

World Transport Policy and  
Practice  
Volume 22.1/2  
May 2016



## Measure No.13: New Public Transport Systems and Networks



Photographer/Copyright: Harry Schiffer.  
<http://eltis.org>

### New forms of public transport services provided in urban areas

Through the introduction of new forms of public transport, a city can encourage more sustainable travel. Examples of interventions include, bus rapid transit (BRT) light rail (LRT) and 'flexible' systems such as demand responsive transport (DRT).

## 13.1 Context and background

This measure review covers the following types of new public transport systems:

*Light rail systems:* The terms 'light rail', 'tram' and 'light rapid transit' are often used interchangeably. In this measure review, the term 'light rail' is used to refer to electrified local urban rail systems that are able to run on street but may also incorporate grade-separated (above or below ground) sections, and that have some degree of segregation from general traffic.

*Bus Rapid Transit (BRT) systems:* The US Federal Transit Administration<sup>1</sup> defines BRT as "an enhanced bus system that operates on bus lanes or other transit-ways in order to combine the flexibility of buses with the efficiency of rail". The key defining feature of BRT systems is the use of significant sections of fully segregated bus lanes (or busways) across the network. To a greater or lesser extent, BRT systems may also incorporate enhanced safe stops or stations; off board payment systems; high quality and high capacity vehicles op-

#### Key messages:

- Light rail (LRT) and Bus Rapid Transit (BRT) systems can increase passenger carrying capacity, increase use of public transport, and deliver land use strategies; e.g. regenerating former industrial areas, intensification around transport nodes or increased economic activity in central areas.
- Bus Rapid Transit (BRT) can meet similar objectives to LRT, but at a much lower cost. It can also be delivered in a much shorter timescale.
- Economic analysis is available for LRT and BRT schemes. For LRT they were more likely to be projections before scheme implementation, with positive Benefit-Cost-Ratios (BCRs) ranging from 2-3. However, no evidence was identified to validate these BCRs post-implementation so they must be treated with due caution.
- Post implementation analysis of BRT schemes produced positive BCRs ranging from 1-3.
- LRT and BRT have a positive effect on land values near stations, but can negatively affect values near routes.
- Urban Demand Responsive Transport (DRT) systems can be an effective means of providing transport to the 'mobility poor' at a lower cost than alternatives (such as subsidised single ride taxis). They will normally require subsidy however.

#### Potential interventions

- Light rail systems:
- Bus Rapid Transit (BRT) systems
- Demand Responsive Transit (DRT) systems.

Note: Personal rapid transit systems (PRT) are not considered here as they are not yet available in every day urban settings (instead being deployed in highly controlled contexts such as airports). Bus network extensions are covered in Measure Review No12.

erating at a high frequency and the use of consistent branding across vehicles and infrastructure.

*Demand Responsive Transit (DRT) systems:* DRT (also termed as paratransit in the US) refers to any non-private transport mode that offers flexible, tailored routes and service timings in response to changing passenger demand. This measure review considers urban demand responsive bus services only.

Personal rapid transit systems have not been considered as these are not yet widely available in every day urban settings (instead being deployed in highly controlled contexts such as airports).

### *13.1.1 Objectives of new public transport systems*

Light rail and BRT schemes are intended to provide high capacity, intra-urban (and often, but not always rapid) mass passenger transport. They may be motivated by primary objectives to increase passenger carrying capacity along congested urban corridors and/or to encourage modal shift from private car. A secondary objective may be to improve local air quality and/or to reduce greenhouse gas emissions.

Light rail in particular and to some extent BRT may also be incorporated into broader land use planning strategies to encourage (transit oriented) development along particular corridors and at particular nodes.

DRT schemes are seen as offering a potentially more efficient alternative to subsidised scheduled public transport services, often in rural contexts, but also along lower density/lower demand urban corridors. Historically, in urban contexts DRT systems have been most commonly used to provide specialised services for particular user groups e.g. The elderly or the mobility impaired. However, in general public transport network planning, DRT may be used to feed scheduled services, providing a means of serving the 'first and last miles' of an inter-urban public transport journey.

## *13.2 Extent and Sources of Evidence*

This review has drawn on 27 items of evidence. Given that the success of large infrastructure schemes like light rail is highly dependent on context (land use planning, economic circumstances and the regulatory environment for example), several meta-studies have been included to cover the required breadth of circumstance. Reliance on a smaller number of single evaluation studies was felt to risk misrepresenting the potential for new public transport measures to be (un)successful. The meta-studies are nevertheless complemented by evaluations of single interventions.

The level of current research activity centred on new public transport systems varies according to the type of intervention under scrutiny. BRT systems are presently an object of great interest, given the growing number of systems being delivered across the world. New light rail systems also tend to attract research interest, given their long term impacts on land use, land values and their immediate impacts on the transport system and travel behaviour. By contrast, there are not many sources on urban DRT systems, not least as a consequence of their being few such systems in existence.

In terms of the currency of evidence, the meta-reviews of light rail systems are now around 10 years old (coinciding with a particular policy interest in light rail in the late 1990s in the UK), but these have been complemented by more recent case studies. Evaluations of urban DRT systems are scarce and the review has relied upon an EU evaluation conducted in 2003<sup>2</sup> and an evaluation conducted in Manchester, UK in 2005<sup>3</sup>. Evidence on Bus Rapid Transit is more up to date, with sources from the last five years being readily available.

Case studies have been drawn from several European nations, the USA, several South American nations (particularly relating to BRT), South Africa and South Korea. Evaluations tend to have been commissioned by European, national or local governments and conducted and reported by either academics or consultancies. This review has drawn on a balanced mix of evidence from both consultancy and

academia.

With respect to intervention scale, the case studies reviewed usually relate to public transport schemes implemented in a single urban area or several urban areas for comparison in the case of meta-studies.

The post-implementation evaluation studies reviewed in the next section have tended not to employ cost benefit analysis. They rely instead on performance indicators to measure schemes against one or more of their objectives. Projected benefit cost ratios for a number of UK light rail schemes (prepared during scheme appraisal) were readily available however, and these are reported later. One meta study of BRT systems<sup>20</sup> was found to include a detailed post implementation cost benefit calculation. No cost-benefit analyses were identified for urban DRT systems.

### 13.3 What the Evidence Claims

Evidence is presented on the impacts of light rail, BRT and DRT interventions in turn:

#### 13.3.1 Light rail systems

As noted in the introduction, light rail systems may be constructed to meet a mix of objectives including: increasing passenger carrying capacity, improving mobility, achieving modal transfer from the car, improving local air quality, reducing greenhouse gas emissions and supporting land use policies.

1. *Passenger demand:* Two meta-analyses<sup>4,5</sup> illustrate the extent to which ef-

fectively planned light rail systems can be successful in attracting high numbers of passengers (meeting or exceeding patronage forecasts) and in re-cooping capital costs (see Manchester - UK, Vancouver - Canada, St Louis - USA, table 1).

Factors contributing to the success of light rail schemes, in terms of passenger demand, have been identified (from the meta-studies) as: locating lines in high density areas; high levels of segregation, ensuring integration rather than competition with feeder bus networks (which may be challenging in deregulated regimes), existing high levels of public transport usage, serving areas with strong and growing levels of economic activity and encouraging new development along new lines and at stations. Conversely, absence of these factors can result in failing or poorly performing systems (see Sheffield - UK ), as can serving low income areas (which may already be served by cheaper bus based public transport), poor public relations and negative local attitudes towards a new public transport system.

2. *Impact on car use:* An overview of the impact of mass rapid transit schemes in the UK, conducted by the Commission for Integrated Transport<sup>6</sup>, suggested that light rail systems attract between 2.5% and 20% of passengers from private cars . However, modal transfer can be expected to be much larger from existing public transport services - up to 69% of passengers were found to have transferred from other forms of public transport.

As stand-alone interventions, the light rail schemes reviewed by Babalik-Sutcliffe<sup>4</sup>,

Light rail scheme	Patronage Actual / Projected [% difference]	Annual cost per passenger	Farebox recovery ratio (%)
Manchester Metro-link (UK)	44,500 / 35,700 [+24%]	£1.71	143
Vancouver SkyTrain (Canada)	136,000 / 100,000 [+36%]	£2.19	38
St Louis MetroLink (USA)	24,515 / 13,000 [+89%]	£2.33	46
Sheffield SuperTram (UK)	18,700 / 70,700 [-74%]	£3.40	52

**Table 1:** Light rail outturn annual patronage versus forecast patronage  
Source: <sup>4</sup>



which included systems in the UK and the USA, were generally shown to be ineffective in reducing car traffic overall. It is argued that additional complementary measures to restrain car use are required to achieve this aim.

*3. Local air quality:* This is in contrast to a study by Ewing et al<sup>7</sup> which estimated that the extension to the TRAX light rail line in Utah, USA contributed to a reduction in traffic along the light rail alignment of between 7,500 and 21,700 vehicles per day. This estimate is subject to a number of assumptions concerning what traffic levels would have been in the absence of the light rail line and should therefore be treated with caution. Nevertheless, the authors took a central estimate of a reduction of 10,400 vehicles per day to estimate a reduction in nitrous oxide emissions of 16.6 kg per day.

*4. Greenhouse gas emissions:* Boarnet et al<sup>8</sup> assessed the impact of the new Exposition light rail line in Los Angeles. They estimated that households living within half a mile of a new light rail station reduced their daily average carbon dioxide emissions from motor vehicles by of the order of 30% to 35%. No significant change in carbon dioxide emissions from motor vehicles was observed in households living further than half a mile from a new station.

*5. Land use planning:* There are several examples of how successful light rail systems have been delivered as part of wider spatial planning strategies. Land use policies in Vancouver were adapted to focus new employment and housing developments around planned SkyTrain stations to stimulate passenger demand. The SkyTrain system was also used successfully to encourage regeneration of former industrial areas of the city<sup>4</sup>. Similarly, the Docklands Light Rail (London, UK) successfully catalysed the regeneration of the Isle of Dogs area of East London into a financial centre following the transfer of port activities to a location further down the River Thames<sup>9</sup>. This effect is not universally observed however. After five years of operation, the South Yorkshire Supertram (Sheffield, UK) was found to have had no observable impact on planning application submissions or land uses<sup>10</sup>.

*6. Impact on property values:* Studies have shown that property values tend to be higher within light rail catchment areas, though again this is not always the case. In their meta-analysis, Hass-Klau et al<sup>5</sup> found residential property prices to be between 3% and 20% higher within light rail catchment areas (external factors are not controlled for in this cross-sectional analysis however). Cervero's<sup>11</sup> analysis revealed that (all else being equal) apartment prices were typically 17% higher in proximity to the East Trolley light rail line, San Diego (USA). This effect was not apparent along other light rail lines in San Diego, however.

A longitudinal analysis by Yan et al<sup>12</sup> revealed that property prices in the corridor of a new light rail line constructed in Charlotte (North Carolina, USA) were lower before the system was constructed (attributed to being located in an industrial area), but the price differential reduced after the light rail system was introduced. This analysis of temporal change confirms that land values can increase over time as a consequence of the introduction of the light rail system. By way of a contrast, a monitoring study of the South Yorkshire Supertram (Sheffield, UK) indicated that house prices in the vicinity of the new tram line actually fell in the first five years of operation. This was attributed to the disruptive effects of construction. Prices subsequently recovered to be equivalent to other parts of the city and there remained an expectation that over the longer term, prices along the light rail line would continue to inflate<sup>10</sup>.

*7. Wider economic impacts:* Hass-Klau et al's<sup>5</sup> meta-analysis of light rail systems in Europe and the USA provided insights into some other general economic impacts over the long term. It should be noted that the following claims are based on quite simple trend observations and the impacts of other external factors have not necessarily been controlled for:

- Rates of household car ownership were observed to be lower and also to grow more slowly within light rail catchment areas. The extent to which this was observed varied quite significantly across case study areas. For example in Montpellier (France), 2+ car owner-

ship fell by 1% in the tramway corridor, but rose by over 3% away from the corridor. This effect was much weaker in the UK case studies. For example, in Manchester (UK), 2+ car ownership grew by 4.7% within the tram corridor, and rose by 5.3% outside the corridor.

- New light rail stops in town centres were found, in some circumstances, to increase pedestrian footfalls in retail areas. This claim is based on limited data from Strasbourg where footfall increased from 88,000 to 146,000 one year after the light rail line opened.
- Light rail connections to city centres were seen to be successful in attracting large employers to city centres and also increased city centre rents which had the effect of attracting higher end retailers (Nantes, France is cited as an example).

8. *Cost benefit analyses:* The post-implementation evaluation studies identified through this measure review did not include cost benefit analyses. However, it is usual for Benefit to Cost Ratios (BCRs) to be estimated as part of scheme appraisal and projected BCRs for a number of UK light rail schemes are presented in Table 2. These are shown to range between 2 and 2.7 .

Scheme	Benefit-cost ratio
Croydon Tramlink	2.7:1 <sup>14</sup>
Nottingham Express Transit Phase Two line	2.47:1 <sup>15</sup>
Manchester Metrolink: Oldham and Rochdale line	2.5:1 <sup>16</sup>
Manchester Metrolink: Ashton-under-Lyne line	2.1:1 <sup>16</sup>

**Table 2:** Projected (a-priori) BCRs for UK light rail schemes

Cervero and Guerra<sup>13</sup> estimated monetised social benefits of light rail systems in the USA (based on a calculation of 'consumer surplus' rather than BCR) and found that 10 out of the 12 systems tested produced social benefits net of costs. Their calculations compared the present 'with light rail' scenario to an alternative 'without light rail' scenario and relied on an assumed transfer of passengers to car and a hypothetical bus based public transport system.

9. *Deliverability:* Given that light rail schemes are amongst the most expensive and difficult local transport intervention to plan, finance and deliver, it is relevant to note that proposed light rail schemes have the potential to fail in the planning stages (at some considerable public cost), given lack of available public finance and/or perceived high levels of risk from potential (private and public sector) investors. In a UK context, this includes highly developed schemes in Leeds, Liverpool and South Hampshire<sup>16</sup>.

### 13.3.2 Bus Rapid Transit systems

BRT systems may be implemented to meet similar objectives to light rail schemes but at a lower cost. Objectives typically include increasing passenger carrying capacity, achieving modal shift from the car and/or reducing car traffic, enhancing mobility options, reducing public transport journey times, reducing greenhouse gas emissions, improving local air quality, improving road safety and supporting land use planning strategies. There may also be social equity aims, in for example providing improved transport accessibility to lower income groups.

1. *Passenger carrying capacity and impact on car traffic:* Two case studies<sup>17,18</sup> illustrate the extent to which BRT can deliver high capacity passenger transport. The Istanbul Metrobüs system has a design capacity of 24,000 passengers per hour, but the system has been observed to carry up to 60,000 passengers per hour in peak periods and suffers from over-crowding at stations. It is estimated that the system achieved a 9% modal shift from car use<sup>17</sup>. Ridership of the Los Angeles County Metro Orange Line BRT system also exceeded

expectations attracting 21,828 average weekday boardings (the target for 2020 was 22,000 weekday boardings). 18% of riders had transferred from driving and consequently time spent in congestion on a nearby highway was observed to reduce by 14%. However, BRT travel times were higher than expected - 41 to 50 mins compared to the anticipated 29-40 minutes<sup>18</sup>. The longer journey times were caused in part by the lack of selective vehicle detection to provide priority at signalised junctions and a need to reduce bus speeds to avoid collisions at junctions.

*2. Journey time savings:* Notwithstanding the longer than anticipated journey times on the Orange Line system, 85% of previous transit riders and two thirds of previous drivers reported journey time savings on switching to BRT<sup>18</sup>. Vaz and Venter<sup>19</sup> report that users of the Johannesburg Rea Vaya system experienced journey time savings of between 10 and 20 per cent. Alpokin and Ergun's<sup>17</sup> case study of the Istanbul Metrobüs indicated that passengers saved 50 minutes per day on average (based on the before and after journey times reported by 1000 users of Metrobüs).

*3. Greenhouse gas emissions:* A meta-study by Embarq<sup>20</sup> reports carbon dioxide emissions savings of between 27,000 tonnes and 61,000 tonnes of carbon dioxide per year for different case studies (table 3). Note that these estimates are subject to some uncertainty given their reliance on modelling exercises and inherent assumptions.

<b>BRT System</b>	<b>Estimated CO2 savings (ton CO2 / year)</b>	<b>Source</b>
Istanbul Metrobus	61,000	Alpokin and Egrun <sup>17</sup> reporting a secondary calculation by the Istanbul Public Transport Authority
Johannesburg Rea Vaya	40,000	JIKE <sup>21</sup>
Mexico City Metrobus	27,000	INE <sup>22</sup>

**Table 3:** Estimated carbon dioxide emissions savings

*4. Local air quality:* Turner et al<sup>23</sup> reported that the Bogota (Columbia) Transmilenio system produced a 43% reduction in Sulphur Dioxide, an 18% reduction in Nitrous

Oxide and a 12% reduction in fine particulates .

*5. Road safety impacts:* The Embarq meta-study<sup>20</sup> reports that BRT can contribute to a 33% reduction in crashes involving any vehicle type (based on case studies from Latin America and India). The authors note that research on the road safety impacts of BRT is limited however. By contrast, the Los Angeles County Metro Orange Line BRT system initially had a negative impact on local road safety – there were several collisions between cars and buses at junctions when the system began operating. Accidents were reduced by reducing bus speeds at junctions.

*6. Land values:* Like light rail, BRT has been shown to have a positive effect on land values in proximity to stations, but can negatively affect land values in proximity to busways<sup>20</sup>. Cervero and Kang's<sup>24</sup> analysis of a new BRT line in Seoul (South Korea) indicated price premiums in the vicinity of BRT stops of 10% for residential properties and 25% for non-residential properties. Rogriguez and Mojica<sup>25</sup> conducted a before and after study of an extension to the Transmilenio system (Bogota, Columbia) and identified a 13-14% increase in property prices in the BRT catchment relative to properties outside of the catchment area.

*7. Land use changes:* Cervero and Kang<sup>24</sup> also identified that the new BRT line in Seoul contributed to land use intensification – property owners were prompted to convert single-family dwellings into apart-

ments along the BRT alignment.

*8. Overall cost-benefit analyses:* In considering the combined effects of some of

the aforementioned benefits, the Embarq study<sup>20</sup> reported a post implementation cost-benefit analysis of four BRT case studies (Bogota, Mexico City, Istanbul and Johannesburg). Benefits captured include change in travel time, change in vehicle operating costs, change in carbon dioxide emissions, change in exposure to local air pollutants, road safety benefits, and changes in physical activity. Estimates of BCRs ranged from 1.2 (Mexico and Johannesburg) to 2.8 (Istanbul). With this style of cost benefit analysis, travel time savings are shown to make the biggest contribution to benefits. It is also noted that most users of the BRT systems came from lower to middle income groups, demonstrating potential to meet social equity aims. This is in contrast to light rail systems which were observed to be less successful in serving lower income groups.

*9. Deliverability:* BRT systems may be chosen in favour of light rail alternatives given their lower construction costs and hence anticipated lower risk and shorter delivery time-scales. Indeed the Istanbul system was partly conceived to deliver additional passenger transport capacity across the Istanbul Straits of the Bosphorus while a new railway tunnel was constructed. Alpokin and Egrun<sup>17</sup> note that local government was able to fund the scheme without the need for international loans, that fare revenues are higher than operating costs (operating costs are 3.56 USD/vehicle-km while fare revenue is 4.75 USD /vehicle-km) and that the system had started to recover its capital costs after five years of operation.

#### *Light rail and BRT systems: Methods and evidence gaps*

It is possible for certain attributes of light rail and BRT systems to be effectively evaluated through simple performance indicators - for example, reporting passenger numbers or journey times following scheme implementation. In meta-studies, descriptive statistics have been used to compare land values or car ownership rates inside and outside of system catchment areas. Such simple observed trends should be treated with some caution as, for example, land values and car ownership will clearly be impacted by other fac-

tors such as income or proximity to urban centres. Nevertheless, the results tend to be consistent with studies that have employed more sophisticated regression modelling to examine the impact on land values of new transport systems while controlling for other factors. In this respect, a limitation is that relatively few studies have examined changes in land values after scheme implementation. This is arguably of greater interest than the more common cross-sectional regression analyses which compare land values within and outside of system catchment areas.

Few studies were identified on the impact of light rail and BRT systems on emissions and this represents an evidential need. Studies of emissions that were identified tended to rely on simulation modelling, rather than on observations. The BCRs presented for UK light rail systems are also based on a-priori forecasts. No follow-up studies were identified during the course of this review to examine the accuracy of the predicted BCRs. The results of modelling and forecasting exercises should always be treated with due caution, given their inevitable reliance on assumptions. The road safety impacts of light rail and bus rapid transit are unproven and this represents a further evidence need.

#### *13.3.4 Demand Responsive Transit schemes*

The primary objectives of DRT systems in urban areas are: i) to promote social inclusion by providing efficient public transport access to jobs and services and, ii). to achieve this at a lower cost than conventional, scheduled public transport services<sup>26,27</sup>. Laws et al<sup>27</sup> note that there may be a secondary environmental objective to reduce car dependency and congestion by encouraging people to adopt public transport use. Demand responsive services may typically be targeted at the 'mobility disadvantaged' including low income, elderly or disabled groups as well as lower density neighbourhoods with limited scheduled public transport services. It is increasingly recognised that DRT systems may also be able to support some commuter trips between employment and residential zones in (sub)-urban areas that are not well connected by conventional public transport.



There are few evaluation studies of urban DRT systems as services have more typically been adopted in rural areas (where scheduled public transport is less viable). This review has relied upon evaluations of DRT services in Manchester, UK<sup>3</sup> and a study of the DRT systems that were initiated across Europe under the European Commission funded SAMPLUS (System for Advanced Management of Public Transport Operations) programme<sup>2</sup>.

Six DRT services, branded as 'Local Link', were rolled out in Manchester, UK in 2002. The evaluation<sup>3</sup> examined a range of policy and operational indicators across the six services, revealing:

#### *Policy indicators*

- Between 34% and 59% of trips were to 'target destinations' (e.g. to health, employment, education)
- Between 75% and 95% of trips were made by users from non-car households while between 33% and 48% of trips were made by users with mobility impairments
- Between 1% and 8% of users would not have made the trip if the service were unavailable
- Between 16% and 66% of users lived outside conventional bus catchment areas

#### *Operational indicators*

- Subsidy per passenger trip ranged between £4.69 and £68.09
- Average weekly patronage per vehicle ranged between 30 and 260 passengers

To summarise, these indicators demonstrate that DRT services successfully met social inclusion aims, reaching those with limited mobility options and providing access to target destinations as intended. By contrast operational performance varied substantially, conveying small numbers of passengers and requiring quite large subsidies in some cases.

The success or otherwise of a scheme was noted to be most strongly related to the geographic characteristics of the area and the operational characteristics of the scheme. These were found to be more important than the demographic character-

istics of the local population. With respect to geographic area, the evaluation report<sup>3</sup> suggests as a guide, that "the optimal size and population density for a successful scheme appears to be 10-15km<sup>2</sup> and 3,500 people per km<sup>2</sup> respectively". Operational success was found to be greater if services were designed to "focus on a few key destinations or clusters of activity".

The Nelson and Mageean evaluation of DRT services<sup>2</sup> initiated across Europe under the SAMPLUS programme provides insights into the impacts of differing operating contexts (financing, level of regulation, urban structure and service design):

- DRT services were all shown to require subsidy, but less so than alternatives such as conventional scheduled services or single ride taxis.
- An implication of this is that DRT services are more likely to be successful in highly regulated markets, which can provide the high levels of subsidy required. In deregulated environments private operators are unlikely to consider running DRT services without public sector support.
- Subsidy is likely to be acceptable if DRT services are shown to be effective at fulfilling one or more social requirements.
- Corroborating the findings of the evaluation of the DRT services in Manchester<sup>3</sup>, the most successful services were shown to operate across a small area in order to balance route directness with route flexibility.
- Operators were shown to prefer independent travel dispatch centres, which demonstrate economies of scale e.g. external service providers offering booking and route scheduling platforms.

**DRT Systems: Methods and evidence gaps**  
There is a clear need for further evaluation studies of urban DRT systems. The studies that were identified presented straightforward performance indicators, though these are considered to be fit for purpose. No cost benefit analyses were identified during the course of the review. Traditional cost benefit analysis may not be an effective means of evaluating DRT against social objectives, given the challenge of

monetizing some of the more nebulous benefits such as improved accessibility or reduced levels of social exclusion.

### **13.4 Lessons for Successful Deployment of this measure**

*13.4.1 Transferability:* The meta-studies used in this review intentionally included examples from a range of different urban contexts. These served to illustrate the importance of factors that contribute to the success or otherwise of light rail, BRT and DRT schemes.

Light rail and BRT systems are concerned with delivering high capacity passenger transport. Issues relating to the success, delivery and resilience of light rail and BRT systems are dealt with together first.

#### *13.4.2 High capacity public transport systems*

*1. Barriers to and facilitators of success:* New high capacity passenger transport systems are most successful if they are highly segregated, operate along corridors with high population densities, and serve areas with strong and growing levels of economic activity. Given the relatively large capital expenditure requirements, strong national and local political support is necessary to deliver schemes of this magnitude. Strong and convincing passenger demand forecasts are also required to attract the necessary long term private sector investment. BRT systems are significantly cheaper, lower risk and consequently quicker to implement than light rail systems.

*2. Complementarity:* Successful deployment is usually accompanied by sympathetic land use policies that prioritise new development in the vicinity of transit stops to stimulate demand. It is also necessary for local bus services to be rationalised and re-organised to feed rather than to compete with new high capacity transit systems. This may be challenging in deregulated markets.

*3. Resilience and durability:* It is important that land use policies that deliver high population densities and economic activity in the vicinity of new transit systems

are pursued and maintained over the long term.

#### *13.4.3 Demand responsive transport systems*

DRT systems fulfil a quite different role to high capacity passenger transport systems:

*1. Barriers to and facilitators of success:* DRT services usually require public subsidy and are most successful in highly regulated environments which are able to provide the necessary level of financial support. Subsidies are likely to be politically acceptable if DRT services are shown to fulfil important social objectives and that this can be achieved at a lower cost than alternative mobility options (e.g. scheduled public transport or single taxi rides).

*2. Complementarity:* Services should be designed to complement rather than to compete with existing mobility options, and in particular local taxi markets.

*3. Resilience and durability:* As Mageean and Nelson<sup>2</sup> suggest a long term view is required in DRT service planning in order to ensure that subsidies can be maintained and that DRT services are given sufficient time to become established.

### **13.5 Additional benefits**

As well as the evidence of economic and financial benefits of interventions discussed above, there are a number of additional benefits that are claimed for new public transport interventions:

- *Social Equity:* A comparative study of four BRT systems showed that most users came from lower to middle income groups, demonstrating potential to meet social equity aims.
- *Improved mobility for disadvantaged groups:* DRT systems also offer social benefits such as improved mobility options for disadvantaged groups, for example those without access to a car and living in areas where conventional public transport is less cost-effective.
- *Wider social benefits:* Estimated

monetised social benefits of light rail systems in the USA, based on a calculation of 'consumer surplus', found that 10 out of the 12 systems tested produced social benefits net of costs

## 13.6 Summary

### 13.6.1 Light rail and BRT systems

Overall, there is convincing evidence that light rail and BRT systems can be successful in delivering objectives relating to increasing passenger carrying capacity, increasing use of public transport and delivering land use planning objectives. Evidence on modal transfer and car traffic restraint is less convincing, suggesting that complementary policies are required to meet these aims. Factors that are key to success are: delivering systems along high population density corridors with high levels of economic activity, a high level of segregation from general traffic, and integration with land use planning policies. Absence of these factors can result in highly expensive, failing schemes. A lack of confidence in passenger demand can also lead to projects failing in the planning stages. Further research is required to generate convincing evidence on local air quality benefits.

*Benefit Cost Ratios:* Projected BCRs for light rail schemes (conducted before scheme implementation) were found to range between 2 and 2.7. No evidence was identified to validate these BCRs following scheme implementation and they must be treated with due caution.

BRT schemes were estimated to have BCRs ranging from 1.2 (Mexico and Johannesburg) to 2.8 (Istanbul) based on a post-implementation analysis.

### 13.6.2 Urban DRT systems

The evidence base on urban DRT systems is comparatively weak. Nevertheless, the case studies that were available indicated that DRT systems can successfully fulfil social objectives (in particular in providing transport to the mobility poor) at a lower public subsidy than alternatives such as conventional public transport or single ride taxis. Strong support from a public sector

body is shown to be a key factor in the long term success of DRT schemes, given that a level of subsidy was required in all cases reviewed. In some circumstances, high levels of subsidy were required given low levels of passenger demand. The most successful schemes served a relatively small geographic area and were targeted towards a focussed set of activity centres. Benefit Cost Ratios: No BCR estimates were identified for urban DRT systems.

It is recommended that further evaluation studies are conducted as new developments in urban DRT emerge e.g. monitoring the development of new innovations such as the uniquely comprehensive KUT-SUPLUS system in Helsinki, Finland.

## 13.7 References for this Review

1. Federal Transit Administration (2014). Bus Rapid Transit [online]. Available from [http://www.fta.dot.gov/12351\\_4240.html](http://www.fta.dot.gov/12351_4240.html). [Accessed 5th December 2014]
2. Mageean, J. and Nelson, J. (2003). The evaluation of demand responsive transport services in Europe. *Journal of Transport Geography*, 11, 255-270.
3. JMP (2005). Local Link Evaluation Study. Manchester, UK: JMP Consulting.
4. Babalik-Sutcliffe, E. (2002). Urban rail systems: Analysis of factors behind success. *Transport Reviews*, 22(4), 415-447.
5. Hass-Klau, C., Crampton, G., Benjari, R. (2004). Economic impacts of light rail: The results of 15 urban areas in France, Germany, UK and North America. Brighton: Environmental and Transport Planning.
6. Commission for Integrated Transport (2005). Affordable mass transit guidance – Helping you choose the best system for your area. London: Commission for Integrated Transport.
7. Ewing, R., Tian, G., Spain, A., Goates, J. (2014). Effects of light rail transit on traffic in a travel corridor. *Journal of Public Transportation*, 17(4).

8. Boarnet, M., Hong, A., Lee, J., Wang, X., Wang, W., Houston, D. (2013). The Exposition Light Rail Line Study: A before and after study of the impact of new light rail transit service. [online]. Available from <http://priceschool.usc.edu/expo-line-study/> [Accessed 5th December 2014].
9. Steer Davies Gleave (2005). What light rail can do for cities? London: Steer Davies Gleave.
10. Crocker, S., Dabinett, G., Gore, T., Haywood, R., Hennebury, J., Herrington, A., Kirkpatrick, A., Lawless, P., Townroe, P. (2000). Monitoring the economic and development impact of South Yorkshire Supertram. London: Department of Environment, Transport and the Regions.
11. Cervero, R. (2004). Effects of light and commuter rail transit on land prices: Experiences in San Diego County. *Journal of the Transportation Research Forum*, 43(1), 121-138.
12. Yan, S., Delmell, E., Duncan, M. (2012). The impact of a new light rail system on single-family property values in Charlotte, North Carolina. *The Journal of Transport and Land Use*, 5(2), 60-67.
13. Cervero, R. and Guerra, E. (2011) To T or not to T: A ballpark assessment of the costs and benefits of urban rail transportation. *Public Works Management & Policy*, 16(2), 111-128.
14. Environment, Transport and Regional Affairs Committee (2000) Eighth Report [online] Available from <http://www.publications.parliament.uk/pa/cm199900/cmselect/cmenvtra/153/15302.htm>
15. Nottingham City Council (2011) Nottingham Express Transit Phase Two: Full Business Case. Nottingham: Nottingham City Council.
16. Knowles (2007). What future for light rail in the UK after Ten Year Transport Plan targets are scrapped? *Transport Policy*, 14, 81-93.
17. Alpkokin, P and Egrun, M. (2012). Istanbul Metrobus: First intercontinental bus rapid transit. *Journal of Transport Geography*, 24, 58-66.
18. Callaghan, L., and Vincent, W. (2007). Preliminary evaluation of Metro Orange Line Bus Rapid Transit project. *Transportation Research Record*, 2034, 37-44.
19. Vaz, E. and Venter, C. (2011). The effectiveness of Bus Rapid Transit as part of a poverty reduction strategy: Some early impacts in Johannesburg. Pretoria, South Africa: University of Pretoria.
20. Embarq (2013). Social, Environmental and Economic Impacts of BRT Systems. *Bus Rapid Transit Case Studies from Around the World* [online]. Available from <http://www.embarq.org/sites/default/files/Social-Environmental-Economic-Impacts-BRT-Bus-Rapid-Transit-EMBARQ.pdf> [Accessed 5th December 2014].
21. Joburg Innovation and Knowledge Exchange (JIKE). 2012. *Innovating knowledge in the City* edited by Joburg Innovation and Knowledge Exchange (JIKE). Johannesburg, South Africa: City of Johannesburg.
22. Instituto Nacional de Ecologia (INE). 2008. *The Benefits and Costs of a Bus Rapid Transit System in Mexico City*. Mexico City, Mexico: Instituto Nacional de Ecologia (INE). Available at: <http://www.epa.gov/ies/pdf/mexico/Metrobus%20Mexico%20Phase%20III.pdf>
23. Turner, M., Kooshian, C., Winkelman, S. (2012). Case study: Columbia's Bus Rapid Transit development and expansion – An analysis of barriers and critical enablers of Columbia's BRT systems. Washington D.C, USA: Centre for Clean Air Policy.
24. Cervero, R., and Kang, C. (2011). Bus rapid transit impacts on land uses and land values in Seoul, Korea. *Transport Policy*, 18(1), 102-116.



25. Rodríguez, D., and C. Mojica. (2009). Capitalization of BRT network expansions effects into prices of non-expansion areas. *Transportation Research Part A: Policy and Practice*, 43(5), 560-571.
26. Wang, C., Quddus, M., Enoch, M., Ryley, T., Davison, L. (2014). Multi-level modelling of Demand Responsive Transport (DRT) trips in Greater Manchester based on area-wide socio-economic data. *Transportation*, 41(3), 589-610.
27. Laws, R., Enoch, M., Ison, S., Potter, S. (2009) Demand responsive transport: A review of schemes in England and Wales. *Journal of Public Transportation*, 12(1), 19-37

## Author information for the Evidence Measure Reviews

No.1	Electric Battery and Fuel Cell Vehicles	Hüging, H <sup>1,a</sup>	hanna.hueging@wupperinst.org
No.2	Cleaner Vehicles	Rudolph, F <sup>1,a</sup>	frederic.rudolph@wupperinst.org
No.3	Urban Freight	Ricci, M <sup>2,b</sup>	Miriam.Ricci@uwe.ac.uk
No.4	Access restrictions	Melia, S <sup>2,b</sup>	Steve.Melia@uwe.ac.uk
No.5	Roadspace reallocation	Clark, B <sup>2,b</sup>	Ben4.Clark@uwe.ac.uk
No.6	Environmental zones	Calvert, T <sup>2,b</sup>	Thomas2.Calvert@uwe.ac.uk
No.7	Congestion charges	Mingardo, G. & Streng, M <sup>3,c</sup>	mingardo@ese.eur.nl
No.8	Parking	Mingardo, G. & Streng, M <sup>3,c</sup>	mingardo@ese.eur.nl
No.9	Site-based travel plans	Bartle, C <sup>2,b</sup>	Caroline.Bartle@uwe.ac.uk
No.10	Personalised travel planning	Bartle, C <sup>2,b</sup>	Caroline.Bartle@uwe.ac.uk
No.11	Marketing and rewarding	Rudolph, F <sup>1,a</sup>	frederic.rudolph@wupperinst.org
No.12	Public transport enhancements	Shergold, I <sup>2,b</sup>	Ian2.shergold@uwe.ac.uk
No.13	New public transport systems	Clark, B <sup>2,b</sup>	Ben4.Clark@uwe.ac.uk
No.14	Integration of modes	Calvert, T <sup>2,b</sup>	Thomas2.Calvert@uwe.ac.uk
No.15	e-ticketing	Shergold, I <sup>2,b</sup>	Ian2.shergold@uwe.ac.uk
No.16	Traffic management	Clark, B <sup>2,b</sup>	Ben4.Clark@uwe.ac.uk
No.17	Travel information	Calvert, T <sup>2,b</sup>	Thomas2.Calvert@uwe.ac.uk
No.18	New models of car use	Calvert, T. & Chatterjee, K <sup>2,b</sup>	Thomas2.Calvert@uwe.ac.uk
No.19	Walking	Jain, J <sup>2,b</sup>	Juliet.Jain@uwe.ac.uk
No.20	Cycling	Parkin, J <sup>2,b</sup>	John.Parkin@uwe.ac.uk
No.21	Bike sharing	Ricci, M <sup>2,b</sup>	Miriam.Ricci@uwe.ac.uk
No.22	Inclusive urban design	Melia, S <sup>2,b</sup>	Steve.Melia@uwe.ac.uk

1	Wuppertal Institut für Klima, Umwelt und Energie GmbH	a	Wuppertal Institut, Döppersberg 19 42103 Wuppertal. Germany.
2	University of the West of England: Bristol	b	Centre for Transport and Society, University of the West of England, Frenchay Campus, Coldharbour Lane, Bristol BS16 1QY. UK
3	RHV Erasmus University Rotterdam	c	RHV BV, TAV Martijn Streng, P.O. Box 1738, 3000 DR Rotterdam, The Netherlands