Strengths and Weakness of Bus in Relation to Transit Oriented Development

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ABSTRACT

While Transit Oriented Development (TOD) has almost exclusively concerned rail based modes there has been a recent interest in bus related TOD with an emphasis on new bus rapid transit (BRT) developments in North/ South America and Australia. This paper takes a critical look at the strengths and weakness of bus based transit systems in relation to TOD through a review of the literature and an assessment of TOD related developments. The performance of BRT systems in relation to TOD are considered with specific reference to BRT systems in Australia. In addition TOD related to local suburban or 'low order' bus service is considered. The paper describes the general concept of TOD and how this relates to features of transit modes, outlines the literature relevant to bus based TOD and identifies the strengths and weakness of bus based transit systems in relation to TOD. It concludes by using the findings of the review to identify ways in which bus based TOD might be better planned and implemented.

1. INTRODUCTION

Focusing urban development around transit facilities is now recognised as a significant way of improving the effectiveness of our public transport systems as well supporting community goals and improving accessibility (Transportation Research Board, 2004). Termed 'Transit Oriented Development' (TOD) this approach is associated with higher density mixed use development near transit with high quality walking environments to assist access.

In general TOD initiatives have focussed on rail based TOD (or RTOD). Bus based TOD (or BTOD) is clearly a minor subset of TOD implementation (Transportation Research Board, 2004) and is not well covered in the research literature. Dittmar and Poticha (2004) have suggested that the raging light rail vs bus debate is to blame for an unhelpful blurring of the issues associated with BTOD. However they go on to suggest a commonly held view within the development industry that 'rail transit, all other things being equal, attracts more intense development and increases return on investment'.

There is evidence of an increase in the somewhat low profile which BTOD has in the TOD literature. BTOD is seen as an important feature of the growing Bus Rapid Transit field (Transportation Research Board, 2003). Almost 8% of the TOD initiatives identified in a recent survey of the United States were bus based initiatives in predominantly smaller communities (Transportation Research Board, 2004). So what is the potential for TOD in relation to bus services? How far can TOD be realistically applied in the bus industry?

This paper aims to identify the strengths and weakness of bus based transit oriented development through a review of the literature and an assessment of service developments in Australia. The emphasis of this review is to provide an objective assessment of the capabilities problems and issues of bus in relation to TOD rather than advocating bus in preference to rail (or vice versa). It also aims to identify ways to better plan and implement TOD in relation to bus based on these findings.

The paper starts with a background overview of literature associated with BTOD. Weaknesses of BTOD compared to rail based modes are then discussed. This is followed by a discussion of strengths of bus in relation to TOD. Finally the conclusion summarises the key findings of this review and discusses ways in which BTOD might be better planned and implemented based on these findings.

2. BACKGROUND

A casual reader of the TOD literature might be forgiven for thinking that bus services play no role in the field. However bus based TOD has been identified in typologies TOD characteristics. Calthorpe (1993) identified both an 'Urban TOD' associated with a rail stations and a 'Neighbourhood TOD' associated with bus. This concept is expanded by Dittmar and Poticha (2004) into the framework identified in Table 1.

Table 1 : Typology of TOD and Associated Transit Modes

TOD Type	**Transit Mode/s**	**Frequency**	**Land Use Mix**	**Minimum Housing Density** (units/hectare)	**Housing Types**
Urban Downtown	All Modes	<10 mins	Primary office Entertainment Multi Family Housing	>60	Multifamily Loft
Urban Neighbourhood	Light rail Streetcar Rapid bus Local bus	10 mins peak 20 mins off-peak	Residential Retail Class B Commercial	>20	Multifamily Loft Townhome Single Family
Suburban Centre	Rail Streetcar Rapid bus Local bus Paratransit	10 mins peak 10-15 mins off-peak	Primary office centre Entertainment Multi family housing Retail	>50	Multifamily Loft Townhouse
Suburban Neighbourhood	Light rail Rapid bus Local bus Paratransit	20 mins peak 30 mins off-peak	Residential neighbourhood Retail Local office	>12	Multifamily Townhome Single family
Neighbourhood Transit Zone	Local bus Paratransit	25-30 mins Demand responsive	Residential Neighbourhood retail	>7	Multifamily Single family
Commuter Town Centre	Commuter rail Rapid bus	Peak service Demand responsive	Retail centre Residential	>12	Multifamily Townhome Single family

Source: Dittmar and Poticha (2004)

In general a hierarchy of transit modes is suggested. While bus services are provided at every level, rail based modes are more closely related to higher density and larger scale development while bus based modes with lower frequencies predominate at the lower density end of development. The link between bus and lower density development is repeated in much of the literature. A review of TOD residential density thresholds (Transportation Research Board, 2004) identified consistently lower density expectations for bus based schemes than light rail in San Diego, Washington and Portland.

The co-location of bus services and bus terminals at some major rail stations has been suggested as a potential spur for TOD (Transportation Research Board, 1997). The same source suggested that BTOD is commonly associated with cities without rail. Encouraging development around bus stations is a major feature of BTOD in these cities.

The most common association between TOD initiatives and bus has been related to bus based mass transit systems such as busways or Bus Rapid Transit (BRT) systems. The ability of large scale bus transit systems to encourage land development has been identified as a major benefit of these forms of transit technology (Transportation Research Board, 2003). Table 2 shows some selected examples.

Table 2 Land Use Benefits of Selected BRT Systems

System	Land Development Benefits
Pittsburgh East Busway	59 new developments within 1,500 ft radius of station. $302M in land development benefits of which $275m was construction. 80% clustered at station.
Ottawa Transit System	$1Can Billion ($US 675M) in new construction at transitway stations
Adelaide Busway	Tea Tree Gully Area becoming an urban village
Brisbane South East Busway	Up to 20% gain in property values near the busway. Property values in area within 6 miles of station grew by 2 to 3 times faster than those at greater distance

Source: Transportation Research Board (2003)

The Ottawa transit system is a major icon of bus based TOD. Ottawa's policy of combining integration of land use and transport planning with an emphasis on public transit development over road construction are to be admired regardless of the transit modes involved. Nevertheless it was an integrated high frequency busway which achieved substantial increases in transit patronage and which has been associated with densification of development around busway stations (Bonsall, 1997).

The Curitiba and the Bogata TransMilenio system in South America are the other major icons of both BRT and associated BTOD. A direct link between the accessibility benefits of the Bogata system and land values was identified in Rodriguez and Targa (2004). The integrated land use policy associated with the Curitiba busway has been associated with its significant impact on land development (Smith and Raemaekers, 1998).

While the association of TOD with these large scale bus transit systems is relatively well developed, the relevance of these examples to American (and Australian) circumstances has been questioned. Henry (1989) has stressed the strength of land use controls in Ottawa as a major factor influencing successful land use and transport outcomes. This level of control is considered “formidable” and “most unlikely” in US land use planning (Henry, 1989).

So what is the practical and realisable potential for BTOD? The next sections consider the weakness and strengths of bus in relation to TOD.

3. WEAKNESSES

The following discussion concerns potential weakness of bus in relation to TOD. In each case the significance of the issues raised are assessed on a scale from ‘low’, ‘medium’ to ‘high’ to understand the scale and importance of the weaknesses identified.

3.1 Permanence, Magnitude and Implications for Development Risk

A number of sources question the permanence of bus compared to rail:

> “Developers and home buyers alike seem to be attracted to the permanence of rail transit”
> Dittmar and Poticha (2004)

> “Because the locations of bus routes are not fixed or permanent, this greatly increases the risk of investing in transit-supportive land use development” California Department of Transportation (2002)

The scale and magnitude of rail development is also purported to be significantly higher than for bus and is suggested as a major spur for rail based development compared to bus, (California Department of Transportation, 2002). Certainly significant investment suggests a significant commitment. Commitment and taking development risks are clearly linked. However as Hensher (1999) puts it “What makes for permanence?”. The same source questions wether busway based schemes are less permanent than light rail since no evidence is available that any busway systems have been removed. This theme is taken up by Niles and Nelson (1999) “It is not easy to draw the conclusion that rail transit is both more permanent and a greater attractor of development than is bus transit”. These authors point out that historical studies demonstrate much change and evolution of transit systems of all types. Evidence is quoted of Chicago bus routes which have existed for almost a hundred years. Reference is also made to the considerable number of streetcar systems removed from streets in post-war North America (and the UK).

Some conclusions emerge from these points which relate BTOD to the issues of risk/permanence and magnitude:

- Suburban bus based systems operating at low frequency with minimal fixed infrastructure lack magnitude and permanence for successful large scale BTOD. Lack of magnitude and permanence can create a risky environment upon which to base significant new development. This is a concern of 'high' significance to this type of development.

- This does not mean that smaller scale and less high density development is not possible or desirable in some cases where lower scale bus services operate.
- The argument that fixed rail infrastructure has more magnitude and permanence compared to busway type developments is weak. The Ottawa system appears to be strong evidence to the contrary.

3.2 Newness

The 'newness' of rail investments was cited by the California Department of Transport (2002) as being a factor which provided an advantage over bus based systems in relation to TOD. At first glace this may seem a glib remark since busway systems must also be 'new' when they are constructed. However an important difference between bus and rail is that rail (and light rail in particular) is often introduced as an entirely new mode and usually replaces an existing bus based service. Most BRT systems replace an on-street bus system with vehicles which are also buses. Hence while busways may have significant and new infrastructure they often employ the same bus vehicles on that infrastructure. While the development of some new bus vehicle types is an important part of BRT system design not all BRT systems use radically new looking vehicles.

'Newness' is important to TOD where a significant change from existing obsolescent land uses is required. While this is not always a requirement for TOD it is important in some cases. Clearly this issue is also of less relevance to large scale BRT type systems. BRT systems employing radically new looking vehicles (such as 'Civis') will be less affected by this factor. In contrast TOD based on existing suburban or 'lower order' bus service types with limited fixed infrastructure is likely to be a poor performer in relation to the 'newness' factor particularly where TOD is focussing on urban renewal in 'run down' areas. This viewpoint seems to conflict with the experience of the Central Ohio Transit Authority (Duffy, 2001) who site the successful redevelopment of the Linden centre from the 'worst case of urban blight' and a 'drug house environment' into a successful bus based transit centre including a child care centre, health and community club, bank, restaurants and other businesses. While there is some case to identify 'newness' as a factor reducing the effectiveness of particularly 'lower order' bus based services, the significance of this factor in affecting the success of BTOD is likely to be 'low' to 'medium'.

3.3 Different Markets

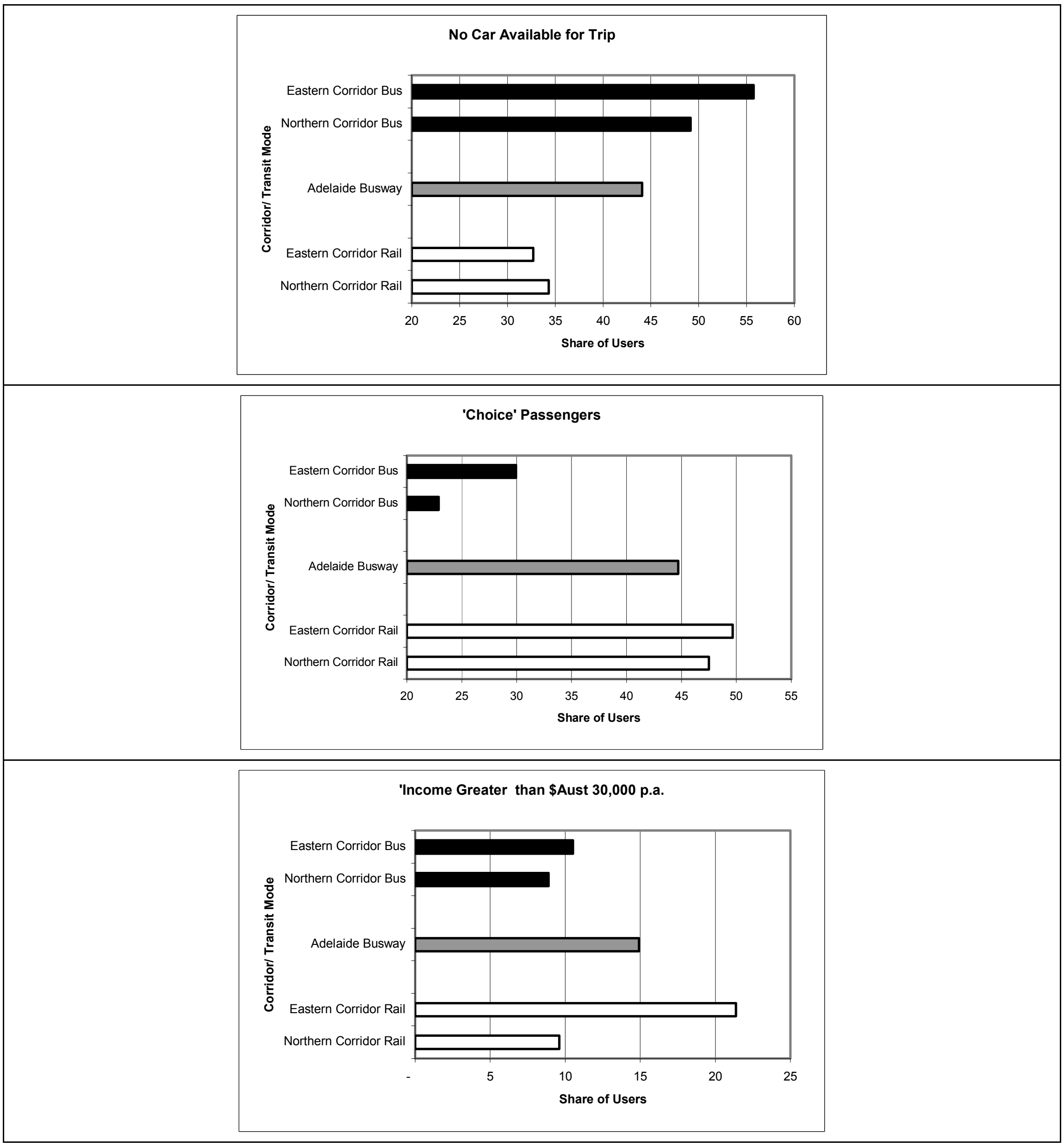
It has been argued (California Department of Transport, 2002) that rail and bus riders are demographically different and that rail attracts 'choice[1]' riders who tend to have higher incomes. It is thus suggested that rail can target a more affluent market for TOD investments and hence will be better suited to TOD in more affluent suburbs or successful 'downtown' development.

Figure 1 shows some demographic data from a series of Adelaide public transport corridors including the O-Bahn busway (BRT system), on-street bus systems and rail systems. In general the hypothesis that rail and bus passengers are different and that rail carries more 'choice' passengers is supported by this evidence. However the

[1] A passenger who has access to a car for travel but decides to use public transport.

busway users tend to have characteristics substantially more in line with rail markets than the bus markets. This suggests that the potential yield from BRT systems in terms of TOD development might be as good as rail systems.

Figure 1 : Comparative Demographic Characteristics – Adelaide BRT, Bus and Rail Corridors



Source: State Transport Authority (1992, 1994), Travers Morgan (1991)

The relationship between affluent riders and more successful TOD is unclear. While higher yield customers are good for any business it does not follow that the market for TOD properties is well represented by higher income groups. Certainly in Australia there is no clear relationship between high density of development (which may be associated with TOD) and affluence. Indeed the contrary is quite often the case.

Overall therefore it is possible to conclude that 'lower order' bus services cater for different markets to rail. They display less 'choice' and low income characteristics.

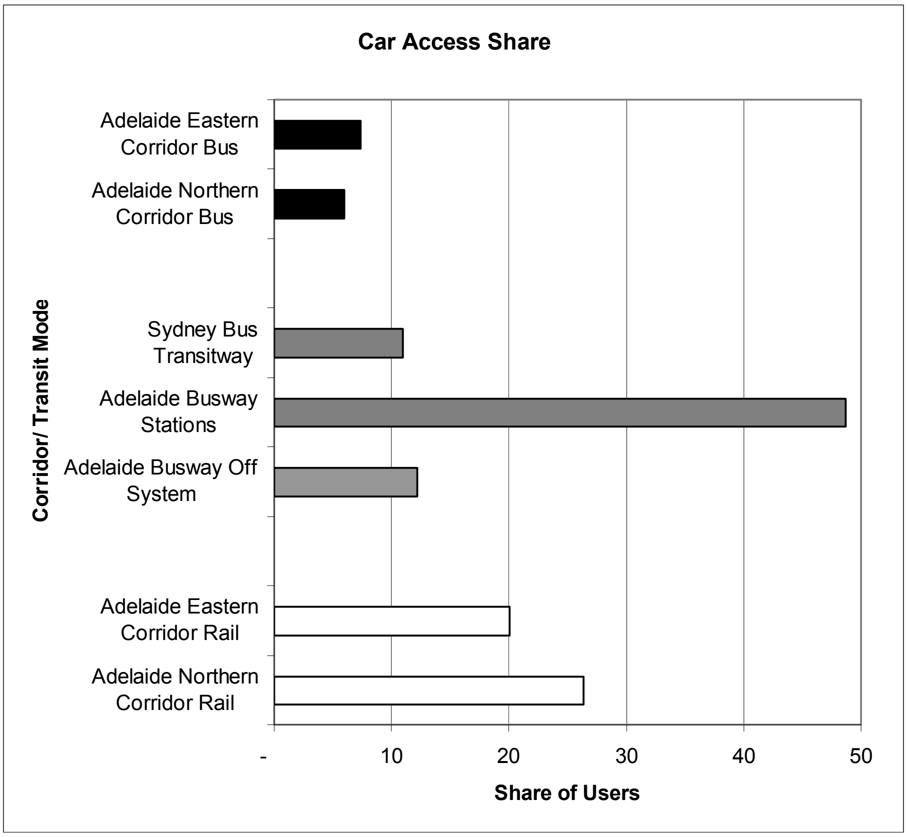
Some researchers have suggested that as a result RTOD is more likely to be successful. However this supposition is not yet supported because of lack of evidence. Thus the significance of this weakness is considered 'low' and 'questionable'.

3.4 Park and Ride

Park and ride (P&R)[2] as an access mode to busways has been identified as a factor which limits TOD opportunities (Dittmar and Poticha, 2004). Over 57% of rail transit agencies involved in US TOD development identified P&R as a moderate to significant factor affecting the success of TOD (Transportation Research Board, 2004). The main concern is the conflict between the need for large parking lots, the need for road capacity to enable a significant volume of car access and the desire for prime space for development and good quality uninterrupted walk access.

Park and ride is also a significant access mode to rail, as well as to busways. Interestingly as Figure 2 suggests, it is less of an influence to on-street bus services than to rail or busways when data in Adelaide is considered.

Figure 2 : Comparative Share of Park and Ride Access to Total Boardings – Adelaide BRT, Bus and Rail Corridors, Sydney BRT



Source: State Transport Authority (1992, 1994), Travers Morgan (1991), Parsons Brinckerhoff (2005)

The evidence in Figure 2 suggests some BRT systems are P&R based and others are not. Adelaide O-Bahn stations are largely P&R based. Discussions with service planners in Adelaide have suggested that there is "no evidence of the busway having

[2] P&R is a global term for car access. In this definition it includes kiss and ride and park and ride car access behaviour

encouraged additional urban development". Excessive park and ride is a major cause of this. However protection of the existing residential character around some busway stations was a major objective of planning some busway stations and certainly affected the decision to avoid TOD at these sites. The busway also runs along a major park. Protection of the park from development was also an important criteria. While the stations on the busway are clearly P&R based and not associated with BTOD, most users of the system (around 70%[3]) do not use the busway stations. These passengers board in the suburbs or the city and travel through stations along the busway to destinations at the other end of the busway.

In contrast to the evidence from the Adelaide busway stations, the Sydney Transitway system and the on-street bus systems in Figure 2 show considerably less evidence of park and ride access than rail. This evidence could be used to conclude that rail has a disadvantage in relation to P&R while bus, certainly on-street bus has an advantage. However the results are more likely to be suggesting that different systems have different characteristics and that generalisations about modes are unclear (and unhelpful). The following are reasonable conclusions based on the above discussion:

- Rail and some BRT systems have high P&R access which is not conducive to TOD.
- On-street bus has a low volume of P&R access which might be seen as a benefit of BTOD over some RTOD's.
- The design of BRT systems needs to exclude or carefully manage P&R where BTOD is to be implemented.

3.5 Industry TOD Capabilities

There is some evidence that implementing successful BTOD is more difficult than RTOD. As the Californian Transit Oriented Development Study suggests "making bus TOD's work will require a focussed approach and an extra level of leadership and intervention than a comparable rail TOD" (Californian Department of Transportation, 2002). It must therefore be of some concern that the recent review of TOD in the US (Transportation Research Board, 2004) has found that only 2 (or 3.4%) out of the 58 transit agencies engaged in BTOD had full time staff to run BTOD programs. The proportion for rail agencies was 42%.

Lack of bus industry capabilities to manage BTOD must be a very significant constraint on effective BTOD development.

3.6 Pedestrian Access

High quality, grade separated and direct walk access is an important feature of successful TOD (Transportation Research Board, 2004). It is the authors experience that this can be difficult to achieve with bus based systems. A major bus station might have 20-30 bus routes with significant volumes of bus movements. Large vehicles like buses operating at high frequency in streets with pedestrians can be dangerous, requires careful management and is certainly unattractive from an environmental, street quality and street amenity viewpoint.

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[3] This data is prior to the extension of the busway to Tea Tree Plaza. While the proportion of station access is likely to have increased as a result it is still likely to be small compared to non-station access.

This problem does affect most bus systems more than rail. Heavy and most light rail is grade separated (although some light rail systems have on street operations in mixed traffic or with pedestrians). There are some bus systems where specific measures have been undertaken to address this issue. The Brisbane Queen Street Mall bus station is a good example. Here buses enter and leave the bus station via separate tunnels. The station itself is underground and lies below a major shopping mall and pedestrianised street.

Difficulties in providing quality pedestrian access are more likely to be an issue for 'lower order' on-street type bus systems particularly at major bus stations (where BTOD is often focussed). Some BRT systems have carefully considered this problem however it remains an issue to be addressed in other systems.

The significance of the issue should probably be rated as 'moderate' rather than 'high'. While quality pedestrian access is a desirable part of successful TOD there is no evidence it is essential.

3.7 Parking Restraint

Car restraint policies are a useful addition to TOD strategies. They can enhance the attractiveness of an area by limiting road congestion and are also useful in providing more land area for residential or commercial development. Links between the success of rail based concentrated development and parking constraint in CBD's have been found (Transportation Research Board, 1997). However car restraint is an easier measure to apply in high density rail based locations because the problems of excessive parking demand are evident. In lower density urban nodes (more typical of 'lower order' suburban bus service environments) enacting car restraint practices is difficult because problems of congestion are often less evident. In addition service levels and the service quality of 'low order' bus based services tend to be low in these locations. Without a quality public transport alternative, it can be argued that car restraint in smaller urban development is less justifiable.

The differential capabilities of bus and rail to influence car parking restraint is probably only influential with 'lower order' suburban type bus services operating in lower density areas. BRT based systems (where P&R is not encouraged) should be able to justify higher density development where parking restraint is feasible.

The significance of this is probably 'high' since car restraint is a very effective means of encouraging transit use and car access can have secondary influences on pedestrian quality and quality of the environment.

3.8 Urban Density

High urban density has been identified as a primary determinant of public transport rider-ship; "nearly every study that has focussed on transit ridership has provided evidence that density is the primary determinant of transit ridership" (Sekin and Cervero, 1996). Density is also seen as a significant factor influencing the success of TOD. Luscher (1995) suggested urban density as the first of six key features affecting the performance of TOD in reducing private auto travel needs compared to lower density suburbs. The same source agrees with the findings shown in Table 1 that bus based services tend to be provided in areas with lower density development than rail services.

Bus services, notably 'lower order' services, will therefore be less successful at achieving patronage growth and in reducing private auto travel in TOD than rail. This is not necessarily true for BRT services, although this will depend on the success of BRT in achieving higher densities.

The significance of this factor is probably 'moderate' to 'high'. While 'lower order' bus services may not achieve rail like patronage or road use reductions, TOD can still occur. However it is likely to have a less significant impact than that experienced for rail and BRT.

3.9 Scale Dilution

One potential disadvantage of bus based TOD is that it is difficult to concentrate development activity around the large number of bus stops available in cities. The Californian Transit Oriented Development Study (2002) points out that it is difficult to focus on the numerous bus stops (3,400 are identified in San Diego) compared to the small number of rail (there are 49 light rail stops in San Diego). Given the significantly larger number of bus stops than rail stops, and the need to manage development to concentrate in a limited number of locations, this problem might be termed 'scale dilution'.

There may be two sides to this issue. While the concept of 'scale dilution' appears plausible, at the same time it is conceivable that a strategy of concentration at a limited number of specific nodes is limiting. Luscher (1995) modelled the impacts of rail and bus based TOD projects in reducing auto use in the San Francisco Bay area. His results demonstrated that, at average levels of TOD performance, a 5% reduction in auto VKM's might be achieved with 82 rail TOD's combined with 246 bus based TOD's. He also notes that there are only 79 rail stations in the bay area. Hence even these modest levels of performance would require rail expansion. The same result demonstrates that without the 246 bus based TOD's the impact on congestion would be considerably less. Indeed over 60% of the reduced VKM.s occur because of BTOD's not RTOD's[4]. Although each RTOD is more effective than the BTOD's identified, the sheer volume of BTOD sites is so much larger than the RTOD's that overall BTOD's have a greater effect.

There is an additional perspective on Scale Dilution which is worth considerering. It is possible that the development of many smaller scale BTOD's will act to dilute the effectiveness of RTOD's. While there is no evidence of this it is certainly an issue worth considering. From a different perspective it could be argued that having the option of smaller scale BTOD's as well as larger scale RTOD's provides greater choice for TOD developers and customers.

Scale dilution is an important issue for bus based TOD. However it is only likely to affect 'lower order' bus based systems. BRT stations should be as limited in number as rail stations. However the significance of this issue to bus is probably 'unimportant' to 'low'. This is because while the significantly larger number of sites for BTOD is a problem, it is also an opportunity for cities to obtain the higher benefit

[4] This is calculated based on Luschers relative RTOD and BTOD population sizes, the estimated reduction in VKM's identified and the number of rail and bus TOD developments required for an average performance of TOD to reduce VKM's by 5% systemwide.

from TOD on a system wide basis. It also increases the communities range of choice regarding the structure for urban development it would like.

3.10 Noise and Pollution

Buses can have more impacts on urban dwellers in TOD's than rail when it comes to the noise and fumes emitted from public transport vehicles. Urban rail usually has the advantage of 'clean' electric power over diesel based bus services. While rail vehicles, particularly heavy rail vehicles, can often be noisier than buses, it is the closer proximity of buses on streets where pedestrians roam and the frequency of bus movements that generates greater noise impacts. Rail based vehicles often generate their noise in tunnels or on rights of way which are remote from major pedestrian areas.

There appears to be some substance to this issue in most cases. Where alternative fuel based buses are used or bus operations are removed from pedestrian areas then these issues may not be so apparent. However in general these circumstances are rare.

The significance of this issue on the performance of BTOD is 'moderate' to 'high'. Successful TOD requires an environment people want to live and work in. Noise and Pollution from buses, unless appropriately managed, create places which are not attractive.

3.11 Frequency and Speed

In identifying the key factors for successful transit associated with TOD, Dittmar and Poticha (2004) note that "after density, the most important questions about transit have to do with service frequency and speed". Heavy rail and light rail tend to operate at higher frequencies than 'lower order' suburban bus based systems. In addition, almost all heavy rail systems and most light rail systems (certainly those in the US and France) tend to operate in segregated traffic conditions. Local bus services tend to operate in mixed traffic. As a result the service speeds on rail are considerably better than bus. Bus also tends to have more stops than rail. This also affects operating speeds.

Criticisms of 'lower order' local bus services in relation to TOD because of poor frequency and speed are valid concerns. They do not apply to BRT although this depends on the degree of right of way segregation applied. Indeed one positive of BRT relative to rail is that service frequencies on busways are much higher than in rail. This is due to vehicle capacity and the number of vehicles required to meet demand. Many busways operate at headways below a minute, whereas rail services require less frequency due to larger vehicle capacity. In addition heavy railways require separation of rail sets using signalling systems due to safety concerns. This can limit heavy rail systems to a minimum headway of around 2 minutes due to requirements to ensure vehicle separation.

The significance of this issue on local bus services is 'moderate' to 'high'. The impact of transit on development requires an effective service offering. Without this the transit element of TOD has little to offer.

3.12 Bus Stigmatization

Buses have a bad image:

> "the bus rapid transit program is trying to change this but bus uses are still stigmatized as second-class forms of transport"
>
> Robert Cervero quoted in California Department of Transportation (2002)

> "Rail has a more positive image than bus"
>
> Dittmar and Poticha (2004)

As Cervero notes, the BRT program is trying to change this. A key question is; Does bus stigmatization affect potential TOD investors and TOD transit customers?

The effect on customers has been illustrated by the work of Currie (2005). This study examined how transit riders perceived travel by various public transport modes including on-street bus, BRT, light rail and heavy rail. A strong preference for rail was evidenced in the collation of international evidence of transfer penalties and mode specific factors[5]. Heavy rail and light rail was perceived to have a benefit over on-street bus valued at up to 20 and 30 minutes of travel time. However this work also demonstrated similar valuations of preferences for BRT systems compared to on-street bus (although research evidence of BRT was limited). This work suggests that BRT shares passenger preferences for rail above local on-street bus services.

This evidence does not concern investors in TOD who do not ride transit. It is certainly possible that developers themselves have negative views of bus compared to rail and it is the developers who influence TOD as must as transit riders.

While the significance of bus stigmatization is currently 'high' it does not need to be a long term issue. Certainly it is likely to afflict on-street, 'low order' bus services more than BRT systems.

3.13 Track Record

BTOD does not have as long a record as RTOD. Also little is known about the impacts of BTOD. Some commentators have also placed doubt on the performance of BTOD; "Experience in California, like the rest of the country, tends to be somewhat mixed regarding bus TOD's" California Department of Transportation (2002).

These comments must be balanced against the positive reports regarding BTOD in Ohio (Duffy, 2001) and Boulder, Colorado (Transportation Research Board, 2004). Nevertheless objective secondary assessment of BTOD schemes is rare so some caution is appropriate. It is possible that some commentators are assessing the performance BTOD, particularly BTOD associated with local 'lower order' bus services, in similar terms to rail based TOD. The evidence from the discussion in this paper above suggests that BTOD for local bus services is highly unlikely to perform

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[5] Transfer Penalties are the perceived disadvantages which transit users value for making a transfer between one public transport vehicle and another, such as at rail stations. Mode specific factors are the perceived values of one transit mode compared to on-street bus. It represents all other factors excluding fare, travel time, wait time, walk time etc which affects passenger perceptions.

as well as rail and RTOD. But this does not mean that BTOD in these circumstances is not a positive program to implement.

Overall lack of track record is considered to have ‘moderate’ to ‘high’ significance for all types of bus services. While it might be theorised that BRT is likely to show good performance relative to rail, evidence on its track record is limited in US and Australian conditions.

3.14 Summary of Weaknesses

Table 3 presents a summary of the points raised above including an assessment of their significance to BRT and ‘lower order’ or local suburban type bus services.

The significant concerns for effective BTOD are (in order of importance):

- Poor bus industry capabilities
- Noise/pollution impacts of buses
- Poor track record.

BRT systems have far less significant weaknesses in relation to BTOD than ‘low order’ bus services. The exception to this rule relates to park and ride access, which can significantly reduce BTOD opportunities in busways designed around park and ride (although this is also true of rail).

BTOD based on ‘lower order’ bus services should be expected to have poorer performance than BRT or rail because of the extent of weaknesses identified. Additional weaknesses considered significant for ‘low order’ bus services were (in order of importance):

- Poor service frequency and low speed
- Bus stigmatization
- Poor control over parking restraint
- Low urban density
- Lack of “newness”
- Poor quality pedestrian access.

However an overall assessment of these factors also requires an understanding of the strengths of bus in relation to TOD.

Table 3: Assessment of the Weaknesses of Bus Transit Oriented Development

Weaknesses	Issues	Assessment of Significance[1]	
		'Low Order' Bus Services	Bus Rapid Transit Systems
Permanence, Magnitude and Development Risk	• Scale/permanence of rail reduces development risk • Some truth for local bus but not for large busways	YYY (For Large Developments) X (For Small Developments)	X
Newness	• Newness changes image of areas in urban decline • New rail usually replaces bus systems but BRT often replaces bus and is hence not as 'new'	Y/YY (Important for Urban Renewal Projects)	X (BRT with new look vehicles) Y (BRT using existing bus vehicles)
Different Markets	• Rail carries more 'choice' and higher income riders than bus • This purported to affect success of TOD but this relationship unclear	Y?	X/Y?
Park and Ride Based Systems	• P&R reduces potential for TOD • Affects rail and some BRT systems but not on-street bus	Z	YY (Only certain designs of systems)
Industry Capabilities	• BTOD may require more careful planning than RTOD • Only 3% of bus agencies have dedicated TOD staff. 42% of rail agencies do.	YYY	
Pedestrian Access	• High volumes of bus movements are difficult to manage when trying to provide quality grade separated and direct pedestrian access	YY	YY (BRT without grade separated pedestrian access) X (BRT with grade separated pedestrian access)
Parking Restraint	• Can be effective in encouraging transit demand and improving walk quality • Less easy to justify in lower density 'low order' bus areas	YYY	X
Urban Density	• High density reduces car use and improved rider-ship • Rail and some BRT can achieve higher density than on-street bus	YY/YYY	Y/YY (BRT without high density development success) X (BRT with high density development success)
Scale Dilution	• It is more difficult to implement BTOD at numerous stops than RTOD at a few stations	X/Y	X
Noise and Pollution	• Buses are usually diesel based polluters. Their frequency & close proximity also make them noisy	YY/YYY (Unless non polluting fuels are used or buses segregated from areas)	
Service Frequency and Speed	• Significant for good transit TOD • Local bus has poor speed and low frequency	YYY	Z/X
Bus Stigmatization	• Transit users perceive bus poorly compared to rail • Developers/TOD investors may agree	YYY	X/Y
Track Record	• Lack of evidence on performance of BTOD. Some perceptions of mixed performance.	YY/YYY	

Note:[1]Scores are "Z" potential benefit for bus "X" no significance "Y" Some Significance "YY" Significant "YYY" Very Significant

4. STRENGTHS

Table 4 shows a summary of the strengths identified in bus based TOD. These are now discussed.

4.1 Complementarity and Ubiquitousness

This is the converse of the 'scale dilution' weakness identified in section 3.9. The results of the work of Luscher (1995) (see earlier) demonstrate that BTOD can work alongside RTOD to achieve higher benefits for TOD on a greater spread and overall scale than by operating RTOD schemes alone. In effect BTOD and RTOD are complimentary measures. In addition the far greater number and spread of bus stop and bus station based locations for BTOD i.e. their ubiquitous nature, make for a far greater potential for TOD than by following an RTOD policy alone.

These comments must be tempered by the doubts raised regarding the effectives and ease of implementation of such a potential large number of BTOD schemes. Nevertheless joint BTOD and RTOD approaches seem an appropriate package of TOD initiatives on a metropolitan wide basis.

The significance of these strengths is considered 'high' for all forms of bus service. These findings also seem to support the idea of complementarity between BRT and other 'lower order' bus based BTOD schemes.

4.2 Flexibility - Choice

Dittmar and Poticha (2004) suggested that bus based TOD schemes may be an attractive option where communities don't wish to have the densities associated with rail. The same authors also suggest that BRT may be an interim step to build rider-ship which may make rail transit more feasible. Both these points suggest BTOD has elements of flexibility which RTOD may not demonstrate.

The significance of these issues to BTOD must be 'high', certainly to the communities looking for an alternative options to (very) high density living. Overall the flexibility of TOD should add an extra capability and strength to the TOD planning approaches since a wider range of options for TOD implementation are available.

4.3 Flexibility – Adaptiveness to Change

The ability to cost effectively re-design and adapt BRT systems to changing market circumstances compared to rail has been highlighted by many researchers (e.g. California Department of Transportation, 2002). Hensher (1999) also draws an interesting dichotomy between flexibility and permanence "the cost of producing flexible service capable of potentially responding to changing geographic activity patterns is the price of reduced commitment to the facility" Hensher (1999).

There is little research evidence valuing the benefits of the adaptability. However it is likely that there is at least some benefit to be gained from providing a flexible planning future. Particularly when our futures are uncertain and our capabilities to invest large sums in expensive projects such as rail are limited. These points suggest a 'moderate' rating for the significance of this BRT strength.

Table 4: Assessment of the Strengths of Bus Transit Oriented Development

Strengths	Issues	Assessment of Significance[1]	
		'Low Order' Bus Services	Bus Rapid Transit Systems
Complement-arity and Ubiquitousness	• BTOD works well with RTOD and can be used to significantly improve overall TOD benefits on an urban areas	YYY	
Flexibility – Choice	• Viable option for communities who done want (very) high density living • BTOD and BRT a stepping stone towards future rail	YYY	
Flexibility – Adaptiveness to Change	• Ability to cost effectively modify services in the future in response to change	YY	
Cost Effectiveness	• Evidence that 'low order' bus is cost effective in low density areas. BRT is cost effective compared to LRT	YYY	
Service Frequency	• Busway systems often run at very high frequencies	Z	YY
Transfers	• Some Busways don't need passengers to transfer. Rail doesn	X	Y/YY

Note:[1]Scores are "Z" potential weakness for bus "X" no significance "Y" Some Significance "YY" Significant "YYY" Very Significant

4.4 Cost Effectiveness

Local bus services are a far more cost effective option for lower density areas than implementing rail in these circumstances. In addition there is evidence that BRT systems might be considerably more cost effective to build and operate than light rail (US General Accounting Office, 2001). The case for cost effectiveness advantages of BRT in relation to heavy rail services is less clear. The higher capacity of heavy rail and the higher demand which rail services usually attract could be costly to cater for with buses.

Cost effectiveness is possibly the most significant variable which can be associated with the assessment of transit systems. It is this authors view that the development of future transit systems should not be a question of bus vs rail. Rather it should concern the level of benefit we can get for the spending the always limited number of dollars available. In this sense cost effectiveness is critical. On this basis this benefit for bus is a 'highly significant' strength.

4.5 Service Frequency

The discussion in section 3.11 highlighted that high frequency services make transit attractive in TOD developments. While frequency is a weakness for BTOD in relation to 'lower order' bus services, as noted earlier, BRT can have superior frequency compared to most rail and light rail schemes. In this case the generally lower capacity offered by BRT vehicles suggests that more of these vehicles are required to maintain a high demand capacity. Many busways operate at headways below a minute.

This strength is considered 'significant' but only applies to BRT systems.

4.6 Transfers

An additional feature of busway based BRT systems is that they often do not require passenger transfers to access the main trunk line transit system since buses pick up in the suburbs then proceed onto the busway right of way without the need for a transfer. It is impractical to run heavy or light rail systems down every street in every suburb. They require feeder bus services to bring passengers to stations where passengers are required to transfer onto rail and light rail vehicles. Passengers dislike transferring. Currie (2005) collated international evidence on the perceived values of passenger transfers and found average values for bus to light rail transfers of 19 minutes and 10 minutes for bus to heavy rail transfers. Values of this order clearly have a significant impact on travel choices.

Clearly the capacity of some busway systems to reduce transfers is of some value compared to rail. However this is only one of many parts of a journey and only applies to certain markets (those making transfers) and also on particular BRT systems (where transfers are not required).

Overall this strength is valued at 'low' to 'medium' significance. It only applies to some BRT systems (those that can avoid transfers).

4.7 Summary of Weaknesses

Overall there are far fewer strengths of bus in relation to TOD compared to weaknesses. Nevertheless most of the strengths identified are highly significant. BRT has more strengths than 'lower order' local bus services.

6. CONCLUSIONS

This paper has identified the strengths and weaknesses of bus in relation to Transit Oriented Development. A large number of weaknesses have been identified. The lack of dedicated TOD development staff in the bus industry, the noise/pollution impacts of buses and a poor track record of bus in relation to TOD were the most significant weaknesses identified for bus services as a whole. BRT systems have far less weaknesses in relation to BTOD than 'lower order' bus services. However BRT systems associated with park and ride access will have limitations in relation to TOD not found in 'lower order' services. Local on-street suburban bus services have many other significant weaknesses in relation to TOD including poor service frequency and low speed, bus stigmatization, poor control over parking restraint, low urban density, lack of the "newness" factor and poor quality pedestrian access.

A smaller number of strengths were identified however these were generally considered to be highlight significant. These include cost effectiveness, flexibility, complementarity/ ubiquitousness and, for BRT, service frequency and transfers.

Overall it is clear that local on-street suburban bus services are more suited to lower density environments. It is also clear that successful implementation of BTOD is a more difficult task than related RTOD initiatives. Nevertheless they can provide an important complementary function in supporting both RTOD and BRT based TOD programs by expanding the benefits of TOD on a more comprehensive scale.

The analysis has identified some important areas for attention in BTOD initiatives for this group of services:

- Bus industry capabilities and dedicated staffing for supporting BTOD initiatives needs to be considerably enhanced. This problem is exacerbated by the lack of knowledge and experience in BTOD planning, implementation and performance.
- While BRT systems are tackling the issue of bus stigmatization it is important that these leanings trickle down into the more conventional bus based services.
- Noise and Pollution remain significant issues for bus. Separation of local bus services from pedestrian areas and use of non polluting fuels should be a priority for bus systems hoping to successfully adopt BTOD strategies
- It may always be difficult for smaller scale bus services to generate an impression of scale and permanence to large scale development opportunities. This problem may best be tackled at major bus stations through innovative and impressive designs which challenge the concept of the bus station as a cold and unfriendly location.

BRT systems have a far stronger capability in relation to BTOD. However the design of car access into busway system design needs to be carefully balanced against the need for BTOD (as it also does for rail). Bus noise and pollution issues are as valid for BRT as they are for on-street bus services. The trend towards modern high quality BRT vehicles is to be encouraged in systems seeking successful BTOD initiatives.

All potential bus based TOD initiatives have a limited and unclear track record. There is a need to build knowledge and gain and share experiences to better develop, learn and sell the potential benefits of BTOD to the community and the transit and urban development industry.

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