A REVIEW ON THE CURRENT CONDITION OF RAIL INFRASTRUCTURE IN SOUTH AFRICA

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ABSTRACT

A well-established rail network is of strategic importance to a country and provides a cost-effective and efficient means of increasing its transportation capabilities. As such, ensuring the condition of the rail network should be of high importance and priority to the public.

This paper evaluates the current state of the public freight and passenger rail networks in South Africa. An evaluation of the freight rail network examines the current condition of the heavy haul freight lines, general freight lines and branch lines, while an evaluation of the passenger rail network examines the current condition of PRASA passenger lines as well as the relatively recent Gautrain passenger lines. The evaluation is based on the state of primary rail infrastructure components (i.e. formation, railway structures, signalling, telecommunications, perway and electrical systems) as well as key contributing factors to the current rail infrastructure condition such as theft and vandalism of railway assets, number of train derailments, collisions and fires. Furthermore, a national and provincial survey grading system of the current condition of rail infrastructure is assessed.

Primary findings of the assessment indicate a significant and increasing maintenance backlog of track infrastructure along the general freight and branch line network and more especially on PRASA's passenger rail network. In addition an increasing trend of theft and vandalism, and an underinvestment of resources required to maintain the condition of certain network sectors have been identified. This has left the overall condition of the majority of networks in a poor state.

This paper will contribute towards current efforts in alerting government and the public at large of the current state of the rail infrastructure in South Africa and the necessity of well-maintained infrastructure to allow the continued and sustainable operation of the railway network.

1. INTRODUCTION TO THE SOUTH AFRICAN RAIL ENVIRONMENT

The South African rail network comprises of two primary units; the freight rail network and the passenger rail network. The public sector freight and passenger rail networks are owned by national government and operated through state-owned enterprises, namely Transnet and Passenger Rail Agency of South Africa (PRASA). The passenger rail network also includes the Gautrain rapid rail link, which is owned through a private-public partnership between the Gauteng Provincial Government and private partners who are structured under the Bombela Concession Company.

It is important to recognise the various roles and responsibilities as well as service delivery obligations of each of the above entities when assessing the state of rail infrastructure in South Africa. A brief description of the primary role players is provided below.

1.1. Transnet SOC Ltd

Transnet reports to the Department of Public Enterprises (DPE) and is primarily responsible for the provision of freight transport through one of its operating divisions, namely Transnet Freight Rail (TFR). TFR is responsible for the management, maintenance and operations of the national freight rail network. The freight rail network is utilised to transport bulk, break-bulk and containerised freight across South Africa and provides links between mines, production hubs, distribution centres and ports as well as to provide connectivity with rail networks beyond South African borders.

The TFR network consists of 30 400 track kilometres and 20 953 route kilometres of which 12 801 kilometres comprises the core network and 7 278 kilometres comprises branch lines. Furthermore, 1 500 kilometres of the core network comprises heavy haul lines for the export of coal and iron ore (Transnet, 2016).

Recently, TFR was allocated R201 billion by the government as part of a massive expenditure program, referred to as the Market Demand Strategy (MDS) (Transnet, 2016). This program is aimed at expanding TFR's existing rail infrastructure in order to increase carrying capacity and cargo volumes in an effort to meet current and future market demands.

1.2. PRASA

PRASA reports to the Department of Transport (DoT) and provides commuter rail services in the Metropolitan areas of South Africa as well as long-distance rail services within and across South African borders through one of its operating divisions, namely PRASA Rail (PRASA Corporate Plan, 2016). PRASA Rail is responsible for rail operations of Metrorail and Main Line Passenger Services, namely Shosholoza Meyl and Premier Classe.

Metrorail currently operates in four South African regions namely Gauteng, Western Cape, KwaZulu-Natal and Eastern Cape. PRASA and Transnet jointly own Metrorail's 468 stations and 3 180 track kilometres of which PRASA owns 317 stations and 2 228 track kilometres (Metrorail, 2017).
As part of the mainline passenger network, Shosholoza Meyl and Premier Classe provide long distance inter-city passenger rail services primarily between Johannesburg, Cape Town, Durban, Port Elizabeth and East London.

Historically PRASA has experienced a lack of investment which has resulted in dilapidated rail infrastructure and rolling stock. There are, however, large capital programmes which are currently underway in an attempt to combat the problem of deteriorating infrastructure. Recently, PRASA embarked on a R172- billion rolling stock acquisition programme and an infrastructure modernisation program (from 2013/14 to 2023). The former entails the acquisition of new rail vehicles while the latter aims at upgrading all rail infrastructure in support of the rolling stock acquisition program (PRASA, 2014).

1.3. Gautrain Rapid Rail Link

The Gautrain is an 80 km rapid rail network which links Pretoria, Johannesburg and the OR Tambo International Airport. The network is unique to South Africa because it provides a high speed passenger rail service and the trains run on a standard gauge railway track. The project is relatively new at this point with 2006 marking the beginning of constructions and operations beginning in 2010.

The Bombela Concession Company is responsible for the operation and maintenance of the Gautrain while the Gautrain Management Agency, established by the Gauteng Provincial Government, is responsible for the management and maintenance of all system assets.

Due to the Gautrain project being a private-public partnership, the allocation of government funding required during Gautrain's operational phase is highly dependent on the Gautrain meeting specified levels of performance, while significant reductions are imposed in the event of underperformance (Gautrain Management Agency, 2016). This provides strong incentives to keep the Gautrain at optimal service levels through adequate operating and maintenance procedures.

2. CONDITION ASSESSMENT OF FREIGHT RAIL INFRASTRUCTURE

2.1. Operational Occurrences

In light of TFR's planned capacity and volume increase, considerable strain on the freight rail network, particularly the rail infrastructure, is envisaged. Adequate rail infrastructure performance is therefore important in ensuring safe and reliable rail operations. As such monitoring the trend of operational occurrences can provide an indication on the state of rail infrastructure.

An assessment of the trend of operational occurrences associated with collisions and derailments affecting the TFR network was conducted. The number of derailments and collisions per million train kilometre from 2011/12 to 2016/17 are presented in Figures 1 and 2.

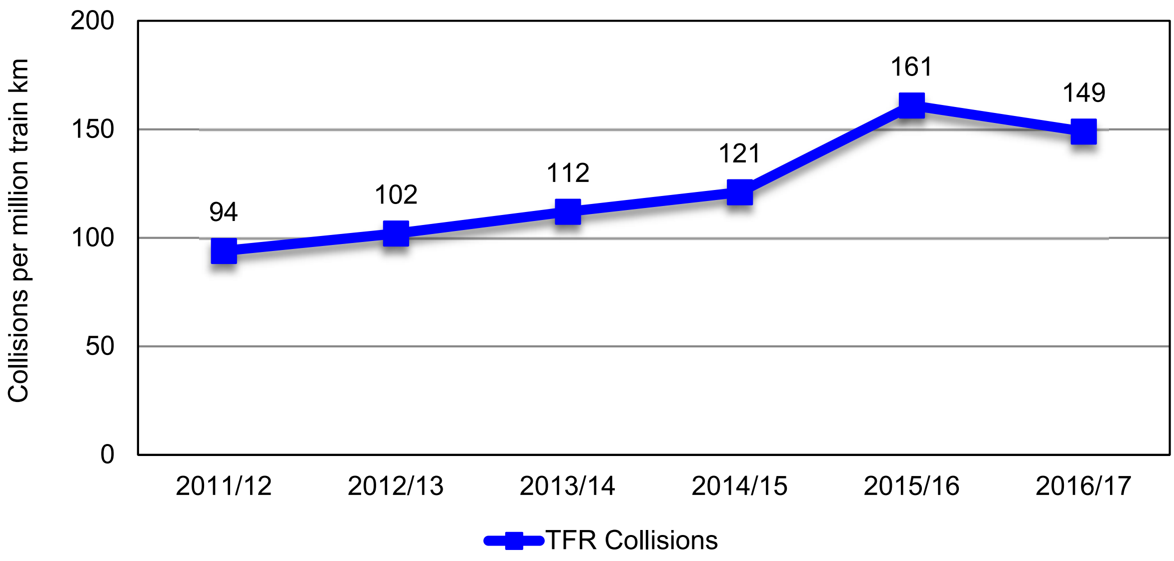

Figure 1: Collisions per million train km: 2011/12 to 2016/17 (Railway Safety Regulator, 2017)

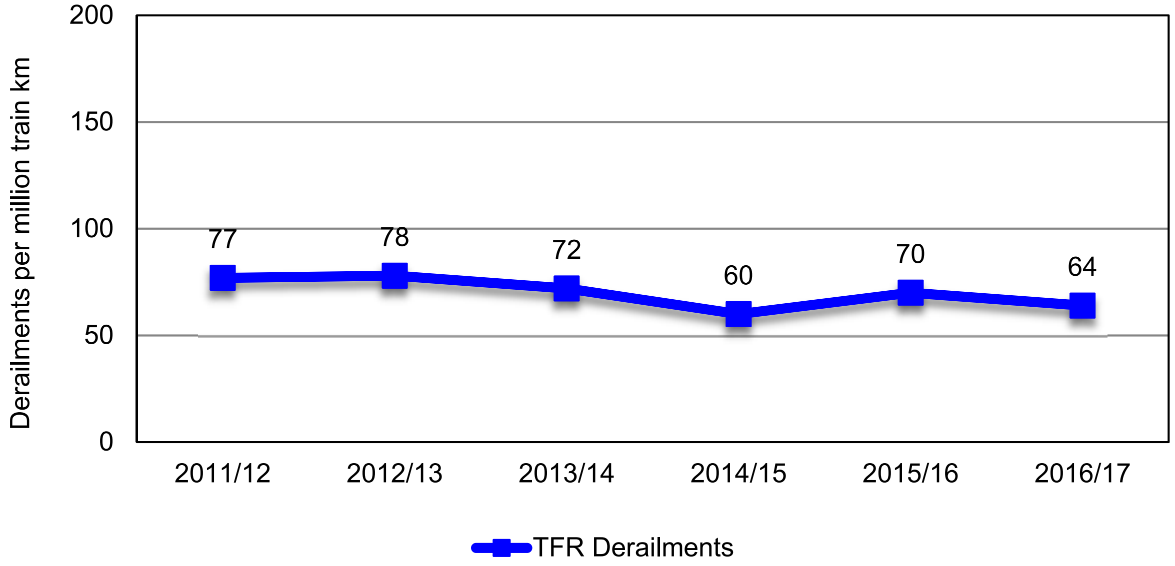

Figure 2: Derailments per million train km: 2011/12 to 2016/17 (Railway Safety Regulator, 2017)

Figure 1 indicates a strong upward trend with an approximate 70% increase in the number of collisions up to 2015/16 and thereafter shows slight improvement over the 2016/17 year. This is in contrast to, a relatively constant rate of derailments over the 7 year period‐as observed in Figure 2. However, no significant improvement in the rate of derailments is depicted in this period.

The above assessment on collisions and derailments may signify the presence of a poor and unmaintained track condition. This is in line with the main root causes of collisions and derailments identified by TFR during the 2016/17 period. These causes include track infrastructure defects such as rail breaks, rail kick-outs, track geometry, gauge widening and defective points and crossings (Railway Safety Regulator, 2017). In addition, a study conducted by Duvel (2015) along the heavy haul iron ore line, identified that rail network failure due to rail breaks was the primary cause of derailments and contributed to 54% of all derailments since 2006. Signalling failures and rolling stock inadequacies were further identified by TFR as contributing factors for the collision and derailment occurrences during 2016/17 (Railway Safety Regulator, 2017).

Furthermore, increased occurrences of theft and vandalism of rail infrastructure equipment are the main contributors to section failures and unreliable train operations, particularly along the general freight lines. This has in turn left certain sections along the general freight network in an unacceptable condition.

Figure 3 shows the occurrences of theft and vandalism to the freight rail infrastructure for the period 2014/15 to 2016/17. Although the data only indicates a slight increase (approx. 10%) in theft-related occurrences, it should be noted that theft of assets at TFR constitutes on average 85% of all safety-related occurrences over this period. A significant increase (approx. 40%) in vandalism-related occurrences is depicted, although vandalism of assets only constitutes on average approximately 14% of all safety related occurrences over this period (Railway Safety Regulator, 2017).

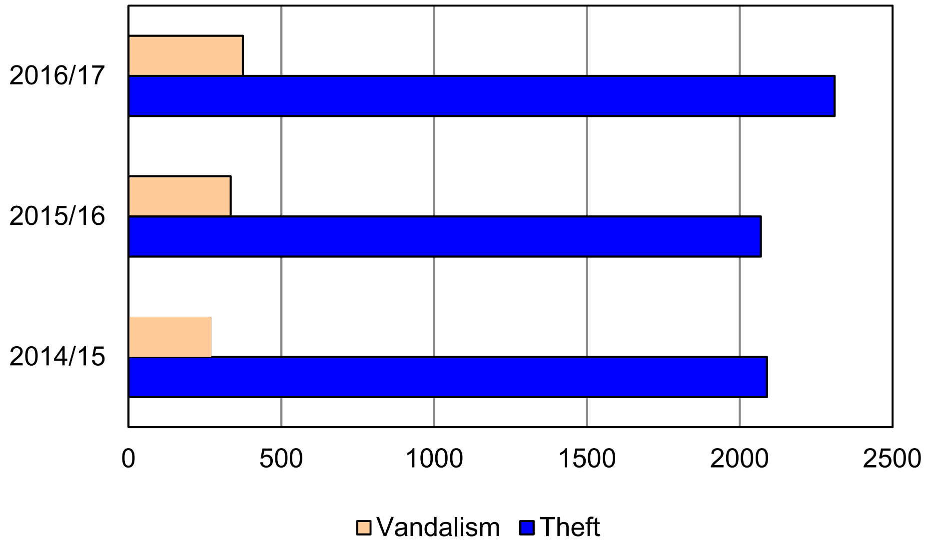

Figure 3: Theft and Vandalism Occurrences: 2014/15 to 2016/17 (Railway Safety Regulator, 2017)

2.2. Network Performance

The TFR core network can be sub-divided into four systems, which are described below. The network performance of each system has been attributed to the condition of various rail infrastructure disciplines/components. Information related to this was obtained from records published by TFR over a three year period up to 2016 and has been summarised and presented in Section 2.2.2 to 2.2.4.

2.2.1. Coal system

The performance of the coal network is indicated to be "slightly below the network average" (Transnet, 2016). One of the limiting factors affecting the performance of the first section of the coal network is the prevalent clayey soil conditions in the track formation (Transnet, 2016). High volumes of plastic clays can sustain the excess pore water pressures during both static and cycling loading. The excessive pore water pressures in turn decreases the bearing capacity of the undrained formation, which may result in track failure (Indraratna, 2012). Furthermore, poor electrical, signalling and telecommunication conditions along various sections of the network have been reported (Transnet, 2016).

Table 1 provides a summary of the state of rail infrastructure components of the coal network from 2014 to 2016. It should be noted that the same condition has been reported over the three year period. This may be indicative of an unmaintained rail infrastructure system where little has been done to improve the condition of under-performing infrastructure over the three-year period.

Table 1: Condition of rail infrastructure – Coal network

Infrastructure Component	Formation	Structures	Perway	Electrical	OHTE	Signals	Telecoms
2014	Poor	Adequate	Adequate	Poor	Adequate	Poor	Poor
2015	Poor	Adequate	Adequate	Poor	Adequate	Poor	Poor
2016	Poor	Adequate	Adequate	Poor	Adequate	Poor	Poor

Adequate Poor

2.2.2. Iron ore and manganese system

High performance levels of the iron ore and manganese network have been reported (Transnet, 2016). These performance levels may be attributed to the adequate performance of infrastructure components along most sections of the network with the exception of poor electrical, perway and telecommunication conditions along a few sections of the network, as indicated in Table 2. In addition, the first section of the network has reported concerns regarding the track over bridge structures. It is speculated that due to the extreme variations in temperature, expansion and contraction of the welded rails may be causing interference between the track and the bridge.

Similar to the coal network, the same condition of infrastructure over three years have been reported by TFR.

Table 2: Condition of rail infrastructure – Iron ore and manganese network

Infrastructure Component	Formation	Structures	Perway	Electrical	OHTE	Signals	Telecoms
2016	Adequate	Poor	Poor	Poor	Adequate	Adequate	Poor

2.2.3. North-eastern system

Acceptable performance levels of the north-eastern network have been reported (Transnet, 2016). These performance levels may be due to recent upgrade measures that were implemented to address poor perway conditions so as to accommodate increased freight volumes as well as growth in traffic from over border regions. Furthermore, recently replaced telecommunication systems have been reported to be in a good condition along some sections of the network (Transnet, 2016), further contributing to the acceptable performance levels of the north-eastern network. However, numerous train delays have been experienced along certain other sections of the network due to the poor condition of signalling and telecommunication systems.

Table 3: Condition of rail infrastructure – North-eastern network

Infrastructure Component	Formation	Structures	Perway	Electrical	OHTE	Signals	Telecoms
2016	Adequate	Adequate	Adequate	Adequate	Poor	Poor	Poor

2.2.4. Intermodal and general freight system

The performance of the general freight network is indicated to be "below the network average" (Transnet, 2016). Although most infrastructure components are in an acceptable condition as shown in Table 4, the performance of the network is severely limited by electrical and signalling related failures.

It has been indicated that poor signalling and electrical related infrastructure conditions are the main contributors to section failures along certain sections of the general freight network. Increased theft and vandalism have been identified as the main root cause for majority of the reported signalling and electrical failures.

Table 4: Condition of rail infrastructure – Intermodal and general freight network

Infrastructure Component	Formation	Structures	Perway	Electrical	OHTE	Signals	Telecoms
2016							

2.2.5. Branch lines

Branch lines constitute 7 278 km (35%) of the total TFR network. At present 3 928 km of the branch lines are operational, of which the state of several lines are in varying degrees of disuse (Department of Transport, 2017). The remainder of the branch lines are currently closed.

The lack of provision of rail services, maintenance and investment in supporting infrastructure to the branch line network, for over 20 years, has resulted in a significant and increasing maintenance backlog of track infrastructure, stations and yards (Department of Transport, 2017). Furthermore, theft and vandalism have occurred on branch lines that are not operational. These factors have left the existing branch line network in a poor and unacceptable condition.

In an attempt to renew the deteriorating branch line network, Transnet and Government have initiated a branch line revitalisation programme to provide opportunities for refurbishment (Transnet, 2016). This initiative has resulted in the commencement of refurbishment of some branch lines and allocation of funds to refurbish others in the next few years.

3. CONDITION ASSESSMENT OF PASSENGER RAIL INFRASTRUCTURE

3.1. PRASA

PRASA accounts for 97% of the passenger rail network in South Africa (PRASA, 2016). Historically PRASA has experienced a lack of investment which has resulted in dilapidated rail infrastructure and rolling stock. Some current challenges facing PRASA due to the prolonged period of underinvestment include:

- Out-dated rail infrastructure, rolling stock and technology
- Low levels of reliability and predictability affecting operational performance
- Increased maintenance and associated maintenance costs
- An open rail system leaving it susceptible to theft and vandalism

Information regarding the condition of rail infrastructure components along the four major sections of the network was provided by PRASA (Vermeulen, 2017). As indicated in Table 5, the signalling and telecommunication systems as well as the structural components are in a critical condition, particularly in the Gauteng and Kwa-Zulu Natal region. In addition to Table 5, poor conditions of the electrical network have been reported as the primary cause of rail network failure associated with rail hook-ups; which is currently affecting the safety and operational performance of trains on the network. Hook-ups occur when the pantographs on top of the locomotives hook the electric cables above.

Table 5: Condition of PRASA rail infrastructure (Vermeulen, 2017)

Section	Perway	Structures	OHTE	Signals	Telecoms
Gauteng South	C	C -	C -	D+	D+
Gauteng North	C+	C+	C	D+	D+
Kwa-Zulu Natal	C-	D+	C+	C+	C-
Western Cape	C+	C+	C+	C+	C+

A-World-class, B-Fit for the future, C-Satisfactory for now, D-At risk, E-Unfit for purpose

More recently, PRASA reported that the main factors contributing to the unreliability of service have been rolling stock failures, infrastructure failures (signalling & electrical) and poor condition of the perway (PRASA, 2016). This is evident in the significant increase of collision (47%) and derailment (74%) occurrences from 2011/12 up to 2015/16, as indicated in Figure 4 and 5. There is however a marked improvement in both collision and derailment occurrences in the 2016/17 year. This may be attributed to the mentioned expenditure programs currently underway to address the poor condition of the PRASA network which includes the Signal Upgrade Project (SUP) aimed at improving signalling related infrastructure failures. PRASA has reportedly spent R 0.9 billion on the SUP in the 2016/17 financial year, which has resulted in certain provinces indicating improved infrastructure condition (PRASA, 2016).

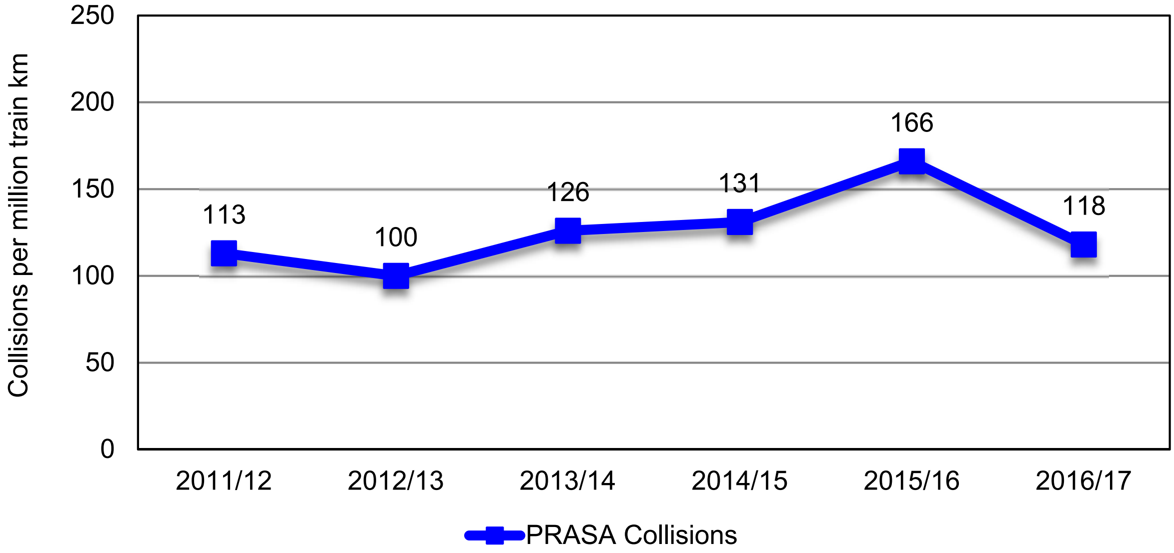

Figure 4: Collisions per million train km: 2011/12 to 2016/17 (Railway Safety Regulator, 2017)

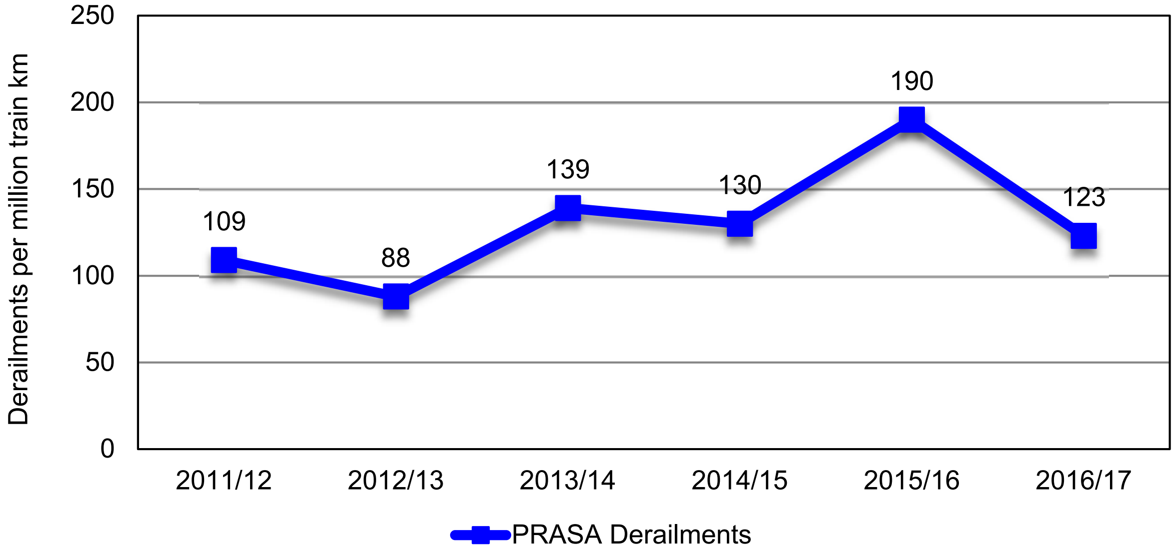

Figure 5: Derailments per million train km: 2011/12 to 2016/17 (Railway Safety Regulator, 2017)

Moreover, increased occurrences of theft and vandalism of rail infrastructure equipment have contributed to section failures and unreliable train operations which have in turn left the passenger network in an unacceptable condition. These issues have been compounded by ongoing train burnings, community service delivery protests, flooding, substation outages and sinkholes on key sections of the network.

3.2. Gautrain

Gautrain infrastructure is separated into two categories, core and non-core assets. The number of maintenance service requests from Gautrain for both core and non-core assets are reported to have decreased since the 2015/16 financial year (Gautrain Management Agency, 2016). This could be indicative of an effective and adequate maintenance programme which implies a sound condition of infrastructure.

Furthermore, Gautrain's infrastructure assets (which exclude land, plants, equipment, rolling stock and buses) have an average useful life of 5-100 years (Gautrain Management Agency, 2016). This is a considerably wide range owing to the fact that various rail infrastructure components have been grouped together such as signalling posts, bridges, tunnels and track formation. However, a conservative conclusion can be made that the infrastructure is in good condition since operations commenced only 8 years ago which places current infrastructure at 3 years over the absolute minimum of the expected useful life.

4. CONDITION ASSESSMENT OF RAIL INFRASTRUCTURE THROUGH A NATIONAL SURVEY GRADING SYSTEM

As part of the 2017 South African Institution of Civil Engineering (SAICE) Infrastructure Report Card project (SAICE, 2017), a survey on the overall condition of infrastructure in South Africa was recently conducted by Rust et al. (2018). The survey population included 669 members from the SAICE across the country. The condition of rail infrastructure was included as part of the survey and a grade for each division of the freight and passenger rail networks was provided. The grade was based on the opinion of SAICE experts within the national and provincial rail sector.

A summary of the obtained grades is presented in Figure 6. It can be observed that the infrastructure condition of only two rail networks were rated above average - the heavy haul freight lines were slightly above average and the Gautrain passenger lines were well above average. The infrastructure condition of the general freight lines were rated average, whereas the branch lines and the PRASA passenger lines were rated below average.

It was also interesting to compare the results of the survey with the findings from the assessment conducted in Section 2 and 3. Similar infrastructure conditions have been reported, with the exception of the heavy haul freight lines which have been classified separately (i.e. coal lines and iron ore and manganese lines) as opposed to rating it as one system as conducted in the survey. The separate classification is due to variations in infrastructure condition of the coal (below average) and iron ore and manganese (above average) networks.

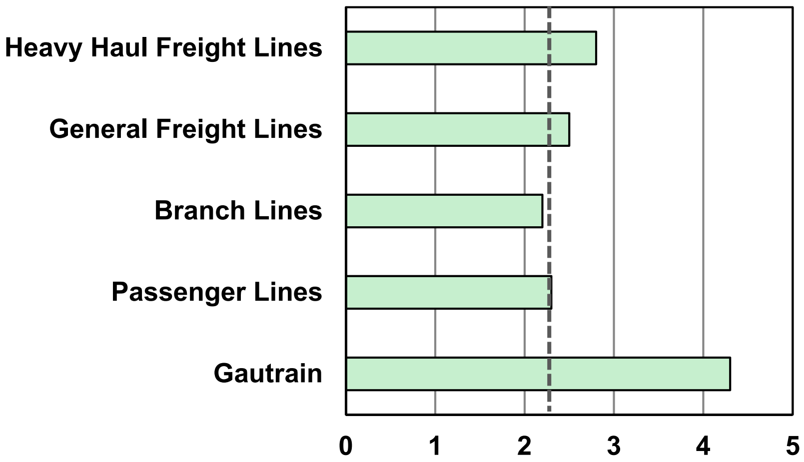

Figure 6: Rail infrastructure condition scores: national survey (Rust et al., 2018)

5. CONCLUSIONS AND WAY FORWARD

Based on the infrastructure condition assessment of the existing freight and passenger rail networks, the following conclusions are drawn:

- The overall condition of the heavy haul freight network ranges from slightly below average to good. Poor electrical, signalling and telecommunication conditions exist on certain sections of the network; however, most infrastructure disciplines are performing adequately.
- The condition of the general freight network is below the network average. Poor signalling and electrical related infrastructure conditions, primarily due to theft and vandalism, are the main contributors to section failures and require special attention.
- The condition of the existing branch line network is very poor. Theft and vandalism as well as the lack of provision of rail services, maintenance and investment in supporting infrastructure to the branch line network, has resulted in a significant and increasing maintenance backlog of track infrastructure, stations and yards.
- The PRASA passenger rail network is in a poor condition owing to faulty signalling, telecommunication and electrical related infrastructure conditions. Furthermore, outdated rail infrastructure, increasing maintenance of rail infrastructure and theft and vandalism need to be prioritised in order to improve on service delivery, which is currently a concern to PRASA operations.

- The Gautrain system is in an overall good condition. The network is still relatively new and high accountability measures in the form of performance-based funding ensure the Gautrain operates efficiently and adequately maintains its system.
- The opinion survey conducted on the condition of rail infrastructure highlighted similar findings to the information provided by TFR (with the exception of the heavy haul freight lines), PRASA and Gautrain.

With the above conclusions in mind, it can be said that the rail infrastructure in South Africa needs improvement and requires immediate attention to the following matters:

- Existing infrastructure requires better safeguarding to decrease and prevent the increasing trend of theft and vandalism.
- In order to increase safety and reliability and to ensure high performance of the rail network, there is a need to prioritise upgrading of old and outdated rail infrastructure.
- Downtimes caused due to lack of maintenance and inadequate maintenance is known to decrease reliability and efficiency and hence the effort and resources invested in an effective maintenance regime need emphasis.
- Current efforts have indicated that funding may be available, but it is crucial to ensure that the funding received is utilised effectively to meet the strategic objectives of the government.

6. REFERENCES

Department of Transport. 2017. National Rail Policy: Draft White Paper. Available at: http://www.transport.gov.za. Accessed: 28/04/2018

Duvel, J. 2015. Heavy Haul Rail Performance at Transnet. Available at: http://www.saicerailwayandharbour.co.za. Accessed: 27/04/2018

Gautrain Management Agency. 2016. Annual Report

Indraratna, B., Nimbalkar, S. and Rujikiatkamjorn, C. 2012. Stabilising railway embankments with geosynthetic grids and drains and a class A prediction of track behaviour. International Symposium on Sustainable Geosynthetics and Green Technology for Climate Change (SGCC) (pp. 21-40).

Metrorail. 2018. Available at: www.metrorail.co.za. Accessed: 27/04/2018

PRASA. 2014. Annual Report – 2013/2014. Available at: https://www.prasa.com. Accessed: 28/4/2018

PRASA. 2016. Annual Report – 2015/2016. Available at: https://www.prasa.com Accessed: 28/4/2018

Railway Safety Regulator. 2017. State of Safety Report. Available at: https://rsr.org.za. Accessed: 27/4/2018

Rust, F.C., Wall, K. and Amod, S. 2018. South African infrastructure condition – an opinion survey for the SAICE Infrastructure Report Card. Submitted to the SAICE journal.

SAICE. 2017. 3rd Infrastructure Report Card, South African Institution for Civil Engineering.

Transnet. 2014. Rail Development Plan. Available at: https://www.transnet.net. Accessed: 28/4/2018

Transnet. 2015. Rail Development Plan. Available at: https://www.transnet.net. Accessed: 28/4/2018

Transnet. 2016. Rail Development Plan. Available at: https://www.transnet.net. Accessed: 28/4/2018

Transnet. 2016. Transnet Integrated Report. Available at: https://www.transnet.net. Accessed: 29/4/2018

Vermeulen, T. 2017. “General comments on condition of PRASA rail network”. [email].