



UNIVERSITEIT VAN PRETORIA
UNIVERSITY OF PRETORIA
YUNIBESITHI YA PRETORIA

Faculty of Engineering, Built Environment and Information Technology

Fakulteit Ingenieurswese, Bou-omgewing en
Inligtingtegnologie / Lefapha la Boetšenere,
Tikologo ya Kago le Theknolotši ya Tshedimošo

CPS Testing

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24 October 2025

Make today matter



Introduction

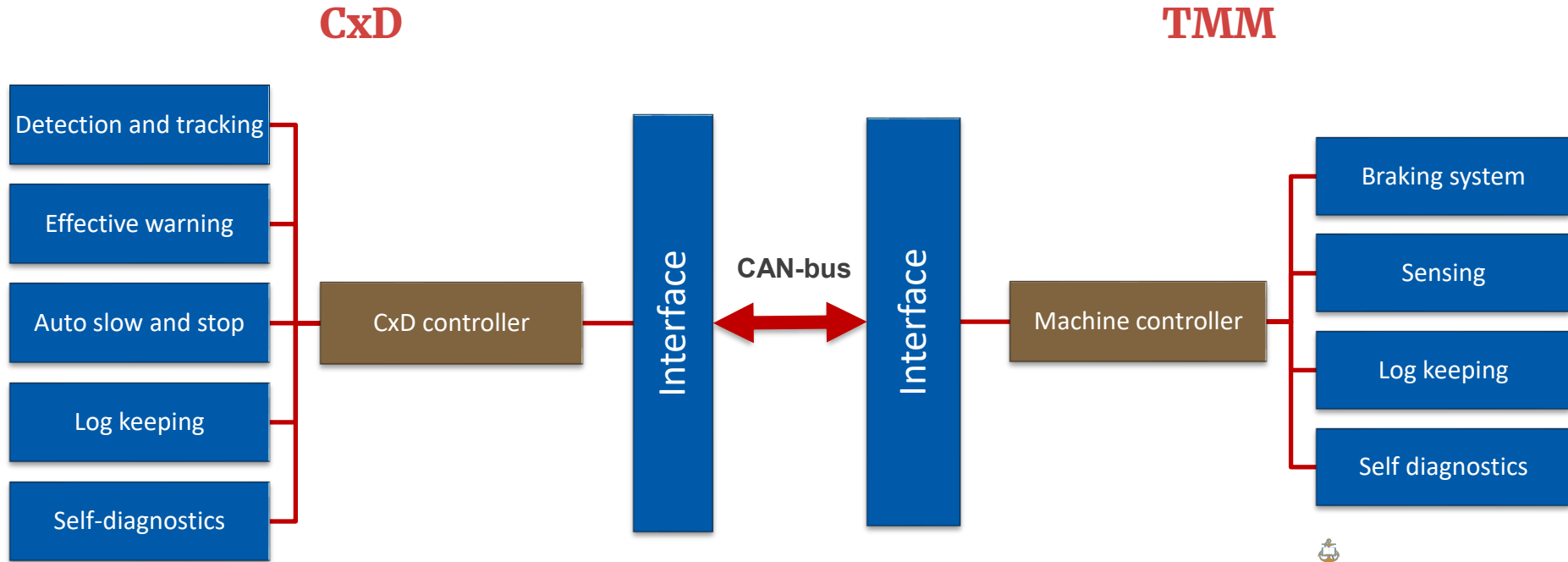
Agenda

1. CPS Requirements Verification Regime
2. CPS testing progress
3. The way forward



Testing

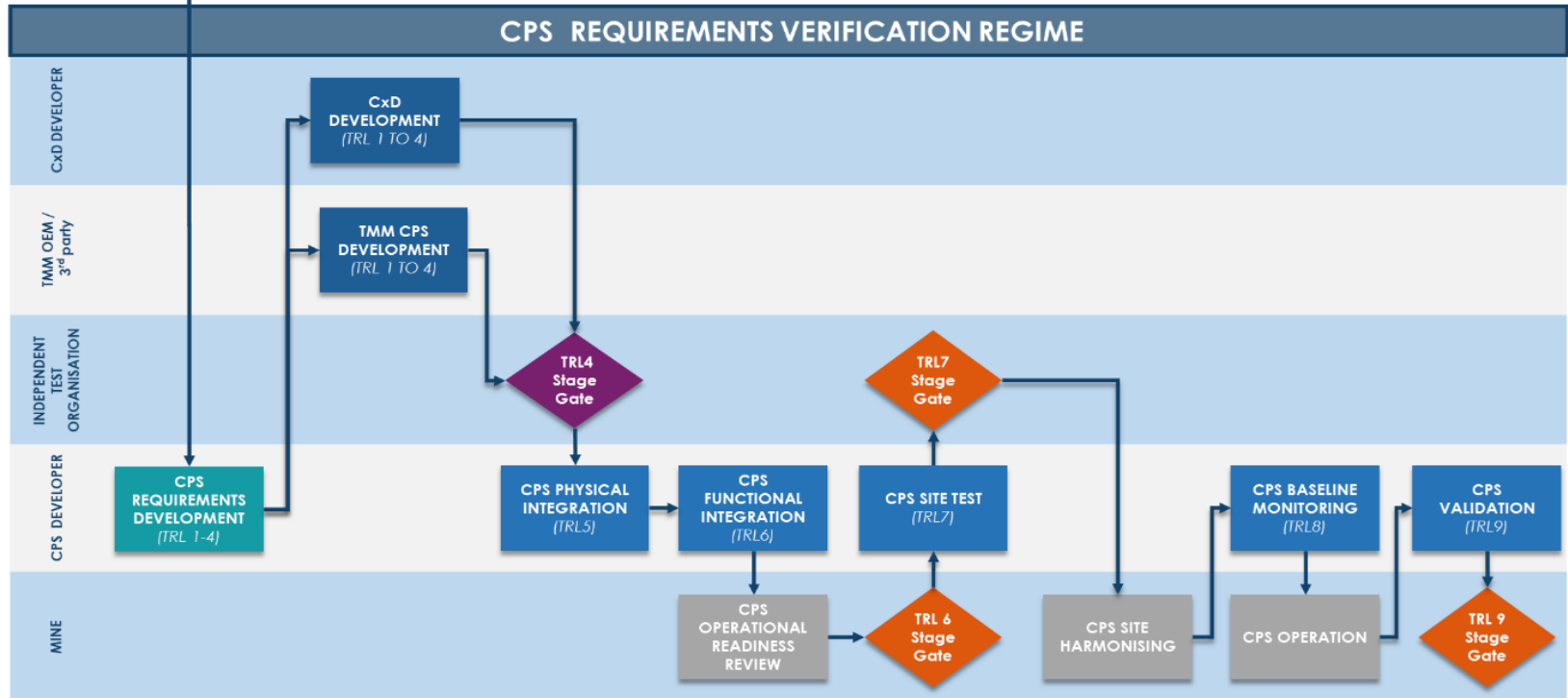
Functions to be tested



CPS Requirements Verification Regime

URS, FUNCTIONAL & TECHNICAL
PERFORMANCE REQUIREMENTS

[FUNCTIONAL READINESS CRITERIA]



Testing

The goal is to ensure that the CPS meets the URS

The ground rules of testing:

1. Test safely
2. Test individual functions
3. Test scientifically and repeatably
4. Test at the earliest opportunity



Background

Stage gate objectives

- TRL4
 - Does the CxD and TMM CPS have the basic functionality to prevent collisions?
 - Testing all products in a controlled environment
 - Repeatable, scientific, quantifiable testing
 - Finding bugs before they escalate
 - CxD and TMM CPS tested separately
- TRL6
 - Has the CxD and TMM CPS been integrated with each other properly?
 - Adapting the CxD to the realities of the TMM CPS
 - Mounting sensors, routing cables, configuring zone sizes, etc.







Background

Stage gate objectives

- TRL7
 - Can the integrated CPS function in a representative environment?
 - Specific interaction scenarios repeated to ensure TRL4 results are still valid
- TRL9
 - Does the CPS work in production?
 - Prevents collisions without negatively impacting production
 - Monitored over a period, statistical evaluation of the CPS performance



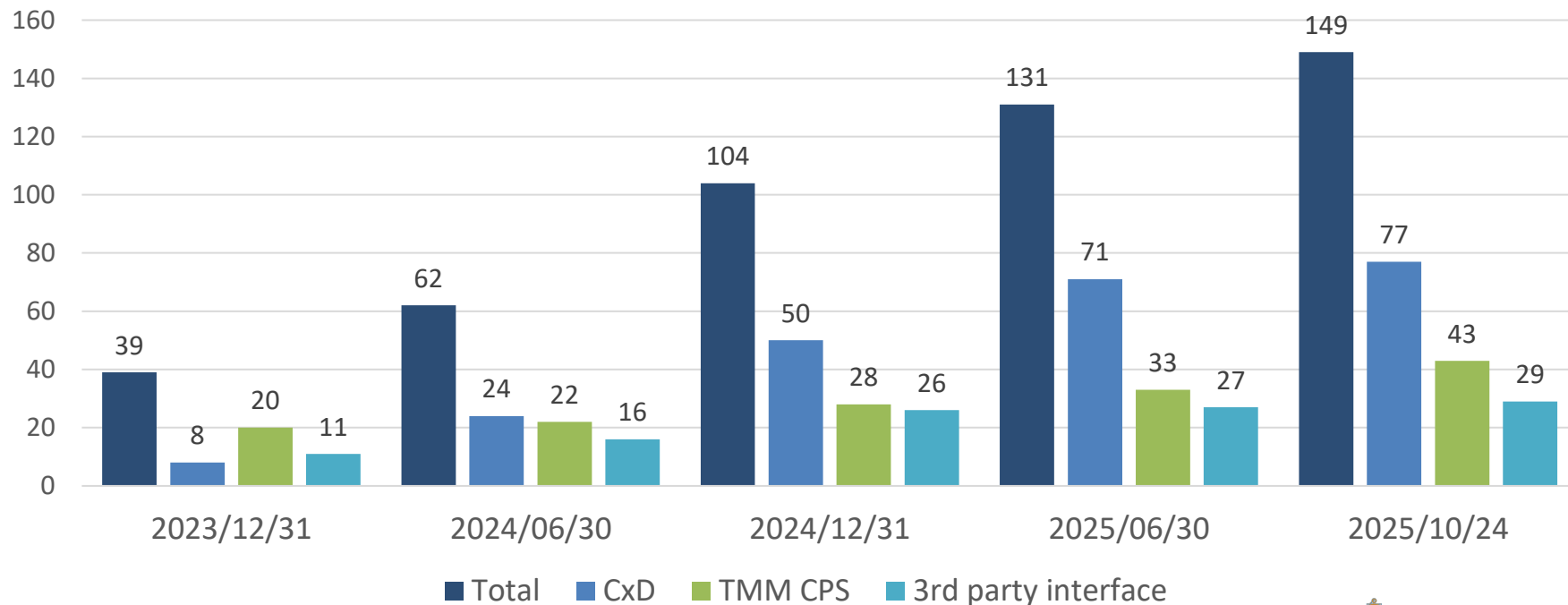
CPS test progress

Progress since end of 2023

- To date, UP has conducted
 - 189 tests
 - 1.6 tests per week
 - 79% verification tests
 - 21% development tests
 - Customers
 - 18x CxD suppliers, 10 local
 - 8x TMM OEMs, 4 local
 - 9x 3rd party interfaces, 7 local
- Pass rate
 - CxD: 62%
 - TMM: 42%
 - 3rd party interfaces: 83%

CPS test progress

Total verification tests done



CPS test progress

CxD test status: Surface mining

No.	CxD	Type	ISO	Log-keeping	Self-diagnostics	Detection & tracking	Effective warning	Controller
1	A	Surf	2024/10/07	2025/02/18	2025/02/18	2024/10/14	2024/10/14	Engaging
2	B	Surf	2024/11/21	2024/11/21	2024/11/21	Engaging	Engaging	Engaging
3	C	Surf	Ordered	Ordered	Ordered	Engaging	Engaging	Engaging
4	D	Surf	2025/05/05	2025/05/05	2025/05/05	2025/05/07	2025/05/07	2025/07/09
5	E	Surf	2024/11/28	2024/11/28	2024/11/28	2025/03/26	2025/03/26	Engaging
6	E	Surf	2024/04/02	2025/10/16	2025/10/16	Engaging	Engaging	Engaging
7	F	Surf	2023/08/01	2024/11/26	2024/11/26	Quoted	Quoted	Quoted
8	G	Surf	2025/02/05	2025/02/05	2025/02/05	Engaging	Engaging	Engaging
9	H	Surf	2024/06/26	2024/06/26				
10	I	Surf	Ordered	Ordered	Ordered	Engaging	Engaging	Engaging
11	J	Surf	2024/09/03	2024/09/03	2024/09/03	2025/11/05	2025/11/05	2025/11/05
12	K	Surf	2024/02/21	2024/05/27	2024/05/27	2025/11/19	2025/11/19	2025/11/19

CPS test progress

CxD test status: Underground mining

No.	CxD	Type	ISO	Log-keeping	Self-diagnostics	Detection & tracking	Effective warning	Controller
1	L	UG	2024/02/07	2024/05/16	2024/05/16	2024/07/29	2024/07/29	2024/07/29
2	A	UG	2024/10/07	2024/09/30	2024/09/30	Ordered	Ordered	Ordered
3	M	UG	2023/05/18	2023/05/18	2023/05/18	2024/08/29	2024/08/29	2024/08/29
4	C	UG	Ordered	Ordered	Ordered	Engaging	Engaging	Engaging
5	N	UG	2023/08/29	2024/02/28	2023/08/29	2025/05/28	2025/05/28	2025/05/29
6	E	UG	Quoted	Quoted	Quoted	Engaging	Engaging	Engaging
7	O	UG	2024/09/16	2025/05/12	2025/05/12	2025/05/20	2025/05/20	2025/05/20
8	P	UG	2025/02/24	2025/02/24	2025/02/24	Engaging	Engaging	Engaging
9	P	UG	2024/07/08	2024/07/08	Engaging	Engaging	Engaging	Engaging
10	Q	UG	2024/07/20	2025/02/27	2025/02/27	2025/08/06	2025/08/06	2025/08/06

CPS test progress

TMM & 3rd-party Interface test status: Surface mining

No.	OEM	Type	Product	ISO	Log keeping	Self-diagnostics	Machine sensing	Machine Controller
1	B	Surface	TMM	2023/11/13		2023/11/13	2023/11/13	2023/11/13
3	G	Surface	TMM	Engaging				
4	P	Surface	TMM	Quoted	Quoted			
2	G	Both	Interface	2024/09/12	2024/09/12	2024/09/12		
5	J	Surface	Interface	2023/10/10	2024/04/03	2024/04/03	2024/04/04	2024/04/04
6	K	Both	Interface	2023/11/30	2023/11/30	2023/11/30		
7	K	Surface	Interface				2025/06/09	2025/06/09
8	K	Surface	Interface				2025/10/08	2024/10/31
9	M	Surface	Interface	2025/10/17	Quoted	Quoted		
10	N	Both	Interface	Quoted	Quoted	Quoted		
11	O	Surface	Interface	2024/01/25	2024/01/25	2024/01/25	Quoted	Quoted

CPS test progress

TMM & 3rd-party test status: Underground mining

No.	OEM	Type	Product	ISO	Log keeping	Self-diagnostics	Machine sensing	Machine Controller
1A	UG	Interface	2023/08/11					
2C	UG	TMM	2024/06/19	Ordered	Ordered	Ordered	Ordered	Ordered
3D	UG	Interface	2025/10/28	2025/10/28	2025/10/28			
4E	UG	Interface	2023/08/15	2023/08/15	2023/08/15			
5E	UG	Interface				2024/12/03	2024/12/03	
6E	UG	Interface				2024/12/04	2024/12/04	
7F	UG	TMM	2025/04/18	2025/04/18	2025/04/18	2025/04/18	2025/04/18	2025/04/18
8H	UG	TMM	2023/08/22	2023/08/22	2023/08/22	2023/11/08	2023/11/08	2023/11/08
9G	Both	Interface	2024/09/12	2024/09/12	2024/09/12			
10I	UG	TMM	2023/10/30	2023/10/30	2023/10/30	2023/10/30	2023/10/30	2023/10/30
11K	Both	Interface	2023/11/30	2023/11/30	2023/11/30			
12L	UG	TMM	2024/05/03	Ordered	Ordered			
13Q	UG	TMM	2024/09/26	2024/11/15				
14Q	UG	TMM			2024/09/26	2024/10/01	2024/10/01	2024/10/01
15Q	UG	TMM			2024/09/27	2025/08/27	2025/08/27	2025/08/27
16Q	UG	TMM			2025/10/21	2025/10/21	2025/10/21	2025/10/21
17Q	UG	TMM			2025/10/21	2025/10/21	2025/10/21	2025/10/21

CPS Test Progress

The way forward

- Updated MOSH specification a significant improvement on original
 - Clearer, simpler, consistent
 - Tests have been adapted to reflect available facilities, pragmatic
 - All TRL4 tests can be conducted
 - Surface specification already available on MOSH website
 - Underground specification in final stages of review
- UP has an 18-week lead time
 - Lead time now longer than three months ago
 - Test focus has shifted from lab-based tests to proving ground tests
 - Reflects the increased complexity, more resources required for proving ground tests

Thank you



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