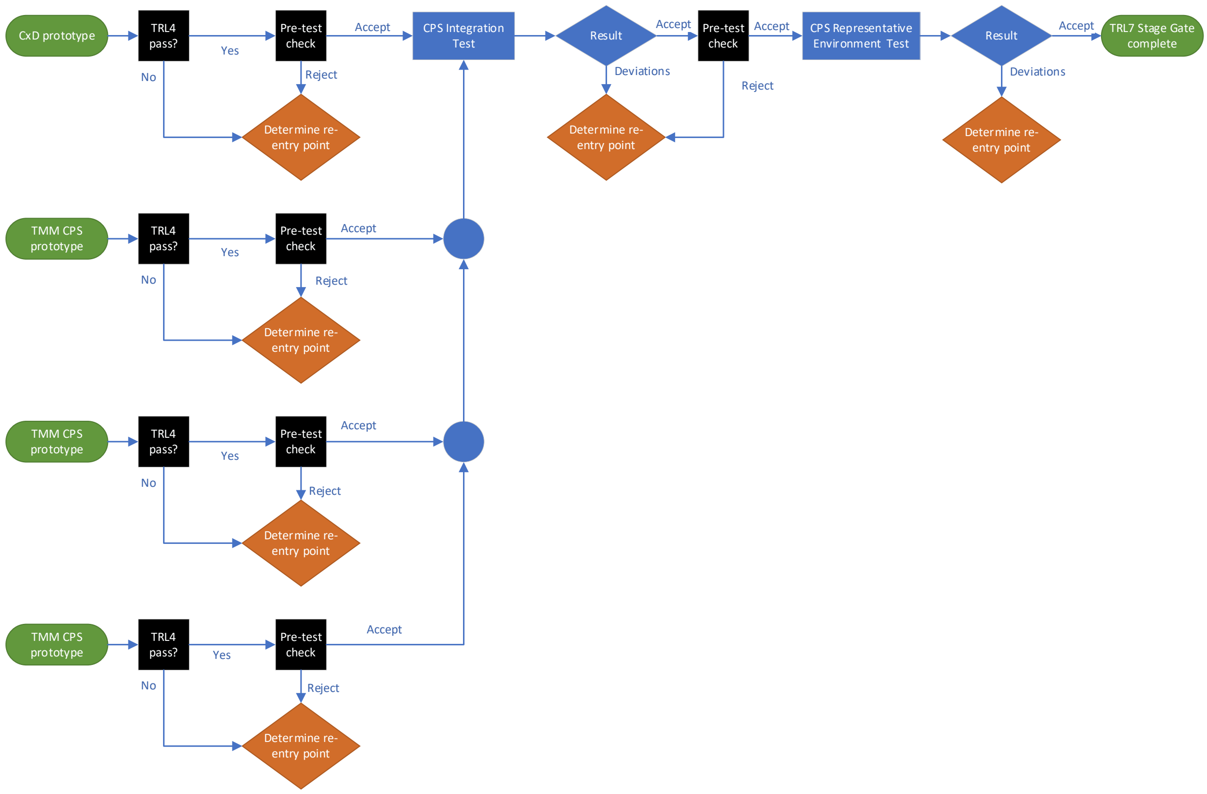

Figure 5: UG CPS TRL7 Stage Gate process

5 Verification test report structure

Two categories of reports are prepared subsequent to verification tests:

1. Stage gate reports
2. Technical test reports

Stage gate reports indicate the high-level progress of a CPS system against the various CPS independent verification tests. The intent of stage gate reports is to give concise information to a non-technical audience of a CPS system's conformance to the F&TPR for UG CPS. Stage gate reports summarize the findings and recommendations of the technical test reports for that specific stage. The stage gate report also highlights critical information that may affect later stage gate tests.

Technical test reports are detailed technical reports providing the specifics of CPS independent verification tests. The intent of technical test reports is to provide detailed feedback to the CPS product suppliers/CPS Developer. Technical test reports are extensive and are intended for a technical audience.

Figure 6 shows the test report structure pertaining to UG CPS verification testing.

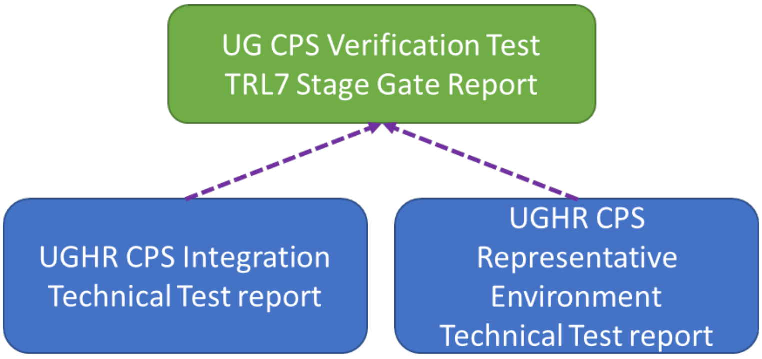

Figure 6: UG CPS verification test report structure

6 TRL 7 Independent Verification test readiness

It is acknowledged that CPS product developers / suppliers have performed many functional tests over the past few years. CPS product suppliers are expected to do extensive in-house tests to verify conformance of its products. Independent verification testing is a reasonably practicable measure to ensure that mining employees are not injured as a result of TMM collisions. It is not the intention or a requirement of the project to have any CPS and/or product re-tested. The onus of such decision is entirely up to the CPS Developer or product supplier to demonstrate conformance to the MOSH CPS functional requirements. A CPS developer or any of its product providers can certify readiness at any given Stage Gate, together with all the information to demonstrate conformance. Such demonstration must include all the relevant functional readiness criteria as defined for all relevant Stage Gates as well as specific results against each function's performance criteria.

Where a CPS Developer or product supplier certifies its CPS product(s)for a specific Stage Gate, it must demonstrate conformance to the readiness criteria of all **prior** Stage Gates, as applicable. It is the responsible legal appointees' responsibility to judge acceptance and take associated responsibility thereof.

With reference to the CPS Requirements Verification Regime, it is important that passing all prior Stage Gates is a prerequisite for conducting the TRL7 Stage Gate. Part of the readiness check will be reviewing the TRL 6 Certificate of Compliance (CoC) to be issued and signed-off by the CPS Developer..

7 Verification test instrumentation

Since the tests documented here are independent verification tests, accurate and reliable instrumentation is a minimum requirement. Various measurements are collected during testing. Table 2 documents the root mean square (RMS) accuracy required of the instrumentation to be used when conducting the independent verification tests in this document. Independent 3rd party verifiers need to ensure that instruments are properly maintained and have valid calibration certificates, as directed by the instrument suppliers.

Table 2: Verification test instrumentation specification

Instrument	State	Accuracy (RMS)
High-precision INSS (HP INSS)	Velocity	0.1 km/h
	Update rate	100 Hz
	Position	0.3 m 95 % CEP
	Heading	0.1°

	Angle	0.1°
Laser range finder or tape measure or similar	Maximum range	50.0 m
	Minimum range	1.0 m
	Accuracy	0.1 m

For the purpose of TRL7 tests the CPS Developer can use instrumentation such that it will provide the CxD and TMM CPS product suppliers with the confidence to submit the CPS for independent verification.

8 Test Protocols

The UG CPS Independent Verification (TRL7 Stage Gate) test protocols are documented in Appendices 1 and 2.

In preparation for each test, the CPS Developer will be required to complete a CPS information sheet. The goal of the CPS information sheet is to:

1. Describe the CPS and its constituting products to ensure that the specifics are accurately reflected in the test reports.
2. Provide a formal sign-off to confirm that the system under test is fully functional and properly commissioned. The integrated system is considered ready for testing.

The CPS information sheet is available in Appendix 3.

Appendix 4 documents a safety protocol to be followed prior to each test. The aim of the safety protocol is to ensure the safety of the test team and observers.

Appendix 1: UG CPS Integration Test

Purpose

Having been successfully tested separately, the CxD and TMM products/subsystems are integrated to form the complete Collision Prevention System (CPS). The UG CPS integration test is conducted to verify the full compatibility and interoperability of the products/subsystems, which are provided by the two different suppliers. Successful completion of this test ensures the integrated system performs as expected and is a critical prerequisite for introducing the CPS to the mine operations with the least risk.

Preceding verification

1. TRL4 UG CxD Independent Verification Tests
2. TRL4 UG TMM CPS Independent Verification Tests
3. TRL6 Operational Readiness Independent Verification

Test facility/site

The site must be appropriately sized for the test being conducted. Tests are highly dynamic and adequate space for run-up, interaction and run-off is required. The site should have:

- An area with a level, even, hard surface where straight-line, dynamic brake tests can be performed.
- A decline ramp with a gradient of at least 10 % where dynamic brake tests can be performed.

Instrumentation

1. 1x test TMMs with CxD commissioned (TMM1)
2. 1x HP INSSs
3. 1x DAQs with CAN interface
4. 1x laser range finder
5. 2x Pedestrian warning system (PWS) units
6. 1x mannequin onto which PWS is fitted during test

Test preparation

1. The CPS Developer will supply the complete CPS (TMM CPS integrated with CxD) in working order.
2. A CPS Developer will submit the signed CPS test information sheet (Appendix 3) to the test engineer prior to testing. All preceding tests as stipulated in the Preceding Verification Tests section must be completed and accepted. No modifications to any aspect of the CPS will be allowed once testing has commenced.
3. CPS Developer will submit latest revision of Section 21 Technical File, including relevant supporting documentation (e.g. ICASA T/A, brake performance test results, EMI/EMC tests, Certificates of Compliance (COCs), TMM OEM approvals, mine approvals, etc.[3]).
4. Cordoned off test area, and a test responsible person that will ensure all aspects in the test safety protocol are adhered to.

[3] See Section 21 Technical File Information Framework, available at www.mosh.co.za/transport-and-machinery/documents

5. Installation of HP INSSs on both TMMs and ensure good satellite reception is obtained.
6. Ensure all personnel, equipment and all obstacles are removed in front and behind the TMMs.

Test method and acceptance criteria

For all of the following scenarios the following General CPS acceptance criteria (AC) will apply. These criteria should be read in conjunction with any specific criteria in any of the test procedures in this test protocol

Table 3: General CPS acceptance criteria, to be read in conjunction with any test specific criteria in this test protocol

AC No.	Criteria	Func. Req. No.
UG.CPS.7.1.AC.0.1	2.5s - 3.0s EW time before automatic slow down and stop intervention	UG.CxDC.08.1 UG.CxDC.08.2
UG.CPS.7.1.AC.2	2.5m - 3.0m stop gap (shortest distance from TMM to nearest pedestrian) for all UG interaction scenarios Stop gap will depend on correct configuration of CxD to accommodate test vehicle MBS • TMM condition (e.g. brake wear, tyre wear) must be considered when determining the vicinity boundary • TMM specific brake performance to be considered and configured • TMM size and shape (footprint) considered and configured • TMM movements & attachments considered and configured	UG.CxDC.02 UG.CxDC.03 UG.CxDC.05 UG.CxDC.06 UG.CxDC.07
UG.CPS.7.1.AC.3	No false interventions and false warnings	UG.CxDC.09
UG.CPS.7.1.AC.4	EW and CPS Stop successfully initiated in all cases Intervention strategy must use TMM capability as reported by TMM during ISO21815-2:2021 capability discovery. Intervention strategy to be consistent and repeatable	UG.CxDC.10
UG.CPS.7.1.AC.5	No movement of TMM when pedestrian within the vicinity and TMM is stationary Vicinity is determined by readily available TMM information indicating operator's intended action	UG.CxDC.12
UG.CPS.7.1.AC.6	CxDC must allow TMM to return to Normal Operation if there is no significant risk of collision as per the mine's standard operating procedure	UG.CxDC.20

1. CxD adaption to TMM performance parameters

The CxD should be configurable to the TMM's performance parameters. The CPS developer should provide documentation to explain the parameters that have been applied for this TMM, why they were chosen and how they consider the criteria.

Table 4: CxD adaptation to TMM performance parameters acceptance criteria

AC No.	Criteria	Func. Req. No.
UG.CPS.7.1.AC.1.1	TMM condition (e.g. brake wear, tyre wear) must be considered when determining the vicinity boundary	UG.CxDC.06
UG.CPS.7.1.AC.1.2	TMM specific brake performance to be considered and configured TMM size and shape (footprint) considered and configured TMM movements & attachments considered and configured	UG.CxDC.07

2. Fail to safe for communication and power interruption

This test is used to verify the correct functioning of the CPS fail-to-safe without human intervention (FTSWHI) when the power to the CxD and CAN communication are interrupted. (Full self-diagnostics can only be verified during operation of the CPS)

2.1. Start recording ISO/TS 21815-2 messages

2.2. With the TMM stationary Release the Park Brake

2.3. Perform the following actions:
1.1.1 Disconnect Power from the CxD
1.1.2 Disconnect the CAN communication cable
2.4. For each action:
1.1.3 Instruct operator to take-off in FWD and ensure locomotion is prevented
1.1.4 Instruct operator to take-off in REV and ensure locomotion is prevented
1.1.5 Instruct operator to use attachment and ensure attachment movement is prevented
1.1.6 Instruct operator to articulate machine and ensure articulation is prevented
2.5. Repeat 3 times for each action

Table 5: Communication and CxD power FTSWHI acceptance criteria

AC No.	Criteria	Func. Req. No.
UG.CPS.7.1.AC.2	Be able to monitor the health of all CPS products. As per supplier FMECA. Detection of critical failure leads to FTSWHI response.	UG.DT.4.1

3. Override

This test is used to verify the correct functioning of the CPS before and after CxD and TMM CPS overrides are activated.

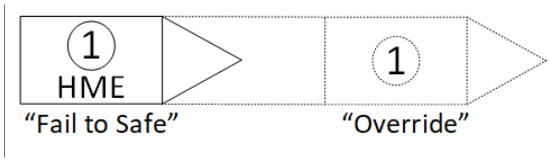

Figure 7: CPS override test configuration

3.1. TMM1 with paired operator is stationary with Normal Operation active.

3.2. **Stage 1: Override inactive**
1.1.7 Induce a failure that will result in FTSWHI on the CxD and STAND_DOWN active.
1.1.8 Expected behaviour:
1.1.8.1 OWS inside TMM1 has EW and STAND_DOWN active.

3.3. **Stage 2: Override active**
1.1.9 Activate the following overrides on TMM1:
1.1.9.1 CxD Maintenance Override.
1.1.9.2 TMM CPS Maintenance Override.
1.1.9.3 TMM CPS Emergency Override.
1.1.10 Expected behaviour:
1.1.10.1 Authentication to activate Maintenance Override.
1.1.10.2 Operator cannot activate Maintenance Override
1.1.10.3 OWS inside TMM1 clearly indicates override active.
1.1.10.4 CxD uses BYPASS_PROPULSION to indicate CxD Maintenance Override.
1.1.10.5 TMM CPS MCI indicates Override on the data message.
1.1.10.6 TMM CPS speed is limited to <5 km/h.
1.1.10.7 Emergency override is limited to <5 min
3.4. Repeat 3 times for each type of override.

Table 6: Override acceptance criteria

AC No.	Criteria	Func. Req. No.
UG.CPS.7.1.AC.3.1	Conforms to requirements of Table 3	See Table 3
UG.CPS.7.1.AC.3.2	Credentials required to activate maintenance override Maintenance override implemented as specified in ISO 21815-1:2022	UG.CxDC.21
UG.CPS.7.1.AC.3.3	BYPASS_PROPULSION is used to indicate override	UG.CxDI.07.4
UG.CPS.7.1.AC.3.4	All override methods limit machine speed to < 5 km/h for all test runs	UG.MC.6 UG.MC.9 UG.MC.10
UG.CPS.7.1.AC.3.5	Emergency Override time limit of 5 min or less. Emergency Override time limit is configurable as per mine requirements	UG.MC.6 UG.MC.9

4. Speed limits

This test is used to verify the correct functioning of the CPS when the TMM is driven into a speed-limited zone and when the design speed limit is exceeded.

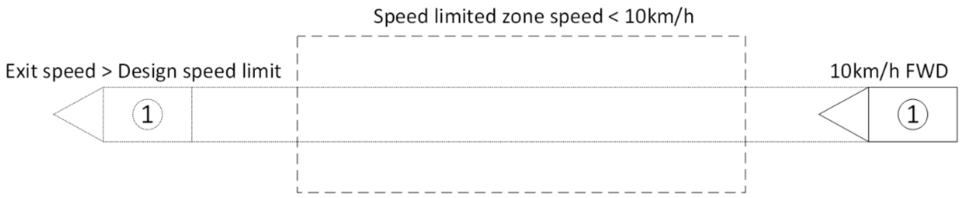

Figure 8: Speed limits test configuration

4.1. Set up the test area as depicted in the figure
4.2. Set up a speed-limited zone
4.3. Record the GPS position of the zone border
4.4. TMM1 with paired operator PWS is outside the speed zone
4.5. **Stage 1: Vehicle entering speed limit zone**
4.5.1. Drive TMM1 towards the edge of the speed-limited zone at 10km/h
4.5.2. Expected behaviour:
4.5.2.1. TMM1 has EW
4.5.2.2. TMM1 has CPS Slow active before entering the speed-limited zone
4.5.2.3. Operator PWS has no EW
4.6. **Stage 2: Vehicle driving in zone**
4.6.1. Drive TMM1 through the speed-limited zone at or below the speed limit
4.6.2. Expected behaviour:
4.6.2.1. TMM1 has speed limit indicated on OWS while in the speed-limited zone
4.6.2.2. Operator PWS has no EW
4.7. **Stage 3: Exceed design speed limit**
4.7.1. Drive TMM1 away from the speed-limited zone and try to exceed the design speed limit
4.7.2. Expected behaviour:
4.7.2.1. TMM1 has EW
4.7.2.2. TMM1 has CPS Slow active when operator attempts to exceed design speed limit
4.7.2.3. Operator PWS has no EW
4.8. Repeat all stages in sequence, 3 times

Table 7: Speed limit acceptance criteria

AC No.	Criteria	Func. Req. No.
UG.CPS.7.1.AC.4.1	Conforms to requirements of Table 3	See Table 3
UG.CPS.7.1.AC.4.2	Speed-limited in demarcated congested areas	UG.CxDC.13
UG.CPS.7.1.AC.4.3	CxDC must ensure the TMM stays at or below the CPS Design Speed Limit	UG.CxDC.19

5. Detection Robustness

This test is used to ensure that the CPS will detect a pedestrian in all working positions on a real vehicle.

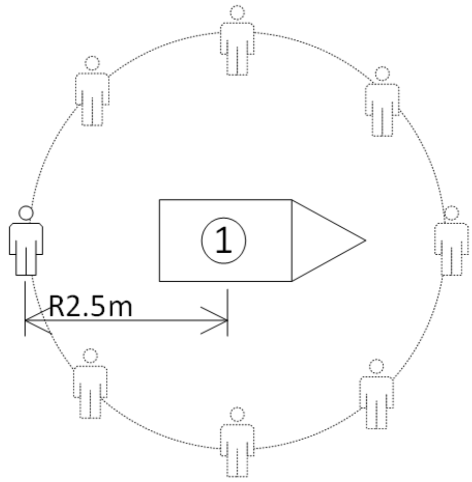

Figure 9: Speed limits test configuration

5.1. Have the operator position TMM1 centre of the intersection

5.2. Instruct the operator to move any attachments to common positions as described in Appendix 3.

5.3. Have a single pedestrian walk slowly around TMM1 at a 2.5m radius.

5.4. Position the pedestrian safely at the side of the vehicle then instruct to operator to try to move the machine, articulate the machine, and move any attachment that is available.

5.5. Repeat for all common attachment positions.

5.6. Expected behaviour:

5.6.1. TMM1 has EW and CPS Stop response

5.6.2. TMM1 is held stationary after stopping (no locomotion, articulation or attachment movement)

5.6.3. Pedestrian PWS has EW

Table 8: Detection robustness acceptance criteria

AC No.	Criteria	Func. Req. No.
UG.CPS.7.1.AC.5.1	Conforms to requirements of Table 3	See Table 3

6. CPS Stop Performance

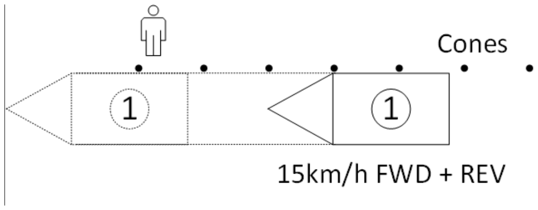

Figure 10: CPS Stop test configuration

6.1. Set up test area with as depicted in the figure.
6.2. Drive TMM1 forwards and attempt to pass the pedestrian PWS with a very small offset at 15 km/h.
6.3. Repeat 3 times in FWD and REV.
6.4. Expected behaviour:
1.1.1 EW on TMM1.
1.1.2 EW on PWS.
1.1.3 TMM1 receives CPS Stop and automatically stops.
1.1.4 Stop gap is 2.5m - 3.0m

Table 9: CPS Stop Performance

AC No.	Criteria	Func. Req. No.
UG.CPS.7.1.AC.6.1	Conforms to requirements of Table 3.	See Table 3
UG.CPS.7.1.AC.6.2	2.5m - 3.0m stop gap (shortest distance between nearest TMMs).	UG.CxDC.02 UG.CxDC.03 UG.CxDC.05 UG.CxDC.07

Deviations from protocol during testing

If any deviation from the test protocol occurs for any reason, have all parties accept in writing:

1. The proposed deviation.
2. Reason for the proposed deviation.
3. Motivation why the proposed deviation will not affect the purpose of the test.

Appendix 2: UG CPS Representative Environment Test

Purpose

The integrated Collision Prevention System (CPS) must be able to decide on the correct action in complex scenarios to prevent collisions on a UG mine. The purpose of this test is to determine if the CPS is able to provide prevent collisions in a representative environment. The test evaluates the integrated CPS against acceptance criteria based on technical requirements in UG CxD F&TPR Specification and Surface TMM CPS F&TPR Specification.

Preceding test

1. TRL4 UG CxD Independent Verification Tests
2. TRL4 UG TMM CPS Independent Verification Tests
3. TRL7 UG CPS Integration Test

Test facility/site

The site must be appropriately sized for the test being conducted. Tests are highly dynamic and adequate space for run-up, interaction and run-off is required. The site should have:

- An underground area with a level, even, hard surface where straight-line, dynamic brake tests can be performed.
- A underground decline ramp with a gradient of at least 10 % where dynamic brake tests can be performed.

Instrumentation

1. 2x test TMM with CxD commissioned (TMM1)
2. 1x DAQs with CAN interface
3. 1x laser range finder
4. 1x Ground speed sensor
5. 11x Pedestrian warning system (PWS) units
6. 1x mannequin onto which PWS is fitted during test

Test preparation

1. The CPS Developer will supply the complete CPS (TMM CPS integrated with CxD) in working order.
2. A CPS Developer will submit the signed CPS test information sheet (Appendix 3) to the test engineer prior to testing. All preceding tests as stipulated in the Preceding Verification Tests section must be completed and accepted. No modifications to any aspect of the CPS will be allowed once testing has commenced.
3. CPS Developer will submit latest revision of Section 21 Technical File, including relevant supporting documentation (e.g. ICASA T/A, brake performance test results, EMI/EMC tests, Certificates of Compliance (COCs), TMM OEM approvals, mine approvals, etc.[4]).
4. Section 21 Technical File contents will be considered by test engineer and CPS developer to determine scope of testing, particularly which TMMs will be used for testing.

[4] See Section 21 Technical File Information Framework, available at www.mosh.co.za/transport-and-machinery/documents

5. Fenced off test area, test responsible person that will ensure all aspects in the test Safety protocol are adhered to.
6. Installation of HP INSSs on both TMs and ensure good satellite reception is obtained.
7. Ensure all personnel, equipment and all obstacles are removed in front and behind the TMMs.

Test method and acceptance criteria

For all of the following scenarios the following General CxDC acceptance criteria will apply. These criteria should be read in conjunction with any specific criteria in any of the test procedures in this test protocol

Table 10: General CPS acceptance criteria, to be read in conjunction with any test specific criteria in this test protocol

AC No.	Criteria	Func. Req. No.
UG.CPS.7.2.AC.0.1	2.5s - 3.0s EW time before automatic slow down and stop intervention	UG.CxDC.08.1 UG.CxDC.08.2
UG.CPS.7.2.AC.0.2	2.5m - 3.0m stop gap (shortest distance from TMM to nearest pedestrian) for all UG interaction scenarios Stop gap will depend on correct configuration of CxD to accommodate test vehicle MBS • TMM condition (e.g. brake wear, tyre wear) must be considered when determining the vicinity boundary • TMM specific brake performance to be considered and configured • TMM size and shape (footprint) considered and configured • TMM movements & attachments considered and configured	UG.CxDC.02 UG.CxDC.03 UG.CxDC.05 UG.CxDC.06 UG.CxDC.07
UG.CPS.7.2.AC.0.3	No false interventions and false warnings	UG.CxDC.09
UG.CPS.7.2.AC.0.4	EW and CPS Stop successfully initiated in all cases Intervention strategy must use TMM capability as reported by TMM during ISO21815-2:2021 capability discovery. Intervention strategy to be consistent and repeatable	UG.CxDC.10
UG.CPS.7.2.AC.0.5	No movement of TMM when pedestrian within the vicinity and TMM is stationary Vicinity is determined by readily available TMM information indicating operator's intended action	UG.CxDC.12
UG.CPS.7.2.AC.0.6	CxDC must allow TMM to return to Normal Operation if there is no significant risk of collision as per the mine's standard operating procedure	UG.CxDC.20

1. Congested passing

This test is used to verify the correct functioning of the CPS when operating close to pedestrians in congested areas.

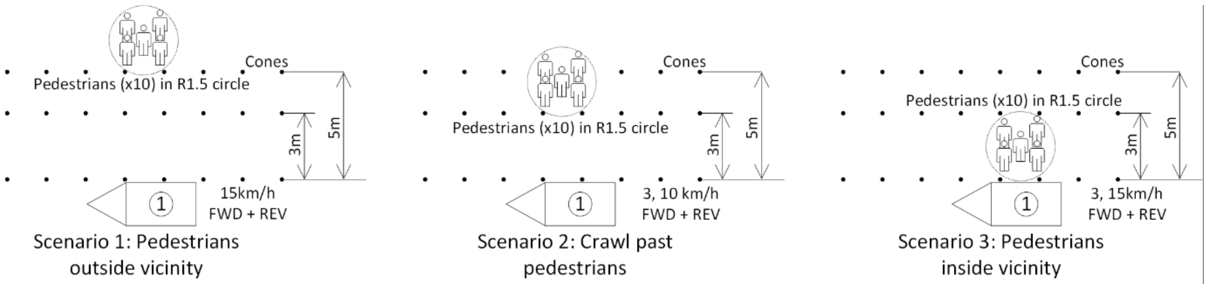

Figure 11: Congested passing test configuration

1.1. Set up test area as depicted in the figure
1.2. TMM1 with paired operator is outside vicinity

1.3. **Scenario 1: Pedestrians outside vicinity**
1.3.1. Place 10 pedestrian PWS units outside vicinity (5m from TMM1's path) in a R1.5m circle
1.3.2. Have TMM1 drive past pedestrians at 15km/h
1.3.3. Expected behaviour:
1.3.3.1. TMM1 has no warnings and Normal Operation response
1.3.3.2. Pedestrian PWS has no warnings
1.3.4. Repeat scenario 3 times each speed for FWD and REV directions
1.4. **Scenario 2: Crawl past pedestrians**
1.4.1. Place 10 pedestrian PWS units 3m away from TMM1's path in a R1.5m circle
1.4.2. Drive TMM1 past pedestrians at 3, 10 km/h
1.4.3. Expected behaviour:
1.4.3.1. TMM1 can pass pedestrians at 3km/h
1.4.3.2. TMM1 has EW and CPS Stop response at 10 and 15km/h
1.4.3.3. TMM1 is held stationary after stopping
1.4.3.4. Stop gap is between 2.5m and 3.0m
1.4.3.5. Pedestrian tag has EW at all speeds
1.4.4. Repeat 3 times at each speed for FWD and REV directions
1.5. **Scenario 3: Pedestrians inside vicinity**
1.5.1. Place 10 pedestrian PWS units such that TMM1 will pass within the vicinity
1.5.2. Drive TMM1 towards pedestrians and attempt to pass at speeds of 3 and 15km/h
1.5.3. Expected behaviour:
1.5.3.1. TMM1 has EW and CPS Stop response for all speeds and directions
1.5.3.2. TMM1 is held stationary after stopping
1.5.3.3. Stop gap is between 2.5m and 3.0m
1.5.4. Repeat each scenario 3 times at each speed for FWD and REV directions

Table 11: Congested passing acceptance criteria

AC No.	Criteria	Func. Req. No.
SM.CPS.7.2.AC.1.1	Conforms to requirements of Table 10	See Table 10
SM.CPS.7.2.AC.1.2	Prioritise most likely potential collision of up to 10 pedestrians Prevent collisions in the presence of up to at least 10 pedestrians	UG.EW.02 UG.CxDC.04 UG.CxDC.13 UG.CxDC.16.1 UG.CxDC.16.3

2. Broken-down TMM

This test is used to verify the correct functioning of the CPS when an employee is working on a disabled vehicle. The pedestrian PWS, simulating the employee, is placed under TMM2 and is therefore obscured.

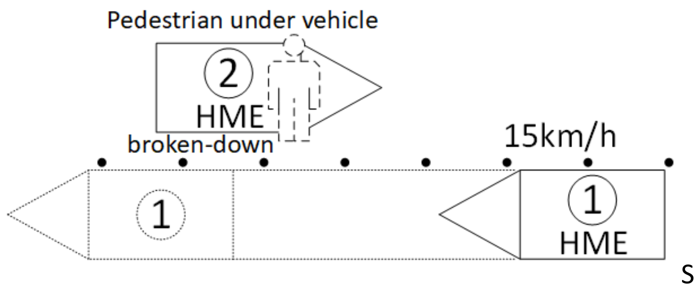

Figure 12: Broken down TMM test configuration

2.1. TMM1 with paired operator PWS is outside vicinity in Normal Operation
2.2. TMM2 CxD is off or marked as disabled, outside the detection area of the test
2.3. Place pedestrian PWS underneath TMM2
2.4. Attempt to drive TMM1 past the pedestrian PWS at 15km/h
2.5. Expected behaviour:
2.5.1. TMM1 has EW and CPS Stop response for all speeds
2.5.2. TMM1 is held stationary after stopping
2.5.3. Stop gap is between 2.5m and 3.0m
2.6. **Repeat 3 times at each speed**

Table 12: Broken down TMM acceptance criteria

AC No.	Criteria	Func. Req. No.
SM.CPS.7.2.AC.2.1	Conforms to requirements of Table 10	See Table 10 UG.CxDC.14

3. Blind approach on incline

This test is used to verify the correct functioning of the CPS when the TMM approaches a pedestrian at the bottom of an incline. The test is performed with the pedestrian standing up and lying down.

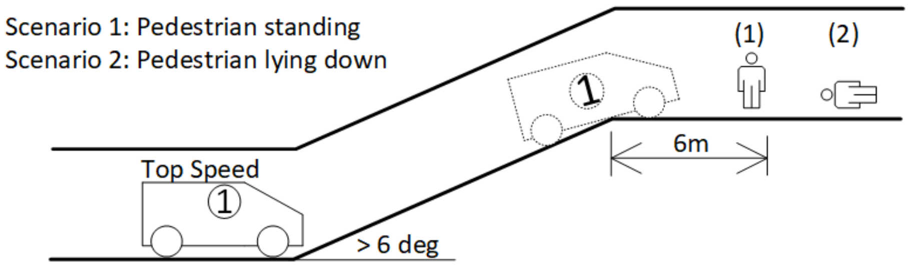

Figure 13: Broken down TMM test configuration

3.1. Place mannequin with pedestrian tag at the top of the incline, in the centre of the board, 6m away from apex
3.2. TMM 1 is at bottom of incline, 15m from apex with a fully loaded bucket
3.3. **Scenario 1: Pedestrian standing**
3.3.1. Drive TMM1 drive FWD towards incline and ascend to approach pedestrian head-on at the machine’s top speed.

3.3.2. Expected behaviour:
3.3.2.1. TMM1 has EW and CPS Stop response for all speeds.
3.3.2.2. TMM1 is held stationary after stopping.
3.3.2.3. Pedestrian PWS has EW at all speeds when TMM1 is in the vicinity.
3.3.3. Repeat 3 times

3.4. **Scenario 2: Pedestrian lying down**

3.4.1. Place the mannequin with the pedestrian tag flat on the floor to simulate a pedestrian lying down.
3.4.2. Drive TMM1 drive FWD towards incline and ascend to approach pedestrian head-on at the machine's top speed.
3.4.3. Expected behaviour:
3.4.3.1. TMM1 has EW and CPS Stop response for all speeds.
3.4.3.2. TMM1 is held stationary after stopping.
3.4.3.3. Pedestrian PWS has EW at all speeds when TMM1 is in the vicinity.
3.4.4. Repeat 3 times

Table 13: Blind approach on decline acceptance criteria

AC No.	Criteria	Func. Req. No.
UG.CPS.7.2.AC.3.1	Conforms to requirements of Table 10	See Table 10
UG.CPS.7.2.AC.3.2	DTS must be able to detect pedestrians in all reasonably foreseeable environmental conditions. E.g. Steep angles/inclines/declines	UG.DT.1.2
UG.CPS.7.2.AC.3.3	CxDC considers readily available information shared via the MCI to determine the vicinity. E.g. Incline/payload	UG.CxDC.23

4. Pedestrian activated emergency stop

This test is used to verify the correct functioning of the CPS when a pedestrian activates the emergency stop functionality on their PWS.

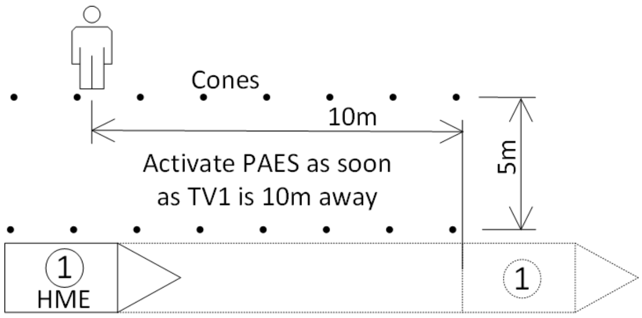

Figure 14: Pedestrian activated emergency stop test configuration

4.1. TMM1 with paired operator PWS has enough run-up to reach to 5km/h
4.2. Pedestrian PWS is >5m away from the side of TMM1.
4.3. Drive TMM1 away from the pedestrian at 5km/h
4.4. Activate pedestrian activated emergency stop as soon as TMM1 is 10m away from pedestrian.
4.5. Expected behaviour:
4.5.1. TMM1 has PAES indicated on OWS and CPS Stop response.
4.5.2. TMM1 is held stationary after stopping.
4.5.3. PWS indicates PAES is active.
4.6. Repeat 3 times

Table 14: Pedestrian activated emergency stop acceptance criteria

AC No.	Criteria	Func. Req. No.
UG.CPS.7.2.AC.4.1	Conforms to requirements of Table 10	See Table 10
UG.CPS.7.2.AC.4.2	All machines in detection area slow down and stop when pedestrian activated emergency stop is activated Response time of less than 1.0s	UG.CxDC.15

5. TMM turning corner towards pedestrian

This test is used to verify the correct functioning of the CPS when the TMM is driven around a corner towards a pedestrian.

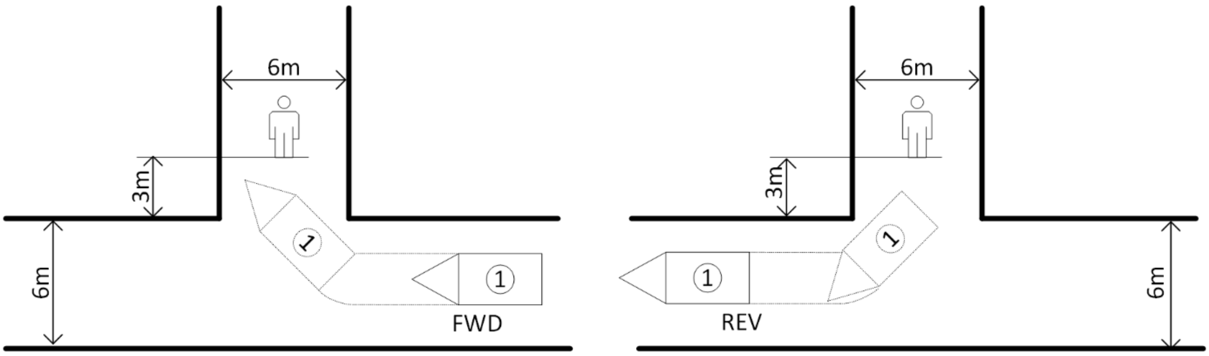

Figure 15: TMM turning towards pedestrian test configuration

5.1. Set up test area to simulate an obscured pedestrian as depicted in the figure
5.2. TMM1 with paired operator is positioned outside of vicinity
5.3. Drive TMM1 straight past the corner and steer towards obscured pedestrian at maximum allowable corner speed in FWD and in REV.
5.4. Expected behaviour:
5.4.1. TMM1 has EW and CPS Stop response for all speeds and directions.
5.4.2. TMM1 is held stationary after stopping.
5.4.3. Pedestrian PWS has EW at all speeds and directions when TMM1 is in the vicinity.
5.5. Repeat 3 times for FWD and REV directions.

Table 15: TMM turning corner towards pedestrian acceptance criteria

AC No.	Criteria	Func. Req. No.
UG.CPS.7.2.AC.5.1	Conforms to requirements of Table 10	See Table 10 UG.CxDC.16.2 UG.CxDC.16.3

Deviations from protocol during testing

If any deviation from the test protocol occurs for any reason, have all parties accept in writing

1. The proposed deviation
2. Reason for the proposed deviation and
3. Motivation why the proposed deviation will not affect the purpose of the test

Appendix 3: CPS information sheet

Table 16: CxD product information sheet

Test details	
Surface CPS test(s) performed	
Test location	
Test date	
Data acquisition (DAQ) system	
DAQ Hardware	
DAQ Firmware	
INSS instrument(s)	
Name of test engineer	
Signature	
Signing this test information sheet confirms that the DAQ and all test instrumentation used during the test were properly calibrated and commissioned and integration with the CxD product was checked prior to commencing with the test.	

CPS Developer details	
Name of CPS Developer	
Section 21 Technical File attached?	
Date	
Signature	
Signing this test information sheet confirms that the CPS was properly integrated, calibrated and commissioned. The CPS is ready for testing. All the required documentation has been attached.	

CxD Details	
CxD supplier	
CxD model	
Serial number	
CxD firmware	
CxD hardware	
RF operating frequencies	
DTS sensing technologies	
ICASA T/A or Spectrum License? Provide details	
EMC tests passed? Provide details	
Name of duly authorized CxD supplier representative	
Date	
Signature	
Signing this test information sheet confirms that the CxD product under test was commissioned and tested as per the CxD specification prior to the commencement of the test. Reasonable steps were taken to ensure integration with the TMM CPS was successful.	

TMM1 details	
TMM CPS OEM	
TMM CPS model	
TMM type	
TMM GVM	
TMM design payload	
Serial number	
Describe common attachment positions (i.e. parking, tramming, operating)	
Name of duly authorized TMM CPS OEM representative	
Date	
Signature	
Signing this test information sheet confirms that the TMM CPS under test was commissioned and tested as per the TMM CPS OEM specification prior to the commencement of the test. Reasonable steps were taken to ensure integration with the CxD was successful.	

TMM2 details	
TMM CPS OEM	
TMM CPS model	
TMM type	
TMM GVM	
TMM design payload	
Serial number	
Name of duly authorized TMM CPS OEM representative	
Date	
Signature	
Signing this test information sheet confirms that the TMM CPS under test was commissioned and tested as per the TMM CPS OEM specification prior to the commencement of the test. Reasonable steps were taken to ensure integration with the CxD was successful.	

TMM3 details	
TMM CPS OEM	
TMM CPS model	
TMM type	
TMM GVM	
TMM design payload	
Serial number	
Name of duly authorized TMM CPS OEM representative	
Date	
Signature	
Signing this test information sheet confirms that the TMM CPS under test was commissioned and tested as per the TMM CPS OEM specification prior to the commencement of the test. Reasonable steps were taken to ensure integration with the CxD was successful.	

Safety sign-off	
Name of test responsible person	
Date	
Signature	

Signing this test information sheet confirms that the test responsible person has taken reasonably practicable measures to ensure the safety of those present at the CPS test, including but not limited to:

- A site risk assessment
- Ensuring adequate emergency medical supplies are available
- Test safety briefing prior to the commencement of testing
- Ensuring steps set out in Appendix 8: Test safety protocol have been followed and will be adhered to

Appendix 4: Test safety protocol

1. Purpose

The purpose of this document is to prescribe the safety management and controls required to ensure that safety and health risks are minimised due to interactions between TMMs and pedestrians during testing at the identified test sites.

Note: this document does not take the place of the pre-test risk assessment which may identify risks that are local or local environment induced. A pre-test risk assessment is always required, which includes a test site safe declaration, prior to the commencement of the tests each day or after a significant event.

2. Scope

The scope of this document applies to the safety management for all CPS testing performed at any test site where the MHSA is not in force. The scope of this document defines the following safety controls at the CPS test sites:

1. Access control and safety management during testing,
2. Emergency management of the test site during CPS testing,
3. Risk assessment completed for the testing,
4. Test area layout including signage for the test area,
5. Evacuation plan,
6. Test plan for each test.

3. Risk assessment

A CPS testing site risk assessment must be compiled for the test site and tests to be carried out. This risk assessment must be filed in a separate document and kept in the site office on the test site for easy access and reference by all on site.

A separate risk assessment will be conducted with all contractors on site and be available on the test site for ease of access and reference by all.

Each CxD and TMM CPS provider or contractor shall have completed an issue-based risk assessment for the fitting to and removal of their CPS systems from the TMMs.

Each TMM OEM provider or contractor shall have completed an issue-based risk assessment for the fitting to and removal of their CPS systems from the TMMs.

All controls defined in the risk assessments must be implemented.

4. Pre-test risk assessment

Prior to testing each day, a pre-test risk assessment must be conducted to ensure that any specific environmental or other risks specific to that day or tests are identified and controls put into place. Note: no tests may be conducted without the pre-test risk assessment being completed and signed off by both the legal appointees and all those involved in the test on that day.

5. Site entry register

Site entry to any person either included in the testing or invited is limited. All persons entering the site are required to sign a test site entry register and sign out before leaving the site.

6. Safety management

In accordance with the MHSA and the OHSA as well as the site safety policy, safety is the top priority on the test site. All persons or TMMs entering the test site must have authorisation to do so and shall comply with all site safety procedures and the test site specific safety requirements contained in this document.

The overarching safety management approach is the safety approach that would normally be followed in accordance with the MHSA and the OHSA. The safety approach is expanded below:

7. Before work begins

The site responsible person shall assess whether the site, task and issue-based risk assessment controls are still valid and address all the risks in the risk assessment,

The site responsible person shall conduct the pre-test risk assessment and sign it off with the test engineer,

- Safety talk led by the site responsible person – all people performing test site work must attend and sign the safety talk attendance register.
- Each TMM operator shall have a pre-start check performed by the operator. The completed pre-start check sheet shall be filed in the filing system and kept in the test site office.
- Each TMM operator shall perform a functional brake test on each TMM prior to the start of testing each day (see Annexure 3 for pre-start checklist),
- The test site responsible engineer shall verify that the test site is safe and that the roads are in an acceptable and safe condition (see Annexure 4 for road audit methodology) and declare the site safe for testing to resume every day.
- The test site responsible person shall check that all people on site are wearing the appropriate PPE and that any tools being used are in a safe working condition and being used safely.
- Both the test site responsible person and site test engineer shall declare the site safe for testing and sign the safe declaration form.

Note 1: No tests shall commence unless all the above has been completed and signed off.

Note 2: While not derogating from employees' rights in terms of Section 22 and 23 of the MHSA, the test site responsible person and/or the test site engineer may stop the test at any time when they deem any situation to be unsafe.

Note 3: Any unsafe condition must be reported and can be reported by anyone on the test site (see Annexure 6 for unsafe condition reporting document and log).

8. Changes in risk during the day

Any changes that may increase the risk to safety and render current controls insufficient, will result in the test being placed on hold or suspended pending further risk assessment. The site responsible person and or the site test engineer will perform a pre-test risk assessment and make the final decision on whether the controls specified in the revised risk assessment are adequate to control the changes in risk. This revised pre-work risk assessment shall be filed in the risk assessment file in the site office.

Note: Changes in risk can emanate from (this list is not exhaustive):

- Heavy rainstorms, high wind where visibility is reduced due to dust,
- Dark cloud that impinges visibility,
- Tyre change,

- Hydrocarbon spills that need to be cleaned,
- Pedestrians or vehicles inadvertently wandering on to the test site,
- Severe road damage that requires repair,
- Lightning,
- Illness of someone who requires immediate treatment on site,
- Injury on site,
- High environmental temperature that has a high risk of inducing heat stroke,
- TMM accident where persons are injured,
- Near misses where a high potential of interaction between TMM and TMM or TMM and pedestrian or TMM and objects occurs.

9. Emergencies

For all emergencies, the number below shall be contacted, and the test site emergency plans enacted.

Emergency number

In the case of an emergency being declared, the following persons will take charge:

- Test site responsible person, and if not available then
- Test site responsible engineer, and if not available then
- The next highest-ranking test site employee on the test site.

All emergencies, as listed below, shall be reported to the site responsible person as incidents as per the test site incident management procedure. The responsible person shall ensure that the incident is reported and follows the above procedure. A copy of the procedure must be available at the test area.

Should an emergency be declared, the process below shall be followed:

- The person in charge shall immediately identify themselves and contact the number above and follow the test site emergency procedures and plans,
- All persons on site, shall listen to the instructions given by the person in charge,
- If possible, the operators of the TMMs shall drive the TMMs to the test site parking area, safe-park the TMMs, exit the TMMs, hand keys to the person in charge (if TMM has keys) and follow instruction given by that person,
- Before doing all of this, all movement/operations on site must be stopped.

10. Personal protective equipment (PPE)

There are four different PPE requirements for the test site:

- Visitors who remain behind the safety barrier in front of the site office: no PPE is required,
- Test site personnel who are not working on the vehicles: safety shoes, reflective vests, or other acceptable high-visibility apparel, and hat (cap or similar sunshade system is recommended),
- Persons working on the TMMs: overall (with reflective bands), safety shoes, hard hat, gloves (if applicable for the task being performed), dust goggles may be required if wind is blowing,
- TMM operators: overalls, safety shoes, safety hats.

- Access to the test site shall be limited to those involved in performing the test, invited visitors, CxD technology providers, CPS interface provider, OEMs and various test functions required to support the test. No person other than those designated to perform the test are allowed on the test site without the permission of either the site responsible person or the site test engineer.

11. Communication

Communication during testing will be via the following means:

- Two-way handheld radios, preferably on a channel specifically for the test,
- Mobile communication via mobile phones,

12. TMM fitment and work area

All CxD technology, CPS interface technology and any OEM fitments will be done in the TMM parking area referred to as the test vehicle parking bay. A 220V power point must be provided for tool energy.

Note: All employees (test site, CxD, OEMs and contractors) shall adhere to the test site tool safety standard. The site responsible person will audit the tools being used and the way in which they are being used on an ad hoc basis. Note: the test site has zero tolerance for any unsafe power tool or other tool used and any deviation from this will not be tolerated on the test site. It is the contractor supervisor that must ensure all fitment and tools used for the fitment are carried out in a safe manner and in accordance with the test site safety standards. The power tool safety and use thereof procedure shall be available in the site office.

CxD technology providers shall ensure that they have consulted with the OEM and have approved drawings for installation on the OEM TMMs. These drawings are to include the location of each component on the TMM (with any accompanying instructions) and electrical connections, etc. and included in the Section 21 files.

13. Environmental management

All chemicals brought onto site and used must have an accompanying Material Safety Data Sheet (MSDS). The MSDS must be lodged with the site responsible person and filed in the MSDS file in the site office. No chemicals are permitted on the test site without an MSDS. (this is for both health, fire risks and controls and environmental risks and management),

Hydrocarbon spills: All hydrocarbon (fuel and oil) spills will be treated in accordance with the test site environmental management procedure, a copy of which must be available in the site office. All spills must be reported to the site responsible person,

Waste and rubbish: Rubbish bins must be provided for the different types of waste. These bins must be located close to the test site office.

Smoking area: Smoking is only allowed in the area demarcated. No smoking is allowed in any other area on the test site.

14. At the conclusion of testing

1. The site test engineer shall declare work ended for the day,
2. All TMMs will go to the test vehicle parking bay, where they will safely park, lock the vehicles and insert wheel chocks,
3. The TMM keys (if TMM has keys) will be handed to the site responsible person who will lock them in the site office key cabinet,

4. If contractors wish to leave their vehicles on site, then the vehicles must be safely parked in the LDV parking area and keys handed to the site responsible person who will lock them in the site office key cabinet,
5. The site responsible person shall check the attendance register and ensure that all employees have signed out for the day,
6. The site responsible person shall check the site and declare it safe to be locked for the night and ensure that all employees are off site and shall lock the pedestrian gate.