Report on Adelaide O-Bahn

Items of Interest for Planning of Cambridgeshire's Guided Busway

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1. Adelaide O-Bahn – Brief History

Adelaide is the capital city of South Australia. It has a population of a little over 1 million, and high car ownership. Its public transport system carries about 56 million passenger trips per year, on 790 buses, 92 diesel or diesel electric rail cars, and 18 trams.

In the late 1970s significant urban growth was occurring in Adelaide's north eastern suburbs, a corridor not served by rail. The area lacks significant industries, and the environment is pleasant with undulating land close to the Adelaide Hills. Therefore, significant numbers of white-collar workers were moving into the area, and many were City workers. The area was also a swinging political seat – an advantage when it comes to major Government projects. A corridor for a freeway had been reserved in the 1960s between the edge of the then inner suburbs and outer parts of the corridor, but Adelaide people had revolted against freeway construction so no urban freeways had been built.

The Labour Government of the time was interested in improving public transport into the area, as travel time by bus from the suburban extremities was around 50-60 minutes. It carried out an extensive detailed public consultation and decided to construct a light rail system from the City Centre, through the Park Lands and inner suburbs (some land purchase was required but much of the route was along a river), then along the abandoned freeway corridor to terminate at Tea Tree Plaza, the regional centre for the area. Feeder buses would meet the trams at various stations and park'n'ride facilities would be provided. In the City, the line would connect with Adelaide's one remaining tram line (City to Glenelg) that still operates today with 1929-built "interurban" tramcars which would have been replaced by the new light rail vehicles.

There was much opposition to the proposal from residents of the inner suburbs as it was of little benefit to those suburbs and the residents considered that the light rail system would damage the river environment, despite the fact that much of the river had been used as a rubbish dump and was generally unattractive. The local Liberal (Conservative) Member of State Parliament supported this opposition.

The proposal was also opposed by the Adelaide City Council, the local government body responsible for an area about 4 km by 2 km in the centre of metropolitan Adelaide (80 km by 30 km). This body was very pro-car and opposed the idea of reintroduction of trams to City streets.

To gain acceptance of the proposal the Labour Minister of Transport decided that the trams would run underground through the City centre, which immediately increased the project cost significantly and gave the Liberal Opposition even greater reason to oppose the proposal. Work commenced on drilling to obtain soil cores for the tunnel project.

At about the same time (1979) there were lengthy bus strikes in Adelaide, which damaged the Labour Government. While drilling was in progress an election was held and the Government changed. The new Minister for Transport was the same local Liberal MP, and he had to find an alternative to the light rail proposal. At that time the German Government was investing in new public transport technology, and Daimler Benz had developed the O-Bahn concept, partly in response to a proposal to operate buses through tram tunnels in Essen. The Government sent experts to Germany to examine the Essen system and a test track, and came back with a report that an O-Bahn could be applied in Adelaide. The O-Bahn was attractive to the Government because it was different from and much more flexible and less expensive than light rail, it was "special" in comparison to an ordinary busway, and would do less damage to the river environment than an ordinary busway which would have to be much wider. An O-Bahn had significant advantages over the light rail in that is was less expensive yet would provide a through journey for most passengers between their suburban homes and the City, something that a rail system could not achieve.

Initially the O-Bahn track was to be used only in the first 3 kilometres along the most sensitive river area, with a busway for the other 9 kilometres. It was later decided that as all buses using the O-Bahn had to be fitted with guidewheels and there were significant safety and ride quality advantages with an O-Bahn track, the guideway should cover the full 12 kilometres.

Construction commenced in about 1982, with the first section to Paradise Interchange (a 6 km length) opening in 1986, and Stage 2 to Tea Tree Plaza (another 6 km) opening in 1989. In the initial stage some bus routes were actually made longer so they could access the track, and there was no time saving on these bus routes. Nevertheless, in surveys passengers indicated that they were saving time, because they had the perception of fast, uncongested, and more reliable, travel.

To win public support in the inner suburbs, it was decided to landscape the entire O-Bahn corridor, with particular attention given to the section along the river. Recreational pedestrian and cycle paths have been provided, and a linear park created.

2. Operational System

Much of the success of the O-Bahn is due to the way in which all bus services using it are totally integrated and coordinated in one master timetable, with the relatively regular services operated on the suburban routes using the O-Bahn being timetabled to provide fairly even intervals between services, thus minimising waiting time at the stations. Frequency and minimal waiting time is a major drawcard of the Adelaide O-Bahn.

On weekdays 15 conventional suburban bus routes use the O-Bahn. Each of these 15 bus routes operate through the normal street system in the City and outer suburbs, with bus stops located at the conventional spacing of three per kilometre. Of the 15 bus routes, 9 enter the track at the mid-point at Paradise Interchange, with the other 6 entering at the outer end at Tea Tree Plaza. In peak periods all of these services operate through to the City, so that the majority of people in the urban corridor can travel to and from work without change of vehicle. Each of these routes operates every 10-20 minutes in the peak, giving a combined service frequency of more than one bus per minute between Paradise and the City, and every 2 minutes from Tea Tree Plaza.

In the middle of the day, 6 of the 15 routes continue to operate every 30 minutes to and from the City, giving a combined headway of 5 minutes on the full length of track. The other 9 routes become feeders at Paradise Interchange, each also operating every 30 minutes. The 30 minute frequency allows provision of easily-remembered "clock-face" timetables during much of the interpeak.

All of the above routes use a common route through the City centre, maximising service frequency for outbound passengers. Selected inbound buses in the morning peak use a different central city route to improve the range of destinations served.

There are also two high–speed limited stop long-distance "Transit Link" bus routes, which actually travel on the O-Bahn, through the north-east urban corridor then across into Adelaide's northern corridor, terminating about 30 km from the City centre. These services each operate every 5-10 minutes in peak periods and every 30 minutes during the day. They follow a different route in the City and use a different stopping pattern on the O-Bahn.

At night the frequency along the O-Bahn drops to one bus every 12 minutes, with only a small number of O-Bahn routes continuing into the suburbs. A fleet of minibuses with flexible drop-off provides a feeder service into the suburbs at these times.

On Saturdays a 12 minute frequency is provided on the O-Bahn, with hourly through or feeder services from the suburbs, while on Sunday a 15 minute service is provided, with hourly through or feeder services on selected routes.

The far outer end of the corridor is served by minibuses operating as "Suburban Link", feeding O-Bahn buses at a major shopping centre about 20 kms from the City. These small buses are used as the street pattern makes operation of large buses difficult.

Adelaide has a completely integrated magnetic-strip ticketing system in which passengers can transfer free of charge between buses, trams and trains within a two hour period. This means that there are few difficulties related to fares when some passengers are required to change between vehicles at times at which their branch route alters from a through service to a feeder service. In addition, passengers that had a through suburb to suburb journey on an "on road" bus prior to the opening of the O-Bahn were not penalised (fare-wise) when their bus route was diverted to the O-Bahn and they had to change buses to reach their destination.

The bus service contractor operating the buses is subject to many safety requirements introduced since 1986. Each driver must receive training to use the O-Bahn. The contractor controls all buses on the O-Bahn through timetabling and through its control centre.

A significant advantage over any rail system is the fact that operations can continue during track closure. When emergencies occur (which is rare) buses can be diverted to the normal road system. When scheduled maintenance is required (eg replacement of pavers in stations), the track is closed and buses diverted with prior notice given to passengers. Such closures usually occur on a Sunday (again, rarely).

3. Station Design

The O-Bahn has three stations:

- Klemzig, a small station 3 kms from the City end of the guideway, mainly designed to allow transfer to a major cross suburban bus service, but featuring some parking. Buses do not normally enter or leave the guideway here except in emergencies.
- Paradise, a large interchange 6 kms from the City end, featuring terminal facilities for non-O-Bahn buses, a major entrance/exit point for O-Bahn buses, and turning facilities for feeder buses which can use the normal O-Bahn stops. It has a large car park.
- Tea Tree Plaza, a large interchange located at the regional centre for the area.

The guideway is discontinuous through stations, allowing buses to enter and leave the track, and to allow buses that are terminating or connecting with through buses to make transfers at convenient platforms and to turn around. The stations also provide space for disabled buses to stop. The design allows buses to overtake – some services operate express, and some stops are "request" only, allowing buses that do not need to stop to pass buses that are stopped. At busy interchanges such as Paradise and Tea Tree Plaza, the O-Bahn buses use separate stops for each route group, so the buses must have the flexibility to pass each other to enter and leave stops.

The O-Bahn was designed well before low floor, accessible buses became popular (there is one such new guided bus in trial on the O-Bahn). Thus, the O-Bahn platforms are not designed specifically with low-floor buses in mind. It is possible in some cases for the driver to make the guidewheel run along the kerb, but this would be difficult if the bus approaches the kerb at a sharp angle (say when moving into a stop after passing a bus at the rear stop).

Each stop has a park'n'ride and kiss'n'ride facility. All parking is free, with the exception of the large car park at Tea Tree Plaza which has secure, paid, parking. There is also a park'n'ride facility in outer suburbs about 5 kilometres from the end of the O-Bahn served by several O-Bahn bus routes. Park'n'ride is very popular, but only constitutes about 20% of total patronage. The amount of parking required is very difficult to predict. Paradise Interchange, for example, commenced with 160 parks and now has about 550.

One difficulty with planning park'n'ride is the compromise that has to be made with the amount of feeder or "run-on" suburban bus service provided. The more that parking is provided, the less people will want to use the suburban bus routes linking with the system. If these suburban routes are reduced in frequency, those captive to public transport are disadvantaged, while those who have a choice will have a greater reason to park'n'ride.

Pedestrians are only allowed to cross the track at the interchanges. At Klemzig and Paradise they do so only under signal control. At Tea Tree Plaza, there is a pedestrian crossing to the shopping centre in an area where buses travel very slowly. In other locations pedestrians must use road or footbridges. No roads cross the O-Bahn at grade.

4. Track

The Adelaide O-Bahn track is of very heavy, modular, construction, elevated a little above ground level to avoid the effects of seasonal soil movement. Every 3 metres a concrete sleeper is supported by two piles which penetrate deep into the ground to give the system stability. The height of the sleepers can be adjusted relative to the piles if the piles sink. Each concrete sleeper supports the pre-cast modular track elements which are of standard lengths and either straight or a number of standard curve radii. The track elements each have a roughened running surface and an upright concrete rail at the edge, and there is a drainage channel between the two track elements which are wide enough for the bus's dual rear wheels.

Engineers have advised that a much lighter construction would be required in areas of rock or more stable soil. The engineering company partly responsible for the original design now says that modern road construction techniques would allow in situ construction of slip-form reinforced concrete track without the need for piles, even on Adelaide's unstable soils. Apparently the structural reinforced concrete of the guideway could be placed for its full length without transverse joints (other than construction joints formed at the end of each day's construction, thus having the attributes of continuously reinforced concrete pavement as applied in the latest concrete road technology. The current O-Bahn has small expansion joints between each track element at least every 12 metres.

5. Buses

The O-Bahn opened with 51 articulated and 41 rigid Mercedes Benz 0305 buses, built in the 1984-1986 period, and these buses are still in service, with one new low-floor accessible Mercedes prototype bus recently entering service. A few years later a smaller number of MAN articulated and rigid buses also commenced operation. The MAN and Mercedes buses have different versions of guidewheel, but a number of technical modifications were made to the guidewheel design by people in Adelaide in the early years. These have enhanced the guidewheel life considerably.

As well as being fitted with guidewheels and guide-arms, each bus has aluminium inserts inside its front tyres. These are designed to support the bus in the event of a tyre blow-out and allow it to be driven to the next station at up to 40 km/h. On the guideway it is particularly difficult to replace a tyre. The inserts are not required at the rear because each bus has dual rear wheels, but there is a special trolley available for fitting under the rear wheels should they "lock up".

Drivers must be trained to take care on the normal road system when driving a bus with guidewheels. The wheels are designed to break off in the event of a sharp impact, and prior to the O-Bahn opening guidewheels were fitted to buses for some months to allow drivers to become accustomed to them – with many guidewheels breaking off in the first few months. They should not be driven into a kerb at a sharp angle, and care must be taken at drainage locations (known as spoon drains in Adelaide) especially when turning. They must not drive over a kerb unless in an emergency.

Raised inspection lids in the roadway or incomplete rough bitumen road edges on unkerbed roads can be a major hazard for guidewheels. A number of road modifications were made to the street system prior to the introduction of guidewheels. In one instance a guidewheel ran up the ramped edge of a pedestrian kerb ramp, turning the bus steering wheel and dislodging the bus driver from his seat with the bus moving across the traffic lanes – fortunately there were no other vehicles in the path of the bus. Thus, ramped kerbs close to where buses travel can be a hazard, and these have been modified where possible.

The bus fleet introduced with the opening of the O-Bahn was not fully air-conditioned, so most buses have sliding opening windows. As the tracks are very close together, the windows on the off side of the bus have a limited opening space to prevent arms from protruding into the path of an on-coming bus.

All buses are capable of travelling at 100 km/h and of accelerating at an acceptable rate. There have been trials with buses that have not met this requirement. If such buses were introduced they would impose lower speeds or acceleration rates on other buses.

Adelaide is in the process of completing an order made some years ago for the supply of new buses by M.A.N. A new contract with Scania is just commencing, and it is proposed to trial a rigid Scania low floor bus and an articulated Scania low floor bus on the O-Bahn in the next two years.

6. Quality of the System – Public Perception of Ride Quality, and Actual Value of Ride Quality over and above a Standard Bus

Public perception of ride quality on the O-Bahn is a very subjective matter, difficult to measure. The author's personal experience, having travelled on the O-Bahn many times over the last 18 years, is that the ride quality is significantly better than that experienced on a normal roadway.

The actual value of ride quality compared with that of a standard bus on a road depends largely on the quality of the ordinary road on which the bus is travelling. Adelaide has a wide range of road qualities, with main roads being controlled and maintained by the South Australian State Government's Department of Transport and Urban Planning – Transport Services Section, while local roads (on which our buses also operate) are maintained by a number of local government authorities. The quality of those roads depends on the quality of initial construction, wear and tear on the road, the time since it was last upgraded, and the amount of disturbance by underground service and drainage authorities. Adelaide also has very unstable soils that rise and fall between summer and winter, causing difficulties for road maintenance and sometimes leading to dips in the road. It is the instability of the soils that led to the decision to construct our O-Bahn on concrete piles with the base of the concrete "sleepers" a little above ground level so that the track is not affected by rising and falling soil levels. The result of this and the heavy track is that the ride feels very smooth compared with most roads. The guiderails add horizontal stability so that the bus does not move uncomfortably from side to side but maintains an even, straight (in line with the track) alignment.

In a paper by FA Wayte and TJ Wilson presented at a 1988 International Seminar on Guided Bus Rapid Transit, there are two sets of graphs showing Comfort levels for the bus on a road (at 70km/h) and on the guideway (at 100km/h). These show the vertical acceleration, lateral acceleration, roll angle, yaw angle and longitudinal acceleration were all significantly less on the O-Bahn than on a normal road.

In a Before and After Study carried out following the 1986 opening of the O-Bahn, it was found that perception of passenger comfort had increased significantly, with a 30% increase in the proportion of passengers disagreeing that the bus was uncomfortable.

In a paper prepared for an International Seminar on Guided Busways held in Adelaide in 1988, Bernard Kluge of Daimler Benz said "The O 305 G articulated buses in service in Adelaide are characterised by having very high stability reserves in pendulum oscillations. The critical vehicle speed for all loading conditions is between 190 and 240 km/h, far in excess of the operating speed of 100 km/h. This is achieved by the real-time jack-knife angle damping, which is active even at small steering angles (0o to 8o pitman arm angle)." He also stated that "In comparison with the cross section of the track of a standard 4m wide busway, there is a margin of only about 10% for vehicle movements in the transverse direction. From the geometrical conditions it can be seen that the rear axles have to be set as absolutely vertical as possible to the longitudinal axis of the vehicle in order to assure accurate mid-track running on the straight. This calls for substantially more demanding requirements than are needed for road traffic…"

The concrete track (which was constructed to tight tolerances to achieve high comfort levels) is more stable than an "average" railway track – certainly of South Australian standards. The O-Bahn involves light vehicles travelling on a very heavy, stable, track, while railways involve heavy vehicles travelling on light, relatively flexible track. Thus, while railways often require re-alignment there have been very few situations in which the O-Bahn track has had to be adjusted, and this is achieved simply by raising the level of the track relative to the pile (eg if a pile has sunk a little).

One lesson learnt in original construction was that it was important to have transitions at the start and finish of high-speed curves. On Stage 1 of the O-Bahn (opened 1986) there are no transitions, so the change from straight to curved track can be felt by passengers – albeit very lightly. In Stage 2 (opened 1989), transition curves were used, so the change from straight to curve is barely perceptible.

Another lesson learnt after opening was that care needs to be taken in the treatment of the relationship between curves and articulated buses. Stage 1 includes a number of curves which were determined to be quite safe for 100 km/h operation. However, it was found that articulated buses would scrub the sides of their rear tyres on the guiderails at this speed. It was also found that they would do the same at a relatively slow speed. A test was carried out with a bus with guidewheels at the rear but this resulted in a very rough ride. After many tests it was determined that if articulated buses operate at 80 km/h through these curves, their rear tyres do not scrub the guiderails.

Another important consideration is that it is necessary to ensure that the gauge of the guidewheels is adjusted from time to time. A bus that has not had its guidewheel gauge properly adjusted gives a rougher (but not uncomfortable) ride than a well-adjusted bus. In this regard it is interesting that the gauge for the guidewheels is actually a few millimetres greater than the gauge of the track, thus ensuring that the guidewheels are always pressed hard against the guiderails.

In Essen, Germany (at least when visited by the author in 1996) there are some sharp curves approaching stops, and the buses there are fitted with rear guidewheels which are designed only to touch the rails at those points, and at slow speed.

The author has travelled on the O-Bahn on many occasions with overseas visitors (politicians and transport professionals) and they have all agreed that the system is most attractive from a passenger viewpoint. Passengers often provide very positive commentary to these visitors as they are very proud of their O-Bahn.

Drivers also provide positive comments to these overseas visitors. The O-Bahn buses are now operated under contract to the department by a private company, but prior to the late 1990s were operated by the author's former employer the State Transport Authority (now called TransAdelaide). The most popular bus depot (out of seven depots at the time) for State Transport Authority drivers was St Agnes, which operated the O-Bahn services), as drivers most enjoyed working on O-Bahn services, with their speed, lack of congestion, and safety.

7. Patronage – How has this changed since Introduction? It is understood that Patronage had been consistent on the O-Bahn services in an otherwise declining Market

Annual patronage on the bus routes using the O-Bahn increased from 4.23 million in 1985/86 (the O-Bahn opened in March 1986) to 7.13million in 1995/96 – an increase of almost 70%. In that same period the population in the main catchment of the O-Bahn increased by 20%, explaining only part of the increased patronage. Also in that same period total public transport patronage in Adelaide dropped from 82 million to 61 million – a 25% reduction, so the O-Bahn certainly went against the general overall trend. Since the late 1990s the O-Bahn patronage has stabilised as the suburban catchment has neared its population capacity. Since 2000 some Adelaide bus routes have had higher patronage increases than the O-Bahn but only because no improvements have been made to O-Bahn services for some years while improvements have been made on the routes with increasing patronage.

On an average weekday about 27,000 passengers board O-Bahn buses, and about 22,000 travel along the O-Bahn on a total of 736 bus trips. About 4,500 arrive in the City in the AM peak hour on about 70 buses.

8. How are Illegal Access and Breakdowns Managed. How Much Trouble Have we had with This?

Private cars can physically drive into some of the station areas along the O-Bahn as there is no guided track in those areas, but there have been few instances of this occurring.

At each entrance to the guided track there is a "sump buster", a device designed to remove the sump from any car that endeavours to enter the guided track. The occurrence of non-O-Bahn vehicles driving on the track is about twice per year, generally involving an intoxicated driver attempting to drive along the O-Bahn between the hours of 1230 and 0500 when buses are not operating – so there is little impact on the bus service. Sometimes it is necessary to bring in a crane to remove the damaged vehicle, which usually does not succeed in travelling far on the O-Bahn, due to the presence of the sump buster and the wide space between the concrete running surfaces. One lady managed to drive her large car some distance along the O-Bahn in daylight hours after being told by her daughter that she could find her way to the City by following a bus!

When the system was being planned it was proposed that bus breakdowns would normally be resolved by carrying a push-bar in each bus, and connecting the broken down bus to the next bus that arrived in the rear. The arriving bus could then push the broken down bus to the next available exit point.

This practice was opposed at the time (1985) by the bus drivers' union which insisted that its members were drivers, not mechanics. It is possible that a different outcome would have resulted now with significantly less union influence.

The Government decided instead to buy a very expensive double-ended breakdown truck featuring retractable guide wheels at each end. This vehicle can be driven, by mechanics, in either direction along the O-Bahn track to rescue a bus. The vehicle (called Dumbo) is used only occasionally for this purpose as the buses are very reliable, and buses generally are more likely to fail at a bus stop (where they will not delay other buses). Dumbo also carries other rescue equipment.

Statistics supplied by SERCo, the current operator of buses on the O-Bahn, show that in the 4.25 year period they have operated the O-Bahn services there have been 11 instances of immobilised buses on the O-Bahn – 2.6 per year. These 11 instances would have affected approximately 60 bus trips out of 3.6 million trips.

For the first six months of 2004 there were 24 occurrences that impacted the normal operation of services, but no cases of buses immobilised due to "normal" breakdown. Reasons for the disruption include branches, logs, cans, tyres, and beer cans placed on track, one car on track, petrol fire on track, objects thrown at buses, and persons under the track. The average clearance time to recover a bus and remove it is 35 minutes, but this depends on the incident.

9. Accident History – Many, Few, Severity of Accidents

The O-Bahn has been operational since 1986. Since that time about 3.8 million in-service bus trips have been made along the O-Bahn, amounting to about 30 million kilometres. This does not include dead-heading buses.

In that 18 year period the only serious or potentially serious accidents involving buses on the O-Bahn track, of which the author is aware, are as follows:

- Some years ago an empty bus departed Klemzig Interchange on its way to the City. A short distance from the station the driver noticed that a bicycle had been left on the track, so he stopped to remove the bicycle. Unfortunately, the driver of a following almost-empty bus was distracted and ran into the back of the stopped bus. It is understood that damage was relatively minor and that there were no injuries.
- Also some years ago a relatively full-articulated bus was slowing down at the exit to the track on the approach to Klemzig Interchange. The driver of the following articulated bus (also full) was distracted and did not notice the bus in front slowing down, and ran into the back of the first bus. Both buses were extensively damaged and there were many injuries. A replacement bus was later built by joining the good front of one bus to the good rear of the other bus. This accident resulted in a court case in which the magistrate decided (what had not been determined prior to this event) that the O-Bahn was a road and that normal road rules would apply.

- A few years ago a bus departed from the depot (empty) without the driver checking that guide wheels were fitted. Unfortunately, the guidewheel on the right side of the bus had been removed by the workshops. The bus entered the guideway at Tea Tree Plaza and the front right wheel mounted the right guiderail so that the bus protruded into the on-coming track. There were no injuries and little damage to the bus.
- Non-guided buses are able to enter stations along the O-Bahn to facilitate passenger transfer. One such bus entered Paradise Interchange to deposit its last passenger. A passenger waiting at the Interchange asked the driver if he could carry her to Tea Tree Plaza as he was returning to the depot. The driver said yes, and, momentarily distracted, forgot that his bus was not a guided bus. He had entered the track before realising this. As it is impossible to reverse a bus on the guideway, he continued the 6 kilometres to Tea Tree Plaza, with the bus suffering only some minor tyre scrubbing and the driver some embarrassment.

Following the accidents various safety measures were introduced, including:

- Any bus driver using the O-Bahn for an unscheduled trip must report to radio control to seek permission;
- Any bus slowing or stopping on the O-Bahn must immediately report to radio control, which immediately sends a warning signal to all other buses, which must then slow down and be prepared to stop. Radio control will then advise the nature and location of the stoppage so that other drivers can take appropriate action. Should the track be blocked for some time, buses will be detoured via the normal road network.
- Flashing lights have been fitted to the roof at the rear of the bus. These must be activated when a bus stops on the O-Bahn.
- Zebra stripes were painted on the rear of buses using the O-Bahn, although this practice appears to have ceased.
- Buses must drive at all times with headlights on when travelling on the O-Bahn.
- Drivers must check the bus guidewheels before departing the depot.
- Improved driver training; in the early days some drivers liked to count their cash while driving the bus – as driving on the O-Bahn is such an easy task. They need to be alert at all times.

In addition to the above, bus drivers are required to maintain a minimum spacing of 160 metres between vehicles. They are assisted in this by distance markers on the track (which are also useful for identifying locations along the track, eg for maintenance purposes.

The accidents were a “wake-up call” to the operators and drivers of the need to be much more vigilant when driving on the O-Bahn.

It should be noted that the O-Bahn buses are fitted with ABS braking, and tests carried out prior to opening indicated that the buses could stop from a high speed in a very short distance (several bus lengths), something impossible for rail vehicles.

When the State Government buys new buses for the O-Bahn (which is likely in several years as most of the buses are now 19 years of age) consideration may be given to installation of devices which can slow the vehicle if it comes too close to a preceding vehicle. Such devices are now available.

Some could argue that rail-type signalling devices should be installed, preventing more than one bus at a time occupying sections of track. Such a system would be very costly and could cause capacity problems. It must be remembered that:

- The vehicles are much lighter than rail vehicles;
- The vehicles can stop more quickly than rail vehicles;
- Rubber tyres and concrete surfaces provide for better braking than steel wheel on steel rail;
- The Adelaide O-Bahn was designed to ensure adequate sight distances (at least 200 metres) to allow buses to stop easily if the driver see an obstruction;
- There is little fog and no snow in Adelaide; drivers are required to reduce speed in fog.

In addition to bus accidents, there have been a number of instances of missiles being thrown at buses, in which bus windshields have been damaged and drivers have suffered injuries. The risk of this is no different to that faced by trains. Measures have been taken to reduce risks, such as security fences on bridges, reducing vegetation (that can hide culprits) and protective windscreen film.

10. Operating Speeds

When the O-Bahn was first opened, the general maximum speed was 100 km/h (although in tests 115 km/h was attained quite easily), with a maximum speed of 60km/h around the sharpest curve (400m radius) at the City exit, and maximum speeds of 40 km/h when entering and leaving the guideway.

Following the rear tyre scrubbing on articulated buses described elsewhere, the maximum speed in the first three kilometres around a number of curves was lowered to 80km/h, which prevents the tyre-scrubbing.

Speeds are now fixed pursuant to the provisions of the South Australian Road Traffic Act. They can be summarised as follows:

- 20 km/h on service roads within interchanges
- 40 km/h entering and leaving the guideway, through interchanges, and through the Park Terrace Tunnel
- 60 km/h on the last bend at the City exit, and on the approach to some interchanges
- 80 km/h on the curves in the first three kilometres, and on approach to interchanges (a rumble strip at these points actually reminds the driver to slow down)
- 90 km/h on several curves in the outer section
- 100 km/h elsewhere (about 7 km of the 12 km length)

Occasionally speeds are checked using conventional speed radar checks.

One of the attractive features of the O-Bahn is the high average speed, which is achieved by the high maximum speed of the buses plus the wide station spacing. It is generally agreed in Adelaide that the system would not have been so attractive if it had more stations. Buses travel the distance from the City centre to the outer end of the O-Bahn at Tea Tree Plaza in 23 minutes, a distance of about 15 kilometres. Prior to it's opening the running time for express buses on the road system was 35 minutes, while on-road stopping buses take 45 minutes.

On the track itself, the 12 km length (including three stations) takes 12 minutes, or an average running speed of 60 km/h.

11. System Capacity

On an average weekday about 22,000 people travel along the O-Bahn. About 4,500 arrive in the City in the AM peak hour on about 70 buses. Over the whole weekday a total of 736 buses (in service) travel along the O-Bahn.

The 70 buses travelling in one direction in the peak hour means that the average headway is about 51 seconds. At 100 km/h a bus travels 1.4 kms in 51 seconds, so there are, on average, long gaps between buses even in the peak period. However, buses do bunch as a result of inconsistent arrivals at the entry points caused by road traffic, and the author has timed several buses in a row passing at 20 second intervals – which, at 100 km/h, is a spacing of 550 metres – more than sufficient to easily stop a bus.

On this basis the O-Bahn track could safely accommodate a bus every 20 seconds, or 180 buses per hour in one direction. If each bus was articulated and carried 100 passengers, the capacity would be 18,000 passengers per hour.

These figures ignore stop capacity. Stops on the O-Bahn easily accommodate the current bus volumes, with the stops having the greatest combination of frequency and dwell time being the outbound central City stops in the evening peak. If we had to accommodate a much greater number of buses than at present we would have to consider:

- spreading buses over different stops or different City streets – but this would militate against the benefits of high frequency;
- some buses being scheduled to skip some suburban stations (this already occurs with two high speed routes using the O-Bahn);
- re-designing the suburban interchanges.

It is understood that bus volumes on some high capacity bus routes in South and Central America accommodate higher bus volumes than the 180 buses per hour mentioned above, using techniques such as special loading pre-ticketed platforms and platooning.

12. Noise – Surveys and Complaints

The rubber on concrete of the O-Bahn bus results in lower vehicle noise than the steel wheel on steel rail of trains and trams.

The author is unaware of any complaints from residents about noise from the O-Bahn. Much of the track is depressed below ground level to assist in the provision of road and pedestrian overpasses, and, where there is space, landscaped mounds have been constructed on either side of the track.

Several years ago as part of an assessment of the possibility of building an O-Bahn to the south of the City, some noise estimates were made for buses on the O-Bahn track and diesel-electric railcars on suburban rail track (as the Southern O-Bahn was to parallel a rail track). The following comparative summary figures for the morning peak period are taken from a table "Summary of Predicted Average Noise Levels for O-Bahn Bus and Rail Events":

	Most Severe Case (1)		Typical Case (2)	
	L_{aeq}, dBA	L_{Amax}, dBA	L_{Aeq}, dBA	L_{Amax}, dBA
O-Bahn	63	80	48-53	65-70
Train	63	95	48-53	80-85

(1) 5m to nearest residence
(2) 20 m to nearest residence
L_{Aeq} = equivalent continuous noise level for a measurement period, weighted for duration and intensity. It is an indicator of average noise level (in dBA)
L_{Amax} – maximum noise level for a measurement period (in dBA)

13. Why the System has not been Extended

The O-Bahn track in Adelaide was constructed in the only lengthy urban corridor that is not served or partly served by rail. The outer end of the corridor was the fastest growing part of Adelaide during the O-Bahn construction period and for some years after – from about 1980 to 1995. This was an area known as Golden Grove which was jointly developed by the State Government and private developers to produce a residential area that a few years ago won international real estate awards as the best housing estate in the world. During its development sales signs advertised that it was served by the O-Bahn.

The O-Bahn track was constructed from a point about 3 kilometres from the City Centre to terminate about 15 kilometres from the City Centre at the regional centre for the area, Tea Tree Plaza. Suburbs now stretch for about 8 kilometres beyond Tea Tree Plaza but further urban growth in the corridor is prevented by a range of hills. In this area the bus routes fan out from the end of the O-Bahn, operating on the normal street system. There is insufficient concentrated passenger demand in this area to extend the O-Bahn.

Consideration was given shortly after its opening to extending the O-Bahn towards the City centre to plug part of the 3 km gap, and a brief engineering study was carried out. Construction did not proceed, however, due to the costs involved, possible disruption to Adelaide's sacrosanct Parklands, and the fact that buses are not severely affected by traffic congestion and are given some priority measures in this section. Most of Adelaide's peak period traffic congestion occurs in the inner suburbs, about 3 to 5 kilometres from the City, and the O-Bahn bypasses that congestion.

O-Bahn track cannot be built on City streets without severe disruption to traffic and pedestrians, unless it is elevated or placed underground. Adelaide's relatively good traffic conditions and the high cost of grade separation are such that it could not be justified. Nevertheless, one of the advantages of O-Bahn track is that buses can use tunnels or narrow elevated track which would pose major problems for ordinary buses.

A few years ago serious consideration was given to construction of an O-Bahn to that part of Adelaide's southern suburbs which is not well served by rail, as the railway line in the south is off-centre to the urban development. This necessitated finding a corridor through continuous urban development in the inner southern suburbs, a difficulty which was not faced to the same extent by the existing O-Bahn to the north east.

The only available corridor in the inner southern suburbs was the previously mentioned railway line, so the plan involved relocating the train tracks to one side of the rail corridor (which has a 30 metre width) and laying O-Bahn track next to them. Unfortunately, there are a number of at-grade road crossings along this railway, so the plan included construction of a large number of under and over-passes for the O-Bahn immediately adjacent to at-grade railway tracks. The cost of doing so was significant, and the Government abandoned the proposal.

Various ideas have been floated for replacing some suburban railway lines with O-Bahns or ordinary busways, and economic analysis has indicated that this would be worthwhile. The idea was even publicly floated in South Australia's recent "Draft Transport Plan". However, it is not currently acceptable from a political viewpoint.