

CPS Functional and Technical Performance Requirements

Prof Herman Hamersma, Pr Eng
23 October 2025

Make today matter



UNIVERSITEIT VAN PRETORIA
UNIVERSITY OF PRETORIA
YUNIBESITHI YA PRETORIA

Faculty of Engineering,
Built Environment and
Information Technology

Fakuliteit Ingenieurswese, Bou-omgewing en
Inligtingtegnologie / Lefapha la Boetsʼenere,
Tikologo ya Kago le Theknolotʼši ya Tshedimošo



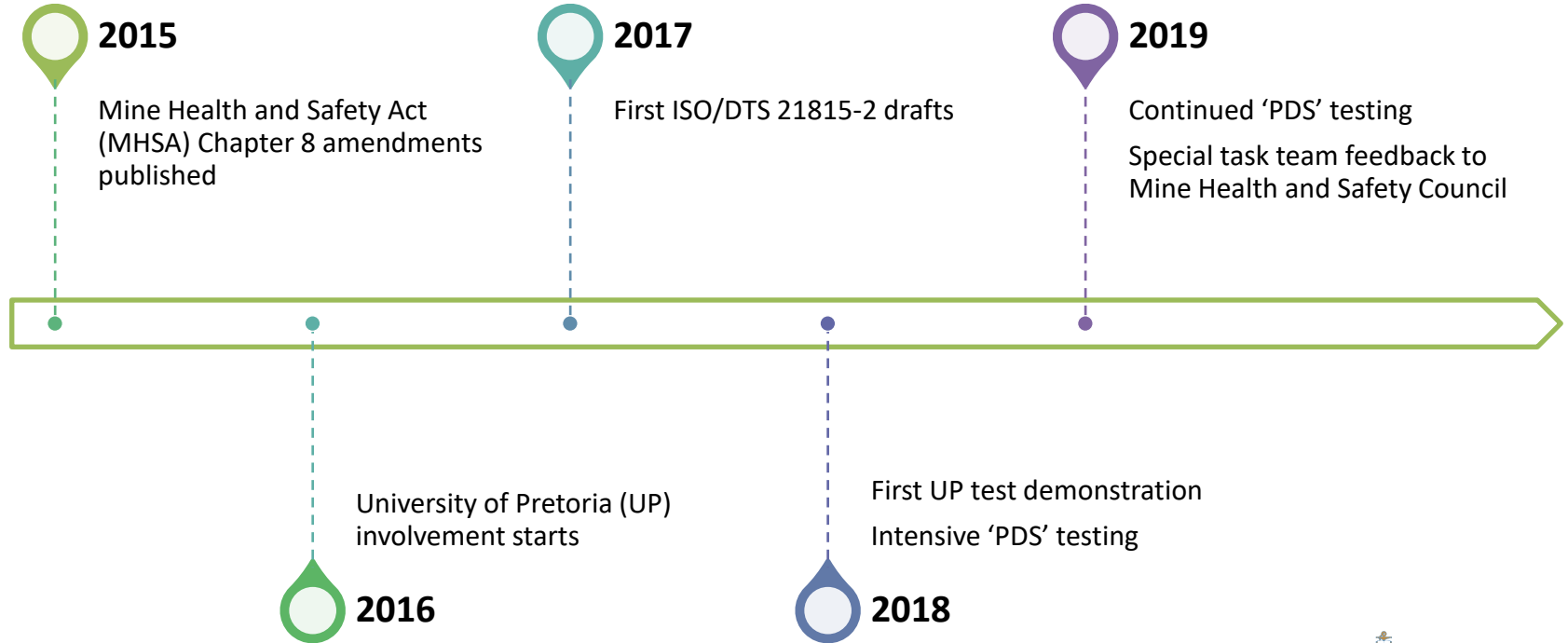
Terminology

Let's talk the same language

- MHPA – Mine Health and Safety Act (Act No. 29 of 1996) and Regulations, as amended
- TMM – Trackless Mobile Machine
- MOSH – Mining Occupation Safety and Health Initiative
- CPS – Collision Prevention System
- CxD – Collision Warning and Avoidance System Device
- PDS – Proximity Detection System
- ISO – International Organization for Standardization
- V&V – Verification and Validation

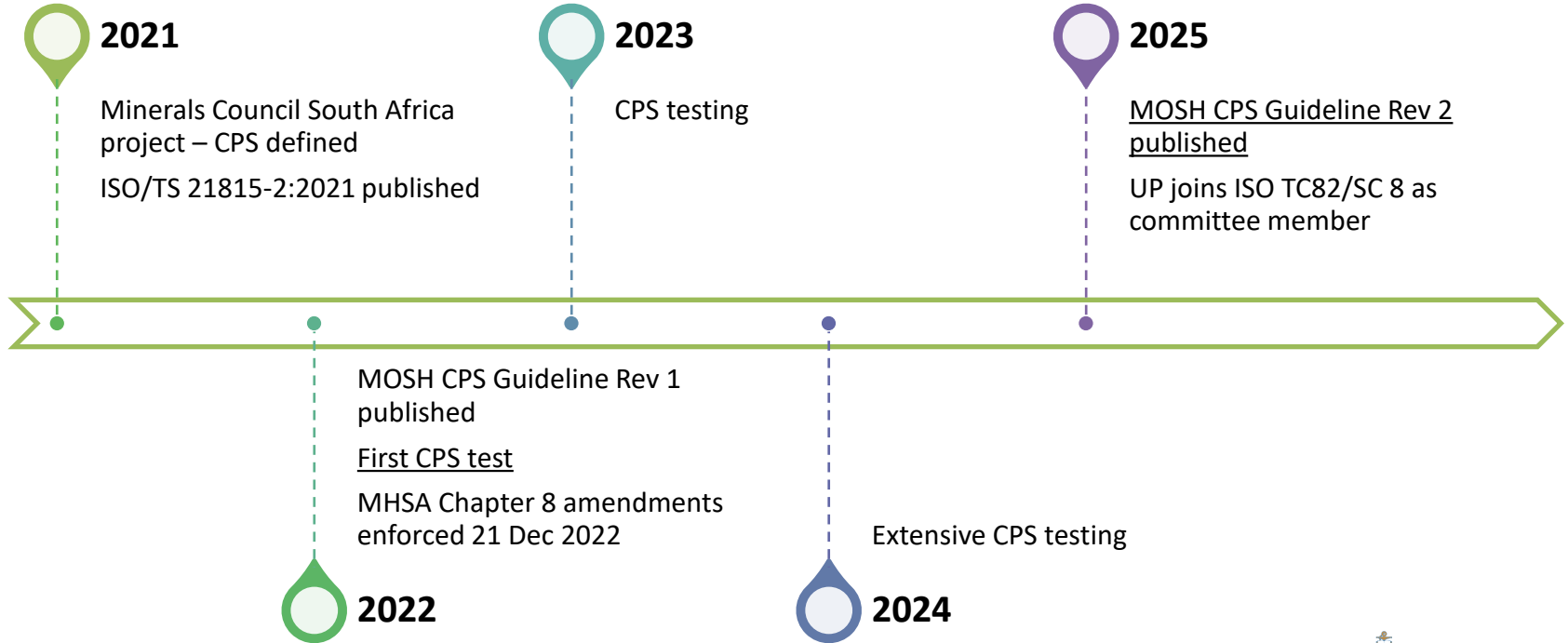
Background

Timeline



Background

Timeline



Current status

Where are we now?

- We have **unique regulations**, not found anywhere else in the world
 - Limited number of suppliers, very **little competition**
 - Lack of **capacity** to develop
 - Lack of **skills** to support
- Technology is **developing very quickly**, we need to ride the wave
 - How do we install, maintain and repair emerging technologies in South Africa?
- Several **problems remain unresolved**, including
 - Nonalignment of expectations in industry
 - Interoperability & Fail-to-safe
- Some suppliers have demonstrated a **degree of capability**

Systems Engineering

1. Incomplete Requirements Leading to Operational Failure

- **Example:** Interaction scenarios are not based on typical mining processes.
- **Risk:** The system may not detect all obstacles (e.g., pedestrians, TMMs).
- **Consequence:** Increased likelihood of collisions due to missed detection scenarios.
- **Systems Engineering Role:** Ensures comprehensive stakeholder and operational requirements are captured.

2. Integration Failures Between Subsystems

- **Example:** Each TMM OEM develops their own interface
- **Risk:** Increased development time, multiple interfaces in the field requiring specialized support
- **Consequence:** CxDs have to develop custom interfaces for each TMM OEM they integrate with
- **Systems Engineering Role:** Manages interfaces and integration across subsystems.

3. Inadequate Verification and Validation (V&V)

- **Example:** Each mine conducts verification and validation of CPS based on their specific use case
- **Risk:** CxD is designed for a specific mine, difficult to adapt to other mines/mining methods
- **Consequence:** The CxD product only works for that specific mine. The CxD developer must repeat verification and validation at each mine, against a new set of rules
- **Systems Engineering Role:** Enforces rigorous V&V processes to ensure products meet the whole industry's needs

Systems Engineering

4. Scope Creep and Project Overruns

- **Example:** User requirements are not based on mining processes, only considers a limited number of interaction scenarios.
- **Risk:** Employees rely on a product that does not work for all scenarios.
- **Consequence:** All significant risk events not covered. Continuous redevelopment is needed. Unstable performance and field support challenges.
- **Systems Engineering Role:** Configuration management and change control to maintain discipline.

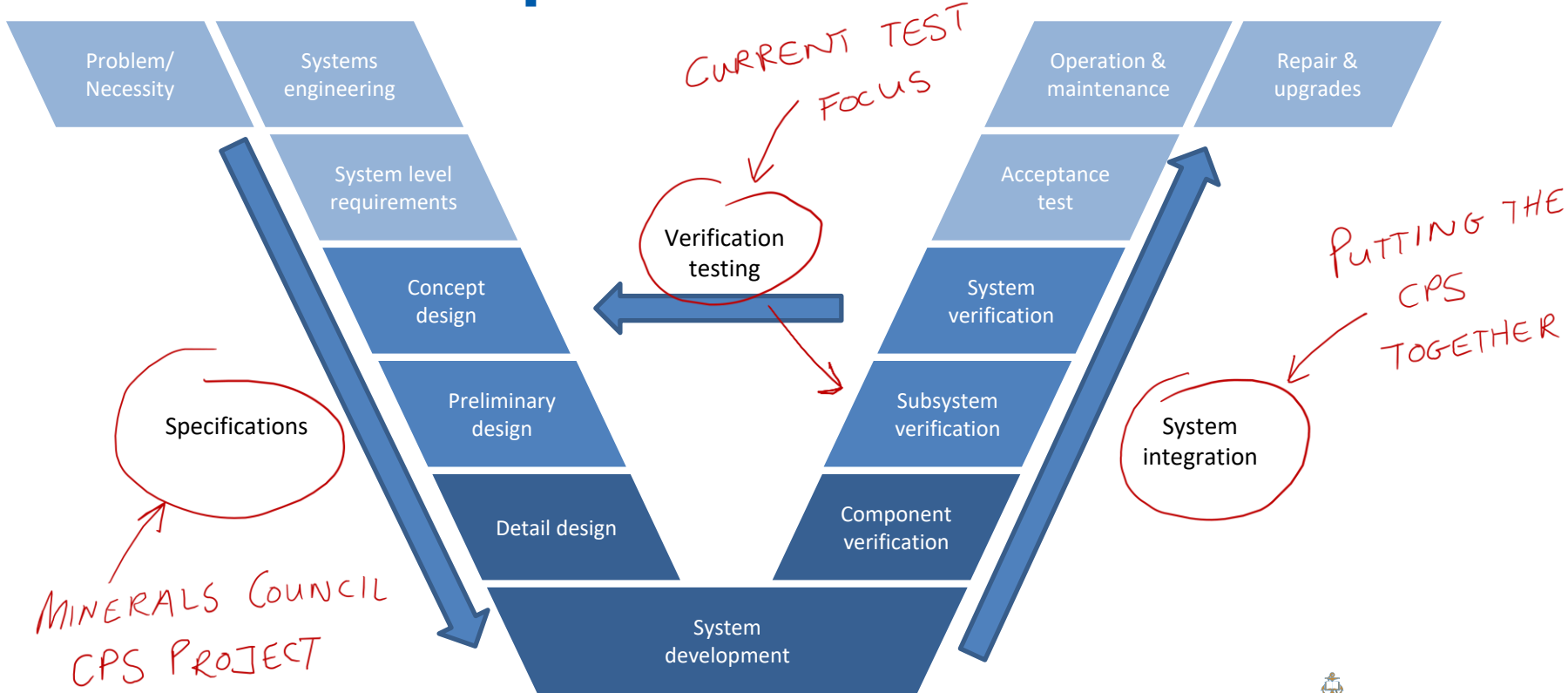
5. Human-System Interface Neglect

- **Example:** A new user interface is too complex for fatigued operators
- **Risk:** Operators are not properly alerted before CPS intervention.
- **Consequence:** Confusion, panic, or override attempts that worsen the situation.
- **Systems Engineering Role:** Integrates human factors engineering.

6. Regulatory Non-Compliance

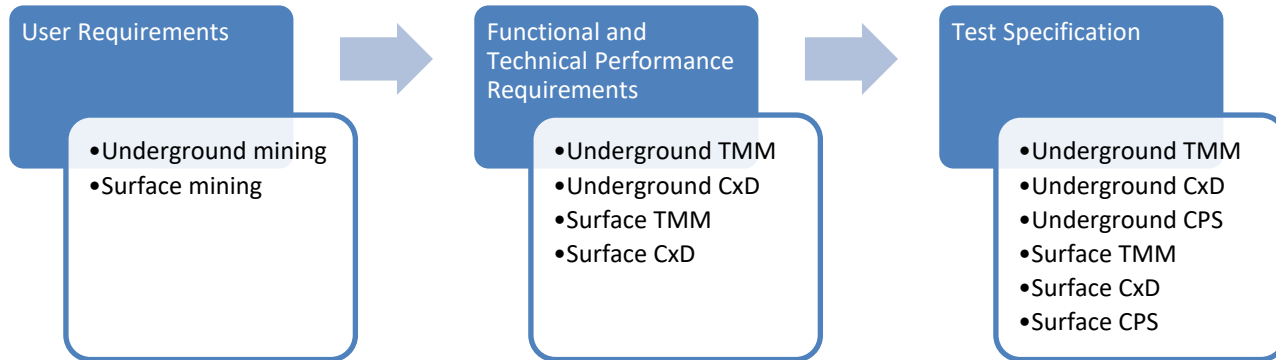
- **Example:** A CPS developer skips formal documentation and traceability.
- **Risk:** CPS product malfunctions, employees at risk of injury due to collisions.
- **Consequence:** Product does not meet the Section 21 requirements of Mine Health and Safety Act and Regulations.
- **Systems Engineering Role:** Ensures traceability.

Product development 101



Systems Engineering for CPS

The MOSH CPS Guideline



TV2

TV3

TV4



TV1

00:00:01

TV1: NOP

TV2: NOP

TV3: Safe Park

TV4: Safe Park



TV2

00:00:01



TV1

TV1: NOP
TV2: NOP

Systems Engineering for CPS

Defining expectations

- **Pros**

- Level playing field through consistency of assessment
- Line in the sand, defining users' reasonable expectations
- Complexity of the technology became more apparent
- End users empowered to engage with rest of the CPS ecosystem

- **Cons**

- Existing products did not meet the requirements
- Significant further development needed
- Difficult conversations between end user and supplier
- Financial implications

Systems Engineering for CPS

Adopting the specification

- **Pros**

- End users are now demanding high-quality products from their suppliers
- Widespread adoption of the specification by local suppliers

- **Cons**

- International suppliers have not adopted the spec widely
- SAMI is exposed to supply chain giants, risking legal appointees to liability if there are injuries/fatalities



Systems Engineering for CPS

Development of new CPS products

- **Pros**

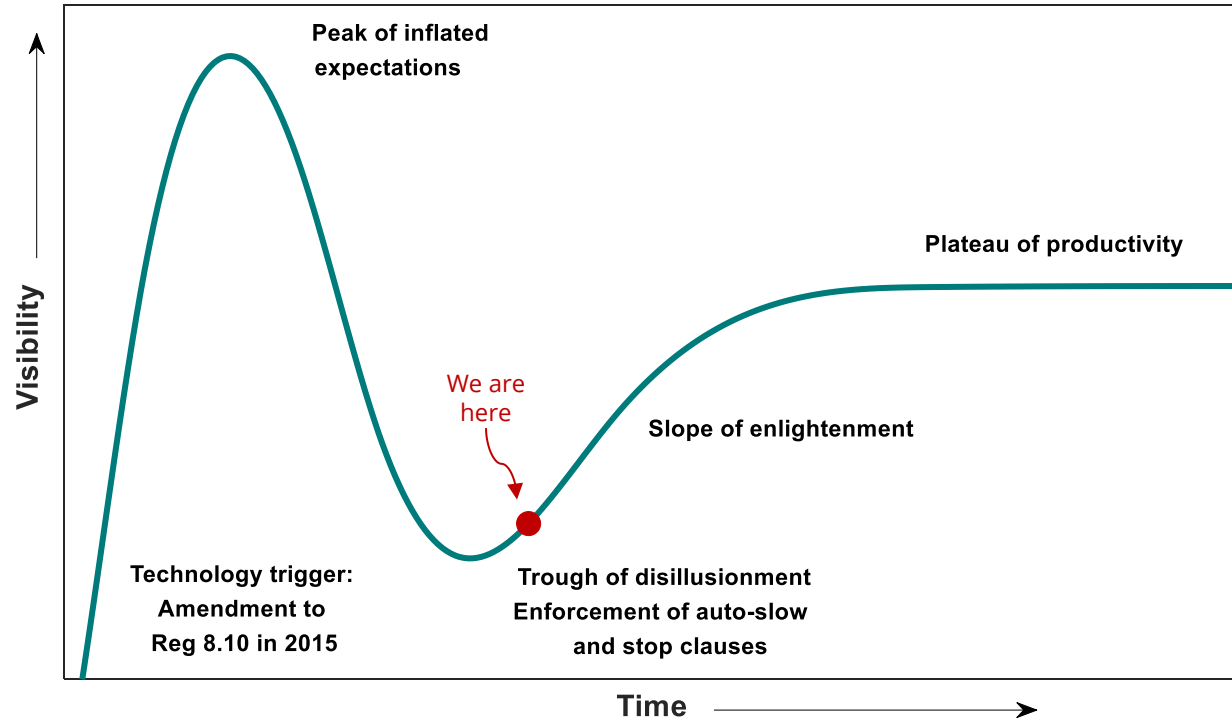
- New, much improved products are coming to the market
- SA products are leading the way, opening export opportunities

- **Cons**

- Development takes time, but Regulator is applying pressure
- Slow progress + realization that products do not perform as good as expected



Riding the hype curve



Systems Engineering for CPS

Concluding remarks

- Applying Systems Engineering principles to CPS has set the tone
 - We have dealt with the art of the possible
 - The result is the MOSH CPS guideline, from user requirement to detailed technical specification
- But the possible still needs to materialize
 - The tree is flowering, the fruit are emerging
- This has not happened overnight or by accident
- South Africa is leading the world for mining collision avoidance

Thank you



UNIVERSITEIT VAN PRETORIA
UNIVERSITY OF PRETORIA
YUNIBESITHI YA PRETORIA

Herman Hamersma

hermanh@up.ac.za

012 420 2926

