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Effective ways to grow urban bus markets – a synthesis of evidence

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ABSTRACT

This paper provides a synthesis of the evidence on the patronage growth performance of bus improvement measures in urban settings. The evidence includes a summary of experience in Europe, North America and Australasia focusing on service improvement measures including network structure and service levels, bus priority measures, vehicles and stop infrastructure, fares and ticketing systems, passenger information and marketing, personal safety and security and synergy effects of measures. The source is the research literature and documented experienced from a series of studies undertaken by the authors over the last decade. It includes the results of an international bus expert 'Delphi' survey concerning bus improvement measures focussed on patronage growth. The paper synthesises the evidence to identify measures which are most likely to grow patronage including consideration of cost-effectiveness of measures.

1. Introduction

Improving the quality of urban public transport is one of many strategies proposed to improve mobility options for the transport disadvantaged (BIC 2003) and to address car dependence and the urban congestion, environmental sustainability and global warming concerns associated with car dependence (Booz Allen Hamilton, 2006; Victorian Competition and Efficiency Commission, 2006). Improving bus-based public transport has been considered a more cost-effective option compared to rail investment (US General Accounting Office, 2001; UK Commission for Integrated Transport, 2005) particularly in relation to the lower density environments associated with Australian and North American cities (Fleming et al., 2001; Currie, 2006). There have been recent substantial investment programmes targeting urban bus service development (e.g. Department of Infrastructure, 2006) and many reviews of the patronage effects of bus development initiatives (e.g. Kinnear et al., 2000) and recent updates of patronage sensitivity measures associated with bus improvements (Balcombe et al., 2004; Australian Transport Council, 2006). Despite these developments there does not appear to be a clear consensus on the most effective means to improve bus services.

This paper aims to synthesise evidence regarding effective and cost-effective policy measures to improve urban bus services. It is sourced from a review of the literature and also from the results of several international consultancy studies undertaken by the authors over the last decade to identify the best ways of improving bus services (e.g. Booz Allen Hamilton, 2000a; Booz Allen Hamilton, 2002). This includes the results of a hitherto unpublished international 'Delphi' survey of bus planning experts aimed at identifying the most effective means of substantially growing urban bus markets (Booz Allen Hamilton, 2000a).

Section 2 of this paper presents a summary of behavioural research evidence concerning the sensitivity of bus patronage to changes in service features. Section 3 presents a review of international experience with bus service improvements. Section 4 presents a summary of the findings of the international 'Delphi' survey of bus planning experts. The paper concludes with a discussion of the key findings from these studies.

2. Behavioural research evidence

Numerous behavioural research studies have been undertaken to measure the sensitivity of bus patronage to changes in service features. Evidence from bus elasticity measures, bus 'soft variable' factors and bus mode-specific factors is summarised below.

2.1. Demand elasticity evidence

Demand elasticities represent the most common means for examining the impacts on demand of different changes in supply within a consistent framework. In simple terms, the demand elasticity is the ratio of the proportionate change in demand to a

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Table 1
Synthesis of elasticity evidence – urban bus service changes

	Fares	Service levels[a]	In-vehicle time
Typical short run elasticities			
Average	−0.40	0.35	−0.30
Maximum possible improvement	−100% fare reduction	Over 100%+	−50% travel time reduction
Maximum possible demand growth	+40%	Very high (200% plus)	+15%
Factors influencing elasticity values			
Time horizon	Long run typically double (range 1.5–3.0) short run	Long run typically about double short run	Very limited evidence: indicates long run 1.5–2.0 times short run
Trip purpose/time period	Off-peak/non-work typically twice peak/work; weekend most elastic	Off-peak/non-work typically c. twice peak/work; weekend most elastic (may be partly frequency differences)	Inconclusive re relative elasticities; although most evidence is that off-peak is more elastic than peak
Trip distance	Highest at very short distances (walk alternative); lowest at short/medium distances; then some increase and then decrease for longest distances (beyond urban area)	Highest at short distances (walk alternative)	Limited evidence – longest trips more elastic than short/medium distance trips
City size	Lower in larger cities (over 1 million population) – USA evidence	Higher in larger cities – EU evidence	No evidence
Base level of variable	Elasticities broadly proportional to the base fare level (based on recent UK study – otherwise limited evidence)	Elasticities increase with headways (broadly proportional up to c. 60 min headway)	No firm evidence – although expect elasticities to increase with proportion of total trip (generalised costs) spent in-vehicle
Magnitude of change	No significant variation in elasticities with magnitude of change (majority of studies)	No evidence	No evidence
Direction of change	No significant differences for fare increases and decreases (majority of studies)	No evidence	No evidence

Source: Synthesised from the following meta studies: (Booz Allen Hamilton, 2003; Wallis and Schmidt, 2003; Balcombe et al., 2004).
[a] Based on medium-frequency services (20–30 min frequencies). Service levels are typically measured by bus kilometres operated, or service frequency.

proportionate change in the service feature being measured, e.g. a fares elasticity at −0.3 means a 10% fare decrease will result in a 3% increase in demand. Elasticities may be derived from either revealed preference studies (time series, cross sectional analysis, panel data or before/after studies) or from stated preference surveys. Table 1 shows a summary of evidence on bus-related short run elasticities synthesised from various 'meta-studies'.

The implication of the findings on typical short run elasticities is that a decrease in fares of say 10% will increase demand by 4%, an increase in service frequency of 10% will increase demand by around 3.5% and a reduction in in-vehicle travel time of 10% will increase bus patronage by about 3%. Hence the 'effectiveness' of bus improvements in patronage terms is driven by the degree to which improvements can act to reduce fares, increase service levels and reduce bus travel time. Interestingly, the three elasticity values are all quite similar for typical situations, reflecting that these three components of the generalised costs of typical bus trips are all of similar magnitude.

These results also set the bounds of how far patronage growth is ever likely to go (although the dangers of applying elasticity estimates to very large changes in supply variables should be noted). Fares for example cannot be reduced more than 100%, i.e. a 'free fares' policy. Hence a bus improvement offering free fares can only ever increase patronage by a maximum of around 40%.[2] Similarly reductions in bus travel time of greater than 50% would be unlikely. Hence bus improvements achieving 50% travel time reduction can only ever hope to achieve a 15% growth in patronage. Service levels, however, can be increased more than 100% (although the evidence and common sense indicates diminishing elasticities as service levels increase). This suggests that increases in service level (frequency) might be the measure which might achieve the highest bus patronage growth, assuming money were no object.

The evidence suggests that in the longer term (over 5–10 years), the impacts of bus improvements on patronage are almost double short run (6–12 months) impacts. Off-peak market effects are larger than peak market and commuter impacts. Market impacts of improvements for shorter distance trips (for which walking or cycling may be competitive alternatives) are larger than for long distance trips. In larger cities (>1 M population) fare elasticities are lower, while service level elasticities tend to be higher. As noted above, the evidence also indicates that market effects are dependent on the initial level of service provided: the service frequency elasticity reduces as the base frequency improves.

A number of studies have highlighted bus reliability as a critical influence on bus markets (CILT, 1985; Bates et al., 2001). Two kinds of reliability measures relate to bus services; where scheduled services are not run (lost bus kilometres) and where running times are variable (poor on-time running).

A number of studies of travel behaviour have found that the punctuality, reliability and dependability of a public transport system are rated by users as a very important feature, affecting their perceptions and usage of the service. Given the importance of this aspect, the extent of quantitative research is surprisingly small. Two aspects of reliability are generally differentiated for bus services (although the distinction between them may not be readily apparent to the user): where scheduled services are not run ('lost' bus kilometres), and where services vary from the timetable (late or early running).

'Lost' service kilometres result in a disproportionate increase in passenger waiting time, in passenger annoyance and in lost patronage. Typically a 10% random cut in services operated will increase average passenger waiting times by 20–30% (Balcombe et al, 2004). Passengers value this 'excess' waiting time at 2–3 times ordinary waiting time, which in turn is valued at 1.5–2.0 times in-vehicle time. The result is that such a service cut would increase

[2] Note that more recent experience of UK free concessionary fare schemes have resulted in an implied elasticity of around −0.3, i.e. a 30% growth in response to free concessionary fares.

the generalised cost of bus travel by 10–15%, reducing patronage by a similar percentage.[3] Perhaps more typically, the lost service kilometres would be say 5% (half of the level assumed here) and hence the loss in patronage would be half this amount.

Poor schedule adherence is the other major form of reliability concern. A service which runs 10 min late on 20% of occasions will result in an average 'excess' waiting time of 2 min, which (as suggested above) equates to about 5 min of ordinary waiting time. This would again result in patronage reductions (relative to a perfectly reliable service) of 10–15%.

These assessments suggest that bus services that are unreliable (through lost services and services not running to time) to the extent assumed here can result in patronage reductions in the order of 10–20%: conversely patronage could increase by this amount if such unreliability problems could be overcome.[4]

2.2. 'Soft' variable evidence

By 'soft' variables we refer to bus service improvements relating to service quality aspects such as cleanliness, security, amenities and comfort. A number of studies of this type have been undertaken, normally involving stated preference surveys (Steer Davies and Gleave, 1990; London Transport, 1997) to estimate the values that bus users might place on these factors. Outputs from some such studies have been drawn together in Table 2, where the effects of improvements to bus vehicle factors have been expressed in terms of their equivalent in-vehicle time savings.

This analysis suggests that bus improvements associated with 'soft' variables are not likely to increase patronage by more than a few percent. The evidence presented suggests air conditioning, CCTV and a smoother ride are the highest patronage impact improvements; however these together are likely to increase patronage by only around 3–4%.

2.3. Mode specific evidence

Perceptions of travel quality have a critical influence on travel behaviour. In addition to the more tangible aspects of travel such as journey time, fare and frequency of service, other perceptual features can substantially affect travel decisions. Such perceptual features vary between public transport modes and their design features, and will include (e.g. Ben-Akiva and Morikawa, 2002):

- Reliability – including the degree of right of way segregation from traffic impacts.
- Information availability – such as bus stop or rail station location, schedule information, destination locations, etc.
- Comfort – ride comfort varies between modes and also for types of right of way.
- Safety from accidents – mechanised guidance is rail is often seen to be 'safer'.
- Security from crime – which can be better for bus than rail.
- Availability – walk accessibility to services, perceptions of frequency.

The impacts of such mode-related features are often brought together and valued through 'mode-specific factors'. Table 3 shows recommended values for mode-specific factors in transport evaluation and modelling in Australia (Australian Transport Council, 2006).

The analysis in Table 3 suggests that assuming no change in fare, access/egress time, transfer time, frequency or travel time, upgrading an on street bus service to a busway would increase patronage by 7.5%, while a guided busway would increase patronage by slightly more, c. 8.5%. Tram and light rail conversion have similar effects to busways (although the quantity of busway evidence upon which this is based is limited, Currie, 2005). Modern heavy rail effects would have slightly higher impacts (up to 14% patronage growth all other things being equal). There is much consistency in these conclusions with other research. Bus improvements such as busways are generally considered to have similar overall patronage impacts to light rail, assuming all other factors are equal (Ben-Akiva and Morikawa, 2002; Currie 2005). However the relative costs for construction, vehicles and operation for busway schemes relative to light rail are considerably in favour of bus (US General Accounting Office, 2001; UK Commission for Integrated Transport, 2005).

2.4. Behavioural evidence – summary

Section 2.1 indicated that typical elasticity values were broadly similar for fares, in-vehicle time and service frequencies. These elasticities indicate that, taking a short run perspective: eliminating fares might achieve a patronage growth in the order of 40%; halving in-vehicle time could achieve a patronage growth of around 15%; while doubling the frequency of typical suburban-frequency services could achieve a patronage growth of around 30–40%.

Improvements to bus service reliability may provide patronage gains in the order of 10–20%, but dependent on the 'base' level of (un)reliability from which the improvements are made. 'Soft' bus improvements such as those affecting cleanliness, security, amenities and comfort are not expected to increase bus patronage by more than a few percent. Of these bus improvements, air conditioning, CCTV and a smoother ride would have the highest patronage impact, but this is unlikely to be above 2% for each measure.

Mode-specific factor evidence suggests that bus improvements from an on street bus service to a busway or light rail would be likely to increase patronage by up to 8–9%, assuming all aspects of service frequency, travel time, fare and access/egress plus transfer quality remained the same. Conversion of an on street bus to new heavy rail infrastructure might increase patronage slightly further (up to 14%). However, costs for light and heavy rail investments of this kind would generally be considerably higher than equivalent bus improvements. The implication is that upgrading a bus service to a busway is likely to be substantially more cost-effective than a rail-based solution as a means of growing the public transport market.

3. Bus improvement experience

3.1. Australia

Table 4 presents a summary of major bus system investments in Australia over the last few decades, together with their market impacts (expressed as % patronage increases on generally a corridor or network basis). This indicates that

- In general the largest impacts on a corridor basis have been from bus rapid transit systems.
- On a network-wide basis, strong patronage growth has been achieved through comprehensive service restructuring and frequency enhancements (as in Perth).
- The results suggest (unsurprisingly) that in general the larger the scale (or budget) of the bus improvement, the large of the patronage growth.

[3] Assuming a typical generalised cost elasticity of −1.0 (refer Table 2).

[4] One of the authors of this paper lives in Wellington (New Zealand). The bus services there recently experienced a severe driver shortage, resulting in service cancellations and late running of the order-of-magnitude assumed here. The short-term effects on patronage were also of the order-of-magnitude indicated.

Table 2
'Soft' bus vehicle improvements - value and est. patronage impacts

'Soft' bus improvement		Valuation[a] (in-vehicle time minutes)	Notes	Estimated patronage impact (%)[b]
Boarding	No step	0.1	Difference between two and no steps	0.17[c]
	No pass show	0.1	Two stream boarding, no show pass vs single file past driver	0.17
Driver	Attitude	0.4	Very polite helpful cheerful well presented vs businesslike and not very helpful	0.68
	Ride	0.6	Very smooth compared to jerky	1.02
Cleanliness	Litter	0.4	No litter compared to lots of litter	0.68
	Windows	0.3	Clean windows, no etchings compared with dirty windows and etchings	0.51
	Graffiti	0.2	No graffiti compared with lots	0.34
	Exterior	0.1	Completely very clean compared to some very dirty areas	0.17
	Interior	0.3		0.51
Facilities	Clock	0.1	Clearly visible digital clock with correct time vs no clock	0.17
	CCTV	0.7	CCTV, recorded, visible to driver plus driver panic alarm compared to no CCTV	1.19
Information	External	0.2	Large route number and destination sign front, side and rear plus line diagram on side vs small signs	0.34
	Interior	0.2	Easy to read route no. and diagram compared to none	0.34
	Info of next stop	0.2	Electronic next stop sign and announcements vs no information	0.34
Seating	Type/layout	0.1	Individual shaped seats with headrests all facing forward vs basic double bench some backwards	0.17
	Tip-up	0.1	Tip up sets in standing/wheelchair area compared with all standing area in central aisle	0.17
Comfort	Legroom	0.2	Space for small luggage vs restricted legroom and no space for small luggage	0.34
	Ventilation	0.1	Push open windows giving more ventilation vs slide opening windows	0.17
		1.0	Air conditioning	1.70

[a] Based on Australian Transport Council, 2006.
[b] Assumes a 20 min bus journey with 5 min access/egress walk, 5 min wait, a \$1.50 fare and a value of time of \$Aust 10.00/h (2006). This makes a weighted generalised cost of 59 min. Forecasts are made by applying a generalised cost elasticity of −1.0 to the change each soft factor has on this base generalised time. These assumptions are based on (Booz Allen Hamilton, 2000b; Australian Transport Council, 2006).
[c] The 0.17% impact of a 'no step' bus is small compared to estimates of the impact of low floor vehicles (Balcombe et al, 2004; 5% and TAS Partnership, 2002; 3–9%). We conclude that this is a 'low' estimate or that it concerns only the implementation of a step and not the provision of an entirely new low floor vehicle.

Table 3
Recommended mode specific values[a] and market impacts

Mode	Right of way	Mode specific factor (min)[b]	Notes	Market effect compared to on street bus (%)[c]
Bus	On street	0	Reference case	0%
	Busway	−4	Better quality of stop, in-vehicle reliability and bus quality	+6.8%
	Guided busway	−5	Slightly better ride quality than busways otherwise same quality as busway	+8.5%
Tram/light rail	Tram on street	−3	Same in-vehicle ride quality as busway but stops not as high quality	+5.1%
	Light rail – segregated right of way	−5	Station quality and in-vehicle ride quality similar to busway	+8.5%
Heavy rail	Old DMU/EMU vehicles	−3	Older station facilities and vehicles. Ride quality similar to tram	+5.1%
	Refurbished DMU/EMU	−6	Improved station facilities and in-vehicle experience	+10.2%
	New modern DMU/EMU	−8	Best quality station and in-vehicle experience	+13.6%

[a] (Australian Transport Council 2006).
[b] Assumes a 20 min average in-vehicle time journey.
[c] Assumes effect of converting an on street bus to the other modes identified with exactly the same service frequency, walk access/egress, service frequency, etc. Forecast is based on the generalised cost elasticity and example given in Table 2.

- The largest single impact in proportional terms (+214%) was the Perth CBD free CAT bus system. These targets short distance (walk) trips which are known to have the highest elasticities (see Section 2.1).

Although evidence is mixed (and patchy), the 'best' improvement measures in terms of patronage growth were (in descending order)

- Bus rapid transit systems (market growth in the order of 20–70% at a corridor level).
- (Free) CBD distributors (market growth around 50–200% affecting CBDs).
- Bus network area restructuring (network-wide market growth around 10–30%).
- Express bus (market growth around 15–30% but only affecting route catchments).
- Increased frequencies/minibus (market growth 10–40% at mainly a route level).
- Bus priority measures (10–50% at a route group/corridor level).
- Bus marketing/passenger information, including TravelSmart (up to 20% at an area level).

Table 4
Australian major bus improvements and market impacts

Project	Corridor patronage growth (%)	Scale of impacts	Mode shift impacts
Bus rapid transit systems			
Adelaide NE O-Bahn 1986–89 (SA)	50%	Corridor	40% new pax from car driver, 17% car passenger, 27% new trips
Brisbane SE busway 2001	60–70% core routes 7% non core	Corridor	26% new pax from car driver
Sydney Liverpool Paramatta T-Way 2003 (NSW)	56%	Corridor	9% new pax from car driver
Melbourne Smart Bus Pilot Project Rte 703, 888/889 2002 (Vic)	18%/32%	Route	
Area bus service restructuring			
Perth 1997–99 (WA)	Midland area 20–25% Canning 20–30%	Network	
National Bus Company, 1994–95 (Vic)	10–20%	Network	
Express and limited stop bus services			
Terry Hills – Sydney CBD 1992 (NSW)	15%	Route	
Adelaide Transit Link 1992–1994 (SA)	Balanced 19% peak, 29% off peak Overlay 34%	Route	33% peak and 42% off peak trips were ex car drivers
Major new bus services			
Perth circle bus route 1998–99 (WA)	15–20%	Network/route	
Midi-mini bus services and increased bus frequencies			
Adelaide frequency increases – includes go zone concept 2000 (SA)	Weekday 7.4% Saturday 20.2% Sunday 66%	Network/ localised	
Penrith Minibus (NSW)	40%	Route	
Croydon Knox City Lo rider 1994 (Vic)	10–15%	Route	
Sandringham bus frequency (Vic)	40%	Route	
Park Ridge expansion 1994 (Qld)	10%	Route	
New/improved local and shopper bus services			
Marion Access Service 1998 (SA)	40%	Route	66% of new pax ex car users
Demand responsive bus services			
Rowville Telebus (Vic)	10%	Route	
CBD distributors			
Perth City (free) CAT Service, 1996 (WA)	214%	CBD	Most likely ex walk pax
Brisbane CBD (free) bus, 1993 (Qld)	New service 58% free fares 50%	CBD	
Bus priority measures			
Sydney Harbour Bridge/Gore Hill, 1992 – (NSW)	23%	Route group	
Glebe Island Bridge, 1995 (NSW)	10%	Route group	
Spit Bridge Military Road, 1974 – (NSW)	52%	Route group	
Eastern Freeway Bus Lane, 1997 (Vic)	10%	Route group	
Johnson Street Bus Lane, 1980 (Vic)	13% (Peak)	Route group	
Bus marketing and passenger information measures			
South Perth TravelSmart, 1997 (WA)	17%	Local area	PT mode share increased from 6.0% to 7.1%
Met Bus Information and Marketing Campaign (Vic)	6%	Network	
Melbourne Tram and Info Marketing Campaign , 1997 (Vic)	7%	Network	

3.2. United Kingdom

A review of bus service frequency increases in the UK (TAS Partnership 2002) established patronage growth in the range of 5–12% and service level elasticity of between 0.2 and 0.4 (very similar to that recommended in Table 1).

The same review quoted research suggesting that passengers perceive bus services as

- ‘Frequent’ – at least 10 min headways; or
- ‘Regular’ – at least twice an hour; or
- ‘Other’ – anything less.

Significantly, of potential users with a car, 60% would consider a ‘Frequent’ service but only 40% a ‘Regular’ one. Almost none would consider using a bus with a headway below 30 min.

A review of the potential for bus improvements through bus priority measures in the West Midlands (TAS Partnership, 2002) suggested patronage growth of the range 7–17% through improvements in reliability (a range consistent with the evidence in Table 4).

High levels of bus patronage growth have been quoted from the replacement of standard bus services with higher frequency minibus services which are better able to penetrate narrow roads in parts of UK cities (an average value of +63% is quoted in Cannock). Replacement of double deck buses with single deck vehicles resulted in growth rates of 3–4% (Glasgow, Manchester and the West Midlands). The major growth factors here are newer vehicles and better safety surveillance as well as no need to climb stairs).

Evidence on market effects of introducing low floor buses suggests patronage growth of around 3–9% (TAS Partnership, 2002).

One of the interesting findings from the TAS (2002) review is the relative cost-effectiveness of bus improvement measures from a financial viewpoint. Fig. 1 shows the evidence on the financial performance (revenue:cost ratio) of UK bus improvements from a review of 20 bus improvement packages that have been introduced.

This appraisal identified service simplification as the single most cost-effective improvement measure. This involves straightening circuitous routes, providing a simple uniform route structure and timetable, and removing variations in running patterns. This can result in both cost savings for this operator and also attracts additional passengers to the more understandable system.

Branding and promotion were rated the second most cost-effective improvement followed by signage/information and bus stop improvements. These measures are not necessarily expensive and

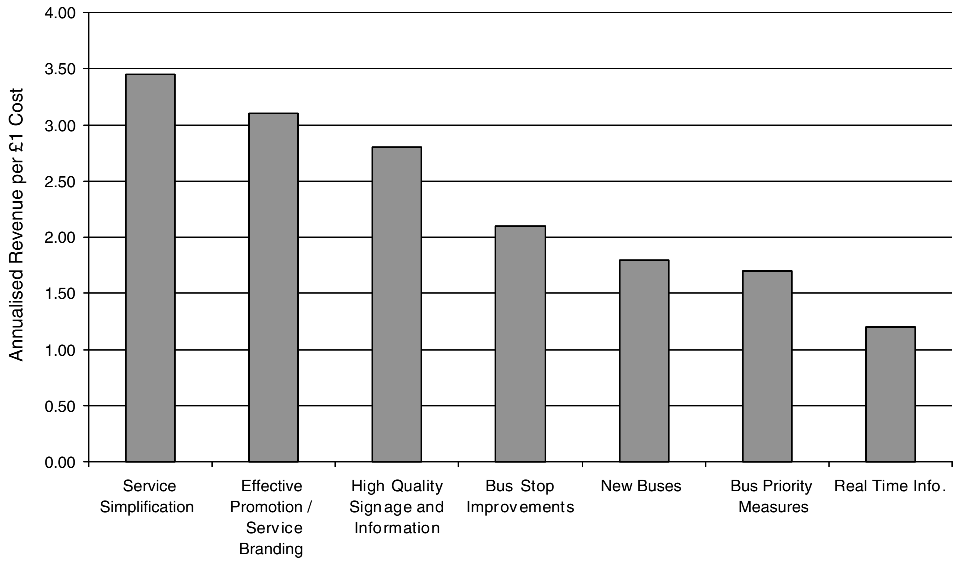

Fig. 1. Cost-effectiveness of bus improvements – UK (TAS Partnership, 2002).

offer a good return relative to costs. Of the information measures identified, real time information was considered separately and found to be cost-effective if deployed carefully to maximise market yield. New buses have some operational and operating cost benefits and are appreciated by customers hence have a positive return if a modest renewal policy is followed. Bus priority measures were considered cost-effective since the costs of implementation are generally modest compared to the benefits in terms of reduced operating costs and increased reliability and patronage.

Overall TAS concluded (TAS Partnership, 2002) that UK experience has shown that:

Improvements to bus frequency demonstrate the greatest proportional and absolute growth in bus use. Typical frequency increases (20–30%) can be expected to deliver patronage gains at around half of the level of service increase. However, typically these will not be financially viable unless bus resources are available at marginal cost to provide these improvements (or possibly if smaller vehicles can be used).

Patronage gains for local bus operations of 5–10% can be achieved with relative ease by tackling appropriate 'soft' components. This should be achievable on a wholly commercial basis. Most of this increase will result from additional journeys made by existing users.

An increase in use in the range 10–25% can be secured by optimising frequencies within existing resources, providing reasonable levels of traffic priority and developing effective information and marketing strategy. At this level around one-third of the new passengers may be expected to have transferred from car. This growth cannot normally be achieved on a fully commercial basis, although financial contributions can normally be restricted to capital investment.

Bus patronage growth above 25% could normally only be achieved by one or more of the following actions:

- Provision of substantial infrastructure (guided busways, dedicated bus roads, comprehensive traffic priority).
- Fares subvention.
- Adoption of a 'balanced' comprehensive transport strategy with commensurate 'sticks' (traffic restraint, parking reduction/charging, road use charging, land use policy, etc.) to reinforce bus development 'carrots'.

We might comment here that the typical farebox cost recovery level of most Australian urban bus systems is considerably lower than that of UK systems. Thus, while the relative cost-effectiveness of different types of measures in an Australian context may well be similar to that in the UK, the absolute commercial viability in Australia will generally be lower.

3.3. Europe

A number of European Union research projects have investigated bus improvement measures in 22 European cities (JUPITER, CAPTURE and OPIUM projects, as reported in Booz Allen Hamilton, 2002). Table 5 presents the major findings relatively to bus improvements and their patronage impacts. Most of the bus improvements examined in these projects were implemented in 'packages', making conclusions on individual improvements difficult to identify.

The schemes with the largest patronage growth impacts (top of Table 5) include busways, increased bus frequencies and bus/HOV lanes. The largest single improvement measured was for a bus/HOV lane in Spain (+53% in patronage).

The JUPITER project suggested the following rank order of bus improvements in terms of patronage impacts:

- Service reliability-based measures (busways, bus lanes, junction priority).
- Frequency of service.
- Passenger information based measures.

In terms of cost-effectiveness, it suggests the following (descending) order of performance:

- Low floor buses.
- Bus priority at traffic signals.
- New interchanges replacing inadequate facilities; and
- Real time passenger information.

4. International expert survey

4.1. Approach

A survey of international bus planning experts was undertaken in late 2000 to explore their views regarding ways to 'substantially' grow bus markets (Booz Allen Hamilton, 2000a). 'Substantial' growth was defined as anything between 50% and 100% over a 3–5 year period. The survey involved a broad 'Delphi' approach

Table 5
EU project experience in bus improvement initiatives

Location	Country	Guided busway	Increase bus frequency	Bus signals priority	Bus/HOV lanes	Branding/marketing	Low floor buses	High quality bus stops	Real time passenger info.	Public access terminals	Website	Smartcards	Park and ride	Journey time decrease	Patronage increase	Mode shift	Payback period (years)
Projects with patronage growth reported																	
Ipswich	UK	*	*		*		*		*		*		*	−4 to 5 min	+43%	25% ex car	–
Leeds	UK	*	*	*	*	*	*	*	*					−33%	+40%	11% ex car	2
Madrid	Spain				*										+53%		
Nottingham	UK		*		*								*		+38%		
Birmingham	UK		*			*	*	*	*					−1 to 5%	+31%	10% ex car	
London Rte 220	UK			*	*				*					−14 to 23%	+6% to +15%	Small decrease in car use	
Manchester	UK				*		*	*						Large	+10% to +12%		
Liverpool	UK		*	*	*	*	*	*	*						+7%	35% ex car	6
Brussels	Belgium								*						+6%		4
Southampton	UK								*						+5%		6
Bilbao	Spain			*			*		*	*					+2%	Small decrease in car use	3
Projects with patronage growth unreported																	
Aalborg	Denmark			*			*	*						−7%	N.A.	8% ex car	2
Hertfordshire	UK											*					
Patra	Greece		*	*					*							2% ex car	2
Skane	Sweden		*											−10%			
Turin	Italy			*													3 months

Source: JUPITER, CAPTURE and OPIUM projects, as reported in (Booz Allen Hamilton, 2002).

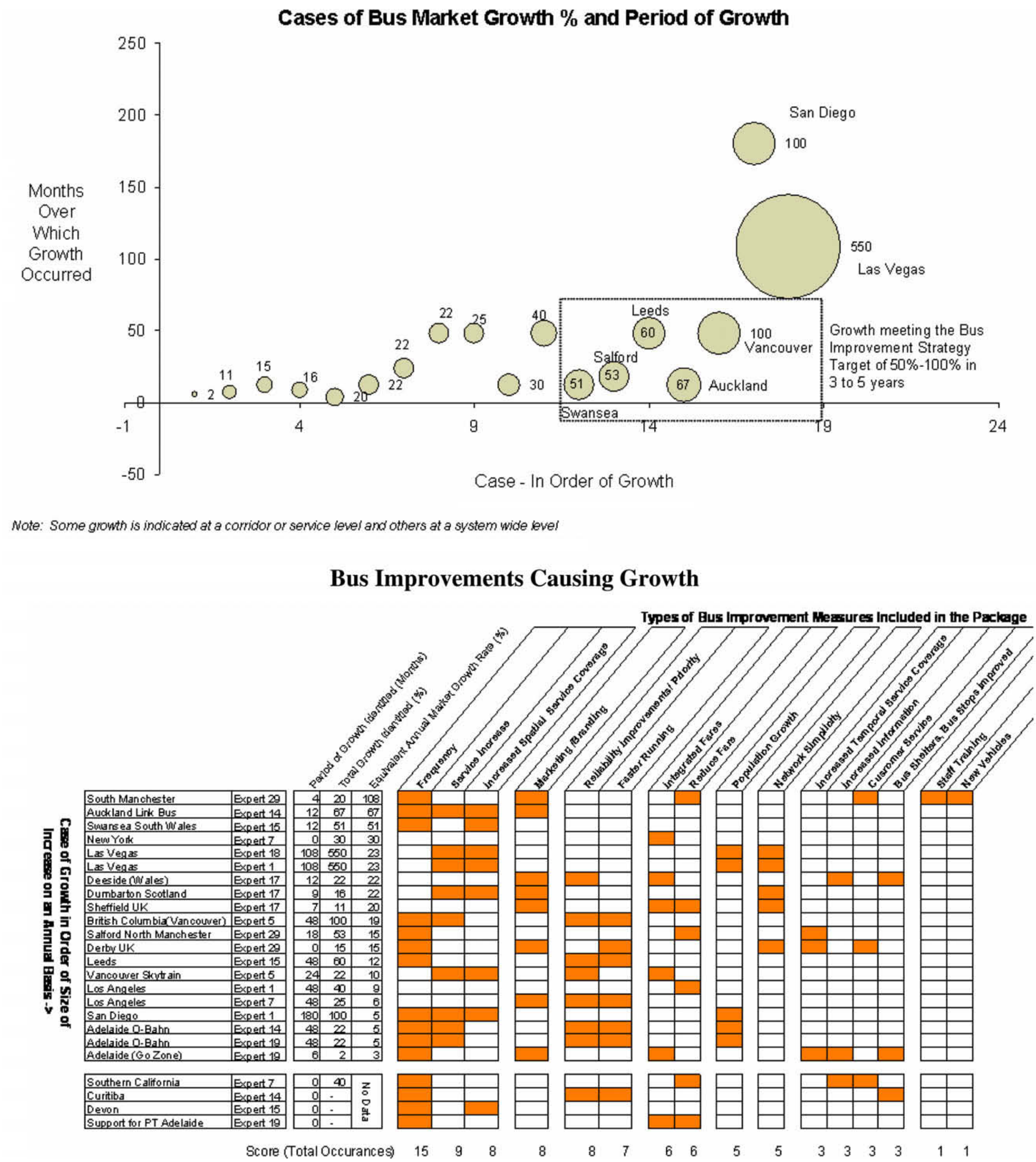

Fig. 2. Cases of substantial bus market growth by period of growth and cause. Note: some of the cases of bus market growth were corridor/part network specific (e.g. Swansea/Salford) while others are city wide.

with a feedback loop to enable a review of individual views based on the first round findings of the group as a whole. 29 experts were targeted from Europe, North and South America and Australasia. 12 full sets of responses were received.[5] The following aspects of bus market development were canvassed:

– Experiences of substantial bus market growth.
– Views on the most likely bus improvements to substantially grow markets.
– Differentiators of bus systems which have high usage.
– Views regarding 'best practice' bus systems.

4.2. Experiences of substantial bus market growth

Fig. 2 shows the evidence on cases of 'substantial' bus market growth identified by the international expert panel, including the factors driving the growth identified.

[5] Panel member names are kept confidential to protect anonymity and ensure objective responses.

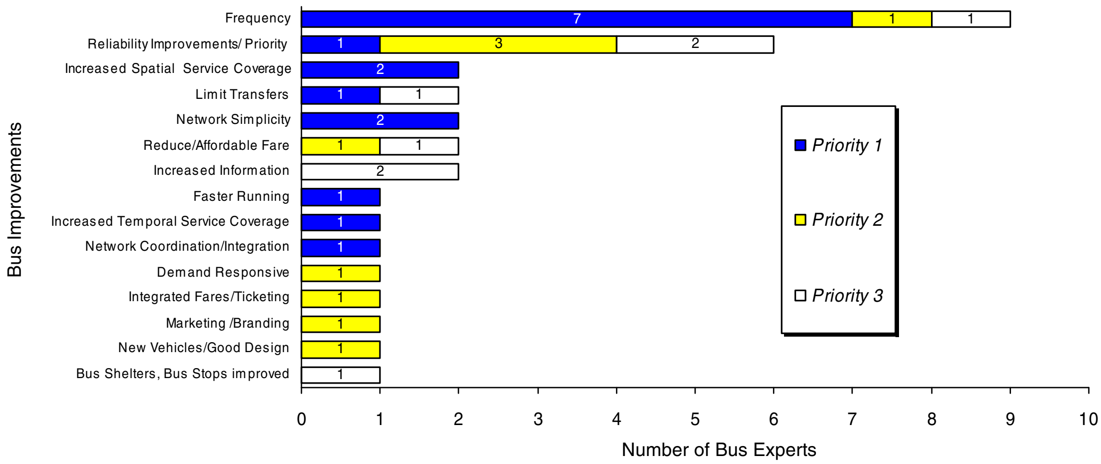

Fig. 3. Bus improvements identified as most likely to grow bus markets.

This indicates that

– Seven cases of substantial growth in bus markets were identified, the largest of which (in percentage terms) was in Las Vegas, USA (over a period of around 10 years).
– The major factors driving substantial growth were increased frequency, increases in the amount of service generally and increases in the spatial coverage of the area being serviced.
– Marketing and measures addressing bus reliability were the next highest ranked measures in terms of market growth, followed by fare-based measures.

4.3. Effective measures to grow bus markets

Fig. 3 shows the results of questions on bus improvements which were considered most likely to substantially grow bus markets. Service frequency improvements ranked highest, followed by reliability-based improvements such as bus lanes, busways and traffic signal priority. Network simplicity was again noted as well as improved spatial coverage of bus services.

New vehicles, bus stop improvements, marketing/branding, integrated fares and demand responsive bus services were also identified as drivers of patronage growth by individual survey respondents.

4.4. Differentiators of high use bus systems

Fig. 4 shows the results of the expert survey in regard to the key differentiators of high patronage bus systems.

Overall, bus systems with a high degree of segregation from road traffic were identified as the best service feature. System features of being 'integrated and seamless' or otherwise providing 'a good image' were also highly regarded.

In terms of the urban environment within which bus operations are provided, low car use, low income and higher population densities were identified as key drivers of high bus use.

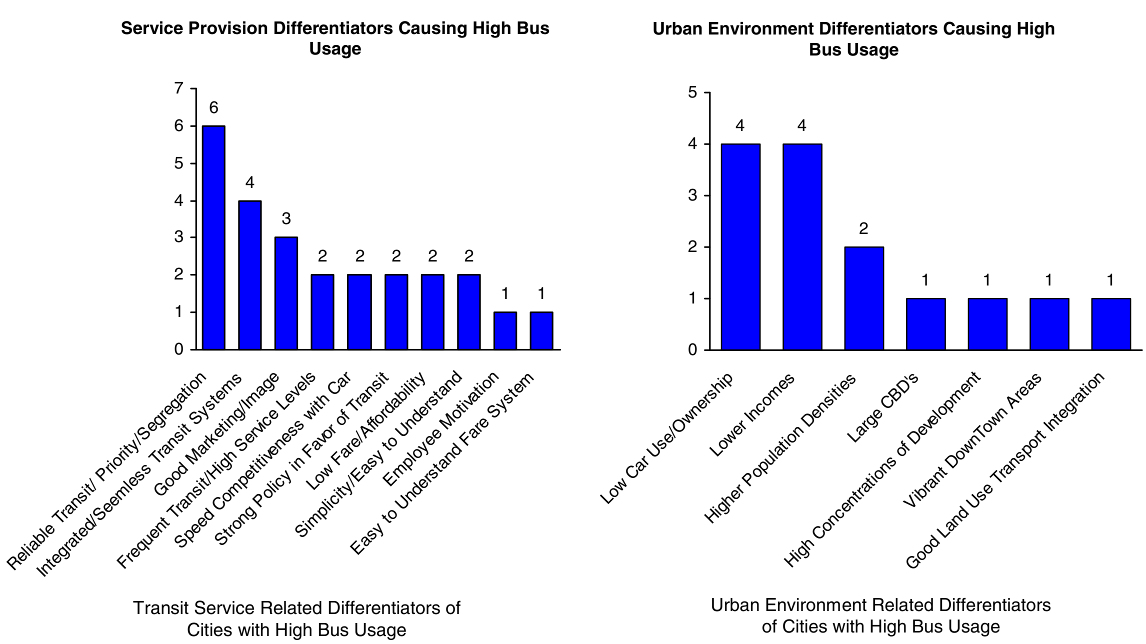

Fig. 4. Differentiators of high use bus systems.

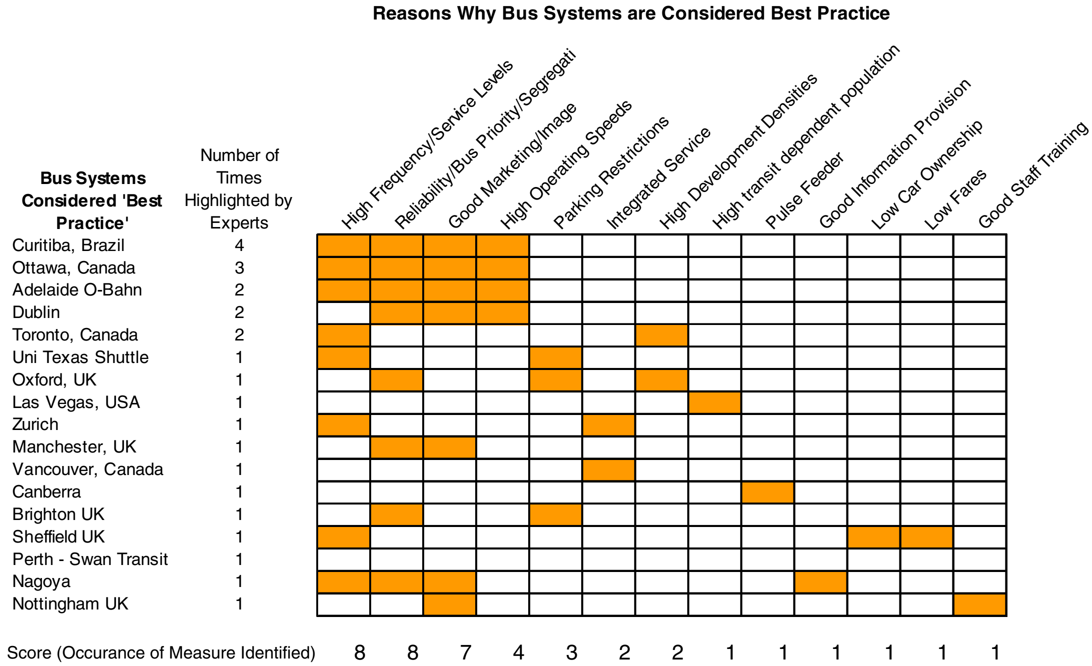

Fig. 5. Best practice bus systems.

4.5. Best practice bus systems

Fig. 5 shows the results of the expert survey with regard to 'best practice' bus systems and the factors that contribute to their effectiveness.

The bus rapid transit systems in Curitiba, Ottawa and Adelaide were identified by a larger number of experts, with a number of other systems being put forward by one or two experts. High frequency, bus segregation and reliability, good image and high operating speeds were the key differentiators identified, for most of the higher performance systems suggested.

5. Discussion and conclusions

This paper presents a synthesis of evidence on the effectiveness and cost-effectiveness of measures to improve urban bus services and attract additional patronage.

Based on market responses to a wide range of bus improvements in many developed countries and internationally, the following findings may be drawn:

Elasticities for the three main attributes of bus services (fares, frequency, in-vehicle time) are of similar magnitude. If money were no object, the greatest patronage increases are likely to result from improved frequencies and service levels, followed by reduced fares and then reduced travel times.In cases where service reliability is poor, reliability improvements can provide significant patronage gains (typically up to 10–20%), often at low cost.'Soft' variables (e.g. comfort standards, security, cleanliness) would, if implemented as a package, generally only improve patronage by a maximum of 5–10%.

The evidence on the intrinsic attractiveness of different transport modes ('mode-specific factors') indicates that

- All other factors being equal, rail-based systems may attract somewhat greater patronage than bus-based systems (with the possible exception of guided/unguided busways).
- Once costs are taken into consideration, upgrading of urban corridor services to a busway would generally be substantially more cost-effective in Australian conditions than providing rail-based services.

Experience with major bus system improvements (in Australia and Europe) provide findings consistent with the market response evidence above:

- The largest patronage growth levels were related to increases in service levels and in bus rapid transit and bus priority systems targeting improved reliability.
- Area bus network restructuring and the introduction of free CBD bus services was also identified as high market growth bus improvements in Australia.

The survey of international bus experts has also identified the following key features desirable for high bus patronage growth:

- Service frequency increases.
- Bus reliability and speed features associated with Bus Rapid Transit systems.

BRT systems in Curitiba, Ottawa and Adelaide were considered 'best practice' by many expert panel members in the survey.

These findings come from diverse sources and countries (in the developed world), but provide a very consistent message. The principal drivers of patronage growth for urban bus services are service frequency improvements and measures associated with bus reliability such as busways, bus lanes and other traffic priority treatments.

These measures may not necessarily be cost-effective. A rather different set of lower cost (and financially viable) measures were identified in the UK and European reviews of cost-effective measures. Service simplification, branding, marketing and signage/information measures were identified as the most financially viable approaches. Further evidence on the financial viability of different improvement measures in Australia (and New Zealand) would be highly desirable.

The paper has noted a number of important contextual constraints within which these findings must be considered. The base quality of bus services being improved is an important determinant of how far they can be improved. The urban context of land use density, car ownership and income levels are also primary determinates of bus usage. Evidence of patronage growth therefore requires some interpretation of context in order to judge the importance of bus improvements proposed and the value they will bring in terms of patronage growth.

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