RSR Railway Safety Regulator

Analysis of South African Level Crossing Accidents and Possible Solutions to Improve Safety

OFFICIAL SIGN-OFF

Level crossing occurrences contributes to a number of fatalities and injuries in South Africa on an annual basis. This research was conducted in collaboration with the University of Pretoria and will highlight the extent of the level crossing accidents with the aim of finding ways to address such accidents. The research will also investigate what factors contribute to level crossing occurrences and suggest solutions that may be more effective in tackling this issue while contributing to the body of knowledge in the rail sector.

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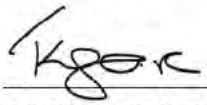

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Abbreviations and Acronyms

BOC	Bombela Operating Company
CBRTA	Cross Border Road Transport Agency
CSIR	Council for Scientific and Industrial Research
DoT	Department of Transport
GMA	Gautrain Management Agency
MTSF	Medium Term Strategic Framework
NDP	National Development Plan
NIP	National Infrastructure Plan
NRSR Act	National Railway Safety Regulator Act 16 of 2002
NTLA	National Land Transport Act
PRASA	Passenger Rail Agency of South Africa
RAF	Road Accident Fund
RSR	Railway Safety Regulator
RTIA	Road Traffic Infringement Agency
RTMC	Road Traffic Management Corporation
SABS	South African Bureau of Standards
SADC	Southern African Development Countries
SANS	South African National Standard
SANRAL	South African National Roads Agency
SATS	Legal Succession Act of South African Transport Services
SMS	Safety Management System
SoS	State of Safety Report
SPADS	Signals passed at danger
TFR	Transnet Freight Rail

Definitions

Unless the context indicates otherwise:

"**association**" means an association recognised by the Regulator and includes a railway industry association;

"**human factors**" means factors which include the perceptual, physical and mental capabilities of people and the interaction of individuals with their job and working environments, the influence of equipment and system design on human performance, and the organisational characteristics that influence safety-related behaviour at work;

"**industry**" means the railway industry and includes operators, suppliers, carriers, contractors and consulting engineers;

"**integrity**" means a condition in which individual components of a system and the total system are unified, consistent and fit for purpose*[Definition of "integrity" inserted by s. 1 (b) of Act No. 69 of 2008.];*

"**Minister**" means the Minister of Transport;

"**network**" means a system of railway infrastructure elements comprising track, civil infrastructure, train control and signaling systems and where applicable electric traction infrastructure which constitutes running lines, and any part of the following on which those elements are situated:

(a) railway yards;

(b) marshalling yards;

(c) sidings and private sidings;

(d) freight terminals;

(e) depots;

(f) stations; or

(g) any other matter that may be prescribed;

[Definition of "network" substituted by s. 1 (c) of Act No. 69 of 2008.]

"**network operator**" means the person or persons who have the ultimate accountability for one or more of the following:

(a) the safety of a network or part thereof including the proper design, construction, maintenance and integrity of the network;

(b) ensuring compliance of rolling stock with the applicable standards of the network; or

(c) for the authorising and directing of the safe movement of rolling stock on the network;

[Definition of "network operator" substituted by s. 1 (d) of Act No. 69 of 2008.]

"**operator**" means a network operator, train operator or station operator or a combination of two or three of them;

"**person**" includes an unincorporated body, an organ of state and the Minister;

"**prescribe**" means prescribe by regulation;

railway" means a guided system designed for the movement of rolling stock that has the capability of transporting passengers, freight or both on a track and includes the land, network, rolling stock, plant, machinery, goods and other immovable or movable property of every description or kind used or set aside for use in connection with or for the purpose of a railway operation;

railway industry association" means an association recognised by the Regulator in terms of section 7 (2) (b);

"**railway occurrence**" means a railway accident or railway incident prescribed as such, which could include criminal activity;

"**railway operation**" means the activities performed by a network operator, train operator or station operator, or a combination of two or three of them;

"**Regulator**" means the Railway Safety Regulator established in terms of section 4;

"**rolling stock**" means a vehicle that can operate on a railway, irrespective of its capability of independent motion;

"**safe railway operation**" means a railway operation in which the risks associated with the railway operation which may impact on the safety of persons and property transported by railway and the safety of other persons, other property and the environment, are as low as is reasonably practicable in the given set of circumstances, and does not include security;

"**security**" means freedom from intentional harm or damage to persons or property;

"**safety**" means the lack of railway occurrences, fatalities, injuries or damage within railway operations;

"**risk**" means the probability that injury or damage will occur;

"**safe**" means free from any hazard;

"**safety management system**" (SMS) means a formal framework for integrating safety into day-to-day railway operations and includes safety goals and performance targets, risk assessment, responsibilities and authorities, rules and procedures, monitoring and evaluation processes and any other matter prescribed;

"**safety management system report**" means a written submission, made by an applicant, in support of a safety permit application that describes the applicant's safety management system and may include any other matters prescribed;

"**safety permit**" means a permit issued by the Rail Safety Regulator.

"**train operator**" means a person or persons who have the ultimate accountability for—

(a) the safe movement of rolling stock on a network;

(b) safety and integrity of rolling stock; and

(c) safety of freight or persons being conveyed;*[Definition of "train operator" substituted by s. 1 (f) of Act No. 69 of 2008.*

Occupational Health and Safety Act, 1993 (Act No. 85 of 1993)

The following definitions are applicable to the interpretations of the Occupational Health and Safety

Act, 1993 (Act No. 85 of 1993)

"accident" means an accident arising out of and during an employee's employment and resulting in a personal injury, illness or the death of the employee;

"Chief executive officer" means in relation to a body corporate or an enterprise conducted by the State, means the person who is responsible for the overall management and control of the business of such body corporate or enterprise;

"Hazard" means a source of or exposure to danger;

"Danger" means anything which may cause injury or damage to persons or property;

"Department" means the Department of Transport

"Employee" means, subject to the provisions of subsection (2), any person who is employed by or works for an employer and who receives or is entitled to receive any remuneration or who works under the direction or supervision of an employer or any other person;

"Employer" means subject to the provisions of subsection (2), any person who employs or provides work for any person and remunerates that person or expressly or tacitly undertakes to remunerate him, but excludes a labour broker as defined in section 1(1) of the Labour Relations Act, 1956 (Act No. 28 of 1956);

"Incident" means an incident as contemplated in section 24(1);

"Inspection authority" means any person who with the aid of specialized knowledge or equipment or after such investigations, tests, sampling or analyses as he may consider necessary, and whether for reward or otherwise, renders a service by making special findings, purporting to be objective findings, as to:

- the health of any person;
- the safety or risk to health of any work, article, substance, plant, or machinery, or of any condition prevalent on or in any premises; or

the question of whether any standard has been or is being complied with, with respect to any work, article, substance, plant, or machinery, or with respect to work or a condition prevalent on or in any premises, or with respect to any other matter, and by issuing a certificate, stating such findings, to the person to whom the service is rendered.

"Inspector" means a person designated under section 28.

"Local authority" means any institution or body contemplated in section 84(1)(f) of the Provincial Government Act, 1961 (Act No. 32 of 1961); any institution or body contemplated in section 84(1)(f) of the Provincial Government Act, 1961 (Act No. 32 of 1961);or

any regional services council established under section 3 of the Regional Services Councils Act, 1985 (Act No. 109 of 1985); or any other institution or body or the holder of any office declared by the Minister by notice in the *Gazette* to be a local authority for the purposes of this Act.

"Major incident" means an occurrence of catastrophic proportions, resulting from the use of plant and machinery, or from activities at a workplace;

"Properly used" means used with reasonable care, and with due regard to any information, instruction or advice supplied by the designer, manufacturer, importer, seller or supplier, as the case may be;

"Reasonably practicable" means practicable having regards to:

- the severity and scope of the hazard or risk concerned;
- the state of knowledge reasonably available concerning that hazard or risk and of any means of removing or mitigating that hazard or risk;
- the availability and suitability of means to remove or mitigate that hazard or risk; and
- the cost of removing or mitigating that hazard or risk in relation to the benefits deriving therefrom.

"Regulation" means a regulation made under section 43.

"Standard" means any provision occurring:

- in a specification, compulsory specification, code of practice or standard method as defined in section 1 of the Standards Act, 1993 (Act No. 29 of 1993); or
- in any specification, code or any other directive having standardization as its aim and issued by an institution or organization inside or outside the Republic which, whether generally or with respect to any article or matter and whether internationally or in any country or territory, seeks to promote standardization.

"Workplace" means any premises or place where a person performs work in the course of his employment.

Overview

1. Overview

The Railway Safety Regulator (RSR) obtains its legal mandate from the National Railway Safety Regulator Act no. 16 of 2002 as amended (“the Act”). The main objectives of the RSR are to oversee the safety of railway operations, promote improved safety performance in the railway industry, develop any regulations and standards required in accordance with the Act, monitor and ensure compliance with the Act, and give effect to the objectives of the Act. The protection of people (public and employees), property and the environment are paramount.

The RSR Strategy must provide a framework for strategic safety planning across the rail sector and interfaces with other modes of transport. It also needs to serve as a catalyst for the promotion of safety in the railways in a manner that will support and recognise the government’s focus on shifting passengers and freight traffic from the road to rail. Currently the railway industry is guided by various legislative frameworks pertaining to railway safety.

One of the ways in which the RSR monitors the safety performance of railway operations is through the analysis of the occurrence data reported by the operators. The RSR produces an Annual State of Safety Report (SoS) that outlines the safety performance of railway operators from recorded and analysed safety data.

The railway industry is a major player in the South African transport sector. This important role is undermined by the increasing accidents especially at the level crossings. Railway accident prevention and protection are a key part of a wider picture of transport safety. The rail sector thus needs to improve its knowledge management to work out suitable responses to the constantly increasing number and severity of level crossing accidents by identifying and analysing mitigating measures that should be taken.

Railway stakeholders have been implementing a variety of countermeasures for many years to improve railway safety. This research study will highlight the extent of the level crossing accidents with the aim of finding ways to reduce such accidents. Level crossing occurrences contributes to a high number of fatalities and injuries in South Africa. This topic becomes more complex as it affects both railway operators and road users when an incident occurs. While safety measures exist at all legal level crossings the number of level crossing accidents continue rise. The following is a snapshot of major accidents that have occurred at level crossings in South Africa over the past 15 years:

- 13 November 2006, Faure level crossing accident, 19 people were killed at a level crossing near Somerset West when a Metrorail train collided with a truck carrying farm workers
- 25 August 2010, Blackheath level crossing accident, 10 children died because of a level crossing accident between a Metrorail commuter train and a minibus taxi;
- 13 July 2012, Hectorspruit level crossing accident, 26 people were killed at a level crossing
- near Hectorspruit, Mpumalanga, when a coal train collided with a truck carrying farm workers; and
- 4 January 2018, Geneva level crossing accident, 24 passengers died and 260 were injured because of a level crossing accident between Main Line Passenger Services Train 37012 and an articulated truck.

It is important to note that level crossing accidents are a shared responsibility of several transportation players that includes the national government, railway operators, private landowners, local municipalities as well as the private road users. The RSR tends to investigate the key contributing factors to level crossing accidents with the intention of mitigating the risks of level crossing occurrences.

A total of 133 level crossing occurrences were reported during the 2018/2019 reporting period. This is a 6 per cent increase compared to the previous reporting period. The average number of level crossing occurrences over the last 10 years amounts to 117 per annum. The actual number of level crossing accidents reported by operators per year confirm that there has been a steady increase in the number of level crossing accidents over the past five years.
This research study will focus on the following category of occurrences recorded in the SoS reports for the period 2008 to 2019:

- Category D-a – Collisions between rolling stock and road vehicles at recognised level crossing on a running line.

2. Purpose of the research study

The purpose of the study is to analyse the level crossing accidents and come up with possible solutions to improve safety at level crossings across South Africa using a mixed research design approach towards establishing the causes of such accidents with the view to minimise such accidents in the future.

The following objectives will assist in addressing the problem:

- Assess the root cause of accidents at level crossings;
- Determine the contributing factors to level crossing accidents;
- Analyse the current risk control measures at level crossings; and
- Provide recommendations on better safety measures to be implemented at the level crossings.

This study is significant for several reasons. Firstly, it will attempt to identify the root causes of accidents as well as the factors that contribute to accidents at level crossing. In the end, the study is significant as it proposes the way forward to save the economy and lives lost through level crossing accidents.

In addition, the study will improve operational efficiency considering that when a level crossing accident occurs, operational disruption follows which interfere with efficiency and effectiveness of the transport system. This study will inform the RSR and railway operators on better approaches to increase safety at level crossings and, therefore, minimise accidents at the level crossings.

3. Stakeholders

Within socio-technical systems there are several stakeholders each with their own roles, responsibilities, goals, and constraints. These stakeholders consist of the Department of Transport, the RSR, and railway operators of which there are over two hundred. For the purposes of this study, the two major operators, namely the Passenger Rail Agency of South Africa (PRASA) and Transnet are discussed in this section. . The background and relevance of these role players are discussed in the following sections.

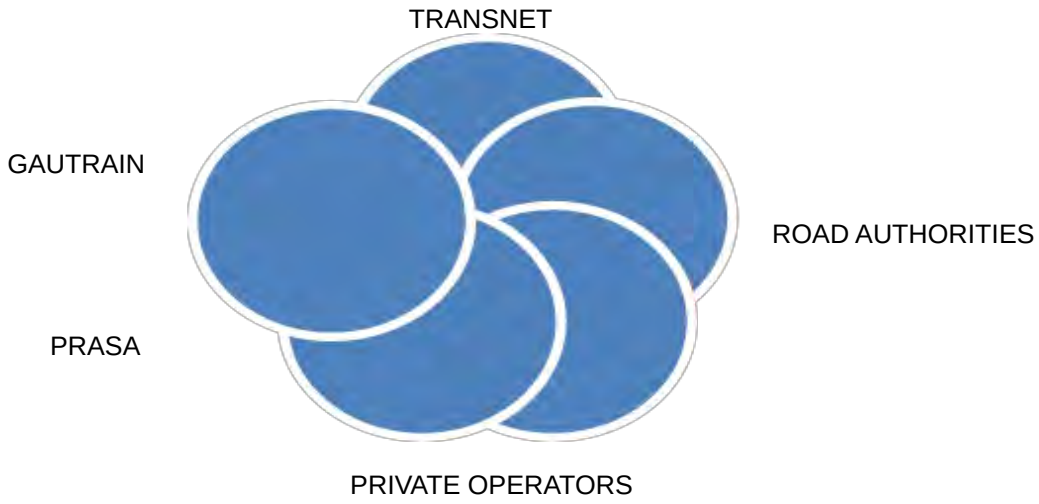

Figure 1 **Level Crossing Stakeholders**

3.1 Department of Transport (DoT)

The responsibilities of the DoT pertaining to the rail sector include:

- Research, formulating legislation and policy for the development of sustainable rail transport;
- Assigning responsibilities to the 12 public entities that report to the Minister of Transport and other levels of government; and
- Rail economic and safety regulation through standards, infrastructure development strategies, and systems that reduce system costs and improve customer services (South African Government, n.d.).

3. 2 Railway Safety Regulator (RSR)

The National Railway Safety Regulator Act no 16. of 2002 (2009) provides for the establishment of a national regulatory framework for South Africa and, therefore, the RSR was established. Prior to the establishment of the RSR, the South African railway environment was self-regulated. One factor which led to the establishment of the RSR was the acknowledgment by the government that railways are key to sustained economic growth and that safety plays a pivotal role in advancing operational efficiency of South Africa's railways (RSR, 2011a).

3.3 Transnet

Transnet is a State-Owned Company (SOC), wholly owned by the South African government and is the custodian of rail, ports, and pipelines. Transnet is responsible for enabling the competitiveness, growth, and development of the South African economy through delivering reliable freight transport and handling services to satisfy customer demand.

3.4 Passenger Rail Agency of South Africa (PRASA)

PRASA is a national government business enterprise that reports to the Minister of Transport and is wholly owned by the South African government (PRASA, 2013). The vision of PRASA is to be South Africa's number one public transport operator responsible for rail (urban metro commuter and long distance intercity and cross border train services) and bus transport services (PRASA, 2013). Over 2.2 million passengers are transported across South Africa daily by metro commuter rail services in different corridors with level crossings.

4. Benchmarking

4.1 Level crossing occurrence European Union (EU) versus South Africa

4.1.1 Background

The intent of this benchmarking exercise is to compare the annual number of level crossing fatalities, serious injuries and accidents that have taken place from 2010 up to 2018 in the EU to those that have taken place in South Africa. The intent is to normalise the numbers and compare E U accidents with those taking place in South Africa. Level crossings not only represent the physical intersection (of a railway track and a road), but also an intersection of responsibilities and interests. A high-level monitoring of outcomes, therefore, provides objective evidence for efficient safety improvements (2020, p **44** Report on Railway Safety and Interoperability in the EU).

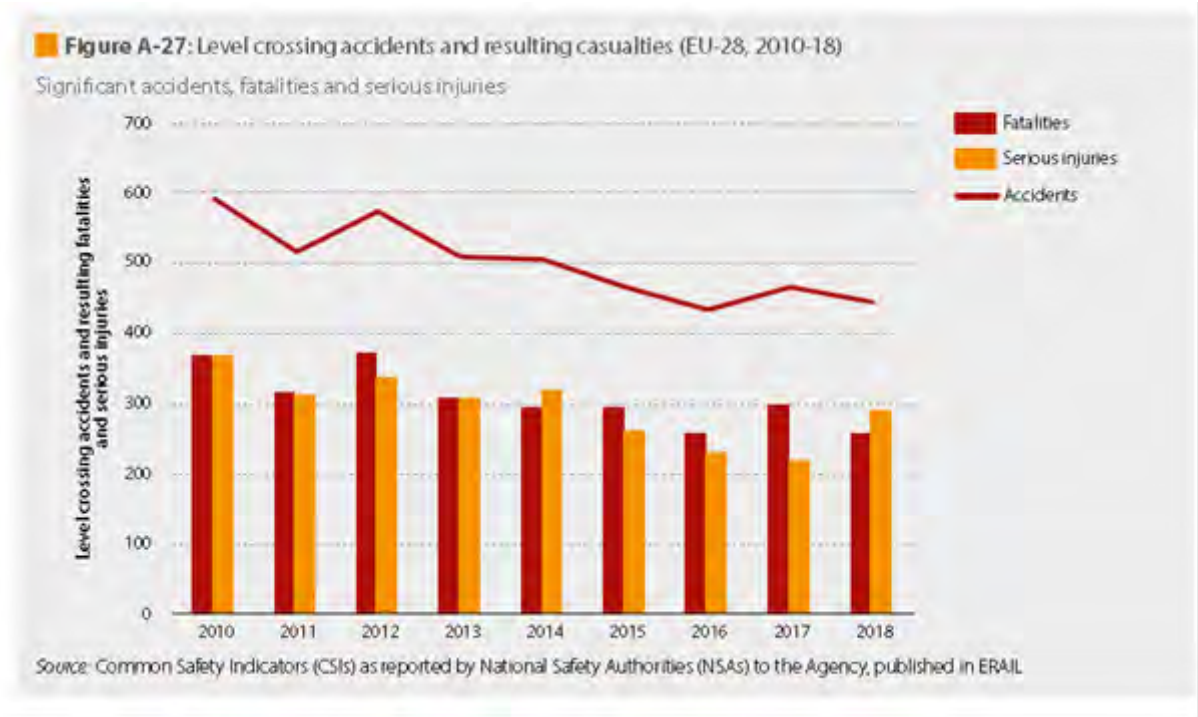

Figure 2 EU Level crossing accidents and resulting casualties (EU-28, 2010-18)

- There are about 105 000 level crossings in the EU-28 countries.

"In recent years, a weekly average of six fatalities and an additional six serious injuries occur at level crossings in Europe."

- Notably, it appears that a slower pace of improvements in road safety (compared to rail safety) impacts the progress of improving level crossing safety levels;
- Countries with the lowest accident rates typically feature comprehensive strategies for level crossing safety improvements visible that translate, among others, in a low number of poorly or not protected level crossings; and
- A common feature of the countries with the highest accident rates is a low population density and low railway traffic volumes. These conditions perhaps provide less incentive for a comprehensive management of level crossing safety.

4.1.2 "Each year people die in accidents involving road vehicles colliding with trains at level crossings. A total of 98 per cent of these fatalities are attributed to faults by the road vehicle driver" **(European Level Crossing Forum).**

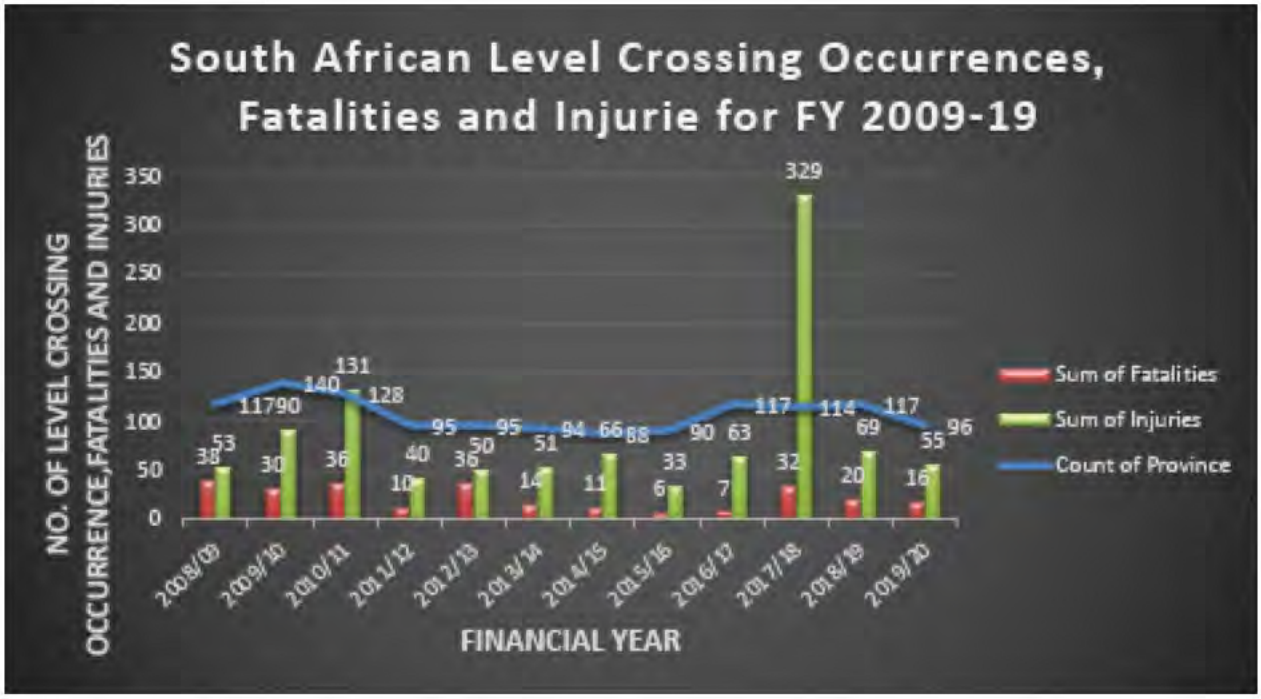

Figure *3* **South African** *l*evel *c*rossing*a***Accidents and resultant** *c***asualties (2010-2009)**

(also fix spelling of injury in figure)

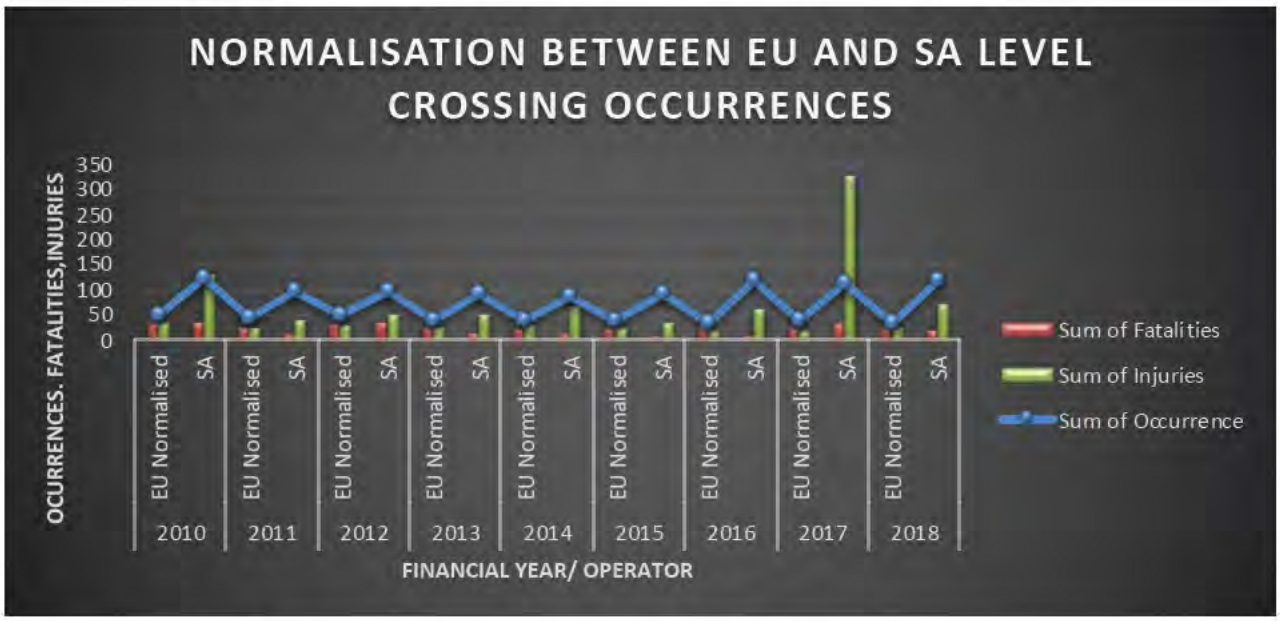

Figure *4* **Normalised** *data between* **SA** *and EU*

4.1.3 Benchmarking results analyses.

Referring to Figure 4 Normalised nata between SA and EU countries, one can conclude the following:

- The total number of level crossing occurrences/accidents happening within the South African rail environment from 2010 to 2018 exceed those taking place within the EU countries consistently and by a huge margin;The total number of level crossing accident-related injuries within the South African rail environment from 2010 to 2018 exceed those taking place within the EU countries consistently and by a huge margin; and
- The total number of level crossing accident-related fatalities within the South African rail environment is comparable to those taking place within the EU countries and at times less than those taking place within the EU countries (example: 2011, 2013, 2014, 2015 and 2016).
- In conclusion it is noted that there is a need to reduce the total number of level crossing accidents as well as the total number of level crossing accident-related injuries to improve the South African level crossing safety performance to be in line with that of the EU countries.

5. Literature overview

This chapter gives a detailed understanding of the theory behind the analysis of level crossing accidents, the current countermeasures present at level crossings in South Africa as well as the conclusion on the data received on railway stakeholders.

5.1 The White Paper on National Transport Policy

The White Paper on National Transport Policy of 1996 set out the vision for South African transport as being to provide safe, effective, efficient, and fully integrated transport operations and infrastructure, which will best meet the needs of freight and passenger customers. The emphasis of the 1996 White Paper is public transport policy development where the customer or user is central within the transport system. Key considerations for the development of transport policies should be safety, affordability, quality, and the provision of improved service levels. In addition, the White Paper highlights government's need for efficiency, integrated operations, infrastructure, and support for economic, social, and environmental development.

The White Paper does not contain much on railway safety. But the comments on road safety provide an insight into the thinking about transportation safety. Through a consultative approach between the DoT and the provincial authorities, an integrated road traffic quality management and monitoring approach will be introduced, which will address, inter alia:

- Road traffic control;
- Legislation and adjudication;
- Training, education, and communication;
- Road traffic administration and information systems; and
- Road and traffic engineering.

The White Paper (Department of Transport, 2014) asserts the importance of rail for both freight and passenger transport and is a point of departure for any discussion on national land transport. It sets out the vision for South African transport *"to provide safe, effective, efficient, and fully integrated transport operations and infrastructure, which will best meet the needs of freight and passenger customers".*

The six broad goals as outlined in the White Paper are:

- To support the goals of the Reconstruction and Development Programme for meeting the basic needs, growing the economy, developing human resources, and democratising decision making;
- To enable customers requiring transport for people or goods to access the transport system in ways which best satisfy their chosen criteria;
- To improve the safety, security, reliability, quality and speed of transporting goods and people;To improve South Africa's competitiveness and that of its transport infrastructure and operations through greater effectiveness and efficiency to better meet the needs of different customer groups, both locally and globally;
- To invest in infrastructure or transport systems in ways which satisfy social, economic, or strategic investment criteria; and
- To achieve the above objectives in a manner which is economically and environmentally sustainable and minimises negative side effects.

Among the policy principles set out are that there are elements of infrastructure and operations where the principle of cost recovery from direct users will be applied as far as possible, and on the other hand, elements which cannot or should not be paid for by the user, but which provide social benefits (mobility and accessibility). In the case of the latter, government will contribute to the financing of services that are socially necessary. The intention is to regulate only where it is essential, for example to ensure that desired services which would not be financially viable are provided, to ensure level playing fields and to regulate for safety.

The *National White Paper* sets out, among others, the following strategic objectives for land passenger transport:

Spatially:

- To encourage more efficient urban land use structures, correcting spatial imbalances and reducing travel distances and times for commuting to a limit of about 40 km or one hour in each direction; and
- To promote the use of public transport over private car travel, with the goal of achieving a ratio of 80:20 between public transport and private car usage.

Customer-based:

- To ensure that passenger transport services address user needs, including those of commuters, pensioners, the aged, scholars, the disabled, tourists, and long-distance passengers;
- To improve accessibility and mobility, limiting walking distances to less than about 1 km in urban areas;
- To ensure that public transport is affordable, with commuters spending less than 10 per cent
- of disposable income on transport;
- To promote safe and secure, reliable, and sustainable passenger transport; and
- To provide readily accessible information for the assistance of passenger transport users.

Planning and regulatory:

- To provide appropriate institutional structures, which facilitate the effective and efficient planning, implementation, funding, regulation, and law enforcement of the passenger transport system, devolved to the lowest competent level.

Operational:

- To ensure that operations become economically viable, requiring the minimum financial support;
- To ensure that transport modes are integrated in respect of scheduling, routes, and ticketing systems; and
- To ensure that land passenger transport operations are more environmentally sensitive, sustainable and energy efficient.

Rail is seen as an essential long-term component of the network for both freight and passenger transport. The national transport authority will own the commuter rail infrastructure, rolling stock and land associated with rail reserves, until the provincial or metropolitan transport authorities are able to take over this responsibility. Any further provision of rail infrastructure for commuter transport will be determined by a combination of market needs and social considerations.

5.2 The National Railway Safety Regulator Act No. 16 of 2002

The RSR Act recognises that safe railway operations are fundamental to the safety of all persons and the environment. The RSR is charged with overseeing the safety of railway transport while operators remain responsible for such safety within their areas of responsibility. The Regulator also has to promote improved safety performance in the railway transport industry to promote the use of rail as a mode of transportation.

Safe railway operations promote the use of railways as a mode of efficient transportation. It also recognises that safe railway operations must be effective-

ly overseen, managed, and coordinated to ensure their safety. In the RSR Act an important acknowledgment must be noticed. It acknowledges that railway safety has a relationship with occupational health and safety and with security. Safety and security matters are interconnected, and the Regulator has a primary role to play in safe railway operations and a supporting role in occupational health and safety, and security.

Coordination between all organs of state is important in that it has a role to play in railway operations. They must cooperate with one another to give effect to the principles of cooperative government and intergovernmental relations contemplated in Chapter 3 of the Constitution.

The RSR Act provides for the establishment of the Railway Safety

Regulator as well as safety standards and regulatory practices to:

- provide for and promote safe railway operations;
- encourage the collaboration and participation of interested and affected parties in improving railway safety;
- recognise the prime responsibility and accountability of railway operators in ensuring the safety of railway operations;
- facilitate a modern, flexible and efficient regulatory regime that ensures the continuing enhancement of safe railway operations; and
- promote the harmonisation of the railway safety regime of the Republic of South Africa with the objectives and requirements for safe railway operations of the Southern African Development Community.
-

According to the RSR Act, safety means the lack of railway occurrences, fatalities, injuries, or damage within railway operations. This definition will be applied when developing the National Railway Safety Strategy.

- "railway occurrence" means a railway accident or railway incident prescribed as such, which could include criminal activity;
- "railway operation" means the activities performed by a network operator, train operator or
- station operator, or a combination of two or three of them;
- Another valuable definition in the RSR Act is that of a safe railway operation;
- "safe railway operation" means a railway operation in which the risks associated with the railway operation which may impact on the safety of persons and property transported by railway and the safety of other persons, property, and the environment, are as low as is reasonably practicable in the given set of circumstances, and does not include security;

Firstly, it is important to note that it includes passengers and freight transported by the railway. It also includes the safety of other persons, property, and the environment.

5.3 Current safety control measures at level crossings

Protection at level crossings is divided into passive and active systems of protection. Passive protected level crossings are those level crossings equipped with warning signs, devices or any protection equipment that does not react to the presence of an approaching train. Active protected level crossings are level crossings equipped with flashlights and boom gates which are triggered by a train. The following is a list of level crossing protection found in South African level crossings.

Sign Control

Road traffic signs provide protection for road users and the protections include the following: yield control sign (R2), stop sign (R1), traffic light, level crossing hazard marker warning (W403 or W404), stop line road marking (RTM1), no overtaking road marking (RM1), level crossing warning marking (WM1), level crossing advance warning (W318) and many more signs found on and around level crossings.

Flagman

Industrial level crossings normally have road signages as well as flag signals. Flagman uses flag signals to prohibit road movement over the level crossing when a train is approaching, during shunting movement or as a form of temporary control during construction or during temporary failure.

Locked gates

South Africa has many farm road level crossings, mostly in the Northern Cape. The busiest level crossings are located at Military Road, Steenberg and Buttskop Blackheath. At farm road level crossings, the main level of protection is locked gates with the addition of electrical shock warning signs. The owner of the property shall ensure that gates are locked when not in use and that they are unlocked for individual road vehicle movements across the railway line.

Boom protection

Most urban streets level crossing employ booms and flashing lights/signals for protection. The principal operation of this type of protection; a train approaching the level crossing will drop the approach track which will in turn drops the crossing control relays and activate flashlights. When the approach track drops the booms also drops seconds later. At a railway crossing a flashing red light indicates that a train is coming, and you may not drive on until the light stops flashing (SA learner manual driver). With booms down and flashlights activated the vehicle driver is supposed to stop until the boom gate is released again.

Traffic signals

On rural roads with surfaced unnumbered routes that carry less than 300 vehicles per day, traffic signals are used in conjunction with warning signals. Traffic signals are used to control road vehicles at level crossings. If traffic signals fail, the traffic signal control revert to that of a flashing red light or display no light. This will require all road vehicle to stop and decide whether it is safe to proceed or not.

Whistle boards

Whistle boards are erected alongside the railway line to inform train drivers to sound the locomotive whistle. When the train passes the whistle board, the train driver must sound the whistle so that pedestrians and motorists are aware of the coming train.

5.4 Factors that lead to level crossing accidents

Section 38 (4) of the Act stipulates that the Regulator may, or upon receipt of a directive from the Minister must, investigate any railway occurrence for the purposes of preventing similar occurrences in the future (National Railway Safety Regulator Act No.16 of 2002, 2009). Between 2009 and 2018, the RSR has investigated 25 level crossing occurrences and the investigation reportsfrom the RSR have revealed that the root cause of accidents is non-compliance to road signage by road vehicle drivers.

Section 38 (1) of the Act specifies that the operator must investigate every railway occurrence that takes place directly or indirectly in connection with that operator's railway operations, among others, identify the root causes thereof, within a reasonable time after that occurrence. The occurrence reports from TFR and PRASA also revealed that the main root causes of these level crossing accidents are due to road vehicle drivers not adhering to road signage. The lack of compliance to the road signage among vehicle drivers is influenced by driver behaviour. There are a lot of contributory factors in accidents that are linked to human behaviour (Wallace et al 2008).

a) Fatigue and hypo vigilance

Fatigue is related to the physiological processes underlying alertness or wakefulness, while hypo vigilance is related to information processing and sustained attention (Wallace et al, 2008). The characteristics of road geometry and roadside environment, including other factors that define the driving task can have an impact on driving performance by affecting arousal, alertness, and information processing. An under-demanding monotonous road environment with low traffic density can produce fluctuations of arousal that decrease alertness and vigilance (Moller, H).

b) Familiarity and exposure

In some of the investigation reports it is revealed that the most motorists tried to drive through the level crossing at a high speed while the train was approaching. This is familiarity and exposure; the vehicle driver is familiar with the level crossing which leads to the driver risking or finding it interesting to take such risk.

c) Distraction

Distraction can be in a form of noise where the vehicle driver cannot hear the oncoming train, it can also be anything around the level crossing that takes the driver's attention such that they do not adhere to the road signs.

6. Methodology

The methodology followed in this report will analyse level crossing accidents that have taken place over the past 10 years. The focus of this report will be mainly on Transnet and PRASA. This report will firstly highlight the hotspot areas for level crossing accidents a well include an analysis of the results of level crossing investigations that have been done by both the trains operators and the RSR over the same period. The train operators as well as the RSR have a set process/methodology when doing occurrence investigations and the results and recommendations coming from these reports is a reputable source of information when it comes to determining the immediate causes as well as root causes of level crossing accidents within the context of the South African rail environment. The recommendations contained in these reports also gives the reader a view of the identified gaps/risks in and around the major contributory causes to level crossing accidents.

6.1 The method of investigation

The method of incident investigation followed by both the RSR and rail operators is formalised and the content of the generated reports cover the full investigation process. The standard adopted method of rail incident investigation entails the following aspects:

- Onsite inspection
- Interviews with the relevant personnel
- Documentation verification
- Photographic evidence

The results of the investigation are reflected in standardised formal reports covering the following content:

- Executive summary;
- Abbreviations;
- Statement of intent;
- Background to the investigation;
- Date, time, and location;
- Trains involved;
- Persons directly involved;
- Persons injured;
- Asset condition damaged;
- Weather;
- Description of the occurrence site;
- Evidence obtained;
- Interviews;
- Documents;
- Observations;
- Photographic evidence;
- Evidence analysis;
- Findings;
- Immediate cause
- Root cause
- Recommendation; and
- Evidence register.

For the purpose of the report the following key elements of the currently sourced investigation reports will be highlighted and where analysed.

- Occurrence date
- Report description
- Level crossing location
- Injuries and fatalities
- Immediate cause
- Root cause
- Core recommendations

6.2 Data gathering process

In terms of data gathering for analyses the following process was followed:

a) A request was made to the relevant internal RSR departments for the following information:
   - All the RSR adhoc level crossing investigation reports.
   - All the level crossing category D-a occurrences from 2009-2019.

b) A formal request was made by the RSR to both Transnet and PRASA requesting the following information:

- The names and locations of the top 10 most high-risk level crossings;
- The accident/occurrence history of the top 10 most high-risk level crossings over the past five years (i.e., from 2014 to 2019);
- Copies of all/any Investigation reports of investigations that was conducted following any occurrence that happened at these level crossing sites over the past 5 years (if available); and
- Copies of the latest Physical Assessments and Risk Assessment Reports on the top 10 most high-risk level crossings done in accordance with SANS 3000-2-2-1 (Level

  Crossing Standard-Annex A & B).

6.3 Data gathering challenges

It is noted that in terms of the information requested from both Transnet and PRASA only a partial submission has been received to date. The RSR is currently awaiting the submission of the outstanding information. The current analyses are based on the information that has been sourced to date.

7. Data analysis

7.1 Transnet Freight Rail and PRASA level crossing occurrence data over the past 10 years

Quantitative data analysis utilised for this research is sourced from the RSR Occurrence database reported by the operators as per the RSR Act. The data analysis focuses on the number of occurrences reported to the RSR by the two major operators between 2009 and 2019. The purpose of focusing to the two major operator is to ascertain the level of impact of the level crossing occurrences on the safety of the public.

Through the analysis of the overall occurrences that occurred over the 10-year period, it can be deduced that TFR had a high number of level crossing occurrences in the year 2009-10, however, they had a high number of injuries in the 2017-18 period due to the level crossing occurrence that involved the passenger rail train.

This analysis indicates that careful consideration shall be taken in the protection of public level crossing as depicted in Figure 5 South African level crossing accidents for the period 2009-19.

The data analysis will focus on:

- Finding the provinces that have a high number of level crossings occurrences;
- Finding the level of protection for the level crossings with a high number of occurrences;
- Finding the ownership of those level crossing; andFinding the current state of the level crossings if they are active or dormant.

The outcome of the data analysis will assist in focusing on the root causes and providing practical solutions in the curbing the increasing level crossing occurrences.

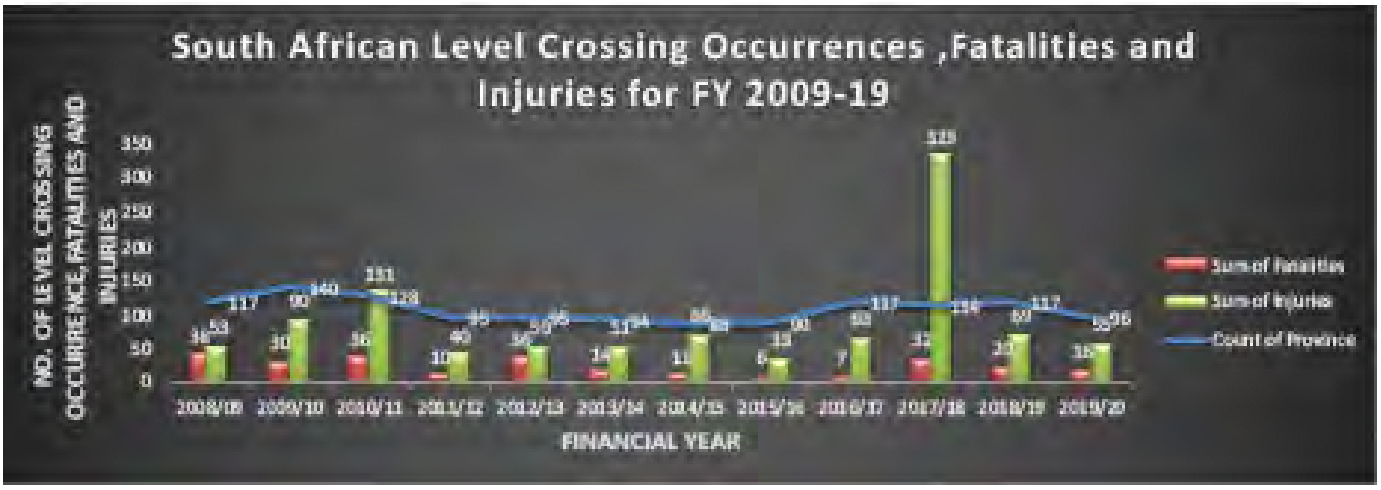

Figure *5* **South African** *l***evel** *c***rossing** *a***ccidents for the (2009-19)** *(add s)*

7.2 Identification of TFR high risk level crossings per province

Financial Year	Province with the high number of level crossing occurrences
2009- 10	North West
2010-11	North West
2011-12	KwaZulu-Natal and Western Cape
2012-13	North West
2013-14	North West
2014-15	Gauteng and KwaZulu-Natal
2015-16	North West
2016-17	Mpumalanga
2017-18	North West
2018-19	North West

Table *1* TFR high risk level crossings per province

The data analysis of the TFR level crossing occurrences reported per province indicates that the North West had the highest number of occurrences reported for a period of seven years.

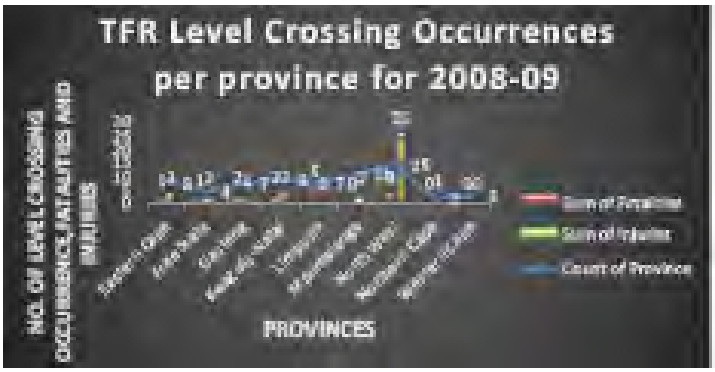

Figure 7 TFR *level crossing occurrences* per province (2008-09)

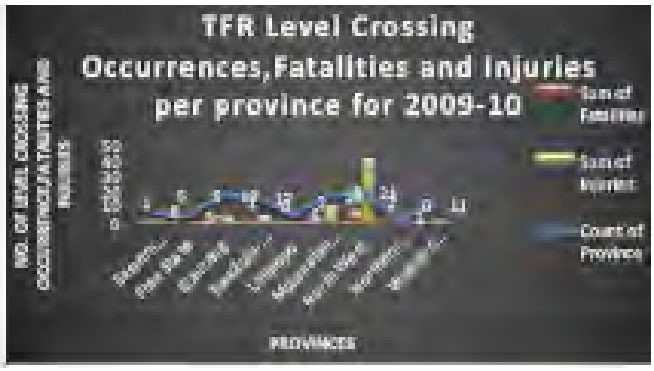

Figure 6 TFR *level crossing occurrences* per province (2009-10)

Figure 8 TFR *level crossing occurrences* per province (2010-11)

Figure 7 TFR *level crossing occurrences* per province (2011-12)

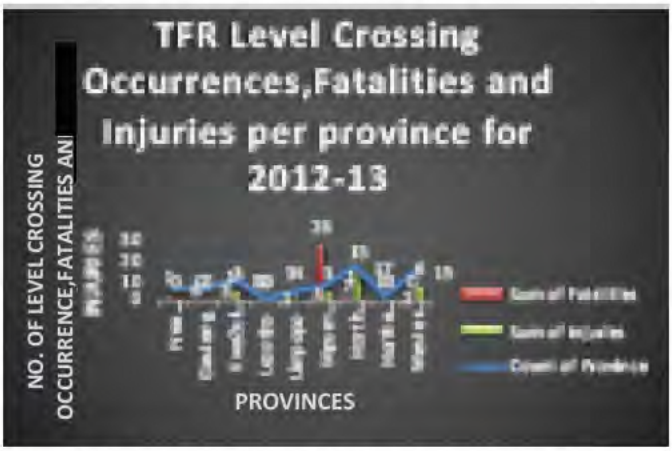

Figure 9TFR *Level Crossing Occurrences* **per province (2012-13)**

Figure 10TFR *level crossing occurrences* **per province (2013-14)**

Figure 11TFR Level Crossing Occurrences per province (2014-15)

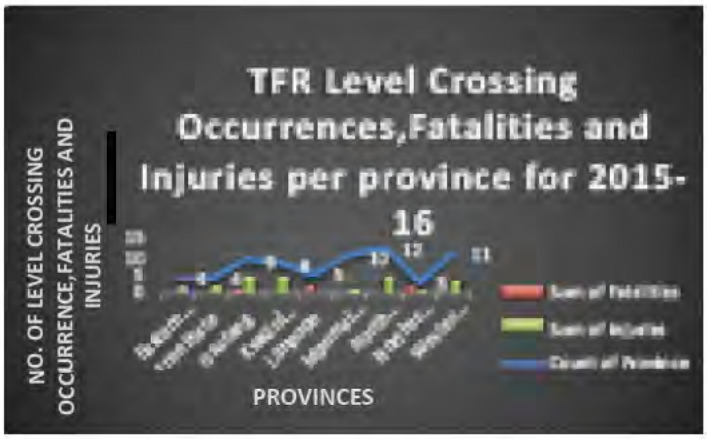

Figure 12TFR level crossing occurrences per province (2015-16)

Figure 13TFR *level crossing occurrences* **per region (2016-17)**

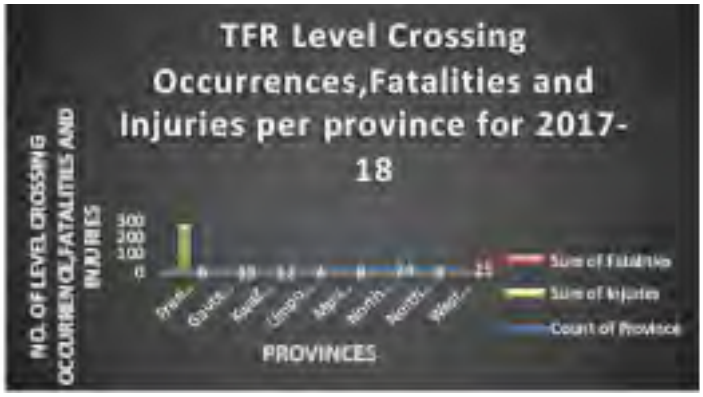

Figure 14TFR *level crossing occurrences* **per province (2017-16)**

Figure 15 TFR *level crossing occurrences* **per province (2018-19)**

7.3 Identification of PRASA high risk level crossing per province

The analysis of the occurrence per province depicts that the Western cape had the highest number of occurrences reported over the period of 10 years.

Financial Year	Province with the high number of level crossing occurrences
2009- 10	KwaZulu Natal
2010-11	Western Cape
2011-12	KwaZulu Natal and Western Cape
2012-13	KwaZulu Natal
2013-14	Western Cape
2014-15	Western Cape
2015-16	Western Cape
2016-17	Western Cape
2017-18	Western Cape
2018-19	Western Cape

Table *2* **PRASA Provinces with high risk level crossings**

Figure 16 **PRASA** *Level Crossing Occurrence* **per province (2009-10)**

Figure 17 **PRASA Level Crossing Occurrence per province (2010-11)**

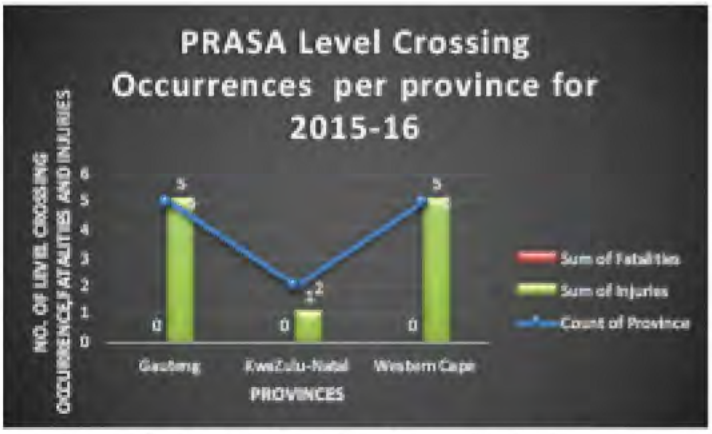

Figure 21 **PRASA Level Crossing Occurrences per** province **(2011-12)**

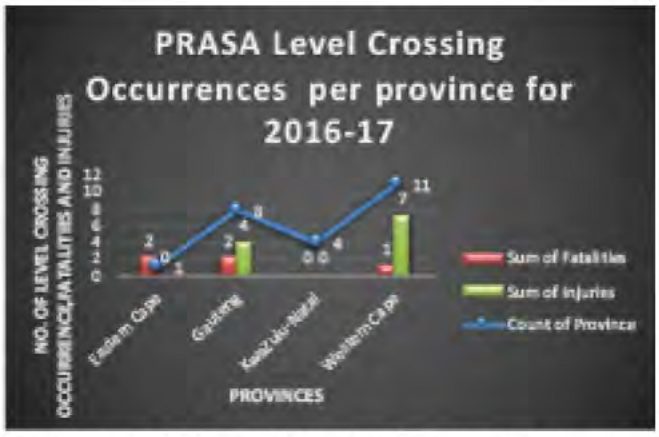

Figure 18 **PRASA Level Crossing Occurrences per** province **(2012-13)**

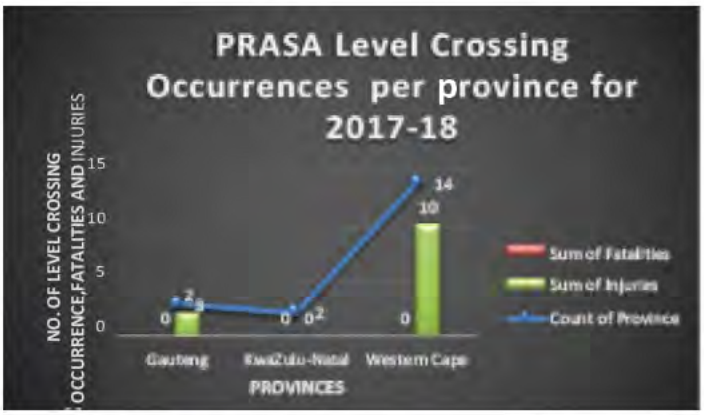

Figure 19 **PRASA Level Crossing Occurrences per** province **(2013-14)**

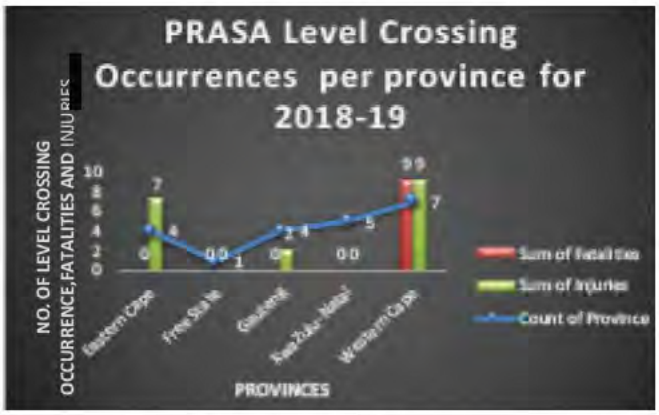

Figure 20 **PRASA Level Crossing Occurrences per** province **(2014-15)**

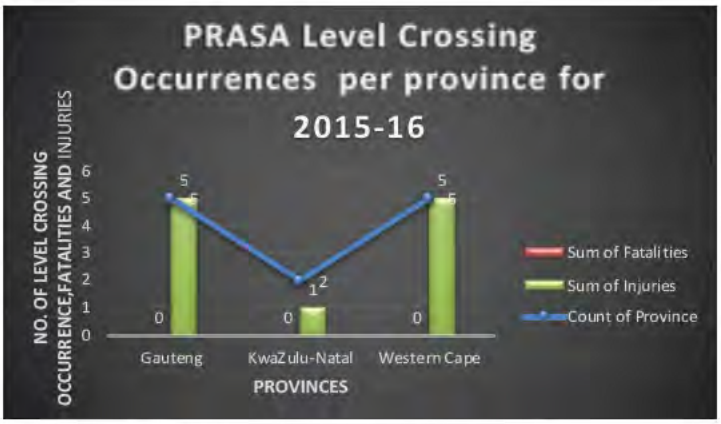

Figure 24 **PRASA Level Crossing Occurrences per** province **(2015-16)**

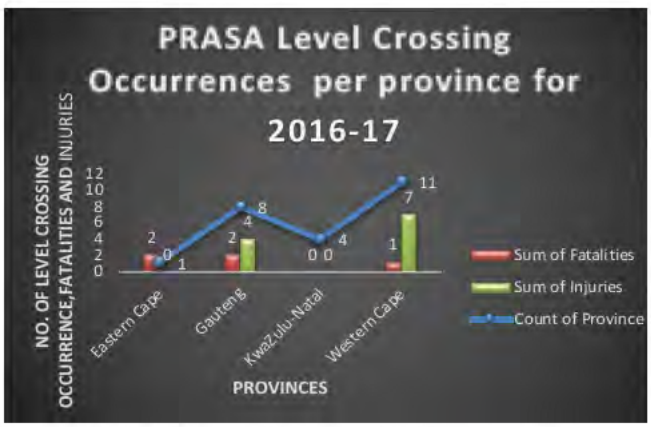

Figure 25 **PRASA Level Crossing Occurrences per** province **(2016-17)**

Figure 23 PRASA Level Crossing Occurrences per province (2017-18)

Figure 22 PRASA Level Crossing Occurrences per province (2018-19)

7.4 PRASA level crossings ownership, level of protection and status

The purpose of this section is to provide an overview of the overall status, ownership, and the level of protection of the level crossings in the PRASA network. Ascertaining this information will assist in allocating responsibilities to the stakeholders to ensure that:

- Level crossing incidents are reduced;
- Through the level of protection upgrades in area when there have been a high number of occurrences, andto ascertain if the public level crossing is fully protected or qualify for the solutions discussed section 9.

Based on the data in Table *3* **PRASA *l*evel *c*rossing *s*tatus, *o*wnership and *l*evel of *p*rotection** the Western Cape Province has a high number of level crossings with 30 level crossings owned by the public and only 16 of the 52 level crossings have active protection.

This analysis collates with the findings in section 7.3 that shows that most of the level crossing occurrences in the PRASA network occurred in the Western Cape for six consecutive financial years.

Table 3 PRASA level crossing status, ownership and level of protection

		Status			Ownership (Public/Private)			Level of protection	
Province	*Number of level crossings*	*Active*	*Dormant*	*Inactive*	*Departmental*	*Private*	*Public*	Active protection	Passive protection
Gauteng	28	27	0	1	16	7	5	2	26
Western Cape	52	42	0	10	2	20	30	16	36
KwaZulu -Natal	32	30	0	2	6	12	14	3	29
Grand Total	***112***	***99***	***0***	***3***	***24***	***39***	***49***	**21**	**91**

7.5 TFR Level crossings level of protection and status

The purpose of this section is to provide an overview of the overall status, and the level of protection of the level crossings in the TFR network. Ascertaining this information will assist in allocating responsibilities to the stakeholders, to ensure that:

- Level crossing incidents are reduced;
- Through the level of protection upgrades in area when there have been a high number of occurrences; andto ascertain if the public level crossing is fully protected or qualify for the solutions discussed section 9.

The research is focusing on the level crossings that are owned by the public and verify against level of protection per number of occurrences. Based on Table 4, TFR level crossing status and level of protection, TFR has 504 level crossings that require active protection.

This analysis collates with the findings in section 7.3 that shows that most of the level crossing occurrences in the PRASA network occurred in the Western Cape for six consecutive financial years.

The table depict the TFR overall number of level crossings based on the ownership types and differentiation on the status and the level of protection.

		Status		Level of Protection	
Ownership	***Number of Level Crossings***	***Active***	***Dormant***	**Active protection**	**Passive protection**
Public	2172	1664	508	1668	504
Private	5413	4106	1307	4216	1197
Departmental	891	726	165	704	187
Cattle	138	43	95	0	138
Grand Total	8614	6539	2075	6588	2026

Table *4* TFR *l*evelcrossing *s*tatus and level of protection

8. Root cause analysis

8.1 PRASA AND TRANSNET INVESTIGATION REPORTS SUMMARY (2014 - 2019).

Report Number	Occurrence Date	Report Description	Location	Injuries and fatalities	Immediate cause	Root Cause	Core recommendations
1.	10 March 2014	Investigation report into the circumstances surrounding the collision of a passenger train number 74013 and a private motor vehicle where there were minor injuries at a farm crossing situated at kmp 9 mast pole 21at the Birch farm crossing at approximately 08:00 on Monday, 10 March 2014.	Kmp 9 mast pole 21 the birch farm crossing	None	The driver of the road vehicle failed to stop at the farm crossing.	Driver of the road vehicle failed to stop at the farm crossing.	1. Communication and Media should engage with the local community via print media and/or distribute flyers to the community, schools and the local post office boxes, making the community aware of the inherent dangers associated with the level crossings. 2. Public awareness to be conducted with the farmers in this area to ensure that the farm crossing gates are always kept locked. 3. Track Inspector to certify the line safe for the working of trains after all incidents. 4. A risk assessment to be conducted on this farm crossing. 5. All farm Crossings to have concrete level crossing blocks installed. 6. Grass at all level crossings to be cut twice a year instead of once a year. 7. PRASA to conduct proper sign on procedures and substance abuse testing to be conducted at sign off at sign off.

2.	6 June 2014.	Investigation report into the circumstances surrounding the collision of a passenger train number 47014 and a private motor vehicle where there were no injuries, at a level crossing situated at kmp 16 mast pole 4 at the Molteno crossing at approximately 17:50 on friday,6 June 2014.	Kmp 16 mast Pole 4 at The Molteno crossing	None	The driver of the road vehicle failed to stop at the level crossing until the train had traversed over the Level Crossing.	Driver of the road vehicle failed to stop at the Level Crossing.	1. Communication and Media should engage with the local community via print media and/or distribute flyers to the community, schools, and the local post office boxes, making the community aware of the inherent dangers associated with the level crossings. 2. Public awareness to be conducted with the residents in this area. 3. A risk assessment to be conducted on this level crossing. 4. The level crossing warning signs boards and crossing blocks had been broken out of the ground during the unrests in Molteno and need to be replaced. 5. MLPS to ensure that scotch blocks are placed on all locomotives before departing from the departing depot. 6. MLPS to ensure that train crew receives a safety talks on a daily / weekly basis.

3.	27 July 2014	Report of the investigating team that investigated the circumstances that led to the level crossing incident between Shosholoza Meyl train 37012 and a white Toyota	Addo km/p 143.1. and 142.14	None	Failure on the part of the driver of the motor vehicle to stop at a level crossing and wait for the train to go pass	Possible ignorance and/ or total lack of respect of road signs on the part of the driver of the motor vehicle.	1. Proper sign on procedures beimplemented at PRASA rail, which includes substances abuse testing in the presence of a Section Manager prior to signing on duty. 2. Drug screening is performed on PRASA train drivers after they are involved in an incident. 3. PRASA train drivers be informed what the procedures is when they are involved in an incident and not to disturb the scene of the incident in any way 4. Task observations are done on train personnel. 5. Proper hand over from the train manager to RIC are explained to all train managers on PRASA trains.

4.	4 October 2015.	Investigation report into the circumstances surrounding the collision of a mlps train 47014 and a private motor vehicle where the driver of the motor vehicle had minor injuries, at a level crossing situated at kmp 34 mast pole 1at the Reeston crossing at approximately 09:35 on sunday,4 October 2015.	At kmp 34 Mast pole 1at the Reeston crossing	1 person- minor injury.	The driver of the road vehicle failed to stop at the level crossing that is protected by stop signs, flashing lights and cross arms until the train had traversed over the level crossing	Driver of the road vehicle failed to stop at the level crossing that is protected by stop signs, flashing lights and cross arms. Intolerance/ Impatient	1. A level crossing awareness to be conducted. 2. Infra to investigate the possibility of installing cameras at the level crossing to observe traffic offenders. 3. Infra to investigate the possibility of speed ripples to be constructed on either side of the level crossing to slow down approaching traffic.
5.	4 May 2016	Formal line investigation investigating the circumstances leading to level crossing accident of train 17005 At Arriston on 04 May 2016	Klerksdorp and Orkney mainline	None	Lorry driver failed to stop at the stop signat the level crossing	Not adhering to traffic signs	1. Infra has to look at options that the booms and flashing lights are working in this abnormal situation. 2. Road sign and whistle board to be erected 3. Road markings to be reported.
6.	30 May 2016	Investigation report into the ci cumstances surrounding the level	Kmp 88 mast poles 10 - 11 between	None	The driver of the road vehicle failed to wait	1. Driver of the road vehicle	1. Communication and Media should engage with the local community via print media and/ or distribute flyers to

		Crossing incident of a Mlps train number 74013 and a Toyota motor vehicle where there were no injuries, at a public level crossing situated at kmp 88 mast poles 10 - 11 between Skietfontein – Bowkers park at approximately 08:30 on Monday, 30 May 2016	Skietfontein – Bowkers Park		clear of the level crossing before pushing his vehicle over the Level Crossing that is protected by Level crossing warning boards, stop demarcation on the tar road, stop signs and cross arms until the train had traversed over the level crossing.	failed to wait clear of the level crossing before pushing his vehicle over the level crossing that is protected by level crossing warning boards, stop demarcation on the tar road, stop signs and cross arms. Intolerance / inpatients.	the community, schools and the local post office boxes, making the community aware of the inherent dangers associated with the level crossings. 2. All locomotives are to blow their hooters at the Lesseyton Level Crossing starting at the first whistle board for three seconds and then from halfway between the first and second whistle boards continuously until the leading locomotive is clear over the level crossing. A notice is to be put out to the MLPS and TFR train crew against signature. 3. No drug testing was carried out after the incident.

7.	14th February 2017	Investigation report Into the circumstances surrounding the level crossing incident collision at Witbank level crossing of train 78091 at km/p 114/10 at approximately 07:05 on Tuesday, 14th February 2017.	Witbank Level crossing at km/p 114/10	Three persons- minor injuries.	The motor vehicle driver overtook the vehicles which were already standing at the level crossing.	The motor vehicle driver did not adhere to road signs.	1. Levelling of the level crossing. 2. Enquire about the advertising process in the Witbank news to publish flyers as a form of awareness. 3. Traffic officials to be visible at the level crossing during peak hours. 4. Billboards to be erected before approaching the level crossing. 5. Faded markings to be re-painted.
8.	24 May 2017	Formal line investigation investigating the circumstances leading to the level crossing accident of train 17005 At Kanana on 24 May 2017	Lava and Orkney at kilometer point 14.12	One Person- minor mnjury.	The vehicle driver drove onto the railway line and stopped in front of the train.	Negligence by the driver of the vehicle by not adhering to the road regulations.	1. 1.Backup-Batteries to be replaced (To get booms working). 2. Road markings to be upgraded- pained

9.	4 January 2018	The report of a formal joint board of inquiry which investigated the circumstances that led to the collision between a Shosholoza Meyl train no. 37012 and a trailer of a third-party mechanical truck loaded with soya beans, registration number JWC868 NW at a level crossing between Geneva and Bosrand stations at or near kilometre point 21 and mast pole 14 ("kmp 21/14"), in the Free State province, at approximately 08:46 o n Thursday, January 2018 which caused 24 fatalities and approximately 260 injuries to train passengers.	Kilometre Point 21 And mast pole 14 ("kmp 21/14"),	24 Fatalities 260 persons-injuries	Driver failed to stop the truck at the stop sign and drove into the level crossing when it was unsafe to do so.	Driver ignored the locomotive's whistle, failed to observe. and obey the advance road warning signs.	1. Conduct public awareness campaign at the Geneva level crossing. 2. Consider nationwide electronic and print media campaign. 3. Cut the overgrown vegetation on the North- Eastern side of the level crossing. TFR, PRASA and other stakeholders should conduct a Post-accident risk assessment to determine the adequacy of the level crossing protection. 4. 4.TFR and local road authority should improve the road surface at the level crossing and the turning angel on the south- western side to enable trucks with trailers to complete their maneuver over the level crossing through a straight movement, before making a turn. This is likely to enable trucks to pass over the level crossing much quicker. 5. Conduct physical level crossing assessment in line with SANS. 6. Implement effective substance abuse testing program. 7. Sensitise all involved on the spirit of the contents and expectations of the interface agreement entered between TFR and PRASA.

10.	07 June 2018	On 07 June 2018 at approximately 10:27 while MLPS Train 74013 was proceeding over the level crossing at kilometer 14 mast pole 08 a white Isuzu bakkie KB250 LE registration number DNV 591EC drove into the side of the leading locomotive (E7082) of the passenger train.	Kilometer 14 mast pole 08 Molteno Crossing.	Four Persons- minor injuries.	The driver of the road vehicle failed to stop at the level crossing that is protected by stop signs and cross arms until the MLPS train 74013 had traversed the level crossing. Intolerance / Inpatients.	The driver of the road vehicle failed to stop at the level crossing that is protected by stop signs and cross arms until the MLPS Train 74013 had traversed the level crossing. Intolerance / Inpatients.	1. The Fftness for duty process to be put in place by MLPS. 2. The river of the bakkie did not adhere to the Road Traffic Act. Level crossing awareness to be conducted. 3. Joint risk assessment between TFR and MLPS to be done. 4. No speed monitoring is being carried out on MLPS. A speed monitoring plan is to be put in place and by MLPS.

11.	15 February 2019	Report of the joint (Transnet Freight Rail/ PRASA) board of inquiry that investigated the level crossing collision between passenger train no. 17007 (Premier Classe) and a white isuzu bakkie, with registration numberCW, at kilometer point 55,969 situated between Sandhills and Orchards, north of Worcester, at approximately 14:14 on Friday, 15 February 2019 resulting in two) passengers being fatally injured and five others injured and hospitalised	At kilometer point 55,969 situated between Sandhills and Orchards,	3-Fatalities 4-Multiple injuries.	The level crossing collision was caused by the fact that the driver of the bakkie failed to stop and observe the oncoming train before crossing over the railway line.	The root cause thereof could not be determined as the driver of the bakkie was deceased.	1. Conduct joint level crossing awareness. 2. Engage the local municipality to re-paint faded GM7 (stop wording) and RTM1 (stop line) at the level crossing. 3. Conduct physical assessment in line with the requirements of the latest level crossing standard (SANS 3000-2-2-1:2012).

8.2 RSR ADHOC LEVEL CROSSING INVESTIGATION REPORTS SUMMARY (2009 to 2018)

No.	Occurrence Date	Report Description	Location	Injuries and Fatalities	Immediate Cause	Root Cause	Core Recommendations
1.	9 September 2009	Report of the investigation into the circumstances which led to the level crossing accident at Distell on the Stellenbosch-Vlottenburg line on 9 September 2009	Distell on the Stellenbosch-Vlottenburg (27.193km)	Two-persons fatal.	None mentioned in the report.	Sub-standard road user behavior in that the driver of the road vehicle did not abide by the level crossing signage and proceeded to cross the level crossing in front of the advancing train.	1. The signal apparatus cabinets which create visual obstruction should be repositioned. 2. The relevant Road Authority should be requested to repaint the road markings and reinstate the rumble strips. 3. The road reserve fence should be reinstated. 4. All Metrorail level crossings in the Western Cape should be inspected for visual obstructions, signage etc. and repairs should be carried out where necessary. 5. The road layout at this level crossing should be re- engineered to reduce the risk of visual obstruction of oncoming trains being created by vehicles using the side road to Distell adjacent to the crossing. 6. Long term development of the Distell 7. complex should be discussed with Distell 8. with a view to mitigating the future road -rail 9. interface risks possibly including the closing of one of the level crossings.

2.	2 March 2010.	Ad hoc Investigation -level crossing accident at Mogwase (Rustenburg- Northam) on 2 March 2010 in-volving train, no 8844 and vehicle DRH 366 NW	On the railway line between Rustenburg and Northam at the Mogwase township.	Seven-Persons Fatal Two-Persons Injured	The driver of the road vehicle did not stop at a safe distance from the railway line to allow train number 8844to cross the road without hitting the vehicle.	Sub-standard maintenance to the Toyota Venture in that the vehicle's brakes were inadequate.	1. The road next to the railway line at the level crossing should be repaired. 2. Road markings to be added on the road at the level crossing. 3. Road signage and road markings should be maintained to a proper standard as laid down in the South African Road Traffic Signs Manual for the level crossing.

3.	04 October 2012	Level crossing Investigation in Boshoek, North West Province	Boshoek level crossing.	Nine Persons Injured	The driver of the vehicle contravened the rules of the road by attempting to overtake the stationary truck that had stopped at a crossing resulting in the collision with the train.	The root cause of this incident was attributed to vehicle driver behavior.	1. TFR and all the role players to co duct a level crossing assessment (physical assessment and risk assessment) as per the level crossing standard (SANS 3000-2-2-1:2012) in order to ascertain the adequacy of the present controls and to determine if there are more controls that should be afforded to the level crossing. 2. TFR and all the role players to conduct on- going public level crossing awareness campaigns with t h e aim of highlighting dangers associated with the railway crossings.
4.	05 November 2013	Sasolburg level crossing accident	Sasolburg level crossing	None	Failure by the driver of the vehicle to obey the level-crossing signage.	The root cause for this accident could not be determined.	1. Sasol and all the role players must without delay conduct a level crossing assessment (risk assessment) using the level crossing standard as guidance, to establish the adequacy and efficiency of the present controls. Should the assessment determine that more controls are necessary, that needs to be implemented without further delay. 2. Sasol to ensure that whistle board are erected at the correct distances as per the standard.

							3. TFR to ensure that all the drivers at the Sasolburg depot follow the same procedure. If the normal working procedure is that train must stop before the level crossing, then all trains must stop, and if the procedure says no stopping, then no train should stop. This should limit the confusion to road users of certain trains stopping and others not. 4. The network operator (Sasol) must engage road authorities to repaint the road markings at the level crossing. 5. The network operator (Sasol) must engage road authorities to look at the possibility of introducing traffic calming measures (speed humps) on both sides of the level crossing.
5.	25 January 2014	Tabak-Bleskop level crossing accident	Bleskop level crossing	Two-persons fatal.	Failure by the driver of the vehicle to obey the level- crossing signage.	The root cause for this accident could not be determined.	1. TFR and all the role players must without delay conduct a level crossing assessment (risk assessment) using the level crossing standard as guidance, to establish the adequacy and efficiency of the present controls. Should the assessment determine that more controls are necessary, that needs to be implemented without further delay. 2. TFR must engage road authorities to repaint the road markings at the level crossing. 3. The tree that is obstructing the level crossing sign needs removed. 4. TFR to engage with the relevant authorities to reposition the Anglo- American direction/guide sign in such a way that it does not obstruct motorists' view of oncoming trains.

6.	17 January 2015	Bergkelder level crossing investigation	Bergkelder level crossing in Stellenbosch	One-person fatal. Two -persons seriously injured.	Failure by the motor vehicle driver to observe all the road signage and stop at the level crossing.	Failure by PRASA management to have a plan of how to protect the level crossing when the boom gates have failed. This is with the understanding that the risks increase when the booms are locked in the upright position.	1. PRASA together with all the role players (including road authorities) must without delay conduct a level crossing assessment (risk assessment) using the level crossing standard as guidance, to establish the adequacy and efficiency of the present controls. Special emphasis must be put on identifying the risks when the boom gates are inoperative. Should the assessment determine that more controls are necessary, that needs to be implemented without further delay. 2. When the booms are inoperative PRASA to ensure that a flagman is deployed to the level crossing at all times. This must be implemented with immediate effect. 3. PRASA should conduct regular level crossing safety awareness campaigns, with specific focus to the communities that live in the areas along the Muldersvlei-Cape Town line. 4. PRASA to engage the relevant parties with the view of cutting all the trees that obstruct the view of motorists.

7.	29 June 2015	IMPALA Luka level crossing occurrence	IMPALA Platinum -Luka level crossing	None	Failure by the car driver to observe and obey all the road signage and stop at the level crossing.	Failure of road users and motorists to follow and observe level crossing warning signs, road signs and to pay attention when approaching rail crossings. The motorists' failure to take sufficient care or action was the major cause. This is largely attributable to inattention and driver distraction, risk taking and disobeying, as well as a lack of knowledge of the road rules	1. IMPALA together with all the role players must without delay conduct a level crossing assessment and risk assessment utilising the level crossing standard SANS 3000:2-2-1:2012, a s a guide, to establish the adequacy and effectiveness of the present controls. The focus should be on the level of the protection required as per classification in the level crossing level of protection as stipulated in the standard. 2. IMPALA should partner with the road traffic authorities and initiate regular enforcement operations at Luka level crossing and other high- risk level crossings. They should also encourage and instill the culture of reporting bad driving and hazardous situations at the level crossing. 3. IMPALA should engage road traffic authorities and together they should conduct regular level crossing Safety awareness campaigns, with specific focus to the communities that live in the areas along the Phokeng area.

							4. IMPALA should consider moving the Speed humps (traffic calming measures) at Luka level crossing backwards before reaching the Stop sign to allow motorists to reduce speed and stop way before the level crossing. This will enable to motorists enough time to observe the level crossing and react accordingly, in accordance with the Speed hump Regulation 319 of the National Road Traffic Regulations. 5. IMPALA management to develop an Employee Assistance Program and develop a formal procedure to refer employees that have been involved in incidents for counselling and/or evaluation for fitness for duty. 6. IMPALA management to develop a Return- to-work procedure following an incident. The return-to-work procedure should include the counselling and/ or evaluation from the EAP to ensure that employees are fit for duty after an incident.

							7. IMPALA management to ensure that the substance abuse testing is conducted immediately after an incident. 8. IMPALA management to ensure that the substance abuse testing after an incident includes drug testing conducted at a medical facility for all employees involved in the incident, as per the requirements of SANS 3000-4. 9. IMPALA management to review the loco driver task observations to be more comprehensive and to incorporate all their relevant tasks and immediate corrective action in the case of any transgressions. Task observations must be conducted at intervals not exceeding 30 days as stipulated in SANS 3000-4.
8.	07 July 2015	Magogong level crossing collision	Between Hartswater and Magogong level crossing at kilometer 42 mast poles 15 (km/p 42/15)	Three-Persons Fatal.	The driver failed to stop his vehicle at the stop, sign at the level crossing and wait for the oncoming train to pass and clear the level cross-ing.	The root cause could not be determined.	1. TFR must conduct a public level crossing 2. awareness on the inherent risks associated with railway operations from Taung to Hartwater. 3. TFR must conduct a risk assessment in this level crossing in accordance with clause 6 of SANS 3000-2-2-1 (the Network Operator and Road Authority conduct a level crossing risk assessment on existing level crossing, to identify hazards associated with such level crossing arising from railway traffic; road traffic; the rail network; the road layout and condition; adjoining property and geographical considerations). TFR must ensure that stop wording markings on the tar road are visible 4. TFR must ensure that physical assessment is conducted at the level crossing after the collision in accordance with clause 5.2. (b) of the level crossing standard (SANS 3000-2-2-1:2012) after the collision which resulted in a fatality.

							5. TFR must ensure that trains reduce their speed to 30km/h when approaching level crossing between Taung and Hartswater. Train drivers travelling in the section between Taung and Hartswater must be made aware of the fact that trucks with more than 24m in length coming from the farms side will not be able to clear the rail line when approaching the stop sign on the main road. TFR must have an engagement meeting with all the farmers next to level crossing between Taung and Hartswater to make the truck drivers leaving their farms aware of the danger of the level crossing and the fact that the truck will not clear the crossing when it stops on the second stop sign of the main road coming from the Farm side. TFR must ensure that there is a board that will warn the truck driver about the clearance from the level crossing. 6. TFR must ensure that they comply with SANS 3000-4:2011, clause 6.2.7.1(b) “the operator shall implement and maintain a management information system that shall include safety (risk) profile data that contain occurrences, operational restrictions, finding from boards of inquiry, work attendance records and fitness-for-duty outcomes”.

							7. TFR must ensure that supervisors are trained on how to conduct risk profiles for their employees 8. TFR must ensure that all level crossings is opened every two years to check if fastening are still intact. 9. TFR must ensure that all their locomotives are fitted with a black box and that the system is working properly 10. TFR must ensure that health assessments are scheduled and conducted on return to work following absenteeism (Note: Return to work process is part of the attendance management strategy and should include the period after which interventions are implemented for health assessments) as per SANS 3000-4:2011 clause 6.3.6.3 (f).

9.	29 January 2016	The collision between train no 7406 and the tractor at the Nolte and Buckingham level crossing.	Nolte and Buckingham level crossing	One-person fatal	The immediate cause of the occurrence was determined to be that the driver of the tractor failed to stop at the stop sign	The root cause of the occurrence could not be determined.	1. TFR to conduct a risk assessment on the level crossing. 2. TFR must ensure that the vegetation at the level crossing is cut to ensure that the sight distance is not obscured. 3. TFR to ensure that the substance abuse is conducted immediately after the incident and that the manager who attends the site must also ensure that they have working equipment. 4. TFR must conduct safety campaign to sensitise the farmers and their employees about the dangers of the level crossings. 5. TFR must ensure that the blocks on the level crossing are even to accommodate all the vehicles.

10.	19 March 2016	The collision between train no 1282 and the private vehicle at the Moorresburg level crossing	Moorresburg level crossing.	One-person injured.	The driver of the vehicle failed to stop at the stop sign.	The root cause could not be determined. Contributory cause-. the level crossing was protected on one side only.	1. TFR must conduct a risk assessment on the level crossing to establish ifthe protection afforded is sufficient. The risk assessment should include the footpath for the pedestrians thus the assessment reveals that the path is needed, the relevant stakeholders must be engaged. 2. TFR must ensure that during shunting, the level crossing is protected on both sides. 3. TFR must be clear on what should be done following an occurrence with regards to the removal of train crew. It must not be left to the discretion of the train crew to decide whether they can continue with their duties or not. 4. TFR must ensure that the drug test is conducted as stipulated in SANS 3000-4:2011. 5. TFR must intensify their safety awareness by visiting the schools in the area, and sensitize the pupils on the dangers of the train.
11.	19 March 2016	The collision between train no. 3516 and the motor vehicle at the Muldersvlei level crossing	Muldersvlei level crossing	Motor vehicle occupants sustained minor injuries.	The driver of the vehicle failed to stop and wait for the oncoming train to pass and clear the level crossing.	The root cause could not be determined.	1. TFR must ensure that the track is maintained according to the manual for track maintenance. 2. Regular safety campaigns or awareness campaigns must be conducted at the level crossing to sensitize the road user of the danger of not adhering to the road sign when approaching level crossing. 3. TFR must ensure they must clean the drainage and also to consider replacing the existing culverts with the bigger ones.

							4. Testing for substance abuse should be conducted post occurrence asrequired in SANS 3000-4:2011. Testing for abuse should include alcohol, illegal and legal drugs. 5. PRASA should ensure that the train crew is relieved of their duties immediately after an incident. 6. TFR must ensure that all signage is erected in according with the standard. 7. TFR must remove one speed restriction board in the section and put the correct one in order not to confuse the train driver.
12.	20 May 2016	The collision between train no 8420 and the bakkie at Beerspruit level crossing	Beerspruit level crossing in Limpopo Province	One1-Person Injured.	The immediate cause of the occurrence was determined to be that the driver of the bakkie failed to stop at the stop sign.	The root cause of the occurrence could not be determined. The contributing cause of the occurrence could be determined to be that the sight distance from the direction where the bakkie was coming from is obscured by overgrown trees.	1. TFR must engage with the owner of the guesthouse about conducting a safety awareness for the guesthouse clients and the employees about the dangers of not adhering to the road signage at the level crossing. 2. TFR must conduct a risk assessment on the level crossing. 3. TFR must engage with the owner of the guesthouse to trim the grown trees to ensure the safety of all the level crossing users.

13.	29 May 2016	The collision between train no 1106 and the tractor at the Level Crossing between Dalton and Jaagbaan	Level Crossing between Dalton and Jaagbaan	One-Person injured	The immediate cause of the occurrence was determined to be that the driver of the tractor failed to stop at the stop sign.	The root cause of the occurrence could not be determined. The contributing cause of the occurrence is determined to be that the level crossing visibility is non- existent at the crossing because of the sugar cane that was grown	1. TFR must conduct safety campaigns to sensitise the farmers and their employees about the dangers of not adhering to the road signage at the level crossing. 2. TFR must engage with the farmer to clear off the reserve to ensure the safety of all the users. 3. TFR must conduct a risk assessment on the level crossing.

14.	19 August 2016	Letsitele level crossing investigation	Letsitele and Lethaba at km 105/16	Three-persons serious injured Nine-minor injuries	The motorist failed to obey the stop sign and attempted to surpass the motor trolley on the level crossing	Inadequate traffic law enforcement interventions at the level crossing	1. TFR and all the role players must without delay conduct a level crossing risk assessment using the level crossing standard as guidance, to establish the adequacy and efficiency of the present controls. Should the assessment determine that more controls are necessary, these should be implemented immediately. 2. TFR must, after performing level crossing risk assessments, conduct safety awareness campaigns in the local communities and surrounding areas to highlight the dangers of trains at Level crossings. 3. TFR must engage the local municipality to repaint the faded road markings and ensure that the road markings are regularly maintained on the level crossing. 4. The relevant department within TFR Tzaneen depot must ensure that they conduct regular vegetation control on and around the level crossing to improve the sight distances. 5. The local road traffic authorities must intensify traffic law enforcement at all level crossings.

15.	13 September 2016	The collision between train no.005 and the bus at East/West level crossing	East/West level crossing in Amandelbult mine.	The bus occupants sustained injuries and were taken to hospital.	The immediate cause of the occurrence was determined to be that the driver of the bus failed to stop at the stop sign.	The root cause of the occurrence could not be determined. The contributing cause of the occurrence could be determined to be that the sight distance from the direction where the bus was coming from was obscured.	1. 1.Amandelbult mine in conjunction with the bus service providers must conduct the safety awareness about the dangers of not adhering to the road signage at the level crossing. 2. Amandelbult mine must trim the grown trees and cut the shrubs to improve the sight distances. 3. Amandelbult mine must ensure that the concrete blocks on the level crossing are replaced. 4. Amandelbult mine must ensure that substance abuse testing is conducted immediately after an incident as per the Human Factor Standard: SANS3000-4: 2011. 5. Amandelbult mine must ensure that testing of substance abuse before duty commences is conducted as part of the fitness for duty, as per the Human Factor Standard: SANS 3000-4: 2011

16.	14 September 2016	Goudeon level crossing collision	Goudeon level crossing, km/p 08/08	One-person fatal.	The vehicle driver failed to observe the signage at Goudeon level crossing when he overtook three vehicles at the stop sign.	The following root causes were identified: Non-compliance by the vehicle drivers to observe level crossing signage and Inadequate enforcement of level crossing rules to vehicle drivers by the Road Traffic authority. Contributory causes were identified:	1. 1.TFR management must conduct a level crossing awareness campaign. The campaign should include all the relevant stakeholders including the municipality traffic police. 2. TFR management must engage the municipality regarding the informal taxi rank near Goudeon level crossing that may be causing an obstruction to the motorists approaching the level crossing. 3. TFR management must evaluate the current level of protection at the level crossing and improve the existing controls in accordance with the level crossing assessment and as stipulated in SANS 3000-2-2-1 Clause 5, 6 and 7. 4. TFR perway management must engage with the municipality to ensure that the poor road surfaces, broken concrete blocks and faded road markings observed at the level crossing are corrected.

						Unsafe conditions: track conditions, poor road surfaces and faded road markings. An increase of road traffic using the level crossing due to a new residential development in Protea.	5. .Grown vegetation and trees blocking the view of the level crossing must be cleared. 6. PRASA management must ensure compliance to the Train Working Rules by enforcing compliance and refrain from allowing trains with defective critical safety systems such as the hooter to run. 7. PRASA must submit a plan to the RSR detailing plans to fill the vacancies at Randfontein depot. 8. PRASA management must monitor and ensure the EAP procedure is such that train crew involved in occurrences can be attended to without delay and that they are immediately assisted.
17.	23 September 2016	Pienaarspoort level crossing collision	Pienaarspoort level crossing	One-person fatal.	The vehicle driver failed to adhere to the level crossing signage and attempted to drive at a high speed through the level crossing while the train was coming.	Lack of law enforcement to the road traffic users at the level crossing.	1. TFR must engage with Road Authorities to enforce compliance to level crossing signage by road users. 2. TFR in-conjunction with PRASA and Road Authorities must conduct a level crossing risk assessment for determination of the level of controls required to mitigate the risks to acceptable levels.

18.	18 May 2017	The collision between Train No. 0993 and the private vehicle at the Millsite level crossing.	Millsite level crossing in Gauteng	One-person severe injuries	The vehicle driver failed to observe the signage at the level crossing.	Non-compliance by the vehicle drivers to observe level crossing signage.	1. PRASA management should conduct a level crossing awareness campaign. The campaign should include all the relevant stakeholders. 2. Train crew should protect the train as required by TWR clause (11007.0)). 3. All relevant stakeholders must form part of risk assessment. PRASA should conduct risk assessment at the level crossing as per the requirement of the standard SANS3000-2-2-1). 4. PRASA must ensure that the drainage system is at the crossing is regularly cleaned. 5. PRASA must ensure that the boom gates maintenance records are up to date for and that are recorded in a language that all employees responsible for boom gate maintenance can understand as per PRASA language policy. 6. PRASA must review and consider upgrading the booms to cover the full length of the road lane.

19.	25 May 2017	Swartruggens level crossing investigation	Located between Swartruggens and Twyfelspoort.	One-person fatal.	The motorist failed to obey the stop signs and attempted to surpass the train on the level crossing.	The contributory factor identified was: Inadequate traffic law enforcement interventions at the level crossing.	1. TFR and all the role players must conduct a level crossing risk assessment using the level crossing standard as guidance, to establish the adequacy and efficiency of the present controls. Should the assessment determine that more controls are necessary, these should be implemented without delay. 2. TFR must conduct awareness or induction sessions with all contractors that conduct work on and around the railway lines to highlight the dangers of trains. This includes level crossings. 3. The relevant department within TFR must ensure that they conduct regular vegetation control on and around the level crossing to improve the sight distances. Also remove all the old sleepers left after maintenance work.

20.	03 June 2017	Sandfontein level crossing collision	Sandfontein level crossing km/p km 176.435	One-person fatal. One-erson minor injuries	The vehicle driver failed to observe the road and level crossing signage at Sandfontein level crossing when he failed to stop his vehicle at the stop sign, crossed the rail and collided with the train.	Non-compliance by the vehicle drivers to observe the road and level crossing signage and inadequate enforcement by the Traffic police. The following contributory causes were identified: 1.Unsafe Conditions: Poor road surfaces, faded road markings and potholes. 2.Unsafe conditions: speed humps erected too close to the rail crating an additional hazards.	1. TFR management must engage the municipality and law enforcement officers to jointly conduct regular level crossing awareness and to enforce compliance to the road and level crossing signage. 2. TFR management must ensure that the vegetation at the Sandfontein level crossing is maintained to always ensure that visibility clear is for the vehicles. 3. TFR management must evaluate the current level of protection at the level crossing and improve the existing controls in accordance with the level crossing assessment and risk assessment. 4. TFR management must ensure that the two speed humps erected close to the rail are removed immediately since they create an additional hazard. However, the speedhumps may be constructed in a manner that all the necessary safety measures are observed. 5. TFR management must engage with the municipality to ensure that the poor road surfaces, damaged road edges and faded road markings observed at the level crossing are corrected.

21.	04 August 2017	Investigation into Ariston level crossing collision where train No. 7203 loaded with lime collided with a motor vehicle	Ariston level crossing in Klerksdorp	None	The immediate cause of the occurrence was determined to be that the driver of the vehicle failed to stop at the stop sign.	The root cause of the occurrence was determined to be lack of traffic law enforcement.	1. TFR management must intensify level crossing awareness campaign. The campaign should include all the relevant stakeholders including the municipality traffic police. 2. TFR must engage the owners of the plot to trim the overgrown trees and the relevant department in TFR must trim the vegetation on the service road that is obscuring the sight view. 3. TFR must ensure that the level of protection in the form of flashing lights and booms is restored and functional. 4. TFR should also engage the local municipality to install traffic calming measures for additional protection. 5. Substance abuse testing should be conducted immediately post occurrence (clauses 6.4.9.2 and 6.9.5.3 of SANS 3000-4:2011). Substance abuse testing should include testing alcohol, chronic substance abuse, as well as illegal and legal drugs. 6. TFR must ensure that the train crew is relieved of their duties immediately after an incident as per SANS 3000-4:2011.

22.	29 September 2017	Rasimone level crossing	Rasimone level crossing in Rustenburg	Two-persons fatal.	The vehicle driver failed to observe the signage at Rasimone level crossing.	The contributory cause identified was: The lack of traffic law enforcement.	1. TFR management must intensify level crossing awareness campaign. The campaign should include all the relevant stakeholders including the municipality traffic police. 2. TFR must trim the vegetation in the vicinity of the level crossing to improve the visibility. 3. TFR must conduct a traffic count to establish if the level of protection at the level crossing is sufficient. And if the level of protection is not sufficient according to the traffic count it must be upgraded immediately. 4. TFR in conjunction with the local municipality to establish a service level agreement as to ensure that the road markings are always visible, fix signage and to restore the rumble strips.

23.	14 April 2018	The collision between Train No. 5906 and a private vehicle at the Groutville level crossing at kilometer point 113/435 in KwaZulu-Natal.	Groutville level crossing at kilometer point 113/435	One-person fatal.	The vehicle driver failed to observe the stop sign at the level crossing.	Non-compliance by the vehicle drivers to observe level crossing signage. Contributing factors a) The topography of the level crossing influenced the behavior of the road users. The obstructed view caused by the overly grown vegetation and the ballast stockpile created a scenario where road users cannot easily see the locomotive when stopping at the stop sign. b) The road users adopted a behavior of stopping over the first line on the level crossing in order to get a clear view of an incoming train.	1. TFR management should conduct a level crossing awareness campaign. The campaign should include all the relevant stakeholders. 2. Train crew must protect the train as required by TWR clause (11007.0)). 3. TFR must ensure that the overly grown vegetation is always cut and maintained short in all level crossings to ensure clear visibility of the oncoming trains and signage. 4. TFR should conduct or implement disciplinary 5. actions against train driver's behavior that fail to adhere to the train working rules 9007.11.2.2 at the level crossing.TFR must ensure that the drainage system at the level crossing is regularly cleaned and maintenance must be conducted. 6. TFR must conduct and submit the level crossing risk assessment to the RSR when complete. 7. TFR must intensify community awareness for the dangers at level crossing. It is recommended that awareness campaigns should be conducted at the schools in the area to sensitise the pupils of the dangers of trains. 8. The TFR management need to ensure that the speed monitoring is executed effectively. 9. Management must conduct safety briefings and/talks before the commencement of every shift. Furthermore, TFR should implement and adopt a safety culture to enforce train working rules for when approaching level crossings. Training of the training working rules should be conducted for all the train drivers.

24.	12 May 2018	Vlakdrif Level crossing collision	Vlakdrif level crossing kmp 41/13 -14	4-Persons Fatal. 1-Person Injured	The vehicle driver failed to observe the road and level crossing signage at Vlakdrif level crossing when he did not stop his vehicle at the STOP sign and collided with the train 3018.	Non-compliance by the vehicle drivers to observe the road and level crossing signage Inadequate enforcement by the Traffic police.	1. TFR management must engage the municipality and law enforcement officers to jointly conduct regular level crossing awareness and to enforce compliance to the road and level crossing signage by vehicle drivers. 2. TFR management must ensure that the vegetation control at the Vlakdrif level crossing is executed as required to always ensure visibility for the train and vehicle drivers. 3. TFR management must evaluate the current level of protection at the level crossing and improve the existing controls in accordance with the level crossing assessment and risk assessment. 4. TFR management must engage with the municipality to ensure that the poor road surface conditions, the damaged road edges, flattened rumble strips and faded road markings observed at the level crossing are corrected with immediate effect.

25.	19 June 2018	Brits level crossing investigation	Brits level crossing. Marikana to Pyramid South.	None	The immediate cause for this incident was attributed to the failure to obey the level-crossing signage by the truck driver.	The root cause was the inadequate traffic law enforcement interventions at the level crossing; and the inappropriate behavior by motorists at the level crossing.	1. .TFR and all the role players must without delay conduct a level crossing risk assessment using the level crossing standard as guidance, to establish the adequacy and efficiency of the present controls. Should the assessment determine that more controls are necessary, these should be implemented immediately. 2. TFR must conduct safety awareness campaigns at Brits and in the surrounding communities/areas. These campaigns need to be conducted periodically at intervals appropriate for the conditions and risks the level crossing 3. TFR must engage the local municipality to repaint the faded road markings and repair the un-down rumble strips. 4. TFR to reposition the speed hump which is too close to the stop sign.
26.	12 August 2018	Mamreweg level crossing collision, between a motor vehicle and train 1282.	Mamreweg level crossing	Five-persons injured.	The motor vehicle driver was driving at night on a rainy weather and collided with train 1282 at Mamreweg level crossing	The motor vehicle driver failed to adhere to the level crossing signage at Mamreweg level crossing. Contributing factors: The two train drivers changed trains whilst part of wagons of train 1282 were still occupying Mamreweg level crossing.	1. TFR must revise their safe operating procedure for exchanging trains at Mamreweg as it is posing risk to the railway operations. 2. TFR must put measures in place to lighting at the crossing for the safe of the level crossing users. 3. TFR must review and monitor existing controls to prevent or reduce the risk of recurrence at Mamreweg level crossing.

8.3 RESULTS OF INVESTIGATION REPORT ANALYSIS

Based on the analysis of the both the TRANSNET/PRASA and RSR Investigation Reports the following can be concluded.

Prasa &transnet investigation reports immediate & root cause analyses results

Level crossing accident aause.	Description of level crossing accident cause.	Number of reports that reflect this finding.	Percentage of total findings	Total number of Investigation reports.
Immediate cause	The Driver of the road vehicle failed to stop at the crossing	11	100%	11
Root cause	The driver of the road vehicle failed to stop at the crossing/non-adherence to road signage/road regulations.	10	91%	
	Root cause could not be determined.	1	9%	

RSR adhoc level crossing investigation reports immediate & root cause analyses results

Level crossing accident cause.	Description of level crossing accident cause.	Number of reports that reflect this finding.	Percentage of total findings	Total number of investigation reports.
Immediate cause	The driver of the road vehicle failed to stop at the cross-ing/failure to obey level crossing signage.	23	88%	26
	Attempting to over-take Stationary vehicle that stopped at the level crossing	1	4%	
	The driver of the road vehicle was driv-ing at night/rainy weather collided with train	1	4%	
	None mentioned in the report.	1	4%	

Root cause	The driver of the road vehicle failed to stop at the crossing/non-adherence to road signage	9	34.5%	
	Lack of/inadequate enforcement by the Traffic Police	6	23%	
	Sub-standard vehicle maintenance (Brakes)	1	4%	
	Failure to have fall back plan when boom gates failed	1	4%	
	Root cause could not be determined.	9	34.5%	

8.3.2 Immediate and root cause analyses findings based on the overall analyses of the results.

Based on the analyses of the immediate causes of level crossing accidents it can be concluded that the major immediate cause of level crossing accidents within the South African context is, 'The driver of the road vehicle failing to stop at the crossing/failure to obey level crossing signage'. As indicated in the tables above this is the finding of the immediate cause of level crossing accidents in 100 per cent of the investigations done by PRASA/ TRANSNET and 88 per cent of the ad-hoc investigations done by the RSR for the period 2009 to 2019.

In the case of the investigations done by PRASA/TRANSNET to establish the root cause of level crossing accidents over the same period the major root cause determined was, 'The driver of the road vehicle failed to stop at the crossing/non-adherence to road signage/road regulations.' In 91 per cent of the findings whilst in the case of the RSR ad-hoc investigations 34.5 per cent of the root cause is attributed to, 'The driver of the road vehicle failed to stop at the crossing/non-adherence to road signage' and 23 per cent attributed to, 'Lack of/inadequate enforcement by the Traffic Police'. A total of 34.5 per cent of the RSR ad-hoc investigation have a finding whereby the root cause could not be determined.

Based on the findings above it is noted that the proposed solutions to address the problem of a high number of level crossing accidents should be focused on the following:

a) Addressing the unsafe behaviour of the driver of the road vehicle,
b) And/or alternatively physically preventing the driver of the road vehicle from entering the danger zone by providing adequate protection against this unsafe behaviour ,and
c) Eliminating the risk (Closing the level crossing by constructing a bridge) applicable to high risk level crossings.

8.3.3 Analyses of the core recommendations contained in the level crossing investigation reports.

The analyse of the core recommendations contained in the investigations reports was done for the following reasons:

- It provides a better picture of the possible contributory causes to level crossing accidents, and
- It provides a picture of the common gaps/risks at level crossings that must be addressed.

The table listed below contains the common recommendations contained in the level crossing investigation reports. The risk that these recommendations intent to address has been added as well as the entities that are responsible to address these risks.

No.	Key recommendations	Identified risk	Responsible entity
1.	**Communication and Media:**		
	Involves creating public awareness via print media and/or distribute flyers to the community, schools and the local post office, boxes, making the community/user of the level crossing aware of the inherent dangers associated with the level crossings.	Lack of awareness amongst the users of level crossings (inclusive of Road Vehicle Drivers around the dangers of level crossings)	Network Operator/Train Operator/Road Authority/Local Authority.
2.	**Enforce compliance to level crossing signage**		
	Road authorities to enforce compliance to level crossing signage by road users.	Poor compliance by road user may result in level crossing accidents.	Road authority/Local authority.
3.	**Level crossing maintenance management.**		
	Level crossing physical/risk assessment needs to be conducted in line with SANS 3000-2-2-1.	Level crossing stakeholders not up to date/aware of the latest risks at the level crossing. level crossing cevel of protection not up to date to address increased traffic volumes.	Network operator/ train operator/ road authority/local authority.
	Outstanding rail operator maintenance need to be done at level crossing (example: vegetation control, installing missing whistle boards).	Poor rail side maintenance may result in level crossing accident.	Network operator/ train operator
	Outstanding road authority maintenance need to be done at level crossing	Poor road maintenance may result in level	Road authority/local authority.

	(Example: Faded signage and/or road markings).	crossing accident.	
4.	**Train operations management**		
	Enforcement of operating rules (Example: blowing train hooter and train speed)	Poor train driver discipline may result in level crossing accident.	Network operator/train operator
	Drug testing/substance abuse testing	Train driver under the influence of drugs may cause level crossing accident	Network operator/train operator
5.	**Level crossing/road engineering design.**		
	Redesign level crossing and/or road to address poor sighting distances and/or unsafe layout.	Poorly designed level crossing and/ or road may result in level crossing accident.	Network operator train operator/oad authority/local authority.

9. Solutions to reduce the risk of level crossing accidents

9.1 Elimination of level crossing with unacceptably high level of risk

There is no one single measure for increasing safety at level crossings. The only efficient solution is to separate railway and road traffic in two levels by building overpasses or underpasses. This option is, however, not practical as a general approach because of financial and physical constraints.

In terms of the way forward the only practical solution is a risk based approach that prioritises the most-high risk level crossings for elimination by means of a formalised yearly elimination programme that is funded by all the relevant stakeholders inclusive of the National Government.

Prior to 1992 there was a central fund for the elimination of or improvement to protection levels at level crossing. This was governed by the Level Crossing Act no. 41 of 1960. The reasoning behind the repealing of this Act in 1992 was that all the dangerous level crossings had been eliminated and there was no longer a need for a special fund. The thinking at the time was that all future eliminations or improvement to the protection level at level crossings would be dealt with between the rail operator and the road authority and each party would budget accordingly.

With the establishment of the RSR under the National Department of Transport, there is an opportunity to level the playing fields between the rail operator and the road authority and establish specific principles to be followed about the elimination of dangerous level crossings. This should entail a combined risk evaluation per level crossing on a regular basis and a the introduction of a dedicated elimination fund. The frequency and minimum standard for risk assessments is already contained in the current SANS 3000-2-2-1 Level Crossing Standard. It also contains a recommended funding model.

The re-establishment of the Level Crossing Elimination Fund will assist in the practical application of the model and ease current funding constraints experienced by all the affected stakeholders.

9.2 Educating road users (road vehicle driver and other level crossing users)

Overview

Considering the ongoing research and experience of the systems approach to road safety, the role that road user education, driver training and publicity campaigns play in influencing safe driving behaviour is being re-examined (World Health Organisation, 2004). Motorists tend to choose a certain level of performance that depends on how they wish to cope with the task demanded of them, which makes the distinction between performance and behaviour important in the examination of such road safety interventions (Haid, 2002; Henderson, 1991). The World Health Organization suggests that when used in support of legislation and law enforcement, education, publicity, and training can create shared social norms for safety (World Health Organisation, 2004). There is currently no effective model for the relationships between how people drive and how they learn to do so safely, road safety educational countermeasures must be developed through carefully designed human factors and educational research (Henderson, 1991; Sentinella, 2004), (Wallace et al. 2008).

The use of media

The use of the media for publicity to raise awareness and inform users about the dangers in and around level crossings. This is done in the hope that it will result in a change in attitude and behaviour. There are, however, limitations in terms of evaluating the effectiveness of media campaigns (Wallace et al. 2008).

Educational programmes

This can be achieved through more emphasis on educating road users on level crossing dangers. As a first step, level crossing safety-related education can start at primary school level through the design and implementation of a curriculum that includes teaching youngsters about the dangers in and around the railway environment (inclusive of level crossings) in order create basic awareness. The second step that will assist in the achievement of this educational goal is to broaden the curriculum at driving schools for young drivers to be more aware of the dangers in an around the use of level crossings.

9.3 Enforce compliance to level crossing / road signage

Traditional enforcement methods

This method entails the use of manual/traditional methods such as the issuance of traffic fines as part of the enforcement process. There is a need for a higher level of traditional traffic enforcement within South Africa. This is confirmed by the fact that the road accident numbers on the South African roads are among the highest in the world. A concerted team effort must be made between the relevant rail operators and the affected road authority/local authority to identify high risk level crossings and improve the visibility of traffic officers as well as the enforcement of traffic rules in and around these level crossings. Traffic rules are to be enforced strictly and include the issuing of fines/penalties.

Automated enforcement methods

Automated enforcement entails the use of new technology such as cameras as well as movement/ speed detection equipment that is used to capture images of road users that are breaking traffic laws.

9.4 Level crossing maintenance management.

It is the rail operators' primary responsibility to ensure that the rail network is safe for the passage of trains. For this reason, the responsibility for level crossing maintenance within the rail reserve reside within the domain of the operator. Mandatory maintenance activities linked to the rail operator are as follows:

- Annual level crossing inspections;
- Vegetation control;
- Re-installation of stolen rail signage (example: whistle boards); and
- Maintenance of level crossing blocks.
- The road authorities are responsible for the maintenance of the following level crossing elements:
- Annual road inspections;
- Replacement of missing and/or faded road signage;
- Repainting of faded road-markings; and
- Resurfacing of the road.

The current SANS 3000-2-2-1 level crossing standard recommends that a level crossing physical/risk

Assessment be conducted involving all the relevant stakeholders every five years.

As part of its mandate to oversee safety within the rail environment, the RSR must ensure that the minimum actions mentioned above are executed by the rail operators by means of regular audits and inspections.

The RSR's mandate does not extend beyond the rail operators and for this reason, there are no tools for enforcement when it comes to the road authorities/ local authorities. There is a need for better integration in terms of approach and improved means of enforcement when it comes to the aspect of road authorities/local authorities executing their duties.

9.5 Train operations management.

This element is the responsibility of the train operator since it relates to the management of train drivers. The main activities linked to the train operator are as follows:

- The drafting and updating of train working rules in and around the safe operation of level crossings.
- The communication and training of the train drivers in terms of the application of these rules.
- Strict enforcement of operating rules (example: blowing the train hooter and train speed monitoring).
- Drug testing/substance abuse testing of train drivers. (human factors management

9.6 Level crossing/road engineering design.

Entails the redesign of the level crossing and/or road to address current risk at the level crossing. This aspect entails the following elements:

Upgrading of the level of protection of the level crossing

Upgrading the protection and warning systems at a level crossing for it to be in accordance with the latest SANS 3000-2-2-1 level crossing standard based on the latest risk assessment/physical assessment. In terms of the current level crossing standard a risk assessment/physical assessment must be done at least once every five years at every level crossing as well as immediately after a level crossing accident. Operator compliance to this requirement of the standard must be monitored more closely by the RSR.

Level crossing closure

In Europe and the United States, an advanced form of crossing closure has been tested. The four quadrant gates are designed to close off a crossing entirely so that cars are physically prevented from accessing a crossing when a train is approaching. In addition, sensors on the track can notify an oncoming train whether the track ahead is obstructed. If the driver does not react to the warning, the train's brakes will automatically engage. This is an example of intelligent transport systems (ITS) or positive train control (PTC). The US Department of Transport (2001) reported that quadrant gates reduced the risk of dangerous behaviour around level crossings (Wallace et al. 2008).

Improved awareness of approaching trains

Refers to alerting devices that enhance train conspicuity, thus attracting the motorist attention to increase the likelihood that a motorist will see the approach of a train in sufficient time to safely cross at a level crossing. May include the headlights of the train or lights attached to the side of the locomotive and/or wagons (Wallace et al. 2008).

Sighting distances and obscurity of trains

This aspect refers to the visibility of the train that can be obscured because of the less than desired angle between the road and the railway line. Sight distance can also be affected by buildings and structures next to the road or railway line. Adequate sight distance depends on the speeds of both train and motor vehicle. It has been demonstrated that the risk of a collision is seven times higher when the road is parallel to the tracks and the train is approaching from behind the driver's field of vision (Caird, 2002; Wallace et al., 2008).

Decision-making

According to Tustin (1986) the situation faced by a motorist of any vehicle at a crossing occurs in three areas or zones. Information handling zones are areas of the road that motorists make decisions about the level crossing ahead (Tustin, 1986). The three zones include:

- Approach zone – This zone is the area of the road in which motorists begin to formulate actions needed to avoid colliding with trains. Scanning for trains or signals, recognising any hazards, and deciding the proper course of action are behaviors that motorists use in this zone. The motorist must be aware of the crossing ahead, with information usually provided to the driver by an advance warning sign or pavement markings. The driver must take notice of the crossing through visual observations, control devices or sounds from the train horn (klaxon). Warning systems should be placed in an area that provides sufficient warning to motorists to alter their speed and take appropriate driving action as required on-recovery zone – This zone begins at the point along the road where motorists must decide to stop (after stopping at a 'Stop' sign or giving way at a 'Give Way' sign) if a train is approaching. If the stop / go decision is delayed beyond the beginning of the non-recovery zone, the amount of road remaining will be insufficient to avoid a collision with an oncoming train. The non-recovery zone ends at the beginning of the hazard zone and starts at the stopping sight distance required by the vehicle speed. Proper design and installation of warning systems and control devices will provide most drivers with the information needed to make the decision (in time) to stop if required. Provided with such information, the motorist must operate their vehicle as required by the prevalent conditions (e.g., visibility of an approaching train), (Wallace et al. 2008).

- Hazard zone – This zone is the rectangle formed by the width of the road and distance measured along the road on either side of the tracks. This zone is the area where stopped or approached vehicles are capable of colliding with approaching or stationary trains. The objective of this zone is for the motorist to cross the tracks safely. Obeying warning signals and protection systems is crucial for crossing safely in this zone. (p31-33), (Wallace et al. 2008).

Road surfacing issues

This option refers to improving the quality of the surface on approach to level crossings. The intent is to enable the road user to stop in time based on a good quality road surface since a poor-quality road surface will have the opposite effect (Wallace et al. 2008).

Low-cost warning systems

The idea behind low-cost warning systems is to be able to actively protect more level crossings using less money. This approach has been adopted as part of the latest reviewed SANS 3000-2-2-1 level crossing standard that is yet to be published. Once published, the standard will enable financially constraint rail operators the option of installing low-cost warning systems such as flashing red disks. This approach will increase the number of active protected level crossings because of the lower costs.

Heavy vehicle issues

There are several specific safety issues that must be considered for trucks at level crossings. Longer trucks need more time to clear the level crossing from a stopping position. The issue of public roads running parallel in close vicinity to the railway line also needs to be considered. Braking and acceleration performance of a truck is also a pertinent issue for level crossing safety. The function of a vehicle's braking performance is subject to stopping sight distance.

If a crossing experiences a significant percentage of heavy trucks, any given sight distance will dictate a slower speed of operation to allow for the braking performance of these vehicles.
(Tustin, 1986; Wallace et al., 2008).

Rumble strips

Rumble strips are either grooves or rows of raised pavement markers that are placed perpendicular to the direction of travel to alert drivers to an approaching change of roadway condition or hazard requiring substantial speed reduction (Washington State Department of Transportation, 2004). The intention of rumble strips is to provide both an auditory and physical (vibration) stimulus that can be felt by both the driver and vehicle occupants. The corrugation height for passenger vehicles can be quite shallow (around 8mm), yet still produce significant stimulus in a vehicle (Rechnitzer, 2002; Wallace et al., 2008).

Road blockers

Road Blockers refer to physical obstruction barriers that protrude out of the road surface to physically prevent motorist from crossing the level crossing whilst the train is crossing. These barriers mechanically move back into the road surface once the train have passed, and it is safe for the road traffic to cross the railway line. This form of level crossing protection requires communication with the signalling systems and, therefore, can only be considered as a viable option along rail corridors that have an advanced signalling system already installed.

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PRASA AND TRANSNET INVESTIGATION REPORTS

[1] Investigation report into the circumstances surrounding the collision of a passenger train number 74013 and a private motor vehicle where there were minor injuries, at a farm crossing situated at Kmp 9 Mast Pole 21 at the Birch farm crossing at approximately 08:00 on Monday, 10 March 2014.

[2] Investigation report into the circumstances surrounding the collision of a passenger train number 47014 and a private motor vehicle where there were no injuries, at a level crossing situated at Kmp 16 mast pole 4 at the Molteno crossing at approximately 17:50 on Friday,6 June 2014.

[3] Report of the investigating team that investigated the circumstances that led to the level crossing incident between Shosholoza Meyl train 37012 and a white Toyota, 27 July 2014.

[4] Investigation report into the circumstances surrounding the collision of a MLPS train

[5] 47014 and a private motor vehicle where the driver of the motor

[6] Vehicle had minor injuries, at a level crossing situated at Kmp 34 mast pole 1at the Reeston crossing at approximately 09:35 on Sunday, 4 October 2015.

[7] Formal line investigation investigating the circumstances leading to level crossing accident of train 17005 at Arriston, 04 May 2016.

[8] Investigation report into the circumstances surrounding the level crossing incident of a MLPS train number 74013 and a Toyota motor vehicle where there were no injuries, at a public level crossing situated at Kmp 88 mast poles 10 - 11 between Skietfontein-Bowkers park at approximately 08:30 on Monday, 30 May 2016.

[9] Investigation report into the circumstances surrounding the level crossing incident collision at Witbank level crossing of train 78091 at km/p 114/10 at approximately 07:05 on Tuesday, 14th February 2017.

[10] Formal line investigation investigating the circumstances leading to the level crossing accident of train 17005 at Kanana, 24 May 2017

[11] The report of a formal joint board of inquiry which investigated the circumstances that led to the collision between a Shosholoza Meyl train no. 37012 and a trailer of a third party mechanical truck loaded with soya beans, registration number JWC 868 NW at a level crossing between Geneva and Bosrand stations at or near kilometre point 21 and mast pole 14 ("Kmp 21/14"), in the free state province, at approximately 08:46 on Thursday, 04 January 2018 which caused 24 ("twenty four") fatalities and approximately 260 ("two hundred and sixty") injuries to train passengers, 04 January 2018.

[12] On 07 June 2018 at approximately 10:27 while MLPS train 74013 was proceeding over the level crossing at kilometer 14 mast pole 08 a white Isuzu bakkie kb250 le registration number DNV 591EC drove into the side of the leading locomotive (e7082) of the passenger train, 07 June 2018.

[14] Report of the joint (Transnet freight rail/PRSA) board of inquiry that investigated the level crossing collision between passenger train no. 17007 (Premier Class) and a white Isuzu bakkie, with registration. Number cw29170, at kilometer point 55,969 situated between Sandhills & Orchards, north of Worcester, at approximately 14:14 on Friday, 15 February 2019 resulting in two (2) passengers being fatally injured and five (5) others injured and hospitalized, 15 February 2019.

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[8] Magogong Level Crossing Collision, 07 July 2015.
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