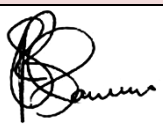
MINE DRIVEN TESTING OPTIONS

FOR COLLISION PREVENTION SYSTEMS

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

Rev 2

Mine Driven Testing Options for CPS - Acceptance			
Name	**Signature**	**Organisation**	**Date**
Kobus Blomerus		**SECDI**	**03 April 2023**
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1. Purpose

The purpose of the document is to define alternative options for mines to consider when deciding an approach to its Collision Prevention System testing.

2. Background

The Minerals Council board requires the following testing conditions to be upheld:

- Tests to be performed under well-controlled conditions.
- Tests to be done with appropriate test instrumentation.
- Tests to be conducted by experienced human resources.
- Tests to take account of well-defined industry test procedures to ensure repeatability.

3. The CPS Testing Specification

The Minerals Council project placed specific focus on the development of a single ruler that all CPS products can be measured against to ensure that it is **without risk to health and safety when used properly.** The project therefore developed the CPS Testing Specification that provides detailed test protocols, the required controlled environment, test instrumentation, test equipment (TMMs and LDVs) and the expected performance for products being tested.

4. The integrated CPS Testing Regime

The Integrated CPS Testing Regime specifically addressed the following aspects of a report issued by the Mining Regulations Advisory Committee (MRAC) Task Team on TMM:

- There is a lack of **independently** demonstrated Technology Readiness of solutions.
- Lack of an **independent** test arrangement and test opportunities to demonstrate PDS solutions that include **all** OEM machine types.

A diligent execution of duty to ensure that CPS products are without risk to health and safety when used properly, must therefore include assuring that the challenges that were identified have been resolved.

The objective of the integrated test regime was to ensure CPS testing in the quickest and cheapest way for all CPS role-players. (Mines, OEMs and OTMs).

5. To Re-Test or to Test

As of the date of this document, no CxD or TMM CPS product has been **independently tested** against the CPS F&TPR Specification. The interpretation held by some mines, that CPS products have to be retested, since it was tested against the CMS guidelines is therefore a fallacy and not supporting the key role of demonstrating CPS Product conformance.

Any mine that does not ensure that its CPS products have been demonstrated to conform to the CPS F&TPR Specification will not have executed its duty to **ensure that CPS products are without risk to health and safety when used properly.**

6. Requirements for alternative testing options.

Further to the mentioned aspects, the Integrated CPS Testing Regime applied the **Technology Readiness** Level (TRL) **Model** to achieve 3 further objectives:

1. The application of **element testing** in order to ensure conformance at the lowest possible testable element level.
2. **Minimising health and safety risk during testing**. This is achieved not only by the logic of testing but also by using simulated testing with LDVs for the riskiest tests in controlled environments.
3. **Parallel** TMM CPS and CxD **TRL 4 testing, before** physical and functional **integration** to reduce the safety risk when doing integration testing. This approach also reduces the time required to integrate.

The requirements for alternative testing options must include the above 3 aspects as well as:

4. Testing against the **F&TPR Specification** and associated **Testing Protocols**
5. Ensuring **independent** testing
6. Testing for **unintended consequences**. The Minerals Council Project has a work package that is addressing unintended consequences. It is important to consider the unintended consequences of the specific products, (CxD and TMM CPS) since they have different functionality and execution of functionality (for example auto slowdown and stop)

7. General Considerations for CPS Testing Options

Besides the requirements defined above, it is important that the following general aspects be considered when deciding a CPS testing Option:

- There are at least 600 mines in the SAMI that will require CPS products to be introduced.
- The detail requirements for testing, the equipment needed, and the special arrangements required are well defined in the CPS Testing Protocols contained in the CPS Test Specification. Although not repeated here it is the basis for all CPS Testing.
- The regulatory requirements for the criteria to determine the need for CPS did not change since the initial promulgation of the TMM regulations. CPS products must prevent TMM collisions.
- Modification of the Integrated Testing Regime and the Accelerated CPS Plan will require modification of the CPS Testing Protocols.

8. Alternative CPS Testing Options

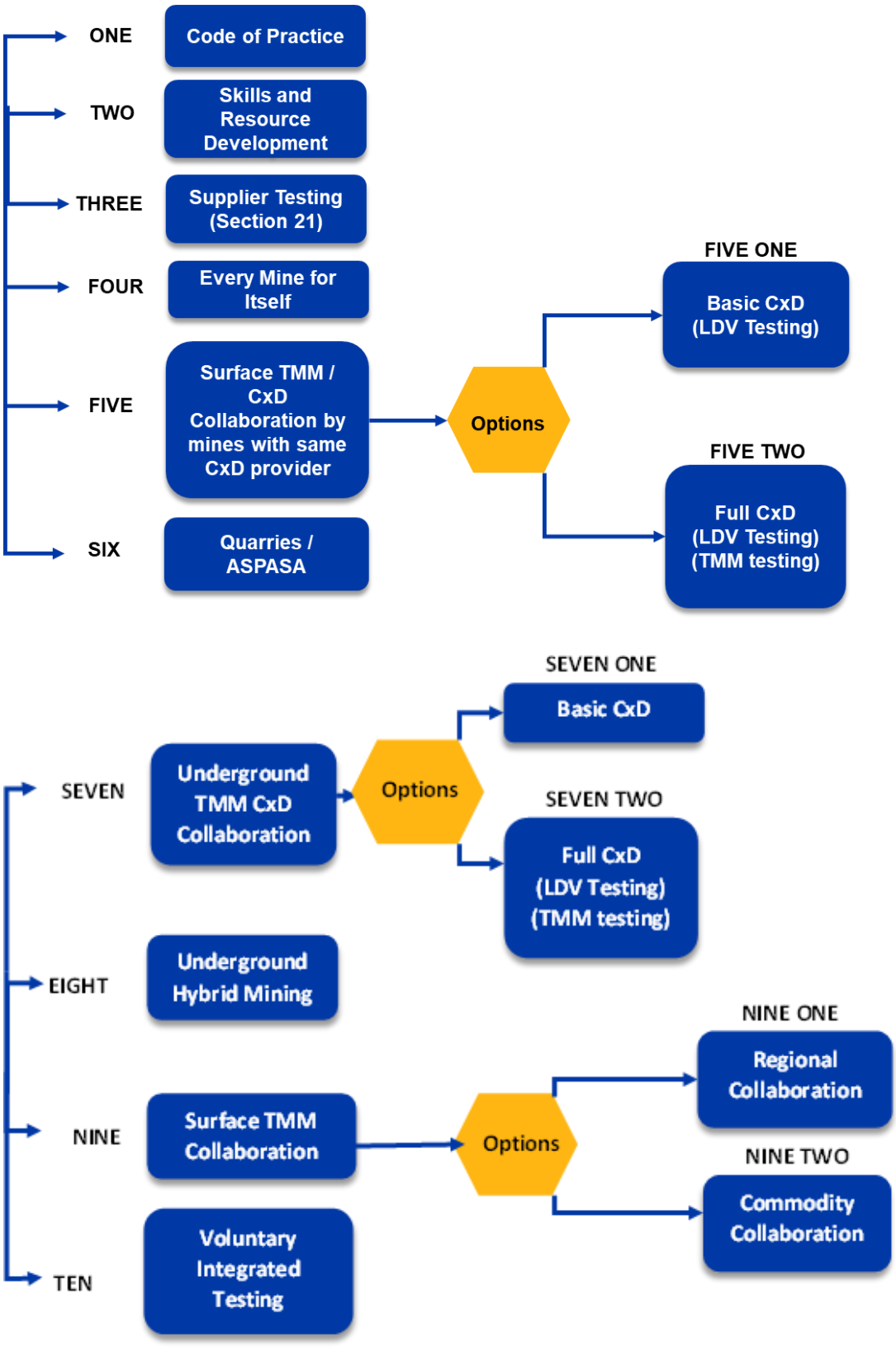

Fig 2 CPS Testing Options

Figure 2 provides a graphical depiction of a number of alternative and complementary CPS testing options. Due to the urgency to assist mines with CPS Testing the above options have been identified to date. Additional options will be incorporated in due course. Not all options have been equally defined as they are still work in progress.

8.1 Option 1: CPS Testing Safe Operating Procedure/Non Mandatory Code of Practice

The option is for collaborating mines to develop a CPS Testing Code of Practice (not to be confused with TMM COP) that can be used for CPS introduction to participating mines. The option is an additional option for all shared testing options. This option that is still to be further developed is depicted in Fig 3.

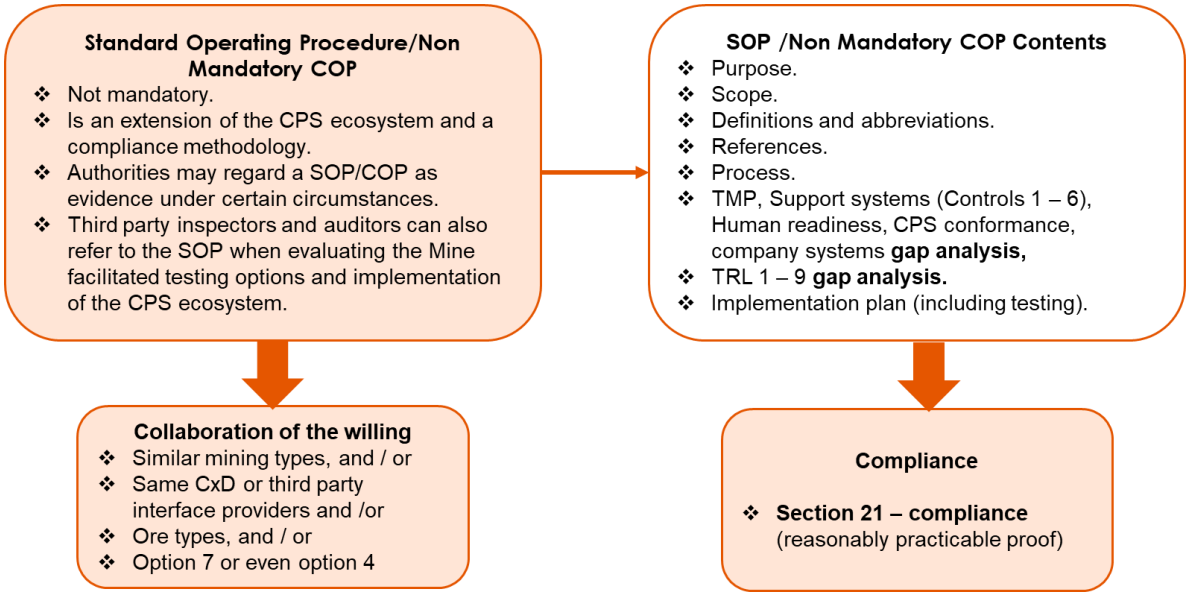

Fig CPS Testing Options 1: SOP/Non Mandatory COP

8.2 Option 2: Rapid Expansion of Testing Skills and Competence

This option is to support the "every mine by itself" option (Option 4) in that it aims to address the critical lack of competent CPS test resources (knowledge and experience). This option is still to be further developed.

8.3 Option 3: Supplier Testing

The option is based on the requirements of Sec 21 of the MHS Act that explicitly places a legal duty on **suppliers** of CPS products to ensure that, as far as reasonably practicable, the CPS products that they supply are **safe and without risk to health and safety when used properly; and that it complies with all the requirements in terms of the Act.** (Sec 21).

In the case of the TMM Regulations sec 8.10, the mine has a legal obligation to introduce CPS to its TMMs where there is a significant risk of collisions between TMMs (surface) and between TMM and pedestrians (underground). The regulations are very specific in the required functionality of the CPS products. A mine therefore has a legal obligation to ensure that the CPS products that it procures will have such functionality.

Benefits of this option

1. It places the responsibility to demonstrate conformance to the CPS F&TPR Specification on the suppliers of CPS products (OEMs, OTMs and 3rd Party providers)
2. The cost of such demonstration is for the account of the supplier(s)
3. CPS providers may choose to follow a testing regime that will enable them to do 1x set of tests, the results of which will be accepted as proof of execution of sec 21 duty by all mines. The condition for this is the use of an **independent and experienced testing organisation** with appropriate test instrumentation.
4. The CPS testing challenge for the mines, disappears in as far as finding the most suitable testing regime is concerned. The OTMs may well adopt the Accelerated Testing approach, al be it with some modification.
5. If CPS providers adopt the Integrated CPS Testing Regime, they will be able to introduce their products earlier in the market, as they will not have to do tests with every mine before a mine can place an order on it.

Disadvantages

1. CPS providers will recover the cost of demonstration via CPS product pricing.

8.4 Option 4: Every Mine for itself.

The option entails that every mine takes responsibility for doing its own CPS testing. This is very much the option that the early adopters had to follow since there were no other options at the time. The benefit that individual mines now have, is that a CPS F&TPR Specification exists that is supplemented with a set of Test Protocols specified in the CPS Test Specification.

Benefits of this option

1. Every mine is in full control of its CPS testing.
2. Basic and advanced CxD (TRL 4 and TRL 7) tests can be done back-to-back

Disadvantages

The option implies that every mine will have to:

1. Test with **TMMs** at basic CxD testing (TRL 4) This is much riskier than testing with LDVs. This will require specific Risk Assessments to introduce controls to manage the risks.
2. Pay the full cost of test planning, test site preparation, testing instrumentation and CPS testing.
3. Dedicate production TMMs to testing (high impact on production because these machines are normally load and haul machines)
4. Install CPS products on the Test TMMs.
5. First test TMMs and pass TMM CPS test. (TRL 4)
6. Test CxD (TRL 4) and pass the test.
7. Integrate CxD and TMM CPS do and pass the TRL 5 integration tests.
8. Test functional integration and pass all the TRL 6 tests.
9. Set up a testing area as per the requirements of the Testing Protocols
10. Develop a testing plan.

11. Develop training material for training CPS Testing resources. This can be outsourced to a capable organisation.
12. Appoint CPS testing resources or assign resources to CPS testing
13. Procure a set of required CPS testing instrumentation.
14. Use trained and experienced operators for testing and providing specific testing training and remove these operators from production for testing
15. Control the significant risk during testing, especially for multiple interactor tests
16. Prevent the potential lack of repeatability should re-testing be required at a later stage.
17. Compensate for the additional testing time, due to of all the requirements of the MHS Act when testing on-mine
18. Obtain exemption from DMRE to allow for on -mine testing. Current detection only products will have to be removed from machines for duration of testing.
19. Consider that long-term testing of new CPS versions/products will require the mine to retain and maintain their testing areas and arrangements to retest failed products or to test revised/upgraded products in the future.
20. Acknowledge that a significant portion of any test is the analysis off, and reporting of the test results. This reporting can take a long period of time and must be available to allow for external review as part of the Section 21 file and accident analysis, when an incident occurs.
21. Provide for assessment of potential third party testing organisations for its reporting competence before contracting them.

In as far as a mine is involved in the actual execution of the testing it is also sharing the responsibility for the integrity of the tests.

8.5 Option 5.1: Surface TMMs: Same CxD Provider Basic CxD Shared Testing

The option is based on the reality that every mine can only use one CxD brand on a specific mine, pit or shaft in order to ensure interoperability. The option is that all mines using the same CxD brand, share the basic CxD testing by using a **single testing site** where the TRL 4 CxD tests can be executed with LDVs. The option includes the execution of the tests by the independent testing organisation.

Benefits of this option.

1. The riskiest part of CxD testing is done by simulation, using LDVs and not TMMs
2. All participating mines share in the cost.
3. Only 1x testing site per CxD brand has to be prepared or only one testing site depending on the site chosen.
4. A CxD brand has to be tested only once at TRL 4.

Disadvantages of this option

1. An appropriate surface will have to be prepared where the tests can be conducted in a controlled manner.
2. An independent test witnessing organisation will have to be appointed to verify that the tests have been conducted in accordance with the testing protocols and that the actual test results have been captured and reported correctly.

3. Depending on the selected test site, if CxD tests do not pass the acceptance criteria, re-testing may have to be done at a later stage. This means the test site will have to be set up again in the future or that an alternative site may have to be used during the re-test. Repeatability will be lost, with limited comparisons to the first test (the one that initially failed) if the correct site is not chosen.
4. Advanced CxD testing will still have to be done by every mine, with all the associated disadvantages as defined in option 4.
5. On-mine testing is time consuming and will put a significant strain on the test team.

8.6 Option 5.2: Surface TMM: Same CxD Provider Full CxD Shared Testing

The option is based on the reality that every mine can only use one CxD brand on a specific mine, pit or shaft in order to ensure interoperability. The option is that all mines using the same CxD brand share the full CxD testing by use of **as few as possible testing sites** where the basic and advanced (TRL 4 and TRL 7) CxD tests can be executed. The option includes the execution of the tests by an independent testing organisation.

Benefits of this option.

1. The riskiest part of CxD testing is done by simulation, using LDVs and not TMMs.
2. The advanced CxD testing will affect only the mine(s) where the test site(s) will be.
3. All participating mines share in the cost.
4. A limited number of testing sites (1 per CxD brand) have to be prepared depending on the site selected.
5. Only 2x sets of tests must be done per CxD brand.

Disadvantages of this option

1. An appropriate site will have to be selected or a surface will have to be prepared where the tests can be conducted in a controlled manner.
2. An independent test witnessing organisation will have to be appointed to verify that the tests have been conducted in accordance with the testing protocols and the actual results have been captured and reported.
3. Depending on the selected test site, if CxD tests do not pass the acceptance criteria, re-testing may have to be done at a later stage. This means the test site will have to be set up again in the future or that an alternative site may have to be used during the re-test. Repeatability will be lost, with limited comparisons to the first test (the one that initially failed) if the correct site is not chosen.
4. There are approximately 15 surface CxD suppliers. Currently only one testing organization has sufficient test experience to conduct tests.

8.7 Option 6: Surface TMM: ASPASA/Quarry Shared Testing

The option is based on the reality that every mine can only use one CxD brand on a specific quarry in order to ensure interoperability. The option is that all ASPASA mines using the same CxD brand share the full CxD testing by use of as few as possible testing sites where the basic and advanced (TRL 4 and TRL 7) CxD tests can be

executed. The option includes the execution of the tests by the independent testing organisation. The rationale of this option is that due to the limited size of Quarry TMMs smaller testing sites could be used.

Benefits of this option.

1. The riskiest part of CxD testing is done by simulation, using LDVs and not TMMs
2. All participating mines share in the cost. The per mine cost will be a fraction of any of the alternative on mine testing options.
3. Due to size of TMMs test site will be smaller.
4. Only 1x testing site has to be prepared.
5. A CxD brand has to be tested only once.

Disadvantages of this option

1. An appropriate test area and surface will have to be prepared where the tests can be conducted.
2. An independent test witnessing organisation will have to be appointed to verify that the tests have been conducted in accordance with the testing protocols and that the actual results have been recorded and reported.
3. Depending on the selected test site, if CxD tests do not pass the acceptance criteria, re-testing may have to be done at a later stage. This means the test site will have to be set up again in the future or that an alternative site may have to be used during the re-test. Repeatability will be lost, with limited comparisons to the first test (the one that initially failed) if the correct site is not chosen.
4. There are approximately 15 surface CxD suppliers. Currently only one testing organization has sufficient test experience to conduct tests.

8.8 Option 7 Underground TMM: Basic CxD Shared Testing

The option is based on the nature of the underground TMM CPS technology, that requires a limited number of vehicles and space to do the tests. The option is that all **underground** mines contract the independent CPS testing organisation to use a single test site and test arrangement to test all Basic CxD brands on an off-mine testing site.

Benefits of this option.

1. The riskiest part of CxD testing is done by simulation, using LDVs and not TMMs.
2. All participating mines share in the cost. The per mine cost will be a fraction of any of the alternative options.
3. No mine has to set up any testing site with all the associated disadvantages.
4. Only 1x set of tests have been done per CxD brand.

Disadvantages of this option

1. An independent test witnessing organisation will have to be appointed to verify that the tests have been conducted in accordance with the testing protocols and that the actual results have been recorded and reported.

2. Mines must still do the advanced CxD tests (TRL 7) on their own using production TMMs and setting up a test site at every mine or if some mines collaborate at one of the collaborating mines.

8.9 Option 8: Underground TMM: Full CxD Shared Testing.

The option is based on the nature of the underground TMM CPS technology, that requires a limited number of vehicles and space to do the tests. The option is that all **willing** mines contract an independent CPS testing organisation to use a single test site and test arrangement to test all Basic CxD testing and a single test site to test all Advanced CxD tests. Alternatively, the "same CxD supplier" option can be followed for Advanced CxD tests.

Benefits of this option.

1. The riskiest part of CxD testing is done by simulation, using LDVs and not TMMs.
2. An advanced CxD test area has to be set up at only one mine. (Maseve for example)
3. All participating mines share in the cost. The per mine cost will be a fraction of any of the alternative on mine testing options.
4. Only 1x set of tests have to be done per CxD brand.

Disadvantages of this option

1. An independent test witnessing organisation will have to be appointed to verify that the tests have been conducted in accordance with the testing protocols and to ensure that the correct results have been recorded and reported.
2. Production TMMs will be needed to do the Advanced CxD testing.
3. If only 1x Advanced CxD testing site is chosen that site will have to facilitate testing of all underground CxD brands.

8.10 Option 9.1: Regional based shared testing.

This option entails that mines in a specific **geographical area** share CPS testing. The option can be combined with options 5.1, 5.2, 7 or 8 depending on the Surface or Underground TMMs

Benefits of this option.

As per options 5.1, 5.2, 7 or 8

Disadvantages of this option

As per options 5.1, 5.2, 7 or 8

8.11 Option 9.2: Commodity based shared testing.

This option entails that, mines, mining a **specific commodity**(s) share CPS testing. The option can be combined with options 5.1, 5.2, 7 or 8 depending on the Surface or Underground TMMs

Benefits of this option.

As per options 5.1, 5.2, 7 or 8

Disadvantages of this option

As per options 5.1, 5.2, 7 or 8

8.12 Option 10: Voluntary Integrated Testing.

This option is the same as the Accelerated CPS Testing Plan.

For underground TMM CPS the only difference between this option and Option 8 is that OEMs and OTMs are also participating in the initiative.

For surface TMMs depending on the number and profile of collaborators there are also merit in voluntary integrated testing.

Advantages and disadvantages are as per Accelerated CPS Testing Plan.