CHAPTER 1

Adelaide: innovations in transport systems, infrastructure and services

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Abstract

Adelaide, South Australia is a city with a long tradition of state of the art planning of its urban development and transport systems. As a planned 'new world' city it has largely escaped many of the traffic and environmental problems that beset other cities. An ongoing feature of its transport planning has been a readiness to adopt, adapt and attempt innovative solutions that are arguably 'world's firsts'. This chapter describes two such solutions from the last quarter of the twentieth century: a guided busway and a fully reversible one-way road. Further developments using Intelligent Transport Systems (ITS) technologies to meet community goals for improved public transport operations are also described.

1 Introduction

Adelaide is the capital city of the state of South Australia in Australia. The state occupies about 15 per cent of the geographical area of Australia but is home to only eight per cent of the nation's population. The Adelaide metropolitan area had a population of 1,072,585 as recorded in the Australian national census of 2001, of a total of 1,467,261 in South Australia. It is the fifth largest city in Australia, behind Sydney, Melbourne, Brisbane and Perth.

Adelaide is a planned city, dating from its establishment in 1836. Its population still values the contribution to their way of life made by Colonel William Light, the town planner responsible for the design of the city centre in the 1830s. Since then generations of planners have continued the work initiated by Colonel Light. The most recent urban planning strategy [1] for the metropolitan area was released at the start of 2003. This was followed in April 2003 by the release of a Draft Transport Plan [2]. Transport planning and the provision of public transport services in Adelaide are the responsibility of the state government. Local government

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authorities are numerous but small, there being 18 separate municipalities in the metropolitan area. Whilst many of the municipalities have interests in transport planning, they have few resources for this – with the possible exception of the Adelaide City Council, which is the municipality covering the central business district (CBD) and the nearby residential suburb of North Adelaide. This municipality covers the original city laid out by Colonel Light.

The growth of the metropolitan area slowed substantially in the last quarter of the 20th century. Until that stage it was the third largest city in Australia, but in the last 20 years it has been overtaken in size by Brisbane and Perth. Its population is aging, with a median age of 37 years in the 2001 Census, compared to 33 years in the 1996 Census. Today Adelaide may be described almost as a north-south linear city, stretching perhaps 80km long and 15km wide at its maximum along a coastal plain, constrained to the west by St Vincent's Gulf and to the east by the Mount Lofty Ranges. The city continues to spread at its northern and southern extremities, and the new urban strategy plan [1] seeks to limit that spread. At the same time, the last decade has seen significant redevelopment of the inner suburban and central city areas, with substantial residential infill development. There has been a strong movement back to inner city living.

As a consequence of its origins and development as an evolving, planned city, the ethos of good planning and the consequent importance of technological innovation building on good planning principles and practice have been important characteristics of transport planning and the provision of transport infrastructure and services in Adelaide for many years. This chapter describes some of the best examples from the last 30 years. These concern two major innovations in infrastructure provision: (a) the O-Bahn guided busway and (b) the Southern Expressway reversible flow motorway, and most recently, the implementation of bus priority and dynamic, real-time public transport information systems.

2 Overview of Adelaide and its transport systems

Adelaide is a good example of a 'new world' city, developed along planning principles and practices that have been generally in line with the 'best practice' of the day. The legacy of that development is a medium sized city that has a well planned road network, largely rectilinear in nature and with substantial capacity on much of its major road network, that has provided a firm basis for travel mobility. Congestion, whilst always a perceived problem, has not been a significant feature of the transport system's performance in Adelaide. For example, the Australian federal government's Bureau of Transport Economics valued the annual cost of traffic congestion in Adelaide at US $300,000,000 p.a. in 1999, significantly less than the congestion costs in all of the other mainland state capital cities except Perth [3]. This is not to say that congestion is not a local problem, especially in peak periods, but chronic area-wide congestion has not been an issue. Adelaide has been seen as a '20 minute' city in terms of travel times to access facilities and services, and this concept is strongly supported by its inhabitants as one of the benefits of life there.

The rectilinear grid pattern on which the main road network is based also extends to the minor road and local street systems in the older parts of the metropolitan area – those developed before the 1970s. This gave rise to particular problems with through traffic infiltration of local street networks to avoid certain bottlenecks on main roads, at least in peak periods. The solution, from the 1970s until the 1990s, was the progressive development of local area traffic management (LATM) programs, for which Adelaide was a national leader. Early schemes were based on physical road closures, and then the LATM approaches evolved through the use of physical speed control devices to 'local area speed limits' and eventually to lower urban speed limits, differentiating between different functional classes of roads and streets. This evolution was fuelled by a desire for environmental improvements in residential and retail areas that did not impose undue additional costs on local residents and businesses. Subdivision patterns changed in the 1970s, to curvilinear 'catchment' street network layouts of loops and culs-de sac, but most recently the trend has been a return to rectilinear grid layouts with inbuilt LATM measures. These new designs, well represented by the major Mawson Lakes residential development in the northern suburbs, attempt to restrict opportunities for through traffic intrusion whilst providing adequate opportunities for efficient public transport (bus) operations and for walking and cycling – opportunities that the catchment layouts did not.

In Adelaide's history of progressive planned development is the realisation that it was the first Australian city to turn away from major urban expressway building. The 1960s 'Metropolitan Adelaide Transport Study' (MATS) plan for an extensive urban expressway network was abandoned in the 1970s – in favour of more balanced transport, which led to the development of the O-Bahn guided busway. When Adelaide did come to build a new expressway in the 1990s – the Southern Expressway, as described in this chapter – it did so with a cognisance of the potential problems for urban development of untrammelled expressway construction and so sought to minimise the influence of the new infrastructure on that development.

In urban planning terms, a satellite urban development at Elizabeth began in the 1950s and further plans such as that for the Monarto satellite city were proposed, although these plans did not come to fruition. Decelerating population growth was the eventual demise of Monarto, although the plans were always controversial. Elizabeth proved at best to be only a qualified success. Other problems emerged for it, such as social isolation, and by the 1980s growing unemployment when the core industries around which it was planned had changed or relocated away from Adelaide.

Quality of life issues are important for Adelaide and its citizens. The city may be seen as promoting high quality urban life styles for residents and visitors alike, with adequate (if aging) facilities and infrastructure, orderly government, and a tradition of progressive social change that is mirrored in its adoption of modern urban and transport planning methods. Like many cities it sees problems of congestion, environmental degradation and an over-reliance on private motor vehicle transport, but the reality for Adelaide is that these problems are sometimes perceptions rather than reality, when compared to other cities around the world.

Technological innovations in infrastructure provision have been a feature of Adelaide's transport planning, in compass with the city's progressive social thinking. The O-Bahn is a prime example, as is the more recent Southern Expressway development. This 24km expressway through the southern suburbs was built as a reversible flow road, using the latest Intelligent Transport Systems (ITS) technology. The road is effectively just a single carriageway of a conventional expressway, allowing for flow in one direction only, and the flow direction is reversed from morning to afternoon. In this way the road provides additional necessary capacity for peak period traffic movements, which are strongly tidal in nature. Thus the expressway is expected to have less influence as an agent for further urban sprawl than would a conventional dual carriageway expressway that always permitted two directional flows. Other examples of technological innovations in transport systems operation include Australia's first electronic ticketing system for public transport, introduced in the mid-1980s, and concomitant fare structures and shared ticketing arrangements for different public transport modes. The recent competitive tendering system for operating public transport services by different private operators was based on a continuation of the shared ticketing arrangements for travellers.

Public transport viability is now a core community transport planning issue – whilst the city has seen many innovations in service provision/contracting and in technology (*e.g.* bus priority systems, ticketing systems, and advanced traveller information systems (ATIS) as well as the O-Bahn guided busway), nevertheless the system continues to struggle. Overall population growth is small and will remain so without more immigration but demographic change is there and poses significant problems for future needs for transport services and the availability of resources to provide those services. The CBD focus of the public transport routes limits this collective mode's usefulness for cross-city travel, while service reductions (in terms of both frequency and coverage) outside busy periods further limit availability. Thus there is low coverage (except close to CBD) and low usage.

Transport planning for Adelaide is the responsibility of the State Government through its Department of Transport and Urban Planning. The department recently released its new transport strategy plan [2], which focuses the development of greater sustainability in Adelaide's transport system. The Strategy Plan recognises transport as a derived demand, in that travel is generally not undertaken for its own sake, but rather as means for people to engage in broader social, economic and environmental activities. Transport is therefore equally able to facilitate or undermine these activities. Four organising principles are identified for ensuring the positive contributions of the metropolitan transport system to urban life:

- integrating transport and land use planning
- recognising transport's contribution to social inclusion
- acknowledging transport's role in economic development
- minimising transport's impacts on the environment

The new Strategy Plan for Adelaide thus seeks to reach three main goals:

1. ensure the environmental sustainability of the metropolitan transport system

2. provide a new emphasis on cycling and walking as viable transport modes
3. realise the full potential of the metropolis's public transport system.

Possible methods for the achievement of these goals are exemplified by the transport innovations described in the remainder of this chapter.

3 The O-Bahn guided busway

Travel in Adelaide is dominated by the private car, with 79 per cent of all person trips being made either as a car driver or passenger [4]. The public transport system carries only five per cent of all trips. Adelaide's public transport system is largely dependent on buses, which carry 80 per cent of all public transport trips. Whilst there are some 126km of suburban passenger railway, comprising four separate rail lines radiating from the city centre, the mode share for passenger rail (0.8 per cent of all trips, 16 per cent of the public transport based trips) is very low due to the small extent of the network for suburban use, and the radial orientation of the rail network – which makes it generally unsuitable for inter-suburban travel. There is also a single tramline (the 'Glenelg line') between the city centre and the popular seaside Glenelg centre. This line is 11km long. On an average weekday the tram-line carries some 6400 passengers, compared to the total rail patronage of 35,000.

A comprehensive bus network provides the large majority of the metropolis's public transport. There are 1120km of bus routes, which includes the 12km of the O-Bahn Guided Busway. The O-Bahn is the jewel in the crown of the Adelaide public transport system. Completed in 1989, it is the world's first fully operational guided busway. The O-Bahn route connects the CBD with the regional centre of Ti-Tree Plaza in the north eastern suburbs. Public acceptance and use of the O-Bahn is very high. It carries about 20,000 passengers per average weekday, of a total of 157,000 bus passengers in the metropolitan area. The success of the O-Bahn may be gauged in terms of its unit operating costs per passenger-km. The cost for the O-Bahn bus services is $US0.20/pass-km, compared to $US0.31/pass-km for regular bus services, $US0.31/pass-km for the tram, and $US0.37/pass-km for suburban rail [4].

These costs illustrate a general result: bus systems are less costly in terms of both capital investment and operating costs than other public modes. They also offer flexibility in service provision. At the same time, buses are often seen as inferior to other public transport modes, especially rail. One reason is that buses generally operate on conventional roads in mixed traffic, where they have to compete with private and commercial vehicles, and are subject to the delays and congestion of the road system. This can lead to unreliable schedules and a lack of comfort for the travelling public [5].

The Adelaide O-Bahn was planned and built to try to overcome the perceived problems for urban bus transport. Whilst incremental schemes providing facilities such as bus-only lanes and bus priority at intersections have been implemented in many cities, dedicated busways are much rarer. A busway can provide the same exclusive right-of-way for buses as that available for rail systems, thus offering uninterrupted travel, greater reliability and improved comfort. In addition, the same vehicle that operates along the busway (*i.e.* the line haul component of the route) can also be used for local feeder services (pickup and distribution), thus avoiding the need for intermodal transfers as when different modes or vehicles provide line haul and feeder services. Busways would then appear to be very useful – so why have there been few implementations around the world? The answer appears to be in the difficulty in operating conventional busways with manual vehicle control [6]. The right-of-way required for a conventional busway is usually much greater than that needed for a railway, because the buses have to be steered manually and need lane widths of at least 3.5m plus shoulders and possibly safety barriers. This may be a critical factor in urban areas, where right-of-way space may be constrained (*e.g.* in the median of a motorway) or expensive to purchase. Further major costs may arise if the busway has to be elevated, depressed or put into a tunnel.

A guided busway such as the Adelaide O-Bahn can overcome these problems by using a fixed track for the line haul section. Bus operations still retain route flexibility and convenience of operation in the origin and destination areas at either end of the route. The track need only be a little wider than the bus itself, and offers high speed operation, comfort and smooth riding in an exclusive operating environment that other types of vehicles cannot use. This concept was adopted for the Adelaide O-Bahn. The O-Bahn technology originated in Germany, where it was intended to reduce the required width of bus-only lanes in congested inner city areas. It was adapted in Adelaide for high speed line haul purposes. Figure 1 provides an illustration of the Adelaide O-Bahn in operation.

The design adopted for the Adelaide O-Bahn is to fit horizontal guide-rollers to the front steering wheels of a conventional bus, and to run these modified buses along a raised concrete track which includes vertical guide rails – see fig. 1. The interaction between the guide rollers and the concrete rails steers the bus when on the track. The 12km of the O-Bahn track is fully grade separated from all other roads, and passenger interchange points are widely spaced. This allows running speeds of up to 100km/h. Buses can operate at small headways along the O-Bahn track. The drivers of O-Bahn buses do not steer their vehicles whilst on the track, rather they accelerate and brake only and leave all guidance to the trackway. Thus the O-Bahn provides the desirable characteristics of both a commuter rail system – limited stops, high capacity and speed, smooth ride, etc. – and a bus system – flexibility and through service into suburban areas without the need to change vehicles.

Currently some 13 suburban bus routes feed into the O-Bahn, providing frequent services (60 buses/h in peak periods, 20 buses/h off-peak) along its service corridor.

Construction of the O-Bahn began in 1983, with services on the first stage operating from 1986 and the full route completed in 1989. Since then it has become the most popular public transport route in the metropolitan area. Evaluations of the system have been provided by Chapman [6] and Makele [7]. Whilst these have suggested that, on the basis of social benefit-cost analysis, the O-Bahn is not economically viable, *e.g.* Chapman found a BCR of 0.77, these results have to be viewed in context – the general performance of public transport in metropolitan Adelaide is poor in direct economic terms, with the operating cost of O-Bahn buses being less than two-thirds of that for regular buses [4] and average occupancy levels for O-Bahn buses are almost twice those of conventional buses [7]. Relative to

Figure 1: A bus using the Adelaide O-Bahn guided busway.

commuters. Patronage in the corridor has continued to increase even though there have been substantial decreases elsewhere [6]. A basic objective of the O-Bahn was to significantly reduce travel times for public transport users in the corridor and this has been achieved, especially for those who use the 'park and ride' facilities provided. On the other hand access time (*i.e.* walking and waiting) has increased for some users, and this was found by Chapman [6] to provide the main 'drag' on the economic benefits achieved.

Cost-benefit analysis is limited in scope to the directly observable costs and benefits for the system. The O-Bahn's undoubted popularity relative to other public transport modes suggests that its non-quantifiable benefits are significant. In combination they may well outweigh the net negative economic worth reported by Chapman [6], and thus offer justification for the system on the basis of overall benefits and community wellbeing. It should further be noted that the capital cost of the guided busway was less than half that of a comparable rail system, while the modifications to conventional buses to permit their use of the busway are quite minor.

4 The Southern Expressway – a fully reversible road

The southern end of the Adelaide metropolis now presents another innovative solution to a transport problem. As described previously, Adelaide is a 'linear' city with a long north-south axis, lying along a coastal plain between the sea and the hills. In the latter part of the twentieth century considerable residential expansion occurred along the coast in the southern region, although the major employment and commercial facilities have remained in the central areas, or indeed spread into the northern suburbs. This led to significant tidal flows of commuters, stretching the available road capacity to its limits – for some flow directions and at some times of day. Figure 2, taken from Baukes [8], provides an indication of the intense tidal nature of traffic flows in the southern corridor.

By the mid-1990s the two existing main roads in the corridor were approaching their capacity to meet the peak tidal flows, and so a solution to produce additional capacity was required. At the same time there was strong community pressure against the construction of a full new urban expressway link, on the grounds that such a facility would further encourage residential development at the southern fringe of the metropolitan area and thereby lead to greater urban sprawl and the degradation of the tourist and recreational areas found just south of the metropolis (*e.g.* the wine region of the Southern Vales and the coastal resorts beyond). A solution providing additional capacity for peak period flows only was therefore required. The answer was a fully reversible expressway, providing two or three

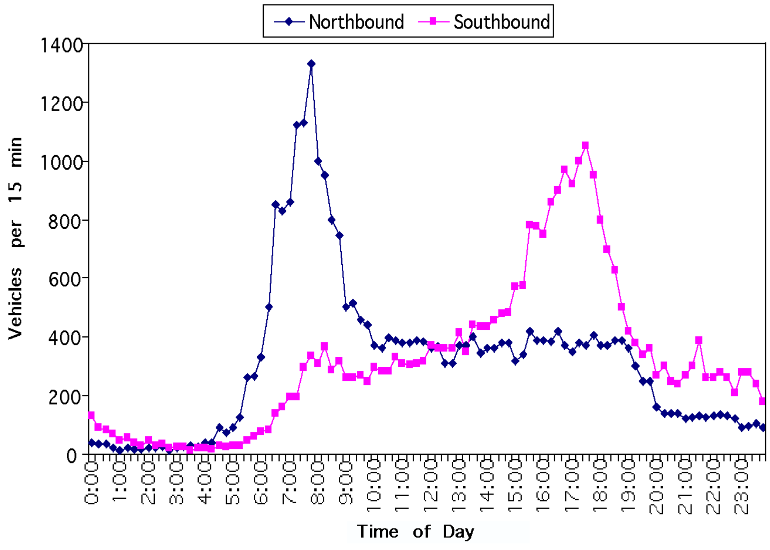

Figure 2: Traffic flows on Main South Road, Adelaide, before the opening of the Southern Expressway. (Source: [8])

additional lanes for peak period traffic only [9, 10]. The key objectives of the new road were to [9]:

- improve accessibility
  - for people leaving in the southern region of the metropolitan area
  - for commercial traffic to industry
  - to tourist locations south of the metropolitan area
- provide for economic development in the southern region
- minimise travel times and traffic congestion
- improve road safety in the southern region

The expressway was designed to operate at 100km/h under free flow conditions and to cater for use by buses and heavy goods vehicles. Connections to the arterial road network are via single carriageway ramps operating in a reversible manner and controlled by an Advanced Traffic Management System (ATMS) including demand responsive traffic signals, changeable and variable message signs, bus priority and a real time incident management system. The connection layouts had to be practical, safe and understandable for motorists. The ATMS is required to prevent any vehicle from entering the expressway travelling in the wrong direction, to quickly detect any errant vehicle that is travelling in the wrong direction on the expressway, and to provide clear, positive and unambiguous advice to all motorists should such an event occur. There is also a need to allow emergency vehicles to reach any part of the expressway. Coad and Dickson [10] summarized the performance objectives for the ATMS as to:

- be cost effective
- optimize change of direction of traffic flow
- allow flexibility in changing the time and direction of travel
- prevent ‘wrong way’ traffic movements
- be automated and ‘fail safe’
- detect and manage incidents
- interface smoothly with the existing (SCATS) road network traffic management system
- present a familiar traffic management environment
- allow for traffic diversion
- link to emergency and maintenance services
- provide information to road users both on the expressway and on the parallel arterial road route

The first 7.5km stage of the expressway was opened in 1998, and the second stage was opened in 2001. The full road is 22.5km long, and besides its end points has four intermediate interchanges, for traffic to enter or leave the expressway. The highway design and engineering details of these interchanges are critical, as what is an on-ramp at one time of day is an off-ramp at another [7]. Further, drivers need clear and unambiguous information about whether they can enter or leave the expressway at a given interchange at all times. Figure 3 shows the reversible operation of the road.

Figure 3: Reversible traffic flows on the Southern Expressway – (top) morning northbound, (bottom) evening southbound.

The road is fully instrumented, with inductive loop detectors in all lanes at 500m spacing, 25 pan tilt zoom video cameras offering full visual coverage of the road in daylight and at night, changeable message signs (CMS) and variable message signs (VMS) to provide accurate information to drivers at strategic points on and adjacent to the road, and en-route driver information signs (ERDIS, which are only activated in case of an incident). Access points are controlled by boom gate barriers and variable pavement markings.

Despite its novelty, Adelaide drivers have accepted the Southern Expressway with alacrity – something that was certainly desired but not completely expected by its planners and designers. Very few incidents have been observed or reported, and the reversible road has operated day in and day out with few problems beyond those to be expected on any major arterial route. The expressway has proven to be a successful project both in design and implementation [10]. The road has to be closed completely twice per day at the changeover of flow direction (usually at about 2:00 pm and again at 2:00 am). Closure times are of the order of 25 min to ensure all previous traffic has left the road, and few problems have been reported. The integration of the expressway's ATMS into the existing metropolitan SCATS traffic control system has also proven successful, and has avoided the possible 'bottlenecks' at either north or south ends of the expressway when expressway and arterial road traffic flows merge. The success of this road is due to the diligence and competence of its designers and traffic controllers, and it has shown how innovative – if not unique – practical solutions to traffic problems can be found using ITS technologies.

On-road traffic studies using instrumented probe vehicles [11, 12] have shown that the Southern Expressway has reduced travel times in the corridor by 25 per cent and fuel consumption by seven per cent *for the peak flow direction*.

5 Bus priority and public transport information

The current problem for Adelaide of a public transport system struggling to remain viable and then to play a much more significant role in satisfying urban travel demand was discussed earlier in this chapter. This concern is reflected in the new strategic transport plan for Adelaide [2]. One current project seeks to use ITS technologies to provide real time information to bus operators, bus drivers and bus passengers as one initiative to improve both service and patronage. This ITS trial has the following objectives:

- to improve bus schedule adherence by providing real time information directly to drivers
- to provide real time information to customers on forthcoming bus arrivals (at kerbside and by telephone), forthcoming stops (in buses), and to facilitate transfers between services and modes

Figure 4: ‘Smart’ stop on a CBD bound bus route in Adelaide, showing stop location and real time display. Map also shows GPS traces of buses.

- to provide 'intelligent' priority for buses at signalised intersections, and
- to improve management of bus services

Bus priority has been used for many years at a number of inner city signalised intersections, usually through the provision of a bus only lane on an approach leg, from which a bus will trigger a special 'bus-only' phase of the signals, either to provide it with an early release so that it can jump ahead of the general vehicle queue on the approach, or can make an opposed (righthand) turn from a lefthand side lane (often cutting across one or more lanes of through traffic to do so, hence the need for the bus only signal phase). This method has been easily adopted within the framwork of Adelaide's SCATS demand responsive traffic control system (the specific implementation of SCATS in Adelaide in known as ACTS, the 'Adelaide Coordinated Traffic System'). Whilst this implementation has a degree of intelligence – for example the bus only phase can only be activated by a (bus like) vehicle occupying the bus only lane at the stop line – it does no more than allow that vehicle priority use of the intersection. Further intelligence is sought in the new trial, on the basis that a bus running behind schedule may be assisted if it can be provided with an early (regular phase) green time at a signal, whereas an on schedule or ahead of schedule bus does not need this assistance. Therefore the location of buses needs to be monitored in real time, and checked against their schedules.

The current trial is therefore concerned with real time bus monitoring and comparisons with assumed or required schedules. Bus location information is collected using GPS, and this information is then used to provide a bus driver with information about travel progress relative to schedules, to inform passengers on the bus about expected arrival times at downstream stops (using VMS displays in the vehicle), to inform intending passengers waiting at bus stops (using VMS displays at these 'smart' bus stops), and to provide information to ACTS indicating if a bus needs priority treatment at critical intersections. The trial is currently in progress on a major east-west bus route with multiple services, running through the CBD. Figure 4 shows a trace of GPS bus positions along a segment of this route, and a display of one of the smart bus stops on the route.

The trial is ongoing and there are as yet no definitive results from it, but most favourable reports from both drivers and passengers are being received. If the trial is successful, then the system will be progressively extended across the metropolitan bus route network.

6 Conclusion

Adelaide represents a class of 'new world' cities of medium size that have benefited from the application of good technical planning principles and practices over many years. Its problems relate more to changing circumstances, especially economic and demographic change, that are to a large extent determined by outside forces (such as economic competition between regions and globalisation). Its concern today is with the economic, social and environmental sustainability of both its population and its urban fabric. What Adelaide has in its favour is a track record of transport planning and technological innovation that has provided a number of significant developments in transport infrastructure provision and in infrastructure and service management. Its comparatively small size certainly assists in the implementation of innovative schemes in that larger cities with more complex systems and problems may experience more difficulties in taking similar steps, although the resource constraints stemming from the smaller resource bases available to the relevant agencies may also inhibit them from undertaking those innovations.

Nevertheless, Adelaide's track record in technological innovation to improve urban transport systems is significant. The examples of the O-Bahn guided busway and the reversible flow Southern Expressway show what can be done in a city prepared to try new solutions to its transport problems. The new initiatives in ITS for improved public transport operations also show promise for the future.

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