

IDENTIFICATION OF TRANSIT STOPS IN SUBURBAN MELBOURNE FOR MYKI-LINKED BICYCLE FACILITIES

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ABSTRACT

Rapid population growth in urban areas and car-centred urban transport development is accelerating urban sprawl in many parts of the world. Unmitigated urban sprawl has caused serious social, economic and environmental problems, such as traffic congestion, air pollution, and social exclusion in disadvantaged locations with poor accessibility to transportation and other essential facilities and services. Which in turn have pushed for a shift towards transit-oriented development (TOD). TOD in general emphasizes the importance of a well-connected multimode public transportation in improving economic efficiency, social equity, and environmental quality, and community wellbeing. TOD in suburban Melbourne aims at the improvement of public transportation system in terms of its connectivity, reliability, efficiency, flexibility, and accessibility. This study focuses on the improvement of the multimode public transportation infrastructure in the Knox local government area (LGA), an outer suburban area of the Melbourne metropolitan region in Australia, by identifying premium transit stops to implement flexible and secured bicycle storage and hire facilities that are linked to Myki, Victoria's new smart-card ticketing system for public transport. Key criteria used in the identification of premium transit stops in the Knox LGA for Myki-linked bicycle facilities include: (1) spatial accessibility to public transportation facilities and services, conceptualised as the shortest network distance from each individual household address to the nearest transit stop; (2) existing service capacity at each transit stop, indicated by the current weekday and weekend service frequencies; and (3) existing patronage size at each transit stop - measured jointly by the total number of households (indicated by the address points) which have their shortest network distances associated with the specific transit stop; and the total population that reside within these households (derived from the 2006 Mesh Block level population census). These criteria have been derived in this study through GIS-based procedures (1) for the representation and organisation of relevant geographical features into a transit-oriented geodatabase; (2) for network-based shortest path and service area analyses; (3) for integrating Mesh Block level census data (population, dwelling and land use) and service frequency data for each transit route with spatial datasets including address points, transit stops (including both bus stops and train stations) and road networks in the Knox LGA; and (4) for generating geovisualisations of the findings, including disadvantaged areas that have poor access to public transportation and potential transit stops where Myki-linked bicycle facilities may have an immediate impact on the use of public transportation. The scalable geodatabase templates and automated geoprocessing models deployed in the study may be applied to other urban regions in Australia with a view to improve the existing public transportation systems.

INTRODUCTION

As urban population growth continues to exponentially accelerate throughout Australia, the need for efficient utilization of existing and proposed public infrastructure increases simultaneously. Such factors have mandated for a rethink in the way public infrastructure is organized and how future growth can be made sustainable. A paradigm of thought that has recently come to the surface is Transit-Oriented Development[1].

One of the drawbacks of current development styles is the separation of land-use from zoning. Separating commercial and residential precincts will invariably increase the amount transportation required. Increasing the demand for transportation will accentuate the points along the transportation networks that are prone to congestion. This is often realised as a 'peak-hour traffic jam' – in which there is the greatest demand for transportation. Traffic congestion alone is forecasted to cost the Australian industry over twenty billion dollars a year in lost earnings by 2020[2].

Transit-Orientated Development (TOD) is a move towards development that centres on access to public transportation. At the heart of the TOD approach is that citizens can commute to work places, shopping centres and educational institutions through a well networked, interconnected public transportation system – without relying on single-vehicle motorised transport. Such development requires the mapping and implementation of a holistic public transportation system – from the start node (the commuter's front door) to the end node (the commuter's final destination). It requires public transportation that is convenient,

timely, seamlessly connected and safe. The emphasis must shift from single transit nodes to the resulting networks.

Within the Transit-Orientated Development framework is the key goal of social inclusion [1]. People who cannot afford to own a car or pay for running costs can take advantage of a design paradigm that focuses on less reliance on long-distance travel and more on interconnectedness. Elderly and disabled people will also benefit in future developments being engineering towards more accessible, safer and efficient public transportation. Younger people, who cannot legally drive, can use the system to get to school and acquaintances' houses without causing inconveniences to their guardians. By encouraging walking and zoning, TOD and mixed zoning has the potential to improve the health and well being of the citizens.

Currently, the State Government of Victoria is introducing its transport plan[3] and its development plan (known as Melbourne 2030[4]). It is moving towards a TOD-styled architecture but is still in its infancy, which is evident by poor or non-existent connectivity between many different modes of transportation. As part of the transport plan, links between buses and trains are being improved but links between other modes of transport (such as pedestrian and cycling) have been neglected.

Part of the implementation of the Victorian Transportation Plan was the Parkiteer (corruption of the phrase "park it here") Bicycle Cages [5]. These were placed at busy train stations, such as Sunshine station with the view of cyclists using them to securely lock their bicycles and to catch public transport. It was done with the intention of increasing patronage of the train system. Such systems (including ride-share) can be applied to bus stops that have sufficient patronage and frequent services.

The focus of this research paper is on the links between pedestrian / cycling and the surrounding bus stops and train stations. Each address is able to be located with its nearest transit stop along a network of roads, bicycle paths and footpaths. This paper looks at a possible solution to the questions regarding the characterising of public transportation access and distinguishing between areas of advantage (areas serviced by frequent and diverse public transportation infrastructure) and disadvantage (areas serviced by infrequent and sparse public transportation infrastructure). These can be determined through the use of hotspot analysis. The hot spots will show areas that have a disadvantage to public transportation access, and conversely the cold spots will show areas that have an advantage to public transportation access. This focuses on an important part of the TOD paradigm, in that all modes of equitable transportation should be fundamentally connected and realised as transit opportunities.

These points are discussed through a case study of the Knox LGA. The study area section gives a broad outline of the Knox local government area and a geographical breakdown of population, land use and private motor vehicle access. The methodology section describes how the model was created and the expected outputs in terms of a network base geo database. The results and discussion draws conclusions on whether we have achieved our aims and the recommendations section details how these processes can be improved and expanded to a wider area.

STUDY AREA AND SOURCE DATA

The Knox local government area is comprised of established outer-eastern metropolitan suburbs of Melbourne, with growth areas to the east and south largely outside the municipality. According to the Bureau of statistics, the total population of the Knox Municipality was 155,969 in 2009[6]. Compared to the rest Metropolitan Melbourne, the Knox LGA has relative high rates of vehicle ownership and usage. This is attributable to the distance the LGA is from the central business district. [7]

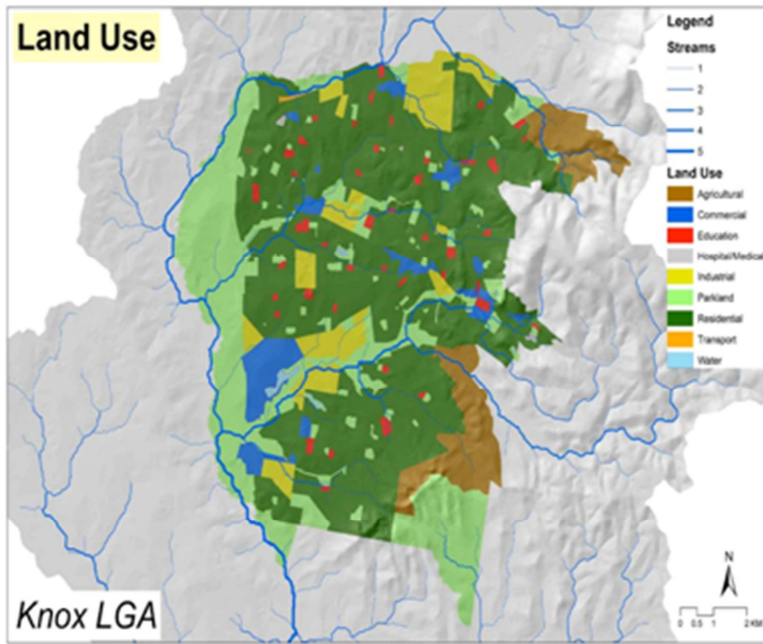


Figure 1 - Knox LGA land uses



Figure 2 - Knox LGA - Public Transportation

The Knox LGA has twenty bus routes (including two smart buses) and the Belgrade railway line passes through the north-east section, with four stations. Smart buses differ from normal buses in that they are tracked through a GPS system, which allows for commuters to be informed when the next bus is arriving. Smart buses are a premium service and have routes that extend across multiple local government areas. Below lists the datasets that are used in this paper. The final dataset is for use only with visualisation.

Name	Description	Source
Address Points	Contains individual dwellings points.	VicMap 2007
2006 census Mesh block	Contains land use, population and dwellings to mesh block scale for the Knox City LGA.	Australian Bureau of Statistics 2006
Railway Stations	Contains the railway stations as point data.	VicMap 2007
Railway Routes	Contains the railway routes as linear data.	VicMap 2007
Bus Stops	Contains bus stop locations as point data.	Knox City Council
Bus Routes	Contains bus routes as linear data.	Knox City Council
Road Network	Contains road information in a linear format.	VicMap 2007
Melway	Road directory image, showing land use and roads	Melway

METHODOLOGY

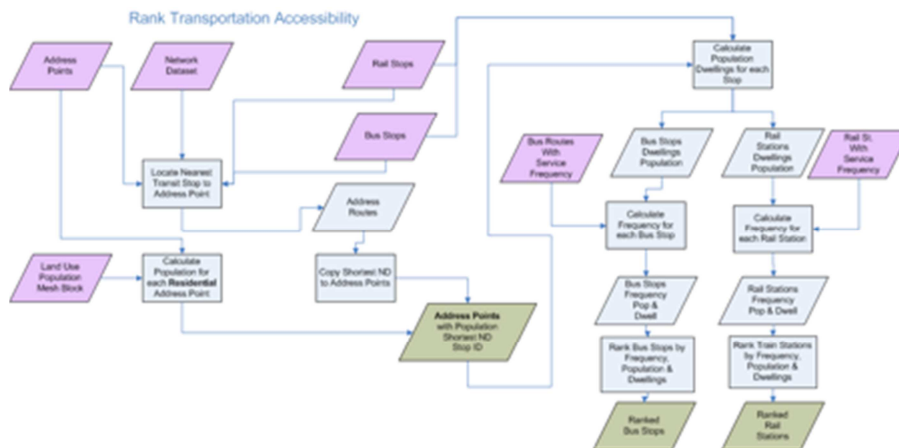


Figure 3 - Model Diagram

The inputs for the model are listed under the heading of source data. It is recommended that the address points and transit stops are geo-referenced before employing them as this reduces the need for computing during run time. The first step is to locate each address point to its nearest transit stop. This creates a layer which holds the routing information (along the road network), named address routes. Once the nearest transit stop has been located it is then copied back to the address point along with the shortest network distance to the transit stop. The population is also calculated for each residential address point (ignoring non-residential addresses) by dividing the population by the number of address points (individual dwellings) and saving it back to the address points. The population and dwelling data is then summarised by each transit stop. The transit routes (bus and train), which hold the service frequency information, are then related to its relevant stops. The service frequency is then summarised by each transit stop (remembering that a transit stop can be serviced by more than one route and each route has more than one stop). The individual transit type is then ranked according to the number of dwellings, the number of population and the frequency of existing services.

RESULTS AND DISCUSSIONS

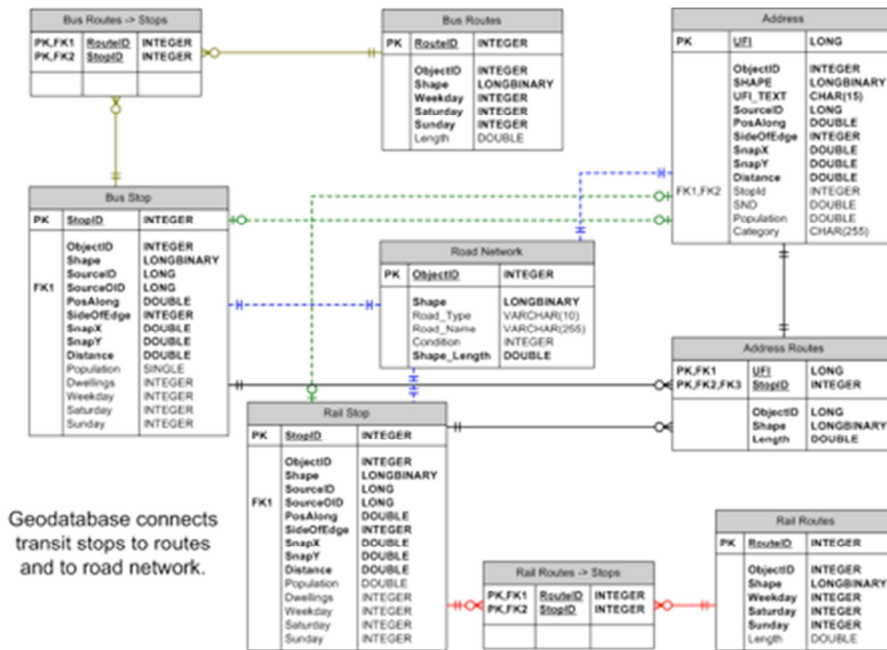


Figure 4 - E-R diagram of Geodatabase

The primary output of the model is in the form of connected transportation datasets within the geo database. The geo database associates the road network to the individual transit stops through the SourceOID fields. PosAlong and SideOfEdge determine where the transit stop is located against the road, with SnapX, SnapY & Distance calculating how far the stop is from the network route node. The Primary Key for the Road Network is the ObjectID, which is employed by the ArcGIS network analysis tools. The routes are associated by geometrically locating the stops along the routes. One route may have multiple stops and one stop multiple routes. Therefore, a secondary table needs to be created to keep the information normalised. Once the Addresses are located to the nearest transit stop, the shortest network distance can be calculated to that stop. This relationship also works in the reverse, which allows the individual stops to have a total population and dwellings count.

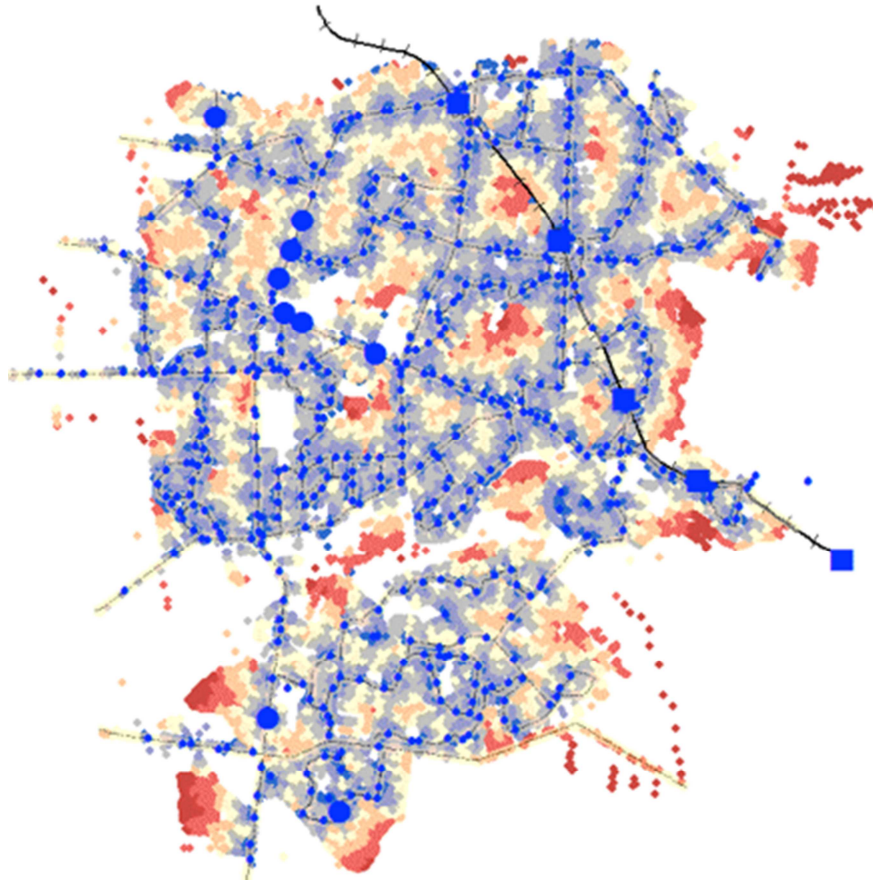


Figure 5 - Premium transit stops and public transportation accessibility

The above image gives a broad overview to where areas of transportation advantage (blue) and disadvantage (red). The area that is at the far south is suffering from edge effects, whilst the south-western areas and the eastern areas are not serviced by transit links from other local government areas. The solid blue circles are bus stops that have been identified to have both the highest relative frequent services (50% weighting) and catchment areas (50% weighting). These have mainly occurred along the major highways and throughfares of the Knox Local Government Area (and around the major shopping centres). The blue squares are the train stations that are within the local government area.

RECOMMENDATIONS

So far the processes discussed have only taken into consideration one form of transportation which - that of address point to nearest transportation stop (which is two possible modes – cycling and walking). No preference has been given to any particular method of public transportation – i.e. both buses and trains have been assumed to be acceptable to the average commuter. As discussed earlier, this is an assumption that is at best tenuous. Cost-based analysis which takes into consideration transportation method desirability would alleviate the problem. Such implementation would need to move from a single-mode transportation network to a multi-mode transportation network.

In a single-mode transportation network, only one type of transportation route (in this case, the road network) is taken into consideration when calculating route data. In a multi-mode transportation network, any number of different transportation routes may be incorporated in determining quantities such as shortest network distance. Multi-mode transportation networks also add additional complexity to the system. Passengers can only board at stations along a train route; buses and cars share roads but never share rail lines with trains. The interchanges between different modes of transportation need to be taken into consideration when mapping such a system. There is also a cost in terms of time to change from one transportation type to another (for example: waiting for the next bus to arrive, or trying to find a car park at the station). The geometry also becomes extremely important – platforms at stations cannot be directly accessed by walking across the tracks. The issue of bus stop locations also becomes important – a bus route will make use of one side of the route going, and the opposite in returning.

The first step in converting the created geodatabase into a multi-modal transportation network is to create an overarching dataset that has the road network, rail network, bus network, bike and pedestrian network

as subsidiaries. Moreover, a movement cost matrix needs to be created for every junction between the differing modes of transportation. The geometry of the individual entry/exit points needs to be accurately mapped in order to achieve meaningful results. Tunnels, bridges, intersections, overpasses and underpasses need to be distinguished from each other to prevent accidental routes where it would be impossible to employ in real life. An example is that an address node cannot map directly to a section of road that is underground or aboveground unless there is some connecting artifice – and only that artifice may be used to create a feasible route.

So, in that manner the road network datasets will need to be able to accurately model the geometry of roads that have extra features – such as bus lanes and dedicated bus routes. As lanes do not permit the patronage of private vehicle access, it is possible to have a road that is congested to private vehicles, but is relatively light for bus traffic. Therefore, the transportation network will vary between private and public transportation, even if they share the same resources.

As mentioned earlier, the different transportation timetables have only been stored as frequency rather than as actual times. This makes it possible to predict how many services will pass through a stop on a given day but not at which time of the day. Usually there are more services during the morning and evening peaks than the middle of the day or at night. This has not been reflected in the data analysis undertaken thus far. To calculate the time that each route will take, it is imperative to know precisely when the connecting service (in a multi-nodal network) is arriving. It is possible to have the shortest network distance to take a longer time than an alternative route. This is due to the timing of the services or the speed of traffic during differing periods of the day. Time is extremely critical. During certain times of the day roads become clearways (where a road converts from a single lane to a double lane road), restrictions are not only placed on turns, but trains and buses run along different routes and the roads conditions (traffic volumes) vary.

The turn tables will also need to reflect the different restrictions placed upon the different modes of transportation. The manner in which these turns are modelled into the resulting transportation network are important as they will significantly alter the cost it takes to move from origin to destination, especially if the route transverses through shopping precincts and business districts. For example; across much of metropolitan Melbourne, there are dedicated bus lanes and bus-only turns. These are designed to improve the flow of bus traffic so that they operate according to their respective timetables. This has a negative effect on private transportation – as they are restricted to their respective lanes and cannot make a turn if it is a bus-dedicated turn. The turn tables become even more complicated when restrictions are placed on turns during certain periods of the day – usually during morning peak, the inbound lanes (towards the city) and outbound (away from the city) during the evening peak. If the turn table is divided between the transportation modes, then new columns must be added to indicate the time of day that the turns are valid for. It is highly likely that any future analysis will require one network dataset to be run multiple times against different turn-tables to accurately describe the traffic conditions at any given time.

This is shown in the figure below, in which rules are set for various routes – given the relevant network. A station is the overarching transit terminal which may house many different types of interchanges. Each interchange is connected by a route, with a permitted mode of transport – which forms part of the network structure. Each interchange is then in turned governed by a number of services which run according to the permitted modes and routes. At the heart of all this is the networks (such as car, bus, train) which is comprised of a series of routes connecting the various interchanges.

The power of this recommended model is the ability to accurately map the time it takes to descend from one interchange and embark on another – usually walked by the commuter, which can easily be neglected because of the short distances involved. It can prevent problems where trains and buses may arrive and depart at the same time, but because of an unaccounted “route” the commuter misses the connection and has to wait for the next service.

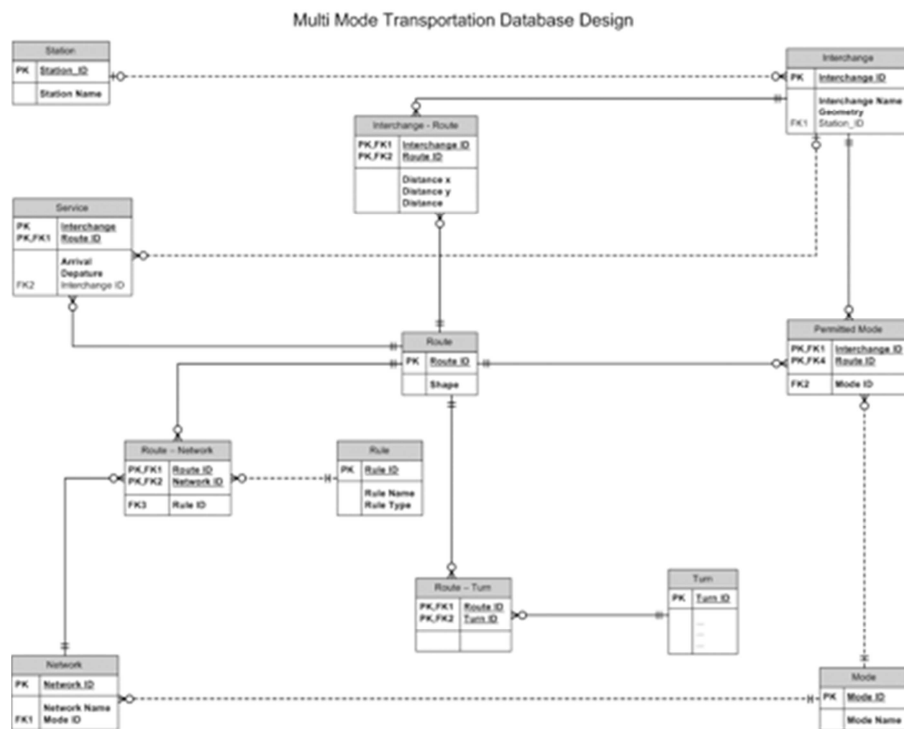


Figure 6 - Overview of Multimode Network

REFERENCES

1. Finkenbinder, A., K. Britt, and C. Blair, Cox, Transit-Oriented Development Tools for Metropolitan Planning Organizations, Center for Transit Orientated Development, Editor. 2010, Reconnecting America: Berkeley, California. p. 1 - 33.
2. Potterton, P., Estimating urban traffic and congestion cost trends for Australian cities, Department of Transport and Regional Services, Editor. 2007, Bureau of Transport and Regional Economics: Canberra, Australia. p. 1 - 143.
3. State Government, The Victorian Transportation Plan, Department of Transport, Editor. 2008, Government of Victoria: Melbourne. p. 1 - 164.
4. Interdepartmental, Melbourne 2030: a planning update - Melbourne @ 5 million, Department of Sustainability and Environment and Department of Planning and Community Development, Editors. 2008, Government of Victoria: Melbourne.
5. Bicycle Victoria. Parkiteer Cages - Bicycle Victoria. 2010 [cited 2010 10th of August]; Available from: <http://www.bv.com.au/bike-parking/43422/>.
6. Australian Bureau of Statistics. 3218.0 - Regional Population Growth, Australia, 2008-09. 2009 [cited 2010 12th of August]; Available from: <http://www.abs.gov.au/ausstats/abs@.nsf/Latestproducts/3218.0Main%20Features52008-09?opendocument&tabname=Summary&prodno=3218.0&issue=2008-09&num=&view=>.
7. Co, B., Knox / Maroondah / Yarra Ranges Bus Service Review (Recommendation Report), d.o. transport, Editor. 2010, Booz & Co: Melbourne.