MINING OCCUPATIONAL SAFETY AND HEALTH INITIATIVE

Leading Practice Adoption System

MINERALS COUNCIL
SOUTH AFRICA

TRAFFIC MANAGEMENT TECHNICAL GUIDE
FOR
UNDERGROUND TRACKLESS OPERATIONS
IN
SOUTH AFRICA

February 2020

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DEFINITIONS AND ACRONYMS

All words in the definition table are indicated by Italics in the document.

Access roads	Roads used for any other purpose than hauling of broken ore.
Control	An object, human action or combination of the two introduced in operations in order to eliminate or mitigate against occupational health and safety hazards.
COP	Latest revision of the Mandatory guideline for a Code of Practice as described by section 9 of the Mine Health and Safety Act (Act No. 29 of 1996).
Cross-fall	Means the transverse sloping of a roadway towards the shoulder or gutter on either side.
Curve	Means any bend in a road that results in a gradual change of direction in the horizontal plane.
Decline/Incline	Means a tunnel with a gradient intended to connect workings with different elevations.
Exclusion Zone	No go area.
Gradient	Means the amount of slope a haul road has from the horizontal along the length of the road, measured in degrees. Where the grade is given in percentage, grade (%) is determined by dividing the road's vertical rise by its horizontal run and multiplying this value by 100.
Implementation	A process of introducing practices.
Induction	Any intervention / mechanism to communicate relevant rules of the mine and that have proof of doing.
Intersection	A place where two or more roads meet.
LHD	Load-haul-dumper
Leading Practice	The current best tried and tested way to do something.
MOSH	Mining Industry Occupational Safety and Health
OEM	Original Equipment Manufacturer
Overtaking	Vehicles moving in the same direction with one moving faster than the other with the intention to pass the slower vehicle.
PDS	Proximity Detection System
Pedestrian	Any person on foot.
Reasonably practicable	Practicable having regard to: (a) the severity and scope of the hazard or risk concerned; (b) the state of knowledge reasonably available concerning that hazard or risk and of any means of removing or mitigating that hazard or risk; (c) the availability and suitability of means to remove or mitigate that hazard or risk; and (d) the costs and the benefits of removing or mitigating that hazard or risk.
Risk area	Means an area where there is a likelihood that uncontrolled interaction of vehicles or vehicles with persons may result in injury or harm to persons or equipment.

TMM	Trackless Mobile Machine: any self-propelled mobile machine that is used for the purpose of performing mining, transport or associated operations underground or on surface at a mine and is mobile by virtue of its movement on wheels, skids, tracks, mechanical shoes or any other device fitted to the machine, but excludes rail bound equipment, scraper winches, mono rail installations, static winches, draglines, winding machinery installations, track mounted conveyors and any equipment attached thereto.
Traffic Management Plan	A plan established to clearly direct and control traffic at specific areas.
Traffic Management System	The collective mechanisms employed by the mine to ensure optimized and safe movement of vehicles and pedestrians.

Objective

Traffic management, or lack thereof, has been identified as one of several factors that if dealt with appropriately, could improve the safety performance of underground trackless operations significantly. Notwithstanding the prevailing requirements of all relevant legislation governing the operation and use of trackless mobile machines (TMM) at any mine, this document seeks to assist the mining industry to identify potential improvement to existing controls and operating procedures. In so doing, this will enhance existing measures to prevent traffic related accidents as well as indicate possible gaps that exist in current operating protocols in the industry.

Applicability

It is noted that the contents of this document may not all be applicable to each underground trackless operation across the diverse South African mining industry. The reader is advised to focus all attention on sections of this document that are relevant to the current or intended type of operation that the reader is responsible for.

Introduction

Traffic management is all about the movement of persons and vehicles. Safe movement of persons and vehicles has been a challenge in underground trackless operations since the introduction of TMM in the South African mining industry. The Minerals Council's MOSH Transport and Machinery (T&M) team recently facilitated the documentation of a Traffic Management Leading Practice for surface operations, and the MOSH T&M Underground Industry team saw it as an opportunity to develop a similar guideline for good practice for underground trackless operations.

This document seeks to consolidate best practices from the industry into a single good practice technical guide that may be adopted by underground trackless mines to assist in the management of traffic. When a new site or mine is planned and designed the principles of this document may also be considered and incorporated as part of the pre-planning and design.

Acknowledgements

In the true spirit of "for industry by industry" this document was initially developed by the MOSH T&M Open Cast/Pit Industry Team and adapted for underground trackless operations by the MOSH T&M Underground Industry Team. The Minerals Council that facilitated the development wishes to acknowledge the following industry members:

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Table 1: Participating Industry Team Members

Traffic management scope

Traffic management deals exclusively with the safe interaction and movement of people and vehicles. Proper traffic management is achieved by the establishment of an effective traffic management system, the maintenance and improvement thereof, as well as assuring adherence to all controls used as part of it. Hazard sources from equipment as well as equipment operators are not included in the scope of traffic management. Hazards and hazard sources from the operating environment are, however, included i.e. water, dust, heat, poor visibility, noise, etc.

The Earth Moving Equipment Safety Round Table (EMESRT) adopted a nine-step hierarchical type model around design, operation and reaction which clearly identifies the areas of focus for the end user, mining companies, the original equipment manufacturers (OEMs) as well as third party suppliers of vehicle interaction systems to provide a 'one voice' of the industry approach. Figure 1 below is a summary of the nine "levels of control" as will be used as a guideline for this document. This document focuses on levels 1, 2, 3, 6 and 7. Autonomous vehicles and levels 4, 5, 8 and 9 are specifically excluded.

EMESRT

1	**Site Requirements**	Equipment specifications, standards, mine design/plans	YEARS
2	**Segregation Controls**	Berms, access control, traffic segregation, time schedule	MONTHS
3	**Operating Procedures**	SOP's, maintenance, road rules, quality control, lockout	WEEKS
4	**Authority to Operate**	Training, licences, induction, access control	DAYS
5	**Fitness to Operate**	Fatigue state, drug & alcohol, medicals	SHIFT
6	**Operating Compliance**	Pre-start, safety test, machine health, event recordings	HOURS
7	**Operator Awareness**	Cameras, live maps, mirrors, lights, visible delineators	MINUTES
8	**Advisory Controls**	Alerts: Proximity, Fatigue, Over-speed, Vehicle stability	SECONDS
9	**Intervention Controls**	Interlocks: Prevent Start, Slow-Stop, Rollback, Retarder	MS

Figure 1: EMESRT vehicle interaction controls, description and effective time

1. TRAFFIC FLOW AND RISK ANALYSIS

The foundation of an effective *traffic management system* is a traffic flow analysis.
The information that the mine needs is:

- Who goes where, why, when, how and for how long?
- What can go wrong on the way, while there or coming back?

The traffic flow and risk analysis should be based on current operations and layout of the mine. The risk analysis must identify all hazards related to vehicle and *pedestrian* movement for the specific mine. The analysis must include but may not be limited to the elements defined herein.

The mine's operational processes as defined in the mine's risk management documents are to be used for identification of *pedestrian* and vehicle interaction and movements related to each operational process separately, as well as general movement thereof on the mining area.

When considering *controls* to mitigate identified unwanted events (risk descriptions) the mine must follow the hierarchy of *controls* to eliminate the unwanted events as far as practicably possible. The hierarchy of *controls* is described briefly in figure 2 on the next page.

Hierarchy of Controls

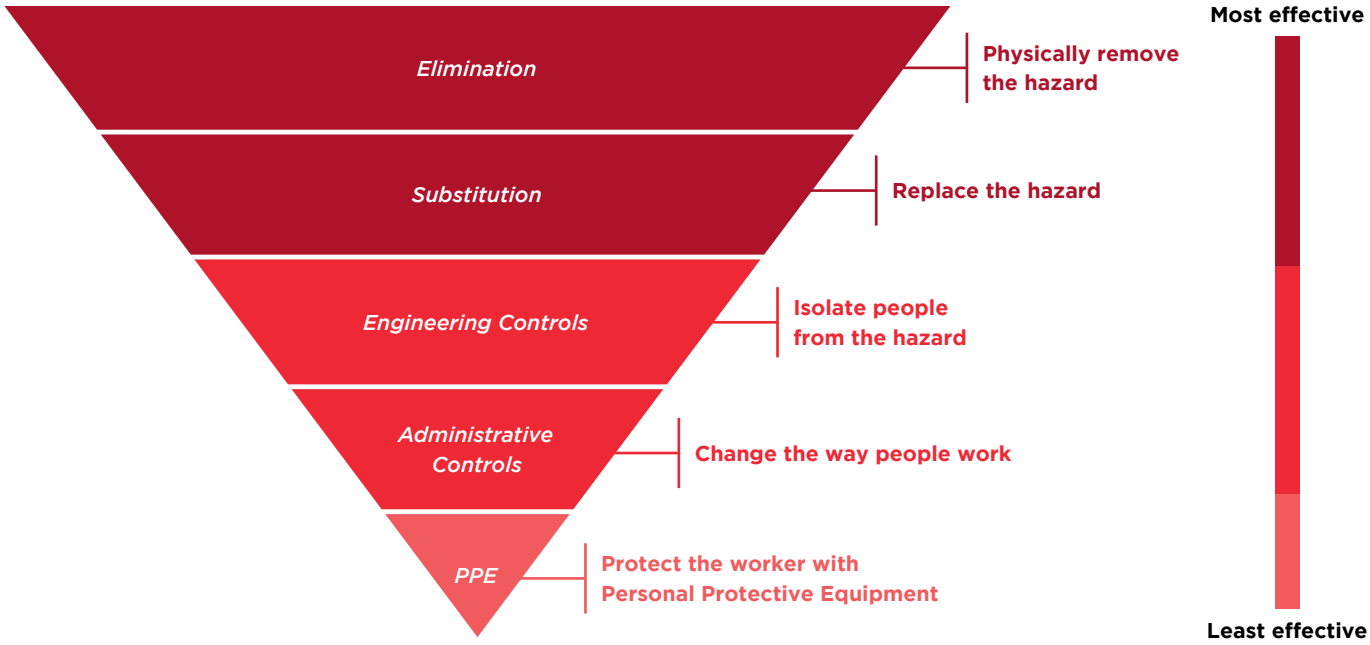


Figure 2: Hierarchy of controls in the safety context

The mine's *traffic management system* must be based on the equipment as described in the official equipment register and all requirements of the mandatory code of practice (COP) for the operation of *TMM*, specifically, the selection of appropriate equipment for the operation. The relevant details of all functions performed using vehicles must be considered to identify hazards and unwanted events, e.g. not omitting transportation of materials using an *LHD* when considering functions.

THE FOLLOWING ARE THE MINIMUM REQUIREMENTS TO CONDUCT A TRAFFIC FLOW AND RISK ANALYSIS:

- A mine layout (current or planned) with clearly identified access routes, haulages, cross cuts, boards, pillars, development ends, stopes, *pedestrian* walkways, training facilities, waiting places, maintenance workshops, parking areas, belt drives, tips, etc. The layout must indicate at least the following information:
  - » Direction of travel
  - » Types of vehicles/equipment
  - » *Pedestrian* movement

  It is important that the layout plan clearly indicates potential interaction points between vehicles and other vehicles, vehicles and *pedestrians*, vehicles and objects/equipment and vehicles and voids (risk of falling over/into).

- Identify hazardous areas on all roads and routes on the operation including, but not limited to, sharp bends and corners, *intersections*/cross cuts, narrow roads/haulages, inclines and declines (hazardous *gradients*), blind spots, poor visibility areas, fixed structures, etc.

- Identify the hazards and unwanted events (iteratively) posed by vehicle and *pedestrian* movement related to all identified operational activities. These must include but not be limited to all the relevant elements addressed in this document.

Define all the unwanted events (risk descriptions) from each hazard. These are to be specific to specific locations on the mine layout (i.e. "what could go wrong here?" not just in general). The persons that might be harmed in an unwanted event must be specifically identified.

Determine the worst-case consequence of each unwanted event.

Identify existing controls per unwanted event (i.e. per risk description).

"Determine the worst-case consequence of each unwanted event."

- Conduct a risk rating exercise according to the mine's risk management system.
- Consideration is to be given to the applicability and effectiveness of all the elements and principles contained in this document to reduce the probability and/or consequence of an unwanted event in order to prevent or mitigate the unwanted event. Recommendations are to be made on applicable elements and *controls* that can be implemented.
- Record the outcomes of the traffic flow and risks analysis process.

2. MINE LAYOUT AND ROAD SYSTEMS (ROUTES)

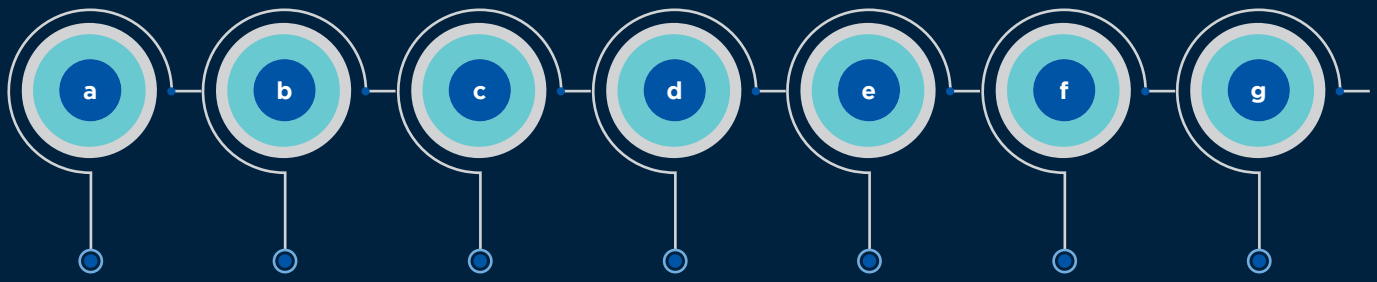
Every effort must be made to avoid creating dangerous areas, interaction of persons and machinery, permanent obstructions and restricted clearances during the design of roadways, tipping areas, multiple cross overs, refuelling bays, workshops, muck piles, etc. The design of roadway networks must be based on principles of separating production vehicles from service vehicles and persons from vehicles. This includes single direction flow of traffic with separate entry and exit points as far as reasonably practicable.

2.1. ZONING AND ZONE CONTROL

Zoning provides the mine with a practical control to ensure that only authorized vehicles and *pedestrians* enter demarcated zones. This can be done either through physical *controls* (e.g. barriers) or adherence to administrative *controls* (e.g. visual markers/demarcations). Specific traffic management rules, other than the normal rules, as determined by site specific risk assessments, must be displayed at the entrance to applicable areas.

2.1.1 Areas of the mine should be zoned in accordance with the risks (including interactions) specific to the area in order to differentiate *risk areas* and relevant *controls*.

2.1.2 The risk areas to be defined in accordance with demarcated zones such as:



Exclusion zones	**Restriction zones**	**Danger zones**	**Vehicle only zones**	***Pedestrian* zones**	**Mixed zones**	**Restricted speed/gear zones**
No entrance for vehicles or *pedestrians*	Only specific vehicles or *pedestrians* allowed	High *risk* area where additional precautions may be applicable (e.g. loading areas)			(vehicles and *pedestrians*)	

2.2. ACCESS ROADS

2.2.1 Access *roads* should be routed such that traffic flow is directed and controlled (no shortcuts possible).

2.2.2 Pedestrians should be separated from roads by separation mechanisms such as dedicated walkways, marked crossings, handrails, and time zones and/or movement rules. These should be utilized as appropriate to achieve effective separation.

2.2.3 Access *roads* should have effective controls to prevent vehicles from leaving the road uncontrolled by installation of barriers where the risk requires such and as far as reasonably practicable.

2.2.4 Road routing should take cognizance of services, infrastructure, fire risk and emergency response.

2.3. ENVIRONMENTAL/OPERATING CONDITIONS

When designing roads and operational procedures, environmental conditions and the effect thereof must be considered and incorporated into such designs. These include, but are not limited to:

- Exposure of TMM operators/pedestrians to noise
- Exposure of TMM operators/pedestrians to dust
- Ambient temperatures and possible effects of seasonal changes
- Water ingress (slippery roadways, splash on person's face)
- Ventilation flow
- Hydrocarbons (fluids)
- Illumination and reflectivity of the surroundings

3. ROADWAYS DESIGN

Roadways should, as far as reasonably practicable, be:

- *constructed separate from the general movement of pedestrians;*
- *designed to make provision for water drainage where the risk of water accumulation exists;*
- *constructed and maintained with such material as to ensure proper road holding, reduce the risk of skidding and enable machines to be stopped safely under various operating conditions; and*
- *constructed such that the lowest maximum angle of inclination (as per the equipment register) is not exceeded to avoid high torques during upward travel and ensure steady braking during full load downward travel.*

3.1. ROADWAY DIMENSIONS

When determining the dimensions of a roadway, the following must be taken into consideration:

- Intended use of the roadway. i.e. vehicles only or mixed travel
- Equipment dimensions and capabilities (including turning radius)
- Speed of travel
- Single or dual direction of travel
- Mining methods and geological features (e.g. dip, reef height, slips, etc.)
- Safe passing distance between machines (where applicable)

The mine must determine a safe minimum clearance (sidewall and hanging wall) around the largest *TMM* required to use the roadway through a risk assessment. Such minimum clearances must be monitored along with roadway maintenance on a continuous basis and where restrictions are observed additional *controls* must be put in place and managed. Height indicators installed on *TMM* are an effective way of measuring and monitoring roadway height.

3.2. SERVICES

Routing of services must, as far as practicable, be designed to be separate from the *TMM* roadways so as to eliminate maintenance personnel in the roadways. Where this is not practicable conduct a risk assessment and apply an alternate method. For example, services must be suspended securely on the up-dip side of the roadway. Where services cross over roadways it must be protected, clearly demarcated and comply to the minimum height clearance and where restrictions are observed additional *controls* must be put in place and managed.

3.3. CROSS-FALL OF ROADS

It is essential that road surfaces have a cross-fall to ensure water runoff, depending on the drainage concept used. The cross-fall angle underground largely depends on the dip of the strata. It must be noted that excessive angles may cause slipping of machinery.

3.4. DRAINAGE

It is critically important that adequate drainage be provided to remove water from the surface of the roadway to avoid slippery conditions. Means must be provided to direct water away from the roadway to a dedicated collection point to avoid accumulation in the roadway.

3.5. INCLINES AND DECLINES

Inclines are to be developed with inclinations within the safe and productive operating parameters of the equipment in use at the mine. The standard for the *leading practice* is 12° or less. Inclines should be built with a constant inclination; footwall irregularities must be smoothed, and spillage removed as variation in *gradient* has a detrimental effect on *TMM* operation.

Entry to declines/inclines from the horizontal should have a gradual transition to reduce dynamic loading and to improve line of sight over the horizon. The rate of transition over this distance is to be constant taking into consideration the parameters of the equipment in use at the mine.

3.6. CURVES

When designing curves, the following aspects should be taken into consideration:

- Vehicle dimensions, turning radius and speed
- Vehicle visibility chart
- Traffic flow and volume (zone classification)
- Intersections near a sharp curve are to be avoided. If an intersection must be on a curve, then an adequate radius must be allowed to minimize unnecessary maneuvering by vehicles.
- As far as practicable, cross fall should be sloped to the inside of a curve.

"Inclines are to be developed with inclinations within the safe and productive operating parameters of the equipment in use at the mine."

3.7. INTERSECTIONS

Intersections can be hazardous and should be minimized as far as reasonably practicable. Intersections are to be designed and constructed such that it manages traffic flow while minimizing the risk of dangerous interactions. As far as practicable:

intersections should be at right angles to enhance visibility;

multiple intersections are to be avoided but spaced adequately where unavoidable;

intersections with declines or inclines should be minimized; and

intersections must be constructed as flat as possible to facilitate visibility.

Intersections must be indicated on the underground traffic plan and must clearly indicate all stop signs and/or traffic lights as per risk ranking.

3.8. VENTILATION CONTROLS

Ventilation design must be incorporated into the design of a *traffic management plan*. The number of roadway access points through ventilation controls should be minimized as far as practicable. Where vehicles must go through ventilation controls it is preferable to use automatic or semi-automatic doors without the vehicle operator having to disembark. If ventilation brattices are used, then it must be constructed using see-through material.

3.9. SPEED

The safe speed in an area is a risk-based determination considering the mine design and several other parameters such as road design, road condition (varying based on current road condition and determined at beginning and during shifts) vehicle manufacturer requirements, tyre manufacturer requirements, load, layout, dimensions, machinery type, slope, safe braking and following distances as well as traffic interactions. Braking distances as per SANS 1589, dynamic tests and calculations are to be used to determine safe speeds and following distances.

In declines/inclines, gear selection must be done prior to entering the roadway. All machines must engage the appropriate gear that will limit the vehicle to a safe speed (as per site risk assessment). Changing of gears, depressing a clutch or driving a vehicle in neutral while in a decline/incline must be avoided (the transmission should always be engaged).

The use of speed control devices (e.g. limiting functional gears, automatic speed governors) and logging of speed for monitoring and management purposes is considered as best practice.

3.10. EDGE PROTECTION

At any edge where there is a possibility of a vehicle falling down or into; edge protection, a berm or suitable barriers of sufficient strength and height (per application) is required. The edge protection, berm or barrier must be maintained to ensure continuous effectiveness.

4. ROAD MAINTENANCE AND REPAIR

Poor road condition increases the safety risk on roads significantly. Road maintenance and repair is a key control to mitigate this risk. This is particularly important where traffic volumes and uncontrolled water have a negative impact on road conditions. Poor road conditions are also a major contributor to vehicle wear and tear.

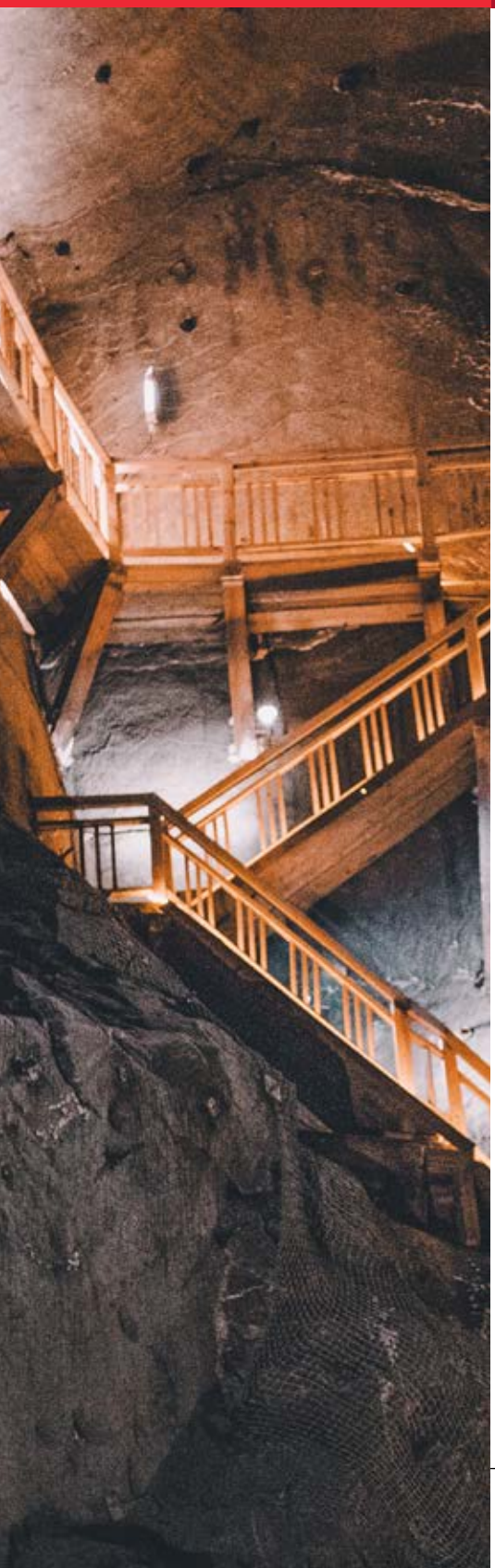
A road maintenance and repair standard must be compiled that addresses, as a minimum, the following:

- General safety requirements when working in a portion of the road
- Appointments and responsibilities
- Maintenance strategy and periodic maintenance
- Frequency of inspections
- Minimum physical items to be inspected (inspection list)
- Deviation escalation (e.g. Trigger Action Response Plan)
- Repair procedures
- Record keeping

In drafting road inspection and repair standards the following should be considered as a minimum:

- Road surface condition (slippery surface, potholes, etc.)
- Water accumulation on the road
- Hydrocarbons (fluids) on the road surface
- Hanging wall and side wall conditions
- Presence of debris and loose material
- Condition and cleanliness of berms/barriers
- Dust prevention or reduction measures.

5. PEDESTRIAN MOVEMENT



Controlled *pedestrian* movement is as important as controlled vehicle movement.

- The first objective for the mine is to minimize interactions between vehicles and *pedestrians* by separating them. This is done by carefully determining all *pedestrian* movement required, why *pedestrians* need to be in different areas, when they need to be there, and for how long they need to be there. (Consult Element 1 of this technical guide).
- Access to the trackless section of a mine should be controlled in order to ensure that the mine's traffic management system always functions as intended.
- All *pedestrians* allowed access to the trackless section are to be inducted to the mine such that the *pedestrian* is fully aware of applicable risks and rules. Proof of such induction is to be retained as well as the period of validity of such induction. Operators of TMM must also be inducted on the rules applicable to *pedestrians*.
- *Pedestrian* routes must be the safest route between places where *pedestrians* have to call or work. These are to be planned to minimize exposure of the *pedestrians* to vehicle movements by separation or the installation of barriers, crossing points, etc. that are sufficient to manage unavoidable interactions between *pedestrians* and vehicles.
- No person should enter vehicle-only areas as a *pedestrian* unless authorized to do so for exceptions like breakdowns or service department inspections, etc. For such events, a safe work procedure is to be established and followed.
- Safe work procedures must be established for mixed zones (vehicles and *pedestrians*). Such procedures must cover, as a minimum:
  - » Applicable right of way
  - » Positive communication means for *pedestrian*-to-operator interaction
  - » Safe passing rules
  - » Where applicable, proximity detection system *(PDS)* reaction rules
  - » Means to monitor adherence to the applicable rules
  - » Rules for remote controlled *TMMs*

6. GENERAL TRAFFIC RULES

6.1. TRAFFIC SIGNS

The purpose of signage is to provide unambiguous information and/or instructions to both equipment operators and pedestrians. Signage is to be laid out for maximum visibility. A change management process must be put in place to ensure that traffic signage is continuously updated in line with changing mining operations.

"The purpose of signage is to provide unambiguous information and/or instructions to both equipment operators and pedestrians."

6.1.1 The position of signs must be indicated on the mine traffic management plan.

6.1.2 All *underground road signs are to align with the national road traffic signage and SANS1186 as far as practicable, and/or customized signage as used on the mine. All signage must be well embedded.*

6.1.3 Selection *and placement of signs should consider road and vehicle design, road conditions as well as site specific visibility risks.*

6.1.4 The *signs must be inspected, cleaned and maintained on a regular basis to ensure continuous effectiveness.*

6.1.5 Signage *can be enhanced with the use of reflective material or lighting (e.g. flashing lights, robot lights, LED display screens, etc.).*

6.1.6 Route *Markers: Route markers' primary function is to indicate the zone classification. The design and placement of the route markers should take the driver's visibility into account. It may also be used to assist operators to judge following distance (i.e. markers can be installed at fixed distances from each other to assist operators in estimating following distance).*

- Use practical markers such as pillars, light fittings, hanging fixtures, sidewall markings, etc.
- Colour coding is a good practice to classify zones as per the following examples:
  - » Exclusion zones: No route markers, just no-entry signage
  - » Vehicle only zones: Red markers
  - » Pedestrian only zones: Green markers
  - » Mixed zones (vehicles and pedestrians): Red and green or orange markers

6.2. RIGHT OF WAY AND INTERACTION RULES

Interaction between vehicles and *pedestrians* must be controlled. If total separation cannot be achieved, a site-specific risk assessment must be conducted to determine right of way and interaction rules. Due to typical driver visibility restrictions in underground operations it is common practice for the vehicles to have right of way, however, the rules of interaction must be clearly defined, and both *pedestrians* and vehicle operators must be aware of such rules.

When defining such rules, the following must be considered:

- Effective means for the *pedestrian* to get the attention of the operator
- Effective means for the operator to acknowledge the presence of the *pedestrian*
- Safe movements after acknowledgement of each other's presence, considering all possible interaction scenarios (e.g. moving in the same/opposite directions, moving across paths, etc.)
- Safe position for the *pedestrian* to move out of the way of the machine

6.3. LOADING RULES

The mine must have a safe loading procedure (based on the mine's risk assessment) that defines the rules and requirements for loading that at least address the aspects below.

6.3.1 Loading areas should be demarcated as danger zones.

6.3.2 Before loading operations commence, the area should be inspected and declared safe for loading operations to commence. The operator of the loading *TMM* must also inspect the area before loading begins.

6.3.3 For truck loading operations:

- the loading TMM operator must ensure that the truck being loaded is positioned such that its cab is never under or in reach of the loading TMM's discharge point before the load is discharged.
- The loading TMM operator must give a positive communication signal that the TMM being loaded is in the correct position before loading.
- On completion of discharging the load and when the loading TMM operator is satisfied that the receiving TMM is loaded as per the mine's specific loading procedure, the loading TMM operator needs to give positive communication to the receiving TMM operator to move off.

The mine's loading procedure should specifically address, amongst other things, the prevention of overloading and how to address overloading situations.

6.3.4 Noise and dust management should be addressed as part of the mine's risk analysis and procedures.

6.3.5 Where more than one *TMM* is used in the loading operation, a waiting/change out area should be established such as to ensure that the maximum number of vehicles that potentially can approach the loading area can wait without the risk of collision. A safe parking distance at the waiting/change out area must be established by the mine's risk assessment and communicated to all operators and *pedestrians*.

6.3.6 If there is a need for any other vehicle to enter the loading area, the operator of the other vehicle must establish positive communication with the loading *TMM* operator (or appointed supervisor) and obtain permission before entering the loading area.

6.3.7 If there is a need for any *TMM* or *pedestrian* to enter the loading area, the operator or *pedestrian* must establish positive communication with the *TMM* operators or *pedestrians* in the loading area and obtain permission before entering the loading area.

6.3.8 If there is a need for any other *TMM* or *pedestrian* to enter the loading area, all loading activities must be stopped with the loading *TMM* in a safe position before the other *TMM* or *pedestrian* enters the loading area.

6.4. TIPPING POINT RULES

The mine must have a safe tipping procedure (based on the mines risk assessment) that defines the rules and requirements for tipping and must at least address the aspects below. Particular attention must be given to the risks associated with congested tipping points.

6.4.1 The procedure must include the list of the specific machines that the procedure addresses for the task.

6.4.2 Where tipping operations are taking place the tipping areas must be demarcated and clearly marked as a danger zone.

6.4.3 An inspection of the tipping area must be done before every shift and duly recorded.

6.4.4 Where more *TMM*s are used in the tipping operation than what the tip area can accommodate, a tipping vehicle waiting/change out area must be established to ensure that the maximum number of vehicles that potentially can approach the tipping area can wait in the waiting/change out area without the risk of collision.

6.4.5 Tipping is always to be done in an orderly way giving due attention to all vehicles or *pedestrians* (Tip Attendants) present in the tipping area. A robot system can be used to manage traffic at tipping areas.

6.4.6 Noise and dust management should be addressed as part of the mine's risk analysis and procedures.

6.4.7 On approach to and exit from the tipping area the *TMM* must be positioned such that it can move safely taking account of all other vehicles in the vicinity.

6.4.8 A *TMM* must have enough space to be moved safely in the tipping area and to be maneuvered to stop safely at right angles to the tipping point.

"Muck bay areas should be demarcated as danger zones."

6.4.9 TMM operators are to make full use of all visibility aids (including mirrors) and other reversing aids throughout the tipping operation in order to monitor the position of the *TMM* in relation to the tip edge.

6.4.10 If there is a need for any *TMM* or *pedestrian* to enter the tipping area, the operator or *pedestrian* must establish positive communication with the *TMM* operators or *pedestrians* in the tipping area and obtain permission before entering the tipping area.

6.4.11 If there is a need for any other *TMM* or *pedestrian* to enter the tipping area, all tipping activities must be stopped with the tipping *TMM* in a safe position before the other *TMM* or *pedestrian* has entered the area.

6.5. MUCK BAY RULES

If the mine utilizes muck bays, the mine must have a procedure for muck bays based on the mine's risk analysis that defines the rules and requirements. Muck bay areas should be demarcated as danger zones. The loading and tipping point rules above shall apply to muck bay operations.

6.6. DEDICATED TRAMMING ROAD RULES

As far as practicable, dedicated tramming ways must be one-way routes. The mine must have a procedure for tramming road rules based on the mine's risk analysis that defines the rules and requirements and that at least addresses the aspects below.

6.6.1 The tramming road must be clearly marked as a vehicles-only zone using the correct markings as per the mine's procedure, e.g. red markers.

6.6.2 Where speeds differ for different zones, the applicable speed limits (speed or gear selection) of the zone must be clearly displayed at every access point to the route. (Not applicable to a single speed operation).

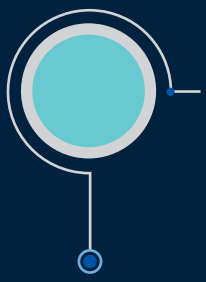
6.6.3 A safe following distance must be determined by a risk assessment such that timeous emergency action can be taken when required. The mine must have a means to indicate such a safe distance in the route (e.g. spacing of route markers, lights, sidewall markings, pillars, etc.).

6.6.4 If there is a need for any other *TMM* or *pedestrian* to enter the dedicated tramming road, the operator or *pedestrian* must establish positive communication with the *TMM* operators in the tramming road and obtain permission before entering.

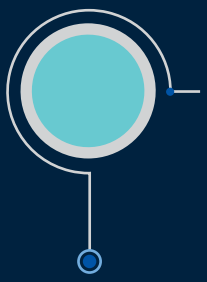
6.6.5 Where it is not practical to have a single direction roadway (i.e. for dual direction travel), there must be a procedure that defines the rules and requirements for vehicles to pass each other that at least considers the aspects below:

- Roadway conditions in terms of surface and gradient
- Roadway design (width, height, illumination, etc.)
- Types of vehicles (visibility, mass, cabin configuration, etc.)
- Right of way rules with regards to full versus empty vehicles
- Site breakdown and recovery rules
- Position of *pedestrians* and interaction rules

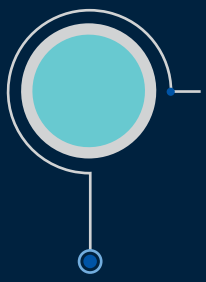
As an example, heavier *TMM* must pass on the downdip side of a strike roadway and lighter vehicles to pass on the up-dip side. The vehicle on the up-dip side should preferably remain stationary while the vehicle on the down dip side has right of way.



6.10.1 Overtaking is not permitted.



6.10.2 Where vehicles need to pass while traveling in the same direction, the forefront vehicle must stop, or where possible, make way by moving into a cubby. The operator of the passing vehicle must ensure that it is safe to pass before passing the stationary vehicle.



6.10.3 Where other activities must be undertaken on a dedicated tramming road (e.g. road maintenance, recovery operations, abnormal obstructions, etc.), there should be adequate means of warning and communication to the vehicle operators, e.g. signage, barricades, warning lights, etc.

6.7. BREAKDOWN AND RECOVERY RULES

The mine must have a procedure that addresses breakdown and recovery based on the mine's risk assessment. To cover the requirements of a traffic management plan, the procedure must consider at least the following:

6.7.1 Means for the operator to make the machine safe.

6.7.2 A means to indicate the broken-down vehicle.

6.7.3 A means of communication to inform maintenance/recovery personnel.

6.7.4 A task risk assessment should be carried out and documented by the person that will oversee the repair/recovery.

6.7.5 Where towing must be undertaken, an appropriate towing plan which includes authorization, dedicated routes, route clearance requirements, towing time as well as possible escort of the towed vehicle.

6.7.6 On completion of the repair/recovery, communication must be made to the control room or designated supervisor coordinating the activities in the area.

6.8. IN-FIELD MAINTENANCE/REPAIR ACTIVITIES

6.8.1 As far as practical, the vehicle being maintained must be positioned such that it does not cause an obstruction to other vehicles and *pedestrians*.

6.8.2 The mining supervisor in charge of the area must be informed of the activities taking place.

6.8.3 The area where the maintenance takes place must have been declared safe.

6.8.4 Area must be adequately demarcated (e.g. physical barriers, warning triangles, warning lights, glow sticks, etc.).

6.9. INTERSECTIONS

6.9.1 All intersections must be approached with caution and where practical, speed must be reduced.

6.9.2 Where roads cross it is best practice to stop traffic from all directions. Where this is not practical, traffic from at least two opposing directions must be stopped.

6.9.3 At T-junctions, it is best practice to stop traffic from all directions. Where this is not practical, traffic that is approaching the junction at right angles must be stopped.

6.9.4 Yield signs must not be used at intersections.

6.9.5 Where a decline or incline forms part of an intersection, the vehicles traveling in the decline or incline must as far as practicable have right of way and should not be stopped.

6.9.6 Intersections should be assessed for blind spots and if present, effective means of enhancing visibility or communication between operators should be provided, such as:

- Blind spot mirrors
- Traffic lights
- Signaling/warning devices
- Hooting rules

6.9.7 At intersections where *pedestrians* interact with vehicles, vehicles have the right of way. Adequate means must be provided to ensure that *pedestrians* do not enter the vehicle's path until it is safe to do so.

6.10. CURVES

6.10.1 At curves where there is restricted visibility, effective means of enhancing visibility or communication between operators should be provided, such as:

- Blind spot mirrors
- Traffic lights
- Signaling/warning devices
- Hooting rules

6.10.2 At curves where there is restricted space (one vehicle at a time), effective means must be provided to ensure that only one vehicle enters the restricted area at a time, such as:

- Traffic lights
- Signaling/warning devices
- Access control (interlocked physical barriers, human controlled, etc.)

7. REMOTE CONTROLLED VEHICLES

"This section only applies to vehicles where the operator has line of sight of the vehicle."

This section only applies to vehicles where the operator has line of sight of the vehicle.

- Where a remote-controlled vehicle is in use, the area must be zoned as a restriction zone.
- The operator must be positioned in a safe area away from the path of the vehicle and other traffic (consider a cubby or pillar as barriers where practical).
- Adequate means must be provided to warn persons entering such a zone of the presence of remote-controlled vehicles as well as at the location where the machine is operating (e.g. physical barriers, signage, warning lights, glow sticks, etc.).
- No person or vehicle may enter such an area without the consent of the responsible person and the operator of the remote-controlled vehicle. Once the other persons are in the area, positive communication must be maintained between the operator and the other persons until the other persons have exited the restriction zone.

8. SPECIAL AREAS

Special areas include workshops, brake test points, park bays, refueling bays, tyre bays, wash bays, material loading & off-loading bays, battery bays, shaft stations, other equipment intersections (e.g. chairlift, monorail, conveyor and rail bound equipment), etc.

When determining the controls to manage special areas, due consideration should be given to the following:

- All special areas must have specific traffic management rules
- Special areas must be indicated on the mine plan as updated periodically
- One-direction traffic where practicable
- General signage indicating the type of area and clear site-specific rules
- Limit the quantity of vehicles
- Parking arrangements
- Dedicated and demarcated *pedestrian* walkways
- Controlled human-machine interaction
- Vehicle types permitted in the area
- Vehicle specifications (turning radius, size, configuration, etc.)
- Ancillary equipment in the area
- Maintenance of the area
- Applicable mine standards

9. DEDICATED PARKING AREAS

Dedicated parking areas must be incorporated in the design and operation of the mine. Such areas must be clearly demarcated, and specific rules posted up.

In designing the details of such parking bays, the following factors must be considered:

- Determine temporary or long-term parking bay positions based on mining method/layout
- Distance to be traveled by the operators from/to the parking bay
- List of permitted vehicles
- Start/end of shift changeover activities (consider high *pedestrian* and machine interface)
- Operator pre-use inspection requirements (adequate space, illumination, ventilation, etc.)
- Vehicle articulation risks (clearance between machines)
- Demarcation methods (to avoid creating additional crushing points between parked vehicles)
- Orientation of the vehicles into/out of the parking bays (one-way traffic flow where practical)
- Maintenance activity requirements (list of permitted activities)

10. BRAKE TEST POINTS

Brake test points must be located before entrances to the operational area(s) or at the exits of vehicle parking areas, whichever is the most practical. Test points should, as far as practicable, be located such that traffic congestion and overruns do not pose any risk to the operator, other vehicles or pedestrians.

11. VISIBILITY AND AWARENESS

11.1. WORK AREA ILLUMINATION

11.1.1 Dedicated or permanent tramming roads and any other area deemed necessary by the mine's risk assessment should be adequately illuminated to ensure visibility of the area.

11.1.2 Lighting must be installed so as to ensure that the vision of operators is not impaired.

11.2. DUST

- The mine must identify areas where dust control is required and the measures to be taken to adequately manage the dust.
- Where practical, automatic dust management methods must be considered to reduce the need for dust suppression by use of vehicles or manual means.
- Due consideration must be given to the dust management means selected to ensure that slipping hazards are not created from excess application on inclines and declines.

11.3. STRUCTURES AND OBSTACLES

Where structures and obstacles can influence traffic, clear demarcation and sufficient prior warning is required (e.g. signage, warning lights, glow sticks, additional illumination, reflective tape, etc.).

11.4. ADDITIONAL VISIBILITY AND AWARENESS AIDS

Should the mine's risk assessment indicate that additional controls are required to improve visibility around vehicles the following should be considered:

- High visibility clothing for all pedestrians
- Additional mirrors such as convex mirrors
- Cameras (for blind spots)
- Motion inhibitor systems
- Safe side passing indication (red/green lights on TMM)
- Proximity detection systems (PDS)
- Where practical, introduce familiarization of all underground workers to the visibility constraints within an operator's cabin of all TMMs by allowing them to physically sit inside the various machine cabins.

12. TRAFFIC MANAGEMENT – ROLES AND RESPONSIBILITIES

In drafting a traffic management plan, it is necessary that roles and responsibilities are determined, defined and clearly understood by all for the activities required for the successful implementation and operation of the mine's traffic management plan.

The activities to be addressed must be, but not limited to the following:

- Regular updates of plans/procedures
- Physical implementation of changes
- Training and awareness
- Maintenance of traffic management elements/components
- Changes in mining method, routes and layout
- Monitoring & evaluation of effectiveness of controls
- Change in fleet (new equipment, increase/reduction)
- Inspections and frequency thereof
- Operator duties
- Updating of emergency preparedness procedures

NOTES