AN OVERVIEW OF THE PERFORMANCE-BASED STANDARDS PILOT PROJECT IN SOUTH AFRICA

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Abstract

The Performance-Based Standards or "Smart Truck" pilot project is a national research initiative that is trialling the introduction of high productivity road freight transport in South Africa. This initiative is being led by stakeholders from the CSIR, government, industry and academia. These "Smart Trucks" are developed and regulated according to a Performance-Based Standards (PBS) framework, which has proven highly effective in Australia, New Zealand, Canada and parts of Europe. The pilot project was initiated in 2004, and has since grown to include 245 demonstration vehicles in various industries, which are closely monitored for impact and performance. Over 100 million km of data have been collected and processed to date, indicating overall net benefits of the PBS framework, including: a 12% reduction in fuel use and emissions, a 13% reduction in road wear impact, 39% reduced road crashes, and 22% fewer truck kms travelled on South African roads. The PBS project is on the verge of transitioning from Phase 1 (proof of concept, initial data collection) into Phase 2 (increased participation and data collection and formalisation of an implementation strategy). This paper summarises the project to date, presenting an overview of the research approach, monitoring data and other outputs and findings.

Keywords: Performance-based standards, Smart Trucks, high productivity vehicles, vehicle safety.

1. Introduction

According to the 2016 Logistics Barometer, the cost of road freight transport in South Africa during 2016 was 5.52% of GDP (Havenga *et al*, 2016). This equates to US$7.8bn for fuel, and a further US$11.7bn for the cost of road freight transport excluding the costs of management, administration and warehousing. Currently approximately 85% of freight in South Africa is transported by road (Department of Transport, 2005). In addition to the high costs of road freight transportation in South Africa, the 2011 OECD report, "Moving Freight with Better Trucks" (OECD, 2011) showed that South Africa experienced in excess of 12.5 road fatalities per 100 million heavy vehicle km travelled in 2005, compared with rates ranging from 0.8 to 3.0 of the other countries included in the study. The disproportionately high cost of road freight transportation and road deaths are a serious concern for South Africa and have a significant negative effect on the economy. Furthermore, the Draft Green Transport Strategy: (2017-2050) (Department of Transport, 2017) identifies the need to reduce greenhouse gas emissions in South Africa by 5% during that period. It speaks of "immediate and targeted interventions" to reduce heavy vehicle emissions.

These parallel needs to improve the cost of logistics, reduce crash rates, and reduce CO_2 emissions per tonne.km have prompted a high-level rethink of how heavy goods vehicles are regulated in South Africa. As a result of successful initiatives in Australia, New Zealand and Canada, the introduction of a Performance-Based Standards (PBS) approach in the heavy vehicle sector in South Africa was identified by the Department of Transport and CSIR as a research area warranting funding because of the potential benefits in terms of transport efficiency, road/vehicle safety, emissions reduction, and the protection of road infrastructure. The PBS approach involves setting standards to specify the performance required from the operation of a vehicle on a network rather than prescribing how the specified level of performance is to be achieved. The PBS approach allows a more optimum "match" between vehicles and the road infrastructure.

A need was identified to design, manufacture and operate a number of PBS demonstration vehicles in South Africa in order to gain practical experience in the PBS approach and to quantify and evaluate the potential benefits. Operators of PBS vehicles or "Smart Trucks" are required to be certified through the Road Transport Management System (RTMS) self-regulation accreditation scheme (Nordengen & Oberholzer, 2006; Standards South Africa, 2014). The RTMS originated from recommendations of the South African National Overload Strategy, which sought to address the problem of heavy vehicle overloading and constraints regarding overload control enforcement. The report proposed the introduction of self-regulation as part of a comprehensive long-term solution: a scheme by which initiatives are implemented by industry to establish sound vehicle management practices. Positive outcomes in terms of vehicle load control would complement existing overload control enforcement. Initially, two PBS demonstration projects were implemented in the forestry industry, which were designed and manufactured to comply with Level 2 safety standards of the Australian PBS system (Nordengen *et al*, 2008). These include directional and non-directional manoeuvres such as acceleration capability, low-speed swept path, static rollover threshold and rearward amplification. The positive performance of the demonstration project (Nordengen, 2010) has resulted in the approval to date of more than 250 additional permits for PBS demonstration vehicles.

2. Research approach

For the purpose of the PBS demonstration project in South Africa, it was decided to build on existing international heavy vehicle PBS research, development and implementation. After reviewing the PBS initiatives in Australia, Canada and New Zealand, the Australian PBS scheme (NTC, 2008) was selected as the basis for the South African PBS project. It was recognised that if this scheme was adopted by the South African Department of Transport in the long term, it would need to be adapted to accommodate South African-specific conditions e.g. maximum vehicle width is 2.5 m in Australia and is 2.6 m in South Africa.

A Smart Truck Steering Committee was formed in 2004 and a Smart Truck Review Panel shortly thereafter. The Review Panel guides and manages the project and consists of key experts from government, CSIR and academia. The Steering Committee consists of a wider range of representatives from participating industries, where ongoing industry feedback is provided, and where important updates from the management structures are disseminated.

After consideration of both the safety and the infrastructure performance standards contained in the Australian PBS scheme, it was decided that only the safety performance standards would be used; infrastructure performance standards would be developed based on existing approaches in South Africa for pavement and bridge design and assessment. Guidelines for participation in the Smart Truck demonstration project have been developed by the Smart Truck Review Panel (CSIR, 2018). The infrastructure performance standards for the PBS demonstration project are based on South African methodologies for pavement and bridge design loading analyses. For road pavements, the current South African Mechanistic-Empirical Design and Analysis Methodology (SAMDM) (Theyse *et al*, 1996), which is the basis of the South African pavement design manual for flexible pavements, TRH4 (Department of Transport, 1996), is used to assess the relative road wear of the proposed PBS vehicle combination and a representative baseline vehicle. The requirement for PBS demonstration vehicles is that the road wear per tonne of payload of the PBS vehicle must be less than the equivalent road wear of the baseline vehicle. As the number of different PBS demonstration vehicles increases, the intention is to develop a set of road wear benchmarks (for different vehicle configuration categories) against which proposed PBS vehicles can be assessed.

For the purposes of the demonstration project, assessments of both the baseline vehicle and the proposed PBS design are required. The assessment of the baseline vehicle highlights any safety shortcomings of a legal vehicle (that meets all the heavy vehicle prescriptive requirements) whereas the assessment of the proposed PBS vehicle may have to be iterative, with design modifications eventually resulting in a final design that meets all the PBS requirements. Data on kilometres travelled, fuel consumed, emissions generated, incidents and crashes and violations are submitted by operators on a monthly basis for all the participating PBS and baseline vehicles. A minimum target of 100 million kilometres of data was set, in order to ensure that statistically meaningful data was obtained from which to draw conclusions, particularly with respect to incident and crash data.

3. Pilot project timeline

A timeline of the Smart Truck project is illustrated in Figure 1, showing the history of the project as well as the predicted future. The figure shows the main project milestones: the establishment of the project with the founding of the PBS committee in 2004, the first PBS demonstration vehicles in 2007, and the 100 million km data mark in 2017. These milestones span the first two phases of the project. In Phase 0, the necessary approvals were sought, a PBS strategy (Department of Transport, 2007) was prepared, and research and skills development projects were initiated.

The PBS strategy defined the main objectives of the pilot project as follows:

1. Introduce PBS in South Africa as a pilot project
2. Define the PBS management roles and responsibilities
3. Demonstrate the benefits and viability of PBS vehicles in South Africa
4. Obtain support from Government and other stakeholders
5. Develop a PBS framework for South Africa
6. Formulate and resource a research programme
7. Obtain the participation of all nine Provinces in the pilot project
8. Obtain at least 100 million km of monitoring data before moving into the next phase

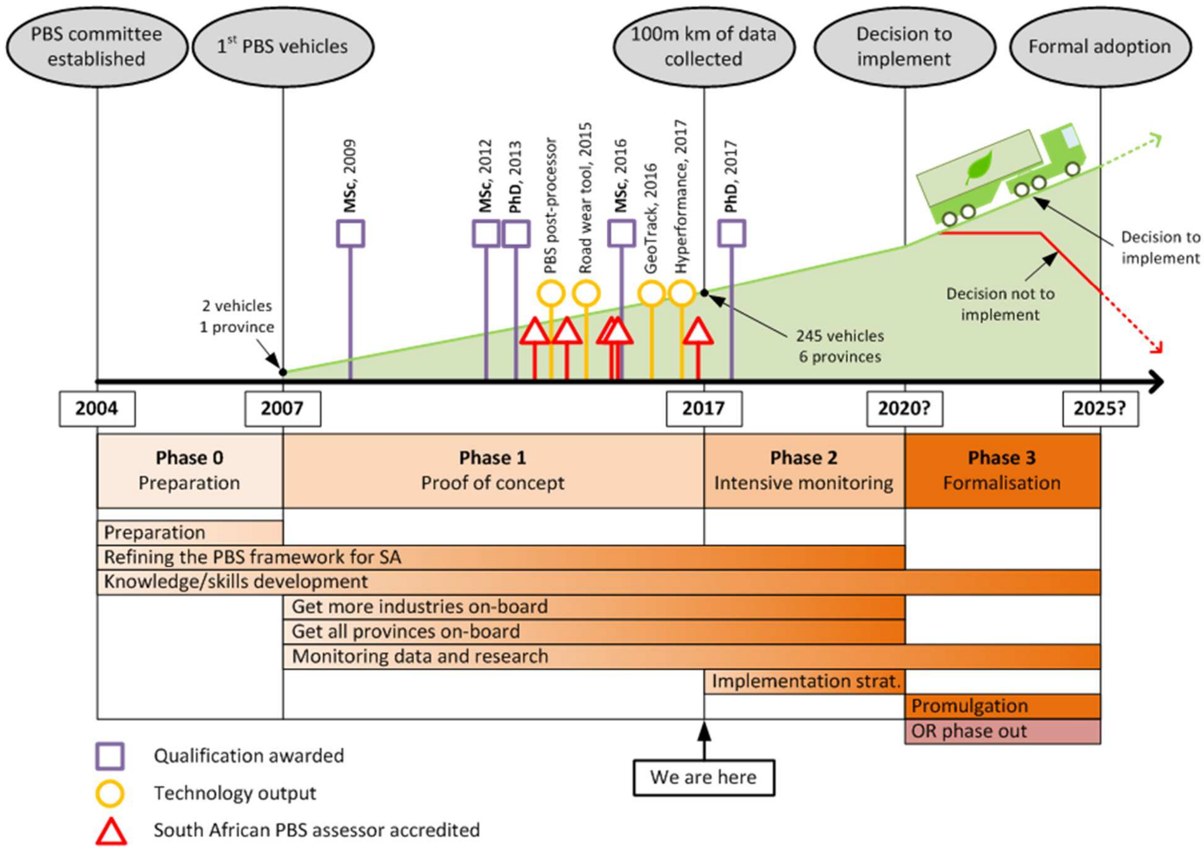

Figure 1: Timeline of the Smart Truck project and important milestones

Phase 1 began with the introduction of the first demonstration vehicles in 2007, in which an added focus was the expansion of the demonstration project into multiple industries spanning multiple provinces. Monitoring activities began and have grown substantially during this time, while research and skills development activities continued and grew. A number of important outputs of the project are highlighted during Phase 1, including the successful completion of three MSc degrees and two PhD degrees associated with the project (skills and expertise development), the formal accreditation of five locally-trained South African PBS assessors, and the production of four accredited technology demonstrators that have and will be used to help industry and government with participation in and management of the proposed scheme.

4. Industry uptake

Various partners in the transport industry have become part of the PBS initiative, contributing to the success of the first phase of the pilot project. Some of the main industry partners and their approximate time of joining the pilot project are summarised in Figure 2. The figure illustrates the growth in the number of operators joining the pilot project and the total number of PBS vehicles in the scheme. The first two PBS pilot vehicles were initiated in 2007 and operated by Sappi and Mondi, and developed with Afrit. Since then numerous additional industry partners have joined the project including AB InBev, Barloworld Transport, Imperial Logistics, Ngululu Bulk, Supergroup and Unitrans. Various OEMs and trailer manufacturers also play a significant role in the project in terms of the design and optimisation of the PBS vehicle combinations. These include Afrit, GRW, SA Truck Bodies, MAN Truck & Bus, Mercedes Benz Trucks, Scania and Volvo Trucks.

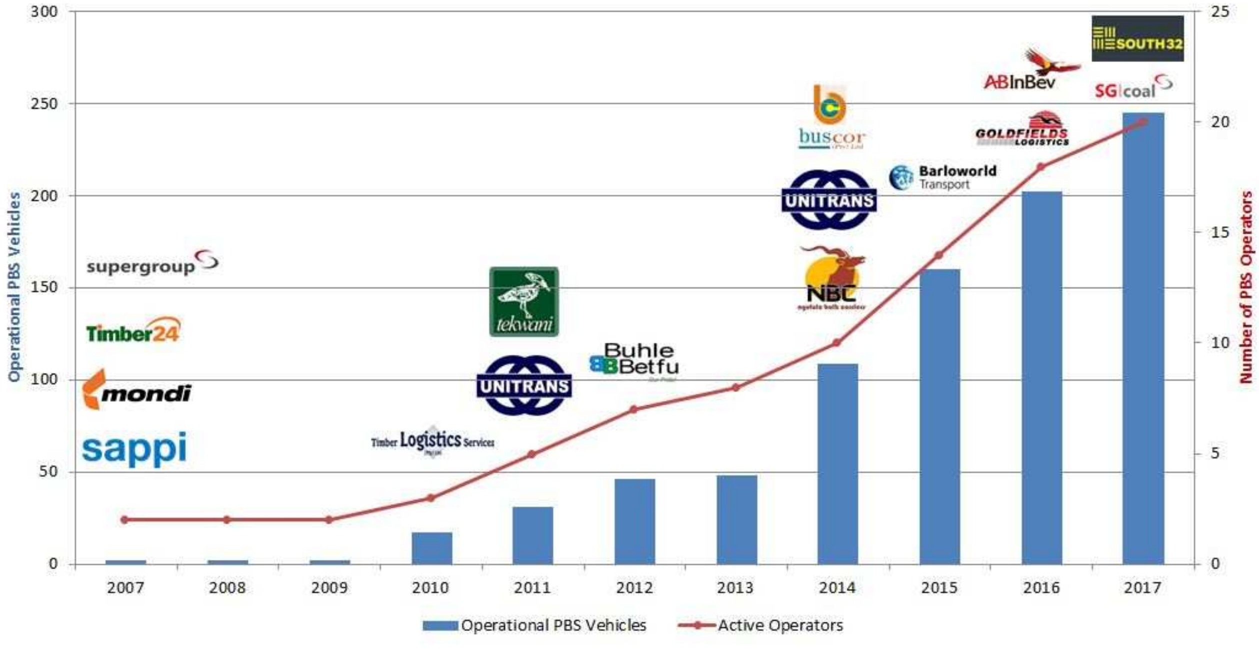

Figure 2: Industry uptake of the PBS pilot project

5. Research programme

Various research activities have been underway since the start of the PBS pilot project. This research programme has helped to mould the technical framework of the PBS project for South Africa, improve the safety and road wear impact of new vehicle designs, and helped to optimise and streamline the vehicle assessment process. In addition to having direct relevance for the PBS project, much of this research has also been disseminated through international peer-reviewed conferences, helping to put South Africa on the global map for its expertise and innovation in the fields of PBS and heavy vehicle safety. To date, outputs of the PBS research programme have included over 30 research papers presented at both local and international conferences, three journal articles, two PhD theses, four Masters dissertations, numerous popular articles and four registered “technology demonstrators” (implemented technology outputs).

Selected local and international research partners are summarised in Figure 3. The PBS pilot project was launched by the CSIR as the main research partner, with support obtained from the Department of Transport, as well as initial funding from the Department of Trade and Industry. Since the inception of the project the Department of Science and Technology has provided core parliamentary grant funding to the CSIR in order to support research associated with the PBS pilot project. The National Heavy Vehicle Regulator in Australia has been a key partner in establishing local PBS assessment capabilities and has provided continuous support and guidance. Research collaborations with universities have been a key component of the programme, and include Wits University, University of KwaZulu-Natal, University of Pretoria and more recently the University of Cambridge. The University of Pretoria and SANRAL are both involved with research associated with the impact of PBS vehicles on the South African Road Network.

Figure 3 – Research collaboration partners

6. Results

The number of PBS vehicles per province in South Africa is indicated in Figure 4. This includes 22 PBS fuel quad tankers that recently started operating on the national highway (N3) between Durban and Johannesburg. These are the first PBS vehicles to operate on the N3 corridor and are the only PBS vehicles currently operating in the provinces of Gauteng and Free State. As can be seen in Figure 4, the 245 PBS vehicles are predominantly operational in the provinces of KwaZulu-Natal (155), Mpumalanga (94) and Limpopo (56), with a limited number operating in Gauteng (22), Free State (22) and Eastern Cape (5). The PBS vehicles currently operating in the Northern and Western Cape are road trains operating in remote areas as part of mining operations (Loeriesfontein and Namaqwa Sands).

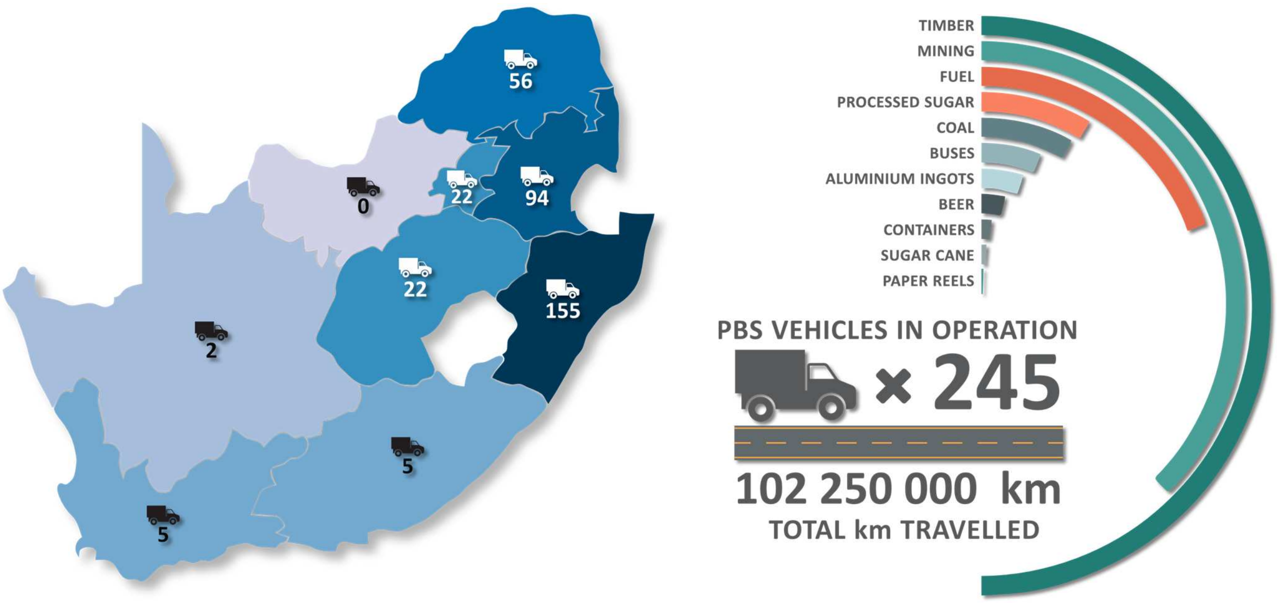

Figure 4 – Overview of PBS pilot project operations per province and commodity

Currently there are more than 20 operational PBS operators in South Africa with a number of vehicle designs and potential operators in the pipeline for future phases of the project. As at the end of June 2017, 102.25 million PBS vehicle kms had been covered. A wide range of industries and commodities are represented, including: timber, sugar, paper reels, mining products (including coal, chrome ore and platinum ore), aluminium ingots, fuel, beer, cattle and containers. There are also 22 bi-articulated PBS buses that operate on various approved routes in the Mbombela area in Mpumalanga province. Figure 5 provides examples of four PBS vehicles participating in a pilot project.

Figure 6 summarises the results of all the monitoring data collected during the PBS demonstration project until June 2017 (since the first two timber PBS vehicles were commissioned in November 2007). Data are shown as a comparison between PBS vehicles and "baseline" vehicles, where the baseline vehicles are conventional vehicles adhering to normal mass and dimension limits performing the same freight task. As far as is possible, the selected baseline vehicles operate on the same or similar routes as the PBS vehicles, with similar lead distances. The figure shows that currently the 245 PBS vehicles are saving an average of 6 238 trips, 737 220 km and 203 465 litres of fuel per month. The average fuel savings is 12.2% and the crash rate of the PBS vehicles is 39% lower than the baseline vehicles.

Fig. 5a 27.67 m, 73.5 t rigid-drawbar.
Payload = 52.14 t

Fig. 5b 21.6 m, 73.7 t B-double side-tipper
Payload = 50.55 t

Fig. 5c 29.6 m, 83.8 t A-double.
Payload = 53.4 t

Fig. 5d 18.6 m, 57.7 t TT/quad semi-trailer.
Payload = 55 000 ℓ (40.2 t)

Figure 5 – Examples of PBS vehicles

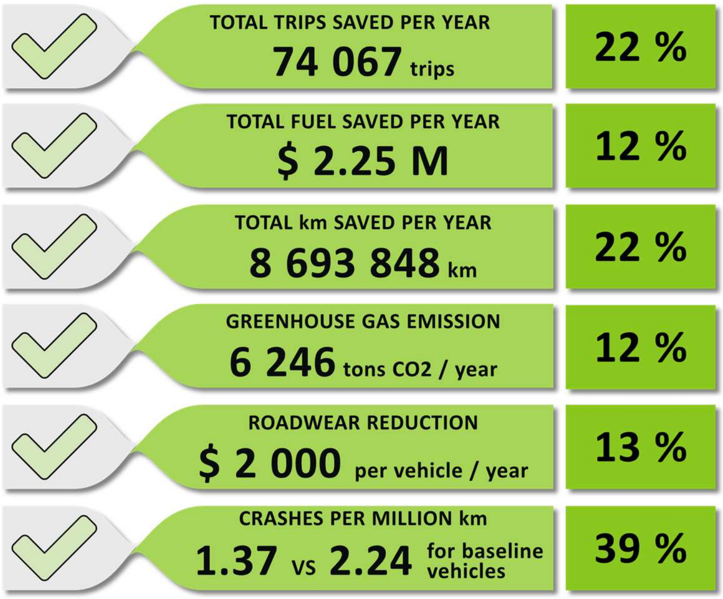

Figure 6 – PBS pilot project measured benefits (as at June 2017)

7. Conclusions and discussion

The PBS pilot project in South Africa has been running for more than ten years, with the first two PBS vehicles having been commissioned in November 2007. By the end of June 2017 there were 245 PBS vehicles participating in the pilot project and over 100 million km had been covered since the start of the pilot. Analysis of the monitoring data has indicated the following benefits:

- Reduced number of heavy vehicle trips on the road network
- Reduced crash rates
- Reduced fuel use resulting in a reduced cost per tonne.km of payload transported
- Reduced greenhouse gas emissions (CO_2) per tonne.km of payload transported

Other benefits that have been observed as a result of the required RTMS certification for participating operators are:

- Reduced overloading and speeding
- Improved driver skills and training

The project has not been without its challenges. The majority of PBS vehicles are longer and/or heavier than the maximum lengths and masses permitted in the regulations, resulting in resistance to the pilot project from some authorities. This underscores the importance of carrying out adequate research and obtaining sufficient monitoring data to verify and support the benefits measured to date. In this regard, robust and real-time monitoring mechanisms in terms of route, speed and mass compliance are also critical to ensure the success of the project in the future.

Significant progress has been made in defining a feasible South Africa-specific PBS framework and developing the required policies, procedures and management structures. There is now a need to formalise and consolidate these and develop recommendations for the way forward, with the possibility of national implementation.

8. References

- CSIR. (2018). "Smart Truck programme: Rules for the development and operation of smart trucks as part of the performance-based standards research," National Department of Transport, Pretoria, South Africa.
- Department of Transport. (1996). "TRH4: Structural design for flexible pavements for inter-urban and rural roads," Technical Recommendations for Highways. National Department of Transport, Pretoria, South Africa.
- Department of Transport. (2005). "National freight logistics strategy," Pretoria, South Africa.
- Department of Transport. (2007). "Performance-Based Standards (PBS) strategy for heavy vehicles in South Africa," Pretoria, South Africa.
- Department of Transport. (2017). "Draft green transport strategy (2017-2050) (Government Gazette No. 41064, 25 August 2017)," Pretoria, South Africa.
- Havenga, J.H., De Bod, A., Simpson, Z.P., Viljoen, N. and King, D. (2016) "A Logistics Barometer for South Africa: Towards sustainable freight mobility," J. Transp. Supply Chain Manag., vol. 10, no. 1.
- Nordengen, P A and Oberholzer, F. (2006). "A self-regulation initiative in heavy vehicle transport to address road safety, accelerated road deterioration and transport productivity in South Africa" in Proc. Ninth International Symposium on Heavy Vehicle Weights and Dimensions, Penn State University, State College, USA.
- Nordengen, P.A., Prem, H. and Mai, L. (2008). "An initiative to introduce a performance-based standards (PBS) approach for heavy vehicle design and operations in South Africa" in Proc. Tenth International Conference on Heavy Vehicle Transport Technology, Paris, France.
- Nordengen, P.A. (2010). "Monitoring results of two PBS demonstration vehicles in the forestry industry in South Africa" in Proc. Eleventh International Heavy Vehicle Symposium, Melbourne, Australia.
- NTC. (2008). "Performance Based Standards Scheme – The Standards and Vehicle Assessment Rules". Prepared by National Transport Commission: Melbourne, Australia.
- OECD (2011). "Moving freight with better trucks," ISBN: 978-92-821-0293-0. OECD Publishing, Paris, France.
- Standards South Africa. (2014). "SANS 1395: Road Transport Management Systems: Part 1: Operator Requirements – Goods," ISBN: 978-0-626-30953-4. SABS, Pretoria, South Africa.
- Theyse, H.L., De Beer, M. and Rust, F.C. (1996). "Overview of the South African Mechanistic Pavement Design Analysis Method". Paper Number 96-1294 presented at the 75th Annual Transportation Research Board Meeting, January 7 - 11, 1996, Washington, D.C., USA.