FUNCTIONAL AND TECHNICAL PERFORMANCE REQUIREMENTS GAP CHECKSHEET FOR SURFACE TMM COLLISION PREVENTION SYSTEMS FOR

..... Product Name and Model

REV 1

CPS F&TPR GAP REPORT APPROVAL			
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1. Purpose

The purpose of the Functional and Technical Performance Requirements (F&TPR) specification, Gap Check sheet is to define the technical and functional performance requirements gaps that exist for a CPS product at the time of the assessment

2. Scope

The content of this CPS F&TPR specification Check Sheet applies to:

- Surface TMM CPS Products

3. Definitions and abbreviations

As per Functional and Technical Performance Requirements Specification.

4. Machine Interface (MCI)

The Machine to CxD interface functional requirements are documented in ISO TS 21815-2: 2021

5. TMM CPS Functions (TMM CPS)

The TMM CPS performance requirements are documented in **Table 5.**

Req No	Function group	Function Name	Function Description	Performance Criteria	Currently Conform Y/N	Target Date	Comments
0	TMM CPS	TMM CPS Functions	The TMM CPS functions must enable an unintelligent TMM the be intelligent to the extent that a fully functional CPS will be available after CxD installation.	See lower level function See General F&T requirements			
1	MBS	Provide ability to slow down and stop	The TMM must have the physical elements and components to slow down and stop the TMM without operator action	as per TMM OEM requirements proportional braking brake wear must not exceed OEM brake wear limits per hours of operation (MTBF must remain as per original design intent) ISO 3450			
2	S	Sense parameters	The TMM must have the physical elements and components to sense the parameters as is required by the TMM CPS and the CxD	as per CXD developer requirements as per TMM OEM specifications as required for ISO TS 21815-2: 2021			
3	S	Sensor Interface with CxD	The TMM sensing data must be interfaced with the CxDC	as per CXD developer requirements as required for ISO TS 21815-2: 2021			

4	MCI	Interface with CxD	The Machine Controller must have communication (interface) capability with CxD via MC Interface	full ISO TS 21815 -2: 2021 functionality including handshaking protocol as per the ISO TS 21815 - 2: 2021 Appendix A			
5	MC	Provide auto slow down and stop	The TMM must have the control capabilities to control the auto slow and stop	as per TMM OEM requirements appropriate for different speed and load combinations including TMM fail to safe routine			
6	MC	Execute CxD instructions	The TMM machine control function must be such that it can execute the CxDC commands, requests and handshaking	After successful negotiation/handshaking, TMM must be responsive to CxD commands as per CxD developer requirements intervention strategies as informed by ISO 21815 - 2			
7	MC	Auto slow down	Decelerate TMM to a predefined speed without operator action	as per TMM OEM specification OEM mean deceleration: 1.5ms^{-2} to safe speed or as per TMM OEM requirements			
8	MC	Retain Control	TMM must not veer to the left or right from direction of travel when executing CxDC commands	No wheel lock (sliding) ISO 3450 limits			
9	MC	Prevent movement	Prevent TMM from swivelling, articulation, boom or scoop activation after auto stop and safe park	prevent engagement of any gear while in safe park. auto lock articulation, boom movement, scoop movement.			

10	MC	Auto stop	Stop TMM without operator action	execute CxD instruction total braking response time < 500 ms as per OEM specification (ISO 3450 conditions) mean deceleration, peak declaration stop gap is variable as per mining process. The functionality to be demonstratable at TRL 4.			
11	MC	Safe Park	Safe Park TMM after auto slow down and stop	auto engage and lock park brake after execution of CxD or MC initiated auto slow down and stop.			
12	MC	Auto slow down and stop safely	Auto slow down and stop without negatively affecting operator health and safety	prevent operator from excessive jerking when stopping			
13	MC	Retain operator control	Machine control function must allow operator action during auto slow down and stop	during CxD initiated auto slow down and stop, operator must be able to brake and steer the TMM			
14	MLK	Provide TMM CPS log keeping functionality	Log and provide a permanent auditable record of all specified information sets	see lower-level functions			
14.1	MLK	Synchronise	CxD and TMM logs must be synchronised with a Universal Time Frame	UTC + 2h synchronised every hour			
14.2	MLK	Record continuously	Record functions continuously at 1Hz	Save data			
14.3	MLK	Date and time stamp	Uniquely identify every data entry by date and timestamp per data type.	UTC + 2h			
14.4	MLK	Receive and store TMM CPS data	Receive and store data from all TMM CPS functions	data receipt capability at 1Hz continuously			

				non-volatile data storage capability of 30 days before overwriting			
14.5	MLK	Data Transfer	Provide for periodic data transfer to mine data infrastructure	at least once per shift Wi-Fi, Local Area Network (e.g. Ethernet), Personal Area Network (e.g. Bluetooth), USB / serial, removable storage			
14.6	MLK	Data Security	Provide data security for stored and transfer of data	As per specialist opinion			
14.7	MLK	Store data redundantly	Log keeping must be done on multiple independent storage devices	at least 2 fully independent storage devices used to record and store data (RAID)			
14.8	MLK	Store firmware configuration	Store the current version of all CPS firmware elements	unique ID and revision date installed/updated			
14.10	MLK	Record LO system health	The TMM CPS system health must be recorded at every TMM start up and thereafter when health status changes	TMM health status indicators green light on Visual display functional Failure red light within 1ms from detection			
14.11	MLK	Record LO failure data	All failure modes communicated by any TMM CPS module has to be recorded.	module, fault code, date and time stamp			
14.12	MLK	FTS log keeping	CPS must fail to safe when machine log keeping system does not work	failure mode communicated to CxDC			
14.13	MLK	Record all machine data sent to CxDI	All data communicated via the CxDI must be recorded	from 5s preceding the interaction, all data communicated through the CxDI must be recorded			

14.14	MLK	Record emergency override	Relevant data for every emergency override must be recorded	TMM ID operator ID date and Time authorised overrider unique ID duration of override			
14.15	MLK	Record interactions	Instructions and responses to be recorded	save data at 10Hz 5s before interaction			
14.16	MLK	Record auto slow and stop	All communicated auto slow and stop interventions from the CxDC to the MC must be recorded by the MLK	from 5s preceding the interaction, all auto slow and stop interventions communicated by the CxDC must be recorded as well as the responses from the MC			
14.17	MLK	Record LO status	The LO's status must be recorded at 1Hz continuously	the status of the LO must be recorded at 1Hz continuously			
15	MLK	Store all data recorded	Data gathered at each shift	Data gathered must be stored for 30 days before overwriting			

Table 5: TMM CPS performance requirements.

6. TMM CPS Functions (TMM CPS)

The TMM CPS performance requirements are documented in **Table 6.**

Req No	Function group	Function Name	Function Description	Performance Criteria	Currently Conform Y/N	Target Date	Comments
1	G	Risk informed	The CPS and all its individual modules must be informed by formal design risk assessment	mineral composition a) Coal b) Iron content operator and pedestrian health operator and pedestrian safety environment impact			
2	G	Be EMC	The CPS must be electromagnetically compatible with other electronic systems on the mine (including detonation systems, V2X) It must not have any negative health impact on operators or pedestrians and no negative functional impact on any other sensing device used on the TMM.	SANS 13766:2013 human impact: ICNIRP ICASA TA			
3	G	Be Robust		See lower level functions			
3.1	G	Prevent dust and water ingress	CPS must prevent ingress of dust and water (including cap lamp)	IP67 rating			
3.2	G	Survive exposure to shock	CPS components must be able to withstand typical vibration, shocks, etc. as normally experienced by TMMs (including cap lamps)	Mil-STD-810G shock			
3.3	G	Survive exposure to vibration		Mil-STD-810G vibration			
3.4	G	Operate at high and low temperatures	CPS components able to withstand elevated internal temperatures and external temperatures (high and low) as	Mil-STD-810G temperatures			

			typically encountered on the mine (including cap lamps)				
3.6	G	Survive solar radiation	CPS components must be able to withstand high temperatures and photo degradation	Mil-STD-810G solar			
4	G	Power supply		See lower-level functions			
4.1	G	Out of cab functions	Off-board sensors as part must be supplied with suitable power supply (e.g. battery)	formal FMECA informed last at least 48 hours before recharging			
4.2	G	In cab	In cab functions must be powered	Powered via ISO/TS 21815-2:2021 connector			
4.3	G	Physical interface	Power cables plugs	ISO/TS 21815-2:2021 connector			
4.4	G	Battery backup	The CPS must have a battery backup capability	48h capacity auto charged able to prevent collisions when on battery backup			
5	G	Be self-diagnostic	CPS functional elements to be self-diagnostic and continuously monitor function availability	be informed by formal FMECA			
6	G	Report Failure(s) to CxDC	All self-diagnostic functions to report failure(s) to the CxD	reporting within 100ms As per CxD developer specification ISO/TS 21815-2:2021			
7	G	Data Logging	The CxD and TMM CPS must have separate data logging capabilities	See CxDLK and MLK functional requirements			
8	G	Installation (Buildability)	All CPS physical components and elements to be designed for effective installation	retrofittable to existing TMMs see lower-level requirements			

8.1	G	Mounting	Mountings not to deteriorate TMM integrity	positioned as per TMM OEM specification not be exposed to operational hazards - falling material, TMM articulation not affect structural safety ie. mountings, drilling and welding. not cause operator injury - bumping, nipping, cutting not cause EMI to other TMM systems			
8.2	G	Cable routing	All cable routing to support TMM maintainability	positioned as per TMM OEM specification as per appropriate cable specification/standard. be protected from normal operating damage ease of securing and removal of all CPS modules and components protected from physical damage not negatively impact on maintainability of other in cab systems			
9	G	Availability	All CPS modules must be designed for availability	98% components (CxD and TMM CPS respectively) 95% CxD availability maintained			
10	G	Maintainability	The CPS to be designed for optimal maintainability	formal maintenance and repair strategy informed quick removal and mounting of modules modular design to facilitate quick fault finding and lower replacement unit cost MTTR = 90min critical spares identified			

				maintenance spares to be plug and play where applicable maintenance tools to be “special tools” designed for correct removal and fitment.			
11	G	Operability	All CPS modules to be operable/configured/tested after maintenance or component replacement. CPS not to degrade TMM operating or production capability	quick reconfigurable/commissioning Not negatively impact TMM operability/production capability – as per TMM OEM specifications			
12	G	Reliability	All CPS modules must be designed for reliability	Formal FMECA informed CPS MTBF > 2000 operating hours redundancy if required			
13	G	Identification and marking	All CPS modules and sub systems to be uniquely identified and marked	item no item name serial number version physically marked data stored in CxDLK/MLK as relevant data displayed on OW display on request.			
14	G	Firmware requirements	Version controlled and electronically updatable	unique identifier version date installed or last updated updatable via TBD recommissioned after update data logged specifically			
15	G	Reporting	The CPS must have a reporting, trending and business intelligence function that is configurable by the mine	Requirements are TBD.			

16	G	Safety integrity	The CPS must be designed for safety integrity	Comply with GMG GUIDELINE FOR APPLYING FUNCTIONAL SAFETY TO AUTONOMOUS SYSTEMS IN MINING - 18 Aug 2020			
17	G	Off board components	Off-board components/units must initiate a fail to safe instruction when they fail.	Initiate FTS For V2X standard = TBD			
18	G	Calibration	All relevant components and/or modules must be calibrated	Calibration items identified specifically Calibration specifications including frequency and calibration standards.			

Table 6: CPS general performance requirements.