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# The Evolution of a High Productivity Urban e-Commerce Delivery Vehicle using Australian Performance Based Standards

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The introduction of High Productivity Vehicles (HPVs) in Australia, through the Performance Based Standards (PBS) scheme, was predicated on new mechanical engineering standards that were mandated especially for these new vehicles. These standards improved vehicle stability, general performance and safety, especially safety. Two national surveys showed both massive safety and productivity benefits compared to conventional Australian road freight fleets. The first Australian PBS vehicles operated under permits from 1997 but the formalized Australian scheme was implemented in 2006. So arguably the introduction of HPVs under permit and now under a formal regulatory PBS framework has allowed some 20 years of research observations. However, only one major type of single rigid, high productivity truck, without a trailer, has been active in an urban environment as a pilot, over that time. This paper examines this special urban High Productivity Vehicle which could be exceptionally useful for the urban freight task in many countries should they ever adopt it.

**Keywords:** Urban Logistics, High Productivity Vehicles, Performance Based Standards, Freight Productivity, New Rigid PBS Truck, innovative urban deliveries.

## 1. INTRODUCTION

The original concept for this specific Performance Based Standards (PBS) urban rigid truck, without a trailer, emerged from Australia's largest urban network operator, the Australian Postal Corporation, in 2003. The proposal was suggested in the international National Road Transport Commission's c international conference proceeding in that year (Hassall, 2003). There was an opportunity to design and use a new rigid truck configuration that was larger than the conventional 3 axle rigid vehicle (12.5 metres with 22.5 tonnes gross vehicle mass GVM) but smaller than the next largest fleet vehicle which used decommissioned semi-trailers (tractor-trailers 19 metres in length, operating up to 42.5 tonnes GVM) that were used in low kilometre urban operations. This new vehicle could replace both classes of existing 3 axle rigid vehicles and six axle semi-trailers both doing urban operations.

This new urban truck concept has been in development over the last 16 years. At this time no manufacturer has produced the exact suggested urban vehicle that has been proposed in this paper although a handful of manufacturers have confirmed the benefits of such a specialist vehicle.

### *1.1. BACKGROUND*

Figure 1 reflects the eventual, and not too detailed, configuration of the rigid truck that could be manufactured, especially for urban e-commerce operations, and is the subject of this paper. It also shows the two current truck types that this specialist vehicle could replace a considerable number of rigid and articulated vehicles if the full design was to be adopted. The original specification for this specialist High Productivity, e-Commerce, retail vehicle, was described by Hassall, 2003 for the National Road Transport Commission (NRTC).

This 4 axle rigid vehicle could replace a significant fraction of smaller urban rigid trucks whose capacities were 10, 20 and 28 mail freight cages. These mail cages are referred to as Unit Load Devices (ULDs) which are a specific mail stillage used by the National Post Office. A mail cage (a ULD) has the dimensions of 1 metre x 1 metre x 1 metre. Initial estimates by using this

proposed new vehicle could see a reduction of 25% of the existing rigid 2 axle and rigid 3 axle postal truck fleet, and almost a 100% reduction of the low kilometre 19 metre articulated trucks performing urban work. (See Figure 1).

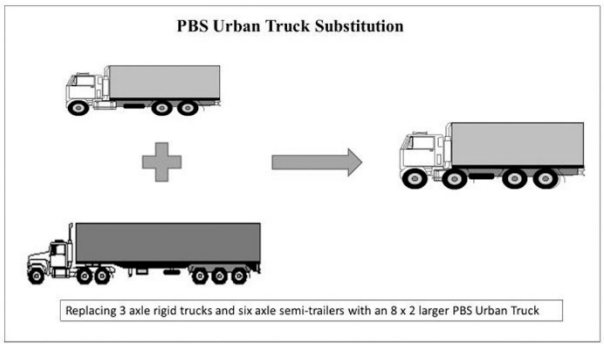


Figure 1. The two vehicle class the new Urban PBS rigid truck can replace.
*Source: (Hassall, 2003).*

## 2. THE EVOLUTION OF THE SPECIALIST URBAN PBS RIGID TRUCK SO FAR

The original specification for the PBS longer urban rigid vehicle was designed to carry 40, one cubic metre ULDs. This was the capacity of the existing 19 metre semi-trailer used in the urban and regional environments. The proposed Prototype 1 vehicle would be a volumetric rigid vehicle where the freight cargo units were no greater than 400 kilograms per stillage unit, ULD. Often e-commerce parcel loads are mostly volumetric in nature and so the operator can expect lighter 'volume constrained loads' and not 'mass constrained loads'. It is to be reiterated that the growth in the e-commerce market is essentially comprised of parcels that move between warehouses to distribution centres, before smaller rigid vehicles undertake customer deliveries. Parcels are essentially a volumetric task thus allowing a high volumetric urban rigid truck to be an ideal choice for this rapidly growing urban e-commerce delivery task.

Table 1 presents the operating characteristics of 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 actually built and operated 'Prototype 2' vehicle. Shown in Figure 2.

It should be noted that although the actual operational Prototype 2 vehicles only managed 36 and not the original planned capacity of 40 stillages, ULDs, the kilometres performed by this vehicle were outstanding. Compared to a standard 8x4 rigid truck whose kilometres were measured at less than 40,000 kilometres per annum in Australia, this prototype performed 156,000 kilometres per annum in its first year. This is much further than either the 3 axle rigid trucks or even the 6 axle semi-trailers actually travel annually in Australia.

Table 1. Comparing the proposed Urban PBS Truck to the vehicles it will replace.

| **Truck Type** | **3 Axle Rigid Truck** | **Local 19m Semi-Trailer** | **Special Truck Prototype 1** | **Special Truck Prototype 2** | **Special Truck 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, Cat 9208.0. 3. Client Truck capacity.
4. With 49O Steer Angle. 5. With 45o Steer Angle.


Figure 2. Proposed Concept Prototype 1 and the actual operational Prototype 2 of the Urban PBS Rigid Truck.
*Source: Australia Post Transport 2003(concept 1) and 2009 actual operational Australia Post HPV.*

It is worth understanding how this level of utilization was achieved by the first operational prototype of this specialist urban vehicle. (Prototype 2) Unlike the smaller 3 axle rigid truck the actual operational Prototype 2 vehicle would be scheduled to move between a major distribution centres, for two daily working shift duties. Usually the third daily return service trip was also undertaken to a regional town that was often up to 150 kilometres from the vehicle's base depot.

The current, or third proposed variation of this vehicle design in this paper, is called Prototype 3. The specifications for this design comprises: a low forward leaning cabin, a twin steer 8x2 rigid truck with a retractable rear axle. It will have height of 4.3 metres and an overall length ranging between 13.5 to 14.0 metres and a GVM of 29 tonnes. (See Figure 3) The body design could carry 40 euro sized pallets, or 32 Australian sized pallets. Again, as this truck would only carry volumetric cargo, and this is a critical feature for the design of this concept vehicle. This capacity will vary slightly if the pallet dimensions are longer or wider.


Figure 3. Proposed Prototype 3 – the 13.5 – 14 m Urban PBS Rigid Truck.
*Source: KC&A and Industrial Logistics Institute Australia*

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.

Table 2: 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 | 1,000 x 1,000mm | =1.0m | <= 400kgs |
| Euro Pallets | 40 | 1,000 x 1,200mm | < 1.5m | <= 400kgs |
| Australian Pallets | 32 | 1,165 x 1,165mm | < 1.5m | <= 400kgs |
| Max Vehicle Length | n/a | 14 metres | n/a | n/a |
| Max Vehicle weight | n/a | n/a | n/a | 29 T GVM |

*Notes: n/a = not applicable.*

### *2.1. MODELLED OUTCOMES FOR THE NATIONAL POST OFFICE*

The inhouse network software simulation modelling, undertaken by Australia Post, for this specific PBS urban truck operating on actual networks showed a utilization productivity gain of 42% over existing 3 axle rigid urban vehicles, a reduction of up to 20% of the rigid fleet numbers, and a complete reduction of the urban articulated semi-trailer fleet. Further examination by the National Transport Commission showed a potential saving of 6 million kilometres per annum in metropolitan truck travel in Australia. (See NTC, 2005). In 2007 the original concept design won a prestigious research award at the University of Melbourne, (UoM, 2007) when the impact of such a vehicle demonstrated the benefits in lowering 'urban freight emissions' through the vehicle's reduced kilometres travelled in urban areas, and by suppressing short and long term growth in the urban truck fleet.

The safety aspects of this vehicle are also important. Replacing urban articulated vehicles with a rigid vehicle will lessen the associated collision damage, as heavier articulated combinations will be replaced with a rigid urban vehicle usually travelling with a smaller momentum within the city limits. Replacing smaller three axle rigid vehicles with larger four axle rigid vehicles will save significant urban trip kilometres and lower trip kilometres lowers the probability of accidents Even the operational Prototype 2 urban vehicle has demonstrated exceptional safety results over the first six years of its urban and regional operations in Australia, attaining an accident free record up to this time.

### *2.2. MODELLED OUTCOMES FOR OTHER OPERATORS*

The following case study examines:

- moving a daily task of 220 cargo pallets over a distance of 55 kilometres from an inner suburb of a high-density city to the outer urban fringe of that same city.
- The configurations used 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 1,165 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 carry mostly volumetric pallets, or other stillages.

Figure 4 examines this comparative task when large Australian sized pallets (1,165 x 1,165mm) are carried by the different configurations for the 220 daily pallet task. The operation has only single stacked pallets. This is often true for urban operations as pallets can weigh over 1 tonne and be at least 0.75 metres high. This often forces single stacked operations. It also often allows quicker unloading. This figure also suggests that the proposed 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 in weight, are common especially in urban e-commerce distribution operations. Parcels and cartons are a common volumetric task.

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 as has been shown by the safety record of the 2009 prototype vehicle which demonstrated exceptional safety results over the four years the vehicle was observed in Australian operations. Hassall, 2018, Hassall et al 2017 for the NTC, Hassall and Thompson 2011, 2015 and Hassall et al in 2014 for Austroads, all reported exceptional safety benefits of Australian PBS Vehicles.

Figure 4 shows the comparison in fleet size to undertake the task with either the two local semi-trailers or the two urban rigid trucks, one of which is the proposed urban rigid Prototype 3 vehicle. 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. In many cases within inner urban operations the two local semi-trailers may well have access problems that can be avoided with a shorter 'prototype 3 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.

| Number of Trucks | Fuel Used (Litres) | GCM (tonnes) | PM (grams) | CO2 (tonnes) | Pallet task | Vehicle Type |
|---|---|---|---|---|---|---|
| 10 | 450.0L | 460 t | 29.0g | 1.17 | 220 |  |
| 10 | 550.0L | 486 t | 24.5g | 1.43 | 216 |  |
| 12 | 471.4L | 300 t | 12.75g | 1.22 | 216 |  |
| 15 | 660.0L | 337.5t | 11.50g | 1.43 | 210 |  |

Figure 4. Urban and Regional workload of the Prototype 3 Urban PBS Truck
Source: K Cowell & Associates 2018

Figure 4 depicts the fuel consumption and emissions' comparison for the two articulated local semi-trailers, and the two rigid truck configurations. For the hypothetical 220 pallet task being examined, the PBS urban rigid truck, truck number 3 in the figure, performs only 4.2% worse than the six-axle local semi-trailer on a $CO_2$ 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 why 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. As the examined operations were simplistic single trip operations, spreadsheet calculations were sufficient in this analysis.

## 3. OTHER USEFUL HIGH PRODUCTIVITY URBAN TRUCKS

### *3.1. THE URBAN B-TRIPLE (THE NETHER-LANDS)*

Two other High Productivity Vehicle configurations that have been used with success in the Netherlands and Australia respectively.

The first truck is a 'short' B-Triple, of 25.5 metres in length that can carry three twenty foot equivalent units, TEUs. In Australia B-Triples can range from 33 metres to 36.5 metres. They can operate up to 82.5 tonnes GVM and up to 90.5 tonnes GVM if operating under the Higher Mass limits scheme (HML). The combination can carry four TEUs or two TEUs and one forty foot container, an FEU. The shorter Netherland's B-Triple is a 'general access' vehicle and with 3 turntables has a much tighter turning circle than the Australian B-Triple. It is ideal for TEU container work for port and intermodal operations.

Figure 5. Short three container B-Triple (the Netherlands).
*Source: Aarts L, et al (2007).*

*Source:* Netherland's High Productivity B-Triple features: Length: 25.5 metres, GVM up to 70 tonnes, Capacity 3 TEU containers.

### *3.2 THE URBAN RIGID TRUCK WITH 4 AXLE TRAILER (AUSTRALIA)*

At the current time some 55 per cent of High Productivity Vehicles approved through the Performance Based Standards) PBS scheme are the rigid truck and trailer combination, where the trailer is attached through a 'drawbar' connection. The four axle trailer combination has been very popular for carrying such commodities as dirt,

sand, construction rubble, quarry materials and even various bulk grains such as wheat or barley.

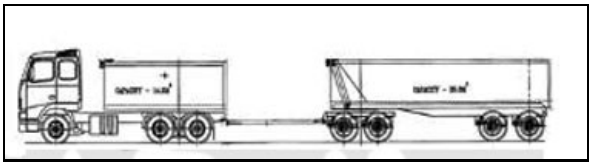

Figure 6. Drawing of a popular PBS Construction/Quarry truck and trailer (Australia)
*Source: K A Cowell & Associates*

This construction/quarry truck has proven to be very popular in Australia, see Figure 6. It has delivered a 20% physical productivity benefit over rigid trucks that tow a three axle trailer. In urban areas this four axle trailer has been exceptionally productive. Five axle and six axle trailers are also operating in urban areas in smaller numbers but with higher levels of productivity and even better safety outcomes.

Figure 7. PBS Rigid truck and 4 axle trailer (Australia)
Source Industrial Logistics Institute database.

Australia's Urban Rigid construction/quarry truck Length: 19-20 metres, GVM 50.5 tonnes up to 56.5 tonnes under Higher Mass Limits schemes.

## 4. CONCLUSIONS

The Performance Based Standards Scheme (PBS) in Australia has allowed for the development of a range of High Productivity Vehicles (HPVs) that have proven themselves to be, not only more productive, but also safer. (Hassall et al, 2014). The introduction of such vehicles has also been occurring in Scandinavia, the Netherlands, South Africa, Argentina, New Zealand, and many OECD countries who are experimenting with their use. However, many countries see HPVs as being bigger, longer and heavier vehicles. However, this need not be so. The Australian Post office proposed a specialist urban rigid truck in 2003 and tried out a variation of this initial concept in 2009. This trial was reasonably successful. With a new focus on the original concept an even more productive, safer, and more accessible urban truck has been proposed and modelled for volumetric, urban, retail and e-commerce operations. This new 'Prototype 3' has been examined in this paper and is being actively discussed with manufactures. This slightly longer 4 axle rigid truck could replace both a large percentage of urban articulated vehicles as well as a smaller number two and three axle urban rigid trucks. This truck will assist in overcoming many 'City Logistics' access and freight exposure considerations for urban, and last mile e-commerce delivery tasks.

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## GLOSSARY

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|---|---|
| ABS | Australian Bureau of Statistics (www.abs.gov.au) |
| ARRB | Australian Roads Research Board (www.arrb.com.au) |
| ARTSA | Australian Road Transport Suppliers Association |
| CO2 | Carbon Dioxide |
| GCM | Gross Combination Mass |
| GVM | Gross Vehicle Mass |
| HML | Higher Mass Limits |
| HPVs | High Productivity Vehicles |
| ILI | Logistics Institute |
| KC&A | Ken Cowell and Associates |
| LDS | Loughborough Design School |
| NHVR | National Heavy Vehicle Regulator (www.nhvr.gov.au) |
| NOx | Nitrogen Oxides |
| NRTC | National Road Transport Commission |
| NTC | National Transport Commission (www.ntc.gov.au) |
| OECD | Organization for Economic and Development Co-operation |
| PBS | Performance Based Standards |
| PM | Particulate Matter |
| SMVU | Survey of Motor Vehicle Use, Cat |
| ULD | Unit Load Device |
| UoM | University of Melbourne |

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