SIMULATING THE IMPACT OF NEW AUSTRALIAN "BI-MODAL" URBAN FREIGHT TERMINALS, UTILIZING PERFORMANCE BASED STANDARD FREIGHT VEHICLES FOR HIGH GROWTH CONTAINER PORTS

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ABSTRACT. Global trade both in bulk commodities and especially in containers have grown by double digit rates in many of the world's large and medium container ports. The Port of Melbourne, Australia's largest container port, is forecasting container growth will rise from its 2007 levels of 2 million twenty foot equivalent containers (TEUs) to 8 million by 2035. As will be the case for many cities that have container ports close to urban precincts, the transport planning especially for the landside logistics is a pressing and immediate planning matter. In Australia the road transport industry has been embracing the use of higher productivity freight vehicles. In 1986, Australia saw the introduction of double articulated combinations referred to as B-Doubles. The re-invigoration of Performance Based Standards (PBS) by the Australian National Road Transport Commission in 1999 (NRTC 1999a, 1999b), and even the OECD in 2005, has allowed for a third generation of road vehicles to now be planned for and in some States also adopted. Equivalent vehicles are being adopted for use in the Netherlands, New Zealand, and Canada with several further countries expressing interest, and this also includes China. The second major strategy to handle the growth of landside freight, especially for major container ports, is though the provision of an urban rail terminal network. The Performance Based Standards road freight framework can also assist such urban rail freight terminals The co-joint solution of using both PBS Vehicles and urban rail shuttles is potentially an even a more powerful combination than either individual mode in servicing a high growth container port. The simulation modelling presented in this paper suggests that this "bi-modal" combination servicing a major container port over the next thirty years is a very powerful urban freight transport strategy.

Keywords: Inter-modal, container ports, Performance Based Standards, transport simulation, urban logistics, freight efficiency, bi-modal terminals, landside logistics.

REZUMAT. Comerțul mondial în vrac şi în containere a crescut în procente cu două cifre in multe dintre porturile mari şi medii de containere din lume. Pentru Portul Melbourne, cel mai mare port de containere din Australia, se previzionează o creştere, de la nivelul de 2 milioane containere echivalente de 20 picioare cubice (TEU), din 2007, la 8 milioane containere echivalente, până în 2035. În aceeaşi situație se vor afla multe alte oraşe care dispun în apropiere de porturi pentru containere, deci problema planificării transportului, mai ales în cazul logisticii terestre, este presantă. Industria transporturilor rutiere din Australia a adoptat vehicule de transport marfă de mare productivitate, în 1986 fiind date în folosință cele dublu articulate numite „Dublu-B". Reactualizarea în anul 1999 a standardelor de performanță (PBS) de către Comisia Națională Australiană pentru Transporturi Rutiere (NRTC 1999a, 1999b) şi chiar de către OECD în anul 2005, făcut să se treacă la pregătirea adoptării unei a treia generații de vehicule rutiere. Vehicule echivalente sunt date in folosință în Olanda, Noua Zeelandă şi Canada, iar alte țări îşi manifestă interesul pentru acestea, fiind de notat China. O a doua startegie majoră pentru a face față creşterii transportului de mărfuri terestru, mai ales în cazul porturilor de containere majore, constă în asigurarea unei rețele urbane de terminale feroviare. Standardele de performanță pentru transportul de mărfuri pot să prevadă şi astfel de terminale feroviare urbane de mărfuri. Soluția mixtă de a utiliza vehicule PBS şi navete feroviare pentru porturile de containere cu creştere masivă poate constitui o combinație mai eficace decât oricare dintre componentele ei. Modelarea de simulare prezentată în lucrare sugerează că folosirea in următorii 20 de ani a acestei combinații „bimodale" constituie o strategie foarte eficace privind transportul urban de mărfuri.

Cuvinte cheie: Intermodalitate, porturi pentru containere, standarde de performanță, simularea transportului, logistică urbană, terminale bimodale, logistică terestră.

1. BACKGROUND

One of the major questions for city planners and freight planners, is what will the freight task be in the future and how will it be handled? The following simulation sensitivity analysis was undertaken to answer this question specifically for the city of Melbourne in Australia. "What will the Melbourne urban road freight task look like in 2030, given the fact that the urban container port task will rise from 2 million to 8 million containers in 2035, and general urban freight will rise by at least 90%?" A secondary but very important question is "what will be the necessary infrastructure that will need to be planned for within this time frame, in order of facilitate the movements of such freight growth?

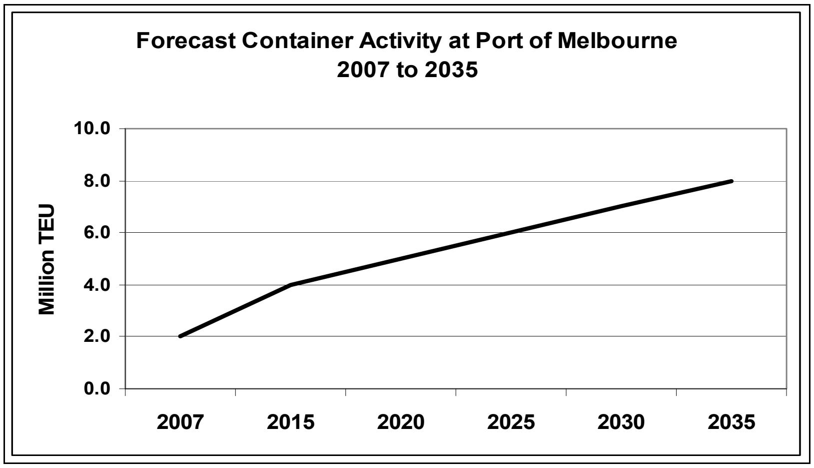

Fig. 1. Forecast Container Growth at the Port of Melbourne.
Source: Port of Melbourne Authority, Department of Transport 2008.

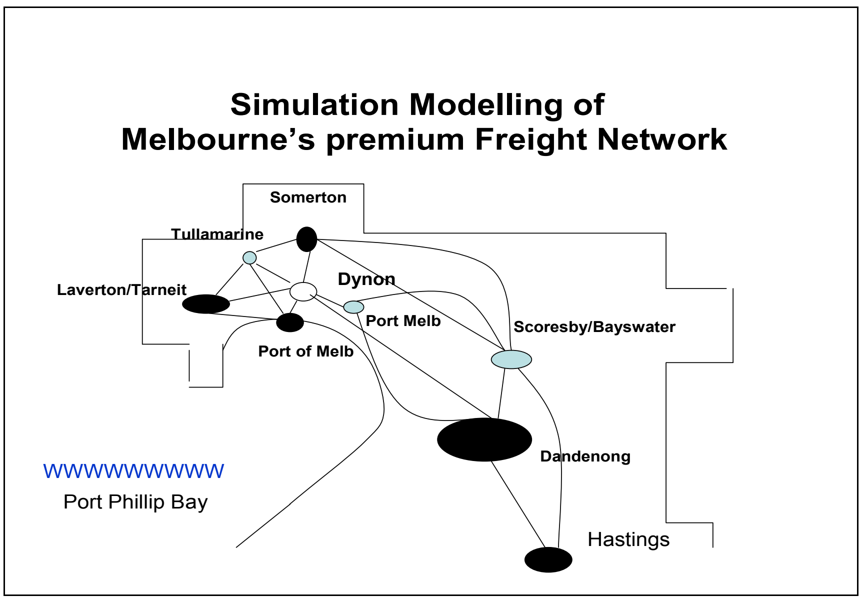

Fig. 2. The Premium Freight Network for the Simulation Model.

2. ELEMENTS IN THE SOLUTION OF THE DISTRIBUTION PROBLEM

The solution, if it was to work, would consist of four parts:

1) the existence of a special "premium freight" network for both road and rail tasks;

2) the ability to use Performance Based Standard vehicles on a premium road and rail network;

3) the existence of the specialized bi-modal terminals, and their ability to despatch urban rail services;

4) the network be regulated by a controlling authority, whereby the terminal rules for the rail and road operators not create their own network rules.

The fourth point is a regulatory provision and does not impact on the simulation model other than through the assumption that the rail and road services run to the planned network business rules.

The premium network is presented graphically by Figure 2. There a five rail terminals depicted. These are the Port of Melbourne, a Western, Northern and South Eastern terminal. Also the twin Port of Hastings is expected to be activated especially for bulk trades by 2030.

New Road Vehicles - "Performance Based Standards". The concept for Performance Based Standards (PBS) was a Canadian concept which was re-activated in Australia by the then National Road Transport Commission in 1999. (NRTC 1999a, 1999b) This new regulatory framework allowed for more flexible vehicle types to be operated on the road network if the vehicle design complied with some 18 higher level operational and infrastructure performance standards. (NRTC 2003)

Not all PBS vehicles are articulated vehicles but for high volume port container work the multi-articulated vehicles are most suitable. Figure 3 is the standard 19 metre single articulated Australian semi-trailer. Figure 4 is the 26 metre B-Double which although it can now be considered as a PBS vehicle it was introduced into Australia in the period 1986 to 1996 prior the National Road Transport Commission establishing the PBS regulatory framework. For shipping container work the B-Double can carry up to 3 TEU containers, or 1 TEU and 1 FEU (forty foot equivalent container.).

Fig. 3. Type 1 vehicle: current Single Articulated Semi-Trailer (length 19 metres, weight 42.5 tonnes Gross Vehicle Mass).

Fig. 4. Type 2 vehicle: current tri-tri B-Double configuration. A PBS vehicle (length 25 to 26 metres, weight 62.5 tonnes Gross Vehicle Mass)

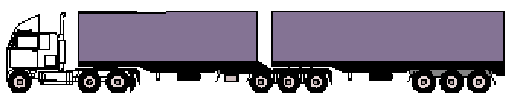

Fig. 5. Type 3 vehicle: super B-Double (non qad axle) configuration. A PBS Vehicle (length 30 metres, weight 62.5 to 68 tonnes Gross Vehicle Mass).

Fig. 6. Type 4 vehicle: B-Triple Tandem configuration. A PBS Vehicle (length 33 to 35 metres, weight 82.5 to 90 tonnes Gross Vehicle Mass).

Figure 5 is the bigger version of the standard B-Double and has the capacity to carry 4 TEU shipping containers or 2 FEU containers. It is referred to as a Super B-Double. Figure 6 is a B-Triple and is equivalent to a B-Double with a second front trailer (or A trailer). The volumetric capacity of the B-Triple is equivalent to the Super B-Double but because of the extra axle group the total GVM capacity is 20 to 26.5 tonnes greater than the Super B-Double.

For countries that operate only single articulated vehicle combinations figures 4,5, and 6 could all be considered as Performance Based Standards vehicles.

The introduction of PBS vehicles must also be accompanied by an appropriate road network and bridge network that can support the mass and the turning circle of these vehicles. In this case study the intra-urban road network is capable of supporting the activities of PBS vehicles. It is referred to as the Premium road network.

What are Bi-Modal Terminals? The bi-modal terminal, figure 7, is a type of multi modal exchange terminal where the urban rail shuttle is supported by high capacity Performance Based Standards articulated freight vehicles. The key freight unit to maximise its throughput is the twin stacks in the centre of the terminal. The terminal has two rail lines and two PBS vehicle paths. Five to ten mobile high lifters service both the container stacks. There is a useable amount of secondary functions in the terminal such as some warehousing, deconsolidation spaces, administration and maintenance blocks. However, within the outer precincts of the terminal it is expected that the zoning will attract larger container parks, large truck fleet maintenance yards, bulk fuel facilities and a variety of private distribution centres.

Many European studies have examined what size the operational terminal size should be (Burciu, et al, 2000) but in this instance the 16 hectare perimeter was advanced by Visser 2004, which also coincided with the median train length of 50 FEUs, which allowed such a rail vehicle to be housed in a 16 hectare precinct.

The basics of the Terminal Operation. The three (and potentially four) terminals run both independent cycles of shuttle trains and PBS trucks.

Rail Cycle. The freight shuttle loads to capacity and delivers up to 50 FEUs to the Port or a major node in the network. It then loads and proceeds back to the originating terminal to unload. A cycle will handle up to 100 FEUs per round trip.

Road Cycle. The road cycle begins with the pickup of two FEUs or up to 4 TEUs by PBS vehicle. This vehicle proceeds to the Port, delivers the load and uplifts another equivalent number of containers. The containers are taken to a destination customer within the city area of the destination bi-modal terminal. They are delivered, and a set of outbound containers (full or empty) are picked up and taken to the bi-modal terminal. Road services do an extra revenue providing hop before returning to the bi-modal terminal.

Figure 8 reflects 'approximate' areas that are being planned for the first 3 bi-modal terminals. The fourth terminal at Hastings in the very south eastern area is not shown on this diagram.

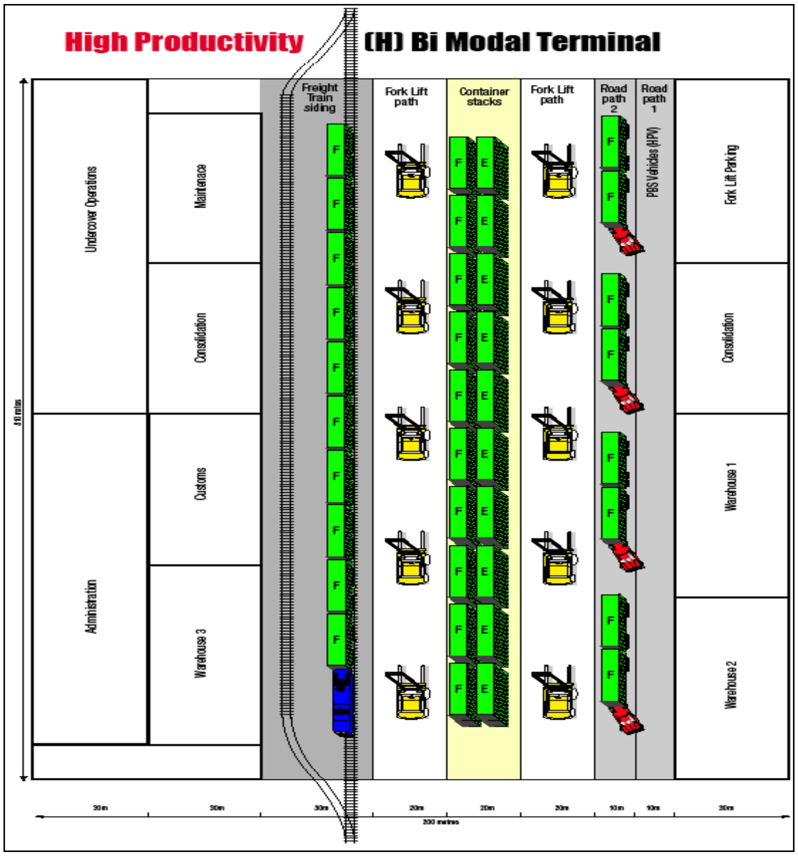

Fig. 7. New Bi-Modal Rail and High Productivity Road Vehicles.
Source: Industrial Logistics Institute 2008.

Fig. 8. Simulation Rail Network as at 2030.
Source: Fltsim2 simulation model rail results for the bi-modal terminals.

3. SIMULATING THE CURRENT AND FUTURE DISTRIBUTION PROBLEM

Simulation analysis is a very useful tool in examining the discrete behaviour of a large and or complex system. If forecasts can be generated for the core parameters of the system and the future system business rules can be agreed, then many scenarios can be generated that should reflect the future state of the system. These scenarios can also be examined as future planning or policy options.

The simulation model chosen was a cargo allocation model that distributes units of cargo:

- across a predefined network;
- by Origin-Destination demand pairs of city freight regions;
- by use of several vehicle classifications (one of which can be a shuttle train) each with a nominated upper and lower bound load factor;
- moved across three to four nominated periods of a day, two periods are usually peak periods, and
- by defined long and short trip operations.

The objective of the analysis was to compare a standard weekday in 2007 with one standard future weekday in 2030 under various fleet distribution scenarios. The model used was a previously developed Bureau of Transport and Communications cargo unit distribution model (BTCE ,1989) that was used for network distribution sensitivity analysis in order to compare different distribution scenarios.

Two major scenarios that were constructed and examined were:

1. The task is left unconstrained using existing vehicle types and no policy intervention,
2. The government allows for both the introduction of Performance Based Standard vehicles (PBS) and rail cargo shuttles up to 50 forty foot containers in capacity (FEUs), to operate on a proposed urban rail network.

The future fleet composition of freight traffic will by 2030 certainly contain Performance Based Standard Vehicles (PBS). Two new categories will be B-Triples and Super B-Doubles which are represented in Figures 6 and 5 respectively. These vehicles would be important in dampening the growth in the number of road trips within Melbourne in the 2030 scenarios.

The network that these vehicles will operate on is still limited to the Figure 2 network with the tonnage tasks escalated by 88% of the 2007 estimated levels.

Data Requirements for the Model. Tonnes by 2030. A significant parameter for the model is the estimate of freight tonnes. The initial requirement was that both a current freight task estimate of metropolitan tonnes be made. Similarly the 2030 scenarios also required a growth factor that needed to be applied to the current tonnage estimates, so that the metropolitan tonnes in 2030 could be estimated.

These re-estimated intra Melbourne truck road freight tonnages were estimated to be 175.2 million tonnes for 2007. This was based on average Victorian long term growth rates of 2.8% per annum derived from changes the Australian Bureau of Statistics Freight growth rates observed since the late 1980s.

The estimates of the Melbourne road freight task forecast to 2030 was diluted by Light Commercial Traffic tonnages and freight tonnes moved within their own local areas, as the terminal model will be moving tonnages across the premium freight network.

The daily estimate across this premium network is 165,000 tonnes per day. This is shown by Origin and Destination in Appendix I.

The Current and future Vehicle Fleet used in the modelling. For the purposes of modelling a simplification was made which used only articulated vehicles within the premium freight network. In the 2030 scenarios a significant percentage of the fleet does upgrade to the new Performance Based Standard vehicles.

The 2007 base year fleet comprises 1,350 vehicles operating across the network portrayed in Figure 2, across four daily shifts. Why 1,350 vehicles? Because the daily freight task in principle can be handled by this number of vehicles across the premium network. The initial fleet contains 150 B- Doubles and 1200 semi-trailers. This roughly reflects the ratio of B-Doubles to semi-trailers in Victoria. However, the main aim of using a limited number of vehicle types is not to replicate the exact number of truck movements, but to look at major freight flows from a higher level of capacity requirement and what the impact of different fleet mixes are. The model does not reflect the reality of thousands of rigid trucks going to thousands of customers it examines major high capacity freight flows on a particular subset of the network.

Rules and Limitations of the model. The freight simulation model performs realistically across several real world business rules that reflect the current operational freight task. However, like all models there are limitations:

1) Only a subset of the Melbourne freight network was used in the simulation model, however, this represented 25% of the cross town tonnages, across 90 origin and destination pairs. The Freight Movements Model uses 1024 Local Government OD pairs. Time did not

permit the full Melbourne matrix being used in the preliminary analysis.

2) The four periods a day that the model undertakes the truck movements across, these are quite flexible as to where these periods are placed in the program. For the simulation runs for this analysis the periods were mapped as 1) a peak period at the beginning of the day, 2) an off peak period following the first peak period 3) a post middle of day peak period , and 4) an evening off peak period. Periods were calibrated as peak or off peak but not by clock time but by high freight demand availability in a period. A high freight demand period would be a peak period.

3) There are no network restrictions on the model for operating various classes of vehicles. The model in selecting a vehicle to a task will assign the most productive vehicle to the O-D route that has the highest tonnes to move. This would mean that high productivity vehicles would be assigned between OD pairs that require them to move the tonnes on that freight link. The limitation in reality is whether or not there a regulatory hindrance to large vehicle movements.

4) The truck fleet used in the analysis was restricted to articulated vehicles performing intra-urban haulage operations between major OD freight centres.

5) As noted in point 4, the model excludes freight moving within "own to own" regions, such as Dandenong to Dandenong, Somerton to Somerton, Laverton to Laverton etc These own area to own area operations actually account for 15% of Melbourne's truck freight movements. (DOI, 2007)

6) Each vehicle type is assigned an upper and lower load factor. Upper load factors were generally set at 99% and lower load factors set at 10%. This meant that trucks could not be assigned to a trip if the lower load factor threshold was not reached. This device prevents a significant amount of empty running.

7) The model is a comparative capacity assignment model. This means that despite the subset of the network examined, which are serviced by articulated vehicles, the comparison between the scenarios will be of most interest.

The model is not an optimization model per se. However, it does try to efficiently assign vehicles and reuse them several times a day. This reflects a degree of realistic best practice.

Rail considerations. Considerable deliberation and discussions were had with regard as to the cartage capacity of the urban rail shuttles for this simulation model. The decision was finally to select a 50 unit urban rail freight train capable of 40 foot container (100 TEUs) unit equivalent Jumbo cargo sprinter. This selected shuttle train type would be estimated at around 690 metres in length. This vehicle type would cause less network inconvenience than longer length shuttle trains as the rail freight task would also be sharing the urban rail network with passenger trains.

Simulation Scenarios considered in 2007 for 2030

Scenario 1: Base case 2007. The base case is the current estimated task for the core network. It delivers the daily tonnes to the destination nodes:

- with a fleet of 1,350 articulated vehicles 150 B-Doubles, and 1200 semi-trailers. Fleet mix completes the task in a day, and roughly reflects the current B-Double to semi-trailer split in Victoria.
- The model assigns a total of 8,570 trips.
- Average load factor from the modelling is 59%.

Scenario 2: 2030 with current vehicle fleet mix. This first of the 2030 scenarios delivers the inflated freight task:

- with a fleet of 2,600 articulated vehicles, 600 B-Doubles and 2,000 semi-trailers. Numbers of both vehicles must go up significantly to handle the future task. Assumes the B-Double growth rate will be higher.
- The model assigns 13,100 trips
- Average load factor from the modelling is 63%.

Scenario 3: 2030 with included PBS vehicles and Rail Shuttles. This is the 2rd of the 2030 simulation scenarios. The freight task is undertaken with:

- 1,410 articulated vehicles, 100 B-Triples, 460 Super B-Doubles, 350 B-Doubles and 500 Semi-trailers, and 7 Shuttle train sets. 65% of the truck fleet converts to PBS vehicles and 7 shuttle trains are introduced.
- The model assigns 6,960 truck trips, which is significantly lower than 2007 movements, with approximately the same total number of vehicles, although the vehicle types have changed.
- Average load factor from the modelling is 64%.

However, this third 2030 scenario runs 7 rail shuttles performing, 42 trips over the day, with a total maximum capacity of 2,100 forty foot container equivalents. This is equivalent to 2,100 single semi-trailer trips. So it can be expected that truck trips will decline, and they do.

4. SIMULATION MODEL FINDINGS IN BRIEF

The Melbourne freight task in terms of tonnes is estimated to grow by 88% by 2030 and this is possibly conservative. Left unchecked this task will need to be handled by 66% more conventional semi trailers and four times as many B-Doubles in 2030. This is a considerable increase in community freight exposure.

Table 1. **Simulation outputs vehicles and trips 2007 and 2030**

Freight Vehicle Types, Numbers and Trips								
Year	**Semi Trailers(1)**	**BDoubles(2)**	**SBDoubles(3)**	**BTriples(4)**	**Urban Freight trains**	**Total Vehicles**	**Total Trips**	**Load Factors**
2007	1200	150	0	0	0	**1350**	8,570	59%
2030A	2000	600	0	0	0	**2600**	13,100	63%
2030B	500	350	460	100	7	**1417**	**6,960**	64%

Note. The higher level Performance Based Standards vehicles will be available in or before 2030.

Table 2. **Simulation outputs vehicles and trips 2007 and 2030**

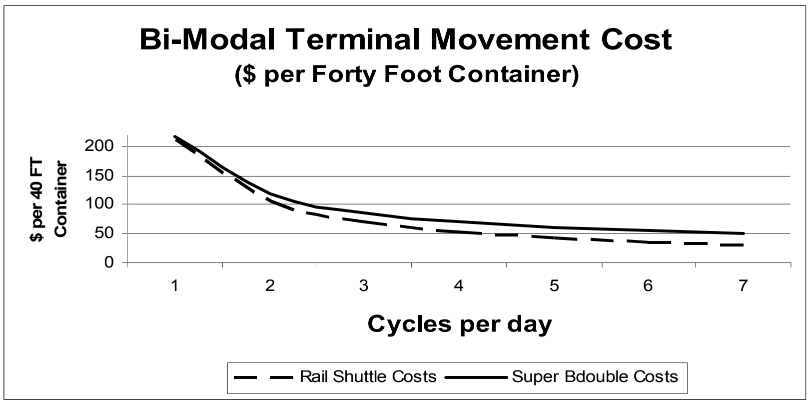

Table 3. **Costs per container for Rail Shuttles and PBS Road Vehicles**

Container Delivery Cost from or to Bi-Modal Terminal by Mode Estimates 2008							
Cycles per Day	**1**	**2**	**3**	**4**	**5**	**6**	**7**
Road $ / 40’Container	218.1	120.0	87.2	70.7	61.1	54.5	49.8
Rail $ / 40’ Container	211.3	105.7	70.4	52.8	42.3	35.2	30.0
Difference $/Container	**$6.8**	**$14.3**	**$16.8**	**$17.8**	**$18.8**	**$19.3**	**$19.8**

Note. Costs are devoid of Port fees which will be levied on road and rail equivalently by 2030.

Lastly, the impact of converting the current fleet mix to 65% PBS vehicles, and implementing 7 rail cargo shuttles onto the 2030 freight task has a profound impact. (Scenario 3, 2030B) The decline in urban freight movements falls by 19% against the 2007 activity figures. From a strategic perspective the combination of both PBS and Rail Shuttles has a major effect on future freight exposure as observed by the public and other road users.

The cost curve behaviours are not dissimilar to those presented in Ballis and Golias 2004 when they examined the mixtures of technologies within an inter-modal freight park. However, the closeness of fit between the two curves reflects the achievement of the high utilization in both modes operating from the bi-modal terminal. The costing methodology for the terminal was essentially an operational accounting based methodology similar to that proposed by Weigmans and Nijkamp 2000.

The terminal costings are done against existing costs as if the terminals were currently operating. It is expected that rail cycles will reach 5 cycles per day and road up to 7 cycles per day. So by comparing these two very high vehicle utilization strategies, rail is still marginally cheaper however, this does not take into account any externality costs or amenity impacts of significantly high truck movements if rail were to never eventuate.

5. CONSTRAINTS AND OTHER CONSIDERATIONS ON THE “BI-MODAL” SOLUTION

The rail connections: To deliver both an urban rail freight terminal network by 2030 or earlier it will be necessary to have access to the existing rail network, or to land corridors that can be acquired in order to link the rail/road terminals and the container port. The rail services also need to have approved pathways approved, especially if the freight shuttles are also running on a shared passenger rail network or competing with longer distance freight trains that may also use the network.

Terminal Considerations. The chosen terminal sites must be acquired as a secondary step after planning is completed. The sites will be preferably zoned with a special industrial zone classification in order to stop residential encroachment that could hinder the surrounding terminal sites also attracting warehousing, container park facilities, consolidation functions and other complementary freight functions. These complementary functions need to be undertaken in the area around the terminal although the terminal itself may host a small quantum of these activities with its own at least sixteen hectare boundaries.

Road and Bridge Considerations. Almost as important as the rail network is the provision of the premium road network. This network must accommodate the mass and the turning circles of the PBS vehicles. It will require a bridge network that will also support these vehicles at equivalent or lower speeds to conventional motor traffic.

Cost. The terminal network could be hugely expensive if no land or infrastructure existed currently. However, as the container port exists then there will be reasonable capacity roads to service the port. When it has been estimated as to how many terminals are needed in which logistics and industrial urban areas then the land acquisition is necessary. In some cases the government may have appropriate land holdings. The rail connections are made considerably cheaper if access can be made to specific links in the urban passenger rail network. This will be considerably cheaper than building a rail freight only network which should be avoided unless one exists. Terminal land use could also be achieved by Public Private Partnerships, Joint Ventures or by Franchises, and all terminals need not follow the same model.

Operators. How many operators is a dependency based on how many licenses the government may wish to issue. There is one argument that suggests for best network utilization one operator is appropriate and another argument that not more than one operator exist per terminal. If a future terminal operator also has existing operations on non urban parts of the network operational economies can be brought to the urban network as well.

Responsible Authority. For a high capacity network that depends on up to seven truck cycles per day and up to six rail cycles per day from three or more bi-modal terminals there must be rigorous compliance to timetables and agreed operational agreements. These arrangements cannot be left to market forces. It is imperative that the government empowers a terminals authority to establish and regulate the network for all operators. The terminals authority may or may not be responsible for land acquisition but it should be involved in the approval of land use planning in the terminals precincts.

Timing. As global shipping and trade continue to grow through off-shoring and globalization when should such high capacity bi-modal terminals start being planned? The usual answer is that acquisition won't get cheaper so at least the first links in the future network should be established as soon as possible after planning is completed. It international trade is growing at double Gross Domestic Product then the task will increase so quickly that it will be an extra degree of difficulty in developing the perfect network if no activity happens over the next generation.

5. CONCLUSIONS

The planning for a near 90% growth in the freight tonnage task for Melbourne, and for a container Port growth of some four times the current number of containers for the city, is very much underway. The uptake of Performance Based Standard vehicles, especially the articulated type for the container port operations, will be a great benefit. The highly important road network, the premium network, to support these vehicles is a high government priority. The declaring of very specific land precincts for the use of rail shuttles to the port area and to other high volume freight hubs is also being planned. This contradicts the commonly held philosophy that rail is only a long distance freight mode. However, the very specialized high capacity terminals will be a very new type of freight element in this network. These terminals will support both complimentary rail shuttle operations and the operations of the new high productivity multi-articulated vehicles that have been permitted to operate under the Australian Performance Based Standards regulatory framework.

The new co-operational terminal network, which is specifically a "bi-modal" terminal network will, at least in the simulation modelling, deliver some quite spectacular results. If the three major bi-modal hubs can be established and be complemented by the PBS vehicle operations, emanating from each terminal, then the freight task growth within at least that section of the city that is supported by the premium freight network can reduce its freight movements in 2030 to a level even lower than what was experienced in 2007, despite a near 90% growth rate across the city and a factor of four growth rate at the container port.. The amenity value of this solution will possibility be an enormous leap in the development of City Logistics concepts and themes. (Taniguchi and Thompson, 2007).

The simulation analysis presented in this paper demonstrates that with the appropriate infrastructure the port related traffics and the road freight movements across a defined premium urban network can hold vehicle trip numbers to a lower level than is being observed currently. In fact the 2030 movements could be 19% lower than what is observed in 2007, however, it must be admitted that the fleet mix has been radically changed. The establishment of major urban terminal locations and the terminals themselves, serviced by much higher capacity vehicles is the crux of the solution. This particular solution may not be totally transferable to all cities as a universal rule, but for many the proposals will be of great interest to those cities with large container ports within their central boundaries.

APPENDIX 1

TONNAGE CALCULATIONS BY ORIGIN - DESTINATION PAIRS

Table 5. **Daily Tonnes by origin – destination 2030 estimates – Premium Road Network**

	From	**PortM**	**Mbnong**	Pmelb	**Somert**	Scores/Bwater	Tulla	Lavert	**Dnong**	**Hast**	**Tarneit/Brim**
To		1	2	3	4	5	6	7	8	9	10
PortM	1	0	16920	4061	1354	2707	3835	2707	19853	226	3835
Mbnong	2	2707	0	677	1354	451	1579	2030	451	226	1579
Pmelb	3	677	2707	0	226	451	451	226	451	226	677
Somert	4	4738	1579	451	0	1128	4512	2707	677	226	2030
Scores/Bwater	5	3384	677	902	677	0	1128	677	4963	902	226
Tulla	6	1579	1579	451	4286	1128	0	3158	677	226	2030
Lavert	7	2256	2030	677	2256	677	3384	0	677	23	1805
Dnong	8	1579	226	677	902	4061	226	226	0	2482	226
Hast	9	451	226	226	226	1354	226	226	4512	0	23
Tarneit/Brim	10	2256	1805	677	3610	451	226	1805	677	2256	0

Note. Place names are abbreviations for specific local government areas, eg PortM = Port of Melbourne.

The daily tonnes were calculated from a combination of trip data available from the Department of Infrastructure Local Government Area origin-destination study and unpublished data provided by Melbourne's largest network transport operator, Australia Post.(Australia Post, 2007) This data was not available for the Department of Transport's own analysis, (DoT, 2007). It should be noted that this model uses trips from both data sources as a proxy for tonnes carried. This is not a true 1 to 1 representation, but in the absence of better data both models, Freight Movements Model and FltSim2, have run with this approximation. The large network operator data was not segmented into Local Government Areas and hence some approximations were necessary to be used with this data.

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