NSW Resources
Resources Regulator

Technical reference guide

Roads or other vehicle operating areas – principal hazard management plan for surface and open cut mining operations

Consultation draft

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Industry Vehicle Interaction Improvement Resources.
Earth Moving Equipment Safety Round Table (EMESRT) and the International Council for Mining & Metals (ICMM) have published a freely available vehicle interaction improvement body of knowledge with practical resources developed through broad global collaboration of all industry stakeholders. The resources are available to the EMESRT website.

Adverse Vehicle Interaction Advisory Committee (AVIAC)
This technical reference guide has been developed by the Resources Regulator in consultation with the tripartite working group the Adverse Vehicle Interaction Advisory Committee. The committee has representatives from the NSW Minerals Council, Cement Concrete and Aggregates Australia; the Mining and Energy Union, the Australian Workers Union and the Resources Regulator.

Amendment schedule		
Date	Version	Amendment
January 2025	First published	Consultation draft

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1. Introduction

Adverse vehicle interactions are a significant hazard on roads and other vehicle operating areas in mining operations, with the potential to cause fatalities and serious injury. In NSW, mine operators are required to eliminate risks to workers or when risks cannot be eliminated ensure they are controlled as low as is reasonably practicable.

1.1. Purpose

This technical reference guide (TRG) provides information to assist mine operators and other duty holders to comply with legislative requirements for a roads and other vehicle operating areas principal hazard management plan (ROVOA PHMP) to avoid adverse vehicle interactions. The ROVOA PHMP must form part of the mine's safety management system (SMS)[1].

1.1.1. Relationship to the Earth Moving Equipment Safety Round Table Vehicle Interaction Improvement initiative

The EMESRT Vehicle Interaction Improvement project is a world-leading collaborative initiative to reduce the risks associated with adverse vehicle interactions on mine sites.

The TRG has drawn on elements of the EMESRT industry resource models and sought to adapt them to suit the broad spectrum of mining operations maturity in the NSW mine safety regulatory environment. There are specific references and adaptions in this TRG to the ICMM vehicle interaction maturity model[2], the EMESRT 9-layer model of control effectiveness and control baseline effectiveness validation process.

It is important to note this TRG is not a full substitute for the EMESRT vehicle interaction control improvement initiative. Use of the information provided in this TRG may not achieve all the outcomes that can be achieved by using the EMESRT resources and processes. For more information on EMESRT and the Vehicle Interaction Body of Knowledge please visit the EMESRT website.

Mine operators that use the EMESRT resources and processes in full will satisfy the requirements of this TRG.

1.2. Scope

1.2.1. In scope

This TRG takes a specific approach to minimise and control the risks of adverse vehicle interactions at the surface parts of mining operations where mobile plant is used.

The TRG uses a layered defence approach to achieve safe operating states for mobile plant. The TRG covers:

- mine design and site standards
- effective road conditions

[1] Work Health and Safety (Mines and Petroleum Sites) Regulation 2022 section 32 and Schedule 1 set out specific matters to address and control relating to mobile plant and roads and other vehicle operating areas.

[2] The International Council on Mining and Metals (ICMM)

- organisational requirements
- traffic management
- potential for interactions between vehicles, pedestrians and fixed plant
- operator requirements
- assistance from technology
- process to implement and maintain vehicle interaction controls.

1.2.2. Out of scope

The following matters are out of scope for this TRG:

- Underground mining operations.
- Remote controlled vehicles.
- Preliminary operations on exploration licences that do not require a PHMP.

1.3. Interactions with other plans and safety management system

The ROVOA PHMP forms part of a mine's SMS. For more information about safety management systems see the NSW code of practice safety management systems in mines.

Controls identified in a mine's ROVOA may interface and/or interact with controls in other health and safety management/control plans. These interplays may degrade the effectiveness of controls. It is important mines have a process that assesses this interplay and have measures in place to address where appropriate.

1.4. Legislative requirements

This TRG provides guidance to mine operators and other relevant WHS duty holders on how to comply with the legislative requirements regarding a ROVOA PHMP.

1.4.1. Managing risks to health and safety

Section 14 (1) of the WHS (MPS) Regulation 2022 requires a mine operator to manage risks to health and safety associated with mining operations. They must do so in accordance with Part 3.1 of the Work Health and Safety Regulation 2017 (WHS Regulation) – Managing risks to health and safety.

1.4.2. Consultation

Part 5 of the *Work Health and Safety Act 2011*, Consultation, co-operation and co-ordination between duty holders, requires persons conducting a business or undertaking (PCBUs) to consult. When managing risks, the mine operator must consult workers and other duty holders at the mine. This includes other PCBUs such as contractors. Further information can be found in section 3.4 of the Guide – Preparing a principal hazard management plan and the:

- NSW code of practice: Work health and safety consultation, cooperation, and coordination (August 2022), published by SafeWork NSW
- Contractors and other businesses at mines and petroleum sites guide
- Consulting workers fact sheet.

1.4.3. ROVOA PHMP

The ROVOA PHMP needs to consider other aspects of legislation, including but not limited to:

- section 28 of the WHS (MPS) Regulation 2022 - Preparation of a principal hazard management plan
- section 32 of the WHS (MPS) Regulation 2022 - Movement of mobile plant
- Schedule 1 section 7 of the WHS (MPS) Regulation 2022 - PHMP Roads or other vehicle operating areas.

1.4.4. Provide information training and instruction

Section 107 of the WHS (MPS) Regulation 2022 –Duty to provide information, training and instruction requires mine operators to inform workers of the risks to health and safety and train them to ensure they are competent to carry out their tasks.

1.5. Acronyms abbreviations and concepts

1.5.1. Acronyms and abbreviations

Name	Definition/detail
AS	Australian Standard
code	code of practice
ISO	International Organisation for Standardisation
layered defence approach	vehicle interaction layered defence approach
maturity framework	vehicle interaction maturity framework
PCBU	person conducting a business or undertaking
PHMP	principal hazard management plan
ROS	required operating states
ROVOA	roads or other vehicle operating areas
Regulator	Resources Regulator
SMS	safety management system
TARPs	trigger action response plans
TMP	traffic management plan
TRG	technical reference guide
WHS	work health and safety

1.5.2. Concepts

Term	Definition
Traffic management plan	A traffic management plan describes how the mine operator will manage the flow of traffic at the mining operation. This includes design parameters and road rules.
Required operating state	Required operating states (ROS)[3] are activities that demonstrate safe vehicle interactions. There are 13 ROS that cover design issues, site standards and operator behaviour. The layered defence approach is used to achieve the ROS's.
Vehicle interaction maturity framework	The vehicle interaction maturity framework uses criteria to establish where on the framework the mining operation sits at the time of assessment. This enables the mine operator to identify the next steps in improving its management of vehicle interaction risks.
Vehicle interaction layered defence approach	The vehicle interaction layered defence approach[4] (layered defence approach) assesses the actions to achieve the different layers of protection. The approach has 9 layers of protection. Note: The complexity and level of risk at the mining operation will determine the sophistication of the controls implemented and the nature of technology assisted controls required.

2. Risk management and control

Hazard identification, risk assessment and control are critical steps in ensuring safe work systems and a safe work environment.

2.1. Identifying hazards

Table 1 below includes a non-exhaustive list of hazards associated with roads and other vehicle operating areas, along with possible consequences and issues to be considered when assessing and controlling risks. When developing the ROVOA PHMP the mine operator should evaluate the mine's history including previous incidents, mine design, the geotechnical conditions at the mine, mining method, and mobile plant to be used.

Table 1 - Hazards to be considered with roads and other vehicle operating areas

Hazard	Possible consequence
Collision between mobile plant: • interaction with other heavy plant • interaction with light vehicles • interactions with public vehicles.	• fatality • serious injury • plant damage.
Collision between mobile plant and people.	• fatality

[3] Required operating states are based on a model developed by EMESRT

[4] The vehicle interaction layered defence approach is based on the model developed by EMESRT

Hazard	Possible consequence
	• serious injury • plant damage.
Collision between mobile plant and fixed structures.	• fatality • serious injury • plant and structure damage.
Uncontrolled movement of plant: • loss of control on road due to - speed - slippery surface - soft floors - vehicle malfunction (e.g., brake failure) • parking up.	• fatality • serious injury • plant damage.
Ergonomic factors: • vibration • awkward postures • fatigue.	• Personal injury.

2.2. Assessing the risks

The Work Health and Safety (Mines and Petroleum Sites) Regulation 2022 requires that mine operators conduct a risk assessment to identify all aspects of risk to health and safety associated with roads or other vehicle operating areas.

The risk assessment must be conducted by a person or group that is competent to conduct the assessment, in regard to the nature of the hazard. The Guide - Preparing a principal hazard management plan provides further details regarding the need for competent persons, a comprehensive and systematic process and choosing the risk assessment techniques.

The following documents may also be useful:

- NSW code of practice: How to manage work health and safety risks
- National Minerals Industry Safety and Health Risk Assessment Guideline

For further information on managing risks under the WHS(MPS) Regulation, including specific obligations for conducting risk assessments, see the Guide - Managing risks in mine and petroleum operations. Risk analysis methods should be documented and maintained and should:

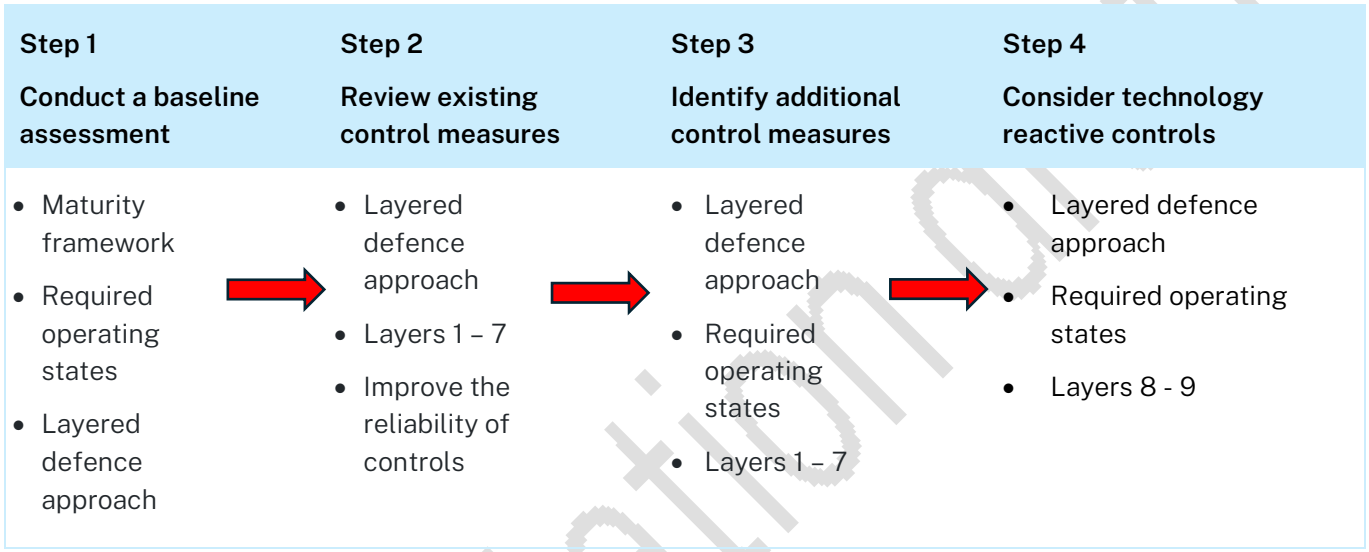
- describe the methods used at the site to identify the level of risk, threats, controls, and consequences (e.g., risk assessments, bow-tie methodology)
- describe methods used to assist in risk evaluation
- justify why they were valid and reliable methods
- include a record of the most recent risk assessments.

2.3. Steps to implement and maintain vehicle interaction control measures

This section provides guidance to mine operators on verifying where they are on the vehicle interaction journey. There are 4 steps to follow (as shown in figure 1):

1. conduct a base line assessment using the maturity framework
2. review existing control measures using the layered defence approach
3. identify and implement additional controls to achieve required operating states
4. consider implementing reactive technology controls.

Figure 1 - Vehicle interaction improvement model



2.3.1. Step 1 - Conduct a baseline assessment using the maturity framework

The vehicle interaction maturity framework[5] (maturity framework) guides mine operators through a process of assessing the maturity of a mining operation (below and also in Appendix A) in managing vehicle interaction risks, based on the elements of the vehicle interaction layered defence approach (layered defence approach).

Using the maturity framework enables mine operators to identify the steps to improve their management of vehicle interaction risks by strengthening the controls detailed in the layered defence approach.

The maturity framework uses criteria for mine operators to establish where on the framework the mining operation sits at the time of assessment. There are 5 escalating levels of maturity for the protections in the layered defence approach.

The mine operator can use the maturity framework as a guide to help strengthen the layered controls implemented at their site. The mine operator using this approach can verify that the required operating states are supported through robust business inputs, to the point where the layered controls are enduring.

[5] The vehicle interaction site maturity framework is based on the model developed by EMESRT

The maturity framework can be used at appropriate stages to assess progression at the mining operation and drive continuous improvement in vehicle interaction safety.

Figure 2: The vehicle interaction maturity framework

		1. Compliance focus	2. Exploratory	3. Defined	4. Adoptive	5. Adaptive
General		Company is primarily focused on legislative compliance with regards to vehicle standards and operations.	Company is actively investigating the elimination of unwanted vehicle interactions through mine design, operating procedures, control monitoring and/or elimination technology.	Company is actively pursuing the elimination of unwanted vehicle interactions through mine design operating procedures, basic control monitoring and/or elimination technology.	Demonstrated success in adopting remote and/or engineering technology controls to eliminate/mitigate unwanted vehicle interactions. Coupled with the integrated use of digital data to optimise operations designs and monitoring of work practices.	Implemented leading industry practice in designing remote and/or engineering technology controls to eliminate/mitigate unwanted vehicle interactions. Coupled with the integrated use of digital data to optimise industry innovation of operational designs and monitoring of work practices.
Design	1. Site requirements 2. Segregation controls 3. Operating procedures	The operational standards and designs are focused on the safety and health of employees and based on legislative compliance as a minimum standard. Vehicle operations controls comply with required legislative requirements as a minimum standard.	The operational standards and designs are focused on the safety and health of employees and based on legislative compliance as a minimum standard. With basic VI controls and standards. Vehicle operation controls are defined and effectively implemented.	Vehicle interaction is identified as a critical hazard with the company having defined administrative, engineering and design standards.	Vehicle interaction is identified as a critical hazard with the company actively integrating all levels of controls to eliminate/mitigate risk. Operational controls are integrated with technology controls to provide intervention for non-compliance.	Vehicle interaction is identified as a key critical hazard with the company actively integrating all levels of control to exceed industry leading practices. Technologies are fully integrated with operational controls to provide real time intervention for non-compliance and automated management reporting escalation.
Operational	4. Authority to operate 5. Fitness to operate 6. Operating compliance 7. Operator awareness	Vehicles are operated in accordance with legislative requirements and operational standards with basic situational awareness technology.	Vehicles are operated in accordance with legislative requirements and operational standards. With basic technology implemented to provide improved situational awareness addressing operational specific safety needs.	Vehicle operational controls are effectively implemented that enables direct operator feedback to support improvement in operator behaviour.	Effective implementation of monitoring technology that enables direct operator feedback to support improvement in operator behaviour and provides timely supervisory feedback to allow intervention with ongoing operator deviation from expected performance.	Effective implementation of continuous improvement in operator behaviour programs in order to exceed industry leading practices.
React	8. Advisory controls 9. Intervention controls	Vehicles are operated in accordance with legislative requirements and operational standards with basic advisory technology.	Basic technology implemented to provide advisory alerts/alarms addressing operational specific interaction scenarios.	Advanced technology solutions have been implemented on vehicles with high VI consequence exposure, critical pieces of vehicles to provide advisory alerts/alarms/machine interventions addressing operational specific interaction scenarios.	Vehicle intervention technology solutions have been installed on vehicles with high consequence incident scenarios and digitally integrated with operational controls and mine design standards.	Vehicle interaction technology solutions have been installed across all vehicles (including those with lower consequence incident scenarios). They are digitally integrated with operational controls and mine design standards. Actively supporting technology development to

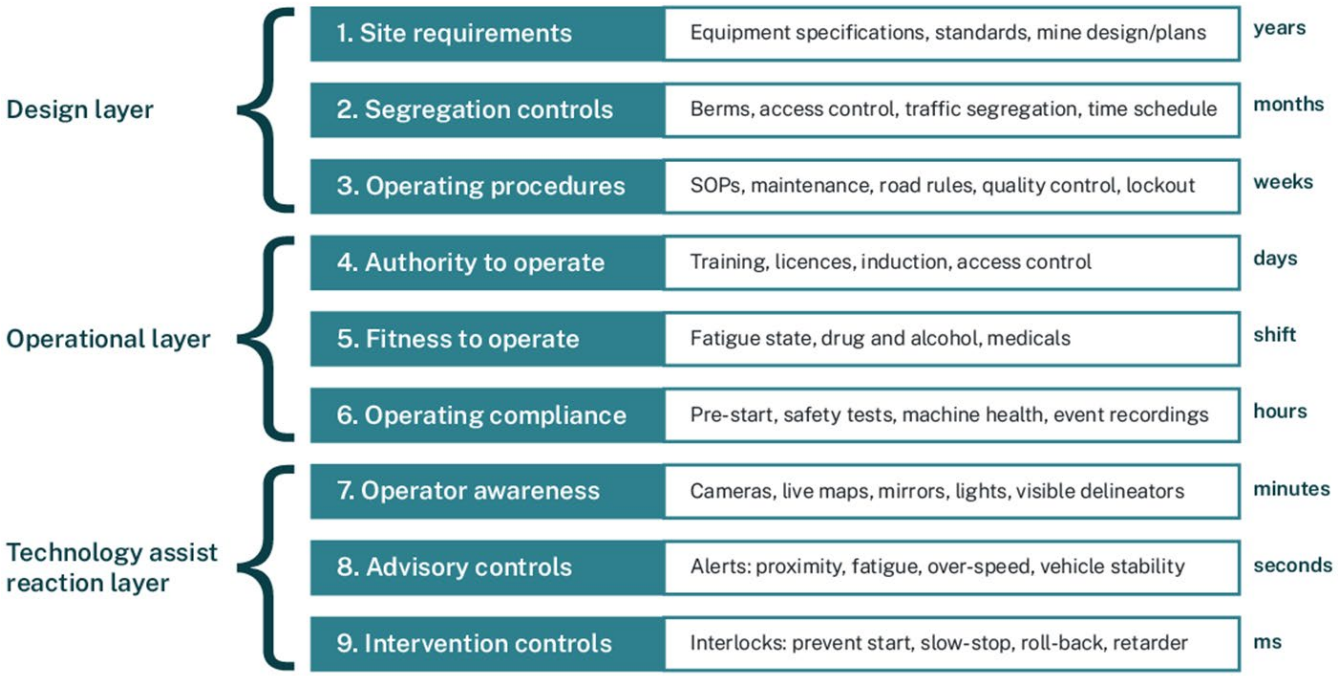
	1. Compliance focus	2. Exploratory	3. Defined	4. Adoptive	5. Adaptive
General	Company is primarily focused on legislative compliance with regards to vehicle standards and operations.	Company is actively investigating the elimination of unwanted vehicle interactions through mine design, operating procedures, control monitoring and/or elimination technology.	Company is actively pursuing the elimination of unwanted vehicle interactions through mine design operating procedures, basic control monitoring and/or elimination technology.	Demonstrated success in adopting remote and/or engineering technology controls to eliminate/mitigate unwanted vehicle interactions. Coupled with the integrated use of digital data to optimise operations designs and monitoring of work practices.	Implemented leading industry practice in designing remote and/or engineering technology controls to eliminate/mitigate unwanted vehicle interactions. Coupled with the integrated use of digital data to optimise industry innovation of operational designs and monitoring of work practices.
					improve industry leading practice.

2.3.2. Step 2 - Review existing control measures using the layered defence approach

Mine operators should review existing controls at the mining operation using the layered defence approach.

Mine operators should verify how the mine's control measures align with layers 1 through to 9 in the layered defence approach shown in Figure 2 below.

Figure 3: Vehicle interaction 9 layered defence approach



Mine operators should implement the layered defence detailed approach below. The actions for each layer when effectively implemented will maintain the 13 required operating states (ROS) as detailed in Section 2.3.3, for safe vehicle and mobile plant operation at mining operations.

Layer 1 – site requirements (equipment specification, standards, mine design and plans

- **Clear accountabilities for planners are included in comprehensive and site relevant road design guidelines and traffic management plans** - Site road design guidelines and traffic management plans identify specific accountabilities for persons designing trafficable areas.
- **Established requirements for parking and resting in vehicles** - Parking and leaving parked positions does not result in mobile equipment interaction incidents.
- **Fit-for-purpose equipment selection and site use approval processes** - Equipment selected for site use is fit-for-purpose and delivers safe and productive outcomes - meeting all site requirements for worker ergonomics, control integrity, matching to existing site technology, equipment performance and operating environment constraints.
- **Give way/right of way requirements information prepared for mobile equipment operators and pedestrians** - Site give way/right of way requirements are documented and communicated in a style that is appropriate for the audience.
- **Lighting, delineation and signs are installed and maintained to standards that meet minimum site road design requirements** - Site road design sets minimum standards for the installation, inspection and maintenance of lighting, delineation and signs that assist vehicle operators maintain situational awareness.
- **Operator display specifications are detailed for mobile equipment** - Operator displays provide the information necessary for safe and productive outcomes.
- **Operator ergonomics are considered for controls and before introducing vehicle alarms and other aids** - Control panels/devices, alarms and other aids introduced to alert the operator and / or improve situational awareness are to be considered so that they are placed appropriately in the cabin.
- **Power line working distance management process** - Safe working distances are always maintained between power lines and mobile equipment e.g. cranes, trucks, forklifts, etc.
- **Processes for confirming that new to site vehicles meet site specifications including vehicle lights, signage and markings (introduction to site)** - All site vehicles in operating areas meet specifications for vehicle reversing and head lights, running lights, indicator and identification numbers.
- **Road design guidelines specify minimum parking area requirements** - Parking area designs are fit for purpose. Parking areas are constructed and maintained to meet site requirements.
- **Road design guidelines specify minimum requirements for delineation** - The design and installation of delineators assists mobile equipment operators to accurately estimate separation distances.

- **Road design guidelines specify walkway designs considering vehicle sight lines** - Walkways are designed, constructed and maintained to site standards.
- **Road design guidelines set minimum standards for the construction and maintenance of the road network** - Road design guidelines require that the development and maintenance of the physical operating environment adequately considers prevailing site conditions, the experience of mobile equipment operators (controllers) and equipment types/mix.
- **Site vehicle clearance distance requirements and processes for accurately estimating distances** - information prepared for Operators - Site clearance requirements are documented and communicated in a style that is appropriate for the audience.
- **Standards that set minimum requirements for cabin integrity, restraints, access and escape, auto shutdowns and other relevant protective systems** - Equipment selected for site use is fit for purpose and delivers safe and productive outcomes.
- **Vehicle interactions are considered as part of the short-term planning processes** - Mobile equipment interactions and operating requirements are always considered when approving, planning and scheduling work.

Layer 2 - segregation control (berms, access control, traffic segregation, time schedule)

- **Access barrier performance, regular inspection and maintenance of barriers for access, boundary fencing and work area barriers** - Access to operational areas for personnel and mobile equipment is well managed. Barriers are in place that prevent unauthorised access including security (for site) and sentries/physical barriers for high consequence activities on site.
- **Minimum requirements for demarcation (guard rails, windrows, bunds) and warning devices (chains, cones, flagging**), information prepared for operators - Minimum site requirements for hazard demarcation, edge protection, barriers, chains and signs, and segregation windrows/guard-rails are documented and communicated in a style that is appropriate for the audience.
- **Infrastructure protection. Placement of barriers and/or warning devices to prevent unwanted vehicle interactions** - Site infrastructure is protected from unplanned contact with mobile equipment.

Layer 3 - Operational procedures (safe operating procedures, maintenance, road rules, quality control, lockout)

- **All safety and operational systems on mobile equipment are maintained** - Safety and operational systems on mobile equipment are maintained to a schedule and when they breakdown. Mobile equipment with critically compromised safety and operational systems does not operate.
- **Clear requirements for loading of trucks by excavator/shovel/loader** - Loading mobile equipment is safe and productive.

- **Established requirements for approaching parked mobile equipment in operational areas** - Personnel approaching a vehicle parked in operational areas are not endangered by an unexpected vehicle movement.
- **General features by vehicle type. Information prepared for operators** - General features by vehicle type are documented and communicated in a style that is appropriate for the audience.
- **Managing road works, including grader operations.** Information prepared for operators - Information on managing road works is documented and communicated in a style that is appropriate for the audience.
- **Minimum requirements for parking in any situation. Information prepared for operators** - Site requirements for parking in any situation are documented and communicated in a style that is appropriate for the audience.
- **Mobile equipment operators follow road rules and adjust based on conditions and circumstances** - Mobile equipment operators follow road rules and adjust based on conditions and circumstances.
- **Pedestrians working in operational area communications protocol** - Personnel working on the ground in mobile equipment operational able to effectively communicate.
- **Positive communication protocol for passing or moving close to a vehicle and entering a work area** - Passing of vehicles is well managed and based on positive communications. All personnel operating vehicles remain alert and situationally aware when working in congested areas
- **Protocols for approaching and accessing mobile equipment** - Approaching and accessing equipment follows defined processes that limit the potential for an unwanted interaction between vehicles and/or pedestrians.
- **Protocols for working on equipment in production areas** - Personnel undertaking servicing, maintenance or recovery work on equipment in operational areas are protected from mobile equipment and other workplace hazards.
- **Refuelling practices** - Trained personnel follow site refuelling procedures.
- **Regular and timely maintenance of communications systems equipment** - Operating sites have highly reliable communications equipment that supports safe and productive mobile equipment operations.
- **Regular checking and maintenance of key systems, brakes, steering, rims and tyres** - as per your mechanical engineering control plan.
- **Regular checking and maintenance of vehicle lights and markings** - Vehicle lights and markings on site approved mobile equipment are visible and functional during operations.
- **Regular checking and maintenance for cabin integrity, restraints, access and escape, auto shutdowns and other relevant protective systems** - The protective systems and safety related components of on-site approved mobile equipment remain functional.
- **Road surface changes are identified and managed by vehicle operators** - There is a site hazard management protocol detailing expected responses from vehicle operators when there are changes in road surfaces.

- **Same direction travelling and queuing separation protocols.**
- **Site process apply to changes in equipment, road networks and traffic flows.**

  Applied and effective processes are in use at the operating site, and these apply to:

  — changes in road networks and traffic flows

  — the introduction of new models and types of mobile equipment and components e.g. introduction of electric battery powered equipment
- **Site specific travelling speed information prepared for vehicle operators** - Site travelling speeds by vehicle type are documented and communicated in a style that is appropriate for the audience.
- **Skilled and experienced personnel are accountable for maintaining mobile equipment** - All workers who maintain mobile equipment are trained, competent and authorised for the tasks that they carry out.

Layer 4 - Authority to operate (Training, licences, induction, access control)

- **Competent and site experienced water cart operators** - Dust is well controlled without overwatering the road surface
- **Protocols for site induction and site and operating areas access** - Induction processes are in place and applied at operating sites.
- **Trained personnel who are supported by an appropriate and up-to-date training management system** - A process should be in place for delivering and maintaining competency-based training.
- **Trained, competent and authorised mobile equipment operators** - All workers who operate mobile equipment at the mine are trained and assessed for competency. This covers equipment operation, other worker/infrastructure protection and maintaining control in the prevailing road conditions.
- **Vehicle hazard awareness for equipment operators** - Equipment operators are aware of operational hazards and their controls.

Layer 5 - Fitness to operate (Fatigue state, drug and alcohol, medicals)

- **Comprehensive fitness for work process includes alcohol and other drugs** - Site requirements that all employees, contractors and visitors be fit for duty (unimpaired) while in the workplace.
- **Fatigue status data send (off vehicle review)** - When fatigue monitoring systems are fitted, they capture and send status data for analysis and monitoring.
- **Fit-for-work processes with specific advice on self-management** - Operating sites should develop and maintain processes that support personnel to be fit for work.

- **Pre-commencement and periodic medicals for mobile equipment operators** - Pre-employment checks and periodic medicals should ensure personnel are capable of fulfilling positional requirements.
- **Site fatigue management processes are comprehensive and optimise work rosters** - Site fatigue management processes are comprehensive and designed to support employees.

Layer 6 - Operational compliance (pre-start, safety tests, machine health, event recordings)

- **Around vehicle inspection or use of spotters to identify hazard before moving** - There are no unplanned vehicle to person or vehicle to vehicle contacts on first movement after parking.
- **Ceasing operations procedure - compromised operating environment and significant interaction threats** - Sites should have cease operations processes (trigger action response processes/plans [TARPs]) in place for situations for when it is no longer safe to continue normal operations using mobile equipment and where significant interaction threats have the potential to develop.
- **Operational equipment data** – Data collected by systems that relate to critical vehicle interactions is reviewed at a determined intervals. For example equipment system data (e.g. tyre pressure and temperature, speed and proximity detection data and fatigue data)
- **Extreme weather TARP** - Sites should have procedures and associated training resources in place for heavy rain and storm situations that increase the potential for unsafe road conditions.
- **Operator pre-start checks include communication system, safety devices, brakes, steering, tyres and running gear** - Checks are made prior to use and as required through a shift to confirm that mobile equipment that is compromised does not operate.
- **PPE, high visibility clothing, lights and alerting devices required in operational areas - information prepared for all personnel** - Site standards for PPE, high visibility clothing, lights and alerting devices required in operational areas are documented and communicated in a style that is appropriate for the audience.
- **Pre-start radio checks** - The communications equipment required for the safe and productive operation of mobile equipment is confirmed as working. Mobile equipment that cannot communicate does not operate.
- **Required emergency checks before vehicle operation** - Information for operator by vehicle type. Required emergency checks before operation are documented and communicated in a style that is appropriate for the audience.
- **Protocols that detail how the status of vehicle alarms and monitors are checked before use** - Vehicle operators check and report on the status of vehicle alarms before use.
- **Regular checking and maintenance of alarms, monitors, cameras and other warning devices** - Mobile equipment alarms, cameras and advice screens are functional, and use is embedded by the workforce during operations.

- **Safety and operational systems on mobile equipment are maintained**. Safety and operational systems on mobile equipment are maintained. Mobile equipment with compromised critical safety systems does not operate.
- **Shift-to-shift communication** - There is a formal process for logging and communicating operational status between work shifts. For example road conditions, intersection changes and changing weather conditions.
- **Proximity detection data is reviewed** – Where fitted and able to provide relevant information relating to vehicle information the data is reviewed at a determined interval.

Layer 7 - Operator awareness (cameras, live maps, mirrors, lights, visible delineators)

- **Demarcation when changed road conditions arise including when commissioning or live testing is being undertaken** - Changes in road conditions are effectively communicated to vehicle operators.
- **Line of sight lines and blind spots by vehicle type. Information prepared for vehicle operators** - Line of sight and blind spot information by vehicle type is documented and communicated in a style that is appropriate for the audience.
- **Line of sight and blind spots from outside. Information prepared for people who work around vehicles** - Lines of sight and blind spot information by vehicle type is documented and communicated to workers who interact with these vehicles in a style that is appropriate for the audience.
- **Vehicle lights and markings requirements** - lights and vehicle markings (e.g. reflective tape/vehicle numbers) are correctly operating such that operators can maintain safe vehicle clearance.
- **Vehicle operator alarm fatigue** – Alarms fitted to alert vehicle operators do not cause alarm fatigue. Human factors are to be considered to support operator situational awareness and reduce information overload (e.g., false alarms, similar signals for different alerts)

Layer 8 - Advisory controls (Alerts, proximity, fatigue, over-speed, vehicle stability) where in use

- **Alarm and vehicle information panel expected response - information prepared for operators** - Where advisory controls are installed they are reliable and advise operators of adverse vehicle conditions in a timely manner.
- **Fatigue alert alarms** - When fatigue monitoring systems are fitted, they have an operator alert function
- **Introduce technology to support existing fatigue management approaches** - If new technology is introduced, it improves fatigue management.
- **New communications or technology equipment, specification, test and commissioning process** - The operational deployment of improvements/new communications and technology

equipment is well managed and meets all functional and performance requirements - whilst causing minimum possible disruption to existing operations.

Layer 9 Intervention controls (interlocks, prevent start, slow stop, rollback, retarder)

- **Mobile equipment when fitted with speed limiting, overload or steering controls, the controls are reliable and repeatable** – When speed limiting and steering controls are fitted they should be verified on commissioning and at regular intervals that they operate as expected.
- **Mobile equipment is speed limited** - Where installed, mobile equipment speed is effectively governed and is designed to be tamper proof.
- **Proximity detection, alerts, advice, and intervention** - When collision avoidance/autonomous systems are fitted, they have intervention capabilities that meet site functional and performance requirements.

2.3.3. Step 3 - Identify and implement additional control measures to achieve required operating states (ROS)

The mine operator should systematically review[6] the resilience and reliability of controls and identify and implement further control measures to achieve the following 13 ROS:

Engineering operating states

1. **Physical barriers provide separation** - Physical barriers minimise interactions between vehicles, co-workers, other items, or equipment. Nil normal operations contact; vehicle to vehicle, vehicle to person(s), vehicle to equipment or environment.
2. **Access control** – Vehicle operators limit movements / activities to designated areas. Access controls minimise potentially hazardous interactions (vehicle to vehicle, vehicle to pedestrian) in operational areas.
3. **Loads are appropriate for vehicle type and site conditions, items are secured during travel** - Vehicle operator or worker loads the vehicle appropriately for site conditions, including securing items. Low levels of harm caused loose objects or loading issues during any vehicle interactions.
4. **Alarms alert operators to nearby hazards and operator takes appropriate action** - Minimise potentially hazardous interactions between vehicles, co-workers or other items/equipment. Alerting alarms or laser barrier/fencing provides timely information on nearby hazards and the vehicle trips and/or vehicle operator responds appropriately. The goal is to achieve Nil approach contact; vehicle to vehicle, vehicle to person(s), vehicle to equipment.
5. **When a vehicle component alarms the operator responds appropriately** - Critical vehicle component e.g., brake or steering system warning alarms. Reduce the potential for loss of control of equipment due to loss or failure of brake or steering system. The vehicle operator responds appropriately to brake or steering system alarms. Nil loss of control of equipment caused by loss or failure of brake or steering system.

[6] The vehicle interaction control framework is based on the model developed by EMESRT

6. **Cabin protection is in accordance with site standards** - Maximum designed operator protection during unwanted vehicle interactions. For surface operations consider the use of airbags.

Organisational operating states

7. **Seat belts are used by vehicle operators and occupants** - To minimise level of harm which results during a hazardous vehicle interaction – Workers traveling in vehicles fitted with restraints wear them when the vehicle is in motion. Vehicle operator and passengers use seat belts / restraints. Maximum designed operator protection during any hazardous vehicle interaction.
8. **Vehicle operator maintains adequate clearances / distances** - Minimise potentially hazardous interactions between vehicles, co-workers or other items / equipment / structure / environmental aspects when operating and traveling along roadways. Nil approach contact; vehicle to vehicle, vehicle to person(s), vehicle to equipment or environment.
9. **Vehicle operators give way appropriately to mobile plant and pedestrians** - Minimise potentially hazardous interactions between mobile plant and mobile plant and pedestrians in work areas – particularly at constructed intersections and where traffic flows come together.
10. **Vehicle operators drive vehicles at speeds which meet site rules and local conditions** - Reduce the potential for loss of control of equipment due to incorrect speed for the conditions. Nil loss of control of equipment caused by incorrect speed for the conditions.
11. **Vehicle operators park vehicles in positions that avoid unwanted interactions** - Minimise potentially hazardous interactions between vehicles, co-workers or other items/equipment. No unintended movement of parked vehicles.
12. **Emergency responders manage injuries at the scene** - Adequately resourced site emergency services respond in a timely manner to minimise the injuries or losses sustained at the accident scene. For major, ongoing situations external emergency services – who are familiar with site conditions – provide back up support to limit the extent of loss. Timely response that removes people from danger, stabilises injuries and provides transport for further treatment.

Worker operating states

13. **Vehicle operators do not drive vehicles when impaired** - Operators maintain control of equipment and do not drive when, due to operator impairment through fatigue, stress, alcohol and other drugs, or work environment stressors they are more prone to make mistakes.

The mine's ROVOA PHMP should establish a 'whole of system' overview and a structure that is linked to operational practice. This provides the mine operator with information and insights about the dynamic interconnects between workers, equipment, the work environment, workgroups carrying out different tasks and overall coordination at the mining operation. This promotes the systematic identification of improvement opportunities.

The mine operator should:

- confirm the safe and productive outcomes relevant to each ROS
- identify actions that prevent or mitigate the ROS's being compromised
- document how each action is implemented and maintained

- consult with knowledgeable workers for review, update, and validation
- confirm the opportunities for improvement required to achieve enduring controls

Once mine operators have established what controls are in place a gap analysis should be conducted comparing the controls in place with those required to achieve – where reasonably practicable – the ROSs that are suitable for the mining operation.

Mine operators should develop and implement an action plan to maintain the control measures for layers 1 through to 9 of the layered defence approach. The controls put in place should be proportionate to the risks identified at that mining operation.

2.3.4 Step 4 - Consider implementing reactive technology controls

Once control measures are in place for layers 1 through 7 in the layered defence approach, mine operators should consider further reactive technology control. Depending on the risks at a mining operation, further reactive control measures may be unnecessary.

Implementing further controls in layers 8 and 9 of the layered defence approach at a mining operation would depend on a number of risk factors, such as the mine design and the number of opportunities for vehicle interactions.

The mine operator should use the maturity framework to establish where the mining operation sits in its journey to implement and develop the layered defence approach through a process of continuous improvement.

2.4. Other matters

2.4.1 Traffic management plan

A traffic management plan[7] (TMP) should form part of the ROVOA PHMP. The mine operator's TMP should;

- be based on risk assessments
- form part of the ROVOA PHMP
- be documented and auditable
- list foreseeable site specific vehicle interactions with potential for collisions
- set out in detail how these interactions are effectively managed.
- describe how off site expectations are managed
- include a current drawing or plan showing critical information.
- identify roles and responsibilities to ensure plan is effectively implemented.
- identify how the controls will be monitored to ensure they are implemented and effective (inspections/audits/KPI).
- be reviewed by the mine operator periodically;

[7] Definition from Resources Safety and Health Queensland Guidance Note QGN 27 Collision prevention (2024)

- when operations and/or plant changes.
- as a result of incidents or accidents (internal or external).
- when information may indicate the plan is or could be ineffective.

All workers should be trained in the TMP as part of the site induction, training programs and procedures as it applies to workers tasks.

Road rules may form part of the TMP as administrative controls. Road rules should be uniform, consistently applied across the mine and monitored for effectiveness. They should be:

- documented and enforceable
- as few as possible
- cover worker and pedestrian movement around mobile plant.
- consistently applied/adhered to by all workers including contractors and public
- part of workers training and assessment.

Where road rules should contribute to safe traffic management. To ensure effectiveness all road rules should be:

- needed to achieve a safe traffic interaction
- clear and unambiguous, and not based on assumptions or conventions
- able to be consistently applied
- able to be monitored and enforced
- able to be understood by workers
- checked so they do not inadvertently create a hazard or require a worker to carry out potentially dangerous actions.
- Safe separation distances for mobile plant should be considered, based on operator reaction time, mine roads and plant conditions.

2.4.2 Review of control measures

The mine operator as required by section 29 of the WHS(MPS) Regulation must review the PHMP and revise the control measures when:

- an audit of the effectiveness of the safety management system for the mine or petroleum site indicates a deficiency in a control measure,
- a worker is moved from a hazard or assigned to different work in response to a recommendation contained in a health monitoring report
- a notifiable incident occurs.

The mine operator should also include in its SMS the following:

- when reviewing control measures, particularly after an incident, do so in the framework of the layer defence model, i.e. consider which controls within layers 1 – 9 failed
- include near miss reporting, recording and control review systems where mobile plant is involved

2.4.3 Interdependency of control measures

Mine operators when choosing the best vehicle interaction risk control measures need to identify and understand the interdependence of control measures;

- put in place using the layered defence approach
- with the business inputs in the control framework that support each control measure
- with other plans within the safety management system.

Risk control strategies established to manage vehicle interactions at mining operations can be complex systems, with many interdependencies arising from different risk controls, multiple business units and individuals. If one part of a complex risk control system is not functioning as required, and goes unnoticed the risk control measures that depend on it may fail[8]. Human centred design[9] and organisational factors such as risk control system design need to result in resilient processes that are aware of the interdependence that support the control measures.

2.4.1. Emergency management and incident reporting

The mine operator should include emergency response to adverse vehicle interactions in the mine's emergency plan.

3. Training for vehicle operators and roadway maintenance personnel

This section provides mine operators guidance on training to ensure vehicle operators are competent and authorised as part of the actions to implement the layered defence approach. Many of the ROS are reliant on vehicle operators being competent in carrying out correct procedures and processes that are established as part of control measures.

Section 107 of the WHS (MPS) Regulations 2022 requires mine operators to ensure that they establish a comprehensive training program that provides appropriate training, assessment, and authorisation to operate all types of vehicles and undertake roadway maintenance.

The PHMP should specify training requirements. It should incorporate – but not be limited to – worker understanding of:

- the roads and other vehicle operating areas
- their responsibilities to drive to conditions
- their responsibility for any passengers they are transporting
- the reporting requirements at the site if/when roads deteriorate.

Workers' training should include the following:

[8] Dekker, S. W. A. (2013). Drifting into failure: Complexity theory and the management of risk. In: Banerjee, S. (Ed.), Chaos and Complexity Theory for management: Nonlinear Dynamics, pp. 241-253. Hershey, PA: IGI Global Business Science Reference

[9] Professor Robin Burgess-Limerick C29001 extension: Case-study of human-centred design of new technology in mining. Minerals Industry Safety and Health Centre University of Queensland 2022

- speed limits
- signage
- blind corners
- wet and uneven roads
- wind rows
- clearances from roof and sides
- obstacles
- pipes
- high-voltage cables and other structures
- ensuring good visibility while carrying large loads in and out of the work areas
- comprehensive assessments of the worker's knowledge after training should be documented
- authorisation is approved on the worker's ability to carry out the task allocated

Appendix A – Vehicle interaction maturity framework

This section provides guidance to mine operators on assessing where they are on the vehicle interaction journey. The vehicle interaction maturity framework[10] guides the mine operator through a process of assessing the maturity of mining operation based on the elements of the vehicle interaction layered defence approach..

Using the maturity framework enables the mine operator to identify the next steps in improving its management of vehicle interaction risks to strengthen the controls detailed in the layered defence approach.

Table 2 shows an integrated continuous improvement process starting with a baseline assessment of site maturity. The maturity framework uses criteria for the mine operator to establish where on the maturity framework the mining operation sits at the time of assessment.

The mine operator can use the maturity framework to strengthen the layered controls implemented. Through this the mine operator can verify that the ROS's are supported. The mine operator should conduct a maturity framework assessment as a first step before implementing the layer defence approach.

How to use the maturity framework

The maturity framework assessment in table 2 should be conducted by people with suitable experience in managing vehicle integration risks in mining operations. The matrix describes what the people conducting the assessment will see after examining relevant document and discussions with relevant workers on site. The matrix describes what the assessors might see at 5 different levels of maturity for each of 3 groups of layers in the layered defence approach. The levels of maturity escalate from basic compliance (compliance focused) to gold standard (adaptive). Once the assessment team is identified it should:

1. gather and review relevant information on vehicle interaction
2. interview a number of workers involved in managing mobile plant and vehicles
3. determine the level of maturity for the different layers as follows:
    a. general
    b. design
    c. operational
    d. reactive
4. mark the box that most represents the mining operations level. This gives the maturity level for that group

[10] The vehicle interaction site maturity framework is based on the model developed by EMESRT

Table 2: Vehicle interaction maturity framework matrix

		1. Compliance focus	2. Exploratory	3. Defined	4. Adoptive	5. Adaptive
General		Company is primarily focused on legislative compliance with regards to vehicle standards and operations.	Company is actively investigating the elimination of unwanted vehicle interactions through mine design, operating procedures, control monitoring and/or elimination technology.	Company is actively pursuing the elimination of unwanted vehicle interactions through mine design operating procedures, basic control monitoring and/or elimination technology.	Demonstrated success in adopting remote and/or engineering technology controls to eliminate/mitigate unwanted vehicle interactions. Coupled with the integrated use of digital data to optimise operations designs and monitoring of work practices.	Implemented leading industry practice in designing remote and/or engineering technology controls to eliminate/mitigate unwanted vehicle interactions. Coupled with the integrated use of digital data to optimise industry innovation of operational designs and monitoring of work practices.
Design	1. Site requirements 2. Segregation controls 3. Operating procedures	The operational standards and designs are focused on the safety and health of employees and based on legislative compliance as a minimum standard. Vehicle operations controls comply with required legislative requirements as a minimum standard.	The operational standards and designs are focused on the safety and health of employees and based on legislative compliance as a minimum standard. With basic VI controls and standards. Vehicle operation controls are defined and effectively implemented.	Vehicle interaction is identified as a critical hazard with the company having defined administrative, engineering and design standards.	Vehicle interaction is identified as a critical hazard with the company actively integrating all levels of controls to eliminate/mitigate risk. Operational controls are integrated with technology controls to provide intervention for non-compliance.	Vehicle interaction is identified as a key critical hazard with the company actively integrating all levels of control to exceed industry leading practices. Technologies are fully integrated with operational controls to provide real time intervention for non-compliance and automated management reporting escalation.
Operational	4. Authority to operate 5. Fitness to operate 6. Operating compliance 7. Operator awareness	Vehicles are operated in accordance with legislative requirements and operational standards with basic situational awareness technology.	Vehicles are operated in accordance with legislative requirements and operational standards. With basic technology implemented to provide improved situational awareness addressing operational specific safety needs.	Vehicle operational controls are effectively implemented that enables direct operator feedback to support improvement in operator behaviour.	Effective implementation of monitoring technology that enables direct operator feedback to support improvement in operator behaviour and provides timely supervisory feedback to allow intervention with ongoing operator deviation from expected performance.	Effective implementation of continuous improvement in operator behaviour programs in order to exceed industry leading practices.
React	8. Advisory controls 9. Intervention controls	Vehicles are operated in accordance with legislative requirements and operational standards with basic advisory technology.	Basic technology implemented to provide advisory alerts/alarms addressing operational specific interaction scenarios.	Advanced technology solutions have been implemented on vehicles with high VI consequence exposure, critical pieces of vehicles to provide advisory alerts/alarms/machine interventions addressing operational specific interaction scenarios.	Vehicle intervention technology solutions have been installed on vehicles with high consequence incident scenarios and digitally integrated with operational controls and mine design standards.	Vehicle interaction technology solutions have been installed across all vehicles (including those with lower consequence incident scenarios). They are digitally integrated with operational controls and mine design standards. Actively supporting technology development to improve industry leading practice.

Appendix B - Safety alerts and investigation reports

Safety alerts

SA23-01 – March 2023 – Unintended movement of haul truck

SA22-05 – October 2022 – Service brakes fail on moving articulated truck

SA21-04 – April 2021 – Worker sustains critical injuries after driving loader over stope edge

SA21-03 – March 2021 - Underground loader makes contact with development drill rig

SA21-02 – February 2021 – Unattended haul truck rolls 65 metres

SA20-09 – October 2020 - Operating mobile plant – incidents and near misses

SA18-13 – December 2018 – Potential fall of excavator over highwall

SA18-10 – July 2018 – Near miss between light vehicle and haul truck

SA16-01 – February 2016 – Driver loses control of light vehicle and crashes in underground mine

SA14-02 – February 2014 – Serious potential incident: underground loader collides with light vehicle

SA10-05 – October 2010 – Water tanker rollover at haul road intersection

SA09-13 – October 2009 – Light vehicle drives off bench in open cut mine

Safety bulletins

SB24-01 – March 2024 – Bulldozer incident increase

SB23-07 – August 2023 – Fitness for work – fatigue

SB22-10 – August 2022 – Mobile lighting plant at mining workplaces

SB22-07 – June 2022 – Collisions on overburden dumps

SB21-06 – September 2021 – Human factors – water carts and cabin interfaces

SB21-04 – June 2021 – Crawler utility vehicle runaway

SB19-10 – October 2019 – Dozer incidents increase despite warnings

SA19-02 – March 2019 – Rise in vehicle collisions raise concerns

SB17-01 – January 2017 – Industry reports more truck rollover incidents

Investigation reports

July 2023 – Investigation report - near collision between haul truck and light vehicle

February 2023 – Investigation report – Death of a worker at West Wyalong quarry

IIR20-14 – November 2020 – Collision between dozer and haul truck

IIR20-02 – January 2020 – Collision between dozer and light vehicle

IIR19-11 – September 2019 – Collision between dozer and light vehicle

IIR19-04 – May 2019 – Collision between semi-autonomous dozer and manned excavator

IIR15-03 – August 2015 – High potential incident. Komatsu 730E dump truck crushes light vehicle