INVESTIGATION INTO THE SMART TRUCK PILOT PROJECT: PROGRESS MADE AND WAY FORWARD

AJ STEENKAMP, PA NORDENGEN*, R BERMAN and L KEMP*****

CSIR Built Environment, P O Box 395, Pretoria, 0001
Tel: 012 841-4698; Email: asteenkamp@csir.co.za
* CSIR Built Environment, P O Box 395, Pretoria, 0001
Tel: 012 841-3945; Email: pnordengen@csir.co.za
** CSIR Built Environment, P O Box 395, Pretoria, 0001
Tel: 012 841-4986; Email: rberman@csir.co.za
*** CSIR Built Environment, P O Box 395, Pretoria, 0001
Tel: 012 841-3964; Email: lkemp@csir.co.za

ABSTRACT

Transport logistics in South Africa forms the backbone of the economy, having represented 11.8% of GDP, or R499 billion in 2016. These costs are significantly higher than many developed countries. The South African transportation sector is vulnerable to becoming less and less competitive due to local and international economic and political instability. South Africa also has a disproportionately high heavy vehicle fatality rate, compared to the rest of the world; with 12.5 fatalities per 100 million heavy vehicle kilometres travelled. The Smart Truck or Performance-Based Standards (PBS) Pilot project was introduced in 2007 as a subset of the Road Transport Management System (RTMS), to increase heavy vehicle safety and road transportation efficiency. The pilot project is nearing the completion of phase one, 100 million PBS vehicle kilometres. The project has shown significant improvements thus far with a reduction in the crash rate of 35.4% vs the RTMS-certified baseline fleet. Significant financial savings have also been recorded with a weighted average reduction in trips of 28.5% and an average 10.8% reduction in fuel consumption. The project has thus far shown the possibility, in conjunction with RTMS, to decrease the transportation GDP by as much as several percentage points given mass adoption which directly translates to savings per annum to the South African economy in the billions of Rand. This paper discusses the possibility of implementing the Smart Truck project nationally, as well as its potential pitfalls. Initial indications, however, showed that the Smart Truck project has the possibility to significantly improve both the safety and efficiency of the transportation sector, with little cause for concern.

1 INTRODUCTION

1.1 Background

Transport logistics in South Africa is the backbone of the economy, representing 11.8% of GDP in 2016 or approximately R499 billion (Havenga, Simpson, King, De Bod, & Braun, 2016). Road freight transport, in particular, is essential to logistics, as approximately 85% of general freight is transported via this mode. The costs of logistics in South Africa's since 2003 are shown in Figure 1-1.

Although the percentage contribution towards GDP has decreased since the peak 2008 it is still significantly higher than many developed countries, as shown in Figure 1-2 (Havenga, Simpson, King, De Bod, & Braun, 2016). For South Africa to remain competitive on a global scale, it is imperative that the cost of logistics is reduced. This is even more necessary given global economic and political instability coupled with looming crises in the form of lack of sufficient education and training (Havenga, Simpson, King, De Bod, & Braun, 2016).

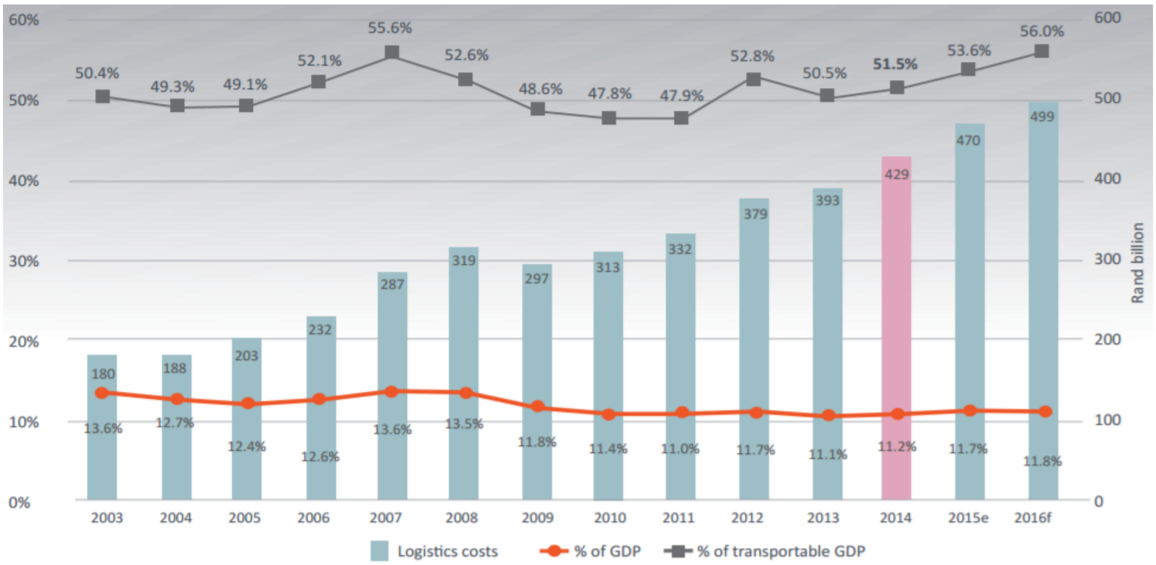

Figure 1-1: Cost of logistics in South Africa since 2003 (Havenga, Simpson, King, De Bod, & Braun, 2016)

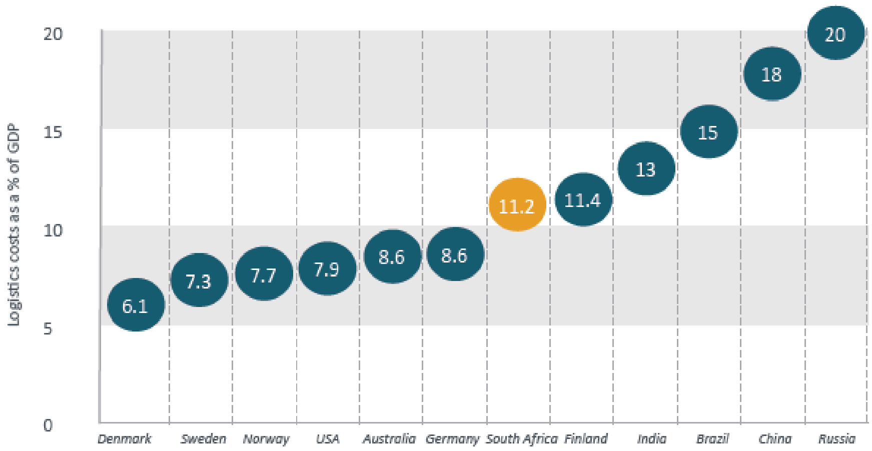

Figure 1-2: Comparison of logistics costs as a percentage of GDP for selected countries (Havenga, Simpson, King, De Bod, & Braun, 2016)

Logistics safety and efficiency in South Africa has long been overlooked and neglected, which has led to rising costs and excessive road fatalities compared to global standards. **Error! Reference source not found.Error! Reference source not found.** illustrates that the truck fatality rate of South Africa was 12.5 deaths per 100 million vehicle kilometres travelled in 2005. This is more than 4 times higher than the next worst performing country considered during the study (OECD, 2011). A 2015 Road Transport Management Corporation (RTMC) study also recorded that 26.8% of road deaths are attributed to heavy and commercial vehicles (Road Traffic Management Corporation, 2015).

1.2 Road Transport Management System (RTMS)

Since 2003, the CSIR with government and industry partners, have pioneered numerous solutions to combat these road transport challenges. The Road Transport Management System (RTMS) is an accreditation as defined in SANS 1395:2014. The RTMS scheme is an industry-led, government-supported, voluntary, self-regulation scheme that encourages consignees, consignors, and road transport operators to implement a management system

Table 1-1: Persons killed in truck crashes per 100 million km travelled (OECD, 2011)

Country	Truck Fatalities per 100 million vehicle kilometres travelled	Year	Country	Truck Fatalities per 100 million vehicle kilometres travelled	Year
South Africa	12.5	2005	Australia	1.7	2005
Switzerland	0.8	2005	Canada	2	2005
Belgium	1.9	2005	Sweden	1.6	2005
United States	1.5	2005	Great Britain	1.7	2005
France	2	2005	**Denmark**	**3**	2004
Germany	1.5	2006			

(a set of standards) that demonstrates compliance with the Road Traffic Regulations and contributes to preserving road infrastructure, improving road safety and increasing productivity. Currently, there are in excess of 10 000 RTMS-certified vehicles, representing over 200 private and government fleets. RTMS has resulted in greater than a 30% reduction in transportation costs, as well as a 60% reduction in crash rates of participating vehicle (Road Transport Mangement System). Since its inception in 2003, fewer than five fleets have opted to withdraw from the scheme due to the resultant benefits (Road Transport Mangement System). The Logistics Barometer report of 2016 has also indicated that RTMS is essential for improvements in logistic efficiencies, truck safety and driver performance (Havenga, Simpson, King, De Bod, & Braun, 2016).

1.3 Smart Trucks (Performance Based Standards)

In addition to the RTMS initiative, the CSIR, with support from other partners including Wits University, University of KwaZulu-Natal, SANRAL, the national Department of Transport (DoT) and the KZN Department of Transport (KZN DoT), have developed the Smart Truck pilot project, also referred to as the Performance-Based Standards (PBS) pilot project. The Smart Truck pilot project has been operational since 2007 and is linked to the RTMS scheme, with RTMS-certification being a prerequisite for participation in the pilot project.

PBS is an alternative to traditional prescriptive heavy vehicle legislation, where the vehicle design limitations are more flexible. PBS offers the heavy vehicle industry the potential to achieve higher productivity and safety through innovative and optimised vehicle design. PBS vehicles are designed to perform their tasks as productively and sustainably as possible, but at the same time ensuring a minimum level of vehicle safety performance. The PBS project also ensures that vehicles operate on road networks that are appropriate for their level of performance. PBS, therefore, ensures a better match between vehicles and the roads, as well as the freight task (National Heavy Vehicle Regulator, 2017). Each PBS vehicle is required to undergo a thorough vehicle dynamics safety assessment, and a road wear impact analysis through the use of computer modelling.

The Pilot project was launched in Dec 2007 with two vehicles in the timber industry. By December 2016, there were 218 operational PBS vehicles participating in the pilot project. One of the objectives of the pilot phase was to complete 100 million kilometres, and to monitor crucial metrics such as crash rates and transport efficiency. This target will be reached during the course of 2017. This paper investigates the progress of the PBS project to date and illustrates the significant impact that it has had on transport safety and efficiency. A further discussion on the potential impact the PBS project can have if it were to be implemented nationally is given, along with an overview of the barriers to entry and a proposed route map.

1.4 Aim

This paper provides a summary of the Smart Truck pilot project performance as the first phase of the project nears completion. The paper further discusses issues related to the possible implementation of PBS through national legislation. Barriers to entry and possible pitfalls are also briefly discussed.

1.5 Scope

This study only focuses on the progress of the Smart Truck Pilot project since its inception in 2007. PBS car-carriers and buses are excluded from this study, with a focus on a specific set of metrics relating to the performance of the Smart Truck pilot project according to the monthly monitoring data. Simple extrapolations will be made to assess the possible impact of PBS if it is included in national legislation. A high-level financial analysis of the potential impact of the Smart Truck project is also given.

2 METHOD

All Smart Truck operators are required to submit specific data, relating to vehicle safety and efficiency, on a monthly basis to the CSIR. The parameters measured per vehicle include:

- Kilometres travelled;
- Number of trips;
- Tonnes transported;
- Average combination mass; and
- Fuel consumed.

These parameters are measured for both the Smart Trucks and baseline vehicles that operate on the same or similar routes, transporting the same commodity.

The crash and fatality statistics have to be recorded for an operator’s entire fleet and are classified as either caused by the operator or by a third party.

The data is validated each month using simple statistical analysis to check if there are any outliers. This includes ensuring that certain calculated variables do not differ more than 5% from the specified value such as the vehicle tare mass. Other values are validated by ensuring that the data doesn’t differ more than 5% to 10% from previous months or is flagged if it is located more than 2 standard deviations away from other data points. Visual inspection is also done on critical values that have historically been found to be subject to large errors. Incorrect values are corrected by the operator before they may submit their data for the following month.

Analysis is performed for each operator by assimilating and transforming the data to the most important metrics. These metrics are calculated for the PBS and baseline fleet for each individual operator. The savings and comparisons are only done intra-fleet per operator to ensure that the vehicles have similar operating conditions such as routes, training, loading practices etc., and to eliminate as many possible sources of variation/error as possible. All savings are then totalled.

The data from all operators are assimilated and transformed to track the most important metrics. Error checks have been incorporated into this process to ensure that data are correctly represented.

3 RESULTS AND DISCUSSION

3.1 Smart Truck Progress Analysis

At the end of February 2017, approximately 92.4 million monitored kilometres had been completed by PBS vehicles. The cumulative kilometres travelled are shown in Figure 3-1. During 2016 and 2017, the Smart Truck fleet completed 2.1 million kilometres on average per month. It is evident that the Smart Truck Pilot project is growing at an exponential rate and will complete the target of 100 million kilometres during the second quarter of 2017.

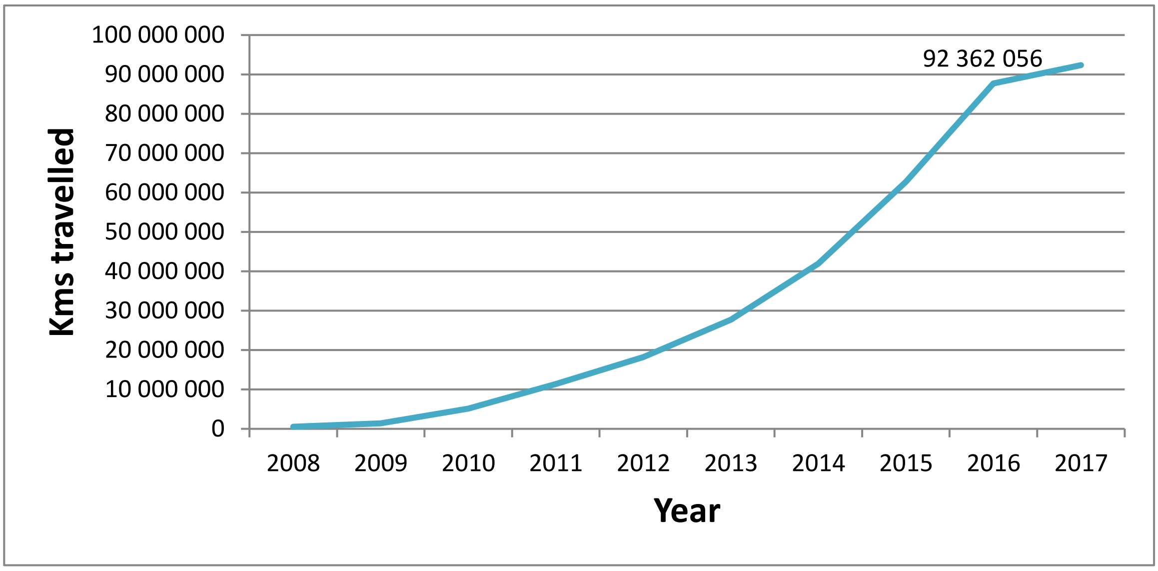

Figure 3-1: Cumulative kilometres travelled by Smart Trucks

At the end of February 2017, there were 215 operational PBS vehicles, but there were approximately 233 registered PBS vehicles at the time. Table 3-1 provides a summary of the maximum number of operational vehicles in each province per commodity during 2016 and 2017. It should be noted that some vehicles transport multiple commodities or operate in more than one province which leads to duplication and hence the actual total is also included. It can be seen that the PBS project has yet to be implemented in all provinces, with KZN hosting the largest number of Smart Trucks with a total of 144 operational vehicles during 2016 and 2017. There is also a large spread of industries and commodities represented in the project, although the majority of vehicles are concentrated in timber and mining.

Table 3-1: Total number of Smart Trucks per Province During 2016 and 2017

Commodity/Industry	E.Cape	W.Cape	N.Cape	Mpum.	Gauteng	Limpopo	KZN	FreeState	N.West	Total
Timber	0	0	0	37	0	0	71	0	0	**108**
Sugar Cane	0	0	0	0	0	0	3	0	0	**3**
Processed Sugar	0	0	0	0	0	0	18	0	0	**18**
Paper Reels	0	0	0	0	0	0	1	0	0	**1**
Mining	0	5	2	12	0	46	19	0	0	**84**
Aluminium Ingots	0	0	0	0	0	0	10	0	0	**10**
Fuel	0	0	0	0	0	0	20	0	0	**20**
Cattle	0	0	1	0	0	0	0	0	1	**2**
Beer	0	0	0	0	0	0	2	0	0	**2**
Buses	0	0	0	12	0	0	0	0	0	**12**
Total	**0**	**5**	**3**	**61**	**0**	**46**	**144**	**0**	**1**	**260**
									Actual Total	**233**

Error! Reference source not found. and **Error! Reference source not found.** illustrate the mass and length distributions of the registered PBS vehicles, excluding road trains that operate on dedicated routes not accessible by the public. It can be seen that more than half of the vehicles have a combination mass of fewer than 68 tonnes and that there is only one combination that exceeds the 80 tonne limit. Similarly, approximately two-thirds of operational Smart Trucks are less than 24 m in length. This represents less than a 10% increase in overall vehicle length compared with the legal prescriptive limit of 22 m.

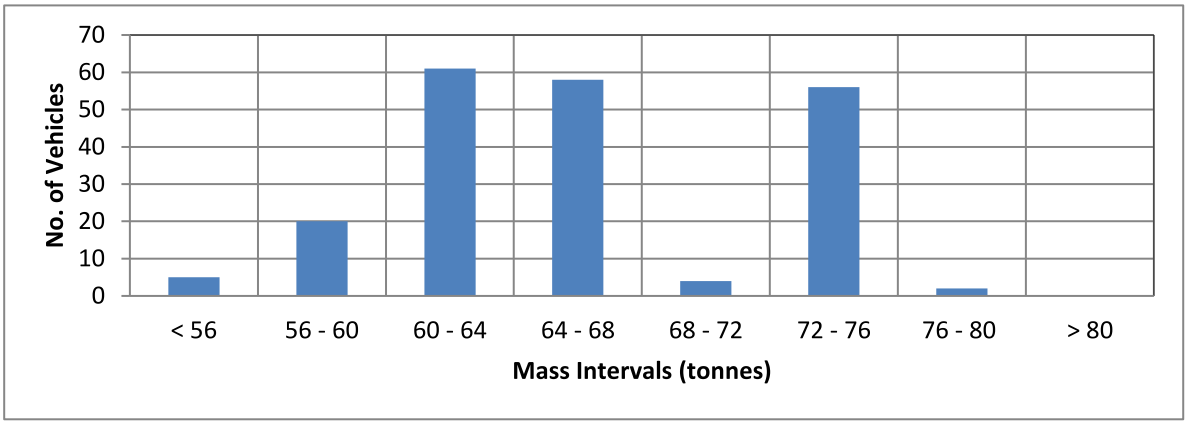

Figure 3-2: Distribution of combination mass of Smart Trucks

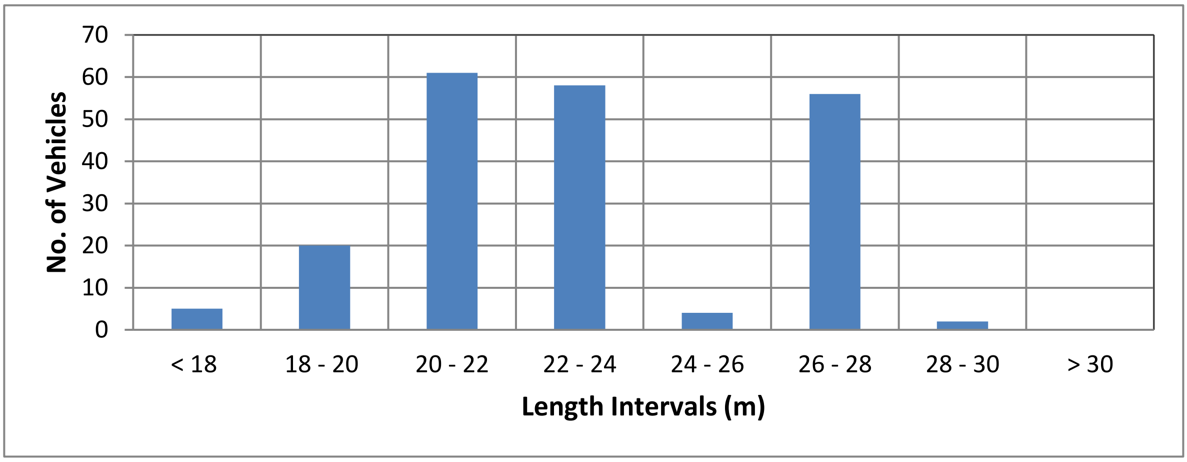

Figure 3-3: Distribution of combination length of Smart Trucks

The Smart Truck fleet has shown significant productivity benefits for vehicle operators and the transport industry in general. By the end of February 2017, the Smart Truck fleet had saved approximately 299 587 trips. The average trip savings during 2016 and 2017 for all vehicles was 37%. The weighted average trips saved was approximately 28.5% when considering the total distance travelled by each vehicle. Reduced trips imply that fewer trucks are on the road, the trucks are able to move the same volume and mass of freight. A 28.5% reduction would imply that more than 1 in 4 heavy vehicles could be removed from the road to transport the same volume and mass of payload. Even in this relatively small test sample, in excess of 33.3 million vehicle kilometres have been saved. This has the potential to substantially reduce road congestion, crashes, road fatalities, pollution and damages to the road infrastructure. It should be noted that all Smart Trucks are required to perform less road damage per tonne of payload compared to the current baseline vehicle used for the freight task. Reduced road wear implies less damage to the road infrastructure when moving the same amount of freight. Smart Trucks are also not allowed to exceed the legal axle and axle unit mass limits, with strict overload control on both axle unit loads as well as total combination mass.

The Smart Trucks have similarly resulted in significant savings of fuel per tonne of payload transported. Figure 3-4 illustrates that at the end of February 2017, the Smart Truck fleet had saved approximately 8.9 million litres of diesel and it is projected that approximately 10.6 million litres will be saved by the end of 2017. During 2016 and 2017, Smart Trucks saw an average fuel saving of 10.3% with a weighted average fuel saving of 10.9% when considering total distance travelled. In 2014, fuel costs accounted for approximately 40% of the total road transport costs. (Havenga, Simpson, King, De Bod, & Braun, 2016).

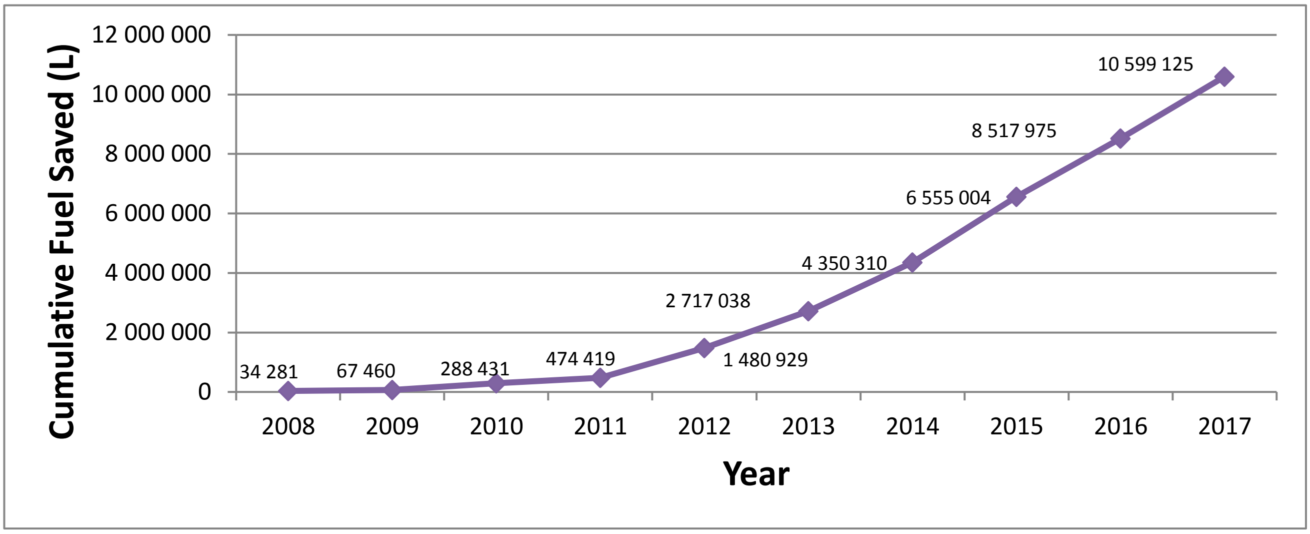

Figure 3-4: Cumulative fuel saved by Smart Trucks

The Smart Truck initiative could, therefore, have a marked effect on the cost of logistics in South Africa. In 2009, there were already more than 320 000 registered heavy vehicles on the South African roads (Arrive Alive, 2017). If for example, 10% of the total fleet were PBS vehicles, the road freight transport GDP could drop in excess of 0.4%, with an equivalent value of R2 billion. The reduction in fuel consumption would have a direct impact the environment, with an approximate reduction of 23 648 tonnes of CO_2 emissions saved directly from the reduction in fuel consumption. This values is obtained by using a conversion value of 2.67 kg CO_2 per litre of diesel combusted (Conversion Factors-Energy and Cabon Conversions 2011 Update, 2017).The reduction in CO_2 emissions from the road transport sector will have a significant contribution towards South Africa meeting its emissions targets, as agreed upon at the Paris Global Emissions Summit in 2015 (United Nations Framework Conventionon Climate Change, 2017). Further reductions in emissions are made due to reductions in various oxides produced during diesel combustion. Prices do however vary substantially, but at the time of writing, the value was R120/tonneCO_2 (CredibleCarbon, 2017). The RTMS and PBS initiatives could, therefore, result in significant transport efficiency improvements and associated financial benefits for operators and the SA economy in general.

As mentioned previously, the heavy vehicle crash rates and fatality statistics for South Africa are substantially higher than many countries around the world. The Smart Truck vehicles have recorded a reduction in crash rate of 56% when compared with the baseline vehicles, as shown in Figure 3-5. It should be noted that all baseline vehicle are from RTMS accredited fleets, which has already shown an approximate 60% reduction in crash rates over non-RTMS accredited vehicles (Road Transport Mangement System). This would imply that the Smart Truck crash rate is approximately 75% less than that of the non-RTMS accredited fleet. In 2013, road crashes accounted for approximately 0.8% of South Africa's GDP, or R4 billion (Viljoen, 2013). The Smart Truck Project has shown the potential to significantly reduce the cost of logistics by improving transport efficiency, reducing fuel consumption as well as a reduction in accidents.

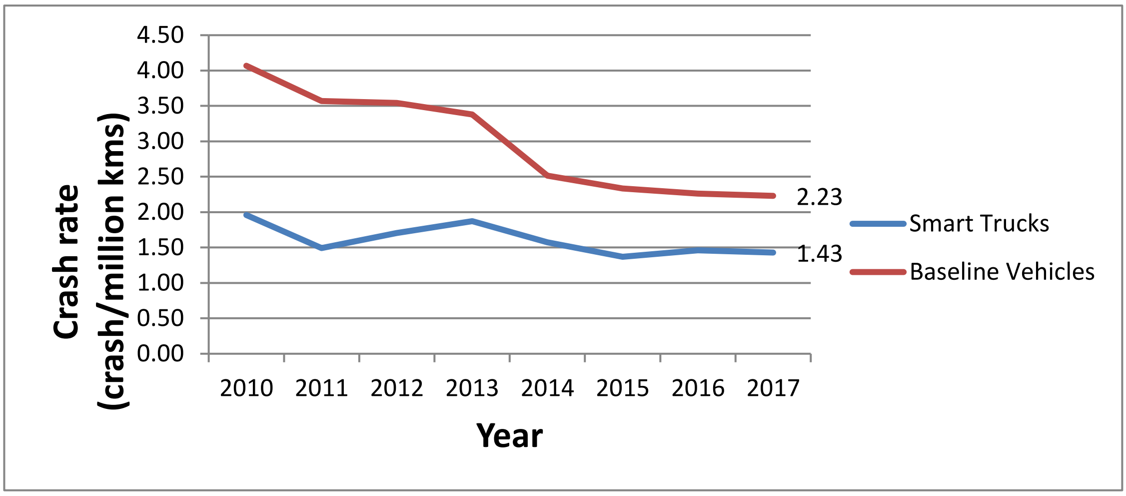

Figure 3-5: Crash Rates for Smart Trucks and Baseline Vehicles

At the end of February 2017, 57% of Smart Truck crashes were caused by third party error. Similarly, 57% of crashes were caused by third party error when considering baseline vehicles. This result shows that there is no significant difference in the way in which the general public interacts with PBS vehicles compared with baseline vehicles. Concerns have been raised that longer and heavier vehicles may increase third party accident rates due to the fact that the general public may not comprehend the increase in time to overtake longer vehicles. These results, however, indicate that this is not necessarily the case and there is little need for concern over increased vehicle length on the approved routes. The reduction in risk due to increased vehicle safety as well as the reduction in the number of vehicles required to transport the same freight offsets any risk posed by an increase in vehicle length.

Currently, there is insufficient data to determine a statistically significant conclusion on the fatality rate for Smart Trucks. It should, however, be noted that to date approximately 86% of Smart Truck-related fatalities have been caused by reckless third party error.

As previously stated, a statistical analysis is performed on the data, with associated visual inspection on key parameters. For example, the calculated tare mass and average payloads are not allowed to deviate more than 10%. In general, the variations are significantly less (typically less than 5%) due to loading practices a result of the RTMS requirements. Outliers and incorrect values are easily detected and corrected. All post processing has been automated and therefore there are no human errors associated with the data. Therefore there is a high level of data integrity.

Other savings that have not been included in this paper include:

- Time savings due to reduced congestion due to high traffic volumes and crashes;
- Road damage savings;
- Logistics savings due to increased quality of road surface leading to reduced freight damage;
- Productivity and life years saved due to reduced fatalities and injuries; and
- Savings to the economy due to a reduction in crashes and fatalities, such as reduced insurance claims and RAF pay-outs.

3.2 Future of Smart Truck pilot project and potential pitfalls

The first milestone for the Smart Truck Pilot project is to complete 100 million monitored kilometres. This will provide all of the relevant stakeholders with sufficient data to make an informed decision on the future implementation of this project. These stakeholders include the national and provincial DoT, as well as the roads and infrastructure authorities. Current metrics show that the Smart Truck project is accomplishing its initial goal of increasing road freight transport safety, whilst simultaneously increasing transport efficiency and decreasing infrastructure damage as a result of a marked decrease in overloading.

The current issues and research questions include:

- Detailed analysis of the influence of Smart Trucks on the road infrastructure when considering horizontal and longitudinal forces during braking and acceleration;
- Detailed analysis of the influence of Smart Trucks on certain structures (specifically older bridges using older design codes); and
- Limited availability of heavy vehicle tyre data.

These and other questions are currently being investigated by the CSIR and other collaborators, although initial indicators show no current cause for concern. Currently, an extension of an additional 50 million kilometres has been proposed in order to answer the remaining questions and to allow for PBS vehicles to be represented in all provinces.

The CSIR has also been involved in discussions on the development of an international standard for PBS. This would include three pillars namely PBS standards, accreditation schemes (such as the RTMS) and intelligent monitoring of PBS vehicles. South Africa will no doubt play a role in the development of this standard due to the experience gained and detailed data recorded from the PBS pilot project.

Should the pilot project be signed into national legislation, it is expected that there would be mass adoption of this system. As RTMS accreditation is required to partake in the PBS initiative, a significantly larger portion of the RSA fleet is expected to become RTMS compliant. This would see a substantial decrease in transportation costs as well as crash and fatality rates, adding tremendous value to the South African economy. It will also be necessary to establish significantly more capability in heavy vehicle performance and infrastructure analysis. In addition to this, it will be necessary to establish a competent back office to undertake the large administrative requirements such as ensuring adherence to the requirements.

4 CONCLUSION

The Smart Truck Pilot project is nearing the completion of phase one, 100 million monitored kilometres. The project currently has in excess of 200 operational vehicles across multiple provinces and industries. PBS Smart Trucks have recorded a 55% reduction in crashes vs RTMS-certified baseline vehicles, illustrating the improvement of safety. The pilot project has also shown significant efficiency and productivity benefits such as a 28.5% average weighted reduction of trips. The PBS initiative has the possibility to reduce the road transport GDP by a few percentage points, equating to several billion Rand per annum.

There are a number of research questions posed in section 3.2 that need to be answered regarding the impact of Smart Trucks in various categories in order for all stakeholders to make an informed decision on the implementation of the PBS initiative. Initial research, addressing these questions, has thus far shown no cause for concern on the national implementation of the PBS initiative.

5 RECOMMENDATIONS

In order to increase the accuracy of recorded data, and to increase the parameters being measured, it is recommended that the logging of vehicle data be automated from the telematics systems installed on all Smart Trucks. This will allow for automated recording of all the specific metrics relating to Smart Truck operations. This data could also be used to monitor compliance of the Smart Truck vehicles, such as geo-fencing approved routes, speeding and overloading, and in addition, may be used to identify possible areas for improvement and optimisation. This could see further reductions in transport costs and further opportunities for innovation.

More detailed analysis of the current data using data science techniques will provide greater insights into the impact of the Smart Truck initiative, as well as the impact the project would have on the transport industry as a whole. This will require collaboration with transport economists.

The remaining questions regarding the Smart Truck initiative are currently being researched, but require significant investment. These questions will be prioritized so that all stakeholders will be able to make informed decisions with regard to the national legislation of the Smart Truck initiative. If this were to happen, it will be necessary to establish significantly more capability in heavy vehicle and infrastructure analysis. It is, therefore, advantageous to collaborate with tertiary institutions in providing additional training and opportunities in these fields of study.

REFERENCES

Arrive Alive. (2017, February 22). *Vehicle statistics in South Africa 1 November 2009*. Retrieved from http://carinsurance.arrivealive.co.za/vehicle-statistics-in-south-africa-1-november-2009.php

Conversion Factors- Energy and Cabon Conversions 2011 Update. (2017, April 26). Retrieved from Carbon Trust: https://www.carbontrust.com/media/18223/ctl153_conversion_factors.pdf

CredibleCarbon. (2017, February 22). Retrieved from CredibleCarbon: https://www.crediblecarbon.com/mechanics/allocated.php

Havenga, J., Simpson, Z., King, D., De Bod, A., & Braun, M. (2016). *Logistics Barometer 2016 South Africa.* Stellenbosch: Stellenbosch University.

National Heavy Vehicle Regulator. (2017, February 20). *About Performance Based Standards*. Retrieved from https://www.nhvr.gov.au/road-access/performance-based-standards/about-performance-based-standards

OECD. (2011). *Moving Freight with Better Trucks: Improving Safety, Productivity and Sustainability.* Paris: OECD Publishing.

Road Traffic Management Corporation. (2015). *Summary of Road Fatalities.* Pretoria: RTMC.

Road Transport Mangement System. (n.d.). *RTMS-SA*. Retrieved from http://www.rtms-sa.org/

United Nations Framework Conventionon Climate Change. (2017, April 26). Retrieved from The Paris Agreement: http://unfccc.int/paris_agreement/items/9485.php

Viljoen, N. (2013). *10th Annual State of Logistics Survey for South Africa.* Pretoria: CSIR.