Note: this is TMM hazard rating and not risk rating

CAS Project
TMM risk based approach - hazard rating for underground TMMs

Item	TMM Type	OEM	TMM type specification	Visibility risk	Visibility risk travel	Visibility aid (camera)	Articulation / Swing	Beacon	Attachment lift	Areas of operation	Previous incidents	TMM Type Hazard rating	V-V interaction (Y/N)	V-P interaction (Y/N)	V-E interaction (Y/N)	V-V auto retard	V-V auto stop	V-P auto retard and stop	V-E auto retard and stop	Antenna placement cover for machine movement	Antenna placement Risk	Beacon	Areas of operation expanded-Route going between sites	Specific controls
1	Dump truck	Epiroc / Caterpillar (Diesel)	All	High	High	Medium	Extreme	High	High	High	High	Extreme	Yes	Yes	Yes	Yes	No	Yes	Yes	1) Must cover articulation and reverse	Damage when placed at rear of vehicle	Must act a beacon when parked in high risk area	1) Workshop 2) Parking area 3) Haul roads 4) Mining cycle 5) Tips 6) Tyre bay 7) Refuelling 8) Main decline when moving between shafts	1) Baseline controls 2) Dynamic zoning 3) Act a beacon when in a safe park state in a high risk area 4) Ensure machine and CxD date and time stamp are accurate 5) Exclusion zone inside operator cabin 6) Articulation and attachment / box lock when in safe park or pedestrian enters danger zone 7) Beacon to limit speed on decline (may be an inclinometer) and in workshops **Reasons for L9 decision:** 1) OEM manuals specifically define risks with equipment use 2) Poor visibility of what or who could be in the vicinity of the machine 3) Interaction with pedestrians 4) High speed of machine and large machine size 5) Visibility when driving forward or reverse 6) Pedestrian crushed in articulation
2	Dump truck	Epiroc (BEV)	MT42	High	High	Medium	Extreme	High	High	High	High	Extreme	Yes	Yes	Yes	Yes	No	Yes	Yes	1) Must cover articulation and reverse	Damage when placed at rear of vehicle	Must act a beacon when parked in high risk area	1) Workshop 2) Parking area 3) Haul roads 4) Mining cycle 5) Tips 6) Tyre bay 7) Refuelling 8) Main decline when moving between shafts	1) Baseline controls 2) Dynamic zoning 3) Act a beacon when in a safe park state in a high risk area 4) Ensure machine and CxD date and time stamp are accurate 5) Exclusion zone inside operator cabin 6) Articulation and attachment / box lock when in safe park or pedestrian enters danger zone 7) Beacon to limit speed on decline (may be inclinometer) and in workshops **Reasons for L9 decision:** 1) OEM manuals specifically define risks with equipment use 2) Poor visibility of what or who could be in the vicinity of the machine 3) Interaction with pedestrians 4) High speed of machine and large machine size 5) Visibility when driving forward or reverse 6) Pedestrian crushed in articulation 7) BEV accelerates and articulates quicker than diesel machines - articulation lock is essential (see risk diagram)
3	LHD	Epiroc (Diesel)	All	Extreme	Extreme	Extreme	Extreme	High	High	High	Extreme	Extreme	Yes	Yes	Yes	Yes	No	Yes	Yes	1) Must cover articulation and reverse	Damage through rocks falling on CPS	Must act a beacon when parked in high risk area	All areas other than inside stopes (panels).	1) Baseline controls 2) Dynamic zoning 3) Act a beacon when in a safe park state in a high risk area 4) Ensure machine and CxD date and time stamp are accurate 5) Exclusion zone inside operator cabin 6) Articulation and attachment / box lock when in safe park or pedestrian enters danger zone 7) Beacon to limit speed on decline(may be an inclinometer) and in workshops **Reasons for L9 decision:** 1) OEM manuals specifically define risks with equipment use 2) Poor visibility of what or who could be in the vicinity of the machine 3) Interaction with pedestrians 4) High speed of machine and large machine size 5) Visibility when driving forward or reverse 6) Pedestrian crushed in articulation
4	LHD	Epiroc (BEV)	ST 14	Extreme	Extreme	Extreme	Extreme	High	High	High	Extreme	Extreme	Yes	Yes	Yes	Yes	No	Yes	Yes	1) Must cover articulation and reverse	Damage through rocks falling on CPS	Must act a beacon when parked in high risk area	All areas other than inside stopes (panels).	1) Baseline controls 2) Dynamic zoning 3) Act a beacon when in a safe park state in a high risk area 4) Ensure machine and CxD date and time stamp are accurate 5) Exclusion zone inside operator cabin 6) Articulation and attachment / box lock when in safe park or pedestrian enters danger zone 7) Beacon to limit speed on decline (may be an inclinometer) and in workshops **Reasons for L9 decision:** 1) OEM manuals specifically define risks with equipment use 2) Poor visibility of what or who could be in the vicinity of the machine 3) Interaction with pedestrians 4) High speed of machine and large machine size 5) Visibility when driving forward or reverse 6) Pedestrian crushed in articulation 7) BEV accelerates and articulates quicker than diesel machines - articulation lock is essential (see risk diagram)

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CAS Project
TMM risk based approach - hazard rating for underground TMMs

Item	TMM Type	OEM	TMM type specification	Visibility risk	Visibility risk travel	Visibility aid (camera)	Articulation / Swing	Beacon	Attachment lift	Areas of operation	Previous incidents	TMM Type Hazard rating	V-V interaction (Y/N)	V-P interaction (Y/N)	V-E interaction (Y/N)	V-V auto retard	V-V auto stop	V-P auto retard and stop	V-E auto retard and stop	Antenna placement cover for machine movement	Antenna placement Risk	Beacon	Areas of operation expanded-Route going between sites	Specific controls
5	Drills	Epiroc	All	Medium	Medium	Low	Medium	High	High	High	Extreme	High	Yes	Yes	Yes	Yes	No	Yes	No	1) Must cover articulation and reverse 2) Must cover Tool extremities	• Extremity cover (particularly when navigating around corners). • Limitation of operator to move into tool working area	Must act a beacon when parked in high risk area or when operating.	All areas.	1) Baseline controls 2) Dynamic zoning 3) Act a beacon when in a safe park state in a high risk area 4) Ensure machine and CxD date and time stamp are accurate 5) Exclusion zone inside operator cabin 6) Beacon to warn of speed limit on decline and in workshops **Reasons for effective warning only decision:** 1) OEM manuals specifically define risks with equipment use 2) Good visibility of what or who could be in the vicinity of the machine. 3) Note: Should drill not be fitted with: pedestrian detection devices that prevent the pedestrian being entangled in drill rotation or movement - stop machine hydraulics automatically should pedestrian walk into "danger zone" while drilling - TMM must be fitted with CPS effective warning, auto retard and auto stop. (level 9) - must be risk assessed for control confirmation as many such incidents have occured in SAM!
6	Roof bolter	Epiroc	Boltec	Medium	Medium	Low	Medium	High	High	High	High	High	Yes	Yes	Yes	Yes	No	Yes	No	1) Must cover articulation and reverse 2) Must cover Tool extremities	• Extremity cover (particularly when navigating around corners). • Limitation of operator to move into tool working area	Must act a beacon when parked in high risk area or when operating.	All areas .	1) Baseline controls 2) Dynamic zoning 3) Act a beacon when in a safe park state in a high risk area 4) Ensure machine and CxD date and time stamp are accurate 5) Exclusion zone inside operator cabin 6) Beacon to warn of speed limit on decline and in workshops **Reasons for effective warning only decision:** 1) OEM manuals specifically define risks with equipment use 2) Good visibility of what or who could be in the vicinity of the machine.
7	LDV	Toyota	Toyota Land cruiser Single cab	Low	Low	Low	Low	High	Low	High	High	Medium	Yes	Yes	Yes	No	No	No	No	1) Must have effective exclusion zone inside vehicle	None	Must act a beacon when parked in high risk area or when operating.	All areas other than inside stopes (panels).	1) Baseline controls 2) Dynamic zoning 3) Act a beacon when in a safe park state in a high risk area 4) Ensure machine and CxD date and time stamp are accurate 5) Exclusion zone inside operator cabin 6) Beacon to warn of speed limit on decline and in workshops **Reasons for effective warning only decision:** 1) OEM manuals specifically define risks with equipment use 2) Good visibility of what or who could be in the vicinity of the machine. 3) Interaction with pedestrians is at a low speed of 14km/hr and research shows limited impact at such low speed (need to check after sales fitment - bull bar etc) - must be risk assessed.

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CAS Project
TMM risk based approach - hazard rating for underground TMMs

Item	TMM Type	OEM	TMM type specification	Visibility risk	Visibility risk travel	Visibility aid (camera)	Articulation / Swing	Beacon	Attachment lift	Areas of operation	Previous incidents	TMM Type Hazard rating	V-V interaction (Y/N)	V-P interaction (Y/N)	V-E interaction (Y/N)	V-V auto retard	V-V auto stop	V-P auto retard and stop	V-E auto retard and stop	Antenna placement cover for machine movement	Antenna placement Risk	Beacon	Areas of operation expanded-Route going between sites	Specific controls
8	Scaler	Aard	Rock Scaler 220E Gen 1	Extreme	Extreme	Extreme	Extreme	Medium	High	Extreme	Extreme	Extreme	Yes	Yes	No	Yes	No	Yes	No	1) Must cover tool extremities 2) Must cover tool head changes 3) Must cover turning on own axis 4) Must have an effective exclusion zone inside vehicle	1) Flasher to be positioned in pedestrian and operator line of site 2) Prox mod to be positioned away from heat of exhaust outlet	Must act a beacon when parked in high risk area or when operating.	Mainly in mining cycle activities	1) Baseline controls 2) Dynamic zoning 3) Act a beacon when in a safe park state in a high risk area 4) Ensure machine and CxD date and time stamp are accurate 5) Exclusion zone inside operator cabin 6) Turning on axis must be specifically catered for in CAS control 7) Beacon to limit speed on decline (may be inclinometer for decline) and in workshops **Reasons for L9 decision:** 1) OEM manuals specifically define risks with equipment use 2) Poor visibility of what or who could be in the vicinity of the machine 3) Interaction with pedestrians 4) High rotational speed of machine and poor visibility 5) Visibility when driving forward or reverse 6) Pedestrian caught in quick rotation of machine 7) Lock of machine during tool changes.
9	Scaler	Bell	Rock Scaler 220E Gen 2	Extreme	Extreme	Extreme	Extreme	Medium	High	Extreme	Extreme	Extreme	Yes	Yes	No	Yes	No	Yes	No	1) Must cover tool extremities 2) Must cover tool head changes 3) Must cover turning on own axis 4) Must have an effective exclusion zone inside vehicle	1) Flasher to be positioned in pedestrian and operator line of site 2) Prox mod to be positioned away from heat of exhaust outlet	Must act a beacon when parked in high risk area or when operating.	Mainly in mining cycle activities	1) Baseline controls 2) Dynamic zoning 3) Act a beacon when in a safe park state in a high risk area 4) Ensure machine and CxD date and time stamp are accurate 5) Exclusion zone inside operator cabin 6) Turning on axis must be specifically catered for in CAS control 7) Beacon to limit speed on decline (may be inclinometer for decline) and in workshops **Reasons for L9 decision:** 1) OEM manuals specifically define risks with equipment use 2) Poor visibility of what or who could be in the vicinity of the machine 3) Interaction with pedestrians 4) High rotational speed of machine and poor visibility 5) Visibility when driving forward or reverse 6) Pedestrian caught in quick rotation of machine 7) Lock of machine during tool changes.
10	Grader	CAT	120 G	Medium	Medium	High	Low	Medium	High	Extreme	Medium	High	Yes	Yes	No	Yes	No	Yes	No	1) Must cover both forward and reverse extremities 2) Note: Grader can travel in forward and reverse at same speed. 3) Must have an effective exclusion zone. 4) Must act as beacon when parked in high risk areas (such as mining cycle or haul roads)	1) Must cover forward and reverse (to include speeds)	Must act a beacon when parked in high risk area or when operating.	Mainly in areas when haul roads must be maintained	1) Baseline controls 2) Dynamic zoning 3) Act a beacon when in a safe park state in a high risk area 4) Ensure machine and CxD date and time stamp are accurate 5) Exclusion zone inside operator cabin 6) Turning radius of 7m must catered for in CAS control 7) Beacon to limit speed on decline (may be inclinometer for decline) and in workshops **Reasons for L9 decision:** 1) OEM manuals specifically define risks with equipment use 2) Poor visibility of what or who could be in the vicinity of the machine 3) Interaction with pedestrians 4) Small turning radius of machine 5) Speed when driving forward or reverse 6) Pedestrian caught in quick turning of machine 7) Machine to crawl in vicinity of other machines

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CAS Project
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Item	TMM Type	OEM	TMM type specification	Visibility risk	Visibility risk travel	Visibility aid (camera)	Articulation / Swing	Beacon	Attachment lift	Areas of operation	Previous incidents	TMM Type Hazard rating	V-V interaction (Y/N)	V-P interaction (Y/N)	V-E interaction (Y/N)	V-V auto retard	V-V auto stop	V-P auto retard and stop	V-E auto retard and stop	Antenna placement cover for machine movement	Antenna placement Risk	Beacon	Areas of operation expanded-Route going between sites	Specific controls
11	Dozer (Underground)	Epiroc	1) Epiroc ST1030 wheel dozer	Extreme	Extreme	Extreme	Extreme	High	High	High	Extreme	Extreme	Yes	Yes	Yes	Yes	No	Yes	Yes	1) Must cover articulation and reverse 2) Must cover Tool extremities 3) Must have an effective exclusion zone	Damage through rocks falling on CPS	Must act a beacon when parked in high risk area	All areas other than inside stopes (panels).	1) Baseline controls 2) Dynamic zoning 3) Act a beacon when in a safe park state in a high risk area 4) Ensure machine and CxD date and time stamp are accurate 5) Exclusion zone inside operator cabin 6) Articulation and attachment / box lock when in safe park or pedestrian enters danger zone 7) Beacon to limit speed on decline (may be inclinometer for decline) and in workshops **Reasons for L9 decision:** 1) OEM manuals specifically define risks with equipment use 2) Poor visibility of what or who could be in the vicinity of the machine 3) Interaction with pedestrians 4) High speed of machine and large machine size 5) Visibility when driving forward or reverse 6) Pedestrian crushed in articulation
12	Dozer (SOT)	Bell (CAT?)	1) Bell (CAT?) D8R	Medium	Medium	High	Medium	Medium	High	Medium	Low	High	Yes	Yes	Yes	Yes	Yes	No	Yes	1) Must cover both forward and reverse extremities 2) Note: Dozer can travel in forward and reverse at same speed. 3) Must have an effective exclusion zone. 4) Must act as beacon when parked in high risk areas (such as mining cycle or haul roads)	Must cover when blade is raised	Must act a beacon when parked in high risk area	Mainly on dumps	1) Baseline controls 2) Dynamic zoning (not critical) 3) Act a beacon when in a safe park state in a high risk area (smaller vehicles running into Dozer) 4) Ensure machine and CxD date and time stamp are accurate 5) Exclusion zone inside operator cabin if PADs are used 6) Attachment lock when in safe park or pedestrian enters danger zone (under blade) **Reasons for L9 decision:** **Note:** Although the hazard rating is high, the dozer must be risk assessed to determine whether L9 or L7/8 is required. Previous incidents of dozers running over LDVs parked in the vicinity has occurred globally. 1) OEM manuals specifically define risks with equipment use 2) Poor visibility of what or who could be in the vicinity of the machine 3) Interaction with pedestrians 4) Risk of running over other vehicles (particularly in reverse) 5) Visibility when driving reverse
13	UV	Aard, SECO, Fermel, Toyota, Bird	1) Aard UV 80 lube 2) Aard UV 80 emulsion 3) Fermel Carr/MKIII RORO 4) Fermel Cassette Carrier 5) Fermel flatbed 6) Fermel K/Cab Flat Crane 7) Toyota LC plus crane 8) Aard lube unit 9) Fermel Mav K/Cab Jampot 10) Fermel Maverick Man Lift 11) Fermel placer dumper 12) Fermel single cab man lift 13) Fermel S/Cab Stad load Bin 14) Aard UV 120 water bowser 15) Aard SECO diesel tanker 16) Aard UV 80 scissor lift 17) Fermel UV 80 Liberator	High	Extreme	High	High	High	High	Extreme	Medium	Extreme	Yes	Yes	Yes	Yes	No	Yes	No	1) **Note:** due to the varied operations of the different UV types, antenna placement must make allowance for: 1.1.) Scissor lift operation, 1.2.) Water and fuel bowser operation, 1.3.) Emulsion and lube operation, 1.4.) Crane operation, 1.5.) Jampot operation, 1.6.) Cassette carrier operation etc. 2) Antenna placement must make allowance for the extreme reaches and operation of each machine type. 3) Due to the nature of many of these operations antenna and cable protection must be considered. 4) Underground to surface fleet CPS must be enabled on many of the UVs.	Due to the nature of many of these operations antenna and cable protection must be considered.	1) Acting as a beacon is critical for most of these machines. Example: scissor lift, lube, emulsion etc. 2) Must act a beacon when parked in high risk area	1) Many of the different UV types operate throughout all areas of the underground operations as well as regularly ascending and descending the decline to the surface.	1) Baseline controls 2) Dynamic zoning 3) Act a beacon when in a safe park state in a high risk area 4) Ensure machine and CxD date and time stamp are accurate 5) Exclusion zone inside operator cabin 6) Articulation and attachment / box lock when in safe park or pedestrian enters danger zone 7) Beacon to limit speed on decline (may be inclinometer for decline) and in workshops **Reasons for L9 decision:** 1) OEM manuals specifically define risks with equipment use 2) Poor visibility of what or who could be in the vicinity of the machine 3) Interaction with pedestrians 4) High speed of machine and large machine size 5) Visibility when driving forward or reverse 6) Pedestrian crushed in articulation

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14	Telehandlers, forklifts, cranes, tyre handler	Manitou	MVT675T, Crane MHT-X 780 T Evolution, 8T MHT 780 Telescopic Handler,	High	High	Medium	Medium	High	High	Extreme	Medium	High	Yes	Yes	Yes	Yes	No	Yes	Yes	1) Must cover extreme of boom extension. 2) Antenna placement must make allowance for the extreme reaches and operation of each machine type. 3) Due to the nature of many of these operations antenna and cable protection must be considered. 4) Underground to surface fleet CPS must be enabled on some of the Manitous. **5) Note:** there is extreme visibility risk when the Manitou is traveling forward particularly when turning right with boom raised >10 degrees	Must cater for boom extension	Must act as a beacon when parked or working in high risk area	Operates mainly in workshop areas (tyre handling, forklift operations, manlift etc)	1) Baseline controls 2) Dynamic zoning 3) Act a beacon when in a safe park state in a high risk area 4) Ensure machine and CxD date and time stamp are accurate 5) Exclusion zone inside operator cabin 6) Beacon to warn of speed limit on decline and in workshops 7) Speed to be limited to 14 km/hr (max speed when tramming) 8) Tramming to be done with boom down (visibility is impaired with boom raised) **Reasons for effective warning only decision:** 1) OEM manuals specifically define risks with equipment use 2) Good visibility of what or who could be in the vicinity of the machine. 3) Stopping machine with load could cause load to drop onto pedestrians (extreme risk)
15	Skid steer loader	Bobcat	S650, S770, TRS0.210	Low	Medium	Medium	Low	High	Medium	High	Medium	High	Yes	Yes	No	No	No	No	No	1) Must cover both forward and reverse extremities 2) Note: skid steer can travel in forward and reverse at same speed. 3) Must have an effective exclusion zone. 4) Must act as beacon when parked in high risk areas (such as mining cycle or haul roads)	1) Little risk 2) Must cover extremes of extension (note: TRL 50.210 can rotate and has large boom extension)	1) Must act as a beacon when parked or working in high risk area 2) Must act as beacon when outriggers and lifting equipment.	1) Operates mainly in clean up limited space areas 2) Not sure about TRL 50.210	1) Baseline controls 2) Dynamic zoning 3) Act a beacon when in a safe park state in a high risk area 4) Ensure machine and CxD date and time stamp are accurate 5) Exclusion zone inside operator cabin 6) Beacon to warn of speed limit on decline and in workshops 7) Speed to be limited to 14 km/hr 8) Tramming to be done with boom down (visibility is impaired with boom raised) **Reasons for effective warning only decision:** 1) OEM manuals specifically define risks with equipment use 2) Good visibility of what or who could be in the vicinity of the machine.

TMM	Pedestrian interaction	Vehicle interaction
Drills	Level 9	Level 7
Roofbolters	Level 9	Level 7
LHD's	Level 9	Level 9 (Crawl)
Dumptrucks	Level 9	Level 9 (Crawl)
Scaler	Level 9	Level 9 (Crawl)
Grader	Level 9	Level 9 (Crawl)
Dozers	Level 9	Level 9 (Crawl)
Bobcat	Level 9	Level 9 (Crawl)
Manitou	Level 9	Level 9 (Crawl)
LDO's	Level 9	Level 7
UV's	Level 9	Level 9 (Crawl)
Proto land cruiser- LDV	Level 7	Level 7
Emergency vehicles – Ambulance land cruiser	none	none