

# **Transforming Adelaide into a city of networked TODs using buses: case study of the Adelaide OBahn**

Andrew Allan<sup>1</sup>, Munshi Nawaz<sup>1</sup> Matthew Fielke<sup>1</sup>

<sup>1</sup> School of Natural and Built Environments, University of South Australia, P.O. Box 2471, Adelaide South Australia, 5001

Email for correspondence: Andrew.Allan@unisa.edu.au

## **Abstract**

The 2010 Planning Strategy and the 2015 Integrated Transport and Land Use Plan aim to re-orientate Adelaide's urban transport system away from private cars towards public transit, cycling and walking. These planning instruments propose an integrated public transport network with Transit Oriented Developments (TODs) connected by transit corridors surrounded by urban residential densities of 35 dwellings/ha. Whilst in the more significant transit corridors, rail and tram networks will dominate, a modernised bus network will be needed to accommodate much of the anticipated modal switch to public transit.

The OBahn serving Adelaide's inner to middle north-eastern suburbs, demonstrates the mass transit potential of buses. However, the OBahn corridor lacks TODs with substantial residential development. It also lacks integration with the northern suburbs rail corridor, although the Planning Strategy does highlight a long term objective to develop a mass transit corridor from the OBahn to Salisbury, on the northern rail corridor. This paper explores the feasibility of bus based public transit in creating a transit oriented city and in fulfilling the Strategy's environmental objectives using the case study of an extended Adelaide OBahn. The methodology applied is a spatial study of the pedsheds along the OBahn corridor (and its extension to Salisbury), and an examination of the route's capacity and likely performance. The outcomes of this research are to determine the extent to which a bus based public transit system can meet the Strategy's goal of increased residential densities both from an operational perspective as well as in contributing to reduced carbon emissions.

Key words: OBahn, TODs, pedsheds

## **1. Introduction**

Modern metropolitan Adelaide reflects an urban form that is the result of cheap oil, plentiful space, affordable suburban bungalow housing and a car based culture. However, contemporary disruptive drivers of change such as climate change, increasing energy costs, the increasing unaffordability of housing, the looming closure of Adelaide's motor vehicle industry, traffic congestion and reduced enthusiasm for the traditional suburban backyard suggest that a rethink of Adelaide's urban form and the transport systems underpinning it are required. The current metropolitan strategic planning approach for Adelaide, has since the introduction of the 30 Year Plan for Greater Adelaide (30YPGA) in 2010, proposed Transit Oriented Developments (TODs) and Transit Corridors (TCs), as a means of increasing Adelaide's urban densities to meet anticipated population growth of an additional 560,000 people to greater Adelaide's existing population of approximately 1.25m. The rationale behind the 30YPGA is partly to fulfil the South Australian Government's objective to reduce carbon emissions through more compact and efficient housing, but it is also (among many

objectives beyond the scope of this paper), to encourage greater travel efficiencies, and less transport related environmental impacts, with carbon emissions being the most significant.

The first part of this paper provides background to the case study selection of Adelaide's own Bus Rapid Transit (BRT) system, the Adelaide OBahn, and how this could be extended to provide an integrated public transit system serving increased commuter catchments in Adelaide's northern and north-eastern suburbs. Transit interchanges along this route currently do not function as TODs with residential densities identical or less than that of the residential areas beyond the immediate pedshed commuter catchments of the transit interchanges. The OBahn route does not function as a transit corridor with housing between the interchanges isolated from access to the transit corridor, and residential densities no higher than anywhere else in the metropolitan area, with Lochiel Park perhaps being the only exception.

The paper then discusses the application of the Local Accessibility Appraisal Tool (LAAAT) that was used to analyse the pedsheds (i.e. the walking commuter catchments), along the OBahn and along a purely hypothetical proposed OBahn extension to the Northern Expressway via the Salisbury Bus-Rail interchange on the Adelaide-Gawler northern suburbs commuter rail corridor. The use of the LAAAT was used to demonstrate the housing development potential of the transit route's largely vacant pedsheds around the interchanges, which would be needed in achieving a transformation of the interchanges into TODs. Estimates of the transit trips likely from this intensification of development are also presented.

The paper concludes with a discussion of the efficacy of the pedshed methodology, the pedshed catchment estimates and the strategic transit planning value of both redeveloping the OBahn's interchanges into TODs and in extending the OBahn in a cross-radial manner to connect with three other major transport corridors in Adelaide's northern suburbs.

## **2. Background**

Mees (2010) in exploring urban transport solutions for suburbia in Australian cities highlighted the tension in the compact city debate in Australian academic circles, between researchers such as Peter Newman and Jeff Kenworthy who advocated rail based transit development (either in the form of light rail or heavy rail), and sceptics of densification of the suburbs which included himself, and researchers such as Pat Troy, Ian Lowe, Brendan Gleeson, and Wendall Cox of the U.S. based consultancy Demographia. U.S. researchers Gordon and Richardson (1997), also weighed into the debate on the compact densified city, initiated by Newman and Kenworthy's (1989) global landmark work titled "Cities and Automobile Dependency" first published in 1989. Carey Curtis (2009) had published widely on TODs with specific emphasis on Perth's experience and John Renne (2013) (a U.S. based researcher who had previously worked with Carey in Australia), is a strong proponent of TODs as a means of combatting auto induced urban sprawl. Mees (2010) was somewhat dismissive of the value of bus-ways, based on lack lustre passenger growth for Brisbane's busway, although he was impressed by the apparent patronage increase for Adelaide's OBahn, even if it appeared to rely on park and ride auto dependent commuting. However, even then Mees (2010) was reluctant to recognise that the Adelaide OBahn's success in increased patronage was due to improved popularity but instead he had claimed that it was associated with population growth from an expanded suburban hinterland within the City of Tea Tree Gully feeding more passengers into the system from further afield, with public transit's overall modal share within the OBahn's hinterland barely affected. Mees' (2010) recommended solution for suburbia was a networked system of bus routes. What is perhaps overlooked in Mees' review is that an OBahn or bus-way is ideally placed to do both-provide

public high capacity transit trunk routes and connect with feeder local bus transit services, that have a long reach into suburbia.

During the past four decades, the South Australian Government's strategic planning efforts have attempted to transform or at least re-orient metropolitan Adelaide from being a monocentric low density city of single storey suburban bungalows serviced by private motorised traffic towards a polycentric urban form, based on a constellation of Transit Oriented Developments (TODs) connected by a network of heavy rail, light rail and bus based public transport corridors. Whilst Adelaide is fortunate to have modal specific public transit corridors already in place, including a 12km long high speed bus-way (the OBahn), 130km of heavy rail fanning out across 6 commuter lines, and 16km of tram-lines, metropolitan Adelaide largely relies on its urban road network and motor vehicles to meet the bulk of its urban transport requirements. Adelaide's road network does predominantly serve the needs of private motorists (with a modal share of nearly 80% of all urban commuter trips) (ABS, 2013), however most of Adelaide's commuter bus operations are also heavily dependent on the urban road system, accounting for 95% of the 50,000,000 bus passenger boardings annually (Adelaide Advertiser, June 9, 2015). In recent years, along some of Adelaide's busier arterial roads and city streets, dedicated bus lanes have been established (at least between the hours of 7am and 7pm on weekdays), and priority traffic signal sequencing introduced to reclaim a greater share of road space previously intended for the use of private motorists.

Despite the rhetoric in the 30 Year Plan for Greater Adelaide (30YPGA) favouring a compact city with indicative urban densities of 35 dwellings/hectare along its transit corridors, apart from Adelaide's CBD, only a handful of suburban centres approach or exceed this level of residential density, including Mawson Lakes, Glenelg and Bowden (which is currently under construction), and indeed some sense of how far Adelaide has to progress to become a compact dense city is reflected by the fact that Adelaide's gross residential density was a mere 1.6 dwellings/ha in 2011 (ABS, 2011-Greater Adelaide (4GADE)-Community Profile). To date, despite the best efforts of past metropolitan strategic planning efforts (i.e. the 1994 Planning Strategy and the 2010 30YPGA), it is only in its hierarchy of retailing centres, that Adelaide has achieved some semblance of a polycentric urban form. Residential and employment densities in the walking catchment (or pedshed) of Adelaide's suburban centres have remained with low densities stubbornly undifferentiated from the wider suburban landscape of largely single storey suburban bungalows. The lack of change in urban form is not for a want of desire or effort on the part of the South Australian State Government, particularly in terms of the intent expressed by the State Labor Planning Minister John Rau. Attempts to start a dialogue by State Government often results in frenzied, vocal local politics and community mobilisation stridently opposing intensification of land uses, particularly for residential purposes, in centres and along arterial road corridors. Suggestions by the State Government to increase residential densities around the Tea Tree Plaza bus interchange where the OBahn terminates 14km northeast of Adelaide's CBD in the past year were met with unanimous local hostility both within the community and from local politicians, whilst at the city end of the OBahn, a project to extend the OBahn with a tunnel into Grenfell Street near the much loved Rymill Park, is now in its fourth major revision during the past year in an effort to placate extremely negative local reaction even though there was to be no net loss of parkland and the proposed works would rather have fortuitously provided the future option of a light rail corridor to the inner city suburb of Norwood. By comparison, major road projects where new or substantially widened road corridors such as Adelaide's \$9.3bn South Road upgrade, with the ultimate transport planning objective of a providing a 78km long high capacity north-south motor traffic spine of 4-6 lanes free from the disruption of traffic signals, has aroused little if any public opposition

either locally or generally in the wider media. Even within existing public transit corridors, where service improvements result in minimal externalities to local communities, such as with the electrification of the 42km Gawler commuter rail corridor, political sensitivities have resulted in abandonment of the project, ostensibly because of funding challenges and a lack of Commonwealth Government support. In the current political climate of South Australia, expansion of the commuter tram and heavy rail network appears to be virtually impossible. A refocusing of transport and urban planning strategizing on buses has the advantage of utilising Adelaide's existing road network, albeit by displacing some private motor vehicle traffic. However, a bus system that ekes out greater transit capacity simply by adding additional buses to bus operations is doomed to fail because service reliability and competitive travel times with private car travel cannot be guaranteed. The experience with public transit improvements in Perth (Curtis et al. 2009, Lindau et al. 2010) demonstrates that for public transit to succeed as a preferred commuter mode of urban transport, it needs to offer competitive door to door travel times, a quality travel experience and cost competitiveness that exceeds the marginal cost of making a trip by private car.

### **3. The Adelaide OBahn-Adelaide's Bus Rapid Transit Corridor**

The Adelaide OBahn, a guided high speed busway allowing operating speeds of up to 100km/h, since its completion in 1989 at a cost of \$A100m, had succeeded as one of Australia's most well patronised and successful bus rapid transport (BRT) commuter routes. In 2015, it carried approximately 31,000 people per weekday (Allan and Fielke, 2015).

The OBahn commences approximately 2km outside of the CBD on the northern side of the Torrens River at Gilberton, with interchanges at Klemzig and Paradise, before terminating at Tea Tree Plaza. The nature of limited stops for this service is a result of large distances between the interchanges however it does allow high average speeds to be achieved (approximately 42km/h) that are competitive with urban road speeds for private car travel. The innovative aspect of the design of this bus way, is that it's exceptionally narrow carriageway corridor (7m in width for both opposing directions of traffic flow), meant that it could be accommodated within the linear park of the Torrens River valley with minimal physical and visual intrusion and little loss of parkland amenity. The OBahn also succeeded in offering outstanding route and service flexibility because although buses required some mechanical modifications (i.e. to steering with a pair of horizontal guide wheels) to operate on the OBahn track, they were able to function as a standard road bus away from the OBahn, thereby allowing feeder and trunk bus routes to be operated by the same bus, without necessitating a passenger transfer as would have occurred if the original light rail proposal for the Torrens River Valley had been adopted.

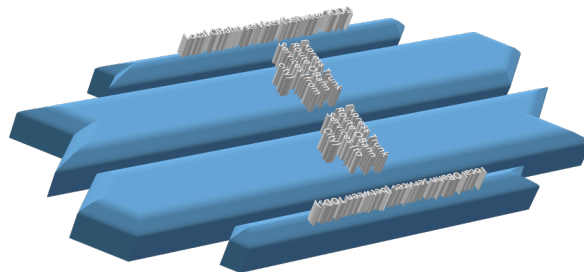
However, the critical shortcoming of the OBahn, is that it is a CBD centric radial public transit service that terminates at Tea Tree Plaza, a middle distance suburban destination. Original planning for the OBahn had allowed for a station where the track passes under Grand Junction Road (Cevero, 1998), which would have provided a route along the alignment of Grand Junction Road out to Port Adelaide, however, this option was never implemented, and given the low density nature of largely industrial and commercial land uses served by this corridor, it is doubtful that viable passenger catchments could have been achieved, particularly since metropolitan and local planning plans did not have any measures in place to facilitate an increase of urban densities at the levels needed to support a BRT service.

### **4. The OBahn as the Lynchpin in a Network of TODs and TCs**

The 30YPGA and its companion plan, ITLUP of 2015 proposes a network of TODs and TCs for Adelaide. In Adelaide's north-eastern suburbs, the OBahn's transport interchanges are



well placed to accommodate future TODs at Klemzig, Paradise and Tea Tree Plaza, which currently function as park and ride stations with negligible development exploiting the high levels of transport accessibility offered by the interchanges. The current plan to extend the OBahn from Gilberton into the city, suggests that there is potential to add an interchange at Gilberton. The low residential densities around these interchanges (apart from Gilberton), would allow substantial development potential if medium to high residential densities were to replace the low urban densities that currently exist at these interchanges. The concept of developing the OBahn into a Transit Corridor (TC) is more challenging for the OBahn. A TC normally implies that there would be transit stops at walking distances along the route, with no dwelling more than 600m from a transit stop, with a separation distance of no more than 1.2km between transit stops. However, unless a dwelling is located immediately adjacent to the TC alignment, dwellings at the edge of the 600m TC at the midpoint between the transit stops would have a Euclidean distance to the transit stop of nearly 850m. The OBahn spacing between its interchanges is more than double an acceptable walking distance, hence without local feeder bus services running in parallel to the TC, it does not quite fulfil the complete definition of a transit corridor. The alignment of the OBahn track within the linear park is also problematical to any intensification of services (such as doubling the track capacity), or intensification of urban development at the interface of the linear park because community opposition is likely to be intense. The lack of a continuous road system in parallel with the OBahn prevents at least in the short term, this limitation being overcome. Transforming the OBahn into a genuine TC could be achieved by duplicating the track, with the outer tracks meeting local transit needs whilst the inner tracks continue to provide a high speed limited stops express service with high passenger volumes. The interchanges would provide the transfer points from the high speed express services to the local services. This approach to transit service provisioning has parallels with super-tall office tower blocks where express elevators provide access to sky lobbies, and then local elevators are used to access particular floors situated between or above the sky lobbies.



**Figure 1: Schematic representation of OBahn combining express trunk limited stops services (inner tracks) with local services between major TODs (outer tracks)**

A glance at the map of suburban northern Adelaide highlights the radial nature of Adelaide public transit trunk routes. Commuter rail lines radiate out from the city centre to Port Adelaide in the north-west and Gawler in the far north-east, with conventional buses filling in the vast intervening urban areas stretching on either side of these rail lines. The OBahn is a northeast radial bus rapid transit route that radiates in a north-eastern direction to terminate at a major Westfields Shopping Regional Mall (Tea Tree Plaza) at Tea Tree Gully. Further north, the Northern Expressway arcs in a crescent through Adelaide's northern metropolitan greenbelt from Gawler to connect with National Highway 1 (Port Wakefield Road) and South Road, Adelaide's main metropolitan north-south road traffic arterial. This expressway has the potential to serve as a bus based transit corridor, however, its primary design intent was to facilitate interstate commercial truck access to Adelaide's northern industrial areas. It is perhaps not surprising that motor vehicles are the preferred mode of travel in Adelaide's

northern suburbs given that the road networks are continuous when compared with the sparse and disconnected public transit corridors in the middle to outer suburban areas of northern Adelaide.

Although OBahn buses do exit the OBahn at the Tea Tree Plaza Bus Interchange to proceed via the arterial road network to Golden Grove and on to Salisbury and Elizabeth, far better public transit integration could be achieved if the OBahn were extended via the bus interchange at Golden Grove, and further stops at Greenwith, Main North Road, and the Salisbury and Elizabeth bus rail Interchanges. The significance of this approach is that it would provide an impetus for new TODs at Golden Grove Village and Greenwith, and transit corridors along the extended OBahn route, which is currently at very low residential densities or undeveloped. There is also potential for a new TOD where this proposed OBahn intersects with Main North Road. As with the existing OBahn route, this extension of 14.3km to Salisbury would have a route alignment through linear parks with some tunnels and bridges, and minimal disruption to the somewhat sparse existing development.

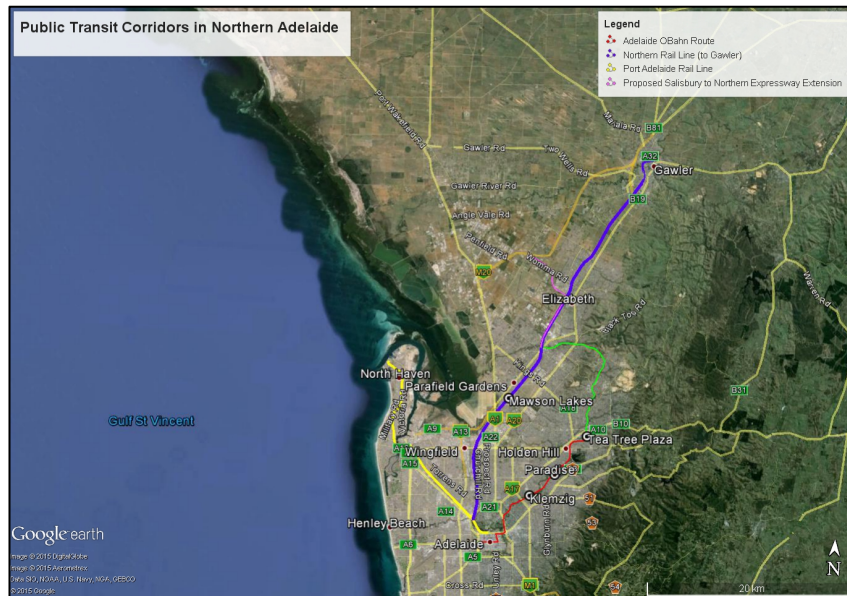
The original OBahn was constructed at a cost of \$104.2m in 1989 (i.e. \$8.68m/km) (Cevero, 1998) and its net present value (assuming an average consumer price increase of 4% per annum), would equate to \$289m today. Whilst detailed costings would at best be an educated guess, based on the original OBahn costings extrapolated to today's monetary values, assuming a similar cost per km, but expanded to 4 lanes (one express and one local in each direction), and with tunnels at Tea Tree Plaza, Golden Grove, Greenwith and Main North Road (at \$150m each), and a major interchange upgrade at Tea Tree Plaza and at Salisbury (at \$60m each), an OBahn extension to Salisbury Station would cost around \$1.064bn. This suggested OBahn extension would have the advantage of integrating major public transport trunk routes in Adelaide's northern and north-eastern suburbs with a cross radial route. Whilst a transfer from bus to rail would be required at Salisbury Station for commuters wanting to travel on to Mawson Lakes or Gawler, the combination of high transit speeds on rail and the BRT, and minimal modal transfer times, would help to ensure a relatively seamless service. An even bolder scheme would be to continue the OBahn extension in parallel with the northern commuter railway line to Elizabeth (another potential TOD with a major regional shopping mall and a railway station), and then have the OBahn connect with the Heaslip/Womma Road Northern Expressway Interchange near Edinburgh Airforce base. Extending the OBahn to the Northern Expressway would add 11.5 km and another \$400m in costs for a double track and four interchanges, and would be relatively affordable given the undeveloped nature of the corridor and the flat terrain. Although this would appear to be a duplication of the rail public transit provided by the northern commuter rail line, its route past the soon to be defunct Holden Motor Vehicle plant offers opportunities for major urban redevelopment on a grand scale. This would integrate the OBahn with the Northern Expressway, which is ultimately planned to link Gawler in the north-east to Willunga on the southern edge of Adelaide's metropolitan area, via South Road along a continuous road corridor offering motorway standards of service along much of its length with operating speeds ranging from 70-100km/h.

At the City end of the OBahn, the State Government has over the past year been working on a proposal to extend the OBahn along Hackney Road and through the parklands to emerge near Rymill Park near Grenfell Street. The rationale for this \$160m upgrade is to have buses avoid peak hour travel congestion, thereby saving up to 4 minutes travel time. Where the OBahn currently ends at Hackney Road in Gilberton, some densification of residential development is currently occurring, however, whilst the State Government have no plans to transform Gilberton into a future TOD, it is ideally placed for this to happen. OBahn buses at this point have to slow to 40km/h to merge with Hackney Road, the eastern chord of

Adelaide's city ring route, hence having an interchange here would be ideal for commuters wanting to access North Adelaide, which is adjacent to Gilberton.

A staged approach over several decades would be required to upgrade and integrate the OBahn into Adelaide's public transit system to the point that it becomes a genuine transit corridor with TODs that are part of a wider networked metropolitan system of TODs that incorporates cross radial middle and outer suburban public transit routes. Stage one would require completion of the current \$160m OBahn extension proposal from Gilberton to the city centre, but with a new interchange developed at Gilberton. Stage two would involve extending the OBahn as a 4 track system with dedicated cycle paths to Salisbury on both sides of the OBahn. Stage 3 would involve extending the OBahn from Salisbury to Elizabeth and then on to the Northern Expressway, also as a 4 track system with dedicated cycle paths. Stage 4 would involve park and ride facilities being developed at interchange, consistent with commuter patronage levels yet in a manner that allows them to become land banks for a future TOD. Stage 5 would involve redevelopment of the interchanges as TODs, and densification of the transit corridor. The final stage could be the most challenging because as has occurred with the current OBahn extension proposal, local residents are likely to vigorously resist change and obstruct the necessary planning changes through rezonings and new regulations. Interestingly, the bulk of the resistance to the current OBahn extension plans as reported in the local Advertiser and Messenger newspapers in 2015 have come from inner city residents that use Hackney Road with key objections being the severance from the Botanic Gardens caused by the Busway, loss of parklands and local access difficulties from Hackney Road along which the OBahn buses run. However, outer suburban residents that use the park and ride facilities at the OBahn interchanges have questioned the value of the project, favouring instead an upgrade of parking facilities at the interchanges. The other challenges in an outer suburban area is that the local suburban arterial routes are high capacity and with 60-80km/h service speeds, the perceived benefits of a dedicated BRT beyond Tea Tree Plaza with only moderate increases in service speeds to 90-100km/h, would be difficult to demonstrate, particularly in terms of the massive capital investment required. In spite of community opposition to the project, which has not been helped by a somewhat one sided reporting of the issue in the local media, the experience of the Perth rail system has demonstrated that perhaps the South Australian Government's strategy is appropriate if the intended outcome is to increase patronage through service reliability and competitiveness, which the OBahn improvements are well placed to do.

Figure 2 provides an indication of the possible extended route that an extended OBahn could take and illustrates how it relates to the existing OBahn route and its integration with the northern commuter rail corridor and the Northern Expressway (orange line) shown as route M20. Table 1 sets out the details of a hypothetical extended OBahn for Adelaide.



**Figure 2: Existing and potential public transit corridors in Adelaide's northern metropolitan area**

**Table 1: Characteristics of a Hypothetical Extended OBahn from Tea Tree Plaza to the Northern Expressway**

Station	Characteristics	Distance from city centre (km)	Maximum operating speeds (km/h)	Cumulative Travel time (Based on express through tracks and parallel local tracks)	Theoretical capacity/hr (Articulated bus with 88 pax and 2 minute headway (h/w))
Tea Tree Plaza Interchange	1	Elevation: 124m	20 km/h	12 minutes (Adelaide-TTP)	
Tea Tree Plaza to Golden Grove	Linear park setting with low density suburban residential (10 dwgs/ha). Hilly terrain.	5km	100km/h	4 minutes	1732 pax from CBD
Golden Grove Interchange	Large District Shopping Centre, School complex, major community centre, recreational amenities and police station. Park and ride facility.	Elevation: 199m	Tunnel interchange		
Golden Grove-Greenwith	Linear Park setting with low density residential (10 dwgs/ha). Hilly terrain.	2.4km	100km/h	2 minutes	1515 pax from CBD
Greenwith Interchange	Small District shopping centre. Park and ride facility.	Elevation: 200m	Tunnel interchange		
Greenwith-Main North Road	Linear Park setting with low density residential (10 dwgs/ha). Largely undeveloped. Hilly terrain.	3.8km	100km/h	3 minutes	1298 pax from CBD
Main North Road Interchange	Major Bus Interchange connecting with bus routes on adjacent arterial road network. Park and ride facility.	Elevation: 52m	Tunnel interchange		
Main North Road-Salisbury	Linear Park setting with low density residential (10 dwgs/ha), light industry and reservoir. Flat terrain with possible flood risk.	3.4km	100km/h	3 minutes	1081 pax from CBD
Salisbury bus-rail Interchange	Major Bus-Rail Interchange connecting with bus and rail routes; major regional shopping mall, local government offices, cinema complex; commercial uses; very limited residential (8 dwgs/ha)	Elevation: 32m	20 km/h		
Salisbury- Holden Plant	Linear Park and industrial uses setting with low density residential (10 dwgs/ha), light industry and reservoir. Flat terrain.	1.6km	100km/h	2 minutes	864 pax from CBD
Holden Plant Interchange	Set for closure in 2017. This is a major site of approximately 130ha.	Elevation: 30m			
Holden Plant-Elizabeth	Industrial uses. Flat terrain.	3.7km	100km/h	3 minutes	647 pax from CBD
Elizabeth bus-rail Interchange	Major Regional Shopping centre; retail and commercial uses; car-parking; schools; government offices; military laser range	Elevation: 27m			
Elizabeth-Edinburgh North	Industrial; military; limited residential. Flat terrain.	2.0km	100km/h	2 minutes	430 pax from CBD
Edinburgh North (Stebonheath & Bellchambers Roads)	Industrial and largely undeveloped.	Elevation: 21m			
Edinburgh North to Northern	Undeveloped land. Flat terrain.	4.2km	100km/h	4 minutes	213 pax from CBD

<i>Expressway (at Womma Road interchange)</i>					
<b>Northern Expressway (at Womma Road interchange)</b>	Freeway interchange in Adelaide's northern metropolitan greenbelt	Elevation: 21m			
<b>For whole route-Adelaide CBD to Womma Road/Northern Expressway Interchange</b>	Double track OBahn along whole extent of route to allow direct express services along the whole route. Average speeds taken as 75% of maximum segment speed.	41.0km	100km/h	35 minutes	2600 pax for 2 min h/w (30 buses/hr) 5200 pax for 1 minute h/w (60 buses/hr) 10400 pax for 30s h/w (31900 pax using a triple articulated bus with 270 pax and 30s h/w)

## 5. Methodology

The existing OBahn corridor from Gilberton to Tea Tree Plaza is characterised by very low suburban gross residential densities of detached 1-2 storey housing on separate allotments of 500-1000m<sup>2</sup> in size, ranging from as little as 3.5 dwellings/ha at Tea Tree Plaza up to 11.0 dwellings/ha at Gilberton (the city end of the OBahn). The gross residential densities for the proposed extension of the OBahn to Salisbury with interchanges at Golden Grove, Greenwith, Main North Road and at Salisbury is similarly characterised by residential densities that occur in the pedsheds of the Klemzig and Paradise Interchanges. Indeed the remarkable feature of residential development in Adelaide's northern suburbs is its uniformly low gross residential density of around 5 dwellings/ha. The main reason for the very low densities is that the OBahn alignment is through linear parks and where there are interchanges, these are dominated by roads, car-parks, open space and non residential land-uses. For this reason, nearly all of the 400m pedsheds around each of the OBahn's existing transport interchanges are devoid of significant residential development. The proposed extension of the OBahn to the Salisbury Bus-Rail Interchange would have an alignment predominantly within a linear park, and where it does run through developed residential areas (i.e. from Tea Tree Plaza to Greenwith), gross residential densities are in the range of 5-10 dwellings/ha. This research assumed that if the 30YPGA were to be taken at face value (i.e. developing transit corridors 800m either side of the transit route at residential densities of 25-35 dwellings/ha with housing occupancy ratios of 2.19 persons/dwelling) then the OBahn offers incredible residential development opportunities to substantially increase residential densities from what it currently is. Including the proposed extension to the Obahn route, the theoretical catchment of an extended Obahn (not including the current OBahn extension proposed from Gilberton to the city), would be 42km<sup>2</sup>, which could conservatively accommodate 105,000 additional dwellings housing 229,950 persons. In practice, however, because the OBahn route runs mostly within part of Adelaide's Metropolitan Open Space system (i.e. network of linear parks), land immediately on either side of the OBahn may not be released for urban development, which could substantially reduce the theoretical estimate of population in the transit corridor. Notwithstanding this, as a starting point, it should be possible to develop the interchanges as TODs. Each TOD provides around 50ha of developable land and in this proposed extension of the OBahn, an additional 8 TODs have the potential to yield 14,000 new dwellings accommodating approximately 30,700 new residents.

The TOD concept, as its name implies, is a dense development node within a public transport system of networked transit oriented developments. It can be mixed use development but usually the planning policy focus is on maximising residential development densities within the TOD, to facilitate as many people as possible walking to and from the transit interchange. Locating residential development in a TOD or TC also makes it feasible for households to rely exclusively on public transit and is preferable to a retail or commercial land use dominated TOD where there's a real risk of commuters driving to the TOD instead

of using transit. The developed area of a TOD around a transport interchange is usually located within the 400m pedshed of the interchange, to encourage walking as the primary mode of transport in accessing the interchange. This research assumed that the residential density target for the TODs along the OBahn and the proposed extension to Salisbury at 35 dwgs/ha which is the nominated density target for TODs as set out in the 30YPGA.

The concept of pedsheds is an established analytical technique in determining development potential, existing urban development spatial efficiencies and transport network efficiencies (Iacono et al. 2010, Curtis 2011, Dill, 2004, Renne 2013, Olaru 2011). The perfect pedshed would have a boundary that would form a circle encompassing all of the area within a 400m radius, where the centroid of the circle is presumably the main access point to the transit interchange. Where multiple access points to the interchange are available, then the centroid would be the centre of the transit interchange. With the OBahn interchanges, the centroid of the interchange was taken as the pedestrian crossing bisecting the OBahn track within the Interchange. A 400m radius was selected because historically, planning literature has adopted this as a central design element of a precinct's essential spatial design characteristics (Ratcliffe, 1981). Within existing urban areas, the size of the pedshed is determined by mapping the continuous boundary formed by the endpoints of all of the radiating routes to a distance of 400m through the network to all points of the compass. Usually, this mapped pedshed will be less than the theoretical (and idealised) circular pedshed. Google Earth Pro was used to map and analyse the pedsheds. This technique, for the purposes of this research, was labelled as the Local Area Accessibility Appraisal Tool (LAAAT). The following metrics were developed as part of the LAAAT (Allan and Fielke, 2015):

**$\Sigma$  Pedshed plotted polygon =**

(Consecutive clockwise plotting of locus of mapped endpoints for all 400m long network paths radiating out from pedshed's geometric centroid) 0 heading to 360 heading (1)

$\Sigma$  (segment lengths of a pedshed path-link)<sub>0-400m</sub> (2)

**Pedshed efficiency**=Area of the actual mapped pedshed polygon (ha) /Area theoretical maximum 400m radius pedshed loci. (ha) X 100% (3)

**Actual Pedshed housing efficiency**=Existing housing in actual mapped pedshed polygon in dwgs/ha /Maximum housing potential in actual mapped pedshed in dwgs/ha X 100% (4)

**Theoretical Pedshed for existing housing efficiency**= Existing housing in actual mapped pedshed polygon in dwgs/ha /Maximum housing potential in theoretical maximum 400m radius pedshed in dwgs/ha X 100% (5)

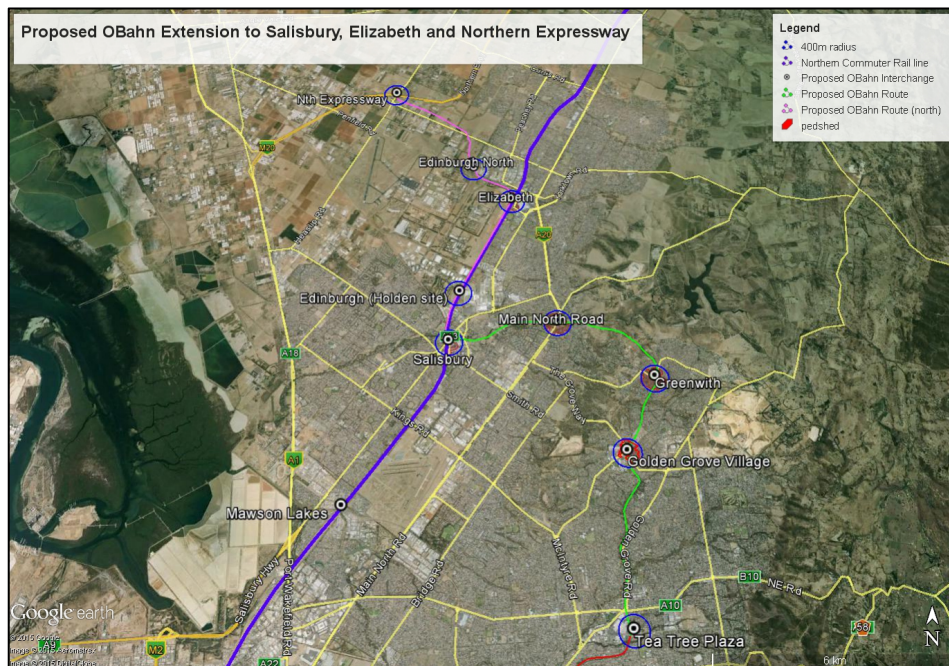
For the purposes of this research project, the main application of the LAAAT was to determine the housing and population potential of each pedshed for an extended OBahn route inclusive of the proposed the additional TODs. It was assumed that within the pedshed, that the households would be car free, and that all commuting trips would be made via the OBahn. In a recent paper by Allan and Fielke (2015), the outward bound commuter trip generation was assumed to be 67.7% of residents based on the 30YPGA of 2.19 persons/dwelling in 2040 and Adelaide's current commuting profile from the 2011 ABS Population and Housing Census. The limitation in this methodology is that Adelaide's commuting patterns, reasons for commuting and population profile are only an approximate estimate. Current commuter patterns in Mawson Lakes, Adelaide's nearest equivalent to a suburban TOD have not been encouraging with only 8% of commuters using public transit to commute (Allan & Fielke, 2015), which would reduce theoretical transit trips by a factor of 12.5. The reason that the existing OBahn succeeds with such a low modal share is that it relies on park and ride commuters drawn from a wide hinterland. This project has not included commuters drawn from the transit corridor, but in a further development of this research, that option will be examined.

## 6. Results

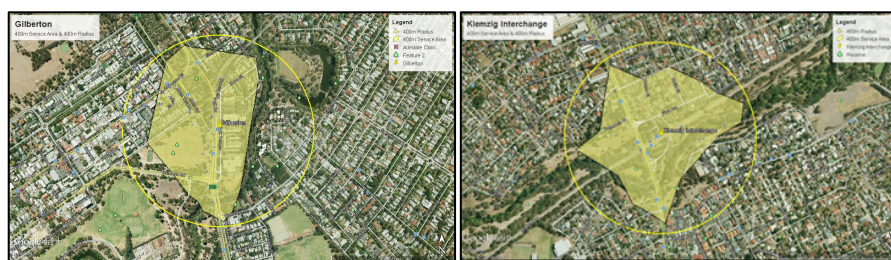
Pedsheds were plotted for each of the anticipated TODs along both the existing OBahn and for the extended OBahn to the Northern Expressway. In the case of the proposed OBahn interchanges at Main North Road, Edinburgh (adjacent to the Holden Factory), Edinburgh North and at the Womma Road junction of the Northern Expressway, only the theoretical pedshed (indicated by a circle of 400m radius) is shown because of the absence of development and a local road network. Figure 3 illustrates the proposed extension of the OBahn from the major existing interchange at Tea Tree Plaza to the Northern Expressway.

The pedsheds for both the existing OBahn and the proposed extension to the OBahn is illustrated in figures 4-15, and includes an investigation of a potential TOD at Gilberton. Table 2 provides a tabulation of the pedshed metrics determined for each of the transit stops along the extended Obahn and weekday peak period commuter trip generation estimates for each interchange. The remarkable finding of the spatial analysis is how underutilised the immediate pedshed around each transit interchange is. This is partly a function of the OBahn location within either a linear park or a commercial/retail precinct (as is the case with Tea Tree Plaza, Golden Grove Village, Salisbury and Elizabeth), however even in the case of Greenwith and Gilberton, the pedsheds with the most fully developed housing, pedshed housing efficiency ranges from 15-19% of the available area.





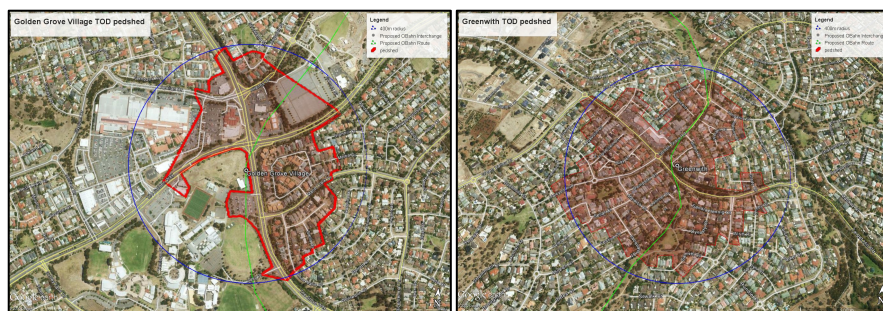
**Figure 3: Proposed OBahn extension to Salisbury, Elizabeth and the Northern Expressway**



**Figures 4 and 5: Gilberton and Klemzig**

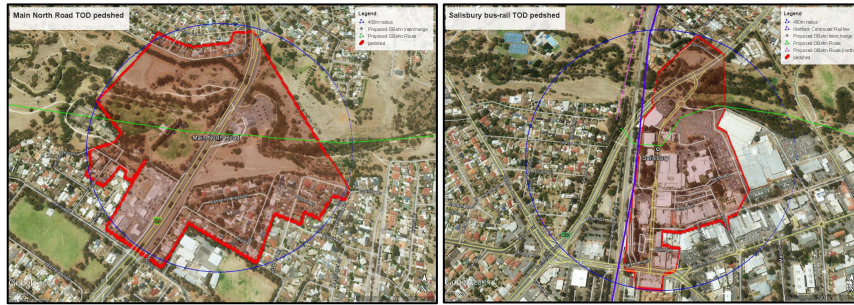


**Figures 6 and 7: Paradise and Tea Tree Plaza (Existing OBahn route)**

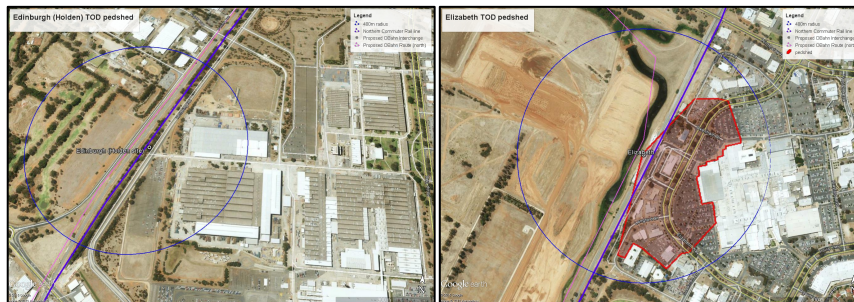


**Figures 8 and 9: Golden Grove Village and Greenwith (Proposed OBahn route)**





**Figures 10 and 11: Main North Road and Salisbury (Proposed OBahn route)**



**Figures 12 and 13: Edinburgh (Holden Factory) and Elizabeth (Proposed OBahn route)**



**Figures 14 and 15: Edinburgh North and Northern Expressway (Proposed OBahn route)**

The analysis as set in figures 3-15 and in table 2 demonstrated that full utilisation of the pedsheds' housing in the 12 potential interchanges set out in the extended OBahn proposal would unlock enormous potential for bus based commuting. A focus on targeting complete commuter dependence on transit within the 400m pedsheds around each interchange would in theory generate sufficient commuter traffic to provide frequent services in the peak period. Assuming a 2 hour peak commuting period, a double track OBahn system allowing express through services on the inner tracks and local services on the outer tracks would allow dedicated one destination services for each TOD, and with development densities at the levels proposed in the 30YPGA of 35dwgs/ha, providing that all commuters in the pedshed use the OBahn to commute, it is likely that sufficient trips would be generated to ensure non-stop express services to each interchange in the peak periods with a 15 minute frequency. The use of an outer track with short interval stops would ultimately allow much larger commuter catchments to be serviced, allowing the attainment of a genuine transit corridor without compromising the high operating speeds of the express inner OBahn track. Unlike the existing OBahn where buses have to stop at each interchange, buses would exit the OBahn inner tracks using de-acceleration de-merging slip tracks and rejoin the express OBahn via acceleration merging tracks. In effect, the double track OBahn system would function in much the same manner as a freeway, with the exception being that the outer lanes would allow safe low speed local services (i.e. with 200m between bus stops). The

analysis has assumed a CBD centric pattern of commuting. However, this proposed extension would facilitate trans-suburban commuting not only up and down the OBahn corridor but it would also connect three major radial transport routes, Main North Road, the Northern Commuter Rail Line and the Northern Expressway. The connectivity provided by this extended OBahn would help to transform Adelaide's northern suburbs into an interconnected network of TODs allowing residents greater scope to use transit to travel to suburban employment locations located in TODs on the transit network. The analysis demonstrated that interchanges such as Tea Tree Plaza, Golden Grove Village, Salisbury and Elizabeth where retail uses and parking dominate, have enormous theoretical development potential, largely because so little housing lies within their immediate 400m pedshed. An interesting finding is that full utilisation of the pedshed for housing capacity at the 35dwgs/ha target density nominated in the 2010 30YPGA, would leave minimal spare capacity for transit corridor passengers outside of the TODs pedsheds, unless the 20s headway was reduced and/or larger capacity articulated buses were used. Hence, full utilisation of the transit corridor might require additional tracks, spreading of the peak period throughout the day or substitution of the OBahn for a metro rail system.

**Table 2: Local Area Accessibility Appraisal Tool (LAAAT) Pedshed Results for Adelaide OBahn (Northeastern Busway) and estimates of weekday peak period commuter trips generated**

<b>TODs (columns)</b> <i>Existing interchanges marked with an asterisk or # for a transit route stop</i>	<b>Pedshed metrics (rows)</b>	Gilberton#	Klemzig*	Paradise*	Tea Tree Plaza*	Golden Grove Village*	Greenwith#	Main North Road#	Salisbury*	Edinburgh (Holden Factory)	Elizabeth*	Edinburgh North	Northern Expressway (Womma Rd)
1. Actual Pedshed area (ha)		23.8	24.4	24.9	24.6	22.6	32.2	37.7	16.2	0	11.0	0	0
2. Gross residential density dwgs/ha		11.0	4.8	6.9	3.5	8.0	10.3	2.9	0	—	0	—	—
3. No. of dwgs in actual pedshed		262	118	171	86	181	332	110	0	0	0	0	0
5. Pedshed efficiency (Eq.3) (based on 35dwgs/ha as set out in the 30YPGA)		47.3%	48.5%	49.5%	48.9%	45.0%	64.1%	75.0%	32.2%	—	21.9%	—	—
6. Actual pedshed housing efficiency (Eq.4) (based on 35dwgs/ha as set out in the 30YPGA)		31.5%	18.2%	28.6%	12.5%	22.9%	29.5%	8.3%	0%	—	0%	—	—
7. Theoretical Pedshed existing housing efficiency (Eq.5)		14.9%	6.7%	9.7%	4.9%	10.3%	18.9%	6.3%	0%	0%	0%	0%	0%
8. Theoretical Pedshed potential for new housing (dwgs)		1,497	1,641	1,588	1,673	1,578	1,427	1,649	1,759	1,759	1,759	1,759	1,759
9. Pedshed population (based on 2040 projection in the 30YPGA of 2.19 persons/household)		3,852	3,852	3,852	3,852	3,852	3,852	3,852	3,852	3,852	3,852	3,852	3,852
10. Potential for transit based commuter trips from pedshed (one way commute). Assumes 67.7% of pedshed residents assumed to make an outward bound commuting trip (See Allan and Fielke, 2015)		2,608	2,608	2,608	2,608	2,608	2,608	2,608	2,608	2,608	2,608	2,608	2,608
31,296 Pax in 355 88Pax articulated buses in 2 hour peak at 20s headways Outward flows for commuters on buses to next interchange shown.		28,688	26,080	23,472	20,864	18,256	15,648	13,040	10,432	7,824	5,216	2,608	—

## 7. Conclusion

The design of transit interchanges in Adelaide has resulted in grossly underutilised pedsheds in terms of the development densities that can exploit the high level of pedestrian accessibility offered within the pedshed. This paper demonstrated the application of the LAAAT in investigating the spatial efficiency of a pedshed for the purposes of investigating its potential as a TOD and transit trip generation potential along a transit route. Ideally, a TOD implies that residential densities would be maximised within the pedshed of interchanges to encourage maximised use of transit for commuting and minimised ownership of cars by households. This paper has demonstrated that the interchanges along the OBahn have substantial potential for increasing residential densities into TODs. An extended hypothetical OBahn as outlined in this paper would potentially add 9 new TODs, that would significantly reduce commuting by car and open up new cross metropolitan transit opportunities across Adelaide's northern suburbs through integration of the OBahn route with Main North Road, the northern commuter rail line and the Northern Expressway. With CBD centric commuting, as assumed in this paper, the ultimate transit capacity of the OBahn in peak periods is perhaps limited to just increasing urban densities within the TODs, and without a double track OBahn, stretching the peak period and very short headways, the goal of a transit corridor along the whole extent of the OBahn may be difficult and impractical to achieve. However, if an extended OBahn were part of a network of TODs interlinked with TCs with local transit Obahn services in addition to dedicated direct high speed express OBahn services, then transit accessible employment would become dispersed throughout suburban Adelaide, allowing bi-directional utilisation of the OBahn in peak periods (effectively doubling the peak period capacity of the OBahn). This paper did not explore the issue of how employment would be accommodated within the TODs, nevertheless, this would seem to be an opportunity for further investigation in future. TODs that are dense with employment and housing would result in much more efficient urban travel outcomes by placing jobs in transit rich locations that could either be accessed by local residents within the TOD or by transiting residents from other TODs.

## References

- ABS (2014), Population Pyramid (Interactive) for South Australia to 2040, Australian Bureau of Statistics, Website: <http://www.abs.gov.au/websitedbs/d3310114.nsf/home/Population%20Pyramid%20-%20Australia>
- ABS (2013) 2011 Census of Population and Housing: Community Profiles-Adelaide Statistical Division-Table B45-Journey to Work, Australian Bureau of Statistics
- Allan, A. and Fielke, M. (2015) Modelling Local Accessibility Networks to Optimise the Planning of Transit Oriented Developments in Adelaide, 2015 Computers in Urban Planning and Urban Management (CUPUM) Conference Proceedings, July 7-10, 2015, MIT, Boston, USA
- Cervero, R. (1998), Transit Metropolis, Washington D.C., United States of America
- Curtis, C., Renne, J. and Bertolini L., (2009) Transit Oriented Development: Making it Happen, Ashgate
- Curtis, C. (2011) Integrating land use with public transport: The use of a discursive accessibility tool to inform metropolitan spatial planning in Perth, Transport Reviews, 31(2), pp. 179-197.
- Dill, J., (2004), Measuring Network Connectivity for Bicycling and Walking, Transportation Research Board Annual Meeting (CD-ROM)
- Dittmar H. and Poticha S., (2004), Defining Transit-Oriented Development: The New Regional Building Block, Chapter 2 of 'The New Transit Town: Best Practices in Transit Oriented Development', Edited by Dittmar, H. and Ohland, G., Island Press, Washington, U.S.A.
- Gordon, P. and Richardson H., (1997), Are Compact Cities a Desirable Planning Goal? *Journal of the American Planning Association*, Winter 1997; 63, 1

- Gothe-Snape, Jackson (2015) Here's a stop. Where are the passengers? 9<sup>th</sup> June, 2015 (p3), in Adelaide Advertiser Newspaper
- Iacono, M., Krizek, K. and El-Geneidy, A. (2010), Measuring non-motorized accessibility: issues, alternatives, and execution, *Journal of Transport Geography*, 18 (1), January 2010, 133–140
- Leslie, E., Coffee, N., Frank, L., Owen, N., Bauman, A. and Hugo G. (2007), Walkability of local communities: using geographic information systems to objectively assess relevant environmental attributes *Health & Place* 13 (1), 111-122, 2007
- Lindau, Luis Antonio, Dario Hidalgo, and Daniela Facchini (2010) Curitiba, the cradle of bus rapid transit. *Built Environment* 36.3 (2010): 274-282.
- Lo, R. H., (2009), Walkability: what is it?, *Journal of Urbanism*, V.2 (2), July 2009, 145-166
- Mees, P., (2010) *Transport for Suburbia-Beyond the Automobile Age*, Earthscan, London
- Newman P. and Kenworthy J., (1989) *Cities and Automobile Dependency: An International Sourcebook*, Gower Technical, USA
- Olaru D., Smith B. & Taplin J. (2011) Residential location and transit-oriented development in a new rail corridor, *Transportation Research Part A* 45 (2011) 219–237
- Ratcliffe, J., (1981) *An Introduction to Town and Country Planning*, Hutchinson, London
- Renne, J.L. (2013) The Pent-up Demand for Transit Oriented Development and its Role in Reducing Oil Dependence, Chapter 13, (pp226-243) in Renne J.L. and Fields B. (Eds) *Transport Beyond Oil: Policy Choices for a Multi-Modal Future*, Island Press, Washington
- South Australia (Government of) (2010) *30 Year Plan for Greater Adelaide: A Volume of the South Australian Planning Strategy*
- South Australia, (Government of), July 2015, *The Integrated Transport and Land Use Plan*
- South Australia (Government of) (2015) O-Bahn City access. Website:  
[http://www.infrastructure.sa.gov.au/public\\_transport\\_projects/o-bahn\\_city\\_access](http://www.infrastructure.sa.gov.au/public_transport_projects/o-bahn_city_access)
- South Australia (Government of) (2015) Development Act 1993. Website:  
<http://www.legislation.sa.gov.au/LZ/C/A/DEVELOPMENT%20ACT%201993.aspx>
- Wilson, T. (February 2010), *The O-Bahn Network: Adelaide's Flagship Public Transport System*, Urban Transport World Australia 2010 Conference, Sydney
- Wills D. (2015) \$9 billion Roadmap, May19, 2015 (p1), in Adelaide Advertiser Newspaper