

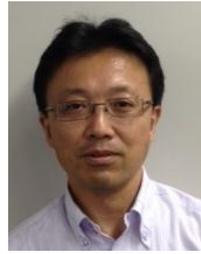
## BEST OF TWO WORLDS: A STUDY OF HEAVY VEHICLE ACCESS IN JAPAN AND AUSTRALIA

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### Abstract

Japan and Australia are two very different countries when it comes to their road networks. Although Japan is many times smaller than Australia it has roughly 1.2 million km of road network compared to Australia's 800,000 km. This equates to a road density of approximately 3,100 m/km<sup>2</sup> of land for Japan, and a mere 100 m/km<sup>2</sup> of land for Australia.

This reflects the nature of each country, Japan's large population and high density urban areas requires careful management of the freight network to allow efficient movement within the space-constrained road network. Australia, on the other hand, has a small population widely distributed in centres over vast distances.

Although the nature of the freight task is different, both countries require detailed knowledge and effective access to the networks to allow industry to efficiently operate. Both Japan and Australia have developed particular strengths as their access frameworks have matured through differing influences. This paper aims to describe these strengths and their benefits.

**Keywords:** road network, database system, Performance Based Standards, ITS, heavy vehicle access

## **1. Introduction**

Countries are facing many challenges with their freight and road networks. Economic expansion leading to increasing freight volumes and increased competition are leading the drive to improving the efficiency of transport. Possible solutions to this, such as allowing larger and heavier vehicles, and improvement capacity of the road network have been promoted, however, there is a critical issue around the large costs involved in the reform of previously constructed road infrastructure.

For this reason, high-level studies for more efficient and safe heavy vehicle traffic have been implemented, and this paper will compare and analyse the two working cases of Australia and Japan.

## **2. The Method of the Study**

### **2.1 Focus of the Study**

It is supposed that in order to allow heavy vehicle run safely and efficiently on the road network, a balance of three factors is necessary. The road (including structures): the standards, capacity, and geometry; the vehicles: their standards and performance; and the driver: techniques and behaviour.

If any of these factors are lacking, an unbalance will exist and can increase the possibility of accidents and undesirable levels of deterioration or destruction of road infrastructure. Therefore, the commonalities, differences and background of the cases of Japan and Australia will be examined.

### **2.2 Comparison of Infrastructure**

A high-level comparison of road and infrastructure standards and operational transport needs and conditions, including land area, population density, varied classes of roads, and road extensions was undertaken (refer Section 3).

### **2.3 Comparison of Regulation and Access**

On the basis of a difference of road architectures between both countries, the actual conditions of regulated operation of heavy vehicles is categorized by size and compared (refer Section 4).

### **2.4 Initiatives for Improving Access**

In conjunction with the comparisons above, current heavy vehicle network access initiatives will be examined with a view on the improvement of the efficiency of the transportation task (refer Section 5).

## **3. Comparison of Infrastructure**

### **3.1 Comparison of Land Area and Road Networking**

The land area of Australia is 7,692,000 km<sup>2</sup> compared to 378,000 km<sup>2</sup> for Japan, whereas the total length of road network in Australia is 813,000 km compared to 1,208,000 km for Japan.

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Australia's land area is 20 times that of Japan's, whereas, conversely Japan's road network is 1.5 times as long as Australia (Ministry of Internal Affairs and Communications, 2011).

Australia road infrastructure is owned and managed by each of the eight states and territories, and the hundreds of local governments. A national highway network also exists that is managed by individual jurisdictions. There are also a number of private organisations operating tollways, and roads on private land (e.g. ports). Japan's network is owned and managed by the central and local governments. The nation's networks of tolled expressways, however, are owned and managed by a separate private corporation (NEXCO).

Figure 1 and Figure 2 illustrate high-level road maps of Australia and Japan respectively, and clearly show the difference in road density, due to the large difference in population size and distribution between the two countries.



**Figure 1 - Road Map of Australia (Commonwealth of Australia, 2010)**



Figure 2 - Road Map of Japan (Vidiani, 2012)

Table 1 lists the road categorisations and lengths, which shows that both network have a similar proportion of roads and that local/municipal roads make up the vast majority.

Table 1 - Categorized Roads and Length of Both Countries

Country	Expressways		National roads		State/ Prefectural roads		Local/ Municipal roads		Total length (‘000s km)
	‘000s km	% total	‘000s km	% total	‘000s km	% total	‘000s km	% total	
Australia	0	0.0%	19	2.3%	122	15.0%	672	82.7%	813
Japan	8	0.7%	55	4.6%	129	10.7%	1016	84.0%	1208

### 3.2 Comparison of Infrastructure Standards

Current design standards of road infrastructure in Australia are usually based upon the Austroads Guide to Road Design (Austroads, 2012). In Japan, design standards are based upon "Road Architecture Regulations" issued by Japan Road Association (JRA, 2009). Table 2 shows a comparison of general access prescriptive vehicles parameters used in road design between both countries.

**Table 2 - Comparison of Prescriptive Vehicle Parameters Used in Road Design**

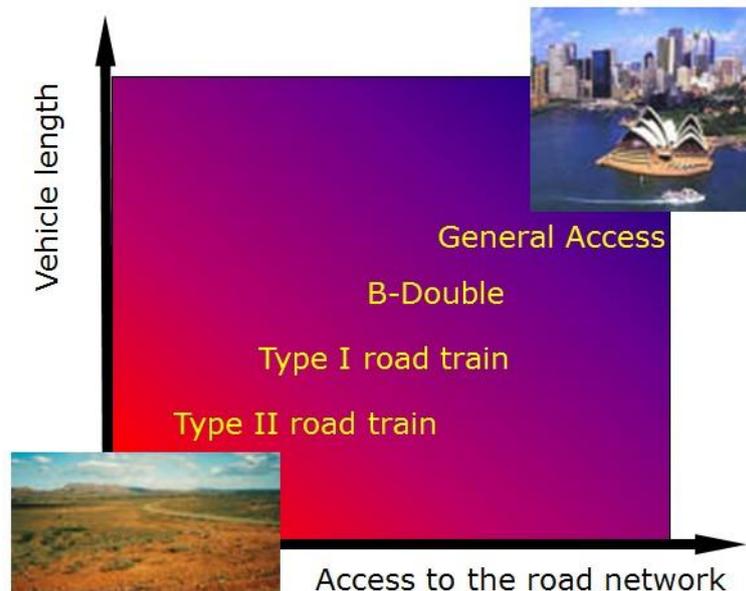
Category	Country	Mass (t)	Width (m)	Height (m)	Length (m)	Minimum turning radius (m)
Single rigid truck	Australia	22.5	2.5	4.3	12.5	12.5
	Japan	20.0	2.5	3.8	12.0	12.0
Semi-Trailer	Australia	42.5	2.5	4.3	19.0	15.0
	Japan	36.0	2.5	3.8	16.5	12.0

Japan, generally speaking, designs for a heavy vehicle fleet with general access. Australia, however, has a much larger range of vehicle combinations, including up to 53.5 m long ‘road trains’ and has four distinct types of network of increasing restrictions. Road design takes into account the largest desired vehicle type for that type of network.

### 3.3 Comparison of the Regulation of Vehicle Access Restrictions

Both countries have various mechanisms in place for the restriction of access of certain types of vehicles. The rigid truck and semi-trailer combinations both enjoy full access to roads in both countries on an ‘as-of-right’ basis. At the other end of the scale, both countries require certain types of vehicles (e.g. Over-dimension and over-mass vehicles) to obtain permits for access to routes, and are usually subject to other operating conditions (e.g. time restrictions).

Both countries also offer restricted networks for certain combinations. This is a small component for Japan, for instance ‘increased mass and height’ roads. In Australia, however, there are four types of restricted network as shown in Figure 3.



**Figure 3 - Outline of Australia's Restricted Access Networks**

These networks are restricted primarily due to the increased mass and size of the vehicles, and the requirements of these vehicles on the network (e.g. increased bridge capacity, larger turning circles).

### **3.4 Comparison of the Access System of Heavy Vehicles**

Comparing the rigid truck and semi-trailer combinations, both countries operate on the same principal of general access. Although the prescribed maximum dimensions are slightly different, networks in both countries provide networks with the capacity for the general operation of these combinations. In direct response to Australia's vast size and wide distribution of population centres, larger vehicles capable of towing up to four trailers have been incorporated into vehicle regulations, and accompanying networks have been defined to allow for greater productivity for moving freight.

Both countries offer a concession on both mass and dimensional restrictions on certain routes that meet particular capacity requirements, or where vehicles have certain components or are of a certain combination.

## **4. Comparison of the Conditions for Heavy Vehicles**

### **4.1 Conditions in Australia**

Australia freight task is forecast to double over the 20 years to 2030 (IBISWorld, 2009). This increase is projected both through export and import volumes, as well as domestic transport. A number of jurisdictions are currently experiencing large growth in the mining sector, which has traditionally moved a large percentage of bulk products by road. This is especially the case as new mines operate and expand in remote locations, often with inadequate links to other modes of transportation.

Furthermore, a large proportion of this growth is in containerised freight. While this allows for some standardisation of the movement and handling of freight, it also poses some challenges for road transport, particularly around potentially unknown masses, and the inefficient movement of containers. Another challenge for Australia is the shortage in the number of drivers, particular skilled drivers for the larger, more productive vehicles. This is forecast to continue and a number of programs have been implemented to encourage young people into the industry. The cost of operation in Australia, particularly the price of fuel, has been increasing steadily. This, in conjunction with increased competition, is leading to tighter profit margins and a need to increase productivity.

With regard to infrastructure, many jurisdictions are generally facing decreases in overall budget, which necessitates the need for greater benefits through better prioritisation of maintenance and development funding for the road network.

### **4.2 Conditions in Japan**

In Japan, the population density is high nationwide, and therefore on rural or municipal roads there exist sections unsuitable for the operation of heavy vehicles. Conversely, some larger heavy vehicles are able to run on the highways, whose main role is for freight transportation, or on the specially designated roads for relaxed mass and dimensional limits.

Similar to Australia, the number of container movements, including international and domestic, has been increasing. However, in recent years, the incidence of the rollover accidents of vehicles carrying international marine containers is actualised on roads. Figure 4 highlights some recent incidents. Due to the number of elevated and space-constrained roads

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in Japan, particularly in urban areas, the potential consequence of these types of accidents is substantial.



**Figure 4 - Examples of Rollovers with Containers (Asahi, 2007)**

Furthermore, there are many issues around road maintenance that are influenced by heavy vehicles. Japan has recently been facing a decrease in the national budget for the development and maintenance of the road network. Figure 5 shows a critical maintenance issue on a bridge deck on a freight route in Japan, and highlights the need to balance access management with freight demand.



**Figure 5 - Bridge Deck Requiring Treatment**

**5. Initiatives for Improving Access**

Both countries have undertaken many initiatives to improve the access arrangements of heavy vehicles. Australia’s main access challenges centre around realising the maximum capacity and efficiency of the network to allow higher productivity freight vehicles (HPFV) to operate.

One of Japan’s major aims is to facilitate the increased movement of containerised freight. This section explores a number of more recent major initiatives.

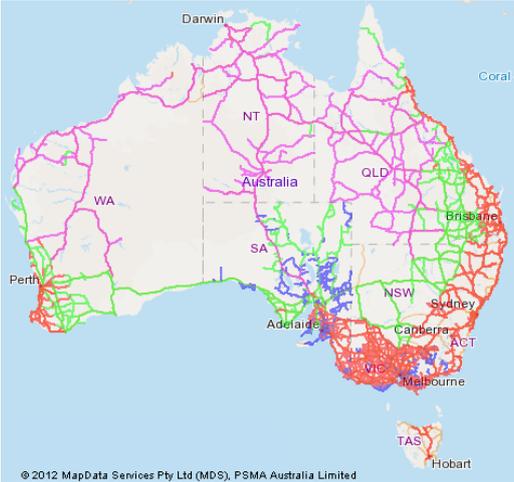
**5.1 Initiatives related to the Network**

Australia has a large number of heavy vehicle combinations with different performance characteristics, and as such has developed a number of restricted access networks over the years. In 2008, the Performance Based Standards (PBS) Scheme came into effect. This scheme aims to match the right vehicles to the right roads through standards requiring a certain level of performance of the vehicle and the capacity of the network. There are four levels of PBS classification (and two subclasses) for vehicles and roads as shown in Table 3.

**Table 3 - Four levels of access under the PBS scheme**

PBS Level	Example Vehicle	Network Access by Vehicle length (m)	
		Class A	Class B
Level 1	Rigid trucks, semi-trailer	≤ 20 m (General access)	
Level 2	B-Double	≤ 26 m	≤ 30 m
Level 3	Double Road Train (Type I)	≤ 36.5 m	≤ 42 m
Level 4	Triple Road Train (Type II)	≤ 53.5 m	≤ 60 m

As a result, the more realistic evaluation method that focuses the dynamic behaviour of the vehicle has been established, that provides both safety and efficiency benefits. Figure 6 illustrates the national PBS network. This is classified primarily through the National Transport Commission’s (NTC) PBS Network Classification Guidelines (NTC, 2007) and is constantly expanding as jurisdictions and local councils continually classify routes and provide certainty of access to industry.

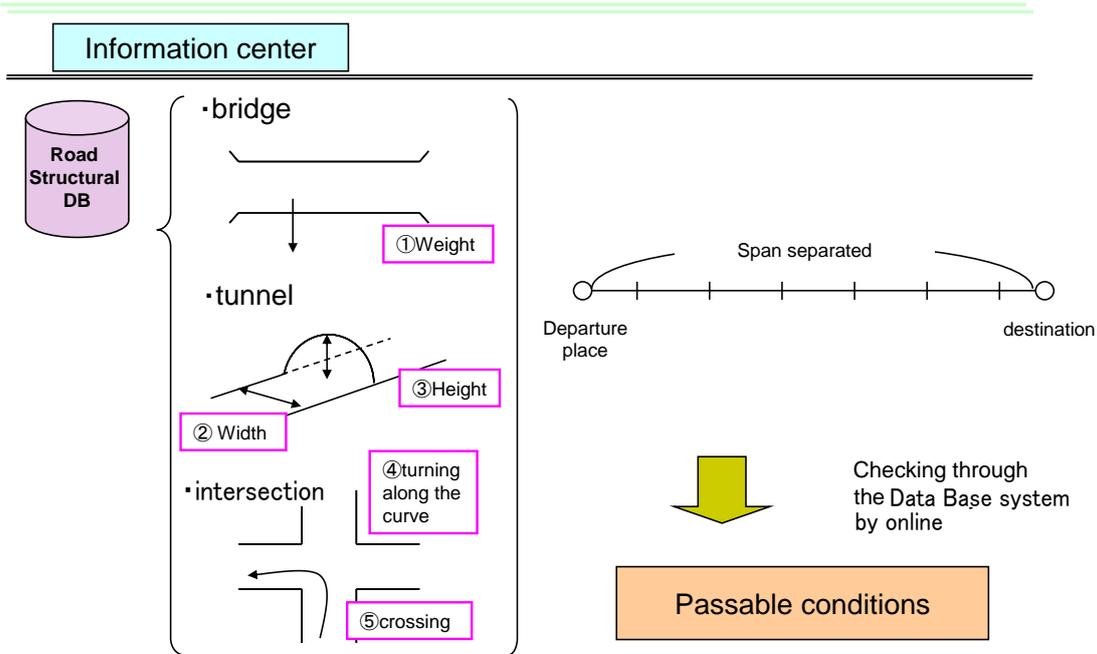


**Figure 6 - National PBS route network (NTC, 2012)**

To date, there are hundreds of vehicles participating in the scheme. These higher productivity freight vehicles enjoy productivity increases in the range of 15% - 100%. The number of vehicle trips is reduced, as is congestion, fuel usage and emissions. A specific example of increased access through PBS has been the recent announcement of a modular B-triple

network. These vehicles have been operating for many years; however industry take-up of these safer vehicles has been hampered by inconsistent policies on access and specifications. Using PBS to define a range of compliant vehicles, this combination now has access to the Type I road train network (similar to PBS Level 3).

Japan has concentrated on fully understanding and documenting the capability of its network. A database of every road and intersection in Japan was created in 2006. This database contains road specifications such as width, radius of curve, inside height of tunnel, loading capacity of bridge, etc. as required to evaluate the access potential for heavy vehicles. In addition to this ‘raw’ data, the database contains processed data and ratings on the capacity of network elements (e.g. largest vehicle suitable for turning in an intersection). The database is updated yearly and regularly utilised for detailed assessment of access. Figure 7 outlines the system.



**Figure 7 - Road data database system in Japan**

Online functionality also exists where a particular route for a certain vehicle type can be generated and evaluated for access suitability. This powerful tool enables very detailed route assessments to be undertaken for the general fleet, and non-standard fleet.

**5.2 Initiatives related to the Vehicle**

There are a number of vehicle design innovations in Australia. ‘Smart’ converter dollies that, depending on speed and other factors, can control the rate of articulation are in limited operation. Vehicles with increased manoeuvrability have also been designed utilising rotatable axle groups, such as that shown in Figure 8, which can also be fitted to longer combinations such as B-doubles. Additionally, there have been a number of innovative combinations appearing, particularly with the vehicle fleets servicing remote area. An example is the “B-A-B” combination which is two B-doubles connected by a converter dolly.

Private industry is leading the innovation for fit-for-purpose vehicles, and is enabled and incentivised by government schemes such as PBS.



**Figure 8 - Example of a PBS Vehicle with steerable trailer axle group**

On the other hand, in Japan there exists no action where the public and the private sector work together. However, some trailer manufacturers have developed and operated vehicles with self-driven trailers. As a result of the large amount of urban freight movement in space-restricted networks, Japan has seen many adaptations and innovations over the years to facilitate manoeuvring and loading/unloading in tight spaces, such as gull-wing doors on rigid trucks, shorter wheelbases and longer rear overhangs, high proportion of twin-steers to allow more mass forward and to reduce turning circles.

### **5.3 Using Route Assessment methods to increase efficient and safe access**

In order to improve the efficiency of transportation and the safety of heavy vehicle operation, it is necessary to identify, upgrade or construct roads suitable for heavy vehicle travel. To achieve this, the potential of the existing road network also needs to be re-evaluated as new methods are developed.

For example, in Japan a database related to the road network has been created. In addition, there is a database containing the level of ease of driving on the road using the method outlined in Figure 9. This ease level is determined by a number of factors including the number of lanes of the road, the geometry and shape of the road, the road environment, etc. In Japan, this additional methodology can be factored into the route evaluation.

Evaluated Ease of Driving Level Chart				
Illustration	Content	Rural Area	Level	City Area
	Evaluated the Road Level for Ease of Driving as 6 Levels	 2 more lanes Gentle curves		 2 more lanes Distinguished Bicycles
 Exclusive for Automotives	Level Most Easy 	 2 more lanes Some tight curves		 2 more lanes One Shoulder
 2 more lanes Longer straight lines Distinguished Pedestrians	Level Very Easy 	 1 lane or 2 lanes Many tight curves		 2 more lanes No Shoulder
		 1 lane Continuous tight curves		 1 lane No Shoulder

**Figure 9 - How to Evaluate the Ease of Driving**

### 5.4 ITS Technology initiatives

In Australia, a system has been recently implemented with the purpose of the increasing transportation efficiency. Operators participating in the Intelligent Access Program (IAP) can be allowed concessions on the mass limits of their vehicle, and potentially increased access. IAP involves the installation of an in-vehicle unit that transmits position, and in some cases mass data back to the service provider. This is helpful for ensuring compliance of restricted access vehicles, and those operating under permit conditions to operate on their set routes and at allowed masses. This framework seeks to provide infrastructure owners with greater confidence that heavy vehicles are operating within their allowed conditions, and thus provides flexibility for them to increase access and efficiency.

Japan has a very advanced infrastructure that supports the large range of telematics services offered by private businesses. This and the large-scale penetration of hand-held devices, leads to lower costs for some kinds of service. As such, Japan has seen widespread adoption by operators of real-time state management of fleets. Additionally, navigational aids are widespread and can provide a large range of information to drivers, as well as real-time updates and warnings, providing both safety and efficiency benefits. It is well recognised that utilising ITS technology is beneficial in enabling heavy vehicles to operate efficiently. The use of software without investing capital in the construction of new road infrastructure is also seen as a very cost-effective approach.

### 6. Conclusion

Methods impacting access for heavy vehicles have been examined and compared between two countries having vast differences in area, population and freight task. As a result of the

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comparison, it was found that a common feature between both countries is the desire to more fully utilise already-existing road networks. The current key method for this has been through the PBS scheme in Australia, and through the creation of detailed databases on the network in Japan.

Both countries have a lot to offer each other, as Australia is realising the importance of detailed and current data on the network, and Japan can envisage schemes like PBS assisting with the increased movement of larger, heavier containers.

Monitoring in some form appears helpful in securing the road conservation and the traffic safety. In that sense, ITS technology is beneficial for administering heavy vehicles, as can be seen in environments, such as Europe and the U.S. where charging heavy vehicles by mass through On-Board Devices is prevalent.

In the future, in order to face the challenges arising such as decreasing income of fuel tax and the deterioration of roads and structure, the administering run of large-sized vehicles appropriately and the improving efficiency of transportation and safety of run on the road may lead to restrain the negative impact of road infrastructures as a result.

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