THE EVOLUTION OF THE PERFORMANCE BASED STANDARDS URBAN RIGID TRUCK

KEN COWELL
Advanced Engineering Diploma QIT, Diploma (Business) Bremer Institute. Internationally recognized truck engineer and national PBS expert and Certifier. Director Heavy Vehicle Industry Australia

KIM HASSALL
Consulting academic, University of Melbourne Department of Infrastructure Engineering. PhD and Masters by research in Freight productivity. Foundation Chair NTARC. Director Industrial Logistics Institute

Abstract

The development of the Performance Based Standards (PBS) scheme in Australia began in the 1997/98 period. In 2006 the scheme was agreed by federal and State ministers although a significant number of High Productivity Vehicles (HPVs) had been operating successfully under State permit schemes prior 2006. With one exception, all the HPVs were heavy rigid trucks with trailers or longer articulated combinations such as Super B-Double, B-triples, or newer road train combinations often referred to as A-Doubles. However, in 2003 (Hassall, 2003) proposed a longer rigid truck for urban operations and this special design was also approved under permit after being performance modeled by ARRB in 2004, (Hood and Cristoforo). The vehicle was designed for the Australian Postal Corporation which arguably has the largest urban delivery networks in Australia.

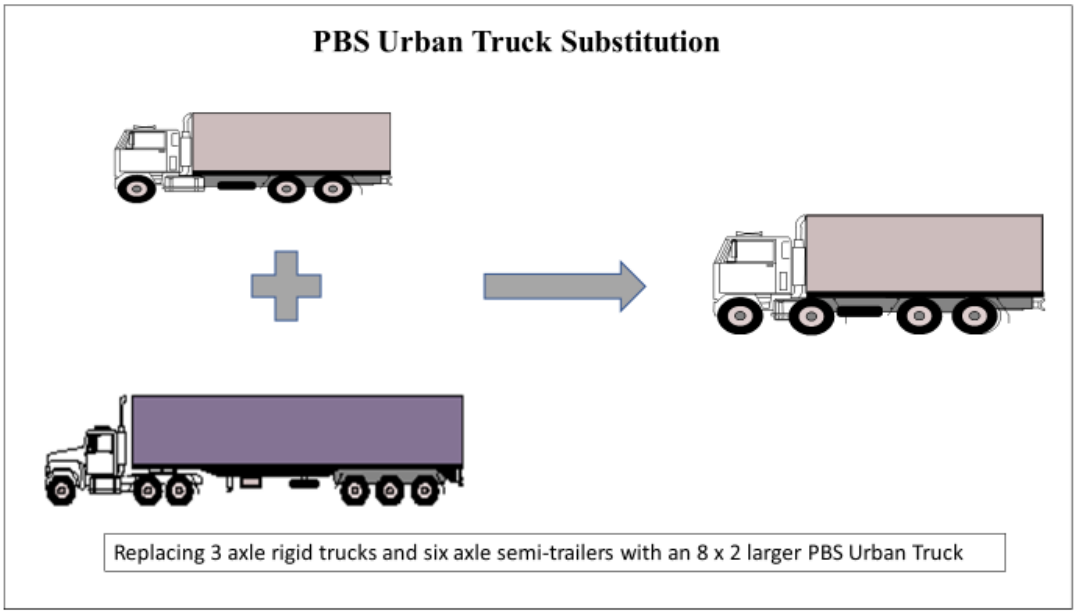
The concept behind the PBS urban vehicle, which is an almost 14 metre rigid truck with four axles, one being a drive axle, was twofold: firstly, as a replacement vehicle for the large number of fleet three axle rigid vehicles, not in combination, (up to 28 tonnes Gross Vehicle Mass) and secondly, as a replacement for a large number of decommissioned linehaul semi-trailers, six axle articulated combinations, that were now undertaking urban work. Many of these articulated vehicles had access restrictions. It was estimated that this new vehicle could save the national postal authority some six million kilometres per annum in major city travel, (NTC, 2005). In the face of massive growth domestically and internationally in urban e-commerce activity, this concept and introduction, of a new urban delivery truck is timely for manufacture consideration and introduction.

Keywords: High productivity truck, urban freight, rigid Performance Based Standards truck, urban deliveries, innovative urban truck, e-commerce truck.

1. Introduction

The original concept for the Performance Based Standards (PBS) urban rigid truck emerged from Australia's largest urban network operator, the Australian Postal Commission, in 2003. There was an opportunity to use another rigid truck configuration that was larger than the conventional 3 axle rigid vehicle (12.5 metres with 22.5 tonne GVM) but smaller than the next largest fleet vehicle that was decommissioned semi-trailers (19 metres with 42.5 tonne GVM) that were used in low kilometre urban operations when capacity greater than the 3 axle rigid truck was required. Figure 1 reflects the eventual configuration of rigid truck that would be experimented with and is the subject of this paper.

Figure 1: What the new Urban PBS rigid truck will replace



Source: (Hassall, 2003)

2. The Urban PBS Rigid Truck evolution so far

The original specification for the PBS longer urban urban rigid vehicle proposed a: twin steer 8 x 2 rigid truck, 4.1 metres high, of length 14.85 metres that could carry 40, one cubic metre, mail cages. These particular stillages are refered to by the postal authority as unit load devices or ULDs. This was the capacity of the existing semi-trailer used in the urban and regional environments. As well this vehicle could replace a significant fraction of smaller rigid trucks whose capacities were 28 mail cages. Initial estimates could see a reduction of 25% of the existing rigid fleet. The proposed Prototype 1 vehicle is a volumetric vehicle where the freight cargo units were no greater than 400 kilograms per stillage unit. It is to be reiterated that the growth in the e-commerce market essentially is comprised of parcels that move between warehouses to distribution centres before smaller vehicle delivery. Parcels are essentially a volumetric task thus allowing a higher capacity urban rigid truck to be an ideal choice for this rapidly growing urban e-commerce task

Table 1: Comparing the proposed Urban PBS Truck an the prototypes it will replace

Truck Type	3 Axle Truck	Local Semi-Trailer	Prototype 1	Prototype 2	Prototype 3
Status	Operational	Operational	Proposed	Operational	**Proposed**
Length	12.5m	19.0m	14.85m	12.85m	13.56-13.9m
Capacity	28 Stillages	40 Stillages	40 Stillages	36 Stillages	40 Stillages
Configuration	6 x 4	6 x 4 + trailer	8 x 2	8 x 4	8 x 2
Ave km/yr[1] (Client)	76,680	< 20,000	> 90,000	156,000	> 90,000
Ave km/yr [2] (National Average)	27,196	71,510	33,020	<40,000	<40,000
Fuel Consumption (l/100kms)	29.50	44.80	31.57	33.14	31.57
Stillages (Client) [3]	28	40	40	36	40
Low Speed Off Tracking	5.87m	6.61m	6.95[4]m	6.07m	7.39[5]m
Outer axle turning radius	<12.50m	12.21m	11.25m [4]	<12.50m	<12.50m[4]

Notes: 1. Australia Post Fleet (pers Comm), 2.ABS Special Data cubes. 3. Client Truck capacity. 4. With 49° Steer Angle, 5. With 45° Steer Angle

Table 1 presents the operating characteristics of the prototype proposals for the new, 'Prototype 3' urban truck and compares it to three operational fleet vehicles: a 3 axle rigid truck, and local 19 metre semi-trailer, as well as a comparison to the actual operational 'Prototype 2' vehicle. See Figure 2.

Figure 2: Proposed Prototype 1 and the actual operational Prototype 2 of the Urban PBS Rigid Truck

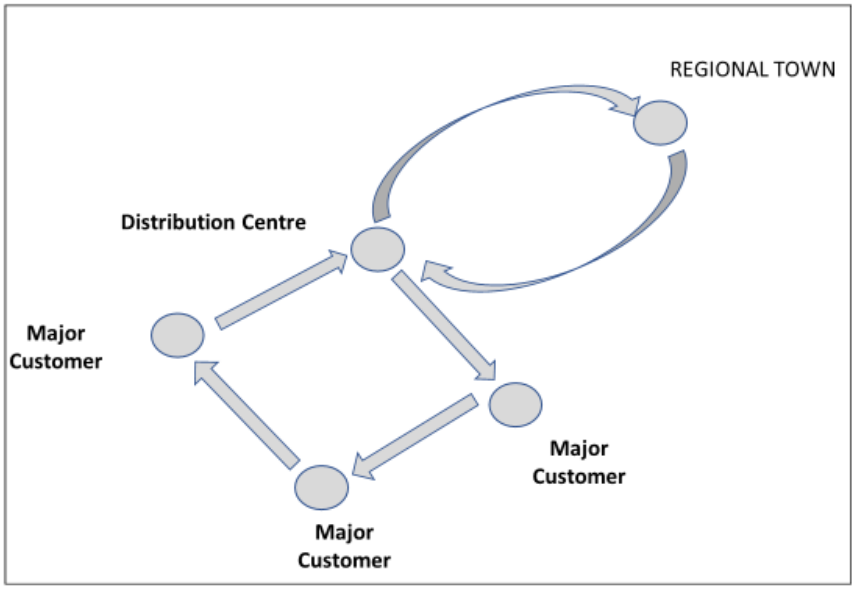
Source: Australia Post Transport 2003 and 2009 respectively

It should be noted that although the actual operational Prototype 2 vehicles only managed 36 and not the original target of 40 stillages the kilometre performed by this vehicle were outstanding. Compared to a standard 8x4 rigid truck whose kilometres were less than 40,000 kilometres per annum in Australia, this proto type performed 156,000 kilometres per annun. This was much further than either 3 axle rigid trucks or even 6 axle semi-trailers in Australia.

It is worth understanding how this level of utilization was achieved. Unlike the smaller 3 axle rigid truck the PBS Prototype 2 vehicle would be scheduled to move between a major distribution centre, and several major customers, on daily scheduled duties. Usually one daily

return service was despatched to a regional town that was often 150 kilometres away, or further
In this way this prototype vehicle not only performed urban operations but also regional linehaul operations. These trips were reflected in the 156,000 annual kilometres performed. See Figure 3.

Figure 3: Urban and Regional workload of the Prototype 2 Urban PBS Truck



The current, third evolved proposal, Prototype 3, is for a low cab forward, twin steer 8x2 rigid truck with a retractable rear axle, 4.3 metres high, with a length between 13.5 to 14.0 metres. (See Figure 4) The body design could carry 40 euro sized pallets, or 32 Australian sized pallets again being volumetric at 400 kilograms per pallet unit with maximum height of 1.5 metres. Attaining the actual 40 volumetric unit load devices (mail cage stillages) was a critical feature to this concept vehicle. This capacity will vary though for larger pallet dimensions.

Figure 4: Proposed Prototype 3 – the 13.5 - 14m Urban PBS Rigid Truck

Source: KC&A and Industrial Logistics Institute

Table 2 reflects to carrying capacity for different size cargo units (stillages). Again, it must be emphasized that this proposed Prototype 3 vehicle is a 'volumetric' carrier and limits have been placed on cargo unit weight and height. The maximum vehicle length would be 14 metres and the maximum GVM when carrying full capacity would be 29 tonnes GVM, although having volumetric cargo units, all utilizing the maximum unit weight, is usually not achieved in volumetric freight operations.

Table 2: Stillage capacity and major dimensions for Prototype 3 of the PBS Urban Rigid Vehicle

Stillage type and other vehicle characteristics	Number of stillages	Stillage Length X Width	Stillage Height	Stillage Weight
Mail Stillages	40	1000 x 1000mm	=1.0m	<= 400kgs
Euro Pallets	40	1000 x 1200mm	< 1.5m	<= 400kgs
Australian Pallets	32	1165 x 1165mm	< 1.5m	<= 400kgs
Max Vehicle Length	na	14 metres	na	na
Max Vehicle weight	na: a	na	na	29 T GVM

Notes: na, not applicable

3. Modeled Outcomes for the national Post Office

3.1 The simulation modelling for the PBS urban network truck showed a productivity gain of 42% over existing rigid urban vehicles, a reduction of up to 20% of the rigid fleet, a complete reduction of the urban articulated semi-trailer fleet and a potential saving of 6 million kilometres per annum in metropolitan truck travel in Australia. (NTC, 2005). In 2007 the original concept design won a prestigious research award at Australia's leading research university (UoM, 2007) when the impact of such a vehicle was modeled demonstrating the benefits in lowering 'urban freight exposure' through the vehicle's productivity benefits which enabled both reductions in fleet numbers and in fleet growth.

3.2 The safety aspects of this vehicle are also important. Replacing urban articulated vehicles with a rigid vehicle will lessen the associated damage with high impact collisions in city areas. Also, even the operational Prototype 2 urban vehicle demonstrated exceptional safety results over the first two years of its urban and regional operations attaining a claim free accident record. (Austroads, 2014). As of 2018 the safety record for this vehicle remains unblemished.

4. Modeled Outcomes for other operators

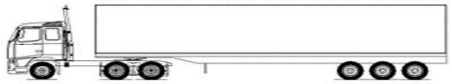
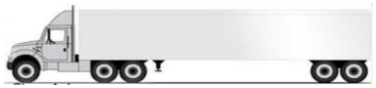
The following case study examines:

- moving a daily task of 220 cargo pallets over a distance of 55 kilometres from a highdensity city to the peri-urban fringe of that same city.
- The configurations are a 6 axle 17.8 metre tractor and tri axle trailer, a 15.5 metre tractor and tandem axle trailer, a 13.5 metre four axle 8 x 2 rigid truck, and an 11.5 metre three axle rigid truck,

- the trip would be a 110 kilometre return journey.
- Pallets will not be double stacked but will be carried two wide in each of the truck configurations
- Pallets used are the Australian dimensions of 1165 mm square,
- Pallet weight, using maximum space capacity, will range from 700 kilograms to over 1300 kilograms. Note that for comparative purposes the new ‘prototype urban e-commerce’ rigid truck will be mostly carry volumetric pallets or other stillages.

Figure 5 examines the comparative task when large Australian sized pallets (1165 x 1165mm) are carried by the different configurations for the 220 daily pallet task. Figure 5 only examines truck carrying capacity with single stacked pallets. This is often true for urban operations as pallets can weigh over 1 tonne and be 0.75 metres high. This forces single stacked operations. It also often allows quicker unloading. This figure also suggest that the 8x2 four axle rigid PBS urban truck is well suited for volumetric operations and has been stated previously volumetric pallets less than 1.5 metres tall and 400 kilograms are common, especially in urban e-commerce distribution centre operations.

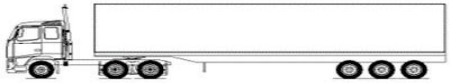
Figure 5: Comparison of urban operations for fuel consumption and pallet carrying capability

Fuel Consumption (litres).	Length (metres)	GCM (tonnes)	Payload (tonnes)	Pallet Capacity "Single Level only"	Vehicle Type
2.2 km/l	17.80 m	46.00 t	29.00 t	22	
2.4 km/l	15.50 m	40.50 t	24.50 t	18	
2.8 km/l	13.5- 14.0 m	+25.50[1] t	12.75 t	18	
3.0 km/l	11.50 m	23.50 t	11.50 t	14	

Notes: 1. Assuming the NHVR allows the same axle weight as that given to a bus + HML allowance, would be 24.00t
Under HML GCM could reach 28 tonnes GVM allowing heavier pallets to be carried.

Figure 6 shows the comparison in fleet size to undertake the task with either the two local semi-trailers or the two urban rigid trucks. Although the 8x2 four axle rigid truck is less efficient than the two semi-trailers it is certainly more productive than the three axle rigid truck. The target 8x2 four axle rigid truck does use less road space than two the three other vehicles. In many cases within inner urban operations the two local semi-trailers may well have access problems that can be avoided with a shorter rigid vehicle. The purpose of the new 'prototype rigid vehicle' is in fact to replace both a significant number to local semi-trailers and three axle rigid trucks doing urban operations.

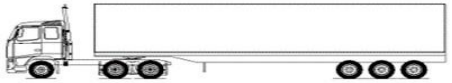
Figure 6: Urban and Regional workload of the Prototype 2 Urban PBS Truck

Number of Trucks.	Space on Road [1]	GCM (tonnes)	Pallets	Vehicle Type
10	583.3m	460 t	220	
10	681m	486 t	216	
12	657m	300 t	216	
15	802.5m	337.5t	210	

Note: 1. Recommended distance between trucks over 7.5m in length @ 80kph = 2 seconds = 45 m, used for 'space on road' calculation, *Source: K Cowell & Associates 2018*

Figure 7 depicts the fuel consumption and emissions' comparison for the two articulated local semi-trailers, and the two rigid truck configurations. For the 220 pallet task being examined, the PBS urban rigid truck performs only 4.2% worse than the six axle local semi-trailer on a CO2 emissions basis and only 4.7% worse than that same truck on a fuel consumption basis. As has been mentioned previously, there are many operational and price reasons that the proposed 13.5 – 14 metre PBS urban vehicle would be operationally preferable to an articulated vehicle and certainly be preferable when compared against a three axle, urban rigid truck.

Figure 7: Urban environmental comparisons for two articulated and two rigid truck operations

Number of Trucks	Fuel Consumed (Litres)	NO_x (kgs)	PM (Grams)	CO_2 (Tonnes)	Vehicle Type
10	450.0L	3.15	29.00 t	1.17	
10	550.0L	3.85	24.50 t	1.43	
12	471.4L	3.30	12.75 t	1.22	
15	660.0L	3.85	11.50 t	1.43	

Source: K Cowell & Associates 2018

5. What other benefits are there besides saving vehicles and generating productivity

The proposed PBS prototype 3, has a low-cab design, will save many of the strains and soft muscle damage that is incurred by Australian truck drivers. Sprains and strains in the Australian transport industry are the most common injury suffered by drivers. These injuries represent 46.4% of driver injuries with a further 16.2% suffering traumatic joint or muscle conditions. (Safework Australia, 2018). Many of these injuries are brought about by drivers pulling themselves up into high cabins on larger trucks as well as suffering knee damage from years of alighting from these high cabins, even though steps are available, and are used for cabin entry and exit. The low- cabin design for the Prototype 3 urban vehicle will have far less 'sprains and strains' incidents than high cabin conventional trucks with the same carrying capacity. Better visibility from a rigid truck in urban areas also has safety advantages for cyclists and pedestrians. (LDS, 2016)

6. What will spark manufacturers' interest to develop a new vehicle type?

The benefits of having this re-designed Prototype 3, PBS truck are very significant. However, there will also need to be some entrepreneurial leadership amongst the manufacturers to produce more than just a few prototypes of such a vehicle. This happens by convincing operators of the capabilities of this vehicle. Moving forward for the manufacturer is something akin to a 'chicken and egg' situation as to who starts the demand rolling for a new rigid truck configuration. Is it the manufacturers or the operators? Operators will pick an alternatively specified vehicle if it is available to buy, or even become interested, if there is a prototype available for inspection, and also if it suits their operational tasks. The take-up of Performance Based Standards in Australia has been very successful with now over 6,000 PBS vehicles in operation in early 2018. Some manufacturers do, however, exhibit some timidity as PBS uptake usually lowers demand for tractor cabs but alternatively does increase the number of trailers in the operators' fleets if they purchase PBS vehicle combinations. However, experience has often shown that a popular new configuration will, in the medium and long terms, be successful as has been the case with the evolution in Australia of B-Doubles, that required a more powerful tractor engine, as well as new concrete agitators that have gone from three axles to five axles even within the last four years, as examples, where the suppliers have had to cater to new market demands.

Ongoing design developments for this 'third generation' prototype urban volumetric 'e-commerce' rigid vehicle, as well as targeted marketing, will both play an important role in enhancing the demand for this urban PBS truck in several countries.

7. Current Status and Concluding Remarks

Although the second evolution of this specialist Urban PBS Delivery truck, Prototype 2, was somewhat operating at less than peak volumetric capacity, due to its shorter length, and operating lower than the initially proposed volumetric capacity, with higher than expected fuel consumption, the vehicle operated at a high kilometre utilization of 156,000 kilometres per annum. At this time a more detailed analysis has been undertaken to align a significant number of aspects in the original 2003 template design into this third, 2018 proposed urban

PBS rigid truck. This vehicle is referred to as Prototype 3. Since 2003, the boom in e-commerce, the continuing decline in the number of skilled articulated drivers, the need to lessen heavy urban truck exposure and to increase safety in urban freight operations (Summerskill and Marshall, 2016), are all good reasons that manufacturers should consider putting this third generation urban PBS truck configuration into at least low volume pilot production.

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Glossary

ABS	Australian Bureau of Statistics (www.abs.gov.au)
ARRB	Australian Roads Research Board (www.arrb.com.au)
CO2	Carbon Dioxide
GCM	Gross Combination Mass
GVM	Gross Vehicle Mass
HML	Higher Mass Limits

HPVs	High Productivity Vehicles
ILI	Industrial Logistics Institute
KC&A	Ken Cowell and Associates
LDS	Loughborough Design School
NHVR	National Heavy Vehicle Regulator (www.nhvr.gov.au)
NOx	Nitrogen Oxides
NTC	National Transport Commission (www.ntc.gov.au)
PBS	Performance Based Standards
PN	Particulate Matter
SMVU	Survey of Motor Vehicle Use, Cat
ULD	Unit Load Device
UoM	University of Melbourne