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O-Bahn Busway
Adelaide's Experience

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In 1980 the state of South Australia contracted with the German supplier of a new busway technology called O-Bahn. The project produced an 11.8-km busway alignment that was built in two phases with public operation in 1986 and 1989. Although the technology has functioned without fault and the safety record is excellent, the project has not experienced robust patronage growth or political success. During the 1990s public transit has been privatized and overall system ridership has declined by 30%. The long-term relationship between the foreign contractor and the local managers and staff failed to create a positive atmosphere for ongoing work, whether locally, nationally, or abroad. Although local and state officials provide positive public comment about their happiness with the technology, their management and policy actions suggest tepid belief in the concept.

With regard to the urbanization pattern of Adelaide, the state of South Australia developed from the first half of the 19th century with its capital at the port city of Adelaide. The city was founded in 1837. Of the state's population of 1,459,000, over 66% reside in the district of Adelaide (1,023,617). In effect, 73% of the state's population reside on 2/10ths percent of the landmass. In 1997, the Adelaide district encompassed 1893 km^2, indicating an average of 541 persons per km^2.

Since 1945, the low-density urbanization of the metropolitan area has continued. The urban area is roughly 80 km north–south and 20 km east–west. The area has been developed with a strong environmental understanding and policy. The historic city is 1 mi^2 with grid pattern streets. Surrounding this central area is a ½-mi greenbelt of parkland. The low-density suburban areas blossomed from the early 20th century with installation of streetcar corridors and further extended to the north, east, and south following the economic growth and motorization of the late 1940s.

PREPROJECT URBAN TRANSIT NETWORK

Before O-Bahn operation the city deployed three urban transit technologies. Over 80% of weekday ridership used standard buses whereas 16% depended on the five radial lines of commuter and suburban railway. This rail operation is one of the largest in the world that relies solely on nonelectrified propulsion. The final few percent of daily riders derive from the one classic tramline plying between the Adelaide central business district (CBD) and the coastal resort of Glenelg. Although an aggressive freeway program was proposed in the mid-1970s, adverse public reaction was generated and much of the program was withdrawn from active consideration. By the early 1970s the Tea Tree Plaza District, northeast of the city center, represented the largest remaining underdeveloped, nonindustrial land parcels within the metropolitan area.

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EFFECT OF POLITICAL ENVIRONMENT

The background of the O-Bahn project relates less to technology than to social, political, and commercial objectives. Broadly, these objectives can be divided into the public agencies directed by the elected politicians and the commercial firms with a product to sell.

South Australia: Political Setting

The state government had encouraged active development of a strong planning agency for the city and for the state from the 1960s. Although major expansion of highway projects was not wanted, decision makers and elected officials understood the region's economy could easily slow if urban mobility was not maintained and increased. The electorate remained very guarded about commitment of public funds to new high-cost projects, that is, light rail transit (LRT). The incumbent party endorsed the recommendation of their planning agency that the Tea Tree Plaza–Torren River corridor should be emphasized with LRT technology. This decision was made shortly before a general election. The major opposition party decided to oppose LRT since their rivals had endorsed it. LRT, not urban mobility, became a political issue. Partly because of this stance, the opposition won the election. Although contracts were let for preliminary LRT design and work by the outgoing party, the new group immediately cancelled the contracts and paid the stated monetary penalties. Such action became the easy part. Now the new government had the dual task of starting a new transit corridor that was popularly supported, but without a rail-based technology option. Simple, nonpriority bus expansion was not accepted as reasonable. The winning party had painted themselves into a corner in that they could not endorse any option that required guided steel wheel, but they still had to embark on a project. In effect, the party was an eligible suitor but did not want to engage the "standard" girlfriend.

Proprietary Firms

From the early 1970s, two German transit suppliers, Daimler-Benz and Ed. Zublin AB, undertook research and testing of new bus-related options. Some of these were demonstrated in München and Hamburg at international expositions. With its strong cash reserves Daimler-Benz directed its staff to promote a new bus-only guideway technology. Locally it became known as O-Bahn, giving a bit of railway connotation of a fixed guideway or path. Except for a small amount of German federal funding of a project in Essen, no German transit

authority was willing to take up this option. Even with strong promotion worldwide, no major city gave serious consideration to this option for a decade. The supplier had the concept and technology but no suitor had the interest or desire to become wed to it without a complete capital subsidy (*1*).

It was in this context that the South Australian officials and the Daimler-Benz/Zublin officials were brought together by their own circumstances. With the focus and goals each group had, the "wedding" was easy to consummate.

PROPOSED CORRIDOR AND ITS DEVELOPMENT

Beginnings of the Project

The South Australian government introduced the German firms to the corridor and asked them to devise a project that would satisfy safety goals, ecologic goals, residential groups, and the transit operator, which was the state transport agency (STA). The Germans realized they had obtained an ideal location because the local government already supported the concept of nonrail technology and possessed the funding to contract the work. Additionally, the government was under pressure to have something operating before the next election. Several geological, civil, mechanical, and project engineers were brought to Adelaide from Germany to assess, design, and implement the project. At the same time, various local larger architectural and engineering firms took on subordinate roles to the imported talent (*2*).

Although O-Bahn technology was selected, in part, to minimize the physical effect on Torren River and the parkland, ultimately the agency extensively altered more than 3 km of the river valley at a cost of more than A$2e6 per km. (A$ = Australian dollars. In early 2001, US$1.00 = A$1.98. Using international practice, monetary values have been written in exponential form. Thus, 1.2e6 would be 1,200,000. The notation 1.2e3 indicates 1,200.) Therefore, ecological conditions were significantly altered. Although visually pleasing, the existing condition is not "untouched" or in a virgin or natural environment.

The government listed two major and three secondary (minor) objectives for the project (*3*).

Major

1. Increase accessibility to CBD from northeast districts with higher speeds, fewer stops, and quicker time.
2. Reduce local congestion by diverting transit onto exclusive guideway.

Minor

1. Design the guideway to permit future modification on the basis of technology evolution.
2. Redevelop the River Torrens Valley as a linear park.
3. Encourage development of Tea Tree Plaza as a regional center.

Engineering Requirements for Guideway

The Northeast Busway was designed with a different emphasis as compared with LRT projects. The guideway was to be a bridge through the inner suburbs, thereby reducing travel times for residents in outlying districts. There was more interest on capacity throughput than on intermediate stations. Rather than six or seven stations considered for LRT, O-Bahn would have just three stations. The stations were planned to permit

- Passenger transfer between bus routes,
- High platform for entry and exit of patrons,
- Climatic shelter for waiting patrons,
- Protected pedestrian areas and walkways,
- Transition entry–exit lanes for buses,
- Ample guideway width to permit passing of vehicles,
- Long-term parking,
- Short-term parking for drop-off and pickup,
- Bicycle access and storage parking, and
- Landscaping.

The alignment was designed with more focus on longer-distance bus routes than for origination of shorter trips by contiguous residents. The three guideway stations serve a modest role in the success of O-Bahn. Modbury Interchange (Tea Tree Plaza) has bus entry onto O-Bahn plus a large parking area. Paradise Interchange Station permits outlying bus routes to enter the southern third of O-Bahn and contains a large parking area. The Klemzig Station has a very small amount of parking and no bus entry for local services.

The greatest engineering task was not the new O-Bahn technology, but the effective treatment of very difficult soil conditions. Within the alignment segment closest to the CBD there was a combination of uncharted alluvial river deposits and numerous areas of trash and debris dumping, sometimes to a depth of 10 m. In the outer half of the alignment valley subsoils are made up of high-activity expansive clay soils with sudden vertical movements in excess of 20 cm depending on weather, temperature, and treatment. It was for these reasons that any technology selected for the corridor would incur higher than normal capital costs. Both an LRT option and O-Bahn option had to channel all the infrastructure load and dynamic vehicle load onto the robust subterranean support design to preclude any direct placement of weight on the weak upper soil layers (*4*).

Climatically, Adelaide experiences no frost in the winter season. However, surface temperature changes can exceed 25°C. Within a 6-h period concrete track elements can expand or contract by 2.5 mm because of temperature ranges from 18°C to 42°C. The foundation for the guideway was installed with a mixture of bored piers and driven piles, depending on the soil conditions encountered. Average installation work provided 72 m of alignment per day for the 11.8-km route.

The guideway was assembled from precast concrete elements that were 12 m in length. Along tangent sections and large radii horizontal curves the guide rails are cast from concrete, but for narrow radii curves the guide rails are made from steel. Since all track elements were precast, the developers sought to limit the number of curvature variations along the alignment. They provided molds for radii from 400 m to 2400 m in increments of 400 m. The only exception to this was a set of special 270-m elements required at the city end of O-Bahn.

Within the station area the guideway equipment is omitted. This requires the driver to take over steering each time the vehicle is passing through the station. Although the guideway is designed for 100-km/h speeds, the unguided segments in stations require drivers to slow to only 60 km/h while passing through. Some peak-hour longer route buses do not stop at the two intermediate stations (field visits to Adelaide in 1983, 1989, and 1991; *5*).

ELITE MAINTENANCE MANAGEMENT OF O-BAHN FLEET

The public operator, with endorsement from the technology suppliers, determined that busway equipment would require a higher degree of maintenance management than had been provided for standard street-based transit buses. In effect, O-Bahn fleet was segregated from the other rolling stock. These buses could be used for conventional street services, but their maintenance supervision would be more detailed and meticulous.

Reliability of equipment was made a strong requirement. There was concern about mechanical breakdown on the exclusive guideway. Since the controlled guideway technology was not electronic but a physical contact of guide wheels along ridged siderails, the decision was made that this group of buses would be segregated from the normal street-oriented fleet of the authority. Additionally, the maintenance procedures for these new buses were more rigorous and frequent because of higher speed and greater daily utilization (*6*).

A fleet of 92 units was initially ordered comprising 41 rigid units and 51 articulated units. Currently the fleet has increased to 117 vehicles assigned for 18 services. For both types of equipment the front axle has a bearing weight of 6 tons whereas the rear and following axles support 11 tons. The project designers recommended a special set of buses in two capacities. The basic bus was the Mercedes O305 with 90 spaces and the peak-demand articulated Mercedes O305G with 150 spaces. This capacity proposal envisioned a crush load of nearly 7 people per m^2. Given the amount of seating proposed and the crowd characteristics of urban Australians (similar to North Americans), a planning load of 4 people per m^2 would be more plausible (*7*).

In the first 27 months of operation O-Bahn experienced three instances in which a bus mechanically failed while on the guideway. A special bidirection emergency vehicle was used to drag the faulty bus off the guideway to the nearest station area.

TRAFFIC EXPERIENCE AND OBSERVED BENEFITS

With the March 1986 opening of the first 6 k, the annualized patronage grew to nearly 4 million users. In the first decade of expansion and operation, the annual ridership reached 7 million, an average of 24,000 users per workday. Two new express bus services were introduced in the early 1990s and represent 1.2e6 annual riders (*8*).

No significant weakening of auto-related mobility has been observed within this corridor as compared with other portions of the metropolitan area. As found in Paris (France) and Washington, D.C. (United States), part of this situation is because of a lack of adequate parking facilities within the on-line stations. Hundreds of spaces are available, but what is needed is an increase of three or four times this capacity. The obstacle has not been funding or physical location. It has been contiguous residents and businesses that fear a tidal wave of morning inbound and evening outbound auto movements. As a result, the full success and benefit of O-Bahn cannot be judged because of lack of auto parking capacity. With nonmotorized vehicle traffic the busway experience has been more positive. When O-Bahn was installed within the Torren Watershed, the authorities built pedestrian pathways and bike paths. These have been used well by all age groups for local and recreational trips.

Of the 18 bus routes using O-Bahn alignment, only eight routes use the whole 11.8-km length. The other 10 routes exit from Paradise Station.

According to current (August 2001) timetables, O-Bahn handles 67 buses in peak direction during a.m. travel. With 50% articulated buses and 50% standard buses, the average load per vehicle is 75 patrons, for a total peak direction movement of 5,025 riders. With average automobile loads of 1.2 people, this bus volume represents a bit more than two road lanes of mobility. Although this volume may appear modest, it does assist Adelaide within a corridor that possesses no freeway route. The weekday volume on O-Bahn buses is 27,000 riders, of which 22,000 are using the guideway sections. Between 8 to 9 a.m., these buses deliver 4,500 people to CBD. Over half the daily ridership is handled in 4 h (the 2-h a.m. and 2-h p.m. peak periods). Rider surveys indicate that 81% of users board before the guideway entry. Of the 19% boarding at the three stations, 3% are transfer bus passengers, 8% are auto drivers, 3% are car passengers, 4% are walkers, and 1% are bicyclists and others (direct meetings, phone conversations, and e-mail with current and former staff of Northeast Busway Project, State Transport Authority, and Policy & Research Unit of South Australia Department of Transportation, 1977 to 2001).

The overall citywide bus patronage has declined from 49.2e6 in 1990 to only 33.7e6 in 1999. At the same time riders using multitrip tickets rose from 22.3e6 in 1990 to 28.1e6 in 1999. This suggests that nonpeak patronage and non-work-related trips have declined across the city.

In local discussion with planners, operators, drivers, and academics, various merits were highlighted for O-Bahn as compared with a standard bus service. These benefits have been documented in local reports, articles, and technical reviews. In design and installation the safe width of the guideway was reduced (3.6 m versus 2.7 m). Earthwork and guideway structures were less costly as a result. Comments from the riding public, as well as the instrumentation, indicated that the ride quality was found to be superior to normal street pavements, in part because of high-quality engineering of trackway components. The open design of the track running surface provided sound traps and dampers for mitigation of operating noise. Because of active guidance control, a higher service speed could be operated safely. The busway alignment generated lower annual maintenance cost due to the robust design of components. When a driver's hourly wage is the same as standard bus operation, the per-bus-km cost is lower because of the higher throughput speed of the bus. The safety of the service is enhanced because of the exclusive alignment, which is completely grade separated from other traffic and land uses.

During peak hours all routes enter onto the guideway to provide a single bus ride into the city center. During evening and base day hours some of the routes change to feeder-type operation and simply transfer their patrons at the guideway entry point stations.

Although local planners state a safe headway of 20 s (3 buses per min) can be operated, current peak operation is 56 s (65 buses per h) for the guideway. The base day frequency is set at 5 min (12 services per h).

COMPARISON OF LRT AND O-BAHN

O-Bahn guideway cross-section, as built in Adelaide, is 30% wider than would be required with LRT.

Although O-Bahn permits buses to operate beyond the exclusive corridor into nearby residential districts without the need to transfer

between vehicles, the exclusive alignment has only three patronage stations compared with LRT designs that would have permitted seven stations.

The CBD routing of O-Bahn continues to provide a single routing which does not reach employment centers to the south and east of the CBD. The LRT proposed would have provided a more effective CBD distribution.

LRT engineering, equipment, and design are based on current operations within more than 200 cities worldwide. O-Bahn is a unique technology, which limits vehicle availability and design skills to the proprietary owners.

STA concluded six factors were superior with O-Bahn when compared with LRT.

- Capital cost was less.
- Capacity for patrons was the same as LRT.
- The economic merit of the project was inferior to LRT but superior on direct financial consideration.
- O-Bahn reduced transfer volumes along the route.
- The project permitted bus entry into CBD without major construction disruptions for new alignment.

COSTS OF CAPITAL WORKS AND ANNUAL OPERATION

Little update has been made of the capital cost comparison among O-Bahn, standard busway, and LRT options as envisioned in northeast Adelaide. O-Bahn was estimated to require A$83.5e6 for civil work and vehicle development. This compared with A$57.4e6 for standard busway and A$123.0e6 for LRT. Excluding rolling stock, the three options were A$57.4e6, A$48.8e6, and A$78.6e6, respectively. The engineers agreed that LRT equipment would be double the cost of O-Bahn buses, but that the bus fleet would require complete replacement in 12 to 15 years compared with LRT vehicle service life of 20 to 30 years. The station costs were double for LRT, but this was because LRT would have offered eight stations compared with only three by O-Bahn. These consultants stated O-Bahn could be operated without a signal or control system using just the driver's vision and judgement. However, they felt such an option could not be applied to LRT so a A$13.3e6 charge was applied for a signaling system. From the environmental standpoint the promoters suggested "future" conversion of O-Bahn to electric bus propulsion, but their cost figures only related to conventional diesel bus hardware. As a result, A$12.6e6 was budgeted for LRT substations and power supply (*9*).

POSTINSTALLATION EXPERIENCE

In the first year, local leaders and proprietary O-Bahn owners proclaimed it a world success. However, over 15 years have passed since Phase 1 opened, and no other corridor within Adelaide has taken up this option. Leeds, United Kingdom, has used a short low-speed section of this technology in its downtown, and Sao Paulo, Brazil, is constructing a suburban line. Sao Paulo is doing this without publicity. What does this suggest?

Disbanded Local Team

For nearly a decade (1979 to 1989) the region developed its local cadre of specialists and engineers for O-Bahn technology. They grew into an effective group that would have been capable of installing several kilometers of alignment per annum. However, by the close of Phase 2, government appeared to have little serious interest in further development. As a result, in the same month that an international conference convened in Adelaide to review the two phases for the work and its effect on the mobility of citizens, notice was made that most nonoperating personnel were to be released to their own resources. In effect, as has been witnessed with Aramis (France), M-Bahn (Germany), Sky Train (United States), Torino Monorail (Italy), Peach-Line (Japan), and TAU (Belgium), the human resources that could have been deployed into other O-Bahn projects were disbanded.

Attempt at Promotion in Other Major Cities

By this time Zublin had taken a relationship with Daimler-Benz for a subcontractor. Although Daimler continued to promote the concept, they did not provide acceptable funding resources for candidate cities. The international development funds from German sources did not find merit in endorsement of this technology. During the last half of the 1980s, Daimler deployed engineers and consultants to cities from Curitibia (Brazil) and Lagos (Nigeria) to Shanghai (China), Delhi (India), Karachi (Pakistan), Honolulu (United States), and Jakarta (Indonesia). Within the socioeconomic priorities of these locations and within the governmental review of funding ramifications, none of the visited nations or cities have made contract for O-Bahn technology in more than a decade. In the mid-1990s, a short O-Bahn CBD section was built in Leeds, United Kingdom, but this has not generated professional papers or international study. From early 2000 an agency in Sao Paulo, Brazil, has embarked on use of this technology for one corridor, but no public release has been available about the project (*10*).

No Attempt to Convert Existing Rail Lines to O-Bahn

Although Adelaide remains "committed" to the single O-Bahn route to Tea Tree Plaza, it is interesting to note that no attempt has been made to extend the current alignment. A southern route was proposed, but preliminary cost estimates resulted in rejecting further study. No public attempt has been made to establish a new corridor and no attempt has been made to convert an existing low-density passenger-only urban railway line to this technology.

Privatization of Transit Service

As in most Australian major cities there had been a multidecade tradition of public funds subsidizing public equity within public transit provision. However, by the mid-1990s, the community's policy and interest appeared to diverge from its past. This was partly because of the United Kingdom's experience with shifting management and equity for urban transit to private groups and individuals and also because of New Zealand's sudden change to privatization of most public entities. STA was directed to place most of its bus operations on the market block and seek private operators and investors to carry on the operation. Although the O-Bahn alignment remains publicly owned, Serco, which is the bus operation on O-Bahn, is private. Even with the greater ridership demonstrated on the busway, private investors and operators are very reluctant to commit themselves to the higher capital cost of busway versus conventional services. These

developments do not suggest any technology defect within the hardware or the operation. O-Bahn has been a very safe, popular, and effective transit device. However, it has not gained effective supporters or contractors anywhere in the world. What are the lessons we might take away from this experience (*11*)?

The selection of this nonrail technology was made primarily for political reasons. The experience points up why political parties, decision makers, and planning professionals should refrain from taking rigid positions in which opposite stands on policy and hardware are automatically established. If you say "yes" then I will say "no." If you say you are "for it" then I will say "I am against it." O-Bahn technology has performed safely and efficiently for 15 years. Adelaide has provided the world with "real-time" experience for this option. However, as an option for other cities, there has been no effective interest. O-Bahn of Adelaide has the potential to remain unique in the world, much like the monorail of Wuppertal, Germany.

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