

# Buses with High Level of Service

*Fundamental characteristics and recommendations  
for decision-making and research*

*Results from 35 European Cities*



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Fundamental characteristics and recommendations  
for decision-making and research  
Results from 35 European cities

Final report – COST action TU0603 (October 2007 – October 2011)

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The participants of this COST action, from 14 EU countries, are contributors - list page 4.



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## Foreword

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### Note to the Reader:

This book is the final report of our COST action; it is not a guide book. It is written by different hands by several groups. Inevitably there are some overlaps of content, some diversity in perspective and style. The editors decided to retain these different "voices" rather than to streamline.

Within such a new and wide domain, there are different ways to analyse the same items. It is important, for a knowledge-sharing COST Action, that you can find different thoughts regarding some items in this very wide subject of BHLS.

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## Executive summary

All across Europe, new urban bus schemes of high quality are being implemented. These are known as BHLS – “Bus with High Level of Service”. They are not necessarily "new solutions" or some innovative form of transport looking for a market. Many BHLS systems restore the efficiency buses had for most of the 20th Century when there were no congestion problems. They improve the network attractiveness with the addition of significant investment in system reliability, customer support and marketing. The bus is the primary form of public transport both in Europe and globally<sup>1</sup>. Where demand is high it is normally transported by Metro and LRT. One of the greatest paradoxes of modern transport planning has been the excessive focus on very expensive projects of limited scope (although effective at their point of application), while ignoring the degraded conditions for the vast majority of public transport customers. These are the result of poor urban structure and form, and greatly exacerbated by urban sprawl. This has contributed to the degradation of economic and financial conditions of public transport in the last four decades of the 20th century, with great loss from public to private forms of transport. Very large public expenditures are then required to try to regain fractions of the lost business. BHLS can help to change part of this context, and it is now important to understand the key factors for the bus revival.

BHLS is a very important response to decades of systematic neglect of the bus mode. It provides a toolbox of relatively modest, cost-effective measures that can be deployed in the biggest or smallest urban areas. It does not always require a very large capital investment, and it blends good operational practice with appropriate technologies. If these modest changes to the operating conditions of the bus are deployed on a very wide scale across Europe, it will impact the daily lives of tens of millions of Europeans and will attract many car users from cars. Such changes need to focus also in urban planning regeneration, land use, space re-sharing, one of the biggest challenges for achieving successes.

Bus based systems, with different configuration and called with different acronyms are already seen in Ireland, France, Spain, Sweden, Germany, UK, Netherlands, Finland and other places make for a convincing argument that we already have a very wide range of excellent transferable solutions, and that it appears that there is no European environment in which BHLS cannot be deployed.

Such systems are called BRT in North America and developing or under-developed countries due to the great support of International agencies, like the World Bank since the 1990s. Since that period, the concept BRT has been written, and a wide bibliography is now available showing the feedbacks from the most capacitive systems in the world, like the TransMilenio in Bogotá, in which the gain of average speed and ridership can be very important. However, we are in Europe into differing economic, cultural, political and social conditions. Our cities are also different.

This report presents the synthesis of 4 years of exchanges between 14 European countries about their BHLS experiences.

The objectives were shortly:

- To highlight the strengths and the various scopes of the BHLS market, by analysing 35 European BHLS schemes (of which 25 were visited and documented by this COST action).
- To define some useful method tools, such as the “system” approach with its key performance indicators and conflicting requirements.
- To define what could cover the High Level of Service for such means of transport.
- To collect key recommendations / messages for promoting and strengthening this market.

The main statements pointed can be shortly summarized as follows, the interest:

- To be aware of the wide range of BHLS solutions, where tram and buses can be even mixed on same corridors; a long term approach can lead at several levels of services.
- To keep a “system” approach also at network scale, while improving the active modes, walking and biking.

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<sup>1</sup> Around 50% of the vehicle-km are made by bus in EU cities with over 250 000 inhabitants, and the percentage attains 100% in small and medium sized cities. The European average of the bus market share is estimated at 50 to 60%. Worldwide, it is 80% - source UITP.

- To continue the extensive deployment of BHLS lines, to develop BHLS knowledge networks, it is essential to get political support at an early stage.
- To integrate the BHLS within the urban planning and to gain citizen and community acceptance.
- To provide priority for BHLS in its right of way, on the same basis as a tramway. Where relevant, to adapt road traffic regulations and to harmonize signage for tramway and BHLS priority.
- To improve the EU bus regulation for BHLS features – e.g. for bi-articulated buses, for doors at both sides, for bicycle racks at the vehicle-front (as in USA/Canada)...
- To promote further research and evaluation regarding BHLS components such as economic, social, urban and environmental impacts, quality measurements, safety, specific BHLS bus market.

## Acknowledgements

During this COST action, from October 2007 up to November 2011, 14 EU countries have been involved: Belgium, Czech Republic, France, Germany, Greece, Ireland, Italy, Netherlands, Portugal, Romania, Spain, Sweden, Switzerland and United Kingdom.

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*Almere, at rail station – high and big information panel*

# 1. Introduction

A “new wave” of quality bus systems has emerged in Europe. These are collectively called “Bus with High Level of Service” (BHLS). Many of the elements are already familiar – priority for buses in traffic, higher quality vehicles, improved comfort at stops, improved information to passengers, integrated ticketing, intelligent transport systems to improve operations management and planning, etc. However, BHLS differs from the conventional approach in three main respects:

- The elements are combined in a holistic way, to achieve a total product improvement rather than just improve specific aspects.
- The BHLS is usually packaged as a concept, given a distinct identity, and marketed confidently to the target market.
- The BHLS usually serves urban and transport policy or strategic objectives, and are not just technical or operational improvements.

This report describes the context in which BHLS and other urban mobility enhancements are developed, the concepts and range of approaches to BHLS, the rich experience in Europe along multiple dimensions (infrastructure, vehicles, operations, impacts), and concludes with recommendations for both policy makers and practitioners at European, national and local level. Chapter 7 provides a 2-page synopsis for 20 different BHLS schemes in Europe. This report is accompanied by a CD which contains a wide range of thematic working papers and more detail about the individual BHLS schemes.

*BHLS as a concept for urban and transport policy.*

To assist the reader, before describing the policy context and BHLS concepts, we first present the broad logic chain of the typical BHLS – i.e. what the BHLS does and why this can solve urban and mobility challenges:

- Bus priority measures, improved running way, and high quality vehicles allow the bus to offer fast, reliable services.
- High quality vehicles, upgraded bus stops, passenger information, and many other features provide a higher degree of comfort and an attractive travel environment.
- Adjusted routes and services allow better connections to the existing network.
- The combination of improved operations, comfort and service, supported by branding and marketing, reposition the bus as a high-quality product.
- All of these factors lead to attraction of new customers to public transport, and retention of existing customers.
- This leads to a mode-shift to public transport from private cars. Mode shift results in less trips and less vehicle-kilometres made by car.
- In turn, this leads to less fuel consumption, reduced Green House Gas emissions, and reduction in other emissions harmful at the local level.
- Emissions from the buses are also reduced, in part as they can now perform at the optimum driving cycle, in part due to investments in newer, cleaner vehicles.
- Improved public transport improves mobility opportunities and quality of life for citizens, especially those with reduced personal mobility, those seeking job opportunities, and those at risk of social exclusion.
- In most BHLS systems, the opportunity is taken to improve the host environment by street-scape improvements and provision of cycle/pedestrian facilities.
- All BHLS exhibit ridership gains which, when coupled with unit cost reductions, contribute to the financial sustainability of the public transport.

## 1.1 EU policies regarding urban mobility issues

At the Policy level, there are a number of key issues of high concern in Europe:

- Reduction of Greenhouse Gas emissions, in particular from the transport sector.
- Rational and efficient use of fuel, and long-term fuel security.

- Efficient and sustainable mobility, both in urban and non-urban areas.
- Quality of life throughout Europe's communities.
- Social equity, and protection of those at risk of exclusion.

European Transport Policy is well documented elsewhere, so we do not review all aspects of it here. Instead, we focus on the policy issues concerning energy consumption and urban mobility.

### 1.1.1 Energy consumption trends in Transportation

The transport sector is the fastest growing source of greenhouse gas emissions<sup>2</sup>. For the moment at least, the increases in car ownership and kilometres travelled by car are outstripping the fuel efficiencies being made by the automotive manufacturers. Unlike other sectors, the inexorable growth in GHG from transport first needs to be slowed and halted, and only then can progress be made on meeting the targets for GHG emission reductions. This will require a change in travel habits, change in mode of travel, and change in the emissions associated with each mode. Public transport has a fundamental role in achieving these targets, while not forgetting the major contribution that walking and cycling can make for shorter trips.

It is commonplace to say that greenhouse gas policies in transport will have to rely on a combination of demand management (i.e. policies in favour to curb usage of private cars by organising restrictive access to city centres, congestion charging schemes or parking policies etc) and technology change. But how significant is each of these broad components? Even an approximate answer to this question is important as it helps to determine policy priorities. This is especially important for innovation, which must provide the 'toolbox' of future solutions. The priorities will not be the same in each country, or even in each city of the same country. In a global context, the fast-growing economies (BRIC countries) will play a key-role in the evolution of GHG emissions. However advanced economies like Europe, which have limited growth potential, should provide leadership on more sustainable communities and should both finance the first efforts and demonstrate what can be achieved.

*PT an efficient tool regarding space and energy consumption issues*

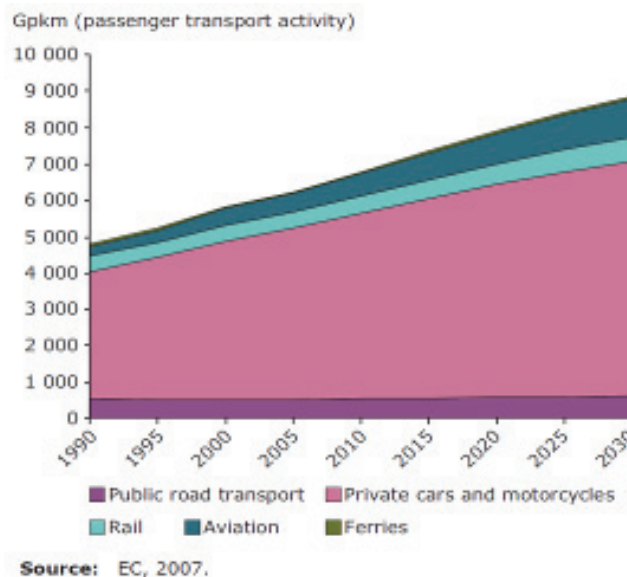


Figure 1: Passenger demand projections for the EU-25, source "European Environment Agency" (2010)

The mitigation options suggested by the report (EEA-Term 2009) include both technical and non-technical options, as outlined in Dalkmann and Brannigan (2007). This proposes a combination of three different approaches, 'avoid'; 'shift'; and 'improve' (ASI) — Hence, public transportation is truly a key tool for this objective.

<sup>2</sup> Transport Outlook 2010: The Potential for Innovation — © OECD/ITF 2010

There is already an existing awareness of the issue of trying to tackle the problem of global warming and its impact, which will increase in the coming years. Cities and societies are concerned and are aware of the decisions that are needed to be taken to tackle the problem most of which will be of financial character. The reduction of the CO<sub>2</sub> emissions is a priority in order to limit their impacts.

### 1.1.2 Some European thoughts about sustainable urban mobility<sup>3</sup>

While the European Union has developed its own field of intervention in transport policy, it does not get involved at an urban level. This is due to respecting subsidiarity (i.e. local decision-taking and responsibility) for planning and transport policy. However, following the recommendations of the mid-term review of the European policy, the EU has undertaken a wide public consultation. This consultation elaborated possibilities of actions in the field of urban transport planning. It has published in 2007 a Green Paper "Towards a new culture for urban mobility" (EC, 2007a), which proposes actions where Europe could act at a local level. 25 key questions provided structure to this reflection and the process of public consultation has been launched in 2008 on these bases.

The main concern for Europe is to give an added value to the other level of governance in the field of urban planning. It can take various forms such as "promoting the exchange of good practice at all levels, underpinning the establishment of common standards and the harmonisation of standards; offering financial support, ..., encouraging research; simplifying legislation and in some cases repealing existing legislation or adopting new legislation". European Commission proposals for the cohesion fund and the funds for the 2007-2013 period describe possible aids in urban areas in order to encourage the implementation of sustainable urban transport plans (EC, 2007b). In the last part, the paper deals with questions developed at a European level and show how they are taken into account at the urban local level.

*The need to integrate the wider metropolitan conurbations.*

Europe considers in her 2007 Green Paper that "coordination between authorities could help tackle the challenges of urban mobility." Furthermore, it recommends to develop a specific approach by "integrating several policies sectors, such as urban planning, economic and social affairs, transport", and to realize "mobility plans integrating the wider metropolitan conurbations. Appropriate organisational structures need to be established to facilitate the development and implementation of these plans". The EU Green Paper recommends to encourage co-mobility and inter-mobility and to enhance connections between different transport modes and to promote efficient and cleaner transport solutions. Finally, the European Union wishes to pursue to encourage best practices exchanges in this domain.

These last points encourage the analysis of BHLS concept and best practices in Europe to fulfil the objectives of enhancement of urban sustainable mobility and urban and interurban public transport within the overall context of European mobility. The larger reference context is provided by the general EU Policy indications as among the others:

- European Commission, (2001) "European transport policy for 2010: Time to decide", White Paper COM(2001) 370 final September, 124 p.
- European Commission, (2005), "Thematic strategy on the urban environment", COM(2005) 718 final, January 2006
- European Commission, (2006), "Keep Europe moving -Sustainable mobility for our continent", Mid-term review of the European Commission's 2001 Transport White Paper, COM(2006) 314 final, June.
- European Commission, (2007a), "Towards a new culture for urban mobility", COM(2007) 551 final, 25<sup>th</sup> September
- European Commission, (2007-b), "Sustainable urban transport plans" technical report 2007/018, September, 18 p.
- EC Communication (2009) "A Sustainable Future for Transport".

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<sup>3</sup> By Odile Heddebaut (on the basis of 2CIMO (Citizen Mobility) Conference paper, Madrid, Sept 2008)

## 1.2 Mobility needs to be solved

GHG emissions and fuel consumption are issues of European and global concern, and rightly are the concern of international, inter-governmental and national institutions. They are about dealing with the consequences of satisfying the demand for mobility.

Mobility itself is also a very high priority. It is also an area of high interest to the EU, especially as it relates to the efficient functioning of the economy and society of the European Union. It is of highest interest at the national and local level, especially in the urban areas, which suffer most from congestion and its direct impact on citizens, business and quality of life. Despite long-established and intensive transportation systems throughout the cities of Europe, there are many outstanding issues relating to mobility needs.

Below are highlighted some key points, of the current needs to be solved generally speaking, regarding different traffic problems:

- 1 Structuring and empowering PT in high density CBDs (Central business districts) with a need to reduce private traffic volumes and impact, but nevertheless improve accessibility. This has implications for city centre traffic arrangements such as lane segregation, priority at crossings, reduction in traffic capacity for private cars, reduction in car parking for commuters, and others. *Structuring lines*
- 2 Enhancing urban development, linked to land use control in non-urban areas, access to former industrial or harbour areas with new developments programmed such as regeneration through malls, recreation centres, new university campuses, hospitals, or other newly implemented infrastructure, where priority is given to high capacity PT as part of the development of the project since the planning stage. *Re-development or conversion project*
- 3 Ensuring PT priority for access to CBDs from the suburban and regional areas, sometimes even using former private railway tracks no longer in use, whenever priority for PT in the urban space (streets, avenues) encounters opposition. *Access to city center*
- 4 Reducing the need to travel on an existing radial network, by means of new orbital lines that link directly attraction poles both existing and newly planned outside the city centre. *Network improvement*
- 5 In highly populated metropolitan areas, surface BHLS systems may appear to be an answer whenever existing PT networks are saturated *Intermodality improvement*

## 1.3 The COST action “BHLS”: context, objectives and partnership

The European bus sector has a long tradition of innovation and development. The precursors to BHLS have been well developed in Europe (see next chapter). However, we could note that in the majority of cases, these were not so well integrated, and were not holistic. The primary innovation of BHLS has been to integrate the elements and reposition the bus product in a confident way. Meanwhile, outside Europe, Bus Rapid Transit emerged based on a wider / similar / different philosophy<sup>4</sup>. It aimed to provide also mass transit in the style of Rail /metro-based systems.

The first known Bus Rapid Transit (BRT) system was launched, without any ITS tools, in Curitiba, Brazil in 1974 as a means of offering efficient and effective bus travel within the fast expanding city. After other efficient examples followed, such as those found in Ottawa, Canada (since 1983) or in Quito, Ecuador (since 1994), which integrated much more ITS. The USA launched the BRT concept in the 90ties and wrote the first guideline in 2004 (recently updated). The most commonly recognised BRT with the highest capacity at this time can be seen in Bogotá, Colombia, called Transmilenio and opened in 2000. Guangzhou, China and Istanbul, Turkey are other very high capacity BRT systems.

Where does BRT and BHLS work best? For what market, for what kind of city, is this concept most suitable and affordable? And does or can this concept really compete with the rail

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<sup>4</sup> Different feelings have been expressed in the group; the chapter 2.1 shows an analysis on these differences. The local context of application have anyway an influence.

*Cost action, a platform to built a knowledge network.*

market? These are some of the issues facing cities throughout the world. There is no magic single solution. Each city faces its own unique set of problems and opportunities, and its own implementation context.

Throughout Europe, bus improvements have followed similar basic principles with each identified with its own name or acronym: In Sweden (as a ‘trunk network’ in Stockholm), in United Kingdom and in Ireland (under the name of ‘Quality Bus Corridor’), in France (BHNS – ‘Bus à Haut Niveau de Service’), in Germany and in Spain under the name ‘Metrobus’, in the Netherlands under the acronym ‘HOV concept’ (‘Hoogwaardig Openbaar Vervoer’ meaning ‘high quality public transport’ with a strong intermodal approach) and in Italy under the name ‘LAM’ (Linea Alta Mobility meaning).

In order to understand how these systems evolved and how they could be best applied to the European urban and economical context, a COST Action, called:

### Buses with a High Level of Service

*Fundamental characteristics and recommendations for decision-making and research*

was approved in April 2007, with a lead time of 4 years from October 2007 until end 2011.

The group consisted of representatives from 14 countries with the main objectives being:

- *To share and analyze current best practice in this field, highlighting our key findings as well as the limits and difficulties to launch such BHLs projects.*
- *To publish our vision with recommendations for decision-makers as well as for EU bus research.*
- *To facilitate exchange of knowledge about BHLs*
- *To contribute to the European Bus System R&D project (EBSF) – [www.ebsf.eu](http://www.ebsf.eu).*

To better organise the work, this COST action is organised into 4 Work Packages (WP) and 4 Working Groups (WG) represented in the figure 2. The first 3 WGs cover all the system components, while the fourth deals with assessment issues and the different impacts of the whole system.

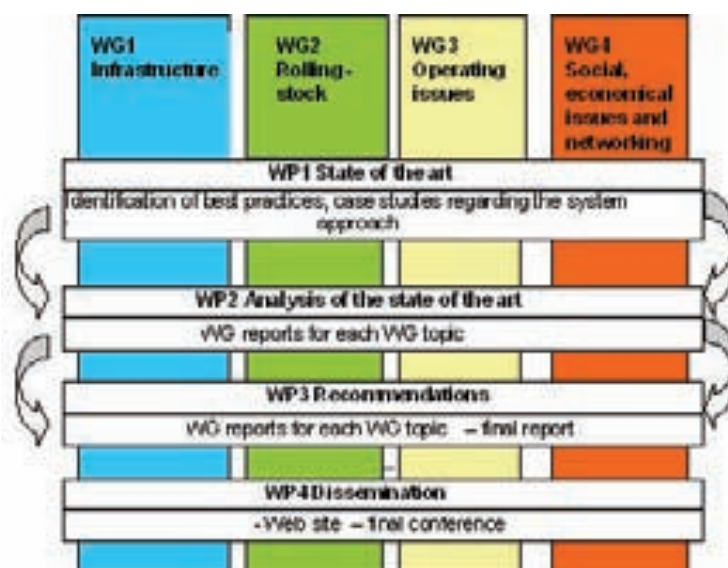


Figure 2: Organisation chart of WGs and WPs

Chairman: François Rambaud <a href="mailto:Francois.Rambaud@developpement-durable.gouv.fr">Francois.Rambaud@developpement-durable.gouv.fr</a>		Vice Chairman: Carlos Cristobal Pinto <a href="mailto:carlos.cristobal@ctm-comadrid.com">carlos.cristobal@ctm-comadrid.com</a>		
	WG1	WG2	WG3	WG4
Chair	Damien Garrigue François Rambaud	Oscar Sbert Lozano <a href="mailto:oscar.sbert@engineers.net">oscar.sbert@engineers.net</a>	François Rambaud	Odile Heddebaut <a href="mailto:odile.heddebaut@ifsttar.fr">odile.heddebaut@ifsttar.fr</a>
COST Officer : Thierry Goger - Brussels (Belgium) - <a href="mailto:tgoger@cost.esf.org">tgoger@cost.esf.org</a>				

As a first step to establish best practices, each country member was requested to identify their best bus-based experiences. They each highlighted at least one example, while taking care to have different approaches to demonstrate the wide range of possibilities that already

exist. The selection of the best bus-based experiences was the choice of the individual country members. On the one hand, there was no precise definition at the outset of the state of the art review about what a BHLS actually is. On the other hand, the rather open choice permitted each country member to select both high-performing systems and also interesting partial or low(er)-level approaches. In fact, this revealed many ideas and techniques of which experts in other countries had previously been unaware. As a result, many useful lessons have been learnt, and all participants now have an expanded and more comprehensive concept of BHLS.

Eight plenary meetings (all WGs) have been organized, which included technical visits of the bus-based systems. In sequence, these were in Dublin, Nantes (with visits to Lorient and Paris), Madrid (with visit to Castellón), Stockholm (with visits to Jönköping and Lund), Hamburg (with visits to Oberhausen and Essen), Manchester (with visits to Kent and Cambridge), Amersfoort (with visits to Enschede, Almere, Plumerend and Amsterdam), and Zurich (with visit to Luzern).

Other specific meetings have been organised, which also allowed visits to other BHLS cases, such as in Lisbon, Prague, Utrecht, Douai, Lille and Gothenburg; and to bus factories in Santiago de Compostella and Helmond.

A total of 35 cases has been described and analysed, 26 of them have been visited during these meetings (all of them into service excepted the Cambridge guided bus scheme which just opened in August 2011). Lots of data have been then collected, they are all summarised into the “xls” file called “master data”, available in the CD attached at the end of this book.

*35 cases described, 26 of them visited.*

## 1.4 Scope of the publication

This is the final report, which presents the main outputs coming from this COST action. It consists of 7 parts, including this chapter, and a CD:

- *The chapter 2: definitions and method tools drafted for the action.*
- *The chapter 3: analysis of the state of the art collected, outputs from the 4 working groups involved.*
- *The chapter 4, recommendations and research field proposals for decision makers.*
- *The chapter 5, that highlights some key-points for BHLS planners.*
- *The chapter 6, conclusion.*
- *The chapter 7, annex which presents 21 abstracts of BHLS visited.*

The CD attached contains this book, all abstracts, and the main electronic outputs collected at the workshops; the content is reminded in chapter 7.5.

The target audience is all kind of urban and transportation decision makers in Europe, but also researchers involved in urban or technical matters regarding public transportation policies, planning and implementing.

## 2. BHLS within the spectrum of bus-based solutions

Structured bus improvements have been observed throughout Europe since the 1990's. These are now referred to as "Bus with a High Level of Service" (BHLS), although the individual EU countries have developed this concept under several different names or acronyms. These countries have followed the same "systemic" approaches that seek to increase both the bus ridership and its quality of service, and to adapt the bus offer to the European urban and economic context.

### 2.1 BHLS among bus-based transit solutions<sup>5</sup>

The European bus sector has a long tradition of innovation and development. Some has emerged from pioneering improvements to the travel experience for the customers. Much has also been in response to the ever-increasing congestion and encroachment by the private car, both on the operating environment of the bus and on its market share.

The precursors to BHLS have been well developed in Europe. Operating environment improvements were already being implemented in the 1970's – bus lanes, bus-only roads, traffic management measures to assist buses, priority for buses and trams at traffic signals, and parking controls. Operations management systems such as AVL/SAE were also already being developed in the 1970's, became commonplace in the 1980's, and evolving to Intelligent Transport Systems (ITS) over the past two decades. A similar timeframe applies to fare collection systems, which were also accompanied by integrated tariff concepts and regional tariff authorities. Enhanced travel information, improved marketing, driver training, and enhanced customer care are now considered 'standard' rather than optional.

However, we could note that in the majority of cases, the individual elements were not integrated in a holistic manner. The pre-BHLS was often trying to solve the problems of deteriorating operating environment and ridership loss. They tended to respond to problems or opportunities, but not to completely reposition the bus product. The primary innovation of BHLS has been to integrate the elements and reposition the bus product in a confident way.

Meanwhile, outside Europe, quite separate developments were underway, based on another philosophy. The precursors to Bus Rapid Transit were aiming to achieve something rather different. Unlike the Europeans, they were not trying to just restore an earlier condition. They aimed to provide a higher-quality of transit environment or travel experience, and to use buses to provide mass transit in the style of rail / metro-based systems.

*BHLS repositions the bus product in a confident way.*

#### **The North American BRT concept development**

North American towns have developed with diffuse and low-density suburbs that do not favor mass transit. Indeed, car ownership growth has led to the construction of large highways rather than the development of rail or public transport networks. In this context, Bus Rapid Transit first emerged in the form of bus lanes on freeways known as "busways". These aimed to improve the bus services and ease access to the Central Business District (CBD) (Los Angeles in 1973 and 1979, Houston in 1979). Nevertheless, in the United States, these busways have often been turned into high occupancy vehicle (HOV) lanes. This answer to the oil crisis has decreased bus performance<sup>6</sup> due to the loss of dedicated lanes.

BRT projects reappeared in the 1990's and focused on speed. BRT was defined in 2002 by Levinson et al. as "a rapid mode of transportation that can combine the quality of rail transit

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<sup>5</sup> From the article, Heddebaut, O., Finn, B., Rabuel, S., Rambaud, F., The European Bus with a High Level of Service (BHLS): Concept and Practice, p307-316 in Lloyd Wright editor "Bus Rapid Transit: A public renaissance, *Built Environment*, Vol 36 Number 3, November, 2010.

<sup>6</sup> Vuchic, V.R, Bruun, E., Krstanoske, N., Euun Shin, Y., Kikuchi, S., Chakroborty, P., Perincherry, V., (1994) The Bus Transit System : its underutilized potential, Federal Transit Administration, Washington, D.C., USA, May, 77 p.



and the flexibility of buses" <sup>7</sup>. As their implementations increased in North and South America, the studies describe a wider spectrum of characteristics to define the BRT systems <sup>8 9 10</sup>. They are ranked in 2006 by Gray et al from "BRT-Lite" to "Full-BRT" depending on their components <sup>11</sup>.

BRT-Lite is the "lower limit" of the BRT concept and must be as a minimum faster than a normal bus line. It is often achieved by greater stop spacing and priorities at junctions. These lines often have their own identity by using a brand name, logo and specific colors applied to buses and stations. BRT-Lite is the most common form of BRT in North America (the Vancouver B-line in 1996, Chicago since 1998, the MetroRapid Bus in Los Angeles since 2000, etc.).

Full-BRT represent bus systems that can achieve metro-style performances. They necessitate full grade-separated transit ways, off-board fare collection, frequent and rapid services, modern and clean vehicles. Bogotá, Brisbane and Ottawa are the most famous Full-BRT examples described by Wright and Hook <sup>12</sup>. This kind of BRT is not really implemented in the United States, but this model is greatly admired and represents the ultimate reference point. Its operational performance combined with its flexibility could be integrated into an environment achieving higher urban densities as said by Hoffman <sup>13</sup>.

Recently, the intermediate "BRT-Heavy" concept has emerged described in 2006 by Gray et al., emphasizing the on-street dedicated right-of-way at the heart of the system to cut time and ensure regular services. Flagship projects such as the Cleveland Health Line and the Eugene EMX Green line should contribute to develop the BRT-Heavy concept. Sixty three percent of American BRT projects scheduled for completion by 2017 as described by Kantor <sup>14</sup> include dedicated right of ways as an integral component.

*A wide spectrum from "BRT-Lite" to "Full-BRT"*

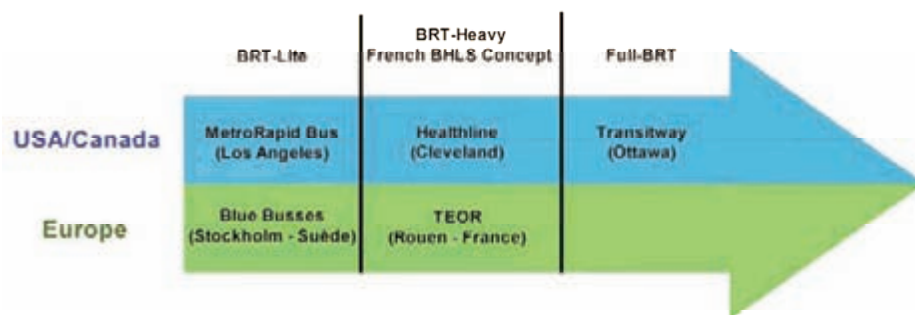


Figure 3: Comparison of the BRT/BHLS concepts based on a few illustrative examples <sup>15</sup>, source: S. Rabuel and O. Heddebaut (based on American (Wright et al.; Kantor et al.) and European studies; 2009).

<sup>7</sup> Levinson, H.S., Zimmerman, S., Clinger, J., Rutherford, S.C., (2002) Bus Rapid Transit: An Overview. In Journal of Public Transportation, 5 No2, pp.1-30.

<sup>8</sup> Levinson, H.S., Zimmerman, S., Clinger, J., Gast, (2003a) Bus Rapid Transit: Synthesis of case studies. *Transportation Research Record: Journal of the Transportation Research Board*, No 1841, TRB, National Research Council, Washington, D.C., pp. 1-11.

<sup>9</sup> Levinson, H.S., Zimmerman, S., Clinger, J., Gast, J., Rutherford, S., and Bruun, E., (2003b) *Transit Cooperative Research Program, Report 90: Bus Rapid Transit, Vol. 2: Implementation Guidelines*, Transport Research Board, Washington DC, USA.

<sup>10</sup> Diaz, R. (ed.), (2009) *Characteristics of Bus Rapid Transit for Decision-Making*, Federal Transit Administration, Washington, D.C., USA, 410 p.

<sup>11</sup> Gray, G., Kelley, N., Larwin, T., (2006) *Bus Rapid Transit, A Handbook for Partners*, Mineta Transportation Institute Report 06-02, San Jose State University, 66p.

<sup>12</sup> Wright, L., Hook, W., (ed.), (2007) *Bus Rapid Transit planning guide*, Institute for Transportation and Development Policy, 823 p.

<sup>13</sup> Hoffman, A., (2008) *Advanced Network Planning for Bus Rapid Transit, The "Quickway" model as a modal alternative to "light rail lite"*, Federal Transit Administration, Washington, D.C., USA, 114 p.

<sup>14</sup> Kantor, D. (ed.), Moscoe, G. Silver, F., (2008) *Bus Rapid Transit, Vehicle Demand and System Analysis Update*, Federal Transit Administration, Washington, D.C., USA, 38 p.

<sup>15</sup> Based on Finn, B., Heddebaut, O., Rabuel, S., *Bus with a high level of service (BHLS): the European BRT concept*. AP050 Bus Transit Systems Committee, Transportation Research Board, 2010.

American research is now turned towards the integration of BRT projects into urban planning with a systemic vision like any other rapid transit system<sup>16</sup> as recommended by Vuchic in 2005. Moreover, Arrillaga et al.<sup>17</sup> in 2004 and Danaher et al.<sup>18</sup> claim in 2007 that the creation of a specific body able to involve all the stakeholders at all planning levels is seen as a condition for success. The most recent BRT studies focus on planning conditions, decision-making processes, BRT integration into existing networks, and the acceptability and image of these transportation systems<sup>19 20</sup>. Studies are carried out in 2010 by Cain et al.<sup>21</sup> about the perception of various public transportation systems in Los Angeles and by Perk et al.<sup>22</sup> on the influence of BRT stations on property value in Pittsburgh. A recent review of BRT systems in the USA by ITDP<sup>23</sup> has identified that while these systems have many positive characteristics, they are well short of international "gold standard" BRT. Political, institutional and technical reasons were identified, with recommendations on how to design and deliver more performant BRT systems in cities of the USA.

Since 2005, a French working group headed by CERTU<sup>24</sup> has defined its own concept of BHLS based on initial local experiences (the "new town" of Évry since the 1970s, the Trans-Val-de-Marne system of Greater Paris since 1993, TEOR in Rouen since 2001) and by adapting BRT to the French urban environment and "transportation culture". A study of implementation and characteristics of French BHLS have been made in a specific group led by CERTU<sup>25</sup>. Since 2007, the 2005 French group decided to share its experiences with 14 others European countries to share view on BHLS, albeit with some unique characteristics from one European country to the other.

#### **European BHLS as BRT inspired by rail performance and adapted to the European urban context.**

In the United States, public transportation essentially answers the needs of commuters headed downtown, from extremely scattered and often far-off starting points. In contrast, European urban models present relatively dense cities with narrow streets where most activities and residence are mixed. This has influenced the public transportation organization that takes advantage of concentrated flows. The demand for public transportation goes beyond peak hour commuting travel and covers all-day, evening and week-end use of the transit systems. In most European cities, the systems of metros, tramways and suburban trains already fulfill the needs of high capacity transit.

European tramways are light systems operating mostly via exclusive on-street right-of-ways (i.e. more like streetcars than fully-segregated light railways) and integrated into the city with at-grade junctions and accessible platform. Capacity is limited by intersection management, with maximum of 6,000 trips/hour/direction for a 45 m long tram with a headway of 3 minutes. The tramway has reappeared in many cities where it had been dismantled, with a new high-performance and modern image and with a strong linkage to enhanced streets. At the same time, buses generally suffer from a negative image due to congestion, irregularity,

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<sup>16</sup> Vuchic, V.R., (2005) Métros légers et liaisons rapides par autobus, modes concurrents ou complémentaires ? *Transportation Public International*, pp.10-13.

<sup>17</sup> Arrillaga, B., Wnuk, L., Silver, F., (2004) *Bus Rapid Transit Demand Analysis Update*, Federal Transit Administration, Washington, D.C., USA, 51 p.

<sup>18</sup> Danaher, A., Levinson, H., Zimmerman S., (2007) *Bus Rapid Transit : Practitioner's guide*, Transit Cooperation Research Program Report 118, Transportation Research Board, Washington, D.C., USA, 241 p.

<sup>19</sup> Golub, A., Miller, M.A., (2007) A decision-support tool for Bus Rapid Transit Systems deployment, revised paper submitted for *Transportation Research Record*, Transportation Research Board, Washington, D.C., USA.

<sup>20</sup> Wright and Hook, 2007 op cit.

<sup>21</sup> Cain, A., (2010) Tangible and intangible service attributes Quantifying the importance of image and perception to Bus Rapid Transit, Paper presented to the 89th TRB Conference, Washington DC, January.

<sup>22</sup> Perk V., Mugharbel, M., Catala, M., (2010), Impacts of Bus Rapid Transit stations on surrounding single-family home values: study of Pittsburgh' East Busway, Paper presented to the 89th TRB Conference, Washington DC, January.

<sup>23</sup> ITDP, 2011, *Recapturing Global Leadership in Bus Rapid Transit: A Survey of select US Cities*, Washington D.C., USA.

<sup>24</sup> Babilotte, C., Rambaud, F. (ed.), (2005) *Bus with a high level of service : concept and recommendations* Certu, Lyon, France, 111 p.

<sup>25</sup> Rabel, S. (ed.), (2009) *Bus with a high level of service : choosing and implementing the right system* Certu, Lyon, France.

discomfort and outdated designs. The tramway has successfully repackaged itself and experienced a European 'renaissance', while the bus was being left behind.

The emergence of the BHLS concept in Europe can therefore be explained by the necessity to fill the gap between the regular bus and the tramway in terms of performance, cost and capacity. Thoroughfares not served by metros or tramways usually present a relatively low user-potential, which does not justify the higher tramway capacity associated to higher cost (€15-30 million per km, full cost including urban integration). The BHLS approach tries to link advantages of an economical bus-based system and performances of heavier systems. It has been inspired by American BRT with regard to methodology and design, favoring a transportation system in which the vehicle is but one of various components. Just like BRT, BHLS remains generic and can be integrated into any type of infrastructure configuration.

### **European BHLS: a different choice of components, compared to the American approach**

In general, very high-capacity configurations using grade-separated transit ways do not suit the European urban context, especially within the inner city (lack of available space, undesirable urban cuttings, low demand. Nevertheless, inspired by tramways projects, the on-street exclusive lane constitutes the fundamental component allowing greatest speed and regularity gains. This gives the possibility to share again the streets in favor of alternative modes (walking and cycling ) despite occasional implementation difficulties as described by Heddebaut in 2007<sup>26</sup>. BHLS can be implemented into congested zones, such as city centers. Moreover, the European concept of BHLS allows for a certain permeability of the exclusive lane, useful in case of a limited but heavily used route (taxis, cyclists, deliveries).

For comparison, in the United States, despite wider and often less congested numerous avenues, the realization of on-street exclusive lanes remains limited. US BRT systems more often use discontinuous and not well-marked bus-only lanes that are mostly limited to rush hours. Outside the CBDs, BRT circulation via reserved lanes is provided by the opportunity to re-develop unused railroads (Miami's South Dade Busway in 1997, the Pittsburgh Busway in 2000, the Los Angeles Orange Line in 2005, etc.) or to use freeway shoulders. Nevertheless, attitudes are progressively evolving. With the implementation of the EMX Green Line in Eugene in 2007 and the Healthline in Cleveland in 2008, the United States now has two BRT-Heavy schemes using axial on-street exclusive lanes integrated into the urban environment (use of grass-planted lanes in Eugene, building-to-building regeneration on Euclid Avenue in Cleveland).

We observe other differences between the characteristics of American BRT and the European BHLS, in addition to their approach to interpreting exclusive right-of-way. In Europe, increase in stop-spacing is blocked by the resistance of users - in particular, disabled persons - whereas increased stop-spacing is a feature of 89% of American projects planned for deployment by 2017<sup>27</sup>. Completely off-board payment, which is currently rare in Europe, should develop with public awareness of this measure's effectiveness (54% of the projects in USA). Lastly, whereas long commute times encourage Americans to retain a high number of seats in their vehicles, in Europe the capacity needs and attempts to reduce costs lead to fewer seats in the vehicles. This design requirement results in a higher proportion of standing passengers in Europe, whose comfort could only be ensured by special modifications of the bus platform, generating additional costs.

While Full-BRT is not present in Europe (except slightly the case of Bus-VAO in Madrid), numerous systems approach BRT-Lite relying on a hierarchical organization of the bus network. These include the Blue Buses of Stockholm (Sweden) since 1999, the Lianes of Dijon (France) since 2004, and the Linea Alta Mobilita in Italy (Prato, Brescia, Pisa). But most of the new projects more or less correspond to America's BRT-Heavy. That is the case in France with 9 systems in operation and over 20 planned (Rabuel, 2009). It is also present in the Netherlands (Amsterdam in 2001, Eindhoven in 2005), England (Leeds in 1998, Cam-

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<sup>26</sup> Heddebaut, O., (2007) Les difficultés de mises en œuvre des sites propres pour les modes de transport collectifs guidés ou non : le cas des lignes de bus à haut niveau de service, In *Recherche Transport Sécurité*, N°94, p. 27-45.

<sup>27</sup> Kantor et al., 2008 op cit.

bridge in 2011), Sweden (Gothenburg in 2003<sup>28</sup>), and Germany (Hamburg in 2005), and is being developed in Spain (Castellón in 2008, projects planned for Madrid) and Italy (projects for Messina and Bologna).

## 2.2 Bus-based “System” definition, a first approach<sup>29</sup>

BHLS, BRT, or other acronyms observed present concepts that have in common to focus on a bus-based system approach (road vehicle urban / sub-urban) with characteristics inspired from rail concept, as a line whose target is to structure the urban network. These concepts are explained in fact according to LRT, because they tend to provide to the bus advantages that allow either to move their performances closer to the tramway, or to be an alternative solution generally presented as cheaper.

*The system approach as a method for BHLS projects.*

They are concerned into a general evolution observed on the classification urban transport techniques where strong contrasts between modes and transport techniques have been disappeared, due to the emergence of numerous hybrid systems taking a component from modes or technical solutions before very different.

This classification evolution strategy allows a much more readable entrance, by the quality and level of service, and not by a technical component, such as in general the rolling stock. It is necessary indeed to consider a definition dealing with the wider concept of a transport system where the rolling stock is only one variable component.



*Figure 4: the emblem “system” sourced from the EBSF project.*

*The whole is greater than the sum of its parts.*

*By Aristote*

In fact, a transport system should now be defined as a **coherent articulation of 3 fundamental elements, i.e. infrastructure, a rolling stock and operating conditions** that allows to offer a public transport service regular and suitable at a given urban context. Hence, different mix of components will lead to form different modes of public transport.

Such a « system » approach leads to a « systemic » definition. Its leads also to highlight the infrastructure as the backbone of the system, giving structure to the capacity and the performance. In fact, this is the visual marker and the manifestation of the system’s permanence or perenity.

The notion of « system » approach is fundamental, as it makes up a method whose objective is to ensure a coherent choice process of all components, according to the project objectives.

<sup>28</sup> Bjerckemo, S.A., (2006) Avancerade kollektivtrafiksystem utomlands - mellanformer mellan buss och spårväg. Tillämpningsförutsättningar i Sverige., (Advanced public transport systems abroad - intermediate systems between bus and tram. Implementation prerequisites and possibilities in Sweden). VINNOVA rapport VR 2007:03.

<sup>29</sup> Into the paragraph 3.4, WG4 adds a complementary view, with presenting the results of a survey about the hierarchisation trend of some bus-based networks (mainly big urban areas).

Within this framework, BHLS is an urban transport system integrating a bus or a coach, defined as a road vehicle with rubber tires, but within new conditions providing an increase in performance thanks to a triple optimization of:

- The internal characteristics of the technical and commercial offer.
- The integration of this offer into the whole public transport network.
- The integration of this network into the urban area..

This increase in performance will raise the attractiveness and competitiveness of the urban public transport and will allow gain of new ridership or ensure an increasing PT traffic.

*BHLS is a bus system that loses flexibility in order to achieve a higher efficiency.*

A BHLS definition can be set up shortly as follows:

*The Bus with High Level of Service is a bus-based system, clearly identified, that is an element of the primary public transport network. It offers to the passenger a very good performance and comfort level, as a rail-based system, from terminus to terminus at station, into vehicle and during the trip. The “system” approach across infrastructure, vehicles and operating tools have coherent and permanent objectives in accordance with the mobility network and city context.*

A BHLS qualification should improve primarily the indicators that are strategic in the long term for the service offer. **Three fundamental indicators** can be considered as the most often strategic, that does not mean always systematically:

- Punctuality / Regularity<sup>30</sup>,
- Frequency,
- Speed.

*What is behind reliability is being predictable for customers.*

To achieve improvements simultaneously on all three of these KPIs, requires an action on infrastructure that provides a Right of Way (RoW) which is not only dedicated, but is also appropriately designed and equipped. This is the only way to give the bus the advantage of these three strategic characteristics.

Excluding a few exceptional cases, this RoW should be on ground level in order to keep the infrastructure cost affordable, exclusive lanes over ground or underground triple at minimum the infrastructure kilometer cost.

**The capacity** of the system is not intrinsically a factor of efficiency. However, it allows to the market to be measured and to know if the offer meets properly the demand, keeping in mind that a higher cost will be justified by a higher ridership. The infrastructure greatly contributes into this factor (station size, overtaking lane, road crossing quality).

*Without a good regularity, the frequency and then capacity cannot be high.*

In addition to the three strategic KPIs, other factors are also important and should be considered for building an attractive service, such as:

- Schedule span / intermodality with the mobility network
- Information / comfort
- Safety / security
- Accessibility
- ...

The identification of the whole system inside the network and among all other bus-based systems will be all the more relevant because the BHLS service differentiation will be effective and useful for the customers (see chapter 3.5.4)

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<sup>30</sup> See paragraph 3.5.2 showing the analysis of these quality indicators from BHLS data collected.

Keep a “system” method at each stage of the decision process.

Into such a complex framework, the decision process should be lead by a “system” method taking into account the governance and urban context, with an iteration between the 3 boxes, as follows in the figure 5:

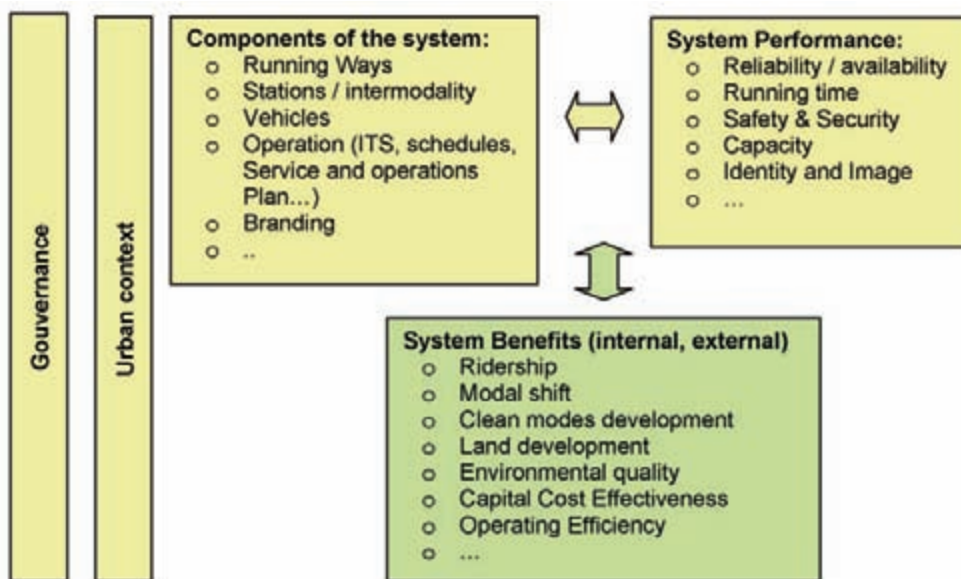


Figure 5: iterative framework “system” for the decision process.

The higher the level of service is, the higher the quality should be.

The third box (in green) deals with the various impacts, internal, but also external. The two chapters 3.3 and 3.4 provide details on the meaning of “Level of service / Quality of service”, in accordance to the fundamental European standard EN 13816 “quality of service” introduced in 2002.

## 2.3 Guidelines used to describe the State of the Art of BHLS in Europe

A major step and achievement of this COST Action on BHLS has been to describe the State of the State of the Art of BHLS in Europe. It was important to know:

- What is BHLS?
- What are its characteristics?
- What does it do?
- Where is it implemented in Europe?

Each country participating in the COST TU0603 action was tasked to collect the data about the most interesting BHLS in their country. An extended template was devised, shown in the accompanying CD<sup>31</sup>. This covered all the 4 WGs domains (described in Figure 2 above).

The aim was to suggest a comprehensive list of possible components that can play a role in the level / quality of service. Their interactions among themselves were actually relevant.

This template was a consolidated proposal that could be adapted as regard to the context. Items that could be more relevant or innovative for the whole system could be expressed with much more details, and new items could be added. Available documents or assessment reports were also requested.

The main WP1 objectives were:

- To describe the most impressive and different BHLS routes into service, showing the «system» approach as it was undertaken as well as its fundamental weaknesses and strengths. What are the components which together play the main role to upgrade and maintain the efficiency/attractiveness? What coherence is important for their choice?

<sup>31</sup> file “BHLS\_components\_COSTTU603.doc”.

- To provide outputs for all WGs in charge of analysis and recommendations.
- To highlight any requirements that could not be solved in the case study (regarding the organisational matters or the technical ones).
- Broadly, to provide an overview of the European state of the art and its current BHLS trends (characteristics, performances, benefits)

The data collection template sought data in the following categories, according to the method shown in Figure 5 above:

1- The urban and governance context

- Main data of the urban area context
- Background of the project and decision process
- Network concerns

2- The component description (1<sup>st</sup> box)

- Running ways
- Station
- Vehicle
- Intelligent Transportation Systems (ITS), operation management tools
- Identity of the BHLS scheme

3- The system performance (2<sup>nd</sup> box)

- In terms of level of service / efficiency of the system
- In terms of quality of service
- Performance of the BHLS management

4- Benefits from the system (3<sup>rd</sup> box)

- In terms of ridership
- In terms of investment and maintenance costs / revenues / safety / security
- Benefits for the customers / neighbourhoods (all externalities)

5- Conclusion: any fundamental weaknesses / points to monitor / difficulties and strengths regarding the expected urban / mobility / cost objectives.

The completed templates for the “State of the art” phase are available in the attached CD.



*The red Zuidtangent route in Amsterdam: impressive interchange with the airport “Schiphol”, secondary lines, taxis and rail station.*

### 3. The BHLS European experiences analysis

Each city or urban area is unique, hence all the systems visited and described are different in terms of urban context, size, polarization, density, public space constraint, etc. When a city or an urban area wishes to choose an additional public transport system, to extend an existing one or to renovate/rehabilitate an existing one, then numerous influencing factors (with different weight or priority) are to be considered, as shown in the graph below. Moreover, any introduction or modification of a new PT system will in turn influence the urban system, at a level not so easy to forecast. The graph below presents these complex interactions.

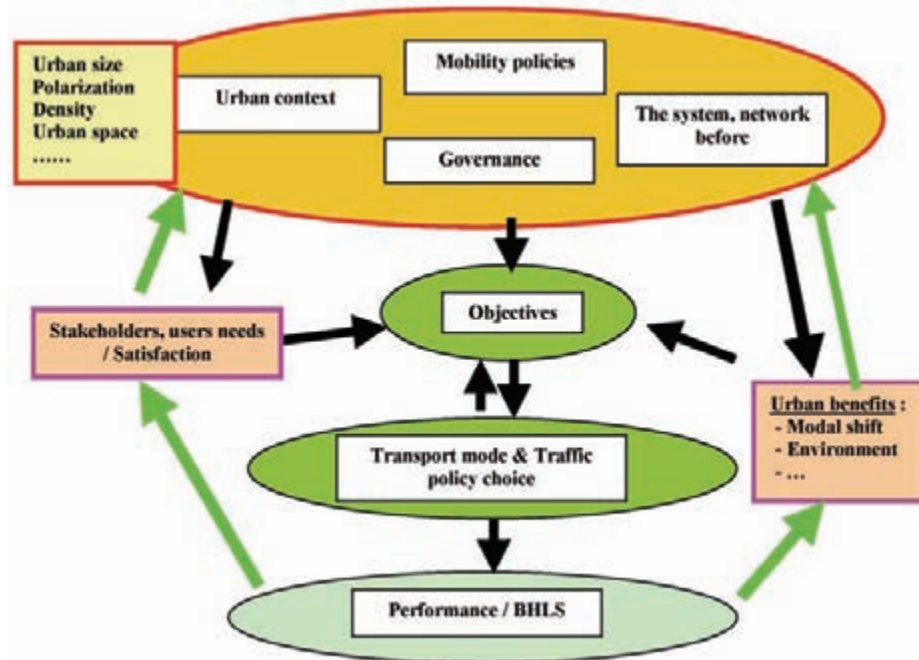


Figure 6: influencing factors when choosing new means of transport or enhancing existing ones.

No PT system can provide the same results or benefits everywhere, and any choice process leads to trade-offs between conflicting requirements, while keeping the main objectives.

Any analysis or comparison process of all these BHLS should not forget this complex framework. Realistic objectives, the level of urban benefits, and passenger satisfaction are strongly related to the system's context, as described above.

A total of 35 cases from the 14 country members of this COST action have been described, and 25 of them were visited during the plenary meetings. This proved to be a useful way of better understanding the context and the quality achieved by the "system" approach. Numerous data were collected using a template developed to include all relevant technical sub-systems and socio-economic issues. Abstracts<sup>32</sup> of these cases descriptions were developed, with summary comments on the weaknesses / points to monitor, as well as the strengths that were observed by the COST BHLS group when comparing all cases.

All these BHLS cases form a wide spectrum of different solutions chosen in very different urban areas, as seen in the figure 7:

- Most of the cities concerned are below 1 million inhabitants,
- The PT market share varies considerably, between 10 and 50% (among all modes).

Two cities, Paris (Île de France) and Madrid, could not be represented as they are "Mega-cities", with respectively 11 and 6,2 millions inhabitants (metropolitan area). Their CBDs offer a very high density and the PT market share observed is hence very different in the

*No PT system can provide the same results or benefits everywhere*

<sup>32</sup> most of them are in chapter 6, all are available into the CD attached



centre or in average in the whole metropolitan area (respectively 20,5% and 31,6%, among all modes).

Although public transport market share tends to increase with urban size, disparities are always observed. Some cities have invested much more resources in PT than others for very different historical reasons, which can be organisational, geographical or economical as well.

Urban density partly explains PT patronage in different urban areas where the number of journeys per day varies considerably. Variations can be considerable from city to city.

Most of the cities visited have a substantial variation in their population and PT modal share. In more western cities, PT performance is very high but ridership is rather low, despite relatively large investments in quality and innovation. On the contrary, systems in Eastern European cities enjoy in general much higher ridership rates, despite considerably older sometimes depleted systems. This reflects the history of the period 1945-1990, during which car ownership remained low and public transport usage high.

These considerations show the key-role of mobility policies and town planning measures in the long term.

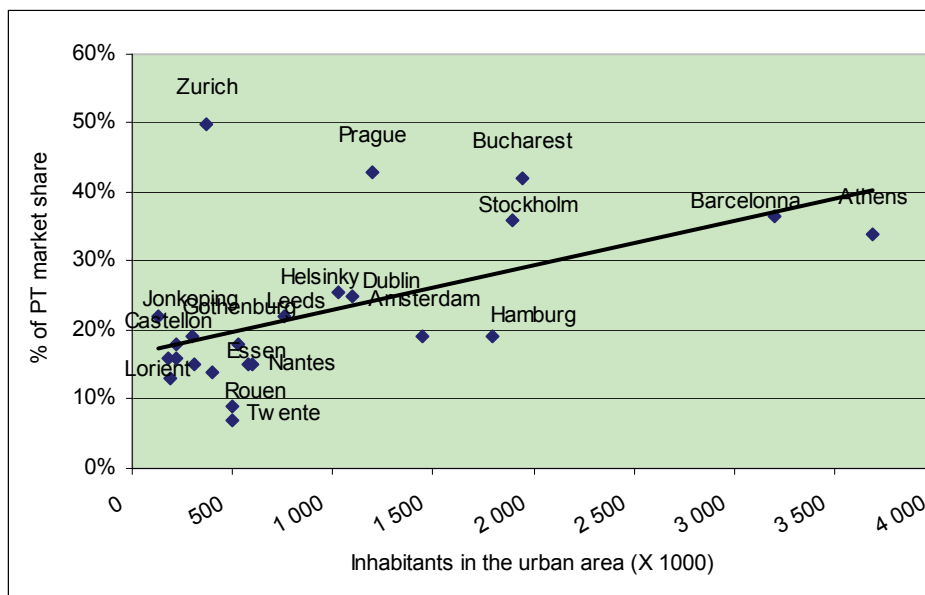


Figure 7: PT market share - variable context of the case studies described – Source COST members<sup>33</sup>

The objective of this analysis is not to re-consider the justification of each BHLS choice, or to identify what could be the optimum BHLS system, e.g. with a set of general characteristics that could be simply implemented everywhere.

According to the complex relationship mentioned above (between urban context and mobility network performances) a less complete or “BHLS-lite” could be actually a better choice for city A, but not for city B. Some specific factors can be more important in city A and much less in city B. Moreover, we can suppose that some components of the 3 sub-systems (infrastructure, vehicle, operating tools) can be very useful in one case and much less in another, whereas other components appear to be common to most systems and rather indispensable or highly recommended...

The objectives within this analysis phase of 35 case studies, is rather to get a deeper understanding of this emerging and broad BHLS spectrum, by highlighting:

- the different BHLS configurations and their role / articulation within the mobility network,
- the components that can play a key-role in the efficiency/ effectiveness of a system,
- the different innovations observed and their role,
- the performances achieved with the indicators chosen,

<sup>33</sup> The perimeter of the urban area is not always defined on the same basis; more information in the EMTA barometer, <http://www.emta.com/>.

- the difficulties presented or observed during the visits, at the different stages of the project (planning, design, implementation, operation).

### 3.1 Planning and decision process, by WG4

The process to initiate, plan and deliver a BHLS is shown in figure 8 below. Conceptually it is quite a simple diagram, with sequential steps. In practice, it can be much more complex. It may involve many actors, whose interests are not always well-aligned or compatible. To date, most BHLS has been new for the area of implementation, so attitudes and processes are being tested. Things which are technically, legally, and financially feasible might still be resisted by some stakeholders, or not be approved at all. Compromises may be required, and parts of the process may require negotiations and some iterations.

Nonetheless, to date some 35 BHLS schemes have been successfully implemented in Europe. This indicates that the process does work in a wide range of environments. Our observation is that it requires understanding, flexibility, care and commitment. To understand the process better, we have identified who were the Promoters of the BHLS schemes, and why they initiated the BHLS projects. We consider that the motivations and the stated objectives have significant influence on the characteristics of the BHLS and how it performs. We also consider some of the barriers they have faced, which may also influence the characteristics of the implemented BHLS. We have drawn on information gathered in the four Working Groups of this COST action, supplemented by some specific enquiries conducted by WG4. This entire process is described in the figure 8.

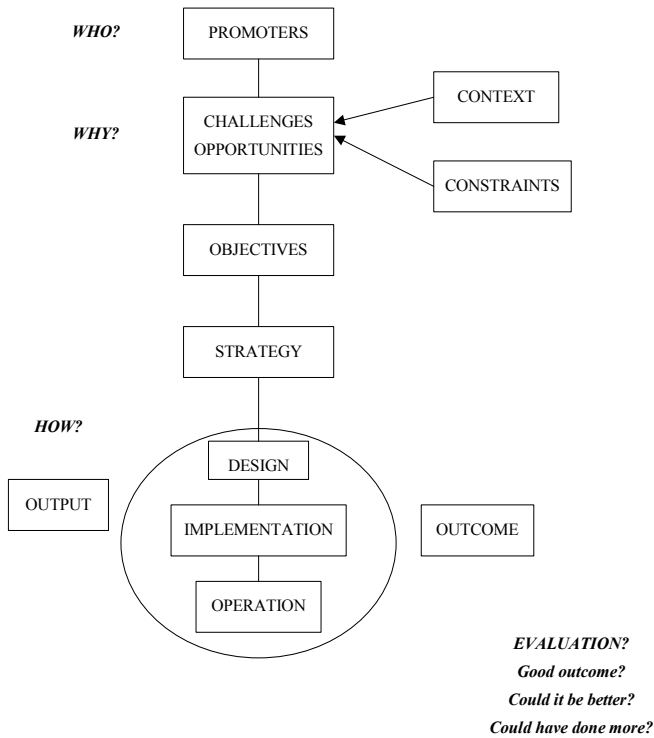


Figure 8 : Implementation process for a BHLS (Source COST BHLS WG4 discussions)

BHLS schemes are initiated when someone has identified that there is a problem to be solved, and has appreciated that a high-quality bus system offers a viable solution. Identification of problems and/or development initiatives may come from urban planners, transport authorities, passengers, operators, stakeholders for sustainable transports, urban developers, and from politicians. General experiences and research in Europe show that this is usually linked to broader urban and transportation plans, and that public consultation is normally conducted (it is mandatory in many countries). BHLS sites advise that it is important to involve politicians early at policy level.

*It is important to involve politicians early at policy level.*

1. State Ministry: 1 (Madrid)
2. Regional authority: 3 (Amsterdam, Castellón, Enschede)
3. Municipal or local Authority: 4 (Lorient, Brescia, Dublin, Gothenburg)
4. Transport Authority: 6 (Stockholm, Hamburg, Jönköping, Manchester, Nantes, Rouen)
5. Public Mixed Level: 2 (Utrecht, Zurich)
6. Public Transport Operator: 1 (Prague)
7. Private Transport Operator alone or with public Authority: 3 (Oberhausen, Paris, Athens)

Table 1: Promoters' of the BHLS project (Source: 20 BHLS answering to COST BHLS WG4 inquiry)

WG4 has launched an inquiry across the case studies of the COST TU603 action to identify (a) who was the promoter of the BHLS and (b) what were the prime objectives and/or motivations for the BHLS systems. We obtained answers from 20 BHLS case studies. Based on the responses, we observe a significant diversity of Promoters of the BHLS projects. Note that the Promoter is not necessarily the long-term ‘owner’ of the scheme (table 1).

Each BHLS project has a set of Objectives. These reflect the interests of the Promoter and of other key stakeholders. The Objectives respond to relevant problems or opportunities at the specific location. They identify the factors that the stakeholders believe would best solve their problems or meet their requirements. When Objectives are being formulated, it is important to have good awareness of possible strategies, available technical solutions, and experience of their outcomes. The context and constraints for design has to be analyzed in a cyclic, recursive process before decision about the alignment, quality and design standards. We have observed that some BHLS sites have well-elaborated objectives, for others there are broad goals. For the 20 case studies that responded, Table 2 presents the primary objectives established for the BHLS schemes.

Modal shift (from car to PT): 6 (Madrid bus VAO, Utrecht, Jönköping, Amsterdam, Enschede, Prague)
Increase efficiency: 6 (frequency, regularity, quality: commercial speed, punctuality) (Nantes, Zurich, Brescia, Prague, Gothenburg, Lorient)
Faster public transport: 5 (Amsterdam, Castellon, Stockholm, Utrecht, Enschede)
Accessibility: 4 (comfort, easy to understand, quality of life) (the user point of view, Zurich, Stockholm, )
Decrease PT costs: 3 (Stockholm, Jönköping, Enschede)
Planning transport structuring PT: 3 (Athens, Paris, Rouen)
Acceptance of bus system and increase of users: 2 (Hambourg, Manchester)
Decrease of Green house gas effect: 2 (Madrid, Zurich)
To begin with a bus based network and then turn into rail based solution: 1 (Dublin)
Increase capacity: 1 (Gothenburg)

*Table 2: Primary objectives for BHLS implementation (Source: 20 BHLS answering COST BHLS WG4 inquiry)*

To obtain strong willingness to improve the PT system using BHLS to complement or be the backbone of the network (Nantes, Lund)
Possibility to convert BHLS into tram, (Amsterdam, Lund, Nantes)
Works constraints (Nantes)
Shorter Journey times (Oberhausen, Lorient, Jönköping)
To take place and space from cars, (Paris, Dublin)
Parking policy if it exists affordable parking in city centres, low fines, (Dublin, Paris)
Car ownership rates (Dublin)
Public consultation and acceptance of bus based systems (Dublin)
How to ensure quality of service and provide high frequency, improve regularity (Gothenburg, Jönköping, Madrid, Manchester, Lorient)
Mix use of RoW, in pedestrian city centre area (Castellón)
Increase of BHLS occupancy (capacity) (Hamburg)
Provide sustainable transport if there is an increase of inhabitants (maintaining car use) (Jönköping)
Insufficient infrastructure (Hambourg)
Costs of projects (Lorient, Madrid, Nantes, Oberhausen, Paris, Rouen)
Progressive step by step possibility of implementation (Prague)
Increase occupancy rate of cars when HOV (Madrid)
Climbe slopes over 6/8% (Rouen)
Heavy car traffic (Paris)
To fit specific different public and social neighbourhood (Athens, Rouen)

*Table 3: Main challenges that BHLS systems have had to overcome to be implemented (Source: 20 BHLS answering COST BHLS WG4 inquiry)*

In several cases, the process starts with a general need or desire to improve the performance of Public Transport to favour sustainable transport, reduce car trips - or an obvious need to respond to decreasing patronage.

For cities where information was available, we have identified the main implementation challenges facing the stakeholders. The responses indicate a lot of issues that have been tackled to achieve the BHLS implementation. In some cases, the issues are still relevant and may continue to influence the context for the BHLS, even after it has commenced operation.. The challenges are shown in table 3 above.

Experience from the sites is that for these first steps in the BHLS process required a careful and inclusive dialogue. When handled well, they provide a strong basis for acceptance, approval, financing and final design and implementation. However, if the objectives are not well anchored with good acceptance, there is greater risk for tough discussions, and problems in the implementing phase that may delay the implementation severely or even stop it.

## 3.2 Urban context, by WG4

### **1.- Taking into account the urban shape and size**

Some elaboration is made here to take into account Public Transport performance and urban context. This allows us to examine the relationship between urban planning, modal choice, the cost of transport and their impacts or externalities for the community. With this perspective, the urban density explains (in part) the Public Transport performance in different urban areas, where the number of journeys per day is very different from one city to another city.

The visited cities present a substantial population variance and Public Transport modal share. West European cities, particularly in France, England, Holland and Germany, present a paradox of demand versus quality of service. In these cities, the Public Transport performance is very high but there is relatively low ridership. This is despite the great investments they have made to achieve this Public Transport performance, including in the BHLS systems. By contrast, the eastern and southern cities of Europe have more ridership, despite the lower level of investments.

These considerations do not invalidate the policies and measures implemented by the cities to create a better Public Transport performance. Nor do they undermine the broader understanding of the conditions in which policy decisions in BHLS investments can be fruitful. In fact, all these cities are looking for a better Public Transport policy to improve the performance of their Public Transport networks and sustainable mobility in their urban areas.

The urban and transportation context of the BHLS implementation varies, and accordingly so do the answers they look for the whole system: frequency, regularity, quality management, commercial speed, punctuality, marketing and capacity. In the examined cases studies, it was possible to find

- small and medium cities with complete BHLS networks (e.g. Almere)
- hierarchy with BHLS as structuring lines at the upper level (e.g. Jönköping, Lund)
- BHLS as complement to the tram and rail network (e.g. Essen, Nantes, TransVal de Marne, Hamburg)
- BHLS filling several operational network functions (cross-city, radial, tangential lines, trunk lines or even feeder lines).

We observe that the highest modal share for Public Transport is seen where Public Transport is treated as a priority mode ahead of cars in transport policy, planning and implementation. Relevant examples include Zurich (50%), Stockholm and Barcelona (c. 40%) and big capital cities like Madrid (32%) or Athens. We also see this phenomenon in the Central and East European capital cities where Public Transport was heavily implemented (e.g. Prague, Bucharest). It is noted that the mode share is not uniquely correlated with the number of inhabitants in the agglomeration. For instance, a less populated city like Jönköping (125 500 in-

habitants) has nearly the same Public Transport share rate of 20% as Gothenburg (530 000 inhabitants) in Sweden (28%) or TVM in Paris (20%).

## 2.- Concept for a typology of the bus based network

We observe in Europe over recent years a trend to develop a “hierarchy” within public transport networks. It has always been customary to have modal hierarchies (e.g. Metro, tram, bus), but now we see the emergence of hierarchies within the bus mode. This “hierarchisation” has been visible in recent BHLS implementations, offering differentiated levels of service, often with distinct branding. This trend is mostly applied in larger network.

We observe that bus lines can be classified by their different functions within the network itself, as illustrated in Figure 9 below. They are then operated in different urban contexts, with different capacity needs and perhaps different operational requirements:

1. *Urban (CBD) routes*: operating within the core urban area.
2. *Local or Distributor routes*: locally in the inner or outer suburbs, including feeder routes.
3. *Collector or Radial routes*: connecting one suburban area or the hinterland with the centre of the urban area.
4. *Cross-city routes*: connecting different parts of the urban / suburban areas via the main city centre.
5. *Peripheral/tangential routes*: connecting suburban areas without entering the centre

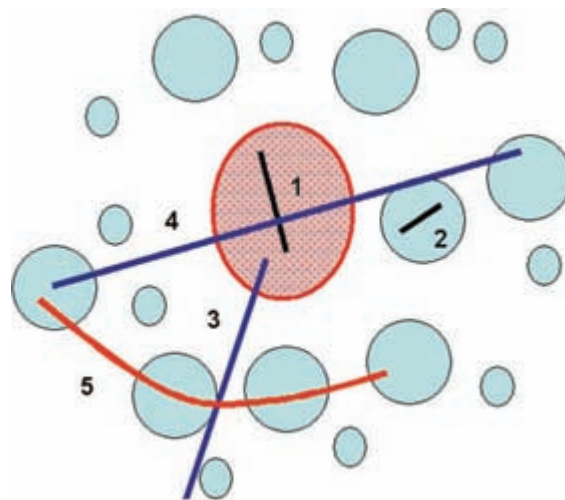


Figure 9: Typology of the BHLS case studies (Source COST BHLS 35 case studies)

This is highly relevant to BHLS, since the technical and performance characteristics of the BHLS tend to reflect the functional type of the route. The 35 case studies sample has been classified within these 5 route types. This gives the typology of the European BHLS, as implemented to date. The cases are mainly in the first and the third categories (68%).

- **Type 1:** The lines inside the city to serve the inner centre (CBD) represent 13 cases and 37.1 % of the sample; this category includes Lisbon Junqueira line, Utrecht, Prague 213 line, Bucharest, Lasi, Brescia, Prato, Madrid line 27, the Hamburg Metrobus, Castellón, the Nantes Busway, Barcelona route 64, and Stockholm Blue busses.
- **Type 2:** Local or distributor routes, of which 2 are observed: Almere, Kent Fastrack.
- **Type 3:** Collectors or Radial routes from one suburban area to the main city centre, are 11 cases and 31.4 % of our sample; this category includes the Dublin Malahide QBC, Oberhausen, Essen, Athens airport line, Madrid bus VAO lines, Lund Lundaänken, Manchester, Purmerend and the Zurich 31 line.
- **Type 4:** Cross city lines, of which 7 cases are observed representing 20 % of the sample. This category includes Lorient Triskell, Rouen TEOR and Gothenburg line 16, Jönköping Citybus-sarna, Leeds, Twente, and the Cambridge Busway line.
- **Type 5 :** 3 BHLS are peripheral or tangential routes (8.5%). This category includes Paris TVM, Amsterdam Zuidtangent, Helsinki Jökeri line.

*BHLS as a tool for PT network hierarchisation.*

## 3.- Practice and data concerning the organisation into a hierarchy of bus based networks

A survey was carried out within WG4 to understand:

- the objectives or reasons for launching such a hierarchisation
- the structure and the functional hierarchy
- type or number and description of differentiation of bus lines within the city network
- description of current typology and, where relevant, what it will look like in the future.
- identification of the different acronyms used.
- the reason(s) behind the hierarchisation of bus lines, related to the attributed functions of each (type of) bus line. Alternatively, reasons for not deciding to establish a hierarchy of bus lines.
- Within the typology, the main characteristics that define the different types.

The full WG4 document presents in tabular form the different forms of this hierarchisation trend, presented by responding city and in hierarchical order:

The motivations and/or objectives for the bus network hierarchy were explained as follows:

- *Great Manchester*: the purpose of the network is to prioritize the radial and orbital routes for investment as they are the key movers of people. GMPTE (the transport authority) acknowledge the limitations of funding for highway improvements and so they are targeting the routes with the greatest patronage levels for investment.
- *Hamburg*: to make the bus network clear; to concentrate the demand. It is mainly high frequency during the whole day (between 3 to 10 minutes), cross linking several metro and commuter rail stations or linking suburbs with the centre on direct routes, own range of line numbers for simple identification, own map. Metrobus does not build its own new bus lanes (they only use existing ones), nor does it build special/dedicated bus stops. The Metrobus concept of Hamburg has subsequently been launched in Berlin (since 2004) and in Munich.
- *Prague*: to increase punctuality and speed; to provide a response to lack of Public Transport capacity in some corridors (e.g. missing rail Public Transport); for economic reasons.
- *Nantes*: the hierarchy began with the re-birth of the tram in the 1980's, and has progressed with the bus sector (master plan to 2030 that introduces the "Chronobus" lines); to build the city of "short distance"; economic reasons as some weak bus lines have been and will be suppressed.
- *Gothenburg*: to tackle congestion and for environmental reasons.
- *Zurich*: The main reason to establish a hierarchy is the number of passengers transported by the bus lines (capacity issue) and the length of the bus lines. There is a need to spread the demand, in a city where cars have been subject to restrictions for a long time. The recent change in the topology map of main bus lines to pastel colour was intended to make them stand out from the rest of the bus lines and to make them more recognizable to the users. There is a planned topology map for the changes that will take place in the network by 2025. It will follow the current topology design and include new tram and bus lines, as well as extensions and changes in the current lines.
- *Barcelona*: to improve the readability of the bus network; for economic reasons.

#### **4.- Observations, findings and lessons learned about bus hierarchy**

The reasons identified as motivations/objectives for the bus network hierarchy are mainly:

- To make the bus network clear, easy to understand.
- To tackle congestion and to contribute to solve environmental issues.
- To prioritize infrastructure investment, according to the potential capacity (A higher capacity/throughput justifies a higher investment on the route).
- To concentrate the demand in order to optimize the loading rate within the whole bus network (trips per km-operated).
- To increase the cost coverage (some weak bus lines can be then suppressed).
- To define distinct products within the network linked with the primary objectives.

Nonetheless, we observe that in practice financial reasons remain very important in all these "hierarchy" approaches (i.e. Nantes, Hamburg, Prague, Barcelona). The first experiences of Nantes and Hamburg, which are already in service for some years, shows a very good impact on ridership increase and on cost coverage. Investing in the infrastructure (dedicated lanes, priority at crossing, etc.) remains the fundamental tool for any financial successes and also for passenger interest (regularity / speed improvement).

Some hierarchisation with dedicated and unique features (e.g. the Busway in Nantes) leads to a stronger identification of the BHLS lines, when compared to others (e.g. "Metrobus" in

Hamburg), where buses and stops are not really different from all other bus lines. However, it is noted that operating dedicated buses on an identified line does result in additional cost.

We observe a trend to offer to passengers a way to improve the “readability” of the bus network, according to the function or the level of service of each route. Identification policies are fruitful tools for helping the marketing activities.

These cities interested in hierarchisation are designing several type of bus solutions which we can view as a spectrum, from local lines through to BHLS “full or complete” offering a high level of quality.

However, there can sometimes be negative effects of hierarchisation. For example, an increase in the rate of transfers is seen in Jönköping. A survey by Lund University has shown that after the opening of the new BHLS network, some residents have lost the direct link which they preferred. This can be made less unpleasant /disheartening if the quality can be guaranteed, as was done through a BHLS approach.

*BHLS, a wide spectrum of solutions.*

Finally, as all urban contexts are so different:

- It is up to each authority to define and build up its own public transport hierarchy through its urban planning. The BHLS concept should be seen as a method or a guideline for local decision makers for designing the different types of bus-based solutions.
- Identification of each level of service can be very fruitful for the passenger while the comfort and information level should reach a common high level across the whole Public Transport network.



*South of Paris: the Trans Val de Marne TVM, the first busy peripheral line, here the old part opened in 1993*

### 3.3 Infrastructure issues, by WG1

The infrastructure sub-system covers running ways (dedicated or not, protected or not, exclusive or shared with other specific modes such as taxis or bicycles, flexible or not), crossings, stations, workshops and depots.



We often say that this sub-system is **the backbone** of the whole system as it provides the basis of the potential capacity, reliability and speed of the system. Moreover it guarantees its permanence. Dedicated lane or RoW (Right of Way) represents **the most strategic** component, the most visible and also the most expensive.

Maximizing the use of road space to best meet the needs of all users including taxis, bicycles, deliveries, tourist coaches along with buses seems to be much more difficult for BHLS than for developing a rail system.

However, as for a rail system, it is also the **most challenging** as in most cases investment involves the development of measures that results in more restricted road space for cars.

*Twente agglonnet: 80% of RoW into a low dense area, an efficient “system” approach.*

Moreover, any BHLS project is very often faced with the demand to use the Right of Way, by taxis, bicycles, deliveries, tourist coaches, etc. They seem less likely to demand such shared access in case of a tram project.

On the other hand, internal and external impacts should be considered, as summarised in the table 4.

*The role of RoW: the backbone of the system*

Dedicated lanes	Internal impacts: on network.	Network ridership
		Modal transfer (from cars, other PT lines)
	External impacts: on the city.	Housing / land cost / businesses
		Pollution / Greenhouse gas
		Accessibilities
	City image	

*Table4: Different impact of dedicated lanes*

All the 35 BHLS cases described have been developed in a local traffic context to meet the needs of each area. There is no single, universal solution. What works in one area may not work in another. However, certain components seem to be more indispensable or highly recommended. The following paragraphs present the results of analysis for each component, observing the different trends. Where possible, their internal (BHLS performance) or external impact on the city or other modes are highlighted.

#### 3.3.1 The running ways observed

##### **A- Typologies of RoW observed**

For analysing the different types of RoW chosen, we will refer to the very simple and pedagogic “infrastructure” classification presented in the table 5 below.

This classification can apply to either the whole line from terminus to terminus, or to a section of the route. Moreover, all of these 3 categories can be implemented and operated in a flexible way, that can be alternated to suit the situation, or even operated “one way” in constrained areas (see § 3.3.4).

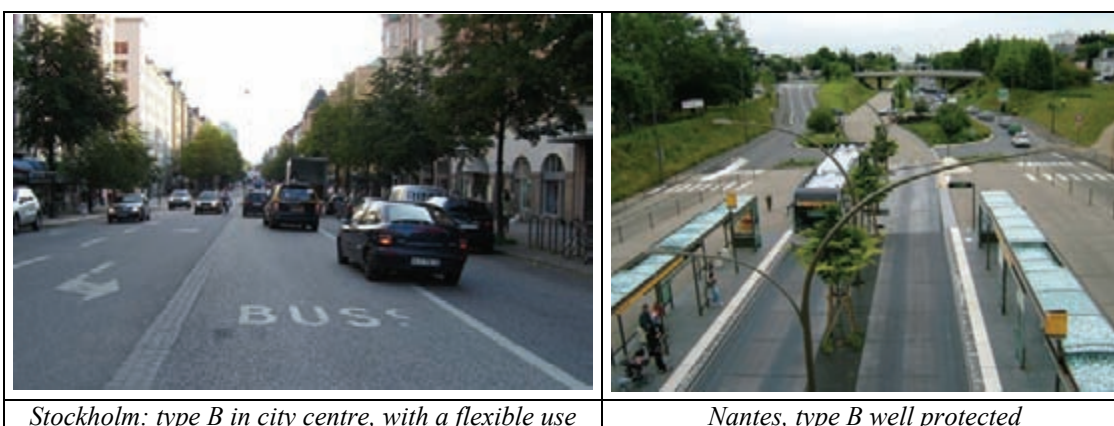
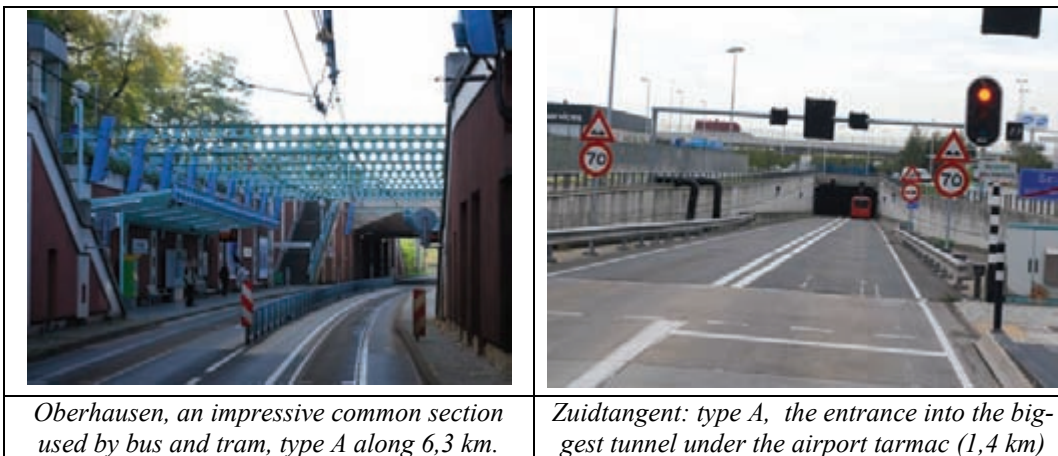


Right of ways categories	Type of system
<p><b>Category A:</b> is a fully controlled RoW without at grade crossings or any legal access by other vehicles or persons. It is also referred to as “grade separated” or “exclusive” ROW and it can be a tunnel, an aerial structure or at grade level. In exceptional cases, the RoW may have at grade crossings with full signal override and gate protection of the tracks and yet be considered as category A, since such crossings have practically no effect on line performance.</p>	Rapid transit systems
<p><b>Category B:</b> includes RoW types that are longitudinally physically separated by curb, barriers, grade separation and the like from other traffic but with at grade crossings for vehicles and pedestrians, including regular street intersections. This RoW category is most frequently used for LRT systems (light rail transit). High-occupancy vehicle (HOV) lanes or roadways represent a low quality RoW category B; they provide better traffic flow than general lanes but do not separate public from private vehicles, the most important element for giving transit the favoured role on the basis of its public service and higher efficiency than private transportation.</p>	Semi-rapid transit systems
<p><b>Category C:</b> represents surface streets with mixed traffic. Transit may have preferential treatment, such as reserved lanes separated by lines (mostly lateral) or special signals or travel mixed with other traffic.</p>	Street transit systems

Table5: typology of Right of Way, source: professor Vukan R. Vuchic, – “Urban Transit systems and technology” – version 2007

From our state of the art review, we have observed:

- A partial use of type A; this was observed in Oberhausen’s trunk section, in Paris where the TVM has access to 4 exclusive bridges, at Zuidtangent where services have several bridges and a tunnel in Amsterdam provides priorities for BHLS; and at Cambridgeshire Guided Busway which has dedicated bus-only road along a disused railway alignment.
- A much wider use of type B with the most impressive examples, such as the Kent Fastrack, Nantes Busway, TVM, Zuidtangent, Twente, Almere, and Hamburg. The use of central position appears to be much more efficient. The central implementation, with contrasted infrastructure, represents a good quality category B (TEOR in Rouen, Fastrack).
- The use of Type C (mostly lateral) where there is limited space or a target in maximising the use of existing road space with a short budget. This was observed in Dublin, Manchester, Grenoble. This approach can be very efficient in some contexts (e.g. Lorient).



*Infrastructure design, a key factor for smooth ride*

The quality of RoW design (flatness, straight layout, no short curves, visibility at crossing, contrast) is a key factor for providing a smooth ride (a special observation in Lorient, where a great improvement have been made before/after the project) which is so important for the comfort, safety, and energy economy.



*Fastrack, Type C: efficient lateral RoW in the suburbs.*



*Lorient, type C with service streets on the sides, just before the biggest interchange with the rail station*

*RoW on motorways is an emerging market.*

A dedicated lane in motorways can be considered as type A, as the road crossings are grade separated. There are only a few examples in Europe where BHLs has a section on motorways. This is, however, a great emerging market:

- Madrid, the most extensive case in Europe: 16 km reversible bus lane in the middle of the motorway A-6 (one way according to the peak flow), partly mixed with car pooling (see the abstract of the Bus-VAO) and connected to the impressive Montcloa interchange hub.
- Zuidtangent in Amsterdam: 5 km on the emergency lane at congestion periods - A9 motorway.
- Bruxelles: A4, lane for bus express lines, launched in 2004, and in 2008.
- Grenoble: 4 km on the emergency lane - A48 – opened by the operator in case of congestion.
- Paris (Briis sur Forge): a bus stop has been built on the motorway A10, linked with a P+R.



*Zuidtangent on the A9, used only in case of congestion: written on the panel, "In case of congestion line buses on the emergency lane"*

The Zuidtangent scheme on the A9 motorway appears to be very simple, very cheap, and also very efficient. The use of the emergency lane remains flexible, only when it is needed and experience has shown that it is not dangerous:

- The first experiment started in the 1990s, and quickly showed a very good safety record.
- A flexible use, only in case of congestion; it is actually used between 1 to 5 hours per day as there is an irregular pattern of congestion. No taxi or tourist coaches are allowed on it.
- The decision to go into this emergency lane is taken by the drivers themselves, according to specific rules given by the operators (i.e. not in case of fog, not in case of accident).
- No colour contrast of the lane, and the vertical signalisation stays static only (low cost).

- Length of the emergency lane: around 5 km (each direction), crossing one or two intersections.
- Several other examples exist in the Netherlands.
- Speed limit for cars: 100 km/h mostly<sup>34</sup>. The speed limit of buses should not be greater than 20 km/h over the car traffic speed (note that these are urban buses with standing passengers, sharp braking must be avoided).

### **B- Importance and role of RoW along the whole route**

The percentage of RoW is highly variable among the sites described, and its effect on the ridership appears to be linked mostly with the context, and not with the quantity or quality of this RoW, as shown in figure 10 below.

*Dedicated lane is a tool, not an objective*

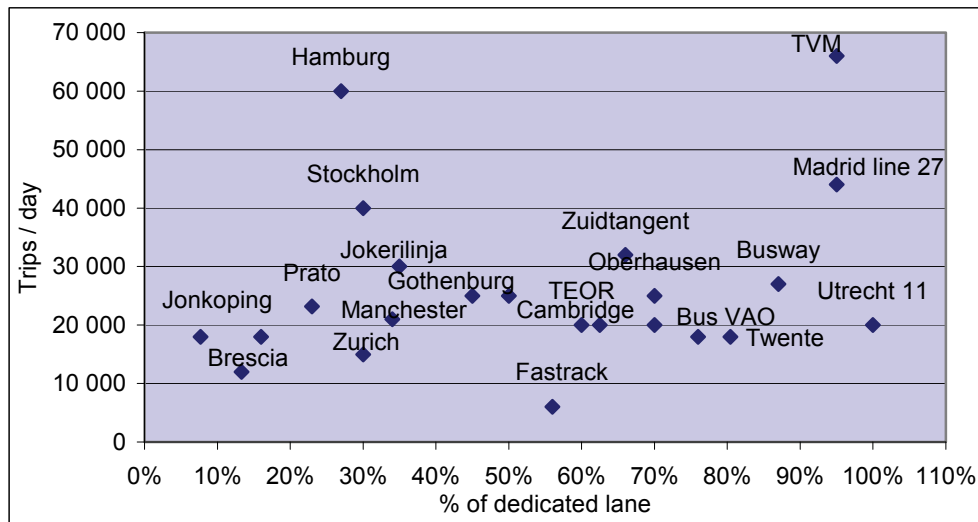


Figure 10 : The relationship between ridership and % of dedicated lane.

While there is a broad relationship between ridership and the extend of dedicated RoW, it is not absolute. BHLS implemented into a dense and urban corridor (like Hamburg, Stockholm) can have a low level of RoW and still have a high ridership. In Stockholm the dedicated lanes were limited as the objective to withdraw a part of the traffic outside the centre has been abandoned. In Hamburg, infrastructure investment has been postponed, as this line could be converted soon to tram. Both examples show some difficulties in regularity, although greatly compensated by an efficient dynamic public transport real time information system, and high frequency of service.

Contrasted results are observed in small cities like Jönköping and Twente: in the two cities, a low and high percentage of RoW is concentrated in a rather small corridor. Such contrasted results are also observed in much bigger cities as well, such as Hamburg and TVM (Paris). The local contexts are different. Nonetheless, the pattern is that a higher rate of RoW results in a higher level of quality in the long term.

The case of Cambridge is particular (opened in August 2011, following some delay due to disputes about construction quality). This scheme is very long, connecting a number of small towns to Cambridge city, which explains one of the lowest level per Km. Fastrack has a very low ridership because it is a recent and first phase of a wide ‘brownfield’ renewal project, that will be developed according to the urban planning growth. This has remained below the original expectation due to the current economic crisis, but it is expected to recover. The project is a PPP (Public Private Partnership) with a 17 year period.

Figure 11 shows no clear relationship between RoW and the rate of ridership increase.

The case of TVM is exceptional. The figure in the chart shows the evolution of the whole line following the short western extension. Specifically:

<sup>34</sup> Speed limit on motorways is limited at 100 km/h at most sections situated in the Randstad (Amsterdam region) for ecology reasons.

- An increase of the whole line TVM St Maur - Créteil/ Rungis by 334% over 15 years
- An increase on the western extension TVM Ouest Rungis/Antony by 23% over one year.

The case of Jönköping remains unique and impressive, as they have achieved a good service with a very low RoW rate, and hence with a very low cost. The urban area is not very dense, and with not a lot of congestion. This scheme has implemented some nice tools, such as some route shortening and a priority at all road crossings (indispensable for getting stable running times). Such a project could be seen perhaps to be more vulnerable in the long term.

The highest level of increase rate (the peripheral Jokeri line in Helsinki) is observed with only 35% of RoW, but always with a lot of priority measures along the whole route, and at all crucial road crossings.

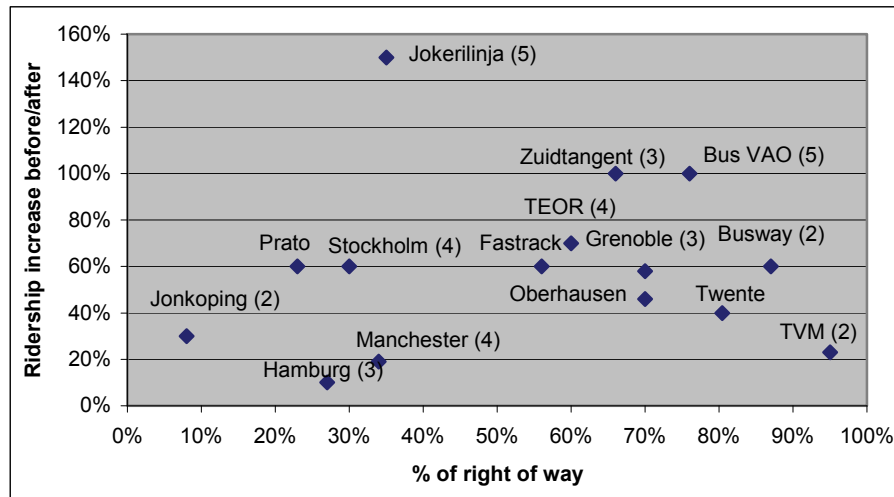


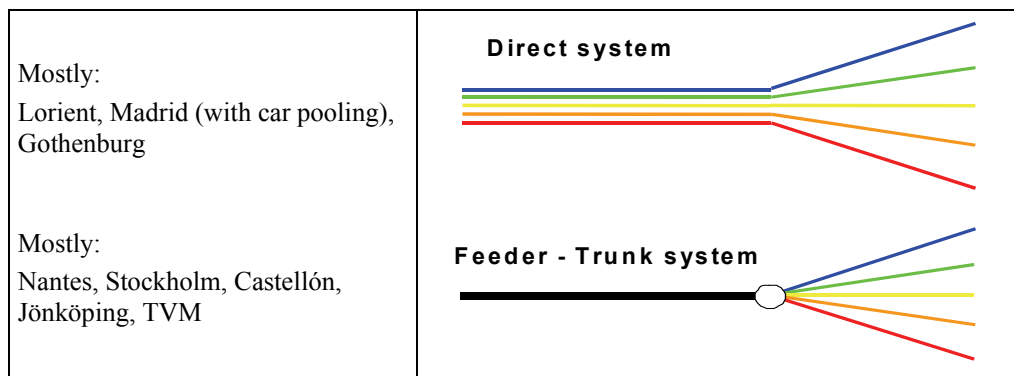
Figure 11: various results in terms of ridership increase - the number into brackets means the number of years of this ridership increase

The role of the RoW, with priority at road crossings, allows a better speed particularly at rush hours, that can last few or many hours. Hence the regularity along the day will be better (much more stable running time along the day), that allows then to get a higher frequency and the capacity expected in these rush hours.

The importance of RoW, and its various configurations, A, B, C, (static or flexible) are tools which are justified by the local context and the “regularity” problems to be solved.

A higher speed is observed for peripheral routes, where much wider distances between stops can be implemented. In these cases, then “A” infrastructure types are much more possible and also suitable for achieving a high speed, the economical factor for any scheme.

### C- Different service layouts or network concepts



As seen in the graph above, we observe two different ways of designing the services into a corridor:

- The direct system allows maintaining of the existing routes, in order not to increase the transfers (which are not attractive for passengers).

- The trunk system tends to increase the transfers, as it is observed generally in a tram, and much more in a metro project.

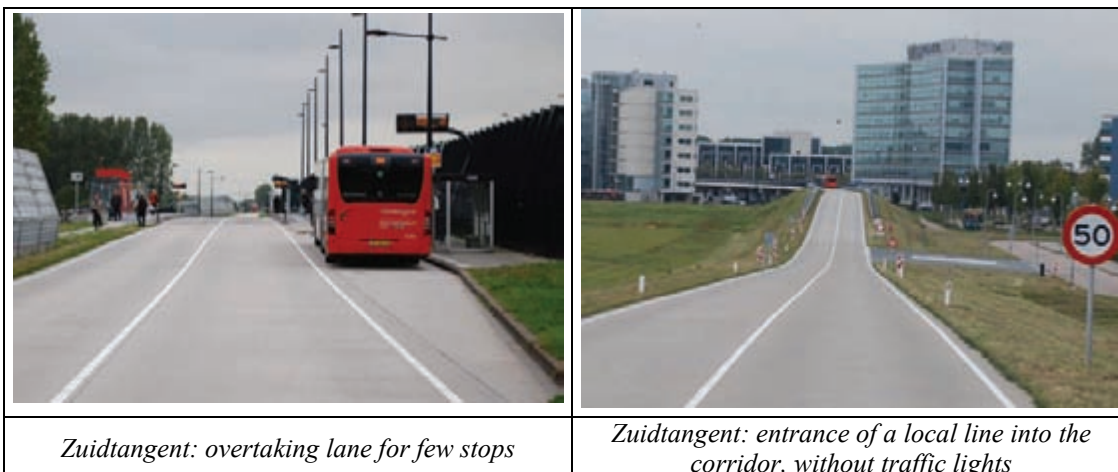
Several BHLS schemes combine these two trends, such as the TVM or the Zuidtangent that integrate some secondary smaller bus lines in limited sections, mostly into the busiest sectors. There is actually a high interest to help the secondary bus network and make a better intermodality among them.

Often the study of passengers' mobility shows that when very few bus lines are crowded in the trunk section, then it can be more efficient to optimise the flow by restructuring the network creating connections merging the flow on few strong BHLS lines.

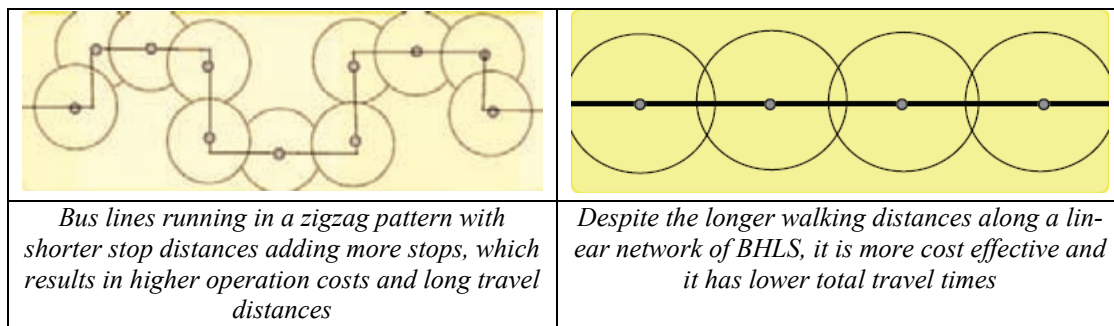
The major constraint on such trunk sections is to manage the flow at road crossings, due to the limits of turning green phases with a high / irregular level of crossing bus flow.



*In Gothenburg, the bus line 16 is the highest capacity route. Bi-articulated buses have their own bay, the first on the left. The second bay (behind) is for all other lines running in the trunk section.*



Regarding the whole design of the route, a stylized picture shows ordinary city bus routes versus BHLS schemes like a metro approach:

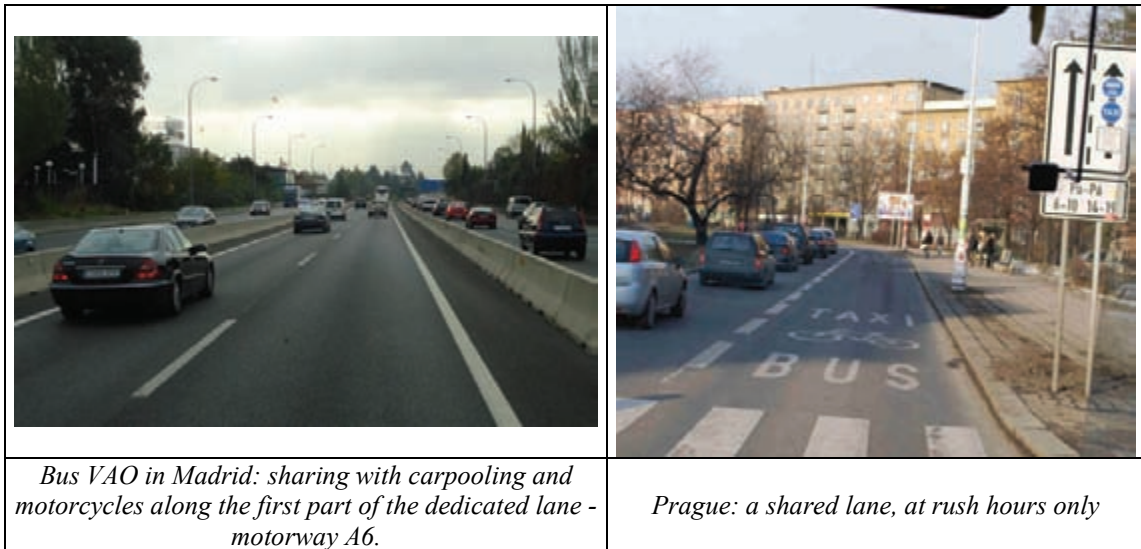


**D- Shared ROW observed with other modes, like taxis, bike, carpooling, motorcycle.**

Generally, most of the BHLS described are not compatible for sharing the dedicated lanes with other modes. The reasons are mainly as follows:

- The most complete or full “BHLS” have a heavy frequency.
- When the distance between stops is long enough (more than 400 m), the bus can reach easily a 50 km/h speed, that becomes to be not compatible with bicycles speed.
- The road crossing priority management is more difficult, the other modes do not want to follow the same RoW after the crossings.
- Safety issues at stops.

However trade offs should be studied and can be possible in some contexts, such as short section in the city centre or in constrained areas (e.g. Prague, Manchester, Dublin); The case of Madrid on a motorway is impressive and shows efficient results.



We can state:

- In case of median bus lane, any sharing with bikes should be discouraged
- Cyclists are very often not disciplined (even more likely in countries with a high level of cycling), so that bus drivers will be always concerned with intrusion by cyclists, and mostly if the cyclists cannot have an other safe way.
- The cohabitation between bus and bike is more suitable in dense urban areas, but not in suburban areas (where bus speed is higher).
- The difficulty to set up design rules, as more experience and evidence are needed.
- The interest to launch a specific study on safety and efficiency in case of a strong demand, regarding all parameters and possible solutions. Compromises can be acceptable.

### **E- Implementation within a “speed limit” zone, inevitable trade-off**

In city centres, more and more traffic calming zones are appearing, in order to improve the walking and cycling modes. BHLS projects are then faced with crossing these pedestrian streets, 30km/h zone, or 20km/h zone, which give a full priority for pedestrians.



*Lorient: the zone 30 in city centre*

Avoiding such zone is not always possible, and then a compromise needs to be found.

Some good solutions have been observed, as they remain short and well organised.

In the case of Lorient, the city centre sector is a 30 km/h zone. The BHLS RoW is central, where the bikes are allowed (picture on the left). However the bicycles could be better with the cars at rush hours in such a good 30 km/h zone.

The case in Hamburg: the Metrobus is implemented into a not very long 25 km/h zone that is one of the biggest commercial zone in city centre. All the bus lines with the Metrobus line appears to be rather respected by pedestrian and bicycles, so that the buses can keep their regularity with a lower speed.

**F - Bus lane Signalisation / protection / contrast / enforcement**

Bus lane enforcement remains a key-issue for all these projects, as the culture of North America with heavy fines (up to \$500) is generally not observed in Europe.



A strong colour contrast of the RoW is always a benefit as it provides a visible solution highlighting bus priority and should aid enforcement. This is in the cases of Rouen, UK in general, Castellón, Paris TVM, where the red colour has been chosen.

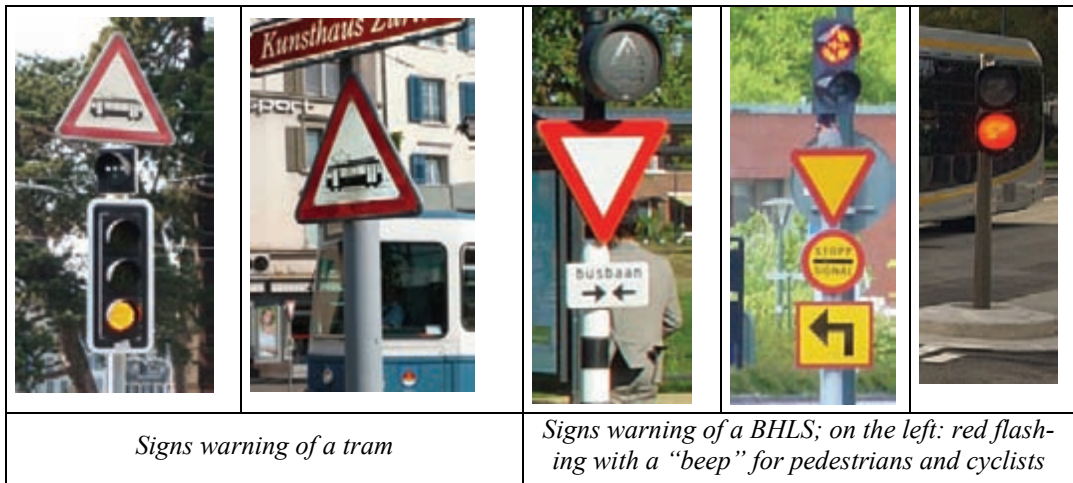


*Rouen: the good red contrast of the scheme – city center.*

Car traps have been observed as a means to protect the entrance of some dedicated lanes, such as in the Zuidtangent, in Almere, in Jönköping, and in Cambridge. However, they are not so suitable for core urban areas.



*Zuidtangent: protection of the dedicated lane - (same tool seen in Almere and in Jönköping)*



*BHLS needs the same priority rules that the tram have.*

We observe above, that a logo of a bus is always missing into the warning sign for BHLS, and by the way, there is an interest to give to this bus the same priority rules than a tram.

Signage cannot solve problems of bad or confusing design, especially when there is inadequate visibility or sightlines



*Twente; access control with barriers and traffic lights*



## **G - Pavement structure and rutting issues observed**

Two pavement structure types are observed: asphalt and concrete. The choice issue (asphalt v. concrete) is challenging for two main reasons:

- Regarding the life cycle cost, concrete technology is less expensive in terms of maintenance although capital investment is more expensive (+ 20 up to 30%). It has a much longer life cycle (40, 50 years generally speaking). The schemes “Zuidtangent” and “Twente” are in concrete all along the route.
- Regarding pavement rutting issues, the main problems are mostly observed at stations, but they also appear along running ways of guided systems or along narrow running ways. The concrete technology appears to provide a much better solution in the long term. It is widely chosen in northern Europe (Sweden, UK, Netherlands, and Germany) and in Switzerland.

Asphalt technology is generally used for running ways, when the width of the lanes can be comfortable. Pavement rutting can be observed in heavy routes (high frequency, big buses, high load). It can disrupt the quality of the system, e.g. in term of accessibility, comfort.



*Twente agglomeration: the entire running ways are in concrete, for maintenance cost reasons*

*Cambridge: the guideway in concrete allows a cheap maintenance all along the 40 km, without the need for rainwater pipes*

The “percolated” asphalt solution is observed in the TVM, with good results. The width of the TVM running ways remains large enough along the whole route (7 m), so that the surface of the pavement did not need to be renewed until 7-8 years, after providing a very good level of service.

## **H - Widths of the RoW**

In some contexts, especially in older city centres with narrow streets, there are serious constraints to implement the desired RoW. In these cases, a reduced RoW width can be useful. The table below highlights some lane width examples. These are related to the speed limit and should be adapted with regard to the surrounding context.

	One way	Two ways
30 km/h	3,25 m	6 m
50 km/h	3,50 m	6,50 m

*Table 6: some data from the French BHLS guide book 2005, to be adapted regarding the local context*

## **Conclusion**

Dedicated lanes with priorities at road crossings	Direct effects	Regularity
		Running speed
	Accompaniment or Attendant measures	Frequency / capacity
		Vehicle capacity
		Sustainable stations in the long term
		Information more stable and accurate (schedule, waiting time...)
Induced effects	Readability of the whole system (dedicated lane, new services)	

*Table 7: the network effects with dedicated lanes*

The role and options for RoW are numerous with direct and induced effects on the performance. Priority at road crossings remains an indispensable component. All these impacts can be summarised in the table 7.

### 3.3.2 Priority measures at road crossings

#### **How to handle BHLS at roundabouts, and the associated priority management**

The design of any RoW through at grade road crossing is a difficult issue. The priority should be to make the bus as efficient as possible. A classic roundabout has 3 drawbacks: no priority in entrance, an entrance more difficult than for cars (long vehicle), a low comfort for passengers.

For these reasons, we observe a lot of designed “straight crossing” through new or existing roundabouts, where cars lose priority inside the ring (e.g. in Nantes, Lorient, Jönköping, Gothenburg). Moreover, in case of a central RoW, roundabouts are very useful for allowing the bus to rejoin the RoW after the intersection.

Based on the BHLS descriptions, we observe efficient results for priority at roundabouts as there is a specific phase for the bus (which is relatively easily to program). However, safety becomes more challenging in more complex environments, and also for big roundabouts where the car speed can be high.



*Lorient : a lot of small traversed roundabouts in the central section where all speeds are limited to 30 km/h; there are no traffic lights due to the irregular bus flow (up to 8 lines)*

#### **Different types of traffic lights, sometimes with priority announcement for drivers**

Considering all the sites visited, there are many advantages to use specific traffic lights for tram and buses in the RoW. These specific traffic lights are with “white symbols”, for avoiding any misunderstanding with the common coloured traffic lights. In France, such signals are only allowed for tram and buses, so that the RoW cannot be shared with bikes and taxis.

Below, 3 different types of such specific lights which have been observed, that cannot be mistaken with the common road lights:



*3 types of traffic lights for tram and bus: Hamburg, Zurich, Twente, Stockholm*



*Almere: announcement of the green phase, allowing a limited speed of the buses, at not over 40 km/h, for safety and comfort reasons*



*Nantes: the R24 sign stopping the cars into all roundabouts (the same for the tram)*

In city centre, often there are several PT lines converging at same crossings. Generally there is a low level of car traffic, a low speed, but a high level of active modes.

In these situations, the best solution is often to manage without traffic lights (tram has anyway priority).

As seen in the picture below, in Zurich, the choice is to maintain always the policeman for traffic control at peak hours only:



*Zurich, city centre, where several tram lines and the bi-articulated bus line 31 are converging*

### 3.3.3 Stations / stops design

In BHLS systems, a station (see definition in the glossary) is not a simple bus stop that can be easily displaced for any reasons (e.g. for works on underground networks - water, gas, etc.). A station is built for permanence, it structures the space around itself, in accordance with its role as a core line like a “full” BHLS.

Hence, for a station, all underground networks should be diverted.

#### **A – Effect of the distance between stations**

This factor is actually strategic for the economy of the project; the correlation with a higher running speed remains indeed fundamental as seen in the figure 12 below.

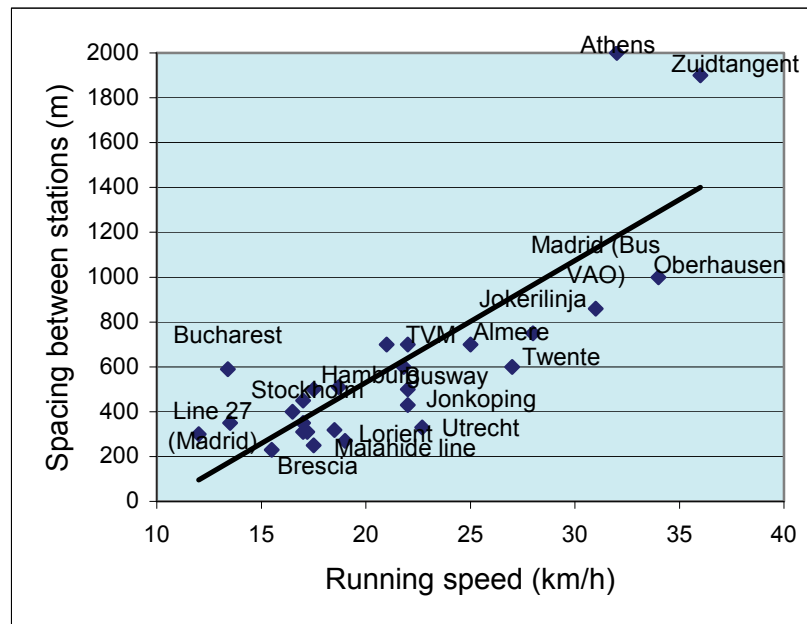


Figure 12: Strong correlation between spacing and running speed.

We observe mainly that:

- Enlarging the stop spacing to over 400 / 500 m (on average) appears to be a minimum for an urban BHLS scheme. In Stockholm, for example, the stop spacing average was initially “200m” and was afterwards increased to 450 m, for financial reasons (better speed).
- The spacing varies a lot between central areas and suburb for peripheral schemes, as seen for:
- Zuidtangent: the spacing varies from 700 up to 5000 m along the section on the motorway (big variation for Purmerend too).
- Cambridge: the spacing varies from 400m in the urban sections, up to 2500m on the guideway between the population centres.
- The lowest stops spacings are seen in Madrid line 27 (300 m), in Utrecht (350 m), that are implemented in high dense areas and in Lorient (270 m), in Dublin (250 m). These schemes aim to maintain the same stops than before, and to get improvements only with the help of the RoW.
- WG3 and WG2 have identified that increased distance between stations lead to drawbacks for passengers who have then a longer walking distance,. This is a problem for elderly or disabled people.

### **B - Comfort, design, equipment observed**

A station (in a dedicated lane or mixed traffic sector) requires high safety for pedestrian crossings, enough bays according to the demand, a straight entrance for the buses, a sufficient width of platform according to the demand, the accessibility for all disabilities, all expected features for an attractive and readable design (branding of the route).



The most impressive BHLS stations are observed in the most complete or full schemes. Examples include Nantes, Rouen, Paris TVM, Zuidtangent, Kent Fastrack, Cambridge (in operation since august 2011), Helsinki Jokeri line, Lorient, Jönköping. These stations play a key role in the identification of the BHLS line, and along the entire route.

Busway: a specific design for all the stations, here the most impressive, junction with the tram line in city centre

Lorient: an impressive “straight” design of the infrastructure allows smooth ride quality.

All of the biggest schemes have adopted ticket vending machines into most or all stations. Examples include Nantes busway, Zuidtangent, TEOR Rouen. Other BHLS of lower capacity/throughput have also adopted vending machines at stations, e.g. Kent Fastrack, Cambridgeshire Guided Busway.

Selling tickets by drivers is not efficient, it can cause serious delays at peak times. It can also disturb the priority request at traffic lights.

A strong trend “intermodality with cycling” has been observed in Netherlands, Sweden and UK, so that almost all stations have some space dedicated for “B+R” (Bike and Ride).



*Twente, bicycle parking at almost every station*



*Cambridge: a wide platform with a great intermodality with bicycles at almost every station*

### **C – Quality of dockings / Guidance practices: trends**

Investment in a high quality of docking at all doors is very important for high capacity BHLS. It reduces dwell times, while providing a high level of accessibility.

Without a guidance system, the design of the stops should integrate a straight entrance, and a kerb height compatible with the type of bus, and with the type of ramp fitted (height from 18 cm up to 21 cm generally – except in Nantes Busway where the height is 27 cm and works with innovative “mini” ramps 30 cm at two doors).

*Guidance systems need a full BHLS approach*

Guidance systems	Advantages	<i>Regular gaps, accessibility for all – gap at or less than 5 cm</i> <i>No ramp</i> <i>No or less contact tyres / kerb</i> <i>Improved dwell time (regularity, speed)</i> <i>Image of the system</i> <i>Site protection with the kerb guidance</i> <i>Riding comfort</i> <i>Compatibility with a tram (same kerb height – around 30 cm)</i> <i>safety</i>
	Drawbacks	<i>A specific fleet is requested.</i> <i>No docking at same bays with common buses.</i> <i>Barrier effect with mechanical kerb guidance.</i>

*Table8: analysis regarding the interest of a guidance tool – Source WG1 discussion*

3 different types of bus guidance have been seen or described in this COST action:

- Optical guidance in Rouen (since 2001) and in Castellón (since 2008).
- Mechanical kerb guidance in Cambridge, firstly developed in Essen in 1980 and several cities in UK (Leeds) also outside Europe<sup>35</sup>.

<sup>35</sup> In Cleveland (USA) this system has been recently implemented, but only with one guiding wheel on the right, without the left guiding kerb, that should well protect the tyres at each station.

- Magnetic guidance in Douai (Not studied on its guidance aspect, because not yet homologated).

Such guidance systems remain a useful tool for high capacity, which may then justify the additional cost. A good level of infrastructure along the whole route (BHLS approach) is needed for achieving the success expected. Even if the two first systems are different we can state in the table 8 their common advantages / drawbacks.



*Manual ramp: observed in all BHLS schemes in Sweden, Netherlands, Germany; suitable due to a very low use throughout the day, even into the bi-articulated bus of Hamburg; handled by the drivers.*

#### **D - Quality of the pavement at stops (problem of rutting)**

The use of concrete technologies (full concrete) are observed mostly in the North and central Europe (in Sweden, UK, Netherlands, Germany), and also observed in Switzerland.

This choice provides a surface that gives long life and very good docking, and provides an interesting contrast at stop areas.

The “percolated” asphalt can be an alternative solution, although not for a heavy use; it has been chosen for each station in the Busway of Nantes.



#### **3.3.4 Flexible / unusual or innovative RoW layout**

Some very interesting examples have been observed, which are presented below. They can give ideas for further innovation:

##### **An alternative RoW solutions, along a narrow corridor**

The case of Rouen shows a good example. The bus enters into the RoW before the road crossing for getting priority and, becoming the first vehicle, runs afterwards in mixed traffic.

##### **A one-way along a station, in a constrained section**

The case of the Busway in Nantes shows an efficient short “one way” section at a station. There is no signalisation, although it operates at a high frequency (3 minutes).

### **A one-way into the RoW**

The case of Almere shown below, a tool for calming the speed of busses.



### **A one-way through a road crossing without signalisation.**

The Twente scheme is located in a low dense area. The image shows below an example of a bottleneck or a “one-way” just through the road crossing, that provides a better protection for pedestrian crossings, while also providing waiting spaces for the left-turn movement for cars.



*Twente scheme: One-way at the road crossing*

### **Overtaking lanes at station in heavy corridors**

The case of Gothenburg shows one of the best example of overtaking lanes. The BHLS line is well prioritised in a trunk section that also has several secondary lines of lower capacity. The connection with these lines is then efficient (photos in § 3.3.1 C). The cases of Almere and Zuidtangente show other examples; several lines are operated along the trunk section and do not stop at the same stations.

### **A RoW crossing a roundabout without traffic lights**

The case in Lorient is a good example, implemented in a zone “30 km/h” (photo chapter 3.3.2).

### **Bus lanes only used in peak hours**

Good examples include the case of Zuidtangent on the emergency lane of the motorway with only static signalisation, and the case of Purmerend with buffer points and barriers.

### **Barriers for protecting a bicycle crossing through a Zuidtangent section at 70 km/h**

A protection for safety reasons that allows the BHLS scheme to maintain a good speed (see photo page 93).



*Warning lights on ground at the crossing for the cars, flashing at each bus arrivals.  
The yellow sign states: "Traffic situation changed"*

### **Road crossing without traffic lights, but with warning lights for cars.**

The Twente scheme above illustrates a small road crossing without traffic lights. Car drivers have a "stop" with small warning lights located on the ground across the width of their lane, before the crossing point; these lights are switched on "red" when the bus arrives.

## **3.3.5 Role of infrastructure tools within the overall system performance**

The infrastructure sub-system integrates many components. Each can play a role in the overall system performance, often in interaction with other infrastructure components.

In reference to the sites described and visited, WG1 set up a table that highlights all these types of interactions and possible roles in the overall BHLS performance.

The reader will observe that:

- All components contribute to the overall performance, with some complex interaction. There is also interaction with the two other sub-systems: vehicles and operations.
- Several different technical skills are needed in the design of BHLS including road safety, traffic management, road structure, operating management, and architects.
- The "infrastructure" sub system will always be the backbone of BHLS. Each city service has its own unique problems that require its own research and solutions.
- For managing this complexity, there is a need to create a "project team" or "project committee" where all technical aspects can be represented, from design to implementation.

The table can be seen in the attached CD.

## **3.3.6 Urban integration / enhancement / intermodality**

As with any transportation project such as tram, urban integration within an efficient intermodality is a key issue for achieving ridership success. However the associated costs can



sometimes be heavy. The additional cost can be as high 20 to 40% of the whole budget, depending on the quality level of the investment. Local constraints will always play a role in this additional cost. Several aspects should be taken into account:

- Quality of works and architect requirements (old district, old buildings, etc), linked with the image of the district, or the image of the city,
- Car space suppressed (parking, car lanes) and other Park and Ride to be built.
- New pedestrian and cycles ways.
- Branding of the system itself, by the stations, by the features all along the route, etc.
- Intermodality (linked with the urban planning objectives) with cycling, other modes.



In all the impressive system approaches, like Busway, TVM, TEOR, Lorient, Jönköping, Lund, Zuidtangent, Twente, Almere, Fastrack, the BHLS projects have supported urban regeneration or development along the whole scheme. In UK (Fastrack and Cambridge), Netherlands, Germany and Sweden, it was recognised that there has been significant investment in intermodality with cycling. This is observed at central rail stations and also all along the route.



### 3.3.7 Infrastructure costs

The two figures below show the different infrastructure costs, covering running ways, stations, and all works and components needed to implement the RoW, such as bridges, tunnel, cycles or pedestrian ways, square enhancement, etc.

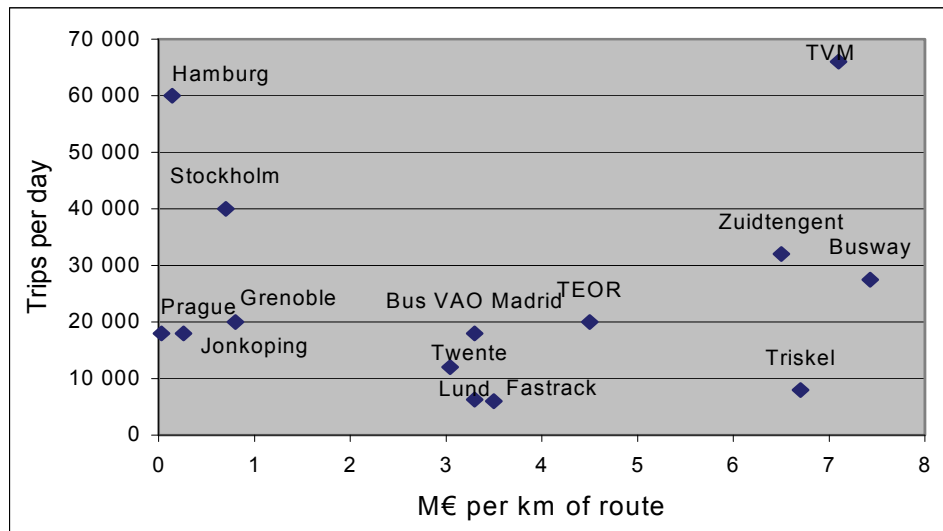


Figure 13 : infrastructure investment cost Vs ridership

These costs do not take into account vehicles, workshops or a totally new AVM system, as these usually cover all the bus network. The traffic priority measures are however integrated, such as priority at traffic lights.

All the most expensive cases (TVM, Triskel, Zuidtangent) involved a significant degree of civil works, such as some bridges, tunnels (a big tunnel is observed under the airport tarmac for the Zuidtangent), or heavy cost in interchanges (the case of Nantes Busway, interchanges Graineraie with feeder bus lines and a P+R).

The heaviest cost observed (outside the range of figure 13 and 14) is Oberhausen, 15 M€ / km along the impressive and exclusive dedicated lane for tram and bus lines. This is 100% type A.

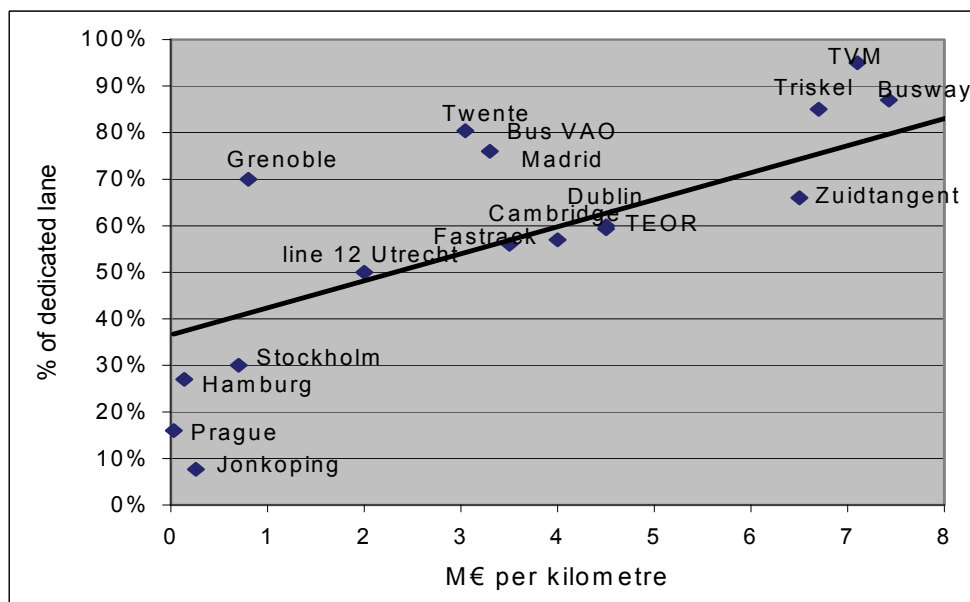


Figure 14 Infrastructure investment cost versus RoW

As a conclusion, some cost figures related to the 3 types of infrastructure, with some comments:

	Infrastructure cost M€ per km	Observation
Type A	15 / 30	With not too heavy constraints, highest priority
Type B	6 / 10	Priority at crossing generally easier than type C
Type C	1 / 4	Disruptions linked with the street activity; More suitable for sharing the space with bikes / taxis.

*Table 9: Infrastructure cost of the different RoW types observed.*



*Madrid: BusVAO, north entrance of the reversible dedicated lane*

### 3.4 Rolling stock issues, by WG2

This section is presented in 3 parts.

The first part (Qualitative aspects) presents the observed practice relating to rolling stock in Europe’s BHLS systems. It considers the following features: bus models, accessibility, number of doors, guidance systems, comfort on board, information technology and other support systems, energy, fuels and drivelines.

The second part (Quantitative aspects<sup>36</sup>) deals with some specific items of interest on which WG2 organised relevant research or analysis.

The third part deals with some points to monitor regarding the bus choice.

#### 3.4.1 Analysis on qualitative aspects.

BHLS vehicle layout includes several aspects such as dimensions, passenger capacity, body type, floor height, propulsion system, guidance system, electronic equipment and other auxiliaries. All of these aspects affect the vehicle’s ability to transport passengers efficiently and in reasonable comfort.

##### 1 - Bus models

System designers have many vehicle size options. Each vehicle type allows different running service parameters. High volume systems will likely require large sized vehicles. The main advantage of larger vehicles derives from reduction in operating costs (especially driver labour costs). However, in low demand corridors, these large vehicles would not be recommended under a “High Level of Service” perspective, as they might tend to lower frequency, and hence longer waiting times for passengers.

The capacity of vehicles equals the number of seats plus the number of standees.

Typical vehicle capacity	Length (m)	Vehicle capacity (passengers)
Standard bus	12	80
Double Decks	12	95
Articulated bus	18	120
Double-articulated bus	24	150
Tram	43	280

Table 10: Comparison among different rolling stock based on 4 persons/m<sup>2</sup> as design standard



< Double-decks buses: a good image both in the UK and Ireland (here DublinBus) , easy for narrow streets.

<sup>36</sup> A general criterion has been adopted for these indexes, taking as reference the one reflecting specific energy consumption, whereby Continental operators refer to fuel consumption using the ratio fuel volume units per kilometer (usually liter / 100 km, or Nm<sup>3</sup> / 100 km in case of gases). It should be noted that in this case “the higher (consumption), the worse (scenario)”, and similarly all ratios will be defined with this same approach.

Typically, single-deck buses have an overall height from the pavement of 3,4 m, whereas low-floor CNG buses with storage tanks on the roof can be up to 3,8 m high. Double-deck buses are often commissioned (Berlin, U.K., Ireland). They require special permits due to heights over 4 m, the maximum permitted height for heavy-duty vehicles under European regulations.

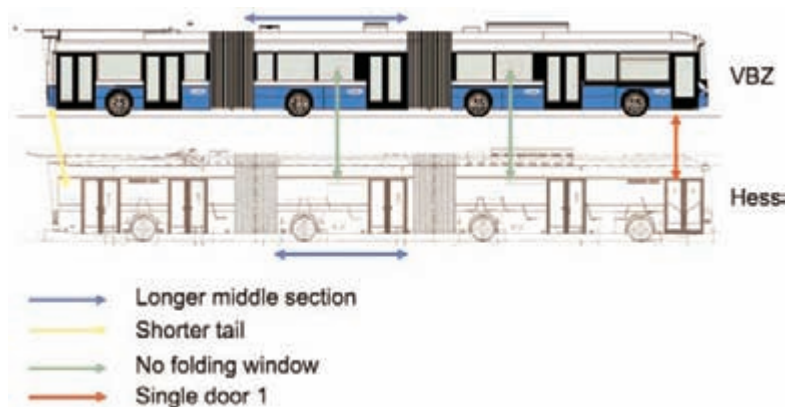
Vehicle size, number of doors and door arrangement affect the dwell time. Most vehicles require about 10 seconds to open and close their doors and pull in and out at a bus stop. However, if the vehicle is larger, an additional time per meter is generally required.

The 18 m articulated vehicle is becoming a common main stream solution for BHLS schemes with high capacity. An articulated bus compared with a standard bus provides:

- higher line capacity, in terms of passengers / hour / direction;
- lower cost per space-km;
- more spacious vehicles;

Disadvantages are represented by more complicated turning geometry and manoeuvres at terminals, and by lower acceleration and lower uphill performance.

A growing number of local authorities and public transport companies in Europe are interested in the possibility of using double-articulated buses 24 metres in length in order to meet even higher capacity needs.



*Vehicle module changes (courtesy of VBZ Zürich) – Improving manoeuvrability and accessibility*

This type of rolling stock is, however, relatively rarely implemented in Europe. There are several reasons for the current dominance of single-articulated over the double-articulated:

- large numbers of single-articulated vehicle orders have produced cost savings through economies-of-scale in manufacturing;
- currently only a few manufacturers offer a double-articulated vehicle, and thus limiting the play of competition during the bid process;
- the length of double-articulated vehicles (24 m and over) requires an adapted infrastructure (length, docking) at stops and at maintenance workshop.

Design studies are in progress to respond to changing needs in terms of image.

## **2 – Accessibility, doors and ramps, guidance**

All the efforts applied to vehicle size can be lost if the vehicle impairs smooth passenger flows. After the physical length, the floor height over ground tends to be one of the most crucial physical characteristics of the vehicle. Vehicle chassis tend to be produced in certain standard floor heights. There are three options:

- high-floor
- 100% low-floor
- mixed low-floor/high-floor (usually 65 to 70% low-floor), e.g., low-entry design.

From the perspective of BHLS schemes, operating with platform level boarding, the two types of vehicles potentially applicable are full and partial low-floor. Also, considering cur-

rent European directives, vehicles must be accessible and consequently in urban service low-floor buses are currently the most widespread models across Europe.

**Low-floor vehicles** make passenger boarding and alighting faster and more convenient: boarding times on low-floor vehicles are reduced by 20% compared with high-floor vehicles. This time reductions can result in higher patronage and greater capacity without increasing the number of vehicles. No-step, no-gap boarding and alighting can significantly reduce the time it takes for customers with disabilities or customers with children in strollers or prams to board and alight from vehicles. The size, number and the location of the doorways all play a role in facilitating efficient boarding and alighting.

Door channels	Boarding	Front alighting	Rear alighting
1	2,0	2,8	1,6
2	1,2	1,5	0,9
3	0,9	1,3	0,7
4	0,7	0,9	0,5
5	0,5	0,6	0,4

Table 11: boarding and alighting times (seconds per passenger for the bus)



In Ostrava (CZ) trolley-bus with 4 doors

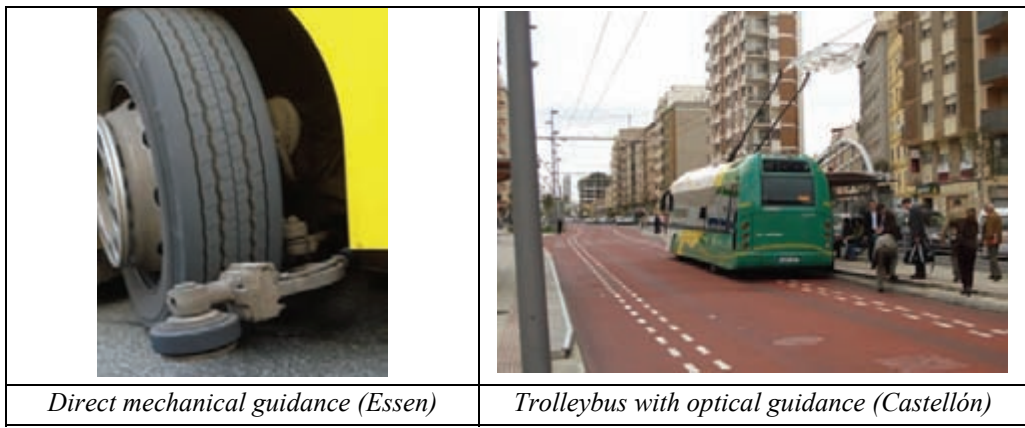
In Prague: bi-articulated bus with 5 doors

**Different types of doors** are observed in use: Swing Doors, Bi-Fold Doors, Plug Doors and Pivot Doors. Bi-Fold Doors that hinge in the middle, as well as at the outside vertical edges, are ideal for BHLS applications. However, bi-fold doors may protrude outside the vehicle, limiting how close to platform edges a particular vehicle may come. Another possibility is represented by sliding doors. These are very effective where wide openings (in excess of 1.2 m) are needed because they can be opened with no internal or external protrusions, although the opening/closing mechanisms can be complex. Many vehicles have also door flap plates or “bridges” that rapidly deploy from the vehicle over the gap to the platform.

**Concerning guidance**, a variety of configurations exists, which can be grouped according to the technical solution adopted:

- *Direct mechanical or kerb guidance*, using guiding wheels rolling in contact with the curb and screwed upon the vehicle steered axle arm. Once on the guideway, the operator does not steer, but applies only power and braking. After leaving the guideway, driver steering is reactivated (Essen since 1980, Leeds, Cambridge since august 2011);
- *Central rail guidance*, using a central rail in the roadway; not implemented in the studied BHLS systems. The TVR system appears to be now abandoned (low level of availability); the Translohr has a continuous mechanical guidance, so that it is classified as tram.
- *Optical guidance*, using cameras mounted in front of the vehicle above the windscreen. They detect two parallel stripes painted on the roadway in relation to the lateral position of the vehicle and transfers the relative position data to a computer that actually steers the vehicle with a servo-motor (Rouen since 2001, Castellón along the whole route since 2008);
- *Magnetic guidance*, using magnets embedded in the pavement, detected by sensors on the vehicle, which support an electronic steering mode. Sensors consisting of multiple magnetometers, compare the relative field strength measured by each magnetometer. From those measurements, the lateral distance to the reference magnet is determined and consequently corrected (Douai, guidance mode not yet approved, the homologation is still awaited).

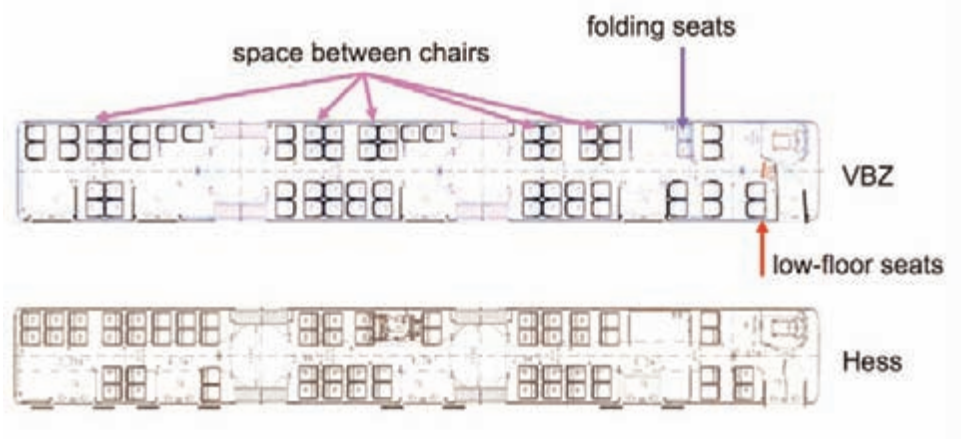
A guidance option need a good level of infrastructure.



Also, further distinction can be made between guidance at stations (Rouen) only and *full guidance along the whole route* (Castellón, and often the kerb guidance). In all the cases vehicles have the technical ability to switch into unguided mode. In the second case, with kerb guidance, guidance along the whole route should imply less width in the segregated lanes, and as a consequence, a lower consumption of space.

*Good and regular gaps are fruitful for high capacity.*

**3 - The particular aspect “comfort on board”**



*Interior layout arrangements (Courtesy VBZ Zürich)*

Internal vehicle design can maximize the number of people each bus can carry, rather than maximise the number of seated passengers. A smaller number of seats increases the total capacity available on a particular vehicle bodywork. If the average trip length is moderate (urban mobility), a higher ratio of standees may be more appropriate and acceptable. A seated passenger occupies approximately 0.35 square meters. Average standee density, as specified by the International Union of Public Transport (UITP), is 4 people per m<sup>2</sup> (0.25m<sup>2</sup> per passenger). The maximum load of a crowded bus<sup>37</sup> is computed assuming an occupancy of 8 passengers/m<sup>2</sup>, thus corresponding to some 0.125 m<sup>2</sup> per passenger. On the other hand, fewer seats provide a more open interior with better circulation characteristics. The number of seats is also very much influenced by the number and location of doors and, on low-floor buses, intrusion into the vehicle interior of wheel wells, fuel tanks, and engines.

Dublin QBC	Nantes Busway	Hamburg Line 5	Lisbon Junqueira	Amsterdam Zuidt'gt	Zurich Line 31	Stockholm Line 4	Pisa LAM	Red-30
84	34	41	38	34	48	38		30

*Table 12: “Sitting comfort”, % of seats in total capacity  
Data from COST 603 System Description Sheets*

<sup>37</sup> From a perspective of safety and braking behavior.

*Speeding up boarding and alighting is a key issue for BHLS.*

Aisle width influence vehicle capacity. Most conventional low-floor vehicles have a minimum aisle width between the rear wheel wells (second and third axle on articulated vehicles) of about 60 cm. The constraint is the width of the two tyres on either end of the axle, the geometry of the axle’s suspension system, and the need to clear drive train components.

Constrained circulation within the vehicle increases passenger service times at stops because (a) it makes it difficult for people in the interior of the vehicle to get off; and (b) it makes it difficult for boarding passengers to circulate to the vehicle’s interior, causing crowding around the doors and reducing useful capacity.



Several BHLS vehicles have passenger circulation enhancements to speed up passenger boarding and alighting as well as circulation within the vehicle. The provision of additional and/or wider door channels improves circulation, as can various seat layouts, including those allowing for wider aisles, and alternative wheelchair fixing positions. A sufficient number of doors should be provided; generally, about one door channel should be provided for each 3 meters of vehicle length.

Buses with doors on both sides are usually operated in airport contexts. The manufacturers confirm that no special difficulties arise in the design of urban buses with doors on both sides, however accessibility and safety questions must be considered and the internal layout (seats) may differ considerably in this case.

Doorway efficiency can also be closely tied to the vehicle load factor and interior design. Once load factors exceed 85%, the area around the doorway will become exceedingly congested. Standing passengers will have little choice but to stand in this area, and thus reducing the effective door width.

Adoption of larger windows (especially on low-floor vehicles) and interior light fixtures that allow for abundant light in day or night to provide an “open feeling” can improve the perception and reality of passenger security. Larger windows for each passenger to see in and out are important for perceived security.

Finally, vehicles should have a high passenger appeal and give passengers a comfortable ride. Desirable features include air conditioning and upholstered seats. Recently developed air conditioning systems require relatively low energy consumption, due to the implementation of more advanced cryogenic fluids and more efficient features.

#### **4 - Information technology equipment**

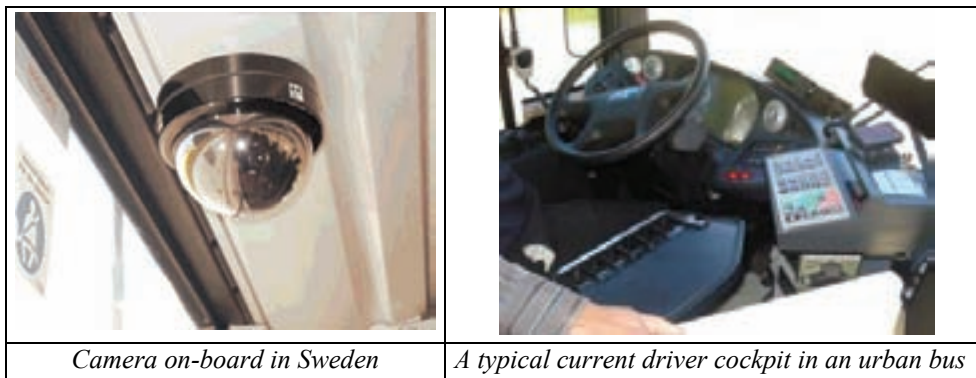
Intelligent Transportation Systems (ITS) is an essential component in a BHLS system, including systems that enhance operations by improving operating efficiencies, increasing service reliability and reducing travel times. ITS in a well-designed BHLS vehicle can include:

- Automatic Vehicle Monitoring systems, (AVM, ‘SAE’ in French) is a key system for monitoring and management of the services. It is based on determining the real-time location of each vehicle, which is equipped with the required hardware and software. The most popular



technology currently used to determine location in an AVM/SAE system is the global positioning system (GPS).

- Transit signal priority, which can alter signal timing to give priority to public transport vehicles. This allows vehicles to improve schedule adherence, reliability, and speed.
- On-board passenger information, usually includes information on the next stop, vehicle schedule, transfers and delays. This is accomplished using an automatic announcing system, consisting of dynamic message signs on-board the vehicle and an audible message of the same information displayed. On-board passenger information can be utilized to display and announce advertisements, making it a potential source for additional revenue. Video displays on-board vehicles may provide entertainment (news and general information), thus giving attractiveness to the service.
- On-board cameras, providing remote monitoring and recording of the passenger environment on vehicles. On-board cameras are a form of crime deterrence. Also, cameras can provide information on driver behavior by recording drivers' actions. Further, camera images can be used to review the seconds just prior to an accident to determine fault and suspected offenders.
- Collision warning systems alert vehicle drivers about the presence of obstacles or impending impact with pedestrians or obstacles. These technologies use microwaves (radar) to scan the environment surrounding the vehicle. Upon detecting an obstacle, the system automatically warns the driver. A similar but more advanced system being developed (collision avoidance) upon detecting an obstacle, has automatic control to decelerate the engine and / or apply the brakes in case of lack of driver response.
- Precision docking assists drivers in accurately positioning a vehicle at a stop location in terms of both longitudinal control (parallel to the station) and lateral control (side-to-side). Sensors continually determine the lateral distance to the curb, front and rear, and the longitudinal distance to the end of the bus loading area.
- Automated Passenger Counters (APC), which automatically count passengers as they board and alight. The main technology used for passenger counting is infrared sensors mounted in the doorway that detect people passing through the infrared beams. (Note that APC has not been observed at any of the visited BHLS systems).



## 5 - Energy, fuels and drivelines

The choice of propulsion technology will have a deep impact on system performance, operating costs, maintenance costs, supporting infrastructure, as well as on travel comfort, environmental impacts, attractiveness to customers, and service reliability. Bus propulsion systems should be “environmentally friendly” by minimizing air pollution, green house gases (CO<sub>2</sub> mainly) and noise. European regulations enforce this feature, especially through Directive 2009/33 for the promotion of clean vehicles in European space. This requires an environmental impact appraisal of bids, including monitored costs of pollutants, CO<sub>2</sub> and fuel, during the whole operating time of the buses.

Most common fuel options currently being considered for internal combustion engines are<sup>38</sup>:

- standard diesel;

<sup>38</sup> For more information, the outputs of the UITP project “SORT”, standardised on-board tests cycles.

- (currently enforced in Europe): clean diesel (low-sulphur content), a fuel type that produces lower air pollution (prevention of acid rain), reducing maintenance costs and improving vehicle durability;
- compressed natural gas (CNG), containing no sulphur, and giving extreme low pollution levels through catalyst filters at the engine outlet (EEV emission levels);
- liquid petroleum gas (LPG);
- bio-diesel, derived from biological sources that can be used in diesel engines;
- ethanol.

Fuels in gas form require a somewhat heavier bodywork due to the need of heavier, pressure resistant tanks, mounted on a frame on the roof of the bus, which reduces slightly the capacity:

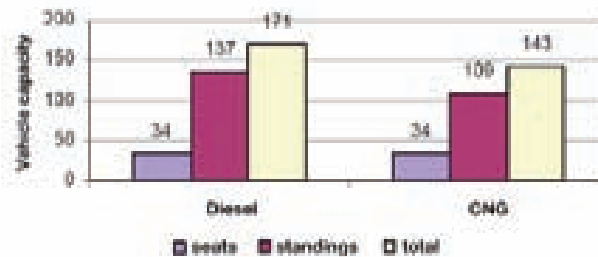


Table 13: articulated vehicle capacity for diesel and CNG energy

Apart from the internal combustion engines, a good environmental choice in urban areas can be trolley-buses. In these systems electrical energy is supplied via trolley poles which make contact with overhead lines; if a mechanical guidance system is adopted, the return current can flow through this central guide rail. Unlike rail vehicles that have only one contact wire because the rails provide the ground, trolley-buses collect power from two wires, one hot, one ground, a fact that can cause some concern in relation with the so-called “visual impact”, as is the case with LRT schemes.

Trolleybuses can adopt on-board energy storage or power generation systems to enable them to operate for short distances away from overhead contact wires, in order to get around obstructions or to get to maintenance facilities if there are central power system problems. These provisions also allow trolleybuses buses to operate without overhead wiring wherever its visual impact is not accepted (historic areas, large crossings).

The strongest advantages of an all-electric vehicle using an external power source are environmental friendliness in terms of both noise and emissions, and very high power and torque output leading to high acceleration rates. Modern electric vehicles also feature much smoother acceleration and deceleration than conventional internal combustion vehicles with multi-shift point hydraulic-mechanical transmissions.

A final advantage of electric vehicles is that because of their lower vibration, all systems (including the electric motors, the air conditioning system, all electronics, and the bodywork) tend to have a longer service life than their thermal fossil equivalents. The disadvantages of trolleybuses are the higher capital costs of the vehicles, the need of an extensive infrastructure (overhead wiring, its infrastructure, the power supply stations along the route, much in the same way as trams), visually-impacting infrastructure, and operational inflexibility.

New systems that are also being developed are dual-mode thermal-electric (the Castellón line, examined in this COST Action), hybrid electric and fuel cell technology.



Fuel cells, and the entire “hydrogen economy”, promise to deliver environmental advantage for the transport system industry, both on tires or by rail, but they seem to be still some years away from massive commercialization and competitive costs.

Hybrid vehicle layout

Nowadays, hybrid systems generate considerable interest, as can be seen in the most recent proposals from almost all European manufacturers, following the trend of the experiences in the market for hybrid buses in the USA.

The choice of the energy storage technology is of utmost importance, as there are several technological possibilities, none of them sufficiently experienced when considering the relatively long life cycle of public transport vehicles.

	Dual mode	Hybrid electric	Fuel cell
Operating principle	Combine an electric trolley bus with an internal combustion engine capable of providing full, stand-alone performance.	Capture energy that is normally lost through braking and coasting to recharge the incorporated batteries or ultra-capacitors, which in turn powers the electric motor without the need for plugging in.	Utilize hydrogen and oxygen to directly produce electricity in the presence of a catalyst, without engines and alternators of any kind.
Possible configurations	1) one axle is driven by the electric motor, the other by the internal combustion engine; 2) using an internal combustion engine and a generator/alternator to provide electric power to the motors that actually turn the wheels, thus avoiding the need for both an electric motor and a mechanical transmission.	1) using the electric motor or the internal combustion engine to propel the vehicle (parallel hybrid) 2) using the electric motor to provide added power to the internal combustion engine when it needs it most (serial hybrid)	1) involving the use of hydrogen gas carried in high-pressure cylinders (up to 350 bar pressure); 2) hydrogen can be obtained from a liquid fuel, such as methanol, in a reformer onboard the bus.  Most schemes so far adopt solution 1)
Advantages	Combine the performance and other environmental advantages of a trolley bus when they are needed with the freedom of movement of a conventional bus	Have the potential to use electricity to power on board accessories or to provide outlets to plug in appliances or tools. A more constant load on the engine (lower consumptions).	Water vapour is the only exhaust product.  It can run on hydrogen created from a variety of renewable sources. Other than fan noise, fuel cell buses are remarkably quiet, just as battery driven electric vehicles.

### 3.4.2 Analysis on quantitative aspects

#### 1- Energy consumption per passenger

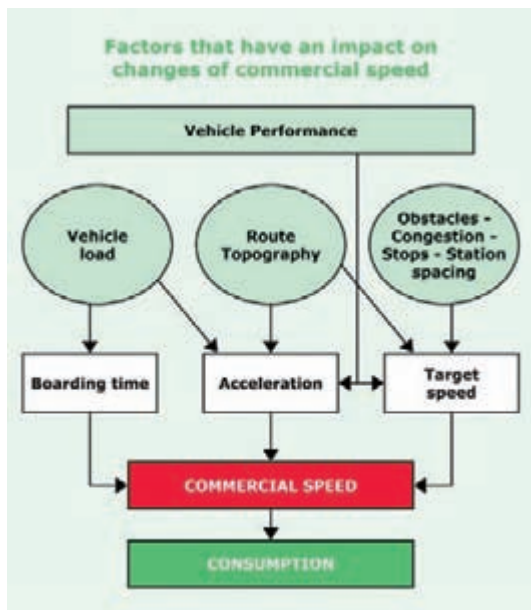
*Table 14: energy contents of fuels and energy carriers - (Directive 2009/33/EC)*

<i>Fuel</i>	<i>Energy contents</i>	<i>Fuel</i>	<i>Energy contents</i>
Diesel	36 MJ/litre	Ethanol	21 MJ/litre
Petrol	32 MJ/litre	Biodiesel	33 MJ/litre
Natural Gas/Biogas	33-38 MJ/Nm <sup>3</sup>	Emulsion fuel	32 MJ/litre
Liquefied Petroleum Gas (LPG)	24 MJ/litre	Hydrogen	11 MJ/Nm <sup>3</sup>

The purpose of this analysis is to show how public transport of high quality or level of service contributes to the reduction of energy needed for mobility, and, specifically, when compared with energy consumed by individuals using private motor vehicles. Consequently, this magnitude may be used as an indication of the requirements for fuel and also of the side effects of air pollution originating from combustion engines.

Data on energy consumption are deduced from the elementary data that have been collected in the Questionnaire "State of the art" (description sheet). In some cases, the records on fuel consumption requested in the description sheets are not made for every single bus, but calculated on the basis of measured or paid fuel consumption and indicative data on specific consumption supplied either by the bus manufacturer or by the engine manufacturer.

From the evidence above it is obvious that a “tank-to-wheel” approach is undertaken, which is useful for the comparison purposes mentioned. However, in the case of gaseous fuels, namely natural gas, an amount of energy which should not be neglected is used at the compression stage of the fuelling station. Luckily enough, the description sheets present data on several fuels, Diesel, Bio-Diesel as Di-Ester, CNG Compressed Natural, Gas Ethanol.



The specific energy contents of all available fuels, liquid, gas, fossil or renewable origin, the allocated costs of the legally limited emissions of carbon dioxide and the relevant life time frame of all vehicle types are also established by current EU Regulations.

According to the table on the right, the consumption is linked with many factors, mainly the infrastructure and the traffic conditions (Graph extracted from UITP’s project SORT - Standardised On-Road Tests Cycles Published in January 2010).

### The case of trolleybuses

In the case of electrical vehicles with external power supply, such as trolleybuses, the available data are given in average energy consumption in kWh / km and therefore require a translation in MJ, which is the energy unit used in Directive 2009/33/EC.

An important fact in this case is the possibility of energy return to the grid through the overhead wires when the bus is braking or running downhill, as the motors can be switched to generators, recovering the kinematic energy, and thus reducing the absolute loss through the braking resistors producing heat. The rate of recovery, according to the available data of the system in question, can be assumed to be around 8,5 %.

### The case of natural gas

Storage of gas on board the bus tanks at a standard 200 bar pressure requires a compression stage with consequent energy consumption. This compression stage can be designed according to two basic options:

- The so-called “slow filling”, usually requiring up to three or four hours.
- The “fast filling” system, whereby the filling station can be arranged exactly in the same way as a normal diesel one, with the filling time needed not exceeding that of fuelling a diesel bus, i.e. around three to four minutes.

An essential component in this compression stage is the inlet pressure of the CNG: the higher this inlet pressure, the lower the energy needed for reaching the final 200 bar in the bus tanks.

### Results

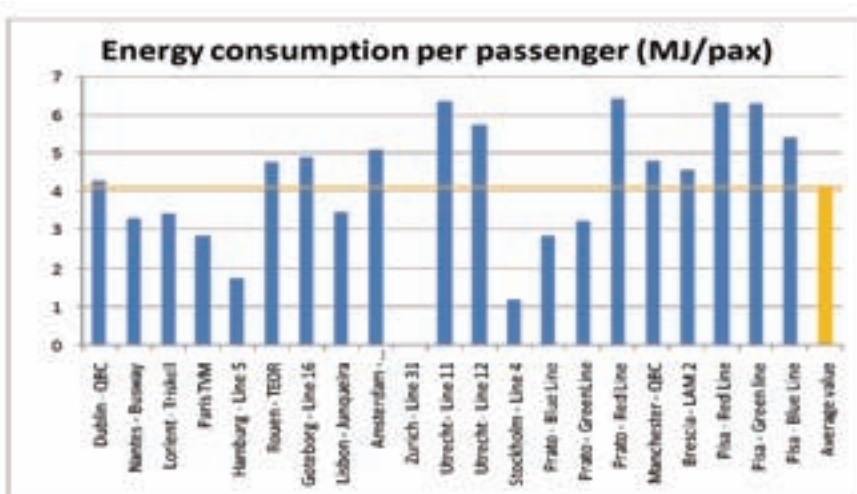
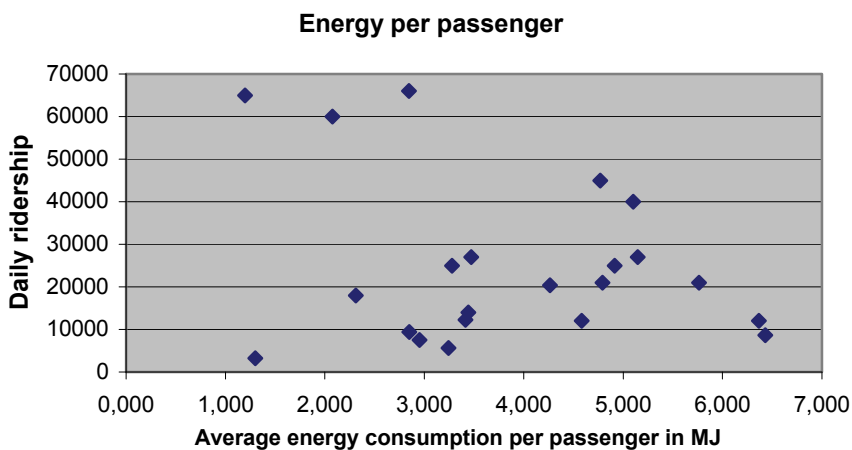
The most important point of energy consumption per passenger shows a low degree of correspondence with the ridership, but follows the general trend of a lower energy per passenger for the bigger capacity systems (from 30,000 trips / day upwards).

As can be seen in the spreadsheet, values for energy per passenger trip range between 1,2 and 6,5 MJ, with a strong concentration around 3 and 5 MJ per passenger trip for systems with around 30,000 passengers trips per day and less<sup>39</sup>.

A "Short Term Scientific Mission" has been carried out complementarily, where by other specific data (namely the "Assessed fuel consumption per passenger place offered") was

<sup>39</sup> The trip length is also a very important factor in the variation in observed values – in fact, it is probably by far the dominant factor but could not be analysed.

computed and presented. (reference “Energy consumption by BHLS Vehicles”, report from a short mission lead by the University Calabria, in the CD).



From STSM on Energy consumption

## 2- Capacity, turnover / effectiveness

The purpose of this second analysis is to give an indication of the overall throughput of the systems in relation to the investment in rolling stock. The methodology adopted intends to avoid the effect of evaluation between the relevant locations and systems, not only differences in price levels (which, across the current European market reality, may be not that big), but also due to the difference in specifications and in the years of commissioning. Effectiveness is the concept deriving from this analysis.

### Methodology

To avoid the above-mentioned side-effects, the data used are intentionally non-monetary, namely the *Bus Passenger Capacity*. This figure shows in principle and in a very distinctive form the size of the buses operated in the system, and, indirectly, the size of the capital expenditure or investment involved. However, differences in the occupancy policies of the various operators appear; with the number of standing passengers per square meter as the main factor of discrepancy. This is due to the fact that the currently enforced type-approval directives in use across the European Union require the total payload to be calculated with an occupancy density of 8 passengers per sq.m., which is obviously somewhat above the generally accepted comfort standards. It should not be forgotten that this Analysis deals on Systems with a *High Level of Service*.

Therefore some capacity data recorded in the Description Sheets may reflect this “type-approval payload”, whilst others may show a more comfort-adapted capacity, which in turn might reflect actual commitments and marketing strategies of the operators involved. It

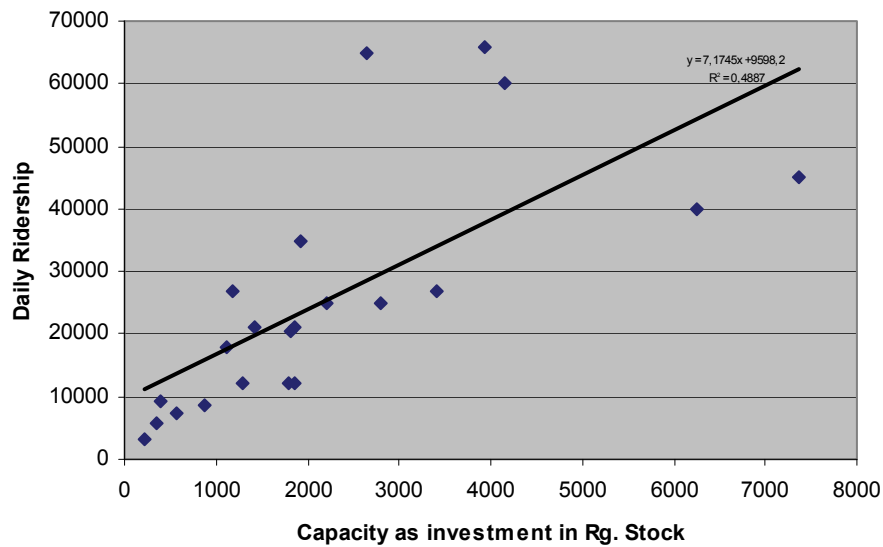
should be taken in account however that this high occupancy density is to be considered for safety purposes, and it cannot be assumed that it will never be reached.

For this reason the results will reflect this difference in policy as well, and will have to be seen always in relation to this whenever a relative low performance figure is obtained.

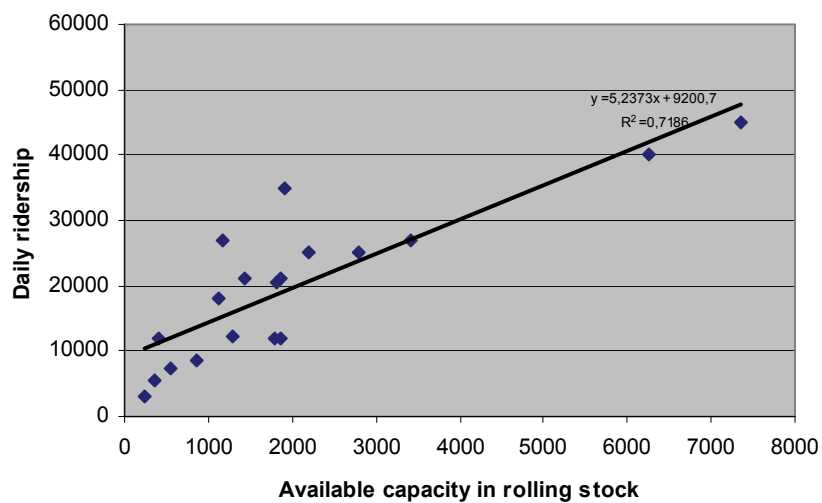
### Results

The effectiveness of the reported systems show a good correspondence between investment in rolling-stock and ridership, provided that the systems over 60,000 trips / day are assigned to another category, as they show a higher degree of effectiveness over the smaller ones. It should be noted however, that in this case, at least three of these systems (Zurich Line 31, Hamburg Line 5, Paris TVM) have no accurate passenger counting systems. Two graphs are shown one with the highest capacity systems, the second without them.

**Effectiveness (All systems included)**



**Effectiveness (2nd Analysis) (2nd version) > 60000 exempted**



### 3- Travelling time, physical effort

Speed and travelling time are two of the main concepts involved in a “high level of service”-approach. This analysis examines the effect of speed of buses as one of the factors in travel-

ling time, trying to detect inter-relations with the factor of “average distance between stops”. This analysis is consistent with the integrative layout of a high level of service system, as bus stops are considered one of the main factors influencing the attractiveness and efficiency of the system.

As a consequence, bus stops represent a significant part of the investment that a HLS-system requires, as they must fulfil a number of specifications, such as design, safety, accessibility and comfort, support of the information system (in some cases including screens and acoustic announcing), the relevant ticketing devices and others.

In some systems, every stop has special features in the pavement of the track or the footpath. In Nantes, the pavement is lowered to ease access to the stop from the pedestrian side. The pavement of the track is then adapted to the increase in the friction stress that the motion of the bus generates when leaving the stop (as, further to the acceleration, the bus recovers uphill its normal level on the street).

Therefore, it is likely that the control of this investment will imply keeping the number of equipped stops at a minimum, which in fact has a good impact on the average speed of the buses as this will reduce the number of stops in the route. Consequently, if the bus stops are fewer, the average speed of the route can be reached with lower speeds. Thus, with lower acceleration periods and lower power needed, the system will require a lower fuel consumption.

In several systems the policy that promotes use of bicycles, and combines this usage with public transport, has been specifically stressed. This analysis does not only aim at the young, active, physically fit part of the population capable of riding bicycles, but also considers the entire population, as public transport has to be a factor for total social inclusion.

In any case, the system has to be attractive because being accessible, with the average distance between stops being the factor that counter-balances the trend that might be taken to reduce infrastructure and fuel consumption, as a longer distance to the bus stop means lower accessibility to the system. Here lies the core of this analysis.

### Methodology

Due to the number of system descriptions available, this analysis encompasses a considerable variety of systems, as depicted above. However, though starting by taking into account the average speed of buses and the average distance between stops, a standard travelling pattern has to be defined.

Description Sheets did not provide a detailed and accurate travelling pattern for the whole area coverage of every system, e.g. considering the average distance from home or, in general, the starting point, to the bus stop and from the destination stop to a possible final destination. This would be a full standard travelling pattern.

Here a partial standard travelling pattern has been adopted, which consists of assuming the travelling time and the so-called “physical effort” *only along the bus line* being analyzed, without walking time to or from the bus line / bus stop from or to the actual origin and destination points.

The standard travelling pattern considered is then:

- Walking time to bus stop along the bus line. The distance in the worst case scenario is half of the average distance between stops. The speed is based on a moderate walking speed of 3,5 km/h, somewhat less than 1 m/s. This walking speed corresponds exactly to  $3500 / 60 = 58,33$  m/min.
- Average waiting time at bus stop. The time involved is on average of half the headway in minutes.
- Riding time on the bus. The speed is the average speed in the line, while the distance has been considered 3,5 km.
- Walking time from final bus stop to destination along this bus line, in the worst case scenario half of the average distance between stops.

As can be seen, in any trip three of the four periods make the physical / psychological contribution to the trip, and thus walking or waiting times, in relation to the full travelling time, have been taken into account as well, as a physical effort.

## Conclusions

The positive effect of the distance between stops and the average speed is very clear, as the fact of increasing the distance between stops from 200 m to 800 m leads to an average speed variation between 15 km/h and 25 km/h, respectively (Figure in the chapter 3.3.3 – A). Here again, the extreme average distance between stops of ZuidTangent (1900 m) and the consequent speed of 35 km/h seems to confirm this second category.

A comparatively stronger correspondence between average distance between stops and the so-called physical effort of the passenger (i.e., the effort of walking to and from the bus stop, waiting for the bus to arrive and queuing for boarding, notwithstanding the mental stress of simply not moving and getting nervous and also without considering the possibility of standing on the bus) is obtained. In this case, the percentage of the trip time where the passenger is not riding can go from 30% to around 75% of the time needed for the whole trip.

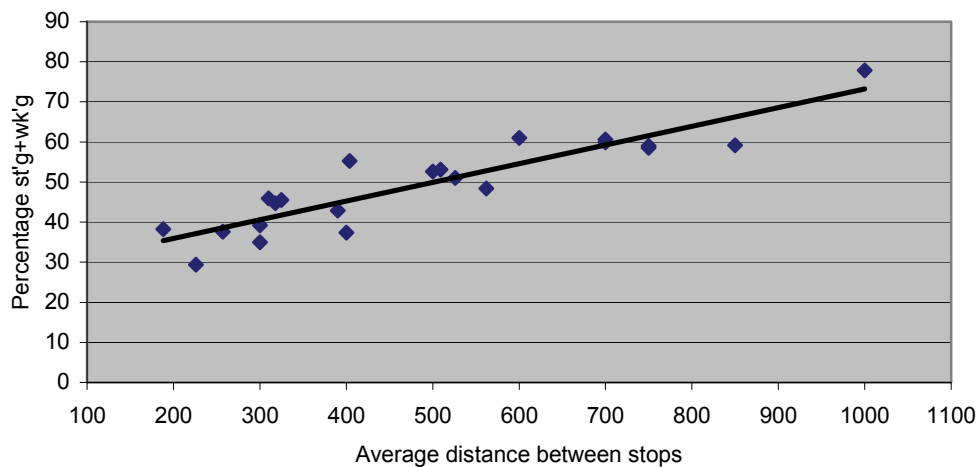
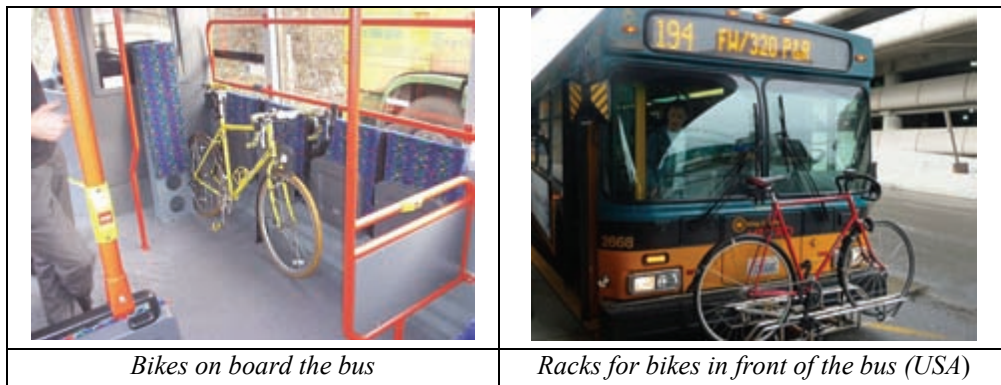


Figure 20: physical effort, the ordinate means “percentage standing + walking during journey”

### 3.4.3 Bicycle in buses, some key-points<sup>40</sup>

In this line of thought, an aspect to be considered when designing bus systems under a system approach is that of the feasible integration of bicycles in the whole mobility scheme, thus enabling carrying bicycles on board of the buses, as it is frequently the case on rail-based PT. This approach is sometimes implemented at off-peak periods (e.g. weekends) and is commonly adopted in the US and Canada, even in BRT schemes (this is not authorized in EU, for safety reason).



<sup>40</sup> References: project PORT-VERT, IFSTTAR, 2010; report “Interdependency of the use of bikes and public transport”, Technical University Dresden, 2010.



The possibility of bicycles embarking in buses and the interaction with the vehicle conception is a very complex question for the following reasons :

1) It is a solution, among others, in order to achieve an intermodality between bus (or other public transport) and bicycle. This solution could be more and more attractive because of the implementation of low floors and other features, but there are many restrictions because of limited space and conflicts with other passengers. It is therefore necessary to limit the embarking by means of selective restrictions (e.g. during peak hours) or tariffing and by developing alternative solutions for bicycle parking at bus stops.

2) The context is very different according to the type of line. In many cases the embarking of a bicycle in a BHLS should be avoided because of the volume of passengers or because of the impact on dwell time. Nevertheless, there could be specific cases where it is appropriate.

This point can be confirmed by the observation of various BHLS lines in Europe.

3) There are many difficulties for the embarking of classical bicycles, but it should be easier for folding bicycles. There is now a big amount of new types of folding bicycles which appear and which are different in terms of characteristics and price.

4) For the embarking of classical bicycle in a vehicle there are four technical possibilities, which are all difficult to adapt to a BHLS :

- embarking inside the vehicles in multifunction areas foreseen for bicycles, wheelchairs and pushchairs. A priority has to be given to wheelchairs ;
- embarking inside the vehicles in specific areas or boxes (problem of space consumption which can not be used for other purposes) ;
- embarking outside the vehicle in racks: but front racks are forbidden in Europe (in spite of the fact that 40 000 buses (often on BRT schemes) are equipped with this device in the USA), and rear racks are rarely used for urban busses ;
- embarking outside the vehicles in a bus trailer. This solution is until now only used on a (very) small number of touristic bus lines, for example in the surroundings of Dresden in Germany.

### 3.4.4 The vehicle investment costs observed

Since different configurations of vehicle type are possible, in term of propulsion systems, guidance systems, on-board equipment, specific design package, the bus cost analysis shows a wide variability of costs.

#### Regarding the different size and propulsion types of common buses.

Table 15 below provides an order of magnitude of purchase costs for different types of vehicles and propulsion types.

Propulsion	Standard	Articulated	Double-articulated.
Diesel	200,000	300,000	600,000
CNG	250,000	350,000	650,000
Hybrid	300,000	500,000	850,000
Trolley	400,000	650,000	1,000,000
Fuel Cell <sup>41</sup>	> 1,000,000	-	-

*Table 15: average vehicle purchase costs (€) – Source: data from different companies, PT operators, personal contacts, WG2 meetings and short missions done during the COST action.*

#### Regarding the BHLS observed.

A distinct bus design is now often observed for achieving a better identity of the BHLS route, in coherence with branding objectives (see chapter 3.5). This trend increases a little bit

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<sup>41</sup> Not yet into market.

its cost investment, its maintenance cost (specific spare parts) and then the operating cost since a specific fleet should be managed (with specific reserve).

The distinct design of the bus can be “soft” with a specific external colour/logo (Fastrack, Cambridge, Zuidtangent, TEOR, Prato, Brescia), or it can deal with the whole design “external and internal” (Busway, Castellon, RATP soon).

Using data collected during the COST action<sup>42</sup>, Figure 21 shows the variability of the investment cost observed (no hybrids have been observed):

- Regarding articulated buses, it shows the variability between the basic diesel unit of Prague and the guided basic trolley of Essen (in between, the specific CNG bus of Nantes costs 460 000€, that means an additional cost of around 30%).
- Regarding the bi-articulated buses, it shows the variability between the basic case of Hamburg and the basic trolley of Zurich.

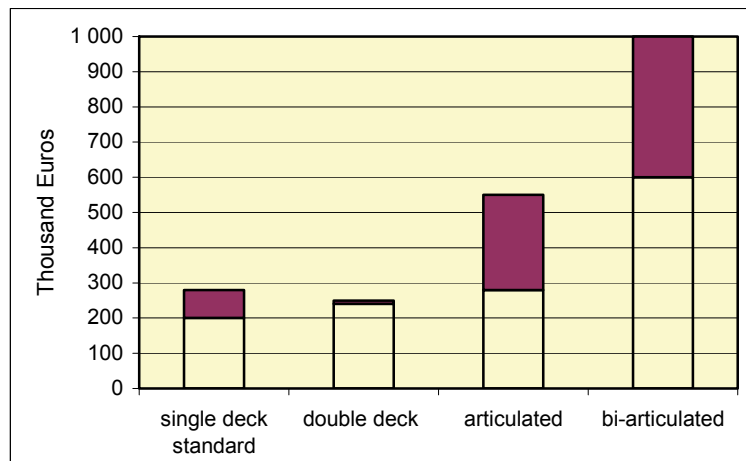


Figure 21: the investment costs of the buses – data from the BHLS systems studied

The figure 22 shows the cost figures, related to the capacity per passenger carried:

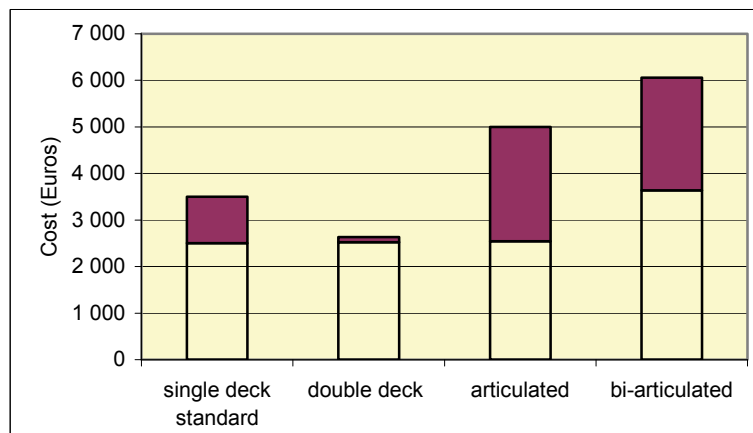


Figure 22: Investment cost per passenger, from data of figure 21

Regarding the “easiness to board and alight” factor “capacity/door” in Figure 23, the double deck (with the best ratio of seats) is much less efficient at stops, while the articulated of Prague with 5 doors (recently chosen for the heavy routes) shows the best rate:

<sup>42</sup> All data are specific to each scheme, related to a different year and with different equipment, so that this analysis should be used carefully, to point general trends - More information in the master data base file in the CD.

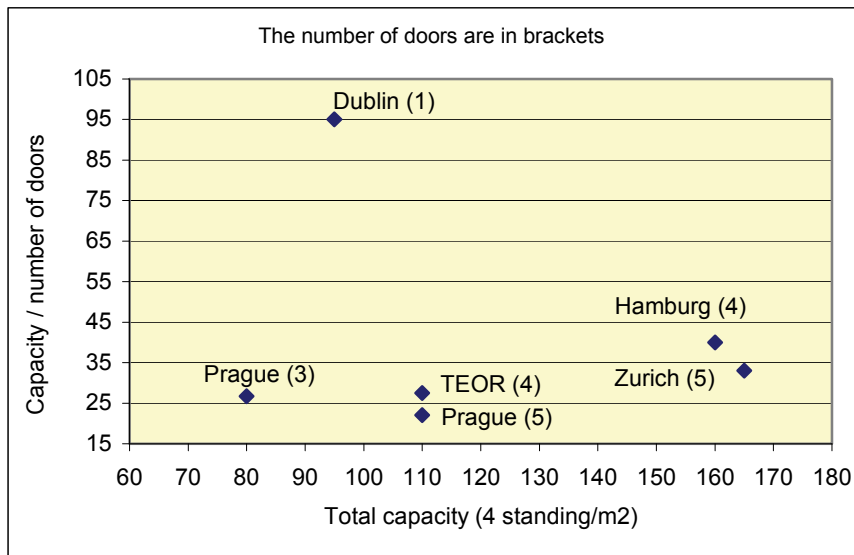
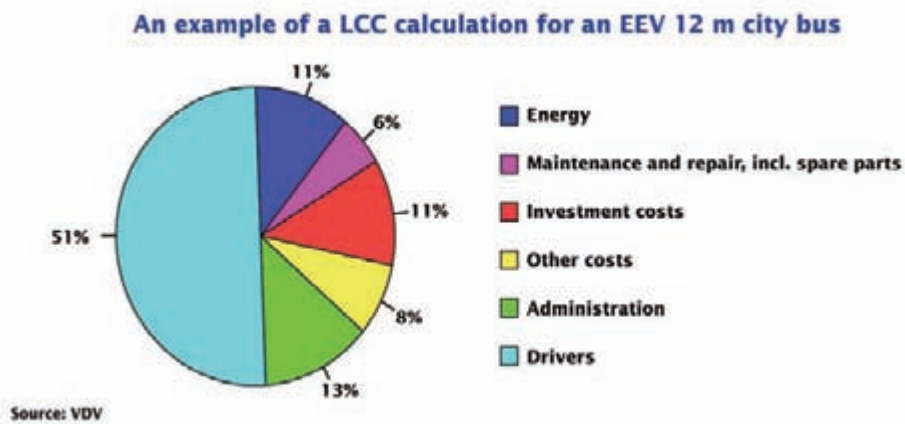


Figure 23: the easiness to board and alight factor, capacity per door available.

Regarding the Life Cycle Cost of the bus, the breakdown of this cost for a common bus, is shown below (Source VDV / UITP, tender structure recommendations – 2009):



### 3.4.5 Points to monitor regarding the bus choice

WG2 has set up a wide range of recommendations on several items that are often key-point of discussion. The full document is available in the CD. The main statements are as follows:

- About models, sizes, structure, capacity, design

The possibility of adopting doors on both sides (as done in Douai, France) allows buses to dock both on the right hand side (for stops located on the curbstone) or on the left hand side (and then making possible median runways with median stations, with less overall width of the whole bus lane).

*Doors on both sides are permitted by the current Regulation 107 UN / ECE mentioned above, whereby safety provisions to avoid opening the wrong side of the bus should be adopted. Automatic vehicle location can provide stop location and characteristics, ensuring safe driver operation control in such cases.*

*Self-service push-buttons (whereby driver intervention is only to unclench door opening) and automatic door closing after a certain idle time can be useful. Fraud concerns should be treated accordingly.*

*In case of a new design (branding demand), it might be considered that the relatively low numbers of buses needed would cause big impacts on the design costs.*

- About sustainability and environmental friendliness. Drivelines, fuels, hybridization  
EU regulations regarding emission levels are currently EURO 5 and EEV, with EURO 6 to come in two years time (2013).

*The array of choice of sustainable fuels is wide enough (bio-diesel, bio-gas, ethanol) to allow the reduction of dependency on fossil fuels, and should always be checked at local level.*

*This issue is not specific to BHLS.*

- About accessibility, social inclusion (mobility impaired passengers)

Any bus-based system must be a means for social inclusion. Accessibility must take in account all aspects along the mobility chain.

*A system approach to the accessibility of the bus system must be consistent with the whole set of provisions aiming at achieving an accessible urban layout. Therefore, efforts made in the accessibility to and inside the bus can not be effective unless they are also supported by accessibility measures in buildings and public spaces.*

- About journey comfort. HVAC<sup>43</sup>, seats, driving techniques, guiding

The more seats in the vehicle, the less the total capacity, so an intermediate point has to be found. One factor to be taken in account is the average length of the journey in minutes. See the Analysis part of this report to find actual seating factors of some systems.

Despite a general widespread interest in integrating soft modes, and particularly bicycles, into the overall PT system, no interest has been observed for enabling bicycles to be carried on board of buses in BHLS systems. No racks (as in the USA) or internal fixing devices have been seen anywhere, while it seems that allowing some bicycles (not foldable) to be carried by their owners might reduce the impact on public space that bicycle parking lots cause.

Heating is common place in Northern European countries. It is becoming increasingly usual to find air conditioning or climate control systems in modern buses, just as it is currently usual as well to get them as standard equipment in passenger cars. Recently, *low consumption* systems have been developed and are finding a wide acceptance..

Driving techniques are important as well. "Ecological Driving" aims at lowering fuel consumption. Some sort of "Comfortable Driving" should be enhanced as well, in order to prevent sudden braking and, as a regulatory measure, to accelerate at rates as low as possible. Although related to the infrastructure aspects of the system, reducing gradient rates and bending radius is also important, for instance cutting through the middle of roundabouts instead of driving all the way round, as seen in Lorient (see Description).

- Safety and security for passengers and drivers

Security can become a major concern, especially during darkness and at times/locations when there are few other passengers. Security cameras can help to deter antisocial incidents and to give reassurance to customers. Cameras can be set to either recording continuously or only record in case of activation by the driver. In some areas, a screen showing to the passengers what the camera is viewing can discourage antisocial behaviour and crime (see London). Security can also be increased by grouping the passengers, e.g. on articulated buses at late or early hours of the day a collapsible or folding partition between front and rear vehicle can prevent disorders to occur out of sight of the passengers (Zuidtangent Amsterdam).

For drivers the hazard of being assaulted is higher if tickets are sold on board. Ticket selling by driver is not recommended on BHLS. Ticket selling by driver is not recommended on BHLS.

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<sup>43</sup> Heating Ventilation Air Conditioning

### 3.5 Operations issues, by WG3<sup>44</sup>

The component parts of the “operations” sub-system are: ITS tools, service design (schedule span, frequency, type of services, driving rules, disruption processes, etc.), fare collection, passenger information, branding and marketing, quality management (including safety and security, driver training and key indicator points).

The analysis of this sub-system focuses on the following four important and complementary fields, which are naturally oriented to both “passengers” / “potential passengers” and service production and operation:

- **Supporting ITS** implemented for operation management, such as AVM (Automatic Vehicle Monitoring) system, priority at traffic lights, ticketing process, dynamic passenger information, and all “intelligent” tools, together with their role in system performance for both operators and passengers.
- **Operation and Quality management** of the system, which includes the quality measurements, the key-indicators used and other organisational matters, e.g. the role of the driver.
- **Performance and benefits** achieved. Passenger satisfaction is highlighted, as well as safety and security issues.
- **Identification and branding** choices of the line, or of the service provided.

In this chapter, we use the terms of level of service (LoS) and quality of service; definitions of both given below:

**Level of Service (LoS):** measures the quantity of the service as it is planned (frequency, capacity, operating span). A “High Level of Service” needs to plan for and reach a high quality (high frequency, high regularity/punctuality). Thus, within the acronym “BHLS”, the objective of high quality is also included. A High Level of Service also means a constant and continuous quality along the entire route i.e. between the two termini.

**Quality of service:** measures the gaps observed between the planned service and the service actually provided (regularity or punctuality, reliability, comfort, accessibility), in reference to the European standard “quality of service” EN 13816<sup>45</sup>.

The term “LoS” is often used to consider quantity and quality criteria (i.e. in USA publications<sup>46</sup>). The term “quality” is more difficult to define as expectations vary from one country to another. For this report a consistent approach using the above definitions has been used to guide the reader.

This analysis is limited to the 35 BHLS case studies described, and related to the European mobility, transport and socio/economic context.

The justification of the quality of all choices are not the subject of this analysis. However, we aim to understand how for each choice, each BHLS configuration can meet its own usefulness, justified by constraints and objectives targeted by the decision makers.

The reader should keep in mind that any new site must carry out its own feasibility study before considering which BHLS level would be most appropriate.

#### 3.5.1 Supporting ITS: trends and role into the performance achieved

During the last two decades, Intelligent Transportation Systems (ITS) have emerged with their own “eclat” in the world of transport and become firmly established. ITS involves the applied use of various engineering disciplines, enabling technologies and management strategies to facilitate modern transport operations and policy development. In this context

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<sup>44</sup> The full text of the “analysis report” made by WG3 is available in the CD.

<sup>45</sup> EN 13816, European standard of “quality of service”, prepared by CEN/TC 320 “Transportation – Logistics and services” approved by CEN (European Committee for Standardization) on 30 December 2001 and published in April 2002.

<sup>46</sup> Transit Capacity and Quality of Service Manual, 2nd Edition (TCRP) Report 100, contains background, statistics, and graphics on the various types of public transportation, and provides a framework for measuring transit availability and quality of service from the passenger point of view.

ITS has had a significant impact in all the recent implementation and operation of BHLS systems/services.

### AVMS, Automatic Vehicle Monitoring System

*AVMS is a tool for the benefit of the total "network"*

The Automatic Vehicle Monitoring system is recognised as the indispensable key component for managing BHLS; in fact most BHLS routes described have already invested in this ITS element in their operation with the capability to provide real time information to their customers at all stops. Some counter-examples are:

- The 3 LAM<sup>47</sup>: in Prato (blu, verde, rossa) were implemented without AVMS. In 2011 the procurement process was completed for purchasing an AVMS for all the PT service in Prato (including the LAM Corridor) and the full operation is expected for the end of 2012.
- The Malahide Line (Dublin) was implemented without an AVMS, although it was under consideration at the time. Following a pilot deployment, AVMS was implemented on the entire Dublin Bus fleet of 1,000 buses, including the BHLS lines, with the last lines joining the system in early-2011.
- The bus lines into the Bus VAO corridor in Madrid: dynamic information is only available at the interchange "Moncloa" with the metro ring (soon to be installed in the buses...).
- In Almere, the AVMS is currently being installed and the dynamic information will be available 2011.

Nonetheless, a high increase in passenger use has been observed even without AVMS (i.e. in Dublin and in Madrid): showing that the huge benefit provided by the new Right-of-Way was quickly recognized by customers. All these cases have demonstrated the interest to implement further a "full" and accurate dynamic information at stops and into the vehicles, that can be provided only by a complete AVMS.

Further examples showing the importance of this component: in Curitiba, after more than 30 years of infrastructure investment for the classic BRT example (built since 1974), an AVMS has been recently implemented for the whole network with Real Time Information at stops (2009 / 2010)<sup>48</sup>.

The AVM Control Centre, almost always operated by the Transport Operator staff, is able to collect and monitor data about the performance of vehicles being used to provide services with 2 main objectives:

- To control, regulate and inform in real time, according to quality objectives.
- To analyse the data collected, for quality control purposes, asset management including performance of infrastructure (RoW / priority at traffic lights, etc.) or anything else, for re-designing services and timetable reliability based on current operational conditions,...

In a number of cases the transport authority finances and remains the owner of the control center and are responsible for purchasing equipment and systems. Vasttrafik (Authority of Gothenburg) for example has provided all of the ITS equipment and is the owner of it. The operators (around 3 or 4) install the Vasttrafik equipments into their vehicles; the Operators have their own control Centers, and are responsible for the operations, dispatching and service regulation. Vasttrafik takes responsibility for information about big events, monitors the service performance and contacts the Operator if they observe that the performance on a specific line or sector has gone outside acceptable parameters, in case of incidents, etc. They have a view on all data, and can also control inter-modality objectives. In accordance with the Customer Charter, Vasttrafik reimburses passengers to use taxi if they experience a delay of more than 30 minutes.



*AVM Control Centre of PT Hamburg, for all lines on surface*

<sup>47</sup> Linea Alta Mobilitad :.high (volume of) mobility line

<sup>48</sup> Ref. article "Bus Rapid Transit: a public renaissance" in the "Built Environment" review Nov 2010

In conclusion, any AVMS remains a tool for the benefit of the total “network”. It is not implemented solely for the BHLS lines.

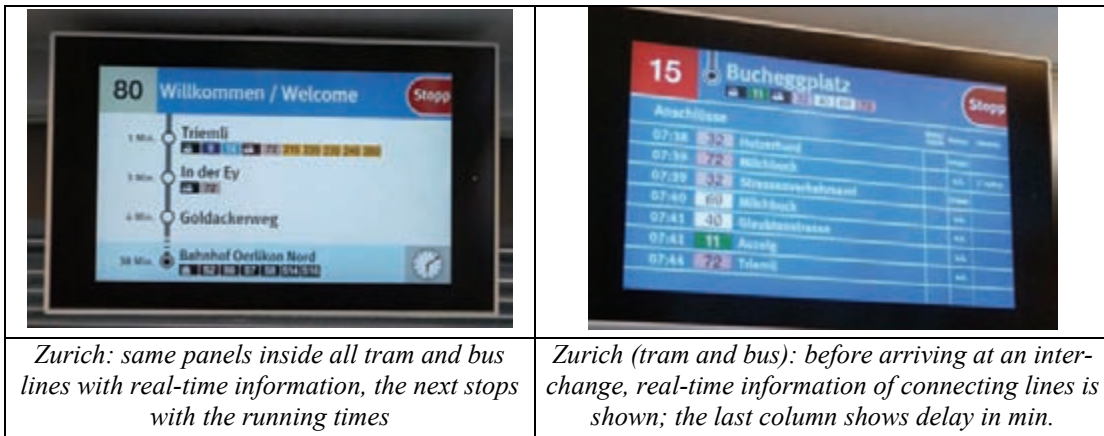
**Dynamic passenger information**

Almost all BHLS routes described currently provide dynamic passenger information. The most common examples provide information to “all” bus stops, where they display information on the next bus arrival, or the two next arrivals.

PPP (Private Public Partnership) has been used to provide finance for Dynamic Passenger Information in the UK in the cases of Fastrack (commitment for 17 years) and Cambridge where the use of the dedicated lane will be charged to operators for operating and maintaining the RoW, stations and the control centre. Revenue of £500,000 per year are expected.

Kent Thameside Fastrack system at Ebbsfleet near London<sup>49</sup> provides RTI (Real Time Information), on its website: bus arrivals and service disruptions. Below, some examples of panels at the bus stops are displayed:

*An interest to provide dynamic information at all stations.*



*Zurich: same panels inside all tram and bus lines with real-time information, the next stops with the running times*

*Zurich (tram and bus): before arriving at an interchange, real-time information of connecting lines is shown; the last column shows delay in min.*



*RATP – Paris: flash codes have been implemented on all tram and bus stations, you can memorize the link into your mobile*



*Metrobus line 5 in Hamburg – information at the rail station, strong visual contrast*

*Almere (NL) – A big panel for each bay, at the rail station connection*



<sup>49</sup> Is located near the high speed station Ebbsfleet (Eurostar line London – Calais)

## Information on the web, by the web

For all BHLS cases, we observe website information of the scheduled time-tables of different routes and maps of the network maps. In some special cases, as into Kent Thameside Fastrack, TMB – Barcelona (Route 64) and EMT – Madrid (Route 27), we can find real time passenger information about the next bus arrivals.

Examples of BHLS websites are listed below:

BHLS	Address	Information	Mark
Kent Thameside Fastrack, UK	<a href="http://www.go-fastrack.co.uk/">http://www.go-fastrack.co.uk/</a>	Time-tables, maps, RTI	9/10
FTR -Leeds, UK	<a href="http://www.goftr.com/leeds/home.php">http://www.goftr.com/leeds/home.php</a>	Time-tables, maps	8/10
Zuidtangent, NL	<a href="http://www.zuidtangent.nl/">http://www.zuidtangent.nl/</a>	Time-tables, maps	7/10
The Jokery Line, Fi	<a href="http://aikataulut.ytv.fi/reittiopas/en/line/">http://aikataulut.ytv.fi/reittiopas/en/line/</a>	Time-tables, maps	7/10
TMB Route 64, Sp	<a href="http://www.tmb.cat/en_US/home.jsp">http://www.tmb.cat/en_US/home.jsp</a>	Time-tables, maps, RTI	7/10

	
<p><i>Grenoble, waiting time on mobile phone</i></p>	<p><i>Fastrak, realtime on Internet : Route A - 'Towards BLUEWATER' At stop, Dartford, Home Gardens</i></p>

On real-time information, we see two emerging trends which are closely linked: (a) the provision of information through third party channels, especially portable personal devices; and (b) specific info-service subscribed by the customer, for receiving the information also much earlier in the journey than at the bus stop, on personal devices. We also observe information provided on the command of the user (“pull”); or sent to the user without having to be asked (“push”).

## Ticketing system

Ticketing system is usually implemented for the whole PT network, and not only for BHLS. Various solutions (i.e. contactless smart card) and different the payment/selling devices location are observed. An enquiry carried out by WG4 identified that no BHLS systems have implemented any different fare structure, pricing and fare products compared to the regular bus lines.

While the technology is the same for BHLS and the general bus routes, sometimes the configuration can be different on the BHLS lines. For example, in Paris, Nantes, Rouen, Zurich, London, Prague and Athens the ticketing machines are located at the stations. In Brescia the automated fare collection is based on the onboard contact less validator.

Only in Nantes, the bus driver is in a closed cabin, as a tram, so that no ticket can be sold. That is a very good configuration for priority at traffic lights and regularity.

In the Zuidtangent, one of the most capacitive line, there are no ticket vending machines at the stations. Passengers can credit their OV-chipcard (means Public Transport chip card = contactless card) at home/vending points (supermarkets, post offices, train stations, etc.), validate on board (product activation and check in/check out). This is not unique for the Zuidtangent, since the OV-chip card can be used for all public transport throughout the Netherlands (train, tram, bus, ferry, metro). The Zuidtangent is, however, one of the few PT systems in the Netherlands where you can credit your OV chip card on board. Besides this there still is the possibility to purchase a ticket from the bus driver.



## Priority at road crossings



Road crossing priority at traffic lights can be found in all cases described in Netherlands, Germany, France, UK, Sweden, Switzerland. Special signs are used to give right of way to the bus. In Jönköping a priority through wide roundabouts is set. In Barcelona we can find a traffic light priority, green-wave based, all along Aribau Street (1.7 km, 7 bus routes, 36 buses/hour, 16 crossings and 8 bus stops).

## Passenger counting tools

The use of Passenger counting tool technologies was not encountered during the COST project visits. Although the technology exists we could not identify any BHLS sites actually utilizing this technology. However “bus laboratoire” are often available and equipped with such system (Nantes).

In Prague, passenger counting tools had been used in 30% of vehicles, but today it is out of operation due to a change in vehicle data transmission system (from radio to WiFi). In 2012 new vehicles will be equipped, and all buses will be fitted by 2015. It is expected that the onboard AVM terminal will provide real-time information also about vehicle occupancy on a specific or scheduled request by the dispatcher control room.

## Enforcement and security tools

Regarding enforcement and security tools, we could find video surveillance systems available in several cases, such as Amsterdam, Dublin, Essen, Hamburg, Leeds, Fastrack, Cambridge, and Zurich.

In Barcelona, Lisbon, Madrid and Nantes, we can find regular enforcement control of bus lanes by means of special vehicles.



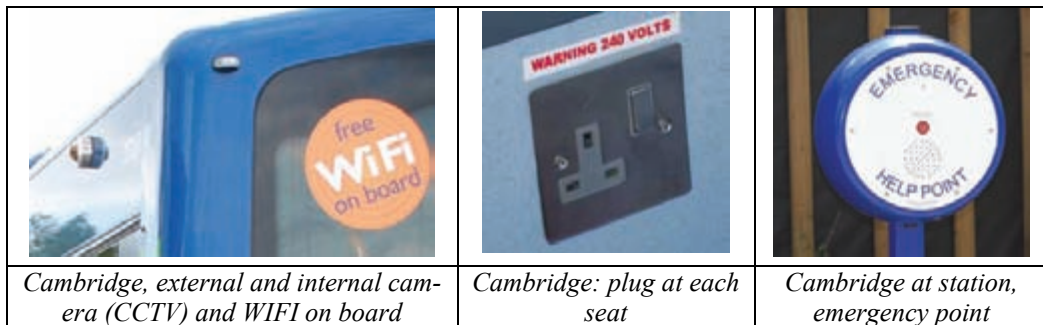
*Manchester : CCTV information on board, with internal and external cameras*

## Innovation or unusual tools

Finally, regarding special ITS tools, we observed the following:

- Busway – Nantes: information about transfer times on board the bus approaching a tramway station.
- ÖPNV-Trasse – Oberhausen: buses share platform with tramway with high frequency.
- Thameside Fastrack – London: interactive kiosk at a bus stop, with Internet access.

- TVR–Castellón: optic guided system like in Rouen (TEOR).
- Fastrack, Cambridge: CCTV with camera inside and outside buses, plug and WIFI inside buses.
- RTI on the Internet and cell phone in Barcelona, Grenoble, Madrid, Lisbon and London.
- DPP–Prague: payment by means cell phone.
- Zuidtangent line 300: the “rhythmic” timetable (see image below).



Cambridge, external and internal camera (CCTV) and WIFI on board

Cambridge: plug at each seat

Cambridge at station, emergency point

maandag t/m vrijdag	vertrektijd
5	26 36 46 56
6	06 16 26 36 46 56
7	02 08 14 20 26 32 38 43 <sup>a</sup> 44 50 55 <sup>a</sup> 56
8	02 07 <sup>a</sup> 08 14 20 26 32 38 44 50 56
9	02 08 14 20 26 32 38 44 50 56
10	02 08 14 20 26 32 38 44 50 56
11	02 08 14 20 26 32 38 44 50 56
12	02 08 14 20 26 32 38 44 50 56
13	02 08 14 20 26 32 38 44 50 56
14	02 08 14 20 26 32 38 44 50 56
15	02 08 14 20 26 32 38 44 50 56
16	02 08 14 20 26 32 38 44 50 56
17	02 08 14 20 26 32 38 44 50 56
18	02 08 14 20 26 32 38 44 50 56
19	02 08 14 20 27 37 47 57
20	07 17 27 37 47 57
21	07 17 27 37 47 57
22	07 17 27 37 47 57
23	07 17 27 37 47 57
0	07 17 27 37 47 57
1	07

Zuidtangent line 300 “full” BHLS : the “rhythmic” timetable, easy to be memorised (also seen in Germany, Sweden, Switzerland).

Some key points from this analysis :

- AVMS always remains a priority even after an efficient infrastructure improvements have been introduced such as in the Dublin QBC and Almere scheme <sup>50</sup> : It is important that any PT mode is designed and operates as efficient as possible and is able to respond to disruption and congestion issues.
- AVMS should be installed, not only for the BHLS corridor itself but also for the overall PT network.

The 3 pillars of any AVMS are:

- The positioning and monitoring of all buses, which need to be supported by a minimum of Right of Ways and priority measures at crossings.
- The communication function between the different sub-systems, vehicle, stations, control center / depots / workshops.
- The Operations Management Strategy, supported by real-time location and communication technologies, the effective analysis and presentation of the relevant information to the dispatchers, the capability of dispatchers to act on the service and/or to send bus/line specific commands/information.

Reliable timetables are fundamental to build confidence in the system for the passengers.

<sup>50</sup> In Curitiba for example, the mythic BRT example since 1974: after more than 30 years of BRT infrastructure investment, an AVMS has been recently implemented for the whole network with RTI at stops (2009 / 2010) – article in Built Environment.

RTI for all stops appears to be an indispensable tool for any “full” or complete BHLS approach : all passengers can get the same service guarantee along the line. However, transport authorities and Operators are reflecting on the best means to achieve this. For financial reasons, display panels could be limited at key stations which are most used. Virtual RTI could be displayed by new mobile technologies like mobile phones via SMS or WAP, and mobile internet devices, flash codes,...

The AVMS (with Internet) is the key-tool for achieving intermodality objectives within the whole mobility network.

Some examples of lessons “learnt” from Transport Operators or managing Public Authorities are highlighted below (not exhaustive):

- The need to increase the internal technical/operational dimensions/capability in order to be able to “choose” and evaluate the different products offered by the emerging ITS market and to follow the procurement, realization and the operation of the identified ITS system.
- Rethinking the company organization on the basis of the possibilities/options provided by the AVM system and the other ITS systems.
- Finally to identify a set of indicators for guaranteeing a high technical performance level of the AVM technologies/components in order to comply with the service quality levels/standards defined in the related BHLS and overall PT service contract.

More important, we have not found any special AVM applications or requirements for BHLS compared to regular bus routes.

However, we have found special ITS applications or requirements for BHLS compared to regular bus routes, in that cases:

- Guidance tools that need a high level of infrastructure along the whole route, BHLS approach (Castellón, Rouen TEOR, Cambridge, Douai).
- Ticket vending machines at stations (Busway, TVM, Fastrack, Zuidtangent, TEOR).
- Internet access at station, plug, WIFI in vehicle (Fastrack, Cambridge).

### 3.5.2 Quality management: indicators and trends observed

The management of BHLS operations is the most strategic task for operators, to ensure that reliability and performance are maintained to a high standard. In some cases, authorities will establish the quality levels through contractual agreements. The operators should make the best in term of resources and tools for guaranteeing these quality levels during the daily service operation. For a BHLS project, the quality objectives should be as important as that used in the design of tramway and rail lines.

Since 2002, the European CEN<sup>51</sup> standard EN 13816 “Public transportation of passengers – service quality” defines this notion of service quality applied to passenger transportation. It defines a management and quality measurement method with reference to the quality cycle concept. The fundamental principle is that all calculation methods are “client” oriented. They must take into account the number of passengers involved by a required quality level. This standard defines the obligatory and optional quality criteria, as a reference tool for measuring the quality of the service with respect to a reference situation. A large set of quality indicators is described and arranged into 8 groups as follows (where only the main items are highlighted):

1. Availability of services	Operating hours, Frequency, Vehicle load factor, ...
2. Accessibility of services	External interface, Internal interface, Ticketing availability
3. Information	General information, Travel information (with abnormal conditions)
4. Time	Length of trip time: trip planning, access / egress time... Adherence to schedule: punctuality / regularity
5. Customer care	Availability of staff, Assistance, ...
6. Comfort	Seating and personal space, Ride comfort, ...
7. Safety and security	Level of accidents,...
8. Environmental impact	Emission norms of vehicles,...

<sup>51</sup> CEN : the European Committee for Standardization

The CEN quality norm EN 13816 is available for quality management and its application in a public transport company goes via a process of certification. It is a matter for bus operators to decide whether or not to opt for certification of bus lines according to this quality standard. It is not necessary to go into a full certification process. EN 13816 norm can be introduced into operation tendering processes.

This European norm provides two measures of regularity/punctuality:

- The percentage of passengers affected by services that do not fulfill its target; with an interval of 2 or 3 minutes more compared to the announced headways ( $NP_i/NP_T$ );
- The percentage of passengers affected by delayed services; by no greater than 3 or 5 minutes, and 1 minute earlier; measured at 59 seconds ( $NP_d/NP_T$ ).

According to this norm, to be considered as a regular/punctual service, it needs to achieve this statement  $NP_i/NP_T \geq 80\%$ . We observe that for BHLS, this limit could be elevated up to 90-95% as shown into the next paragraph.

Note that the calculation process is not simple, as it is necessary to deal with the number of passengers having a service on time, and not just the proportion of vehicles on time.

## 1- About the CEN quality standard application

### a - Regularity /punctuality indicator

Among the 35 BHLS sites described, only 10 are applying the quality certification of the line by using this EU standard. Some of them do so in a contractual context, with possible “Bonus / Malus” impacts. Generally, it was very difficult to collect these quality indicators data. Various reasons can be highlighted, in particular the data confidentiality. Due to competitive tendering situations, operators are reluctant to share data with the public domain. Another reason seems to be the cost of collecting data and completing surveys. In some cases such data were not yet available.

Highlighted below are some results on the reliability objectives (% of passengers having a bus on time) received from sites:

	Regularity, punctuality target	Threshold achieved	Observation
Nantes (Busway)	90% (i+2min)	98%	High efficiency
Fastrack (B)	95% (H-1min;H+5min)	97,5%	High efficiency
Twente (line 2, 3)	80% (H-1min;H+5min)	94,7 / 97,6%	Good protection
Paris (TVM)	90% (i+2min)	95,8%	Heavy loading rate
Grenoble (line 1)	90% (H-1min;H+5min)	95	Good results
Leeds	95% (H-1min;H+5min)	93%	Good protection
Almere (network)	80% (H-1min;H+3min)	91,4%	High efficiency
Prague line 213	80% (H-0min; H+2min)	78 - 86 %	Low level of RoW
Göteborg (line 16)	80% (H-30s; H+3min)	75%	Passenger congestion
Lisbon (all network) <sup>52</sup>	80 % (i +/- 20%i)	93 %	Low level of RoW
	85% (H-0min to H+5min)	87%	

Legend: where  $i$ =interval (regularity objective) and  $H$  = scheduled time (punctuality objective)

Table 16: Regularity / punctuality data collected from some BHLS schemes

It was recognized that investment in infrastructure improvements resulted in good levels of regularity being achieved. RoW contributes to reduce the problems in peak hours (which are sometimes only for short periods along the day), so that people can rely on a consistent run-

Regularity  
allows capacity

<sup>52</sup> For routes with headways less than 20 minutes, the regularity is measured from the headway and not from the schedules. For example, a route with a programmed headway of 10 minutes (one bus each 10 minutes); the regularity target is achieved if a bus passes 8 to 12 minutes after the previous bus (i.e. planned headway +/- 2 minutes). If the route has headways bigger than 20 minutes, then punctuality is measured from the schedules. The quality measurement thresholds achieved include all trips made (weekdays and weekends), but they do not penalise for any trips that were not made due to external factors, beyond the control of the Operator (for example, if there is an accident in the street).

ning time throughout the day. “Urban” RoW seems to be more a tool for offering regularity than a better speed at every time.

Through these examples, we can consider that:

- For a very good BHLS level, the objective of 95% appears to be achievable.
- An objective of 95% is considered for providing an efficient high frequency, and consequently the high capacity expected.
- The level recommended in the CEN Standard (80%, H-1min, H+5min) seems to be not enough for achieving a full BHLS level in working days (higher frequency).

Gothenburg Line 16 is presented here as an example of these issues in practice. The time table of BHLS line 16 of Gothenburg (shown below), has a maximum of 12 services during the core peak hours<sup>53</sup>. This line still faces some challenges to achieve a very high level of headway regularity, when operating at short headways (5 minutes in the peak). The specific issues are (based on a discussion with the authority):

- Västtrafik service lines outside Gothenburg typically reach a good reliability of 90% + ; however, the best tram lines in Gothenburg have only 82% on-time services (city centre); trunk line 16 (bus) has 75% on-time services, including in the city centre..
- A large cause of the unreliability is the unpredictable/uneven travel demand. More or less people are at the stop for an individual bus, so the dwell time may be shorter or longer than the average. This can cause the bus to be a little earlier or later at the next stop. When a bus is even slightly in delay on a busy route, it is likely to have more passengers waiting for it at the next stop, and thus have a slightly longer dwell time. Meanwhile, the bus behind faces less passengers, and starts to catch up. The cumulative effect over a number of stops leads to the classic ‘bus bunching’.
- The delays also impact on comfort. Passengers always try to get on the first bus that arrives, even if there is another bus directly behind it. When the headways are disrupted and two buses get close to each other, the first bus carries the majority of the passengers, so the passenger density can become higher than the norm and feel overcrowded and uncomfortable. Meanwhile the bus behind has plenty of space and even spare seats.
- A second cause of delays to Trunk Line routes is other services using the stops (also a problem for some trams where they share stops with buses). Some bus routes do sell tickets on the bus, and they can obstruct and delay buses or trams behind them. There are 8 other lines into a same central corridor with this line 16.
- For operating better such high capacity, there is a need to help driver to be firm in managing the door closings, for example, with the help of a ring announcing the door closing, like in a rail system.
- Drivers no longer sell tickets on the vehicle. When they stopped selling tickets, punctuality improved by 2-4%.

*The timetable of the line 16, the biggest line with bi-articulated buses in Gothenburg*

<sup>53</sup> Like the scheme in Utrecht, the peak hours are heavily crowded, and so could fit with a tramway capacity. However, due to lower capacity at other time, the tram choice has been postponed.

The calculation for the CEN norm does not provide insights on the irregularity level of delayed passengers. On the other hand, there is a high need to control when and where the irregularity is observed. Hence, other indicators are needed and used, although these are usually not published. We think that sharing such results and launching a benchmarking action or a relevant research action could be fruitful for increasing the knowledge in RoW.

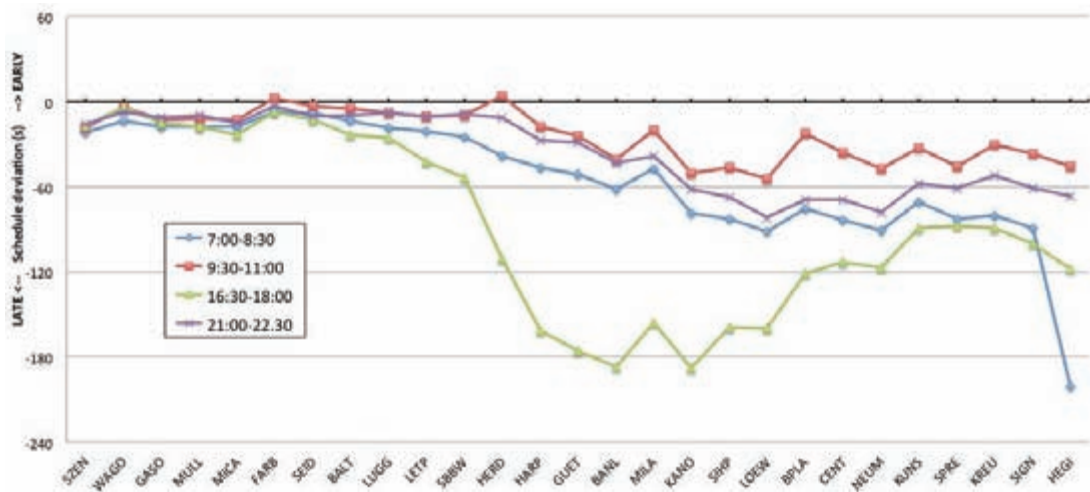


Figure 24: Zurich, mean schedule deviation by time of day at stop level – line 31

The PT authority of Zurich, which has one of the best networks in Europe<sup>54</sup> in term of use and efficiency, shows an impressive quality level although it does not use the CEN standard. Despite a high frequency of all tram and bus lines, all lines are scheduled, and the quality objective is to follow up the schedule adherence, at all stops, at all services. The authority has set up different and numerous analysis, regarding travel time (distribution), speed (distribution), punctuality (deviation at stops, % of departure on time), regularity (distribution at route and stop level).

As shown into the figure 24 (analysis of the bus line 31 described as a BHLS), the deviation at all stops allow to better identify when and where are the problems<sup>55</sup>.

**b - Loading rate indicator**

Highlighted below are results of the loading rates (% of passengers having a bus with a capacity below 4 passengers standing / m2), often responsible for irregularity:

Table 17	Threshold target	Threshold achieved	observation
Nantes (Busway)	80%	Over 80	
Paris (TVM)	80%	76,7%	Often overcrowded
Gothenburg (line16)	Problems of capacity at peak hours (schools university)		
Fastrack (Kent)	No problem of capacity		
Prague line 213	2,6 pass/m2 (average peak)	2,76 pass/m2	

The results highlight the difficulty in providing passenger comfort, particularly at peak hours on BHLS services. “Comfort” is taken as a level below 4 persons per square meter according to the European CEN standard, i.e. as specified for the Busway in Nantes, the TVM in Paris, the line 11 and 12 in Utrecht, the line 213 in Prague.

A good BHLS line seems to be always more attractive than expected, modelling tools often result in underestimations of ridership. Such trends are also observed in tram or metro projects.

<sup>54</sup> 590 trips per inhabitant, a PT market share of 45%.

<sup>55</sup> Reference, study “quantifying public transport reliability in Zurich” by Nelson Carrasco, ETH, university of Zurich.

### c- Availability rate

This item concern technical and human factors, such as breakdowns or driver absentees at departure. There are several ways of calculation.

Highlighted below are results on the availability rate (% of available services):

Table 18	TVM	Busway	Grenoble (line 1)	Fastrack (Kent)	Prague (line 213)	Barcelona (route 64)	Castellón (guided bus)
Availability factor	99%	99,90%	99,90%	99,52%	99,80%	98.51%	98.00%

Regarding these figures, and even though few data have been collected (perhaps not on the same basis...), it can be stated that:

- The bus technology can achieve a very good level of availability (with diesel and gas).
- For a full BHLS level, a rate over 99% can be achieved, which highly contributes to quality.
- The slightly lower level of Castellón is perhaps due to the fact that this route has been recently opened (June 2008) with trolleybuses.

### 2- Different ways of regularity, punctuality measurement

As seen previously, the indicator “Regularity / Punctuality” appears to be the most strategic for monitoring and keeping a good level of “system” quality. Several short-term scientific missions have been made within this COST TU0603 action, in order to analyse the state of the art of this topic. An article was published in August 2010<sup>56</sup>, and is included in the CD.

There is a need to standardize other appropriate indicators, in order to be able to determine reliability performances more widely.

The different methods of regularity calculation that can be observed are presented in the full version, available in the CD.

### 3- Passenger information quality

It is recognised that investment in Passenger Information has raised the public awareness of BHLS. The use of Electronic Screens with very good ergonomics (high contrast) has been observed, sometimes with very large displays at station, e.g. Hamburg, Twente, Almere. Information regarding delays or disruptions is coordinated through a control centre that relays information to vehicles and on bus stops devices and to other media services

Additional needs (such as advertisement, city information, news, etc.) are observed more and more inside the bus (e.g. Fastrack, Hamburg) and also at stops (Fastrack).

Dynamic information at all stations is however quite expensive (both to build and to maintain). Information may be more cost effective if provided directly to the passenger using mobile tools (mobile/ smart phone, SMS, WAP or mobile internet devices, flash codes). These are developing rapidly due to the increased number of travel Information Service Providers. On-line info panels should be used at key points of network.

It is recognised that waiting time algorithms can be more accurate for reliable routes, than with less reliable services. A high frequency tends to help the calculation, as algorithms can take in account the previous bus performance. Even when there is 100% of dedicated lane, a need for information remains, especially for high disruption like breakdowns, accidents, etc.

A BHLS objective should integrate a same level of information quality for all passengers where ever the vehicle stops.

### 4- Driving quality

Driving standards are key to the success of BHLS. Passenger comfort and safety is a priority.

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<sup>56</sup> Article, transit reliability performances, some contribution of a COST research - by Domenico Gattuso, Massimo Galante Antonio Lugarà Salvatore Napoli - Mediterranean University of Reggio Calabria - Engineering Faculty, Italy.

The use of articulated and bi-articulated vehicles result in high numbers of passengers being carried. It is important that drivers are trained to ensure the best quality of ride, provided also by the infrastructure quality.

The sites of Almere, TVM, Zuidtangent with almost 100% of RoW, should offer a very good level of running comfort (not measured). It was noted that in Almere a decision was taken to set the driving speed at 38 kph, since a smooth drive could be assured at that speed.

A gain of fuel consumption has been measured in the TVM: - 6% after the opening of the western extension in July 2007.

## 5- Customer satisfaction

Unfortunately, we have been able to collect very few results about such surveys. Moreover, what is available rarely concern the BHLS itself, but the whole network. The most interesting passenger assessment (before/after) has been provided by the Jönköping scheme<sup>57</sup>. The introduction of the two first structuring lines in 1996 (line 1 and 2, the third one came after this assessment) results to some degree in longer walking distances to bus stops along the trunk lines and more transfers (emergence of feeder lines). A gain of passengers by around 20% has been observed. However this wide passenger survey highlighted the drawbacks provided by this new scheme because more transfers have been introduced, affecting around 36% of the trips. The global results show:

- 37% think that the new traffic system makes things better (45% ride on the trunk lines).
- 32% think things remained the same.
- 31% think the new scheme is worse (this percentage is greater among those who need to transfer).
- The most enthusiastic responses: bus design, information at stops and trip frequency (regularity is above running time).

The two worst factors, transfers and more walking distances, affect older people more than younger people. The increase in the elderly population in the coming years makes this an important aspect.

As a conclusion of these outcomes, this scheme appears to suit younger people better than the elderly as transfers remain an obstacle for using this scheme, especially for older people. However, the objective of this scheme (trunk lines and complementary local and feeder routes) was also for improving the cost efficiency of the previous whole bus network, that explains anyway some non-satisfaction.

We received data from a satisfaction survey comparing a tram and a BHLS line, in Rouen: According to the results below (2004), the satisfaction was higher inside the BHLS line (TEOR) than in the tram line. The main cause is that this tram line has become more congested, somewhat more than TEOR that was a new line with a high frequency in the trunk section (new bigger tram vehicles are already ordered):

2004	TEOR	Tramway	Common buses lines
Global satisfaction	16,2	15,7	15,4

This statement justifies that the main expectation of customers stays the quality of the service, much more that a type of vehicle.

## 6- Seating and personal space

In Figure 25 below, we observe on average a higher seat rate for longer trips. This seems logical as for long trips passengers are more likely to demand a seat..

Moreover, we observe:

- In UK and Ireland, operators prefer to offer a higher number of seats using double-decker vehicles to enhance passenger comfort (Dublin and Manchester).

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<sup>57</sup> Report: Evaluation of the reorganisation of public transportation in Jönköping – Lund University, department of technology and society – Lund 1999.



- In peripheral or sub-urban areas operators have decided to use various types of vehicles: Jokery line is operated with busses with a high level of comfort while Zuidtangent and TVM are operated with urban buses with a low seating rate, likely for capacity reasons; The bus line 651 (operated in the VAO corridor in Madrid) has made an intermediate choice.

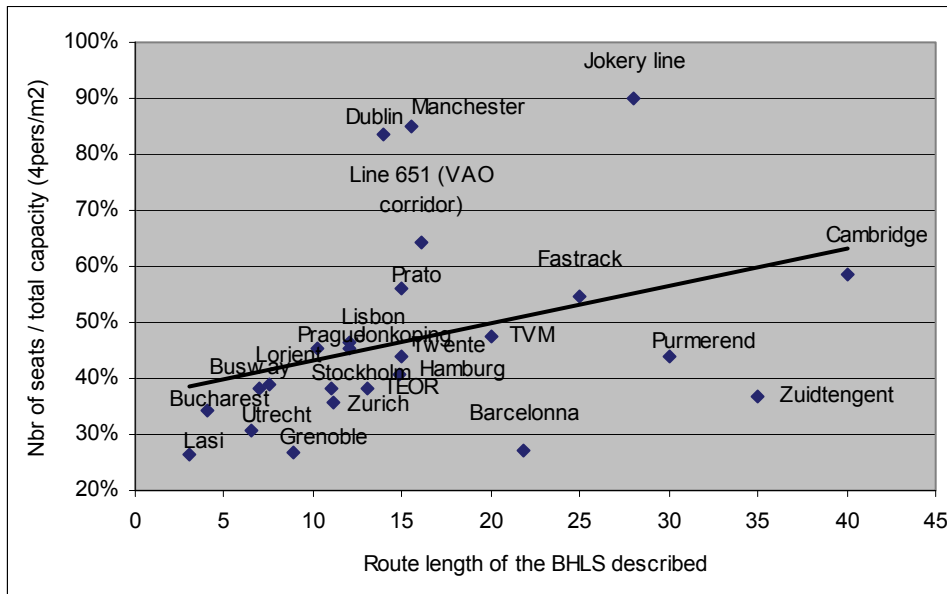


Figure 25 : Relationship « % of seats / route length »

### 7- Hours of operation or schedule span

Into Figure 26 below, the operating time span varies from 14 hours, in small urban areas, up to 21 hours for the larger and active urban areas:

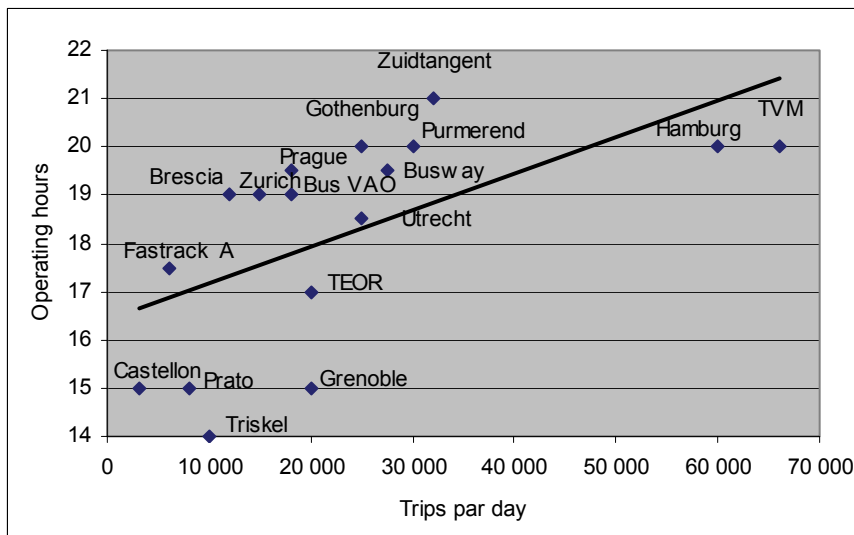


Figure 26 : Relationship schedule span / trip per day

We can observe that:

- An operating time span as large as possible is a relevant characteristic of a structuring line. TVM and the Metrobus in Hamburg offer connection with the metro and the regional train network
- The operating time span is a factor for achieving a higher ridership.

### 8- Frequency

In the figure 27, the variation of headways presented is quite large, from 3,5min up to 30 minutes at off peak hours, the cities are sorted by size of descending order:

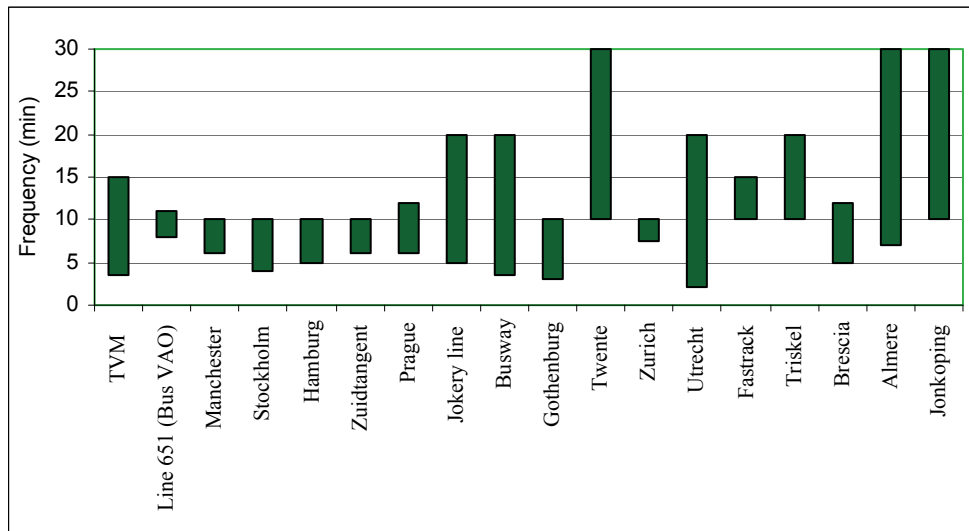


Figure 27: Variation of frequency

We observe:

- Low frequencies at off peak hours are mostly for small and low dense urban areas (Twente, Almere, Jönköping, or peripheral lines like the Jokeri line in Helsinki).
- High frequencies at peak hours allows to cater for much higher demand (TVM, Busway, Utrecht).
- Frequency levels are mostly decided based on the demand.

The importance of frequency and its impact on comfort (for users) and affordability (for operators) is recognised. Hence, during low frequency periods, a high level of punctuality remains a key-factor for BHLS.

Line	Departure Times
6	06:00
7	06:00, 06:30, 07:00, 07:30
8	06:00, 06:30, 07:00, 07:30
9	06:00, 06:30
10	06:00, 06:30
11	06:00, 06:30
12	06:00, 06:30
13	06:00, 06:30
14	06:00, 06:30
15	06:00, 06:30
16	06:00, 06:30
17	06:00, 06:30
18	06:00, 06:30
19	06:00, 06:30
20	06:00
21	06:00
22	06:00
23	06:00

Twente : the timetable for a wide and low dense area (low frequency at off peak hours, but with a very good punctuality)

Conclusion for this whole paragraph “quality management”:

- Regularity appears to be the most important indicator for monitoring a BHLS.
- A high level of regularity allows a BHLS system to provide a high capacity, and also allows it to provide a low frequency (when appropriate) that can be trusted.
- There is a need to benchmark regularity results among BHLS and to explore complementary measurement methods for regularity/punctuality.
- The schedule span, an important factor for achieving a BHLS level.

### 3.5.3 Benefits observed

### 1- Increase of ridership:

A wide variation from 15% up to 150% is observed, as shown in the figure 11 (chapter 3.3.1 B). We observe moreover:

- The overall increase is often achieved over several years; 3 or 4 years appears to be needed for shifting behaviours.
- The case of Jokerilinja, the peripheral line in Helsinki, shows impressive development of the market over a 5 year period.
- By contrast, the case of Hamburg was already a heavily utilised line before the improvement with a better identification.

The ridership increase appears to be much more linked to the context and capacity level before the project, than the % of dedicated lane.

### 2- Modal shift, from cars and other modes

Table 19 below presents data showing results from 2 up to 5 years operation; these results are obviously highly dependant with the local context; nevertheless BHLS schemes can induce a rather high modal shift rate from the car, from 5% up to 30%.

In two cases, rather strange and surprising results were observed:

- In Twente the modal shift from cycling is very significant at 24%. It is not considered as a drawback, as mostly long distances are concerned, always very tiring for these users. With an efficient PT offer, cycling goes toward its complementary market of short distance. More over during bad weather (around 20 days per year in Netherlands, bicycle users take public transport or the car).
- In Stockholm, the modal shift from metro is high, 60%. This means that this scheme is considered as very efficient. In this unusual case, the BHLS lightens the load of the metro traffic, which is dense and often congested in the central area where the metro lines intersect. The BHLS lines carry many passengers for their short distributor trip within the city centre, which would previously have been made as a transfer to another metro line at its busiest part.

Table 19	Trips coming from the car	Trips coming from cycling	From other modes
Busway (Nantes)	30%		
Fastrack (Kent Thameside)	19%		
Malahide corridor (Dublin)	17%		
Line 11 and 12 (Utrecht)	15%		
Bus VAO corridor, all lines (Madrid)	15%		
The Jokerilinja 550 (Helsinki)	12%		
TVM (Paris)	8,5%		
3 lines "Citybussarna" (Jönköping)	6%	5%	13% new trips 1% from special Transport
Line 2 and 3 (Twente)	6%	24%	
Trunk network (Stockholm)	5%		60% from metro

The mobility impact on people with disabilities seems to remain minimal, with very little modal switch from dedicated services (where they exist) to BHLS. It is also a difficult area to quantify. In Germany (even the bi-articulated bus), Netherlands, Sweden, manual ramps continue to be used, so that drivers have to assist wheelchair users to board/ alight the vehicle. For the operator in Hamburg, the regularity impact remains imperceptible for two reasons: (a) no breakdowns with the manual ramp; and (b) on average only one wheelchair demand per day and per driver across the whole bus fleet; hence there is no reason at present to invest more in electric ramps.

### 3- Operating cost and energy consumption

We unfortunately received very few results in this field. Very often comparative calculations are not possible when the new scheme does not replace exactly a former bus line, when the scheme is opening step by step during several years (case of Hamburg), or when the fuel is controlled for the whole fleet and not by line (case of Busway in Nantes, CNG buses). How-

ever, BHLS schemes can have a positive effect with better infrastructure, less stops at crossings, better speed due to a higher spacing between stops.

These two results have been observed:

- TVM (Paris): a gain by 6% of fuel consumption for all buses, after the opening of the western section of 7 km (total length, 20km).
- Twente: a better cost coverage (+47%), a decrease of the operating cost (-5% in average due to the higher speed).
- Schemes in Netherlands (Zuidtangent and Twente): concrete has been preferred for the pavements all along the route, for providing a good contrast and decreasing the maintenance cost of the pavement (however, an additional capital cost of around + 20% has been observed).

#### 4- Safety / security

Few sites provided data regarding safety and security on the BHLS cases, and often not with the same metric (number of accidents by 100 000 km or by year, by month, etc); accidents or events are perhaps not measured with the same definition. Often such data are not monitored by line, but for the whole fleet, so that the influence of the new infrastructure cannot be disaggregated.

Table 20	Accidents/ events per 100 000 km	Comments
Barcelona	14,1	Very dense city
TVM (Paris)	6 / 7	Same level as for common bus lines
Lisbon	4,8	
Nantes	2,14	Same level as for tramway: 2,44 on average in France
Prague	2,1	
Brescia	1,9	

In general, the safety rate remains very good in comparison with the other modes. Regarding the collected data, some different rates can be highlighted in table 20.

We could not collect enough “before/after” data, in order to identify if any negative effect arises from the re-sharing of the public space.

In Nantes, many falls inside the bus are observed (3,39 per 100 000km, 3 times more than in tramway) and also more than in regular buses, due to a higher speed when an accident does happen. 2009 is also a year better than 2008 (-20%), lower speed has been requested at entrance of crossings.

Manchester observed a high decrease of incidents after the bus improvements, by 19% along the line 192 (A6 corridor) for all modes; safety of cycling and pedestrian was also an objective of the project.

The level of fatalities / strong injuries in PT stays anyway at a very low level.

BHLS systems are aimed to be structuring lines. They tend to operate at higher speeds than common lines. As a result, more accidents may be expected with wide impacts into the whole PT network productivity (due to the intermodality factors). Then, with not good implementation, there is a risk to degrade the road safety around BHLS projects.

We suggest then to harmonize accident data collection by line in order to understand better what kind of RoW is safest, and to follow up these complex issues much more precisely for the BHLS. We note that on the similar issue in urban rail projects, a new COST action on LRT safety and public space has been recently approved (TU1103).

While driving technics for bus drivers is always a relevant way to improve the safety, a good layout of the project remains indispensable.

*The signalisation cannot improve a bad layout.*

#### 5- Environmental benefits

We could not get any documented results, as it seems that appraisal studies were not requested (before/ after), at the time of these scheme.

### 3.5.4 Identification and branding choices observed.

Throughout the development of BHLS, many authorities have tried to give BHLS lines a specific identity differentiating them from the traditional bus networks. Branding has been used in an attempt to promote the concept to all stakeholders. The main objective is to create an image representing a modern, comfortable, easy to use, and accessible service to attract new customers. As with all other aspects of BHLS, it must be recognised that there is no single “best” solution. Different strategies have been observed throughout this European state of the art.

The most successful examples for high investment “systems” have seen significant investment in dedicated fleet of branded vehicles, supported by infrastructure improvements, embracing a multi modal network approach:

- In Nantes, the BHLS line called “BusWay” is designed as the fourth line representative of the main network integrated with the 3 tramway lines. Articulated buses have a specific colour and design, distinctive from other buses in the city. The stations are also specific to this line.
- In Rouen, TEOR buses are guided and have a specific colour (blue) and also a specific colour for dedicated lanes (red); the stations are specific, branding with the logo “TEOR”.
- In Paris, the same station design is used for all lines "T" (tramway and TVM). The same approach is used in Rouen (T1, T2, T3).
- In Helsinki, the Jokeri line includes branded buses (new specific fleet painted as Jokerilinja-buses), dedicated bus stops with the same blue colour and a strong marketing campaign.
- In Stockholm, the "Trunk Network" is composed by four lines, with an easy numbering - 1, 2, 3 and 4. Vehicles are painted blue unlike traditional buses, which are painted red. Slogans such as "Think Tram. Use Bus." have been used to remind people that BHLS service can deliver a similar performance to a tramway.

In other areas, different strategies have been successful in implementing BHLS within the overall Public Transport network (in some cases without a dedicated fleet for cost reasons):

- In Hamburg, the bus-based structuring lines are called “Metrobus” with a small logo; Station and dedicated lanes are not specifically designed for BHLS, to allow the possibility for conversion to tram line in the medium term; BHLS branding is based on high frequency, schedule span, dynamic information, reliability of the service.
- In Jönköping, a small city, the transport authority has designed a successful branded structured bus network with 3 lines, utilising new buses of same type as existing, and 3 colours.
- In Lorient, the bus fleets of the main routes are not branded for cost reasons.
- In Twente or Almere, two small urban areas, the BHLS approach is also designed around the use of buses of same type as existing, in both cases for cost reasons.

BHLS does suffer from an identity problem compared with trams, as the physical tramlines clearly demonstrate the presence of services. Some areas have successfully introduced coloured road surfaces to address this issue, however can be significant resistance to the use of this approach. In some areas, only part of the route is covered by “branded” initiatives such as coloured road surfaces. Where services operate in mixed traffic, no identification is provided. There are some good examples demonstrating successful implementation of highly contrasted dedicated lanes: TVR-CAS (Castellón), TEOR, TVM, and almost all UK sites have used the red colour successfully for dedicated lanes.

*A specific fleet impacts the operating cost*

In Lorient a unique approach has been adopted: the buses are not branded (network is not hierarchised) and the BHLS corridors are painted with a red contrast, whether the bus lane is dedicated or not, until the terminus. No negative effect has been observed, even if there is a potential confusion for car drivers by following the bus in its dedicated section.

In Twente, infrastructure improvements including artificial grass lanes have been implemented, but only into a very short dedicated section of the whole route. This initiative makes the BHLS route look like a tram line.

In conclusion of these observations:

- A strong identification (branding) among all components is required, to link the role of the line with a higher quality of service.
- Any BHLS identification initiatives should take into consideration the long-term development of the whole Public Transport network.

- BHLS must be planned considering the hierarchy expected of the bus-based network.
- Identification initiatives can be “light” when the PT network is not planned to be complex, such as into small urban areas – e.g. a good numbering with existing buses
- The role of branding and identification requires further research, as it plays a key role in the successful implementation of BHLS solutions. Visual contrast is important, and also plays also a key-role in safety.

### 3.5.5 Comparison of the degree of “system” approaches

Following the previous analysis, we have established a classification of all BHLS cases into 3 levels, as shown in the graph below. This is based on a bottom-up approach that is pragmatic, subjective, but also limited with the data that could be collected. Some sites have been considered as belonging into two types. We are faced with a spectrum of solutions.

In some cases only limited information could be obtained. Some of them have been withdrawn from this analysis where the available information is insufficient.

The objective remains primarily to highlight some possible correlations between context and technical answer.

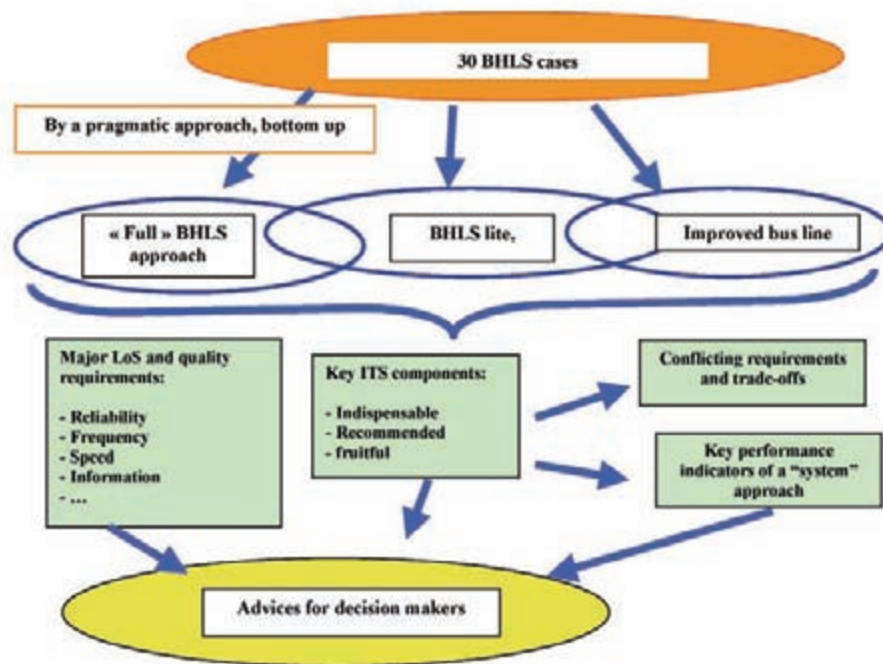


Figure 29: Comparison of the BHLS described by a bottom up approach

The intent of this comparison is not to impose a rigid view or create official labels, since the constraints which influence solutions could vary greatly from city to city. We only aim to reflect one of the most recently observed trends: “hierarchisation” of the lines according to the function into the network. This trend with several bus configurations begins to be observed in Europe, like the program Busway / Chronobus in Nantes, the program “Cristallis”/ “Atobus” in Lyon, Retbus in Barcelona. The common part of the vision is in reality a complete rethinking of the bus network based on hierarchy of lines.

”Full” BHLS solution is not required everywhere. In simple terms, the intent of this analysis is more *descriptive* than *prescriptive*.

#### 1- Sites that can be considered as “complete” or “full” BHLS

The following sites appear to have followed a strong, permanent, global and coherent “BHLS system” approach, with a high level of capacity and performance.

Listed below in table 21 are details related to sites that could be considered as having adopted the full BHLS approach concerning urban planning and infrastructure. The second table 22 highlights some data concerning ITS aspects, operation issues and performances at the sites.

	Paris	Nantes	Amsterdam	Almere	Kent	Jonkoping
Table 21	TVM	Line 4 (Busway)	Zuidtangent	10 lines (trunk network)	Fastrack A and B	3 trunk lines - "Citybussarna"
Opening dates	1993 / June 2007	Nov 2006	2002 / 2007 (2 lines)	1975	March 2006 / June 2007	1996
Role in the network	tangential line	as the 4th tram line	tangential line	structuring network	structuring network	structuring network
Intermodal integration	strong (with RER)	strong (P+R)	strong (P+R, P+B)	strong (P+R, P+B)	strong	strong (P+B only)
% of RoW	95%	87%	66%	99%	56%	7,7%
position of RoW	mainly central	mainly central	exclusive lanes	exclusive lanes	protected	protected
spacing average (m)	700	500	1900	> 600	450	410 - 440
Cost (infra only)	7,1 M€/ km	7,4 M€/ km	6,5 M€/ km	Inside city construction	2 M€/km (PPP)	0,26 M€/km

	Paris	Nantes	Amsterdam	Almere	Kent	Jonkoping
Table 22	TVM	Line 4 (Busway)	Zuidtangent	10 lines (trunk network)	Fastrack A and B	3 trunk lines - "Citybussarna"
type of bus	specific articulated	specific articulated	identified articulated	Standard, articulated	Identified standard SD	identified articulated
dynamic passenger information	stops and on board	stops and on board	yes	on progress	stops and on board (plug and wifi on board)	stops and in board
Priority at crossroads	yes	all	yes	all	yes	all
trips/day	66 000	27 500	32 000 (line 1)	16 000 (line1)	45 000 a week (B)	18 000 (for 3 lines)
commercial speed	21 / 23 km/h	21 / 23 km/h	> 35 km/h	24 - 25 km/h	18.3 km/h	21 - 23 km/h
frequency	3,5 – 15 min	3,5 – 20 min	6 – 10 min	7 – 30 min	10 – 15 min	10 – 30 min
ridership before / after	287% since 1993	+ 60%	+ 100% in 2005	New network	+60% than expected	+ 15 / 20%
Branding	strong (by TVM)	strong	strong	not for buses	strong	not for buses

In all these sites, the following common trends for reaching a strong, permanent BHLS system approach were observed:

- BHLS is a part of the integrated structuring network (like a tram or a metro line), with a strong emphasis on intermodality. A wide schedule span is then observed approaching those of the highest level of the network (regional train, metro, tram).
- A coherent and well-balanced design along the whole route between the two termini has been adopted.
- "Stations" are implemented rather than "bus stops", as they have a permanent location and cannot be easily displaced.
- Significant bus priority measures have been introduced to aid performance of high frequency services: priority at all crossroads and dedicated lanes, mostly in central position or (and) well protected (lateral position are often less efficient).
- A design for high regularity that supports high capacity. Several lines are often provided in the corridors, e.g. Paris and Kent Fastrack.
- A design with limited bus stops to decrease journey times and operating costs.
- Efforts have been made to reduce on board ticket sales by the driver as much as possible, to decrease dwell times at stops. Full off-board ticketing is only observed in the Busway of Nantes: the driver cabin is closed like into a modern tramway.

- Continuous monitoring and control by AVM system that allows the maintenance of regularity and frequency.
- A high level of passenger information on-board and at each stop (soon in Almere).
- A strong branding of the route, that often leads to having a dedicated fleet (distinctive to the other buses of the network).

In general these projects are most expensive when a large proportion of RoW is included. The example of Jönköping however is an interesting example: it is a small urban area and just 10% of RoW was enough to reach a high level of quality. This could be achieved with few traffic problems, and by efficient bus priority measures at every crossroads. In some cases, sites have chosen to design BHLS systems with a view to a possible conversion to tram at some time in the future (Nantes, Twente, Zuidtangent).

The sites in “TEOR” of Rouen and “TVRCAS Línea 1” of Castellón (a very short first phase on service with 3 trolleybuses) have been designed like a tram system, utilising optical guidance vehicles offering very small and consistent gaps, fruitful for high ridership.

In Cambridge, the kerb-guided bus project can also be considered as a full BHLS system approach. (the system opened in August 2011 after some delays). Strong emphasis has been placed on the integration in urban planning and intermodality (connection with the rail station, P+B at each station with CCTV and some P+R). The introduction of dedicated bus lanes will provide certainly many advantages to aid performance and quality.

The case of Bus VAO in Madrid (alternative dedicated lane for buses and carpooling for half distance, in the middle of the motorway A-6 along - 16km) remains very impressive and unique in Europe. Although these lines are not branded and a dynamic information is not yet available everywhere, this scheme can be considered as a full BHLS for the following reasons:

- A very efficient RoW type A (grade separated) along the motorway that provided a high regularity and a much better speed.
- A strong, impressive and close connection with the metro ring line of Madrid (Moncloa station), that provides a high level of intermodality with the structuring network of the whole region.

This approach has achieved a very good modal shift from cars and a high increase of ridership (+50%). However, Real Time Information has still to be introduced to support services at stops and on board (on progress). Sharing the lanes with other uncontrolled traffic (motorcycles, carpooling, taxi) can provide some drawbacks sometimes. Nonetheless, in Madrid, this sharing seems to work well.

## **2- Sites that can be considered as BHLS lite or “small” BHLS**

The following sites display common BHLS characteristics without the full investment displayed by full BHLS sites (as listed above). This may be due to a number of factors including objective of a lower capacity, no hierarchy among the bus network, a lower infrastructure protection for local constraints or cost reasons, lack of ITS, etc... Listed below are details of data concerning urban planning and infrastructure of 8 different “BHLS lite” sites:

For all these sites, common trends can be observed:

- They have all adapted a coherent “system” approach along the entire route, that belongs also to the structuring network (except in Lorient where an interesting infrastructural improvement is observed along a corridor; the bus network did not change and remains not hierarchized for maintaining a very low rate of transfers).
- The provision of infrastructure improvements has been limited (often lateral, often less effective than central), for cost or constraints or flexibility reasons (such as in Hamburg where the aim is to transform the system into a tramway in the medium-term). Hence, some variation of running times can be observed.
- Regarding fare collection, in most cases drivers can sell tickets, which is similar to common bus lines. Nevertheless, the impact on services is reduced due to lower capacity or high rate of season tickets.
- Dynamic passenger information is implemented for the major stops.
- Less emphasis on dedicated branding on vehicles except, for Stockholm and Helsinki where a dedicated coloured fleet has been implemented.



- Branding on infrastructure: often at a low level.
- A trend or a first phase for a strong BHLS network in bigger urban areas (Hamburg, Dublin, Stockholm).

Table 23	Lorient	Dublin	Hamburg	Brescia	Stockholm	Lund	Helsinki	Zurich
	The Triskel	Malahide line	Line 5 Metrobus	LAM 1 and 2	Trunk network of 4 lines	The "Lund link"	The Jokery line	Bus line 31
Opening dates	sept 2007 / 2012	since 1997	2003 / 2007	2006	1998	2003 (first phase)	2003 / 2006	2007
Role in the network	trunk corridor	A wide QBC network	Structuring bus network	structuring network	structuring bus network	structuring network	structuring bus network	structuring bus network
Intermodal integration	strong	strong	strong	strong	strong	P+B at every stops	strong	strong
% of RoW	85%	59%	27%	13%	30%	Around 40%	35%	25%
position of RoW	mainly central	lateral	mainly central	central, lateral	central, lateral	exclusive	central, lateral	central, lateral
spacing average (m)	270	250	510	270 - 180	200		750	414
Cost (infra only)	6,7 M€/ km	4,5 M€/ km	0,14 M€/ km		0,7 M€/km	3,3 M€/ km		NA

Anyway good benefits in term of ridership can be observed.

Oberhausen's site could be considered as a strong BHLS-lite, with its central and new efficient exclusive tramway and bus lane of 6 km (type A infrastructure), where the frequency is very high (1 – 2min) with a high speed (34km/h). This scheme has significantly improved ridership on the whole network (+46%), but it is still limited at this common trunk.

The Zurich public transport network quality and attractiveness are impressive (590 trips per year per inhabitant, one of the highest level in Europe). The bus lines complement the efficient but crowded tram network, so that priority at road crossings is always a trade-off.. The approach shows a good coherence along the whole route.

All these sites have chosen to integrate a strong intermodality with the higher levels of the transport hierarchy (rail network). The intermodality with cycling (at all stops some times) is strongly observed in the countries where the cycling mode has a long tradition: Sweden (Lund, Jönköping mainly) and in Netherlands (all cases visited). The new schemes in Kent (Fastrack) and in Cambridge (Guided Busway) show the same strong intermodality with cycling racks provided at each stop (Cambridge has a long tradition of cycling).

### 3- Sites that can be considered as improved bus lines

Some schemes, such as the Junqueira line in Lisbon, the line 213 in Prague, the route 64 in Barcelona, the link Amsterdam-Purmerend, the QBC in Manchester, were mostly considered as improved bus line, because of:

- A partial implementation
- A design with no identification into the bus network, hence no hierarchisation.

### 4- As a conclusion

The key objectives **to achieve a full "BHLS" project** can be summarised as follows:

- To belong to the structuring network (wide schedule span).
- Integration of a strong intermodality (train, tramway, biking, cars...).
- Mostly stations and not simple bus stops, which can be easily moved.
- Dedicated infrastructure, mostly « central » type B (type A when needed).
- To achieve a rather high distance between stops (for attractive running times).
- To achieve a high reliability (i.e. around 95% passengers having a bus on time).
- Not to sell ticket by drivers, mostly off bus ticketing system.

- Integration of dynamic information at all stops (full ITS solution).
- To be able to offer a High passenger capacity.
- A specific brand/image into the whole system (not necessarily with a specific fleet).

### 3.5.6 Key-components for “operation management and supporting ITS”

The previously described approach allowed the group to identify the key operating components of a “system approach”. These are grouped in three main categories, namely supporting ITS, identification and branding, and service organization.

	WG3 components	for a complete BHLS	Inter-action among components	comments	
supporting ITS	1	Control system (AVM)	****	all supporting ITS	Heart of management, with the objective to manage the whole bus network at minimum
	2	Dynamic passenger information on board	****	1	Other city information can be displayed
	3	Dynamic passenger information at all stops	****	1, 10	Allows disturbances information
	4	Static information at stops	****	1, 10	Indispensable for all kind of bus lines
	5	Information on the web	****	1	For intermodality
	6	Ticketing system at station	***	1	More fruitful for high capacity
	6 b	No selling ticket by drivers	****	7	If not, can degrade priority and regularity
	7	Priority at road crossings, or access control	****	1, 6bis, 8, 10	Important for regularity
	8	Passengers counting tools	**	1	For bus “laboratoire”
	9	Enforcement and security tools (CCTV)	***	1	Important for RoW respect
	10	Personal tools (mobile / Iphone..)	**	1, 3, 6	Increasing market, allows use of social network (facebook, twitter,..)
11	Guidance system	**	1, 5	specific infrastructure design (i.e. kerb height)	
Identification / branding tools	12	Naming / numbering / logo	****	17	To stand out from "normal" services
	13	On vehicles (specific color, design,..)	***	17	Operating overcost – interest for complex network (big cities)
	14	On stop design	****	17	Common approach and services along the route
	15	On infrastructure (by contrast,..)	**	17	Limited at RoW – important for safety and RoW respect
	16	Advertising / promotion campaign	****	17	Linked with the quality provided
Service organization	17	Hierarchised services	***	1	Tend to increase transfers and more walking
	18	Park and Ride	***	1, 9, 3, 10	
	19	Bike and Ride	***	1, 9, 3, 10	Increasing demand
	20	Express services (often at limited schedule)	**	1	Rarely used in Europe - need of passing lanes

Table 24: Key components for operating management and supporting ITS

A qualitative evaluation was performed among all BHLS described to assess the influence of particular criteria for achieving a full or complete BHLS. A star-based scale was used in the following way:

Indispensable	****	Fruitful	**
Important or often indispensable	***	Can be useful	*

AVMS appear to be indispensable for any BHLS project for managing the whole bus network. All the exceptions quoted relating to ITS § 3.5.1 (Dublin, Manchester, BusVAO in Madrid) have already implement AVMS subsequent to the BHLS implementation, or they plan to do so. They also plan to implement dynamic information at most of the stops, and in vehicles as well.

Dynamic information provided to all stops (waiting time for next and following bus, destination, disruption information) is one of the most important aspects as far as passengers are concerned. It would be useful if every passenger wherever they are, could have the same high level of information.

A key issue is often to justify providing dynamic information at all stops, even where stops are not used a lot; indeed this cost can be very expensive, in capital, operations and maintenance costs. The increasing market of mobile phones and “flash codes” may allow information to be sent direct to the passenger and reduce the need for expensive displays in the coming years.

### 3.5.7 Major KPI’s for controlling a BHLS

The domain of performance indicators in PT is always a strategic objective for stakeholders (mainly PT users, authorities, operators, other road users, industry as well). The EBSF project<sup>58</sup>, has been working on this issue within a wide workpackage<sup>59</sup>, and has identified a wide array of indicators that are needed or could be of some interest for all type of bus-based solution.

KPIs suggestions for controlling a BHLS		
Quality	Regularity / punctuality	CEN standard calculation
		Along the day / month: standard deviation
		At peak hours: standard deviation
	comfort	Loading rate at peak hours
		Loading rate along a current day (standard deviation)
		Driving quality (by survey)
	Information	Reliability / availability rate
Safety / security	Rate by 100 000 km	
Complaints	By rate and items	
Performance	Reliability	Service provided / service expected
	Operating speed	Standard deviation
	Capacity	Passengers/vehicle-km Passengers/hour/direction
	Dedicated lanes	Level of respect
	Priority at traffic lights	Efficiency rate
Costs	Operating costs	Per km (maintenance, energy,...)
	Fraud	By rate
Branding	identification	By survey (at PT customer level)
	Image	By survey (at city level)

Table 27: List of indicators suggested for the board

<sup>58</sup> European Bus System of the Future, European research project 2008/2012 – www.ebsf.eu.

<sup>59</sup> Deliverable 1.1.2 called “key performance indicators “ is now available and can be requested at UITP

Regularity /  
punctuality stays  
the key indicator

Table 27 above highlights the core indicators perceived as the most fruitful for monitoring the performance of a BHLS scheme, its high quality expected, both from the operator and user perspective.

Moreover, other indicators can be added at sites to meet local conditions. However any management board, at top level, cannot follow frequently more than around 5 /8 indicators, so that priorities should be made according to the local situation and the most challenging objectives.

### 3.5.8 Conflicting requirements and trade-offs observed

The EBSF project dealt with this topic in the deliverable “D 1.3.1, OVERALL SYSTEM REQUIREMENTS” and points out 16 general types of potential conflicts on system level. These have all been linked to the Basic Functional Requirements to which all kind of bus system solution should respond. It is always a high challenge to perform trade-offs in order to overcome the contradicting requirements when moving from the conceptual level to the level of solutions.

	Contradicting or conflicting requirements		Examples	
	A	B	more A	more B influence
Network – Route design	Bus network hierarchy with feeder lines	Passenger comfort with less transfer, less walking effort	Jonkoping, Nantes, Hamburg, TVM	Lorient, BusVAO (Madrid), Almere
	Large spacing for a better speed	Accessibility demand with low walking demand	lots of full / complete BHLS, Zuidtangent	Lorient, Dublin, Zurich, Almere
	High rate of dedicated lanes	Car traffic and parking demand	Lot of full BHLS, Busway, Twente	Stockholm, Jonkoping, Manchester
	Lanes dedicated only for buses / tramways	Sharing with taxi, bicycle, 2 motorized wheels...	Busway, Zuidtangent, Rouen	Hamburg, Madrid BusVAO, Prague
Boarding / alighting	Off Bus Ticketing, to speed up boarding times	Ticket selling by driver (human service)	Nantes, Rouen,	Majority of the case studies
	Lots of door for decreasing the dwell time	Maintaining a good level of seat capacity	Prague, Hamburg, Zuidtangent	Dublin, UK sites
	Multiple door boarding / alighting for short dwell time	Front door boarding for protect revenues	Majority of case studies	Dublin, UK sites
Rolling stock – Infrastructure	High capacity with a high standing rate	Comfort with a high seating rate	Nantes, Prague, NL sites	Jokiri line, Madrid BusVAO, Dublin, UK sites
	Driver protection and concentration	Passenger contact (human service)	Nantes, some UK, Prague	Hamburg, TVM, improved bus lines
	Innovation (guidance system, alternative fuels, etc...)	Proven technology	Douai, Hamburg,	Busway, Zuidtangent, NL sites, SE sites...
	High kerb systems compatible with tram	Low kerb systems compatible with common buses	Rouen, Castellon, Essen	TVM, Oberhausen, Lisbon
	Specific bus design or specific colour	Flexible management among all bus lines	Busway, Zuidtangent, TVM, UK FTR Leeds, Jokiri line, Stockholm	Lorient, Jonkoping, Lund, Gothenburg, Madrid BusVAO...

Table 28: Overview of the trade offs that have been observed in the existing BHLS projects

In the process of designing any PT service, it is recognised that there is a certain number of critical (and mandatory) requirements that can be conflicting between each other. It is important that the objectives can be clearly understood according to inevitable trade offs, otherwise successful implementation is not guaranteed. It is therefore essential that all issues are

clearly identified to guide decision makers building on previous experiences from other established sites.

In general, a trade-off analysis has to be carried out in such cases to evaluate the best balance between the cost-benefit ratio of the possible applicable solutions to the conflict.

All the BHLS descriptions have shown some solutions or trade offs to address conflicting or contradicting requirements. 12 have been highlighted into the table 28 above.

Additional comments about these 12 trade-offs:

- Hierarchisation issues: this economical approach provides more transfers. On the other hand, passengers, mostly old or disabled people, like to have direct travel, as transfers can be uncertain.
- Distance between stops: despite a better speed and a better quality, elderly and disabled people could be strongly disappointed by increasing walking distances.
- High rate of priority lanes is an essential successful component, which makes BHLS sustainable or permanent. Sometimes, flexible solutions (always with priority at signal lights) are possible and often better in constraints areas. Anyway, this is the most challenging part of the project, as there is generally resistance to reducing space for cars.
- Sharing the dedicated lanes with other modes (taxis, clean modes): such integration should be studied at an early stage with the relevant stakeholders, and not just before the opening of the BHLS service. Such compromise can become a source of downgrading the BHLS service at peak hours, as it is difficult to forecast and manage the demand of such additional modes.
- Ticketing process: BHLS systems function better when the driver does not sell tickets or handle money. Consideration should be given to season tickets and off bus payment systems. Selling ticket by drivers can reduce the benefits of any traffic light priorities. Vending machines can be seen use in most tramway systems.
- Number of doors / Seating Capacity, a difficult issue when designing BHLS services: the over-60 years old population will double in the next 10 years and older people like to sit. However to aid boarding and alighting times more doors assists the time taken to get passengers on/off vehicles. More doors mean fewer seats (although more seat are required as average trip length). In some countries good results have been achieved with few doors and entrance by the front door (i.e. UK sites). Other factors are also relevant, such as fares, width of the platform, and discipline of the passengers.
- The ratio of boarding time to total travelling time is dependent on distance between stops (although this is not the only factor).. Using only front doors for high-demand lines with relatively short distance between stops is not so economical (and also not so practical for wheelchair users, baby prams, etc.).
- Entrance by all doors versus by front door: fraud remains an important issue for these systems (the same problem is experienced in the tramway sector, especially with high capacity). In UK, USA or Canada operators prefer the entrance by the front door whatever the capacity. In continental Europe it is often preferred to have more doors in order to decrease boarding time (also EBSF recommendation). In that case innovations in ticketing systems should help. Compromise solution should be different boarding by type of line (local – multiple boarding / regional – only front doors) or by time of operation (peak – multiple boarding / evenings + weekend – only front doors).
- Vehicle capacity, high standing rate versus high seating rate: more comfort is demanded for longer trips.
- Driver protection: high capacity is less compatible with passenger assistance by drivers, however passengers like the perception of being able to speak to the driver as this makes the bus very “human” or the most appreciated mode. But for high-capacity BHLS (for tram as well), such assistance can have a bad impact on the quality and reliability.
- Innovation versus proven technology: It is important that the specification for any site takes into consideration the risk of new technologies. The risk can be high for small cities, with a limited budget. Additional costs and risks of innovation should be shared with the state level, so that lessons learnt can be spread publicly.
- Accessibility, high kerb versus low kerb choice: guided bus and tram can offer the same gaps with the same high kerbs; except the case of Nantes equipped with short ramps; non-guided bus are mostly compatible with low kerbs.
- Dedicated fleet versus common design of the bus: in the case of high-volume BHLS systems, a dedicated fleet of vehicles aids in understanding the specific service. However, this is less important in less demanding small urban areas where the network is really simple to understand. This additional investment and operating costs of a specific fleet can be too high and actually not so useful for small and simple network (like Jönköping, Lorient, Almere, Twente).

It is essential that each site understands the mobility issues that it is trying to resolve to meet the needs of passengers and cities. Trade offs are required to meet local objectives in the most cost effective way. In overall terms each site has to recognise its own issues. Each site has its own unique starting point objectives and level of ambition.

Generally the technical answers are not always the same; the local context, the behaviours, the objectives in the long term, etc. will play a role in the trade-off.

**Conclusion:**

The highest conflicts are generally generated by creating dedicated lanes, which are the backbone of any permanent BHLS project; a high level of studies and political support is then required. Taking space from cars needs to offer a credible alternative solution to car owners.

Finding the optimal solution to conflicting requirements can be solved better at “network” level, than at “system” level.

This analysis can highlight the main axes of innovations / assessment / benchmarking needed.

### 3.5.9 Enquiry on operating methods and support tools

The COST TU0603 action carried out a short enquiry to understand the technologies and the operating methods used in European BHLS to support Reliability, the most important factor. A total of 12 BHLS systems responded.

Overall, it is seen that Reliability is of high importance. Formal targets are set within the service contracts, and the targets are linked to payments/penalties.

The summary report is in the CD.



*Zuidtangent: crossing with pedestrian and bicycles are protected with barriers and traffic lights along the section that can be over 70 km/h*

## 3.6 Socio-economical and networking issues, by WG4

### 3.6.1 Defining “High Level of Service”

#### **1.- Definition of High Level of Service** (‘BHLS’ is ‘Bus with **High Level of Service**’).

It is very important to define “High Level of Service”. Within the WG4 work, it has been noted that “Bus with High Level of **Technology**” is not necessarily “Bus with High Level of **Service**”. Technology provides supporting tools to achieve the desired higher level of service.

It is not good practice to simply make investments in better infrastructure, vehicles and customer facilities, presuming that this automatically gives “higher level of service”. Undoubtedly there would be some improvements, but there must be an underlying logic that guides the investments and deploys them well. Otherwise, one cannot be sure that the right aspects are being addressed or that the outcomes are sufficient. Further, one cannot be sure if the money has been spent wisely, or if some of the expenditure was even necessary.

A structured definition of “High Level of Service” is required for four related reasons:

- To carry out a *gap analysis*, so that there is a proper understanding of which dimensions of the service are actually in need of significant improvement.
- To determine the *design level of service* for each of the relevant parameters, and to use this as the fundamental guidance for all system and engineering design.
- To *assess the outcome of the design*, first as planned and then as delivered, so that the design is revised or else proceeds knowing where improvements are required at a later stage.
- To *monitor performance against design level of service*, linking payments, incentives and interventions to attainment of the required levels.

Most BHLS systems set objectives for their schemes – in some cases, quite explicit objectives – but we have not yet seen much evidence of a structured approach to defining, designing for, and delivering a multi-parameter High Level of Service.

This is not a criticism of the current BHLS schemes. They have implemented good schemes which have achieved impressive ridership gains and positive customer and public opinion. Nonetheless, it is often not so clear what level of service they have aimed for, nor the extent to which the various elements of the investments are addressing the priority service aspects. It is also not clear if they could have achieved their outcomes with a lower level of expenditure, if it had been targeted more precisely.

There are two readily available reference points for defining high level of service:

- *Level of Service, as defined in the US TCRP Transit Capacity and Level of Service manuals (Report 100- 2<sup>nd</sup> Edition)*
- *Quality, as defined in the EU QUATTRO projects and subsequently in the norm EN 13816*

We consider that the US TCRP Level of Service approach is more appropriate for design of BHLS. It defines different levels of service for various parameters, and it is intended for use in planning and design. It is well documented and reviewed periodically through consultation with the public transport stakeholders. The Quality approach in EN 13816 has a greater number of detailed quality parameters, but is not operationalized to specific values. France has its own NF 13816 “Règles de Certification Spécifique – Services de Transport Urbain de Voyageurs” The next section considers the potential of the TCRP approach for BHLS.

#### **2.- The Level of Service Approach**

The US TCRP Transit Capacity and Level of Service manual states that it is “... *intended to be a fundamental reference document for public transit practitioners and policy makers. The manual contains background, statistics, and graphics on the various types of public transportation, and it provides a framework for measuring transit availability and quality of service from the passenger point of view. The manual contains quantitative techniques for cal-*

*culating the capacity of bus, rail, and ferry transit services, and transit stops, stations, and terminals.”*

Guidance is given for each of the main transit modes: Bus Transit is dealt with in Part 4, Rail Transit Capacity is dealt with in Part 5 of TCRP Report 100, 2<sup>nd</sup> Edition.

The Level of Service approach has three main features:

- A set of Parameters that are relevant to capacity and level of service.
- A Level of Service rating system (A through F), with A being best.
- Quantitative and qualitative specification of each level of service (A through F) for each parameter.

The TCRP approach uses the following Parameters for fixed-route services:

- Service Frequency
- Hours of service
- Service coverage
- Passenger load
- On-time performance
- Headway adherence
- Transit-Auto travel time

For each parameter, quantitative values are given for each Level of Service. In some cases, qualitative explanations are also given. The Level of Service for the specific Parameters for Fixed-Route Transit, based on the TCRP literature, are presented in the detailed WG4 report (contained in the CD).

The values for the various Levels of Service have been developed in the USA in response to their industry needs and goals. Perhaps somewhat different values should be used for European urban passenger transport, especially for the Service Frequency criterion.

The Level of Service approach is quite flexible, and can be used in response to the specific needs of the target area. For example, following a careful study of customer preferences and priorities at the site, and taking account of the technical and financial feasibility, a city might choose to design for the following Levels of Service for a BHLS scheme:

- LoS A for Service Frequency, On-time Performance,
- LoS B for Service coverage, Headway Adherence, Hours of Service, Transit/Auto travel Time,
- LoS D for Passenger Load at Peak time, LoS C at all other times

If multiple lines will use the BHLS infrastructure, the city might design for different LOS by route type or by individual line. The LOS for Service Frequency, Hours of Coverage, would reflect the role of each line in the network hierarchy and the passenger demand.

Whatever approach is used by a BHLS site, the key points are:

- the various service attributes need to be explicitly formulated,
- the target service/quality should respond to the travel demand, and to the customer preferences and priorities;
- the BHLS design should be based on the target service levels, and investment should prioritise the gaps between the existing service and the desired service;
- expenditure on attributes that are not customer priorities, or on attributes that already meet the target requirements, are of limited value and may be wasteful.

As BHLS is an emerging domain, it is likely that some of the initial implementations have been based on what is feasible without rigorous needs analysis. It is essential that lessons are learned about which elements and attributes have had the most impact. This will better inform future system developers on how to optimize their designs and target their available funds to best effect.

### 3.6.2 Financial and economic context

The recent global financial crisis highlights that Public Transport systems provide the means to achieve sustainable cities and sustainable development. BHLS, as it has now developed in



Europe, offers a new and relevant response to those challenges. It can offer an intermediate system for cities or suburban areas that face limitations of investment financing and budget. The BHLS systems can be developed and cover part (case of Essen) or the whole Public Transport network (case of Almere). In a number of cases, BHLS has been implemented where strategic plans had earlier identified the possibility of rail-based modes (e.g. Lund, Kent). In some cases, this has been on the basis that tram could be implemented at a later time when the capacity is required or funds are available. In a few cases, BHLS has been implemented by choice over tram (Amsterdam, Nantes), with investment costs being a significant factor in the choice. There are no cases where BHLS has replaced an existing tram or rail service, nor is there any case where BHLS has been implemented as a substitute for such a line that has been closed. (In Cambridgeshire, the Guided Busway has been constructed mostly on a disused railway line, but this was due to the alignment being available rather than as replacement for the former rail service).

### **1.- Infrastructure**

The European BHLS uses great variety in the infrastructure provided for the improved bus-systems. The range goes from buses running mixed traffic, through priority lanes with just lane markings, up to systems which are fully segregated from general traffic to guarantee uninhibited running. Methods of segregation range from barriers (i.e. Almere, Castellon) and flyovers through to dedicated bus roads (e.g. Amsterdam, Paris, Cambridge). Only kerb-guided busways, as observed in Cambridge, Leeds and Essen, might require a special standard of production. Busways without mechanical guidance are easy to build. Whether the running way is just a stripe on a street, or a dedicated lane, a bridge or an underpass, companies that are active in road construction can do it. The same is true for signalling and signage – the systems are identical to those for car traffic. This makes segregated infrastructure for bus affordable. It is also possible to implement the infrastructure step-by-step, since the buses can still use the normal roads on the sections not yet developed. A good example for this is the Quality Bus project in Dublin, where new fragments of dedicated lanes can immediately contribute to a more steady and reliable operation.

In case of a temporary detour or a permanent allocation, even the route of a BHLS can be adapted easily. The flexibility of bus is a significant advantage to handle sudden road closures as well as the mid- and long-term development of the services.

Many BHLS systems include elements to benefit the host community or to enhance the urban space. At the basic level, pedestrian facilities are improved and cycle lanes are provided. In some cases (especially noted in France and Netherlands), significant effort is made to improve the visual appearance of the urban space, the footpaths and ambience along the BHLS alignment, the linkages to/from the stops, cycle parking, etc. When we make comparisons of the capital costs of various BHLS systems, we should take into account that some BHLS systems have incurred significant costs for urban space improvements, whereas others did not face such costs.

### **2.- Operation**

In most of the European BHLS cases, we observe normal buses (standard and articulated). Usually the vehicles are the same for normal and improved bus routes, although there may be greater use of articulated buses. Even if there are some differences in design, the vehicle body is taken from a standardized bus. Buses with high floors or with doors on both sides, (such as observed in Latin America) are not in use in Europe. As there is no material difference in the vehicles, there does not have to be any differentiation in the staff. The operating reserves therefore can be scaled moderately.

As BHLS in Europe often consists of standard buses running on segregated but normal lanes, the infrastructure is accessible for different operators – if this is desired and authorised. The benefit of a busway can easily be usable for all operators in a corridor. When special vehicles are not required, the integration of a new busway in an existing network is quite easy – at least as easy as a normal adaptation of a bus network.

Experience in the studied sites show there are not any extra costs for the BHLS operation. On the contrary, estimations show lower unit operating costs due to increased commercial speed and less energy or buses in such line or network. However, for the overall operating

cost equation, it must be recognised that BHLS usually involves an augmentation of the service level (thus more buses and more kilometres) albeit at reduced per-kilometre cost. It also involves new and sometimes larger vehicles, which may have higher depreciation and unit costs than the vehicles previously used. Balancing this, all BHLS have achieved impressive ridership gains - some in excess of 100% growth – leading to improved occupancy and revenues.

### **3.- Maintenance**

All cities with a BHLS-system already had a bus network before and usually still continue to operate normal bus routes. The workshops and the know-how of maintenance can be transferred seamlessly – a large advantage of an organic developed improvement. Certainly there is a need for fitting and education, if new technologies for propulsion or power supply are implemented. However, this requirement may also appear in a normal but modern bus network. When articulated buses are added to the fleet or their numbers are increased, it may require additional pits and some adjustment to the maintenance facilities.

If the BHLS has dedicated bus lanes, the maintenance costs of these corridors normally will not differ from normal roads. Snow clearing and repair can be done with the existing equipment and well known technologies. Only in kerb guided busways there might be a need for special equipment. For busways, we have observed that rutting or other degradation of the surface can occur at the bus stops. Where this happens, it is usually due to inadequacies in the design, material or construction. In many cases, the contractor is obliged to make good.

### **4.- “Spin off”-Effects**

If new Public Transport-systems are implemented in a city, additional private investment for house building or renovation can usually be observed. This is frequently observed with new rail and tram lines where the integration with land use is larger and successful.

14 European BHLS examples can witness the same possibility where there is implementation of an improved bus service. Urban renovation or space enhancement is more often taken in charge by public funding. The actual impact is not yet very well known and not measured.

We have observed on many occasions that research on these points has hardly been done for BHLS, even though they are now almost standard for tramway and rail project. There is not sufficient data available to quantify the broader impacts of BHLS.

A further complication is that in many cases the implementation of BHLS was strategically combined with a settlement development like in Nantes. This makes it nearly impossible to study separated induced effects – what is due to the BHLS, what is due to the urban development, and which leads which? In other cases the appearance of public space was not changed at all, while the activities of the residents remained on an average level. However, the installation of a pedestrian area might initiate similar effects. We therefore consider that the triggering of private investment may depend less on the kind of the implemented Public Transport-system, and more on the degree of street regeneration.

## **3.6.3 Social context**

### **1.- Acceptance**

All the observed European BHLS-cases have reported an increasing patronage. This indicates a success in the transport market. These services usually find a good acceptance by the citizens everywhere. However, improved bus-systems always have to grapple with the comparison to rail. Would rail have attracted more people than bus if all other parameters are identical? We have not been able to find an answer to this fundamental question, because in reality one system is never replaced by the other on a straight one-to-one basis. In Oberhausen buses and trams do use the same infrastructure in a corridor of more than 6 kilometres' (Public Transport-route). It is observed that passengers there do not make a distinction between bus and tram if both serve their destination – i.e. a passenger would not choose to let a bus pass by and wait for a subsequent tram. It is hard to imagine that there would be more passengers if the PT-route were served only by trams. This route is 100%-segregated

from road traffic, like the busways in Amsterdam, Cambridgeshire (guided busway), Nantes or Paris. The operation in these cases is similar to rail. This is why we presume that the acceptance of bus comes close to rail if the operating conditions are comparable to rail. Remaining slight differences in acceptance may arise from the vehicles, where the interior of buses seldom convey the generous design of a rail car. Counterbalancing, in many cases there is a higher proportion of seating on bus than on trams (especially Cambridge, Dublin with double-deck buses). This is line with findings made by researchers at ETH in Switzerland or Sweden showing no significant difference in the use of public transport when comparing trams with urban bus systems in comparable performance characteristics (speed, reliability, frequency, coverage).

## **2.- Quality of supply**

Buses can operate on steep and narrow streets, allowing them to offer Public Transport-services to all or almost all settlement areas of a city. That is why the advantage of short and reliable travel times in a central section of the Public Transport-network can be devolved by bus to all areas of the agglomeration. In small and medium-sized cities a fast transport system to or through the city centre would not gain enough time to justify the loss of time when changing to bus on the outskirts. In those cases a central BHLS-section as a trunk route is considered to be an adequate and attractive solution. Such routes bundles the buses from the outskirts and lead them without transfers quickly and steadily into the city centers. Gothenburg, Jönköping and Lorient are cities that have chosen this approach. They show that buses can combine attractive travel times with a high quality of supply for all citizens. Furthermore cost efficient vehicles and a need-orientated infrastructure may retain more resources for tight headways, which is also a component for a high quality of supply.

## **3.- Accessibility**

BHLS is more than just fast and reliable transportation. Most of the examined systems also offer improved passenger information and barrier-free access to platforms and vehicles. Due to the progress in low floor design a slight raising of platforms provides good access to modern low-floor vehicles to most people with disabilities. It is observed that this is also appreciated by the 20-30% of the population who have some minor difficulty in their mobility. For wheelchair users an additional ramp in the vehicle can be an acceptable solution. Access to bus stops is usually not problem in European cities, as large efforts have been made over the past two decades to achieve universal accessibility. Therefore buses can provide a very good accessibility also for disabled persons or families with strollers or prams.

If vehicle floor and platform have the same height (e.g. Amsterdam, Nantes, Rouen, Kent Thameside, Castellon, etc.), the access to the bus is 100% barrier-free. However, this design normally requires straight road sections for the stops.

## **4.- Security**

Transport authorities and operators make large efforts to make passengers feel secure while travelling by public transport. It is increasingly common to have CCTV and security guards (especially in the evening times) in European public transport networks. Bus stops at the surface, a manageable vehicle and the addressability of the driver are good supporting factors for security. This advantage of bus is also valid for BHLS-systems.

## **5.- Ticket price**

In Europe, public transport is considered to be a service of public interest. It is expected to be usable for all population stratum. This requires affordable ticket prices. Considering the capabilities of local budgets, an economical infrastructure can help to keep ticket prices on a low level. Our WG4 analyses show that BHLS-projects can be realized with an accessible investment. In all observed networks the ticket price for using BHLS was the same as in normal buses, even though it is a premium product. Even if distinction in tariff is to be foregone, the cost efficiency of BHLS helps to keep down the ticket prices in the whole network.

## **6.- Rents**

The improvement of Public Transport infrastructure may influence the private houses prices along the corridor. While restoration and renovation works are welcome for the authorities, an increase of rents or housing prices could be undesirable because of the social impacts. For

rail-systems this effect has been demonstrated through studies and empirical evidence. Due to lack of comparable research at the European BHLS sites, it cannot yet be answered if BHLS-systems show a similar outcome. In the observed cases we lacked surveys on the development of housing prices or rents before and after the implementation of BHLS. We strongly recommend that research is done on this subject.

### 3.6.4 Implementation conditions for BHLS results of inquiries by WG4

During 2008, WG4 launched an inquiry into Implementation Conditions and Assessment Framework for BHLS. The method used was a template of questions, which were then researched by members of WG4 for the case in their own countries. The detailed responses are presented in a separate Working Note in the CD that accompanies this Report.

The questions were constructed on the three axes described below. Responses were received from 11 countries: England, France, Germany, Ireland, Italy, Netherlands, Portugal, Romania, Spain, Sweden, Belgium (Flanders). The responses are synthesized in three tables (in the accompanying CD). The approach has been to present similarities and divergences in practice. As with most aspects of BHLS, we do not propose that there is any “ideal” or “correct” approach. Approaches reflect the norms and practice in the host environment. Nonetheless, it is clear that there are some aspects where the practice is common in most or all of the countries reported. It is also clear that some of the ‘divergent’ practices are potentially good practices that others could emulate. We present the set of questions asked and some key findings.

#### 1.- Implementation Conditions

*What level of consultation is undertaken and when within system planning does it take place and with whom?*

*What role do local businesses, operators, politicians and any other bodies play in system planning?*

*Is there any defined link between BHLS and economic regeneration. Have the regeneration effects been studied, is there a difference between BHLS and Tramway?*

*Who operates, who regulates BHLS and does this differ to conventional bus and tramway?*

- We can see that most BHLS is implemented to improve existing bus.
- Only a few cities have implemented BHLS as choice with Tram/LRT (i.e. Nantes, Lund).
- Very few cities use BHLS to achieve major increase in transportation capacity (i.e. Hamburg, Utrecht, Zurich).

#### 2.- Socio-economic assessment

*Is there any consideration, or evidence, on the effects of implementation on the local economy, housing, quality of life? Is it different for BHLS and tramway?*

*Is there a defined approach to socio economic assessment, is it the same for tramway and road schemes? Is it a multi criteria approach?*

*What is the general weight given to cost benefit analysis within a system appraisal?*

- For the countries studied, public consultation is normally required.
- Consultation with business, retail, etc. varies from one site to another.
- Local political support is important, even if not mandatory. Projects are usually prepared by skilled PT and Urban planners and they seek to convince political actors and gain support.

#### 3.- Position of BHLS within the Public Transport Network

*Does the decision to implement start with objective assessment or is the decision taken to implement bus, BHLS or tramway at the outset?*

*Is there a view that BHLS can exist as part of a hierarchical public transport network consisting of different public transport modes, or is it the case that the area adopts either a tramway network or bus based network?*

*Is integration of fares and information between different public transport modes an issue?*

*How do BHLS, bus systems and LRT relate to the public realm – are they seen as enhancing the public realm?*

Generally there are different appraisal basis for BHLS and tram/LRT projects:

- Typically; operating costs, value of time, revenue are considered for BHLS,
- Economic (re)generation, housing, land value, quality of life, access to jobs, etc. impact are rarely or never taken into account for BHLS. By contrast, they are always considered for tram/LRT in justification and appraisal.
- Tram/LRT are seen as enhancing public realm, bus/BHLS is normally not.
- There is little or no effort to study these or other societal issues for bus.

### 3.6.5 Implementation practice

Usually, transit authorities design intermodal urban Public Transport system within cities or metropolitan areas where bus network can provide complementary services (Nantes, Madrid) or structural services (QBC in Dublin). In most cases analysed, the BHLS services are procured on the same basis as the rest of the bus network. There is not any special contract or agreement specific to the BHLS system. Transit authorities and practitioners have tended to view the BHLS services as an improvement of the Public Transport or bus network performance, and not as the creation of a new bus network or service. More recently there are signs that cities approach the BHLS as a new concept, for example as the "RetBus" in Barcelona. There appears to be a transitory phase where it is possible to finalize some perspectives for the forthcoming agreements between transit authorities and operators through explicit tenders and future contracts. The structure and terms of these agreements need to include all the conditions or factors that construct the BHLS system as a multimodal philosophy. Thus, all design is developed to increase the Public Transport modal share by means of the quality and security performance. We have asked the different transport authorities how they can plan bus services in their urban area, to see whether it is easy to implement specific BHLS routes. The questions were the following:

- 1) What is the Basic Model of Bus Service provision in Major Urban Areas?
- 2) At which level of Government is the primary authority for urban bus services?
- 3) In practice, what is the unit of delegation or contract?

The detailed answers are given in the full WG4 document in the accompanying CD.

#### **1- Regulatory and Procurement Aspects of BHLS**

The regulatory and procurement practices for BHLS define the planning, quality, payments, management and other institutional and organizational dimension of BHLS. We examined whether the practice for BHLS is in any way different from what is done in normal bus service in the same city. The main finding is that in most cases there are neither process nor detail differences between BHLS and other bus services for their implementation. The main exception is the UK, where the bus market is deregulated, so any collaborative framework is unique to the BHLS. An extensive analysis is provided in the full WG4 document, which can be found in the CD that accompanies this report.

##### a) Regulation and procurement of urban bus services

Regulation and procurement of the urban bus market varies significantly across Member States, despite an EU Regulation on such services. The full span of regulation includes Public Monopoly, Delegated Management, Controlled Competition, Light-touch Regulation and Deregulation. Territorial scope of the planning and regulation spans national, regional and urban levels. The *unit of procurement or regulation*, ranges from the entire network though to individual routes. The allocation of network and service planning roles and the 'right of initiative' varies across stakeholders. Nonetheless, the BHLS is always planned, regulated and procured within the same framework as the rest of the bus network. When there is such great diversity of regulatory and procurement practice, we consider that that any observed convergence can be taken as a general principle of BHLS in Europe.

## b) Planning and Design of BHLS

The case studies indicate no difference in planning and design practice for BHLS compared to other bus services. Allocation of roles is surprisingly consistent across countries and frameworks, with the exception of UK (outside London). Networks and services are designed and specified by the transport authorities in all cases except UK (outside London) and Ireland.

In practice, dedicated offices or project teams are established for BHLS implementation. For example, in Ireland, a Quality Bus Network Office was established within Dublin City Council to implement the QBC network (now migrated to the National Transport Authority).

## **2.- Financing of the BHLS elements**

Responsibility for financing aspects of BHLS differs only moderately among countries. In the BHLS cases analysed, there is no difference in financing BHLS compared to other bus services. Usually, urban public transport infrastructure investment and rolling stock are fully or part-financed by central or regional governments. Specific equipment can be provided by the operators. Many operators provide ticketing or passenger information technology equipment.

### a) Responsibility for financing BHLS elements

Normally, the responsibility for financing the infrastructure, transport and passenger services is split between transport authority (mainly the city) and the operator. In practice, specific project budgets are put in place for BHLS. For example, the Quality Bus Network Office in Dublin has a dedicated budget line under Transport 21; the Nantes Busway had a dedicated project implementation budget derived recently outcomes from Low Carbon policy. This is considered normal practice for special projects and is not a specific feature of BHLS.

### b) Financial sources for the BHLS elements

The BHLS bus services operating are always funded from the same budget allocation as other bus services. Operators are not charged for using the BHLS infrastructure (for the moment, at least). In France, there is now a State allocation to contribute to financing the right of way for public transport systems, including BHLS.

### c) Tariff-setting and BHLS

WG4 carried out an enquiry among the BHLS schemes to explore two themes on tariff setting for BHLS: (i) is it determined on actual costs and revenues of the BHLS lines; and (ii) is there differentiation between the tariffs for BHLS and those for regular bus service. Responses were received from 10 countries, and the enquiry has been reported in the Working Note "Tariff Setting in Passenger Transport and for BHLS" in the accompanying CD. The key findings are:

- no European BHLS currently bases the User Tariff directly on the costs of production of the service;
- no European BHLS currently uses an explicit formula for a technical calculation of the tariff;
- no site has introduced differential pricing for BHLS relative to other bus services.

This means that authorities have not sought to capture potential BHLS financial gains, neither by charging the passengers more for a premium product that gives them time savings, nor directly recovering the improved surpluses of operators.

We observe that there are not existing mechanisms which adjust the general passenger transport tariffs automatically in response to changes in unit or overall revenues and costs. This means that user tariffs do not respond in a direct way to the changes in cost, ridership or load factor resulting from BHLS and other investment projects. Differential pricing for BHLS will not arise from the existing tariff-setting mechanisms. (The above should not be interpreted as opinion about tariff-setting strategies or recovery of surpluses from operators).

## **3.- Organisation of the Bus Services operating on the BHLS**

BHLS and bus services are procured or licensed in the same way, using the same procedures. The vehicle specification may be different for the BHLS routes in some cases, but they are

still procured within the general procurement procedures and usually as part of a broader urban bus services contract. It can be seen that BHLS services are managed and controlled in the same way as non-BHLS services, although some specific operational procedures may be different. We do not observe any operations management systems unique to BHLS. The performance and quality parameters used are the same for BHLS and non-BHLS services.

More surprising is that the **target values** for these parameters are not different for BHLS and non-BHLS services. The identified exception is Zuidtangent in Netherlands where the performance requirements were raised in the repeat contract. Effectively, for the first 6 years, Zuidtangent operated under the same concession and conditions as other buses. On contract renewal in 2007, the same performance parameters were used but with higher standards/target values, and special penalties also apply.

We note that after a period of problem-solving and confidence-building in which the BHLS is shown to be advantageous and reliable, the performance standards could be raised. However, if the BHLS-infrastructure covers a section of a line or a network only, differences in the target values will hardly be useful.

Attributes of the organisation of the bus services operating on the BHLS are presented in full WG4 document in the CD.

#### **4.-Adjustments to Contracts for implementation of BHLS**

When the enquiry was launched, it was expected that BHLS would require adjustments in the existing standard Contracts or other Agreements. This was expected due to the enhanced infrastructure, vehicles, services, and requirements of a better level of service. However, for most cases analysed, the consistent finding is that contractual changes have not been required to implement these BHLS systems. Annexes/schedules to Contracts may have been modified – e.g. route specifications, volume of service, number and type of vehicle – within the existing and normal provisions for service modifications. This presents two possibilities:

- BHLS can always be implemented within the provisions of the existing Contracts, or
- BHLS implementation to date has been cautious and has avoided Contractual change until the concept is proven and the impacts fully understood.

Planning and operating BHLS (also tram systems in RoW “A”), is different to normal bus services. Despite great diversity in regulatory, procurement, financing and organisation, a harmonisation and equilibrium of rules is needed in future contracts for BHLS services. The different examples of QBC in Dublin or Manchester, TVM in Paris, Nantes Busway, Zuid-Tangent in Amsterdam, small networks as Jonköping, Almere or Enschede can give us direction on how to harmonize this particular Public Transport urban service. RetBus in Barcelona seems to offer a good example of the involvement between the two major actors: the transport authority and the operator for the improvement of Public Transport service. In financing schemes, it is important to implement coherent strategies with the objectives to increase the modal share of Public Transport.

### **3.6.6 Outcomes from the 35 BHLS case studies**

#### **1.- Measured performance of BHLS**

BHLS in Europe is implemented for a wide range of objectives, as described above. Whatever the objectives, each system anticipates gains in ridership. In fact, the transportation, social, environmental or economic objectives can only be achieved if ridership gains are made. Therefore, two questions need to be answered to know if BHLS meets its objectives:

- whether BHLS really is effective in achieving ridership gains,
- which are the contributory factors to ridership gains.

The case studies show that BHLS systems in Europe do achieve significant ridership gains. In some cases ridership has even doubled. We note that BHLS systems often involve significant changes in structure and volume of service. This is in addition to the travel time and quality improvements facilitated by the infrastructure investments. Improvement in each of

these attributes is well known to increase ridership. However, the holistic approach appears to achieve ridership gains that are “more than the sum of the parts”.

To illustrate the European experiences, a set of 35 BHLS systems (of which 27 were visited), is presented in Table 25 and Table 26 below.

Table 25 presents primary characteristics of the BHLS systems, including the total system length and percentage of dedicated lane in kilometers; the nature of the running way; daily carryings; the infrastructure cost; service headway during the peak periods; indication of the maximum time for off-peak periods.

City	System identity	Nature of running way	System Length (km)	% dedicated lane (km)	Passengers per day	COST € Million per km	Headway minutes Peak (Max)
Paris	TVM	Bus-only road	20	95% (19)	66 000	7,1	3,5-(15)
Rouen <sup>1</sup>	TEOR	Bus lane partly	29,8	60% (17,8)	20 000	4,5	2-(8)
Nantes <sup>2</sup>	BusWay®	Bus-lanes	7	87% (6)	27 500	7,4	3,5 -(20)
Lorient <sup>3</sup>	Triskell	Bus lane	4,6	85% (3,8)	9 000	6,7	10
Grenoble <sup>4</sup>	Ligne 1		8,9	70% (6,2)	20 000	0,8	5-(20)
Dublin <sup>5</sup>	QBC	Bus-lanes	14	59% (8,2)	34 000	4,5	2-( 3 )
Hamburg <sup>6</sup>	Metrobus	Bus-lanes	14,8	27% (3,9)	60 000	0,14	5-(10)
Oberhausen <sup>7</sup>	ÖPNV-Trasse	Bus lane	6,8	100% (6,8)	25 000	15	1-2
Essen <sup>8</sup>	Spurbus Lines	Partly segregated lane	16,4 and 12,2	76%, 67%	17 000	n/a	10
Lisbon <sup>9</sup>	Rua Junqueira	Partly segregated	3	(1)	27 000	n/a	2-3
Amsterdam <sup>10</sup>	Zuidtangent	Bus-only road,	56	66% (36,9)	32 000	6,15	6-(10 )
Utrecht	HOV line 11 and 12	Bus lane	6,8 5,7	100% (6,8) 50% (2,8)	20 000 25 000	1 12	5-(20) 2-(15) –
Almere <sup>11</sup>	10 lines	Bus lane	58	99% (-)	16 000	n/a	7-(30)
Purmerend <sup>12</sup>	Amsterdam - Purmerend	Bus partly lanes	20	40% (8)	30 000	n/a	5
Twente <sup>13</sup>	HOV line 2 and line 3	Bus lanes	30	90% (27)	1 318 1 250	3	5-10-(30)
Manchester	192 route (A6 corridor)	Dedicated lane partly	15,5	34% (5,2)	21 000	N/a	6-(10)
Leeds	ftf Leeds	Segregated lane	3,7km (several kurb guidance sections)		7 250	2,7(£)	
Ebsfleet Kent Thameside <sup>14</sup>	Fastrack A and B	Dedicated lane partly	A: 10 ; B:15	56% (16,8)	B: 6 000	3 (£)	10-15
Cambridge <sup>15</sup>	The Busway	Kerb guided	40	57% (23)	20 000	3,4 (£)	20 -(30)
Prague	Line 213	99% Mixed traffic	10,25	0,16	18 000	0,03	6-(12)
Bucharest	main line	Bus lane	65,12	75%		N/a	7
Iasi	main line	Bus lane	60,40	12%		N/a	8
Brescia	LAM 1 and 2	85% mixed traffic	54,2 (28; 26,2)	13% (3,8; 3,4)	12 000	N/a	5-(12)
Prato	LAM: (1 blu, 2 verde, 3 rossa)	Bus-lanes	43,5 (16; 11; 16,5)	23% (2,4; 1,6; 6,1)	9 000, 5 600, 8 600	0,5	7-(15)
Athens	express airport line	Bus lane partly; 80% mixed traffic	38	19% (7,2)		N/a	15-22
Barcelona	route 64	Bus lane	21,8	80% (16,8)	15 300	0,5	6-(10)



Madrid <sup>16</sup>	Bus VAO	Tidal segregated lanes	16,1	24% (3,8)	18 000	3,3	8-(11)
Madrid	Line 27	Bus lane	8,32	100% (8,32)	43 900	N/a	2-4,5
Castellón <sup>17</sup>	TVRCAS	Segregated lane	2	100% (2)	3 200	11	5-15
Stockholm <sup>18</sup>	Blue Bus	Bus-lanes	40,4	30% (12,1)	40 000	0,7	4-(10)
Gothenburg <sup>19</sup>	TrunkBus	partly segregated	16,5	45% (7,4)	25 000	N/a	3-(10)
Jönköping <sup>20</sup>	Citybus-sarna	Partly segregated	39,2	8% (3,1)	18 000	0,26	10-(30)
Lund <sup>21</sup>	Lundalänken	partly segregated	6		6 300	3,3	5
Helsinki	Jokery line	Bus-lanes	27,5	35% (9,5)	30 000	N/a	3-7-(20)
Zurich	Bus line 31	Partly segregated	11,1	25% (2,8)	15 000	N/a	7,5-(10)

Table 25: Characteristics of 35 BHLS systems in Europe (Source: Case studies of the COST TU 0603 BHLS [www.bhls.eu](http://www.bhls.eu))

Table 25 notes:

1. Rouen: TEOR counts 49 000 passengers for 3 lines, 20 000 is for the two biggest lines.
2. Nantes is the line 4 after the 3 tram lines. There are more passengers per day than expected.
3. Lorient is a trunk line with several bus lines. The main lines have 10 000 passengers per day.
4. Grenoble counts 20 wheelchairs within the passengers.
5. Dublin data is for the Malahide Road Quality Bus Corridor; there are other QBCs.
6. Hamburg data is for the MetroBus Line 5; there are other MetroBus lines. Cost is very low because it was a former tram line.
7. Oberhausen represents a trunk route for 1 tram line and 6 bus lines.
8. Essen data are for lines 146 (16,4 km) and 147 (12,2 km). They have 8,9 km of kerb guidance route, passengers are for the both lines, full length.
9. Lisbon has a common section for different bus routes
10. Amsterdam: the Zuidtangent is for 2 bus lines; ridership data is for the line 1.
11. Almere is a trunk network of 58 kilometers for 10 bus lines that was planned for the new town.
12. Purmerend is a link Axis N235 towards Amsterdam with tidal flow bus lanes, only used in peak direction. The three top lines have 5 minutes headway at peak hours.
13. Twente HOV (Hoogwaardig Openbaar Vervoer: High Value Public Transport; same signification for Utrecht) will represent 50km at final stage. Some sections have one bus every 5 minutes.
14. Kent Ebbsfleet Fastrack A and B will have an ultimate network of 40 km of which 75% dedicated. Passengers represent for line B 35 - 45 000 trips a week. Cost is given in £ with a Public Private Partnership (PPP)
15. Cambridge is a project opened in August 2011 that forecasts 20 000 passengers per day by 2016 for several bus lines. Cost is given in £ with a Public Private Partnership (PPP)
16. Madrid : Bus VAO is for high occupancy vehicles (including cars) that are allowed on the bus road and represent 76% of bus lane occupation with car-sharing. Data is for the 651 line into the A6 Motorway corridor where the right of way is at central insertion. There is a reversible (tidal) flow depending of the peak traffic direction (morning towards Madrid) 112 000 passengers into the A6 corridor.
17. Castellón represents the first part of a 2 lines BHLS of 22km (line1) and 18 km (line2). The estimated demand is 21 755 passengers per day for the whole system.
18. Stockholm represents a Trunk network of 4 lines for a total of 163 000 passengers per day (4 lines)
19. Gothenburg data is for route 16, there are other TrunkBus lines (65 000 into the trunk section with line 19).
20. Jönköping has 3 trunk lines passenger data is for the 3 lines (green, yellow and red).
21. Lundalänken (Lund Link) is a prioritized bus corridor for city and regional buses, partly segregated and with dedicated bus lanes when needed.

Table 26 presents changes in ridership for each of the 35 BHLS systems. This indicates growth in the range 20%-134%. It also displays potential explanatory factors for the ridership gains:

City	System identity	BHLS Ridership Change *	Speed ** Change in Operating Speed ***	Peak- Period Headway Reduction	Network Restruc- turing in the corri- dor?	Strong Iden- tity naming / Branding BHLS ser- vices	specific bus fleet	Major Tariff Restruc- turing as part of BHLS?
Paris -1	TVM	+ 7%	21/23 Significant	5 □ 3.5	Significant	Yes	No	No
Rouen	TEOR	+ 70%	17,5 Moderate	Yes	Major	Yes	Yes	No
Nantes	BusWay®	+60%	21/23 Moderate	Yes	Significant	Yes	Yes	No
Lorient	Triskell	-	17/21		No	Yes	No	No
Grenoble	Ligne 1	+ 58%	18/19			No	No	
Dublin -2	QBC	+125%	16,5/18,6 Major	Yes	Minor	No	No	No
Hamburg	Metrobus	+20%	15,9/21,7 Minor	Yes	Minor	Yes	-	No
Oberhausen	ÖPNV- Trasse	+ 46%	34 Significant	Yes	Yes	No	No	No
Essen	Spurbus Lines	-	16,7/30(gui deway)			No	No	
Lisbon	Rua Jun- queira	- -	-			No	No	
Amsterdam -3	Zuidtan- gent	+ 15%	35 Significant	Yes	Significant	Yes	Yes	No
Utrecht	HOV line 11 and 12	-	22,7			Yes	No	
Almere - 4	10 lines	+5%	24/25			No	No	
Purmerend - 5	Amsterdam - Purmer- end	+3%	-			No	No	
Twente - 6	HOV line 2 and 3	:+30%	20,5 and 27			Yes	No	
Manchester - 7	192 route (A6 corri- dor)	+19%	16-18,4	Yes	Yes	No	Yes	
Leeds - 8	ftf Leeds	+75%	18,5 Significant		Yes	No	Yes	No
Ebsfleet Kent Thameside	Fastrack A and B	+60%	13,3 Moderate	Yes		Yes	Yes	No
Cambridge	The Busway	-	60 (guide- way)			Yes	Yes	
Prague	Line 213	+3-5%	21,8		No	No	No	No
Bucharest	main line	-	13,4			No	No	
Iasi	main line	-	17			No	No	
Brescia	LAM 1 and 2	-	15/16			No		
Prato	LAM:	+57%	18 (+5%)	15 □ 7	Major	Yes	Yes	No
Athens	express airport line	-	32			No	Yes	
Barcelona	route 64	-	10/22			No	No	
Madrid - 9	Bus VAO	+70-100%	28,5/33,5	Yes	Minor	No	No	No
Madrid	Line 27	-	10,9/12,8			No	No	
Castellón	TVRCAS	-	18			Yes	Yes	

Stockholm	Blue Bus	+60%	15/18 Moderate	Yes	No	Yes	Yes	No
Gothenburg	TrunkBus	- +73%?	21 Moderate	Yes	Significant	Yes	Yes	No
Jönköping - 10	Citybus-sarna	+ 15%	21/23 Significant	Yes	Yes	Yes	Yes	
Lund - 11	Lundalänken	90% since 2004	n/a-	n/a	yes	Yes	No	No
Helsinki - 12	Jokery line	+100%	26/30 Significant	7 □ 5	No	Yes	Yes	No
Zurich - 13	Bus line 31	+100% week end night services	14,8/17,7		No	Yes	Yes	No

Table 26: Ridership Gains and Selected Related Factors for 35 BHLS Systems in Europe Source: Case studies of the COST BHLS [www.bhls.eu](http://www.bhls.eu) accessed 8<sup>th</sup> March 2011

\* The baseline for BHLS Ridership Growth is usually taken as prior to the major BHLS implementation. In some cases there had been gradual improvements in the preceding years, the baseline usually includes such improvements. Data is given for increase per year.

\*\* Speed corresponds to average or min/mas observed

\*\*\* In some cases, the data was reported as changes in journey time

Table explanation notes:

1. Paris TVM has increased +287% since 2003
2. Dublin data is given for the Malahide line, +50% for all QBCs.
3. Amsterdam: +110-15% per year since 2002 +100% in 2005.
4. Almere knows an increase of +5% per year from 2004 to 2009.
5. Purmerend has increased + 3% each from 1995 to 2010.
6. Twente has increased + 30% for week-days and + 70% on Saturdays.
7. Manchester has increased +19% for all QBCs within 4 years.
8. Leeds has increased +75% from 1995 to 2000.
9. Madrid Bus VAO has increased +100 within 3 years and +300% since 1991 in the A6 corridor. It represents 55% of the market share. Speed data is for the line 651. On the Motorway corridor the bus runs at 70/90 km per hour.
10. Jönköping is expected + 25% for next years.
11. Lund has increased +90% since 2004 but it is more related to the urban expansion and several lines than to the infrastructure.
12. Helsinki increased +150% since 2003 and +10% per year since 2006. Speed data is for rush hours.
13. Zurich : + 100% for the week-en night services.

## 2.- Urban enhancement due to the BHLS implementation

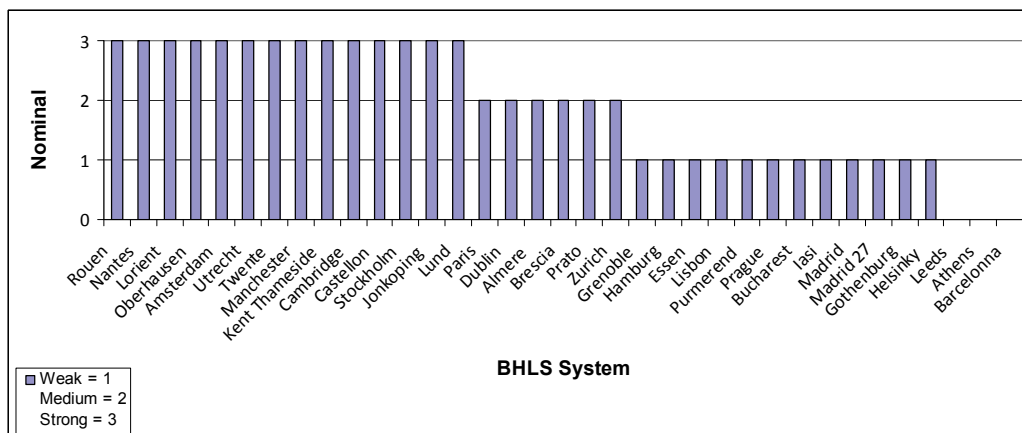


Figure 30: Efforts for increasing the urban environment along the line (at least around the stops), Source: 35 Case studies of the COST TU 0603 BHLS

Our BHLS sample of 35 sites can be classified by the degree of urban enhancement made because of the BHLS implementation. We use this scale for our case studies: If there is no en-

hancement = 0; weak enhancement = 1, Medium = 2; Strong = 3. (in some cases (i.g. Nantes, Utrecht, Rouen) we can see the same improvement of public space as when tram is implemented). The entire table is presented in the accompanying CD.

We observe that implementation of a BHLS line often leads to urban space enhancement, but with diverse degrees. We find half of them (**54%**) have High or Medium enhancements of public space.

12 BHLS (34 %) of our sample have been realized **with strong associated urban space enhancement** (mostly in France, Netherlands, Sweden, UK and Spain). These are Rouen, Nantes, Amsterdam, Twente, Kent Fastrack, Lorient, Oberhausen, Utrecht, Cambridge, Castellón, Jönköping and Lund.

BHLS (20%) of our sample have made medium urban space enhancement.

13 BHLS (37 %) of our case studies have made weak urban space enhancement. There are Grenoble, Hamburg, Essen, Lisbon Purmered, Manchester, Prague, Bucharest, Lasi Madrid (Bus VAO and line 27) Gothenburg, Helsinki.

### 3.- Main Results and Analysis:

The WG4 research has assembled available information, and has gathered supplemental information through surveys and information requests from the sites. We fully acknowledge that we do not have full comparative data for all sites, nor did we have resources at our disposal to conduct deep analysis. With these caveats, we propose the following observations:

- All BHLS case studies show a strong political will to enhance public transport, and choose to do so by means of buses (perhaps also with other modes).
- There is no need to change Public Transport contract or legislation to implement BHLS. No major traffic restructuring is required.
- All the BHLS visited and studied without exception have increased their ridership. There is a major variation in ridership growth, with an observed range of +15%-150%.
- It should be noted that this level of growth is typically achieved over a number of years, as the systems become established and mature. The increase per year is in the range of +3% to +20% (analysing one BHLS line only in a corridor).
- BHLS system daily ridership spans c. 5,000 to 66,000 passengers/day (Paris TVM). These data are for individual corridors, and may include multiple routes/lines on the same alignment. We note that this matches or exceeds the ridership of many tramway and North American BRT systems.
- Number of BHLS in this range: < 10,000 = 5 systems ; 10-20,000 = 10 systems ; 20-30,000 = 7 systems ; > 30,000 = 6 systems.
- BHLS systems invariably offer improved frequency and volume of service.
- In many cases the network and lines within the BHLS corridor have been restructured.

All BHLS have faster speed than normal buses:

- In many cases, BHLS offers improved journey time and operating speed in the range of 14,8 km/h to of 27 km/h **when operating in towns**. Higher speeds are achieved on dedicated busway (Amsterdam, Cambridge) or motorway facilities (Madrid).
- In a few cases there has been little improvement in speed/time, but big improvement in both reliability and variance in journey times.
- < 15 km/h: 5 systems; 15-20 km/h: 13 systems; 20-30 km/h: 10 systems; > 30 km/h: 4 systems (including Cambridge guided BHLS with a commercial speed of 60 kilometres per hour)
- Speed has changed for 13 BHLS systems of our sample. This change is qualified as Major for 1 systems (Dublin); – Significant for 6 systems (Paris, Oberhausen, Amsterdam, Leeds, Jönköping and Helsinki) and Moderate for 5 systems (Ebbsfleet Kent, Stockholm, Gothenburg, Rouen, Nantes).
- The BHLS length can vary from less than 5 kilometres to more than 30 kilometres
- < 5 km = 4 systems; 5-10 km = 6 systems; 10-20 km = 9 systems; 20-30 km = 5 systems; > 30 km = 8 systems (of which 5 have network length effect Brescia, Prato, Jönköping, Stockholm, Twente).

The infrastructure costs have extremely high variation. The range is from €100,000 to €15 million per kilometre:

- €0,1million per kilometre for those with minimal investments for dedicated lane (e.g. Hamburg, Jönköping), to €15 million per kilometres when there is a guidance lane like in Ober-

hausen and Castellón, or the construction of a segregated dedicated line as in Utrecht, Nantes, Paris, Lorient or Amsterdam. These BHLS systems have necessitated civil works such the construction of bridges or viaducts, thus raising the capital investment required.

- All systems have a system identify and most have a unique brand and dedicated fleet:
- Bus identification: 17 BHLS systems have established their own unique product and brand, and seek to clearly differentiate themselves from other bus services. The other 18 BHLS systems seek to raise quality and may have a brand, but do not seek to be separate from the rest of the bus network.

Marketing, image and product repositioning are strong features of BHLS systems. They are seen as **flagship services of the Public Transport authorities**. This is especially the case when the bus is the primary mode in the urban network.

It is clear that BHLS has achieved ridership gains and hence achieved many of its goals. Despite this, there is an extreme shortage of structured research into the individual and linked factors that achieve the ridership gains. This is urgently required to (a) assist future projects; (b) give better understanding of where funds are best targeted; and (c) provide feedback and evidence to policy-makers and transport operators about the effectiveness of investment in BHLS.

#### 4.- Impacts of BHLS

As with any other transportation scheme, the successful implementation of a BHLS project has multiple impacts. Ideally, the impacts of a well-implemented BHLS scheme will achieve all of the stated objectives, while avoiding undesirable or unintended impacts.

Impacts of a BHLS scheme can be broadly grouped in five categories:

- Performance: e.g. service reliability, quality, ridership.
- Transportation system: e.g. modal share, total network effectiveness, transport sector energy consumption and emissions.
- Societal: e.g. access to jobs, social equity, social exclusion.
- Urban: e.g. land use patterns, land and housing values, development, urban economy.
- Economic value: e.g. post-implementation socio-economic CBA, structured impacts analysis.

Urban transportation systems are known to impact on a wide range of such factors. This can be in a positive way when the transportation system is well designed and implemented; or in a negative way when the transportation system is below requirements and hinders other aspects of society or the urban area.

Major transportation projects usually have stated objectives that extend beyond the direct system performance. The associated public expenditure is often justified on the basis of the broader social and urban benefits. In some cases, this is because the direct transportation benefits alone might not be sufficient to meet the standard test criteria.

The question arises whether BHLS schemes achieve stated objectives, both of direct performance/transportation nature and of societal/urban nature. If they do, then we need to know on what scale and whether they reach the level indicated in the scheme justification.

WG4 of the COST TU603 Action has considered this issue both in the review of Implementation Conditions for BHLS, and through a ‘light’ enquiry to the participating BHLS sites. The findings are summarized as follows:

- There is extensive evidence of significant positive impacts in “*performance*” factors such as operating speeds, reliability, ridership gains, quality improvements, etc. All BHLS schemes measure such factors as a matter of course. These are presented in the table above and in detail in the full WG4 document in the CD.
- Evidence of “*transportation factor*” impacts is quite limited. Changes to mode share arising from BHLS are sometimes recorded for the corridor, but are not evaluated network wide. Evidence of BHLS scheme impacts on energy consumption and emissions is very limited.
- There is little or no evidence that BHLS schemes have impacts on either Societal or Urban factors. This should not be construed to mean that BHLS schemes have no such impacts - there is quite simply a lack of evidence of any kind. The facts are not known.

- The BHLS enquiries indicate that in practice these factors are not measured for BHLS schemes, although it is standard to measure them for rail-based projects. There are a few exceptions, - e.g. real estate values for Fastrack – but their scarcity prevents comparison..
- The review of Implementation Conditions already identified that rail-based schemes are appraised in a different, more comprehensive way than BHLS schemes. Social, urban and economic impacts are included in the pre-scheme appraisal, whereas they are usually not included in BHLS appraisal, or at least not quantified in monetary terms.
- These factors are usually measured post-implementation for rail-based schemes, and a substantial body of quantified evidence exists of positive impacts from urban rail investments.
- It was identified that the Finance Ministries (or equivalent) of most EU countries have thresholds for pre- and post-implementation appraisal, with full socio-economic appraisal mandatory for projects above the threshold. The thresholds are in the region of €50-100 million.
- It appears that virtually all rail infrastructure projects exceed the threshold, and hence are deeply evaluated as a matter of course leading to a rich source of information.
- By contrast, BHLS schemes are invariably below the threshold, thus requiring only a light post-implementation appraisal. What is not mandatory is neither budgeted for nor performed, leading to the extreme shortage of any evidence.
- Experience with BRT schemes worldwide indicates a similar extreme lack of data. A few evaluations of Societal and Urban factors have started to emerge, e.g. showing positive impacts on land values and investments linked to BRT, and of user acceptance (e.g. Cain and Flynn, 2010), but these remain quite limited.
- Despite the many BHLS schemes implemented in Europe, and the many BRT and BRT-lite schemes implemented worldwide, policy-makers and decision-takers still do not have any substantive knowledge of what impacts (if any) bus-based transit schemes have on Societal or Urban factors. For example, they do not have evidence-based guidance on whether a bus-based scheme can leverage property development, help to intensify land-use, attract new businesses, or stimulate the local economy. They do not have evidence-based guidance on whether bus-based transit schemes make a meaningful contribution to better employment prospects, to combating social exclusion, or to improved quality of life.
- WG4 recommends that this knowledge-deficit must be overcome through structured evaluation of impacts beyond the direct Performance factors of BHLS. Ideally, it should be mandatory for all BHLS schemes, even those below financing thresholds, at least for a few years until sufficient evidence has been gathered.
- WG4 does not presume the outcome of such measurement, does not presume that BHLS schemes have significant impacts on any or all of these factors, and does not presume that any such impacts are comparable to rail-based investments. The only established fact is that currently nobody has the answers.



*Helsinki: the peripheral Jokeri line, the blue colour at each station with dynamic information – the dedicated lane is here shared with taxis.*

### 3.7 BHLS among other solutions, after 40 years of research and development in urban public transport; perspectives

The objective of this paragraph<sup>60</sup> is to give an overview of some tendencies concerning research and development in urban public transport during the 40 last years, in order to point out some lessons which could be useful for the BHLS development and for the possible BHLS evolution in the next years. The context is the following : BHLS is often observed through the BRT context, it can be also considered through the evolution of urban public transport in France as well as in other European countries. The competition between BHLS and tram is only a small part of the problem.

As regards the development of new ideas in the field of urban public transport we can consider the following simplified chronology, by identifying roughly four periods with of course some overlapping:

- 1970-1980: invention of automatic « new transportation modes » with a decreasing complexity: PRT (Personal Rapid Transit), then ARAMIS, then light automated metros such as VAL system in France or some other systems in North America, Japan and Europe ;
- 1980-1990: beginning of tramway reintroduction in some towns ;
- 1990-2000: new concept called «intermediate systems», but in fact three different types of new guided systems on pneumatic tyres (on ground transportation) ;
- 2000-2010 (particularly 2005): definition of BHNS concept «Bus à Haut Niveau de Service » / BHLS.

It is necessary to take all the transportation modes in consideration, on a long period. Complexity is moving: there is nowadays less complexity for the system or the concept itself, but more complexity for the interfaces, and sometimes for new components.

#### **Forty years of research and development in the field of fully automated urban public systems**

In 1970 and later fully automated urban public systems were considered as an universal potential solution, this contributed to delay tramway reintroduction as well as bus networks improvements. But the diffusion of such a solution was difficult, one of the main reasons was the difficult acceptance of aerial guideway in towns and the high cost of tunnels (or cut-off effect at ground level). In the context of European countries it is nevertheless an adequate solution in some specific cases : for metros and mini-metros in order to increase system attractiveness during off-peak hours, and for short to middle range systems where high frequency is necessary. There is of course more competition between these systems and tram than with BHLS. In some towns where tram was chosen instead of VAL (e.g. Strasbourg, Bordeaux) an argument was the possibility to build a tram network with several lines instead of only one or two lines of VAL. This argument could nowadays be transposed to the choice between tram and BHLS but the context is different and the cost difference is not as high if we compare two systems which are both at ground level instead of comparing a system at ground level with a system in tunnel. One should keep in mind the long time which is necessary for the maturation of such innovative systems, e.g. for VAL system: after 40 years it appears the NEOVAL system with an optimized guiding device.

#### **New guided systems on pneumatic tyres<sup>61</sup>**

The simplified chronology for the development of new systems with mechanical guidance was the following:

- lateral kerb-guidance (above rolling plan): O-Bahn (Essen), guided busses ;

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<sup>60</sup> By Claude Soulas, IFSTTAR - GRETTIA.

<sup>61</sup> Ref: Les transports guidés sur pneus dits « systèmes intermédiaires » dans le contexte de l'innovation en transport collectif urbain – Claude Soulas - Oct/Dec 2003 – Transport Urbain – French version available in the CD.

- central rail, vertical guidance: GLT / TVR in Nancy and Caen ;
- central rail, oblique « V » guidance: Translohr in Clermont-Ferrand, Italy, China,...

The simplified chronology for the development of new systems with “immaterial” guidance was the following:

- wire guidance: old experiments in Fürth, implementation in the Channel tunnel for the service vehicle, in a context which is different from that of urban public transport;
- optical guidance: TEOR in Rouen, CIVIS in Castellón,
- electronic guidance (trajectory storage and transponders): PHILEAS in Eindhoven, EVEOLE in Douai.

### **Complexity of the systems : some lessons from automatic systems and so called « intermediate systems » (e.g. TVR)**

Many problems are due to the interactions between complexity of systems (e.g. with new functions) and complexity of safety regulations. It is now the case with EVEOLE in Douai (evolution of PHILEAS system built in Eindhoven): this system combines several innovations in the field of guidance, wheel orientation, motorization, hybridation, light construction. It could be the case (?) in the next years for innovative BHLS vehicles if new functions appear, for example such as variable capacity for 24 m buses.

The context or general environment of the system has a big influence. For example after a satisfying experiment in revenue service in Rochefort (Belgium), some problems of the TVR in France were due to the modification of the vehicle conception in order to realize a low floor.

### **Bimodality (dual-mode operation): several attempts**

In the field of energetical bimodality the COST action 303 took place around 1980. The final reports were published in 1985: « Technical and economical evaluation of dual-mode trolleybus programs ». It was not related to simple trolleybus, but to dual-mode trolleybus, it means with two full motorizations or supply. The coordination of this action was made by IRT Paris (former INRETS), with contribution of SNV Hamburg.

After this COST action there were only very few implementations of dual-mode trolleybuses, e.g. in France only one network today abandoned: Nancy.

Guidance bimodality (with mechanical guidance) can be considered as an attempt to combine in the same system advantages of guidance (less space consumption, smaller gap in station, ...) and advantages of non-guided vehicles. But:

- there is a general limitation: vehicle length limited to 24 m ;
- in the case of O-Bahn or guided busses the vehicle is simple, bimodality is operational, but kerb-guidance has disadvantages: guideway can't be crossed, curve radius,...
- TVR suppresses the drawbacks of kerb-guidance (by means of a rail under rolling plan) but vehicle is more complex (low level of reliability) and the implementation of bimodality is difficult.

Translohr was first bimodal, but bimodality has been quickly abandoned: it is now a tramway on pneumatic tyres.

The attempt to develop dual-mode systems (with the so-called “bimodality”) is a good illustration of the complexity of the concept of flexibility which is often used to describe different things.

### **Different levels of flexibility: some advantages but ...**

On a technical point of view one can consider the flexibility given by pneumatic tyres for all kind of busses (BHLS and other) as well as for tram on pneumatic tyres (Translohr). This is an advantage for slopes higher than 10% (generally limited to 13 % for comfort reasons) and for small curve radius, but for high performances systems small curve radius have to be avoided in order to keep a sufficient commercial speed.



Another level is the route flexibility. It has to be avoided for line identification, and to favour urbanization. **BHLS is a bus system that loses flexibility in order to improve its efficiency.**

The flexibility in case of perturbations can remain an advantage for BHLS. For tram a higher level of line protection is required and there are two cases: modern trams are bi-directional in order to achieve partial line operation, old trams are mono-directional but a network with several lines permits operation in case of perturbations (e.g. Basel, Dresden).

The flexibility for line utilization is occurred when several bus lines use the same lane. In some towns there is also cohabitation between tram and bus on the same lane.

The flexibility in term of investments is another question which has to be discussed.

### **Urban public transport families in the context of European countries**

There is a big variety of urban public transport systems which are more or less adapted to the various contexts and which have been until now more or less developed:

- on demand systems (collective taxi, minibus...): this is the real domain of FLEXIBILITY. Because of high driver costs in European context this solution can be implemented only as a complement of classical networks in some areas, at some hours ;
- classical bus ;
- BHLS and light tram (on steel wheels or pneumatic tyres) ;
- LRT /Light Rail Transit ;
- classical metro for (very) high ridership;
- classical automated systems on exclusive guideway ;
- PRT / Personal Rapid Transit: an old concept which is still promoted in USA or other countries even if most of the experts consider that this solution is not realistic as far as the objective is to build a whole urban network and not only a very small number of stations in a airport ;
- in the field of ITS / “Intelligent Transport Systems” researches are carried out in order to promote new solutions such as fully automated systems at ground level: cybercars, automated busses,... In term of investment costs these solutions are less expensive than PRT because no exclusive guideway is required, but on the other hand there are many difficulties with safety regulations problems, cohabitation with other vehicles and pedestrians, ... ;

### **BHLS and tram comparison**

The decision to opt for BHLS or tram should not be solely based on cost comparison. For example 30 years ago, a cost comparison came to the conclusion that a fully automatic H-Bahn system would be cheaper than a bus system for a network in the town of Erlangen. But a hypothesis was 1 min frequency at peak hour which means high operation costs for a bus system in a middle town.

Compared to other investigations the FGSV cost comparison (publication 2008) coordinated by V Deutsch (University Wuppertal) has two important advantages:

- it avoids to compare « apples with pears », by choosing identical conditions ;
- it has limited the scope of the comparison to a reasonable ridership for European context.

The choice of some parameters remains of course difficult and results depend on the context. A prudent interpretation of BHLS and tram comparison would come to the following conclusions:

- in term of total cost during a 30 years period, in some conditions a 24 m bi-articulated diesel BHLS can be significantly cheaper than tram, e.g. 30%, but not 2 times cheaper ;
- for a 24 m bi-articulated BHLS trolleybus total costs are comparable to that of tram in some conditions, it means first if we consider a 5mn interval for trolleybus and a 8min interval for tram.

Some elements are not taken into account because they are difficult to monetize, for example the smaller width of the tram lanes which is a significant advantage in some kind of towns.

The global cost comparison points out the importance of some questions such as the cost of electric drive as well for tramway as for electric BHLS (trolleybus). In France the question of an increased use of electricity for private and public transport will be an important topic for the next years, in Germany too.

Another important topic for the next years is the problematic of public transport financing: even if global cost of BHLS can be relatively cheaper per km compared to that of tram in some conditions, the object is to increase significantly the length of networks and the amount of money for public transport should not be reduced.

### **BHLS and tram: more common approaches than differences**

BHLS and light rail represent two transportation concepts which are relatively “similar in nature”. There could be a synergy by developing more of both these solutions (which does not mean that tram has to be built in all the towns) and by developing joint research which can concern both systems:

- common components: stop conception, electric drives for trolleybus or electric BHLS and trams ;
- optimization of the route: distance between stops as well as avoidance of curves, ... have a big impact on system efficiency ;
- land use / dedicated lanes: acceptance, conception, safety issues with pedestrians, ...
- network conception, intermodality, evaluation of the limits of park and ride (perverse effects), multi modal links complementarity between public transport and bike, car, PT, taxis ... ;
- compatibility of a BHLS line with a possible evolution towards a tram line in the future, or toward a trolleybus according to the context ;
- moderation of car traffic and its impact on the attractiveness of public transport in a context where so-called « green car » and electric vehicles development favour the use of private cars inside cities ;
- new approaches for public transport financing: an addition of several solutions.

### **A challenge for BHLS in EU**

Based on our research it is reasonable to state that BHLS can in certain circumstances have potential for improving PT in urban areas.

It is reasonable to state that BHLS can have an important potential in term of number of lines, in certain circumstances:

- concept and vehicles have to remain simple, even if some innovations can be introduced ;
- avoid to focus on the relatively small number of lines where there is competition between BHLS and tram (sometimes political choice / difficult estimation of the increased ridership at middle-time term) if the object is to improve a high number of bus lines ;
- in a context where all systems modes are evolving the aim of COST action is less to say « BHLS is the best solution » than to investigate how BHLS can be improved at different levels ;
- there is a synergy with tram system which represent the same « transport philosophy » compared to other new solutions including individual or public electric cars (e.g. Autolib) and car pooling which is sometimes useful but can have perverse effects: difficult shared use of bus lanes, increasing of car dependency, less consideration for the necessity of land use evolution.

## 4. Recommendations and research field proposals

In this section, we reflect on the analysis of the 35 BHLS sites described, and on the experiences gained. We consider this in 3 stands:

- Experience learned about the preparation and implementation of BHLS schemes. This includes the key barriers observed, areas where there may be technical challenges, and aspects requiring special attention.
- Recommendations for policy-makers and senior officials. These are clustered at EU, national, regional and city level.
- Research field proposals.

### 4.1 Experience learned about preparation and implementation of BHLS

First, it needs to be pointed out that, despite some difficulties observed during the analysis and not always linked to the bus choice itself, BHLS has been generally successfully implemented in the 35 sites in 14 European countries described in this document. More BHLS schemes are in preparation both in additional European cities and in cities where there is already BHLS. This includes:

- Some of Europe's largest agglomerations (Paris, Madrid, Barcelona, Hamburg, Stockholm, Dublin) as well as medium-sized (Gothenburg, Cambridge, Nantes) and smaller cities (Almere, Lund, Prato, Utrecht, Lorient, Jönköping, Castellón).
- Cities with extensive metro and tram networks (Amsterdam, Madrid, Paris, Stockholm, Hamburg), cities with mixed tram and bus (Gothenburg, Nantes, Zurich), and cities which are primarily served by bus (Dublin, Lund, Jönköping, Almere).
- Urban routes (34%) (Castellón), radial routes from the suburbs to the city centre (37%) (Dublin, Nantes, Madrid, Zurich, Essen), peripheral/ tangential routes (Amsterdam, Paris), and local routes networks (Almere, Purmered).
- Cities with different organisational and regulatory frameworks, including public sector (quasi-) monopoly (Dublin, Hamburg, Madrid, Paris), city level contracts (Nantes, Rouen), controlled competition for areas/routes (Amsterdam, Gothenburg) and deregulated markets (Kent, Leeds).

This provides strong evidence about BHLS:

- BHLS can be implemented successfully.
- BHLS is not restricted to a narrow range of situations, it can be implemented in cities of any size and modal configuration, or any organisational framework.
- BHLS is highly adaptable, and can appear in different physical and operational forms to suit the specific local requirements.
- BHLS can in most cases be implemented with lower investments and limited urban impacts related to rail systems. However, enhanced urban quality around the alignment and restructuring the local transport networks, if required, are strongly recommended to get the full advantages. BHLS can also be a valuable tool for urban renewal.

**Nonetheless, this does not mean that BHLS is the most suitable choice in all circumstances.** BHLS is one solution for providing a high quality of service for enhancing public transport networks. The point is that a good BHLS option can be developed for many European situations, which should then enter the alternatives analysis phase. The appraisal process can then determine which option is best suited to the specific local requirements and priorities.

Having established that BHLS can be successfully implemented in a wide range of environments, it is important to identify the challenges that are faced to successfully implement a BHLS scheme that meets the city's requirements. **These challenges can be significant, and should not be underestimated.**

To date, most BHLS schemes implemented in Europe have been innovative – i.e. the BHLS has been implemented in sites where there was no previous tradition of BHLS. The concepts have been new – at least to the local stakeholders. It usually requires a considerable effort to get the stakeholders and the public to understand what the BHLS is, how it is different from their previous idea of bus services, and why it should receive public support and funding or even be considered under PPP projects.

BHLS is also new for those who should plan, design, construct and operate service. Some of the differences include dedicated infrastructure for buses, tram/rail-style stations, new or adapted traffic management design criteria, new pavement and system engineering standards, new customer-support systems, etc.

Innovative projects usually face additional difficulties for implementation, or even for getting approval. Counterbalancing this, innovative projects usually have creative and dedicated leaders and team members, who seek out new approaches, who problem-solve, and who persevere.

Reflecting the specific experience of BHLS projects, and their innovative nature, we have arranged the preparatory and implementation challenges into three clusters:

- **Barriers** are the things that can either prevent a BHLS from happening at all, or which constrain it to the point where the main benefits cannot be gained. The two main barriers are lack of political acceptance for a bus-based scheme, and inability to get sufficient useful advantages on cars either by priority systems or by the realization of right of way. Experience with BHLS in Europe is that Barriers are mostly political and/or attitudinal – i.e. they relate to decisions.

- **Technical challenges** are where the projects face real physical or operational constraints. This includes insertion issues, priority and timing at junctions, capacities, etc. In some cases they may require creative solutions; or in other cases it cannot find a technical solution to fully deliver that it was supposed to fulfill and must be settled for a bit less.

- **Design and implementation.** Everything else requires good planning, expertise, the usual hard work, and sufficient design and deployment resources. There is no reason why they cannot be resolved. However, if they are not given sufficient attention or resource, their quality and effectiveness may be diminished. In turn, this may compromise the quality or effectiveness of the overall BHLS scheme or network when BHLS represents its backbone.

#### 4.1.1 Potential barriers to deployment of BHLS

Three potential barriers have been identified:

- Difficulties to “sell” a BHLS project to all stakeholders, including the citizens.
- Difficulties to gain the required priority on cars or right of way.
- Organisational and regulatory barriers.

##### Difficulties to “sell” a BHLS project at all stakeholders, and finally to the citizens:

One of the key problems to overcome is the ability to convince politicians to support the concept of developing public transports and that they can do it with high quality bus system. And when they choose BHLS to market its advantages to citizens / all stakeholders. It is essential that political support is secured from the design phase through to implementation.

Such projects are never easy, as many stakeholders need to be involved. By introducing new Right of Ways, new constraints for the car traffic or deliveries, new ways of mobility, oppo-

sition can emerge, sometimes very strongly. It is never easy to forecast all difficulties that will need be solved or explained during the study phases.

Many difficult factors should be taken in account during the studies, such as:

- To take place and space from cars, to adapt parking policy.
- To integrate the population increase in the future, to estimate the travel demand and the car use.
- To evaluate all costs of the project.
- To manage a progressive step by step possibility of implementation.
- To organise the public consultation and acceptance of bus based systems.
- To evaluate the possibility to convert BHLS into tram, at what time this could be justified and/or affordable.
- To demonstrate that people concerned by the new constraints will be able to find alternative suitable solution

The communication process takes time and is not an easy process, but this is necessary for being successful and well accepted. The case for BHLS has to demonstrate how the concept can benefit cities and citizens. The perception in some areas is that the bus is second choice to trams. There is still a bad image associated with bus-based systems — that normal buses are often slow, unreliable, not environmental friendly, uncomfortable, low social status, etc. - even when the BHLS project is directly addressing these issues. This image can change by using examples gathered in the COST project.

#### Difficulties to sell Right of Way and Dedicated Lanes:

Right of Way issues have two dimensions. The Technical Challenge (dealt with in the next sub-section) is to find and design a suitable right of way that meets the operational requirements. The potential barrier is getting approval for the desired Right of Way (dealt with here).

EU cities generally have scarce, limited public space, especially in the urban centre – which is often where priority is most needed for the BHLS. This difficulty is also observed in the motorways and main arterial routes approaching big cities.

Regarding city layout, planners could be faced with lack of hierarchy on its streets. Often, what can gained in one direction could be lost in the other direction.

Much opposition is often generated by RoW projects that reduce the car space or changes the whole environment; all impacts should be carefully analysed, according to the legal process. A skilled authority is needed that knows both how to respond to genuine stakeholder concerns and how to guide the proposal through the public opinion and approvals process.

Opposition can also arise from other stakeholders such as:

- businesses and property owners who object to loss of on-street parking on the basis that it will damage their business (even if very few of their customers actually use it)
- property owners and residents who do not wish to have their street allocated for transit schemes, or to attract additional buses or bus customers.

#### Difficulties regarding Institutional and Regulatory issues:

Throughout Europe, Public Transport operates in different Legal, Regulatory, Institutional, Organisational and Financing frameworks. Rather surprisingly, these frameworks do not appear to have been a barrier to implementation of BHLS. At the framework level, the allocation of roles and the financing responsibilities show a remarkable similarity across Europe. The BHLS have all been implemented within existing procurement and contractual frameworks. This is discussed in greater detail in the WG4 section.

The sole exception in Europe is the UK, where the market for bus services is deregulated (except Greater London, which is closely regulated). This makes it difficult to control the development of BHLS, in part due to the number of operators, in part due to their freedoms

to open and close routes, determine price levels, determine quality and customer-facing services. A PPP appears there to be needed for achieving a good “system” approach<sup>62</sup>.

#### 4.1.2 Technical Challenges to deployment of BHLS

Both Technical Challenges and Design/ Implementation Issues (dealt with in the next subsection) can be considered as:

- Issues that are unique to BHLS.
- Issues that are common with tramway and other transit systems.
- Issues that are common with normal bus projects and operations.

Three main Technical Challenges have been identified that are specific to BHLS:

- Designing the required Right of Way, especially in core urban areas.
- Obtaining the Required Priority at Traffic Signals.
- Knowledge and Skill base.

##### Technical Challenges for Right of Way and Dedicated Lanes

Technical challenges arise in designing a suitable right of way - dedicated running way or dedicate lane within the roadway – which is sufficient to meet the operational characteristics required by the BHLS. This can include issues of bottlenecks, lane widths, crossing traffic, junction modification, etc. In some cases, it may require some road-widening and/or pavement reduction, or even some minor land acquisition.

Problems typically arise in older urban areas and on narrow arterials leading to the city centre, where it can be extremely difficult to find a satisfactory solution that is also acceptable to the other road users.

In some cases, the dedicated lane or priority might only be available in one direction, or only at peak hours. In other cases, it may be necessary for the BHLS to operate in mixed traffic on specific sections where no acceptable solution can be found. In a few cases (e.g. Bus-VAO in Madrid), the lane operates in one direction in the morning peak, in the other direction in the evening. In exceptional cases, a short section may have bi-directional running on a single lane (e.g. Nantes).

Also “vital” bus streets as in Lorient can be a part of the BHLS solution in some cases. The buses are given priority by signal and/or physical measures into a common part also for cars which has to follow behind and don’t disturb the bus.

Despite such innovative measures, there may still be cases where it is not possible to devise a running way that offers a sufficient level of performance for the BHLS. In such cases, the only practical course may be to defer or abandon the plan for BHLS, and instead carry out such improvements to the bus route as can practicably be done.

There are also difficulties to create specific infrastructure for bicycles in addition to the BHLS (South of Europe mainly). Sharing the RoW with cycling and taxis is often a strong demand but can cause safety and regularity problems particularly with taxis because they cannot go through the signal priority. There is a need of more analysis and feed backs.

##### Technical Challenges for Priority at Traffic Signals

For most BHLS, priority at traffic signals is a matter of importance to balancing of traffic flows and demands, and adjusting strategies stages and/or cycle times:

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<sup>62</sup> This has been successfully adopted in Leeds, Manchester, Cambridge and Kent.

- In some cases, it can become more problematic and difficult to solve. For example, the flow of buses may be high and the demands for priority may exceed what can be given without negative impacts for other road users.
- Some junctions may be quite complex with heavy vehicular flow, such that demands from the BHLS approach may be more difficult to accommodate, especially if they require a turning phase across other traffic.
- In other cases, there may be sequences of closely-spaced junctions at which it is not possible to assure high priority

The impact of such challenges would normally be to restrict the intervals (headway) at which the buses on BHLS routes can reasonably operate without tendency to bunching and unreliability. In turn, this may restrict the overall capacity of the BHLS.

Difficulty to collect and manage the updated knowledge (technical and legal fields):

The ability to deliver a full BHLS system requires a commitment to investment in Infrastructure /vehicle /operating tools, that concern fields outside public transportation itself, like re-sharing road space, allocating road space to public transport, traffic engineering, transport economy, environmental issues, safety/security, legal issues.

High demand of “innovative infrastructure and signalisation” knowledge for solving problems of regularity / capacity / safety at peak hours; there is a need of more expertise.

Regarding innovation, it is difficult to analyse the risks if the performance cannot be guaranteed. (i.e. APTS guidance, clean buses, etc.).

#### 4.1.3 Design and Implementation challenges for BHLS

Design and Implementation Challenges are normally issues that can be resolved, but either have features unique to BHLS, or require more careful attention to design and/or sufficient resources. They will include features deployed on the BHLS that have not (yet) been deployed on the rest of the bus fleet.

Infrastructure issues

This sub-system is the most expensive, and the most challenging. There are various options available to cities, central or lateral position, flexible or not, common section with tram or other lines.

Difficulties with asphalt choice for high capacity for station or for running ways (problems of pavement rutting).

Difficulties with choosing a contrasted colour (not in UK, always red for every level)

Enforcement of the RoW remains a key-issue for achieving the quality objectives. It increases the operating cost, even if some are made at low cost like in Cambridge with “car traps”, there is a need to compare the efficiency or effects of these enforcement tools implemented.

Bus stations design

Implementing a BHLS station is always difficult, as it is for a tram station. It requires a wider place for providing good comfort and should have permanence for BHLS schemes.

Difficulties to enlarge the stop spacing, for increasing the speed, is a very important factor for good BHLS effectiveness:

- Decision makers normally consider that the public does not like to walk more than previously, but public could be ready to walk a little more if urban management for pedestrians are improved (as shown in BAHN.VILLE project), and in case also of a high quality.

- The needs of elderly and disabled people should be recognized in the design of BHLS systems. Most of these measures are advantages for all passengers and the attractiveness for the public transport system – accessibility to stops, spacing, lighting, clear visible and audible information and non-level boarding.

#### Regarding vehicle issues

Difficulties for choosing an alternative cleaner energy (cost vs. environmental impact). It is sometimes difficult to choose between improved diesel buses, electrical energy (trolley-buses), hybrid solutions or alternative cleaner energy. This issue is not specific of BHLS: it is an issue of strategy for the whole bus fleet.

Access by all doors is not compatible with problems of fraud, but a good speed of boarding is required for BHLS.

Seating capacity or standing capacity? What is best for “speed” of service – UK has history of high seating capacity and single doors – can this be changed. Comfort on board related to average trip length (in min).

Space for prams, wheelchairs, bags, etc.

Balance capacity with service hours, to spread demand and reduce peaks.

Promote the use of monthly / yearly passes or / and smart cards at reduced price to reduce the number of transactions. Moreover, the greater the number of passes is, the lower the problem of fraud is (as in Germany or Switzerland).

#### Regarding ITS issues, mainly the AVM

AVM: this is one of the key components when considering BHLS. It needs to be managed at a network level.

A good level of knowledge is required to introduce a good AVM system. The required expertise might not be easy to get in small urban areas. However, it may be possible to partner with a more experienced bus operator who could provide mentoring and support. Developing good operations strategy and good operations procedures, supported by appropriate staff organisation and training, is at least as important as the technology.

Providing and displaying dynamic information at all stops and/or in BHLS vehicle is expensive. However, information is an indispensable component for BHLS level. There is a need to evaluate the potential of providing this information to mobile devices direct to the customer or by flash codes. There is also a need to build systems to respond to changing conditions, with more efficiency.

Traffic light priority: these can be difficult to achieve in some areas due to political and geographic issues. Even where the operator has an AVM system, there may be difficulties to achieve sufficient precision if the polling cycle is fixed or coverage is poor.

It is more difficult to assure an efficient priority at traffic lights with smaller vehicles that are operating with a higher frequency (and we have to consider priority for both directions).

In a deregulated market, ITS, with a high level of passenger information appears to be difficult to implement due to institutional issues and responsibility for financing; in that case, a PPP approach or other framework agreement may be a solution.

#### Regarding marketing / branding issues

The ability to sell BHLS requires a strong marketing strategy, at network level, integrating the long term. This strategy can include a bus-based network hierarchisation.

Difficulties in an open market (UK), How do you control market? Who decides timetables? Who decides fares?

It can be more difficult to sell a bus project than a tram project.



### Other Issues

Hierarchisation is a key issue for big urban areas, with a need to be able to rationalise some current services with too low ridership.

Tram project seems to have an advantage regarding esthetic issues in implementation, However, some BHLS schemes have shown very good achievements in that regard (Castellón, Nantes, Twente, Rouen, Cambridge) and there are no reason why a BHLS system cannot be given the same urban quality.

The urban quality, especially around stops and accessibility to them should be given a high attention in a BHLS system. There are clear indications in recent literature that the urban quality and accessibility to stops can give increased ridership on the same level as improved public transport operations.

## 4.2 Recommendations / messages for policy-makers decision-takers

Based on the experience gained to date in the 35 European BHLS schemes examined by the COST TU603 action, a number of recommendations and messages can be formulated to policy makers and decision-takers. We have clustered these at EU/National Level (i.e. those who set policy and programmes) and at City/Regional level (i.e. those who implement, and are locally accountable).

### 4.2.1 Recommendations at European / State level

#### **1) To recognise BHLS as a higher-order transit mode, and to include it in policy**

- That at both EU and National level, BHLS are considered as higher order transit mode, with distinct characteristics, and of higher performance than standard, regular, classic urban bus services.
- To include BHLS within transport policy and transportation research as higher-order transit modes.
- To consider BHLS on a comparable basis to tramway/LRT, with due consideration of some performance (such as commercial speed).
- To mandate that BHLS schemes are appraised on a comparable basis to rail-based modes, with recognition of same potential broader urban, societal and economic impacts.
- To mandate socio-economic evaluation of BHLS schemes, even if they are below Ministry of Finance (or equivalent) thresholds, until a sufficient corpus of knowledge has been developed.
- To recognise that it is insufficient to focus only on priority routes or axes, and that network-wide improvements and particularly high level of service enhancements are always needed in a genuine “system” approach. Whether the primary transit axes are served by rail or bus, large numbers of people travel on the rest of the network and solutions are needed for them (e.g. Chronobus, QBC, BHLS-lite).

#### **2) To develop a framework for defining and rating BHLS**

An accepted framework is required of what 'qualifies' as BHLS, and to provide a quantitative and/or qualitative rating. In part, this is needed to assist requirement specification, stakeholder communication, and design; in part, it is required to avoid lesser schemes labelling themselves as BHLS and ‘devaluing the brand’.

The rating work developed within the COST TU603 action, with other work from USA (ITDP) can be a starting point to develop a framework suited to European BHLS.

**3) To continue, enlarge and keep operational the BHLS Knowledge Building and Knowledge Transfer Network, that has been set up by this COST action, at European level:**

- A way to benchmark innovative improvements, to promote research and evaluation.
- A way for collecting much more « infrastructure » knowledge.
- A way to promote common indicators on bus safety / performance / quality measurements.
- A way to organise fruitful technical visits to different BHLS systems, especially for cities launching their first BHLS project.
- A way to promote international cooperation with extra-EU stakeholders (with North America, Middle East and North Africa, Asia, etc.).

This Knowledge Transfer Network could be chaired by UITP or another European association (e.g. POLIS), with free access for the COST TU 603 BHLS members who collected and/or provided BHLS information.

**4) To give BHLS buses “tram-level” priority.**

- A way to improve the efficiency of BHLS and other bus-based solutions.
- A way to improve similarities between bus and tram projects, to reduce signalisation in some context, to keep priority when signals breakdowns.

We suggest to achieve (at CEN level) a commitment on bus priority for testing and studying the conditions for giving to the bus the same status that has been given to the tram in reference to the Vienna convention on Road Signs and Signals (1968). This regulation has harmonised the tramway priority, mainly for safety reasons as the braking performance of rail systems cannot achieve the same level of rubber tyres; however, for economical reasons, the same priority for buses with high capacity can be justified. Moreover some safety reasons can be pointed, i.e. for be-articulated buses. Into the existing priority framework, the tram drivers should keep a duty of vigilance, and obviously should respect the “stop” rules.

**5) To promote efficient RoW enforcement strategies, that can include:**

- Higher fines for a non respect of RoW, according to the potential financial lost<sup>63</sup>
- The use of automatic systems, as seen for speed or traffic lights enforcement.
- An efficient association between police and operators, as seen in the case of Lisbon.

**6) About safety issues:**

- To promote a mandatory road safety assessment before opening any BHLS project, by an external unit (expertise in road safety), at each important phases during the studies, as requested for tramway projects in some countries (i.e. in France).
- To request an annual “safety / performance” assessment report for each BHLS scheme in operation, (as already produced for tram or a metro line in some countries, like France); Km lost by type of problem are interesting data, with suggestions of improvements.

The bus appears to be the safest mode, however BHLS operates at higher speed in specific lanes, so that one’s should takes care to maintain and improve this quality level.

**7) About ITS issues:**

- To promote standardisation of interfaces and open data regarding real time about operation. Internet use is a key factor for intermodality.
- To promote and continue standardisation into the AVMS sector.

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<sup>63</sup> In USA / Canada, the fines with random inspection are in general very high, up to \$700, so actually dissuasive.

- To research and disseminate information about lower-cost ITS options, especially those suitable for BHLS in smaller urban areas.
- To take advantage of new smart phone features and possibilities, and of social networking.

Intelligent and Communication Technology (ICT) must cover basically three main aspects: Real-time Automatic Vehicle Location (through GPS and other complementary devices such as odometers if needed) and route management from the Control Room, giving to the driver the relevant regulation indications and supplying the Users Information System (screens, loudspeakers) with the necessary announcements; Network Structure and Fares System in order to define bus position along the line, controlling line and destination panels and adjusting ticketing terminals operation; and finally the Storage and Dumping System of all data on ticketing, security cameras and CAM (Computer Aided Maintenance). Instant alarm calls mentioned below must be secured with the highest priority through the relevant Emergency Channel.

An ITS Common Platform for Urban Buses is being prepared at European level (see CEN and EBSF project).

### **8) Regarding the EU rules on bus sizes:**

An important point to consider is the fact that double articulated buses of 24 metres in length (and over, as in Istanbul), are very attractive for high capacity systems. They are not yet permitted as such by the current European type-approval provisions, which therefore reduces the competitiveness across Europe. A specific recommendation at legislative and regulatory level is as follows:

“Regulation 107 UN / ECE (United Nations Economic Committee for Europe) and Directives 97 / 27 / EC (modified by Directive 2003 / 19 / EC) and 96 / 53 / EC relative to the maximum authorized masses and dimensions of motor vehicles, should be extended and modified correspondingly in order to include double-articulated buses up to 26m.”.

## 4.2.2 Recommendations at regional and city level

### **1) A strong political will is indispensable, at all stage of the BHLS project**

A long term political support and commitment is necessary throughout all stages of the project (integration of different policies: transport, urban, social, environmental, economic).

A strong willingness to lower the place and use of cars when PT is able to provide a High Level of Service, to think in advance all the interactions with the other transport modes: walking, cycling, other Public Transport, cars (any kind of usage private or shared).

An improved general knowledge and skills is desired for employments about public transport development, systems, strategies and relations to other networks and urban structure to make them more suited to propose good solutions and argue for them.

There is a need to secure the funding of the whole BHLS project seen in a systemic vision.

There is a need to integrate the different planning scales, state, region and local.

There is a need to give a good support and visibility to the PT and BHLS system: vehicles, RoW, platforms and stations (branding, logo, name, shape, colour, signalling, map information).

### **2) A long-term vision should be set up at the city level to obtain support of citizens:**

- Regarding town planning and socio-economical trends.
- Regarding environmental issues and clean modes objectives; BHLS is not the only solution.
- Regarding intermodality.

- Regarding information and ticketing strategies for the whole mobility offer, with the objective of off-bus ticketing for BHLS (no selling ticket by drivers).

**3) An efficient communication strategy for “decision makers” and for “citizens” is needed for any BHLS project.**

This has to start at the design stage and continue right through to implementation and beyond and involve stakeholders to ensure buy in. Lots of items are concerned, such as:

- The costs versus performances / benefits of all options.
- Consequences of introducing BHLS (who loses, who gains, impacts for all modes and PT network).
- Best practices from similar sites that can be visited in EU (scanning and study tours are always fruitful).
- Branding issues, including logos / name(s) for the services, quality and level of service, shape, colour, signalling, map information, in order to link BHLS with the community. However “Do not promise what you cannot deliver during the project”. This will only cause long term problems and resistance to further changes.
- To involve citizens in choices of branding as in Jönköping to create adhesion.

Each urban area is different, so that each one should build its own strategy, with one or several BHLS levels. Each Authority should choose its own hierarchisation into the PT network. Communication support should be as wide as possible.

**4) For planners in charge of a new first scheme, it is high recommended to organise visits to other BHLS cities with politicians and association leaders.**

Such visits allow the stakeholders to better understand the complexity of this domain, the role of the local context, the potential market of BHLS.

**5) A strong “project management committee” should be set up for each BHLS project, as for any complex urban project; its role will be also to:**

- Collect all the needed “system” knowledge available through all stakeholders involved.
- Enlarge the skills with external transport and transit experts, and also with universities as a research resource.
- Define quality and level of service, according to the political demand.
- Coordinate and manage the public / customers consultations.
- Coordinate and follow up all the studies and works, with risk management processes (in case of innovation).
- Inform the decision makers of any “quality” deviation until the opening, so that any trade offs can be decided with transparency.
- Manage the internal / external communication.

**6) To develop a good “RoW enforcement” governance with the operators (in case by contract):**

- The ability to suggest the fines levels, according to the quality objectives.
- The ability to manage / organize enforcement / collect fines.
- To inform citizens.
- To organise an efficient association with the police.

**7) Several innovative tools, flexible or not, have been observed in infrastructure, that are ideas to go further**

See chapter 3.3 “infrastructure analysis” where some unusual tools are highlighted.

#### **8) To ensure the success of the first route or first section to be implemented**

The success of the first section will help for convincing about the following phases.

### 4.3 Research field proposals

Following the “recommendations” phase, below are highlighted fields of research, surveys or evaluation that can help for improving the BHLS market.

Regarding evaluation of benefits and impacts of BHLS, beyond technical and ridership performance<sup>64</sup>:

- Transportation system impacts: e.g. modal share, total network effectiveness, transport sector energy consumption and emissions.
- Societal impacts: e.g. access to jobs, social equity, social exclusion.
- Urban impacts and importance for public transport: e.g. land use patterns and urban spatial/economic structure, land values, development, urban economy.
- Economic value impacts: e.g. post-implementation socio-economic CBA, structured impacts analysis.

Regarding design and optimisation of BHLS:

- Optimisation of service plans and operations of BHLS.
- Organisational methods and structures for BHLS.
- To evaluate the efficiency of the available modelling tools, to benchmark the macro, micro analysis.

Regarding quality / regularity measurements:

- To enlarge and test several types of indicators (i.e. standard deviation indicators) and their geographical presentations<sup>65</sup>. This research needs to include the points of view of authorities, operators and users. Another objective is to test information on regularity/punctuality towards customers.
- To make benchmarking among operational BHLS systems.
- To develop enhancements, where relevant, to the EU standard on service quality (EN 13816) and to monitor applications and organise feedback.
- To define a good set of complementary fruitful KPIs, that can be adapted.

Regarding other different research items for improving / assessing the system approach quality:

- To assess the AVMS management (quality of data, quality of assessment, information on disturbances).
- On customer satisfaction, by comparing indicators among “BHLS” cities.
- On use of the new information solutions like flash code, social networking like Facebook or Twitter, in order to integrate passenger initiatives and reduce reliance on displays at some stops (screens costs at all stops are expensive).

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<sup>64</sup> See also the recent UITP position paper “Assessing the benefits of public transport” on evaluation and impacts assessment trends

<sup>65</sup> The reference to the telediagnostic tools (based on the EBSF IT standardized platform) can provide an important support especially when high frequency has to be guaranteed.

- On new needs into PT and BHLS (Wifi, sockets on buses, information on mobile phones, personal and targeted information, useful related to new technological development).
- On fares issues, the willingness to pay more for faster or better services. the impact on fraud management.

Regarding BHLS market knowledge:

- On the role of BHLS within a PT network (planning, organisation, inter-modality, multimodality, etc.).
- On the image of BHLS (e.g. why tram is considered so exiting and not bus?).
- On public participation and acceptance.
- On sharing data basis for network comparisons.

Regarding financing mechanisms for BHLS:

- Financing mechanisms for BHLS infrastructures and their maintenance.
- Financing mechanisms for transportation services and for customer services.
- Potential for PPP and other forms of private investment.

We suggest also to refer to the roadmap proposed by UITP, manager of the EBSF project<sup>66</sup>.

There is a need to develop joint research between EU research on BHLS and North American research on BRT.

Finally, there is an high interest to focus on prospective issues by 2025 in EU, according to the well known challenges (climate change, population increase, social problems, economical crisis, etc.) and supported by the UITP Public Transport sector strategy of doubling market share in 2025 as compared to 2005<sup>67</sup>: what capacity, what speed, what kind of services, what market share are expected within a scarce public budget and higher fossil energy costs.



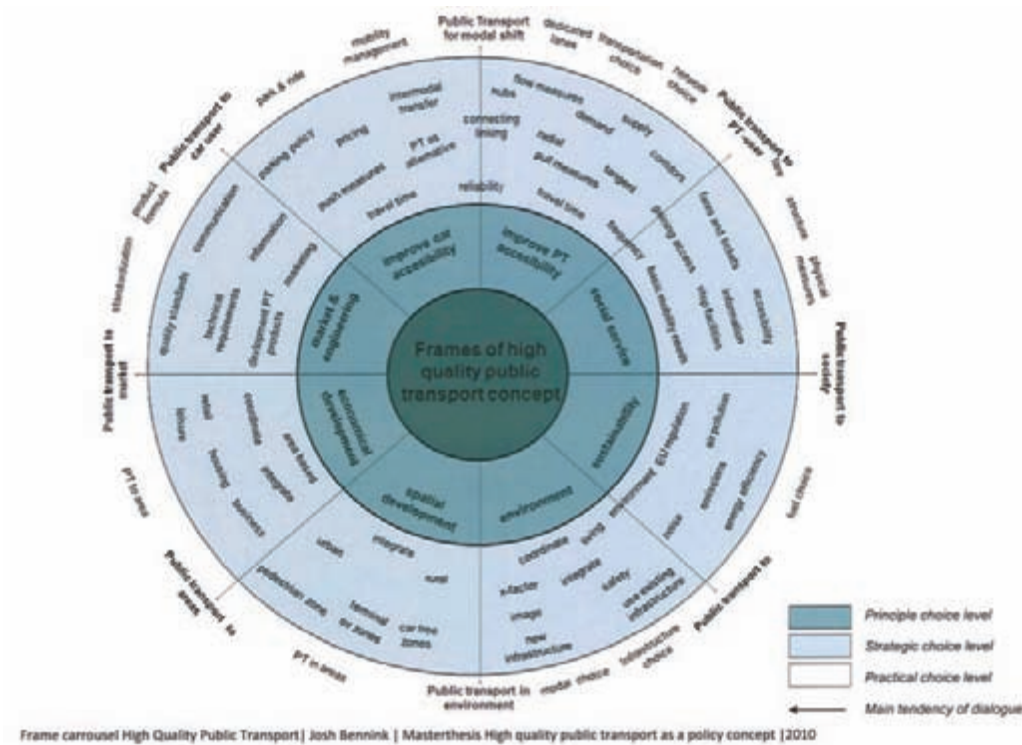
*Hamburg, the “Metrobus” line 5 with bi-articulated busses.*

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<sup>66</sup> Supported by ERTRAC, the European Roadmap written by the “European Bus System of the Future” project has been consolidated and delivered officially in June 2011.

<sup>67</sup> Refer to the UITP PTX2 strategy.

## 5. How to apply a BHLS Concept



Several BHLS concept approaches have been observed and written into guidelines, some at national level, such as in France, in Sweden and in Netherlands, some other more detailed at city level like in Dublin, Paris, Manchester and Hamburg whose strategy were applied later on also in Berlin and in Munich.

*The users needs, as the basis of any BHLS concept approach*

The appellations are very different, choosing wording judged the most appropriate according to the context, the branding objectives or language matters, such as “service”, “corridor”, “quality”. Other have chosen “metro” for branding a mode similar to a heavy one which quality is very well known. We observe that the terms “transit” or “rapid” are never used in Europe.

Moreover, for some cities, we observe a need to define several levels of service, several concept according to the role, the size of the bus line, or the readability that is expected for the passengers, such as in Nantes, Paris or Hamburg, according to the survey results presented into the chapter 3.4. Actually, since some years, it can be observed in Europe, a trend toward a much stronger hierarchisation of all bus lines in the network. This has evolved due to, among others, the recent BHLS approach, spreading at different levels of service.

*Reliability appears to be the most important objective*

Briefly, the main characteristics highlighted for the structuring bus lines “BHLS” are:

- Connection with the upper level (intercity rail network, regional train, metro,...)
- High capacity
- High frequency
- Long span, straight routes, “Go fast”

And the reasons that are more often pointed out are mainly:

- To make the bus network clear, readable.
- To tackle congestion and to contribute to solve environmental issues.
- To prioritise by infrastructure investment, according to the potential capacity.
- To concentrate the demand.

- In any case, to increase the cost coverage, while some weak bus lines can be then suppressed, as said in Nantes.

The cities interested by hierarchisation of bus lines in the network are designing several types of bus solutions and we can present a spectrum from local lines to BHLS “full or complete” offering a high level of quality, as shown in the graph below:

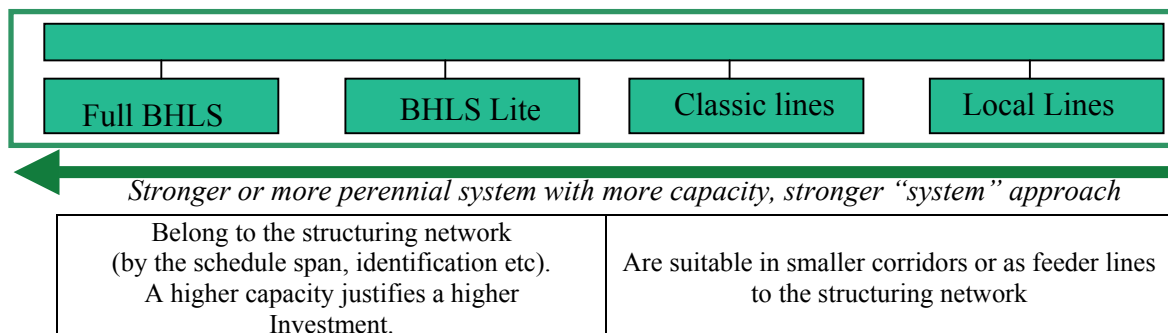


Figure 31: Toward a hierarchisation approach of the bus-based solutions

All these solutions are fruitful solutions and should be designed according to a system approach, integrating the infrastructure in a coherent manner with the vehicle and the operation condition and components.

Obviously, as all urban contexts are different from each other, it is up to the local authorities to decide upon and define its mobility plan with the suitable hierarchisation of the bus-based system.

The BHLS concept should be seen as a method or a guideline for local decision makers for reviewing and designing the different types of bus-based solutions.

The identification of each level of service will be very fruitful for the passenger, it can be achieved through several means, such as:

- The numbering of the line, the choice of a logo,
- A specific design for the bus itself
- An specific design of all stations
- Specific features along the infrastructure itself, a contrast, piece of furniture, marks,...
- The clear identification of the route in all network maps and information tools.

Then several questions have been raised:

- Is there really a need to write down an EU BHLS concept? With its own guidelines? with a specific acronym for all countries?
- Is it better to let each EU country building / translating its own BHLS concept guidelines according to its own language, regulation, urban context? With its own acronym?
- Is it anyway better to advise cities (mainly the biggest one...) building by themselves their different concept application, as they could need several “levels of service”?

The first option does not seem so useful, as so many guide books have already been published in USA, Canada and in some countries in Europe, France, UK, Netherlands. A European guide book will not add more inputs. On an other hand EU countries have a different



language, a different culture in organising public transport, with very different levels of PT use, with different PT financing ways.

The two other options seems to be the best, but, as said into the recommendation chapter, a high interest to exchange the existing experiences, to keep and improve this knowledge network built through this COST action:

- It is up to each authority to define and build up its hierarchisation through its urban planning.
- The BHLS concept should be seen as a method or a guideline for local decision makers for designing the different types of bus-based solutions.

This final report can be the basis of fruitful advises and existing references for countries and cities feeling the interest to set up a conceptual phase, at one or several “levels of service”.

A BHLS concept can be seen as:

- A strategy, system approach, of improving, boosting, or revamping Public Transport (more than trunk lines), as a strategy for regeneration to new standards.
- A tool to fix the main characteristics of High Quality Urban insertion, according to the economic, cultural and social context.
- A pedagogic tool towards all stakeholders.

*BHLS: new ways of thinking Urban Quality and Public Transport.*

## 6. Conclusion

### On decision and project management issues

The importance to plan simultaneously transport investments and development and urban and/or town planning have been highlighted (Lorient, Nantes, Zurich, Lund, Jönköping, Almere, Madrid, etc.). The BHLS success stories are seen where town and country planning, land use and transport planning, and investments are tackled together and simultaneously.

It is important to involve politicians and other decision takers at an early stage. We have seen that successful BHLS projects require extensive dialogue and engagement with stakeholders. This can sometimes be a lengthy process, but experience shows that it does yield good results.

The issue of selecting the optimal transit technology and priority concept is fundamental to both system effectiveness and stakeholder acceptance.

As a mode, the bus appears well-adapted to progressive expanded urban zones (e.g. Almere in the Netherlands, the Fastrack project South-East of London). It can be adapted to different situations in terms of demand, with bi-articulated buses or trolleybuses, as in Hamburg, Utrecht or Zurich.

BHLS has a highly promising market in Europe. It is deployed in cities, medium-sized conurbations, as well as in the outlying zones of the biggest metropolitan areas (e.g. Madrid, Paris) We have observed that the busiest BHLS systems in Europe (Paris TVM, Amsterdam Zuidtangent, Hamburg Metrobus, Madrid Line 27) operate in the range of 30,000 to 66,000 trips per day and for volumes in the range 1500 to 2500 passengers per hour per direction, for one line.

To date, cities have opted for tramway to meet capacity requirements both within and above the current range of BHLS. There are numerous factors which are mentioned for this choice, such as the capacity requirements, the labour and operating costs associated with buses, width constraints in urban areas, opportunities of existing infrastructure, intermodality with the existing network, funding capacity, forecast of land use evolution,... There is then clearly an overlap in the “capacity range” of tramway and BHLS market. Moreover, it remains possible but very rare that BHLS can reach significantly higher capacities in Europe; the case of Madrid is an exception, with very specific configurations: in the heaviest motorway section, 44 small bus lines carry all together 112 000 passengers a day, around 190 bus/hour that makes around 8 000 passengers / hour, but there are no stops on this common section.

Some BHLS projects have been implemented on the basis that they could be converted to tramway at a later date, either when the demand requires it, or when there is funding available. In a few cases, core elements of the BHLS such as stations and the running way pavement are constructed to tramway requirements from the outset to facilitate later conversion (e.g. Zuidtangent in Amsterdam, Lund in Sweden, Nantes Busway). This indicates an interesting strategic approach: first, to induce and/or increase ridership and second to adapt the transit technology (according to the context the changing of the system technology can create some difficulties during the interruption of the line for additional works).

### BHLS within the PT network

In Europe a trend is observed toward a much stronger hierarchisation of bus lines within network. This is mainly due to a combination of financial reasons and intermodality transport policies with heavier transport modes, but also to make the bus network more “easy to use”.

In some cities, BHLS is a core part of the multi-modal network (Nantes, Rouen, Utrecht) showing the same importance as some rail systems

In other cities, BHLS system can be a transit mode in its own right; a new and relevant intermediate capacity system for metropolitan areas as complementary mode to their

(re)structured network (Paris TVM, Hamburg, Madrid Line 27, Stockholm, Zurich); or an appropriate solution for smaller urban areas as the backbone of their network (Lorient, Jönköping, Lund, Castellón )

In general, BHLS in Europe has been implemented within the existing institutional and regulatory frameworks. Contractual change is not required to implement BHLS systems.

Current practice is that the same prices are charged for BHLS as for other buses. To date, no European BHLS has implemented premium pricing or other fares differentiation. All the BHLS studied prices are included into network fare integration.

### **On some infrastructure strategies**

Many BHLS schemes have multiple routes running on common trunk sections. They serve different communities as required, many originating away from the BHLS facility, and then overlap on the common section to give the point of highest capacity/throughput requirement. The main advantage is to limit the number of transfers required, as transfer is well known to be a significant deterrent for passengers. A secondary advantage can be to simplify the stations which would otherwise be the main transfer points.

Some systems share the tramway platform with Buses or BHLS as in Stockholm, Gothenburg, Oberhausen and Zurich. This achieves greater utilisation of the street space allocated to public transport – especially in the central areas where space is scarce - while also allowing easier transfers between these modes.

In 14 of the BHLS systems visited, we observed that the host environment and/or urban streetscape have been improved. This demonstrates that BHLS can contribute to urban enhancement.

We have observed that BHLS is normally designed to facilitate cyclists and pedestrians. Cyclists are normally accommodated in adjacent cycle-lanes to avoid conflict with the buses. At some BHLS systems, there are designated stops where parking facilities are provided for bicycles (e.g. Cambridge, Amsterdam, Almere and Lund). Pedestrian facilities are almost always an integral part of BHLS, and in some cases are significantly improved by general streetscape upgrading associated with the BHLS (e.g. Oberhausen, Twente, Lorient, Castellón).

Some BHLS schemes can accommodate multiple routes/lines with a high collective vehicle throughput (e.g. QBC in Dublin, Purmerend, Madrid BusVAO). However, it becomes increasingly difficult to manage the services if the buses cannot easily pass each other at stops, or if there is insufficient priority at traffic signals. For individual routes, headway control becomes more difficult at headways of five minutes or less, and operators often consider that three minutes headway is the limit for *individual* routes.

### **On quality matters**

First of all is important to clarify that *high level of service* does not necessarily mean *high level of technology*. Further, the High Level of Service needs to be considered for the entire passenger journey. We can use two different approaches to set a definition: level of service or quality. Whichever approach is used, the services attributes must be explicitly formulated and the target services/quality should respond to the travel demand and to the customer preferences and priorities.

The scheme promoters identify the factors that are in need of improvement: e.g. regularity / punctuality, frequency, quality management, commercial speed, etc. The characteristics and performance of the BHLS reflect these requirements.

Frequency, regularity and punctuality are essential to provide high level of service. These attributes are typically the main KPIs (with different ways of calculation) used by management boards and in service contracts.

Personal behaviour is changed in favour of Public Transport when the new passengers find advantage compared with the use of car. Reasons include time and/or cost, easy to use, reliability, especially when there are strong policies in favour of public transport – e.g. parking restrictions into city centres as seen in many BHLS examples studied in this COST Action.

Observed European practice uses reliability targets in the range 80-95%. The European Norm CEN 13816 proposes a value of not less than 80%. Experience with BHLS demonstrates that a target of 95% of passengers “having a bus on time” is achievable. This is also important for managing an efficient high frequency service (avoid bunching), and consequently reach the high capacity expected.

Acceptance of BHLS by the citizens is usually good. BHLS can provide high quality of supply, accessibility and security in the same way as tramways.

### **On observed benefits**

Regarding the ridership increase, a wide variation from 15% up to 150% has been observed, although it can take several years (3 to 4 years) until results are significant.

The case of Jokerilinja (Helsinki), a long peripheral line, is impressive, with an increase of 150% within 5 years.

In the case of Hamburg (increase by 15% within 3 years) this was achieved on an existing busy line when better branding and improvements were made.

The ridership increases arise from a combination of several factors, improved reliability, shorter travel time, increased volume of service, better image and marketing, and focussed car constraint policies. There is not an observed direct relationship with the percentage of Right of Way, even if it is often the fundamental factor.

Data has been collected highlighting that BHLS schemes can achieve high modal shift rates from the car, from 5% up to 30%. This depends on the specific context. The previous rates of PT use were already high in Sweden and Netherlands whereas the previous rates of car use were high in France, Ireland and Spain.

### **On road regulation improvements**

To provide priority for BHLS in its right of way, on the same basis as tram. Where relevant, to adapt road traffic regulations and to harmonize signage for tramway and BHLS priority.

On other words, to give to the bus the same priority rules that the tram have.

To improve the EU bus regulation for BHLS features – e.g. for bi-articulated buses, for doors at both sides, for bicycle racks at the vehicle-front (as in USA/Canada)...

### **On research issues**

After a 4 years “study tour” in European cities, that have implemented a BHLS system, lots of data have been collected, provided either by transport operators/authorities or by specific own COST BHLS enquiries. Some points have been investigated more deeply by means of 7 STSMs.

Nevertheless, there is still a need of further data collection, feedbacks and research, mainly on these different items regarding:

- Evaluation of benefits and impacts of BHLS, beyond technical and ridership performance.
- Design and optimisation of BHLS.
- Quality / regularity measurements.
- Improving / assessing the system approach quality:
- BHLS market knowledge.
- Financing mechanisms for BHLS.
- Joint research between EU research on BHLS and North / South American research on BRT.

## 7. Appendices

### 7.1 Abstracts of the case studies<sup>68</sup>

#### 7.1.1 Line 213 - Prague



**Country :** Czech Republic ; **Region / city :** Prague (1.2 million inhabitants)  
**Type of route :** tangential (connection between housing area and two metro lines)

#### Background / Context

Prague covers an area of 496 square km with almost 1.2 million inhabitants. Prague is characterized by massive commuting from large suburban residential areas to the city centre, which results in high demands on public and also individual transport. The backbone of PT network in city is 3 metro lines (59,4 km), which are supported in city center and middle part of city by trams (network of 141,6 km) and buses at tangential and local lines out of city center (network of 690 km). Metro, tram and about 92% of city bus lines are operated by Prague Public Transit Co., Inc, which is owned 100% by City of Prague. In region there are number of radial rail lines (operated by Czech railways) and a lot of radial, tangential and local bus lines (operated by different operators).

Since 1994 there is developed Prague Integrated Transport System (PIT), which covers all PT modes (included suburban trains and buses) and guarantees integrated tariff and coordination of timetables for easy interchange. The coordinator “ROPID” is also responsible for network planning and contracting (tendering) PT services to operators.

During last 20 years there has been significant priority of development rail modes in city (metro and trams) with huge investment into network extensions. Situation of PT buses was more complicated, because of increasing private motorization and daily congestion on main roads with negative influence to punctuality and commercial speed of buses. Anyway since 1994 was started first projects of dedicated bus lanes and since 2003 was used active priority at traffic lights.

For increasing quality and attractiveness of PT buses was prepared concept of bus network hierarchization (metrobus / normal buses / minibuses). Realization of that project is being in progress. There are step-by-step bus network changing from year 2008. Another good progress is in development of bus priority. Full realization of whole concept including marketing and promotion (“official beginning of metrobus operation”) is still in stakeholder discussion.

#### Description

##### **Infrastructure :**

Length: 10.25 km (16% dedicated – partly shared with trams and partly with taxis and cyclist)

Width of bus lanes: one way – min. 3.25 m

Average station spacing: 600m

Road crossings: grade intersections, priority at 27% of traffic lights

##### **Buses :**

Type: standard busses (planned articulated) – 50% low-floor

Length: 12m (planned 18m with 5 doors for improving the dwell times)

Capacity: 66 (planned 97)

<sup>68</sup> The abstract of the BusVAO of Madrid is available in the CD.

### **ITS tools :**

For passengers(visual and vocal information):

At station: static schedules, ticket vending machines (key stops).

On board: line number, direction, next stop, disturbances or service changes; voice information on demand for blind people – line number and direction + information for driver about getting on of blind person.

For drivers: AVL, priority at traffic lights, door and rear cameras (new vehicles).

For regulator: AVL, radio connection (with emergency button and direct communication to Municipal Police): CCTV (stops, new vehicles).

### **Identification :**

On the bus Same as other busses – logo and colour scheme of company and logo of PIT.

On the running ways Only at dedicated parts – traffic signs by Czech law

At the stations Same as other lines – sign of bus, No. of line and direction, uniform scheme

### **Cost and Financing sources if available (in €)**

Investment costs: 0,03 M€ / km (excl. vehicles)

Vehicles: 0,20 M€ (standard), 0,28 M€ (articulated)

Operating costs: 1,8 € / km

### **Some results**

Ridership : 18.000 passengers / working day

Headways: 6 min (peak), 12 min (off-peak)

Schedule span: 5h00 am – 0h30 am

Regularity : 80% punctuality (H-0min; H+2min)

Commercial speed : 21,8 km/h (peak)

Accidents : 2,1 accidents per 100 000 km

### **Success factors / Strengths**

There are quite good financial support from City of Prague into public transport (operation and investment), which allows very huge density of PT services on one side and quite cheap fares on other side, with result of modal shift between PT and cars 57:43.

Prague PT is also customer oriented by quality management. Internal service quality programme by EN 13816 was developed in 1998 and since 2010 has been included into contract between Prague and all bus operators of Prague Integrated Transport. One of key factors is accessibility for disabled people – low floor vehicles, lifts to metro stations, voice information on demand for blind people (metro, tram and busses).

In bus PT there are good results using dedicated bus lines and also priority at traffic lights. Prague PT offers quite high ratio of articulated buses, which are more effective on high demanded lines. There are also good results providing more doors (4 in 12m bus, 5 in 18 m bus) to decrease boarding time at new vehicles. Quite positive is also new on-board camera system, which decreases level of vandalism.

### **Barriers / weaknesses / Points to monitor**

There is still significant priority for investment into rail modes (metro and trams) and after a lot of changes still relatively low level of attractiveness of PT busses, which in fact decrease amount of money available for further bus system improvement. The BHLS (Metrobus) concept has not yet full stakeholder consensus, which is key reason for its present step by step implementation.

### **Lessons learnt**

There are quite effective using even local priority measures (even short dedicated lanes, priority at traffic lights, right of way for busses at crossroads or for easy bus stop departure, etc.). There are very good results with sharing tram track and tram stops also for busses. There are also quite close cooperation to disabled people communities (consultation of network planning – special bus lines for wheelchair users, consultation of new vehicles construction and equipment, consultation of new information tools and graphic schemes, etc.).

### **References and contacts for further details**

Institution : Prague Public Transit Co., Inc.

Person contact : Jan BARČÁNEK, [barchanekj@dpp.cz](mailto:barchanekj@dpp.cz), +420 296 133 010

## 7.1.2 The Busway – Nantes



**Country** : France - **Urban authority** : Nantes Metropole - 600,000 inhabitants (24 communities).



### Background / Context

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Nantes Métropole is a conurbation, with nearly 600,000 inhabitants; 3 tramway lines have been re-introduced since the 80ies with a great success while re-generating the quality of the districts concerned (improving the clean modes, the public space quality). The fourth corridor along a highway (south east entrance) needed a less capacitive system, but the same implementation quality was expected. Hence the BusWay was built, called line 4, as the fourth structuring line of the network which entered into service on 6th of November 2006. It connects the ring road to the centre of Nantes in less than 20 minutes, with a frequency of 3 minutes at peak times.

This line 4 is a bus-based system implemented exactly as the other tram lines: central dedicated lane as most as possible, ITS equipped stations, priority at all intersections, high frequency, same schedule span, 4 park-and-ride facilities, no contact with the driver, a specific identification with dedicated buses operated only on this line.

### Description

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#### **Infrastructure :**

Length : 6,9 km (87% dedicated – no sharing with other modes or other lines)

Width of bus lanes : 3,5m<one way<4,5m 6m<two ways<7,5m.

Average station spacing : 500 m (15 stations).

Road crossings : 26 at grade intersections (mostly small or urban roundabouts).

#### **Buses :**

Type : 20 specific CNG articulated buses (specific design for this line, closed driver cabin, mini ramps)

Length : 18 m.

Capacity : 110 pass/bus (4 passengers/m<sup>2</sup>)

#### **ITS tools :**

**For passengers:** at station, real-time information displays, clear maps, vending ticket machines on board, real-time information displays: next stop/terminus, disturbances, waiting time of the next connected services of the network

**For drivers and regulator:** AVL, priority signal control at all intersections, driving aid signing for road crossing AVL, CCTV in buses, in some stations and P+R

**Identification : On the bus** , the logo on front buses and at every side buses; different colour and design than other buses

**On the running ways:** a small contrast with a beige asphalt

**At the stations:** distinctive design and colour, distinctive brand



### Cost and Financing sources if available (in €)

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**Average investment cost per km :** 8 M€ (3 time less than for a tramway project).

**Cost of a bus :** 460 000 € (+20% of a common articulated bus).

**Operating cost :** 4,90 € / km (included the dedicated lanes regular maintenance).

### The main results

**Ridership** : demand in peak hour 2000 pass/hour/direction; 28 000 pass/day; an important part coming from the car mobility: around 25%.

**Headways**: peak hours 3,30 min (3min in September 2010) ; off-peak hours 7 min.

**Schedule span**: from 5h am to 0h30 am (19h30) – the same than for the tram lines.

**Regularity** : (2009 results) : 98,5 % of passenger got a bus with a headway not more than Interval + 3 minutes.

**Average commercial speed** : 20 / 23 km/h, rather stable (variation related only to the load).

**Accidents** : No major accident (8,55 events / 100 000km) , no fatalities; mostly injuries inside the vehicles due to strong breaks at crossings (more than in common buses and in tram).

### Success factors / Strengths

A management process exactly as a tramway project, **with a high politician support**.

An **easy and wide urban context** on 75% of the length.

**The integration of the main success tools of a tram**: priority at all intersections, central implementation, comfortable station, information at all stations, no selling tickets by the driver, tram signalisation. An efficient level of service, the same as the other tram : high frequency, long schedule span, efficient information, high visibility into the network, branding.

### Difficulties / Weaknesses / Points to monitor

Difficult works phase entails by car places suppression.

A ridership more important as forecasted (+25%), that makes now the system too crowded at peak hours (bi-articulated vehicles (24,5m) may be required, the route is also able to be converted to a tramway line).

Safety problems at some exit from the station: lack of visibility with the car lanes.

Rutting problems at station with percolated asphalt.

### Lessons learnt

The attractiveness of a bus-based system is not linked to the vehicle itself, but much more with the service offered, and hence with its quality of the infrastructure provided.

There is a high interest to give to the bus the same priority, the same regulation than the tram (no pedestrian marks on the dedicated lanes, in order the bus keeps the priority among all modes).

There is a high interest to have inside the management staff “tram” skills, to make the bus “like” the tram.

The efficiency of a mini ramp (30cm) that can fit over a platform kerb 27cm high.

The impressive efficiency of the bus priority through the numerous small urban roundabouts.

### Strategy in term of system component choice

	1	2	3	4	5
Running ways	lateral ROW mostly ( C )	ROW two directions mostly (B)	ROW with some grade separated crossings (B+)	strategic part ROW (A)	strategic ROW (A) with passing lanes (high capacity)
Stations	Not upgraded	upgraded only (accessible)	upgraded with dynamic information	idem 3 with a specific design	idem 4 with ticketing machines and CCTV
Vehicle	common bus (1)	common bus (CNG, Biofuel, hybrid...)	Trolleybuses	with a specific design	guided buses (specific fleet)
ITS	None	some priority at traffic lights	AVMS (priority at quite all crossings)	idem 3 + dynamic information	idem 4 + no ticket selling by drivers
Route identification	None	specific station	specific colour of the fleet	specific station & buses, ROW contrasted	Strong identification (logo, specific system design)

(1) : can be a standard, articulated, bi-articulated, bus or coach)

### References and contacts for further details

Person contact : Damien Garrigue

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### 7.1.3 The Trans Val de Marne – Paris (RATP)



The first phase – well protected

**Country** : France ; **Region / city** : Île de France (11 M inhabitants, 2,2 M into Paris).

**Type of route** : orbital suburban route, south of Paris.



#### Background / Context

The First phase of TVM or “Trans Val de Marne” (it means a route that cross the department “Val de Marne”) opened in September 1993 from Saint Maure Créteil to Rungis Marché international, 13 Km. This first phase was the beginning of the “ORBITALE” network to built a structuring PT ring around the Paris area. the success of this first phase can be highlighted by these figures:

1993: 23 000 trips per day, 5/8 min headway, with articulated buses like today. PT passengers have gained until 16 min between terminus.

1999: 35 000 trips per day with 1200 passengers per hour/direction in peak hours.

2007, before the second phase: 54 000 trips per day, with a 3,5 min headway at peak hours, now rather congested at some section, and always with the bus capacity (articulated buses).

The second phase of TVM (or called West extension) opened in June 2007 from Rungis Marché international to Croix de Bernis (7 Km) ; Some infrastructure improvements has been also made on the first phase (the whole pavement surface, some stations, the dynamic information system, CCTV by cameras). 66 000 trips per day are now observed.

This TVM line belongs to the structuring network, with the same schedule span than the upper level (metro).

#### Description

##### **Infrastructure :**

Length : 20 km (95% dedicated, mostly central and kerb protected).

Width of bus lanes : one way 3,5 m two ways 6,5 m <math>W < 7</math> m.

Average station spacing : 700 m.

Road crossings : 6 grade-separated over complex crossings or motorways.



##### **Buses :**

39 articulated buses ; length: 18 m ; capacity: 101 with 4 standing pass / m<sup>2</sup>.

##### **ITS tools :**

<b>For passengers</b> (visual and vocal information)	at station	destination / waiting time / disturbances
	on board	next stop / terminus
<b>For drivers</b>	Advance delays / driving aid signing at road crossings	
<b>For regulator</b>	CCTV at big station – a new control centre	

##### **Identification :**

<b>On the bus</b>		2 logos on the side, 1 logo on the front screen
<b>On the running ways</b>	Red asphalt	
<b>At the stations</b>		A logo and a specific station design (like the tram in Paris)

#### Cost and Financing sources if available (in €)

1993 (first phase – 12,5 km) : 7,3 M€ / Km (with 17% of bridges and without vehicles).

2007 (west extension – 7 km) : 7,1 M€ / Km (with 3 bridges – 7,5M€).

Costs of the busses: 0,5 M€ / Km for buses or 300 000€ / buse.

Project financed by the public authority (STIF).

### Some results

Key-indicators:

**Regularity** (July 2008 results) : 95,80 % of passenger got a bus with a headway not more than I + 3 minutes.

### **Running speed :**

First phase (average commercial speed)	21 Km / h	Minimum speed (at peak hours)	17 Km / h
Extension (average commercial speed)	26 Km / h	Maximum speed (off peak – first service)	35 Km / h
Global average commercial speed	23 Km / h		

### Success factors / Strengths

**The central exclusive lane with some grade separated crossings at key areas**, not shared with taxis, cycles or HOV ; for this main reason, the TMV can produce a high frequency service (3,5min) with a quite high quality (regularity) that allows to get the certification of the European standard.

**An efficient fleet management system renewed**, with a dynamic information at station and into buses that provide confidence as for a rail structuring route.

**A large service span**, 4:30 am to 1:30 am (21h), that makes this line as a structuring line as the metro.

**A decrease of the fuel** consumption after the second phase (-6%).

A constant increase (by 7 % a year) of attractivity with now 66.000 trips a day, due also to the fact that TMV network make **the connection with 4 RER and 1 subway**.

### Barriers / weaknesses / Points to monitor

The fact that users can also always **to buy tickets to the driver** (however with a majority of season tickets)

A heavy car traffic with **a lack of bus priority in half of the intersections**, that create some wasting time.

A heavy ridership nowadays that makes the system **crowded at peak hours**, rather at its capacity limit.

The large number of local authorities and territories involved makes difficult the governance of such project.

### Lessons learnt

The strength of well protected and well contrasted central running ways.

The strength of a very efficient information system at station all along the route, with a vocal system and camera at heavy stations.

The interest to have driver keeping the role of information, while having other agent on the line, for a regular contact with the ridership.

### References and contacts for further details

Institut : Operator RATP.

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The new vehicle “Créalys”  
for the BHLS routes



## 7.1.4 The TEOR in Rouen - France



**Country:** France - **Authority:** CREA; Urban area of Rouen Elbeuf Austreberthe 495 000 inhabitants – 1000 up to 5000 Inhab/ km2 in the center.

**TEOR**

### Background / Context

The structuring network of the urban area of Rouen was formed by a tramway line with two branches in the south opened in 1994 and called “metro bus” due to an underground part for the connection to the rail station.

During a hard debate during 2 years, 4 solutions were studied for the second corridor east-west: 2 tramways (iron / rubber wheels), one cable car and a TVR (slopes up to 8% on extremities) ; Finally the solution approved have been a guided bus based system, the first city in the world which implemented the camera guidance system by camera (Optiguide – Siemens). This solution, called TEOR, is formed by 3 lines (T1, T2, T3) with a common section in the centre. The first phase was opened in 02/2001, the second in 07/2007.

Hence TEOR, implemented with a great “system” approach, is now the second structuring PT corridor; it is well identified and with the same High Level of Service than the tram corridor (high frequency, same schedule span).

As it was its first implementation, the “optiguide” system needed around 2 years to be well reliable and safe. Its function has been limited at all stations, in order to offer the same gaps than a modern tramway.

### Description of the main system components

#### **Infrastructure :**

Length: 29,8 km for the 3 lines - 4,5 km of common section – 40% are in mixed traffic – 1 P+R (950 places).

Width of bus lanes: one way 3,5m ; two ways 6,2 m < W < 7 m. – mostly central implemented.

Station spacing: T1 526 m T2 561 m T3 438 m ; only one P+R (950 places), not yet full used.

Road crossings: all at grade except one. Priority at almost all crossings.



#### **Buses :**

Guided bus with the optiguide system of Siemens: 38 Agora (Irisbus) and 28 Citelis (Irisbus). The capacity with 4 standing pass / m2 is around 115 / 125 passengers. The guidance system is operated only at all stations.

#### **ITS tools :**

<b>For passengers</b> (Visual and vocal information)	At all stations	Real-time information: waiting time, disruption - Vocal announce – ticket vending machine
	On board	Real-time information: next station, terminus
<b>For drivers</b>	Priority at all intersections, driving aid signing for road crossing AVL	
<b>For regulator</b>	At station	Security control system
	On board	Security control system

#### **Identification :**

<b>On the bus</b>		1 logo on the front of bus 1 logo on the back of bus
<b>On the running ways</b>	Red asphalt	
<b>At the stations</b>		A logo and specific station design

Ticketing vending machines : all stations will be equipped, either at each platform, either at one platform only (one direction).

#### Cost and Financing sources if available (in €)

Investment cost (including infrastructure, stations, vehicles...): 165M€ in total that means a ratio by 5,5 M€ / km.

Diesel guided articulated bus (18m): 450 000 € (over cost of around 10% for the guidance system).

Project financed by the local public authorities with a subsidy by the state (18%).

#### Some performance data and results

**Ridership:** 49 000 passengers/day (+70%) with rather overloaded peak hours in the common section.

**Headways:** 2 / 4 min in the common section (6 / 10 min for each line).

**Schedule span:** 5h08 – 22h15 (17 hours).

**Regularity:** 80% of the buses are on time (not yet calculated according to the EU standard).

**Running speed:** 17,5 km/h in average.

**Accidents:** not more than for other bus lines.

#### Success factors / Strengths

A full “system” approach with a **strong branding** of the 3 lines: a logo, a specific colour and specific stations.

**The great visibility and identity** of the system, related to the service quality, all dedicated bus lanes are very contrasted (red colour) and so well respected in general.

The **high frequency with a long schedule span** and an efficient information system.

The **guidance system well implemented** that offer a very good accessibility (like a tram) level without ramps.

#### Barriers / weaknesses / points to monitor

A **difficult urban context** in the centre of Rouen: middle-aged district; low spacing, low speed.

The system shows its capacity limits (the interchange with the tram line is very crowded at peak hours);

**Difficulties to achieve a better regularity** level: high frequency in the common section, difficulties to get a good priority at some complicate crossings, tickets always sold by drivers until 2011, as some stations should still to be equipped with vending machines (the west part of T3) – a high priority of the CREA.

A **limited commercial speed** in average due to the rather dense urban context along these routes.

**Putting problems at station**, that could need a concrete pavement; the P+R not used as expected.

#### Lessons learnt

A bus-based system can offer **the same attractivity as a good tram** line as long as an efficient service is provided (frequency, reliability). The first factor expected by passengers is **the guaranty of the running time** (regularity), before the increase of the speed level.

To protect a bus lane is a little **more difficult than for a tram lane**. The very contrasted bus lanes help a lot for enforcement and safety; taxi and bicycles should be forbidden with high frequency and capacity.

The high interest to **avoid any ticket selling by the driver** with high capacitive lines as far as priority at traffic lights is also requested.

A technical innovation (in this case optical guidance) **takes always time** for reaching a good reliability level into a public space (in this case, around 2 years).

#### References and contacts for further details

Person contact Authority (CREA) : Catherine Goniot - [catherine.goniot@la-crea.fr](mailto:catherine.goniot@la-crea.fr)

Person contact Operator (TCAR) : Hervé Mauconduit - [herve.mauconduit@veolia-transport.fr](mailto:herve.mauconduit@veolia-transport.fr)



## 7.1.5 The Triskell – Lorient - France



*the logo Triskel*

**Country :** France

**Region / city :** Pays de Lorient (190 000 inhabitants, within 19 local communities)

**Type of route :** structuring bus-based route of the network.

### Background / context

During the mobility master plan set up in 1985, a debate between a tram and a BHLS system has emerged; regarding the low level of density and the sprawling urban areas, any tram project would be too short, too expensive (common section 2km) while increasing transfers for the majority. A BHLS approach along all the 3 busiest corridors will offer a benefit to much more people. This project called « Triskell » (name of the Celtic sign with three branches that are bound together in the center) has been decided in 1999; This project is only an infrastructure project, in order to make as efficient as possible the running ways along these 3 corridors. Hence, the bus network is not modified and stays not hierarchised (no creation of feeder lines).

The first phase has been opened in September 2007 (4,6km with a central common section where 12 lines are operated, 800 buses per day). The second phase study is on progress and.

A new bridge (mixed traffic with a priority for each bus entrance) is a part of the 1<sup>st</sup> phase, shorting the distance between the downtown (Lorient city centre) and the biggest community around Lorient (Lanester).

### Description of the main system components

#### **Infrastructure :**

Length (1<sup>st</sup> phase): 4,6 km (85% dedicated, partly central, lateral ; 15% mixed traffic) – 15 stations

Width of bus lanes: one way 3,5 m ; two ways 6,5 m

Average station spacing: 250 / 300 m, interchange with the central rail station (12 000 passengers / day)

Road crossings: all at grade crossing, with a priority of the Triskell buses

No P+R (considered not fruitful, due to the mobility plan)

#### **Buses :**

Type and number of vehicle: common standard and articulated buses.

#### **ITS tools :**

<b>For passengers</b> (visual and vocal information)	at station	destination / waiting time
	on board	next stop / terminus
<b>For drivers</b>	Advance delays / priority at all crossing (the bus the first)	
<b>For regulator</b>	A new AVM system	

#### **Identification :**

<b>On the bus</b>	No identification	
<b>On the running ways</b>	Red asphalt for good contrast along the route, even on mixed traffic zone	
<b>At the stations</b>	A specific station design	

### Cost and financing sources if available (in €)

First phase : without bus investment, the total cost is 31 M€HT in which 11 M€HT is for the bridge (240m). This makes an average by 6,7 M€ / km.

Project financed by the public authority (Cap l'Orient).

#### Some performance data and results

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Key-indicators:

**Schedule span:** 6:30 am to 8:30 pm (14 hours).

**Headways:** 800 buses (12 lines) per day into the common section without any regularity among themselves.

**Regularity :** a gain of 7 min at peak hours (high decrease of the running times standard deviation).

**Running speed :** 17 to 21,5 km/h.

**Ridership :** 45 000 trips / day for all lines, in which 19 000 trips on the line 16 (2007).

#### Success factors / Strengths

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Regarding governance issues, **an efficient organisation** is observed, as Cap L'Orient has the responsibility of public transportation and road affairs as well of all communities : a great advantage for managing such a project, as a whole and coherent system into several phases.

**The central dedicated lane** into the central corridor is impressive, with their small circular crossings without traffic lights. This corridor is a zone "30km/h" with several bicycle and pedestrian, that are now into a more safe environment and a much more friendly mobility area. The centre of Lorient looks now much more attractive with much less car traffic. As much as possible the one-way streets have been change into two-ways, that have had a positive impact (traffic decrease).

The objective of the project to give **the priority for the buses**, even in mixed traffic, has been very important; at some crossings, traffic lights for flow regulation have been implemented. Nevertheless, congestion is not a heavy issue for such urban area

#### Barriers / weaknesses / points to monitor

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The regularity is **not easy to be achieved** into the central corridor with so many lines, bicycles, pedestrian. People are not always ready to give priority at buses, as they know that bus drivers stay always careful and can easily brake, much better than tramways.

**The service span** stay short (14h), as common for a small urban area.

The fare collection **did not change**, drivers can sell tickets, always a weak point for the regularity at peak hours.

#### Lessons learnt

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The great interest to have a governance at the good level, in charge also of infrastructure issues and urban planning.

The strength of the contrasted running ways with bus priorities.

The strength of a very efficient information system at the biggest stations all along the route.

#### References and contacts for further details

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Authority: Cap l'Orient

Person contact : André Douineau - E-mail : adouineau@agglo-lorient.fr - +33 (0) 2 97 02 29 47



*The bus crossing the roundabouts, with a total priority, without traffic lights*

## 7.1.6 The MetroBus Line 5 – Hamburg



**Country :** Germany ; **Region / city :** Hamburg (1,8 Mio. inhabitants)  
**Type of route :** radial axis between suburb and city center

### Background / Context

The PT-network of Hamburg consists of regional and urban trains (S-Bahn), a metro system and, besides some ferries, an extensive bus network. Although the number of passengers was increasing perennially, the bus network was often overshadowed by the success of the rail systems. In 2001 the municipal operator (Hamburger Hochbahn AG [HHA]) tried to strengthen the bus network by transferring elements of the rail networks. The bus network was divided into a skeleton of 22 lines with clear and straight routes and reliable, tight frequencies, while most of the other lines were designed for additional services. These 22 lines which became the base frame of the bus network were called MetroBuses. The reorganization of the bus network was quite successful – ridership increased about 11% within 3 years.

Line 5, one of the MetroBus-skeleton, has the highest demand. It conveys about 60.000 passengers per day on a radial axis into the city center and to the central station, serving several interchanges with the rail systems. Parts of the route had been served by a tramway until 1978, the old path is now used for segregated lanes. Because of the outstanding increasing ridership on this line HHA brought double-articulated buses into operation, starting in the end of 2005.

### Description

#### **Infrastructure :**

Length: 14,8 km (27% dedicated/buses only, 6% mixed with taxis, delivery vehicles)

Width of bus lanes: 3,0 m < one way < 3,5m 6,0m < two ways < 7,0m

Average station spacing: 510 m (30 stops)

Road crossings: 37 at grade intersections (mostly with traffic lights)

#### **Buses :**

Type: 24 double articulated buses


Length: 24.8 m

Capacity: 160 pass/bus (4 passengers standing/m<sup>2</sup>)

#### **ITS tools :**

<b>For passengers</b> (visual and vocal information)	at station	Destination / waiting time / disturbances (partly)
	on board	Next stop / terminus
<b>For drivers</b>	AVL	
<b>For regulator</b>	AVL, Control centre, CCTV	

#### **Identification :**

<b>On the bus</b>		Lettering "METROBUS" on the front display
<b>On the running ways</b>	No identification	
<b>At the stations</b>		o at the sign

#### Cost and Financing sources if available (in €)

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Investment cost: terminal loop: 1,4 M€ / adaption depot: 0,5 M€ / buslane already existent (former tram line)

Vehicles: 500.000 € per bus (estimate)

Project financed by the transport operator.

#### Some results

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<b>Ridership :</b>	60.000 passengers/day
<b>Headways:</b>	Inner section: 5 min / Outer section: 10 min
<b>Schedule span:</b>	4h30 – 0h30 (20 hours)
<b>Regularity :</b>	unknown
<b>Commercial speed :</b>	15,9 km/h (peak hours) / 21,7 km/h (off-peak hours)
<b>Accidents :</b>	not more than other bus lines

#### Success factors / Strengths

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The MetroBus-System divides the bus network into a skeleton of cardinal services with a guaranteed level of service and additional lines with lower and various levels. It helps to clarify and to promote the bus network especially to occasional users. The special vehicle and the partly segregated lane raised the success of line 5 above average. Yet the MetroBus concept is not costly: very little investment in infrastructure and – if the standards are fixed with a sense of proportion – moderate increase of operating cost.

#### Barriers / weaknesses / Points to monitor

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The MetroBus concept does not solve problems in performance automatically. It should be combined with improvements in operation (dedicated lanes if possible, priority at crossings) and in the layout of the bus stops. Both aspects can still be optimized in Hamburg.

#### Lessons learnt

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Bus can be more than just bus – if there is a difference to the well-known standard bus services. Diversification accompanied by a good promotion campaign can be a cheap factor of success.

#### References and contacts for further details

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## 7.1.7 The ÖPNV-Trasse (PT-way) – Oberhausen



**Country** Germany; **Region / city:** Oberhausen, 215.000 inhabitants;  
**Type of route:** trunk route linking the new city centre

### Background / Context

Like many cities in the Ruhr-region Oberhausen also suffered under the crises of the mining and steel industry beginning in the 70s of the last century. Within two decades almost all of the coal mines and steel mills, which were the economic basis for the city, were closed down. To cushion the industrial decline the city of Oberhausen initiated a large urban development project on an industrial fallow between the old city and the suburb of Sterkrade. A giant shopping centre combined with a business park, municipal services, cultural locations and an amusement park became the nucleus of a long-term settlement development.

A good accessibility from the older parts of the city to the new city centre by public transport was one of the basic goals of the master plan. To provide a high quality of PT-supply a dedicated way for buses and tram was designed. It starts at the central railway station situated in the old city of Oberhausen and runs until the railway station of Sterkrade, using parts of an abandoned industrial railway. The PT-way was opened in June 1996, just a few weeks before the inauguration of the new commercial centre.

The implementation of the PT-way caused large changes in the PT-network of Oberhausen and a remarkable increase of the operating performance. Together with the reorganization of the bus network tram was relaunched in Oberhausen again after having been absent for 28 years. For this a tramline from the neighbouring town Mülheim was extended to Sterkrade via the old city of Oberhausen. Currently the PT-way is used by this tramline and 6 buslines conveying about 25.000 passengers per day on this section.

### Description

#### Infrastructure :

Length: 6,3 km (two ways) + 0,5 km (one way)  
 Width of bus lanes: 3,6 m (one way) 7,2 m (two ways)  
 Average station spacing: 1.000 m (6 stops)  
 Road crossings: 3 grade-separated, 1 at grade (with priority by traffic lights)

#### Buses/Trams :

Type: no dedicated fleet for the PT-way (standard and articulated buses, metre gauge tramcars)  
 Length: 12,0 m / 18,0 m / 28,6 m  
 Capacity: 70 pass/bus / 110 pass/bus / 170 pass/tram (4 passengers standing/m2)

#### ITS tools :

<b>For passengers</b> (visual and vocal information)	at station	Destination / waiting time / disturbances
	on board	Next stop / terminus
<b>For drivers</b>	AVL	

<b>For regulator</b>	AVL, Control center, CCTV
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**Identification :**

<b>On the bus</b>	No identification The PT-way is just a trunk section in the whole network, some lines pass it, some don't.
<b>On the running ways</b>	
<b>At the stations</b>	

Cost and Financing sources if available (in €)

Investment cost: PT-way + tram afflux (3 km): 130 M€ / adaption stops: 8 M€ / adaption depot: 0,8 M€ / AVM: 5,5 M€

Vehicles: 6 trams, 29 articulated buses, 24 standard buses: 23 M€ (for the network extension in a whole)

Project financed by subsidies from government and by the transport operator:

investment cost: 75% government : 25% operator., vehicles: 20% government : 80% operator.

Some results

**Ridership :** 25.000 passengers/day on the PT-way, 125.000 passengers/day in the whole network

**Headways:** 1,5 min (peak hours) / 2,0 min (off peak hours)

**Schedule span:** 5h00 – 23h30 (18,5 hours)

**Regularity :** unknown

**Commercial speed :** 34 km/h (peak hours /off-peak hours, PT-way only)

**Accidents :** < 1 accident per year (PT-way only)

Success factors / Strengths

The dedicated PT-way provides a high commercial speed and an excellent reliability for bus and tram. Both means of transportation are accepted by the customers without a perceptible distinction. The merging of different lines on the trunk section guarantees a perfect reachability of the new city centre.

Barriers / weaknesses / Points to monitor

The PT-way was implemented on an industrial fallow, what simplified its realization. An implementation in an existing settlement would be much more difficult. For economical reasons the elaborate infrastructure has to be justified with a short headway service. It is not a solution for the periphery.

Lessons learnt

If buses run with the same quality of service than the tram, the acceptance can be adjusted.

References and contacts for further details

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Waiting time

Station at the new city center

„Betreten der Bahnanlagen verboten“ – gemäss BOSTrab § 58

## 7.1.8 The Spurbus (Kerb-guided bus) – Essen



**Country:** Germany ; **Region / city:** Essen (575.000 inhabitants) ; **Type of route:** radial axis between suburb and city centre

### Background / Context

Increasing conflicts between the needs of car traffic and the goal of a reevaluation of the city centres as well as the first oil crises led to a renaissance of public transport in German major cities in the early 1970ies. Supported by a new national development fund many cities started to advance their existing tramway networks to light rail systems (LRT). In the city centres often the tracks were relocated in tunnels to improve the commercial speed of the light rail lines and to clear space for appealing pedestrian areas. The evolution of tram to light rail was accompanied by the setup of attractive suburban railway networks (S-Bahn) in most of the larger agglomerations.

The nationwide improvement of rail made transportation experts and bus manufacturers fear about the image bus, which still remained indispensable. Thus the idea was born, to let bus participate in the benefit of the new LRT-sections, especially of the tunnels. Because of the limited width and for safety reasons it was obvious that buses would have to be guided. In place of other transport operators the municipal transport operator of the city of Essen (EVAG) launched a research project on guided buses in the early 1980ies. The project was patronized by the Federal Ministry of Research and Technology.

Within the project in Essen several kilometers of ways for guided buses were implemented, some for buses only, some for a combined use by bus and tram. For the entering the tunnels an electric propulsion also for the buses was mandatory, so the development of duo-buses (buses with built-in electric and diesel propulsion) was forwarded. However, the weak spot of the project became the bi-mode catenary in the tunnel sections, which could not provide a solid power supply for the buses.

The lack of reliability finally put an end to the idea of a combined use of tunnel sections by tram and bus. At ground level the guided buses did not generate enough benefits to justify the construction and maintenance of the special dedicated way. Step-by-step the guideways were abandoned except the one on the centre strip of highway 40 – the centre strip is too narrow to run buses there without guidance.

### Description

#### Infrastructure :

Length: 16,4 km (Bus 146), 12,2 km (Bus 147), 76%/67% mixed traffic

4,4 km common section (90% [4,0 km] dedicated)

Width of bus lanes: 2,9 m (one way) 6,4 m (two ways, with space for catenary mast)

Average station spacing: 800 m (6 stops, guideway only)

Road crossings: none (the access to the guideway on the centre strip is grade-separated)

#### Buses/Trams :

Type: customary articulated buses with guide rollers

Length: 18,0 m

Capacity: 110 pass/bus (4 passengers standing/m<sup>2</sup>)

#### ITS tools :

For passengers (visual and vocal information)	at station	No
	on board	Next stop / terminus
For drivers	AVL	

For regulator	AVL, Control center, CCTV
<u>Identification :</u>	
On the bus	No identification The guideway is just a section in the whole network, used by two buslines.
On the running ways	
At the stations	

#### Cost and Financing sources if available (in €)

Investment cost: Data not available

Vehicles: 350.000 € (estimate)

Infrastructure is a remnant of a large research project, financed by the Federal Ministry of Research and Technology and the transport operator.

#### Some results

<u>Ridership :</u>	17.000 passengers/day (both lines (, full length)
<u>Headways:</u>	10 min (peak + off peak hours)
<u>Schedule span:</u>	4h00 – 23h30 (19,5 hours)
<u>Regularity :</u>	unknown
<u>Commercial speed :</u>	16,7 km/h (Bus 146), 16,3 km/h (Bus 147); 30 km/h (guideway only)
<u>Accidents :</u>	< 1 accident per year (guideway only)

#### Success factors / Strengths

The guideway provides a high commercial speed, a very comfortable ride and an excellent reliability. The guided buses need less space than normal steered buses, especially when driving with a maximum speed of 80 km/h. The guideway sections which were made of concrete show a long durability.

#### Barriers / weaknesses / Points to monitor

Because of its kerb the guideway is a barrier which does not allow at grade crossings: not for cars, not for pedestrians. This makes it difficult to implement the system in populated areas. Furthermore in such areas the gain of travel time and comfort on short guided sections are often not big enough to justify the expenses for the special infrastructure. The attempt to usher guided buses in tramway- or LRT- tunnels failed because of the complexity of the power supply and the integration in the signaling system.

#### Lessons learnt

Kerb guided buses might be a useful solution for supra-local links.

#### References and contacts for further details

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## 7.1.9 Malahide Road Quality Bus Corridor - Dublin



**Country :** Ireland      **Region / city :** Dublin      **Type of route :** Radial axis into the City Centre.

### Background / Context

Bus lanes have been used in Dublin since the early 1980's to improve the operating conditions for buses in increasingly congested streets. During the mid-1990s, the Quality Bus Corridor approach was successfully demonstrated, joining up bus lanes to giving semi-continuous priority, along with other enabling traffic management measures. Building on this success, a Quality Bus Network has been designed for Dublin, which provides a network of Quality Bus Corridors throughout the urban area. A total of 400km is planned, of which 200km has been completed and a further 50km is in various stages of design and construction. A special Quality Bus Network Office was established to manage all design, public consultation and implementation. Stillorgan Road QBC is the flagship project, which has halved bus journey times and carries about 5,000 bus passengers in the morning peak. This abstract presents the Malahide Road QBC, which reflects typical performance.



### Description

#### **Infrastructure :**

Length: 6.4 km (59% bus lanes, taxis permitted, stopping/delivery prohibited, operational 0700-1900)  
 Bus lanes: Between 3 and 4 metres, lateral, visual demarcation, bus lay-byes, no dedicated passing lanes

Road crossings: At grade intersections (mostly with traffic lights, but not yet with priority for buses)

**Buses :** Standard city double-deck buses, 10/12 metre, low-floor, diesel-powered, 76 seated/15 standing

#### **ITS tools :**

<b>For passengers</b> (visual and vocal information)	at station	Real-time passenger information operational in 2011.
	on board	Standard signage and information
<b>For drivers</b>	AVL, CCTV in buses	
<b>For regulator</b>	AVL, CCTV in buses	

#### **Identification :**

<b>On the bus</b>		Standard signage and information
<b>On the running ways</b>	Standard bus lane markings and signage	
<b>At the stations</b>		Standard signage and information

### Cost and Financing sources if available (in €)

**Average investment cost per km : €4.5 million**

### Some results

**Ridership** : 4,766 passengers in morning peak period (0700-1000); 50% ridership increase since 1997; 17% of passenger growth from car

**Headways**: peak hours c. 2.3 minutes (multiple routes); off-peak hours c. 3 minutes (multiple routes)

**Schedule span**: 0630 - 2330

**Average commercial speed** : 16-18 km/h

### Success factors / Strengths

This is a practical, cost-effective solution that has achieved significant and visible improvements in bus speeds, reliability and ridership. Political support and acceptance has been achieved. Establishment of the QBN Office provides a professional, dedicated resource to systematically deploy QBCs throughout the Dublin area. Sustained annual funding of €30-40 million through to 2011 ensures program scale and continuity. Funding is aligned with other resources such as the Road Construction Programmes where bus lanes are incorporated in the designs. Effective enforcement is achieved through strong cooperation with the *Garda Síochána* (Irish Police).

### Barriers / weaknesses / Points to monitor

Lack of available roadspace/width and competing road/roadside functions limits options at critical areas. Public consultation is valuable, but can be lengthy and local group can organize opposition. Construction is mainly on the city streets, causing some disruptions. Lack of experienced contractors and consultants can be a problem, as can retention of experienced design staff. There has been long delay in developing the new institutional and regulatory framework for passenger transport (main framework elements commenced in December 2009) and no mechanism to ensure that bus service changes were managed in coordination with QBC implementation. There have been delay in implementation of Integrated Ticketing and Real Time Passenger Information, which are being deployed during 2010-11, so the complete Quality package is only being implemented now.

### Lessons learnt

Establishment of a dedicated, professional office is important for a citywide program. Committed, multi-annual funding program has been a major contributor to success in sustained deployment. Lack of a mechanism to plan and deploy bus service changes has reduced the effectiveness in some areas. Delays in implementing ITS systems (smart card ticketing, AVM, priority at traffic signals) has increased dwell times at stops and junctions, and hence the full operational and quality benefits have not yet been achieved (expected in 2011)

### Strategy in term of system component choice

	1	2	3	4	5
Running ways	lateral ROW mostly ( C )	ROW two directions mostly (B)	ROW with some grade separated crossings (B+)	strategic part ROW (A)	strategic ROW (A) with passing lanes (high capacity)
Stations	Not upgraded	upgraded only (accessible)	upgraded with dynamic information	idem 3 with a specific design	idem 4 with ticketing machines and CCTV
Vehicle	common bus (1)	common bus (CNG, Biofuel, hybrid...)	Trolleybuses	with a specific design	guided buses (specific fleet)
ITS	None	some priority at traffic lights	AVMS (priority at quite all crossings)	idem 3 + dynamic information	idem 4 + no ticket selling by drivers
Route identification	None	specific station	specific colour of the fleet	specific station & buses, ROW contrasted	Strong identification (logo, specific system design)

(1) : can be a standard, articulated, bi-articulated, bus or coach)

### References and contacts for further details

Institution: Quality Bus Corridor Network Office ; Person contact : Anne McElligott, Project Manager  
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### 7.1.10 The LAM network – Brescia - Italy



*View of the LAM 1 in Brescia (Linee ad Alta Mobilità)*

**Country :** Italy ; **Region / city :** Brescia ; **Type of route :** structuring urban routes of the whole network

#### Background / Context

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Brescia is an Italian Municipality located in the North of Italy with 191.618 inhabitants. It is the capital of Brescia Province, in Lombardy Region, which has an area of 90,68 km<sup>2</sup> and a density of 2113 inh/km<sup>2</sup>. The metropolitan area counts about 500.000 inhabitants.

The public transport system network counts 18 bus lines which are operating on 14 municipalities of Brescia hinterland. The catchment area is about 360.000 inhabitants.

There are two transport consortiums which manage the peri-urban public transport in order to travel towards the province. At the moment a Lite Rail Transit (AGT) line, which will be operating in the Municipality area, is under construction.

Three LAM (Italian translation “Linee ad Alta Mobilità”) lines are operating in the City of Brescia since 2006:

- 1 Mompiano - Masaccio; LAM 1 (Red Line)
- 2 Pendolina – Chiesanuova; LAM 2 (Blue Line)
- 3 Mandolossa - Rezzato South/North (Virle).

These are the most recent lines realised in Italy which could be compared to the BHLS. These Lines cross the Urban Area, on the contrary Line 3 is operating in the peri-urban Area of the city.

The design of LAM Network is included in an wide Mobility Plan, wherein the main objectives are to implement a higher service frequency and regularity and a high mobility.

The two BHLS lines, LAM 1 and LAM 2 (with the conventional Bus Lines), are part of a feeder system to the railway transport system, in order to enhance the exchange with the urban and peri-urban collective transport system. The Non-BHLS lines have been modified as a consequence of the BHLS lines realisation.

#### Description

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##### **Infrastructure :**

Length: 14Km for LAM1; 13,8Km for LAM2 - dedicated lanes: 15% only , protected with riddles  
Shared with bicycle, taxi, emergency services

Spacing: 270m for LAM1; 188m for LAM2. ; height of kerbs: 16cm.

**Buses :**

43 common standard buses (methane) – low floor, with manual ramp.

**ITS tools :**

<b>For passengers</b> (visual and vocal information)	at station	Real time information or by cellular phones
	on board	Next stops, direction
<b>For drivers</b>	AVM system through the GPS system, with CCTV for security reasons	
<b>For regulator</b>		

**Identification :**

<b>On the bus</b>		yes by the name of the route: LAM (Linee bus ad Alta Mobilità)
<b>On the running ways</b>	not	
<b>At the stations</b>		Specific station with all kind of information

Cost and Financing sources if available (in €)

No data available.

Some results

**Ridership :** 12 000 trips per day for the 2 LAM – 3800 km each day

**Headways:** 5 – 8 min for LAM1; 7 – 12min for LAM2

**Schedule span:** 19h.

**Regularity :** 75% , low level

**Commercial speed:** 15 Km/h for LAM1 ; 16 Km/h for LAM2.

**Accidents :** 1,9 accidents per 100 000km (low level)

Success factors / Strengths

The investment of the AVL system, providing real time passenger information, the 100% low-floor vehicles and a much better frequency.

Barriers / weaknesses / Points to monitor

Lack of intersection priority, a weak branding, the quality management thresholds not achieved, a low operational speed, due to the short spacing.

Lessons learnt

The interest of the AVM system, contributing to design all the structuring lines, a first step very important that allows to justify / evaluate the interest of such a BHLS project.

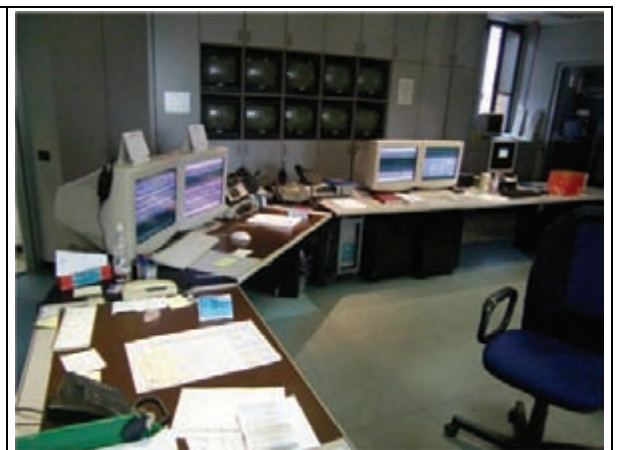
References and contacts for further details

Institut: Universita Reggio Calabria;

Person contact: Professor Domenico Gattuso domenico.gattuso@unirc.it



*The bus stops of the LAM lines*



*AVL system control centre*



### 7.1.11 The LAM network – Prato - Italy



Each LAM are identified by its colour, here the “Red line” bus (LAM, Linee ad Alta Mobilità)

**Country** : Italy ; **Region / city** :Prato ; **Type of route** : structuring urban routes of the whole bus network

#### Background / Context

Prato is an Italian municipality with 186.821 inhabitants, it is the capital of the Prato Province since 1992. Currently Prato is one of the biggest city of Centre Italy (exactly the third city for inhabitants number after Roma and Firenze) and the eighteenth in Italy.

Prato area is 97,59 km<sup>2</sup> wide, has a density of 1.916 inh/km<sup>2</sup>. The urban area spreads over the plain territory between the Bisenzio river (Northern side) and the Ombrone Pistoiese river (Southern side).

Despite the high number of monuments and interesting sites in the city, Prato is not considered as an important tourist destination, thus there is not a high number of visitors.

The collective transport systems in the city of Prato are formed by a railway system (regional and National links) and urban and peri-urban Bus Lines. Two railway lines crossing the city of Prato: Firenze-Prato-Pistoia-Lucca-Viareggio and Firenze-Bologna. The first one is a regional line which provides a link with the city of Florence and the western Tuscany, whereas the second line is a part of the Milano-Napoli line. This is one of the main lines of the Country, thus Prato Station is really important. Prato has three Railway Stations:

Prato Centrale (both for the Intercity and Eurostar lines);

Prato Porta al Serraglio (only ticket vending machine);

Prato Borgonuovo (only ticket vending machine).

Three additional stations are planned to be realized in the future, La Querce, Mazzone, S. Lucia.

The urban and peri-urban public transport network bases on different bus lines operating in the whole Prato area. The responsible of the management of the Public Transport is CAP (Cooperativa Auto-transporti Pratese). 12 lines are operating, and these include also BHLS line linking the city centre with the peri-urban area.

5 LAM (Italian translation “Linee ad Alta Mobilità”) lines are operating in the City of Prato since 2003 / 2005, providing a service with high frequency and high comfort standards: Blue line, Green line, Red line, Light blue line, and Purple line. The first three ones are described, they are the ones serving the urban area, whereas the Light blue line and Purple line link the city centre with the peri-urban area.

#### Description

##### **Infrastructure** :

Blue line: 16,54 km with 6,1 km of reserved lane – spacing between stops: 318 m.

Green line: 11,07 km with 1,64 km of reserved lane and 1 grade separated junction – spacing between stops: 257 m.

Red line: 55,87 km with 2,43 km of reserved lane – spacing between stops: 404 m.

The lines have not conflicting points with motorway and high speed connection. The junctions are characterized by the Traffic light Priority. In order to enhance Public Transport systems and to discourage Private Traffic flow, the plan also defines a realisation of LTZ (Limited Traffic Zone).

Only close to three bus stops overtaking is allowed. The platform is 30cm. High, the same level than the bus floor. Bus Stops are equipped with Ticket vending Machines, but they do not present users information devices.

### **Buses :**

24 midi and standard diesel buses, identified by the colour – low floor, with manual ramp. One of the key elements of these BHLS lines is the possibility to validate contactless tickets and subscriptions.

### **ITS tools :**

<b>For passengers</b> (visual and vocal information)	at station	No real time information
	on board	Contactless validation
<b>For drivers</b>	AVM system on progress	
<b>For regulator</b>		

### **Identification :**

<b>On the bus</b>		yes by the name and colour of the route (LAM) (Linee bus ad Alta Mobilità)
<b>On the running ways</b>	not	
<b>At the stations</b>		Some specific station

### Cost and Financing sources if available (in €)

The costs of the reserved lanes stay very low (0,5 M€/Km) comparing other “full BHLS”, as seen into the table below; moreover about €200.000 were already spent to realise the Interchange park. Regarding the operating costs, in total 1 600 000 km per year are running.

	<b>BLUE LAM</b>	<b>GREEN LAM</b>	<b>RED LAM</b>
Infrastructure realisation costs (€)	86.000	90.000	350.000
Annual operating cost (€)	1.300.000	920.000	1.800.000
Exchange park realisation costs (€)	200.000		

### Some results

**Ridership** : 23 000 trips / day for these 3 LAM (220 / 440 trips/rush hour ); an increase of +57%.

**Headways** : 7 – 8 min for rush hours

**Schedule span**: roughly from 5h40 to 21h20 (16h only).

**Regularity** : the quality control is entrusted to an independent agency (variability of journey time: 22%).

**Commercial speed** :18,8 Km/h for Blue line; 16 Km/h for Green line; 18,4 Km/h for Red line (+5%)

### Success factors / Strengths

The Traffic light Priority, with a good approach of dedicated lane, where needed. A very good “network” and “branding” approach. A very cheap system for a low dense urban area, that can be improved in the future.

The 100% low-floor vehicles and a much better frequency.

### Barriers / weaknesses / Points to monitor

No AVM system, no dynamic information – on progress. A small schedule span

### Lessons learnt

The interest of a very good “system” and “network” approach, with a good connection with the rail network.

### References and contacts for further details

Institut : CTT Company

Person contact :Lorenzo Bettini, [lorenzo.bettini@cttcompany.it](mailto:lorenzo.bettini@cttcompany.it)



*Validating machine on board*



*Blue line bus stop particular*

## 7.1.12 The Zuidtangent lines - Amsterdam



*The impressive connection with the airport Schiphol*

**Country :** Netherlands ; **Region / city :** Amsterdam region 1 400 000 inhabitants **Type of route :** peripheral route, south of Amsterdam

### Background / Context

The first study into what became the Zuidtangent was launched in 1987. The main reasons were: a shift in town planning (new housing and office sites in suburban areas), increasing congestion on the road network, the presence of a major international airport, with a growing importance for the regional economy, insufficient quality of existing PT, as far as it was not oriented towards the Amsterdam city centre, a major flower exhibition in summer 2002.

At the same time, the estimated demand was considered to be insufficient for a light rail solution.

The system has been developed in the 90ties by the Amsterdam regional authority (Stadsregio Amsterdam) and the Province of Noord-Holland. The ambition was to create a high quality public transport system, which fills the gap between regular buses and light rail, and with a high flexibility which adapts to space constraints in the historic town centre of Haarlem. The first route was opened in January 2002. In December 2007, a second route was opened, but on this route the system concept was not fully applied. The commercial speed of the first route is impressive (over 35km/h), partly due to a wide inter-station spacing (1900m in average).

A complete “system” approach has been implemented: a unique identity, dedicated infrastructure, an AVM system with dynamic passenger information, a dedicated fleet, comfortable stops.

The dedicated infrastructure consists of bus lanes and bus ways. The surface of both is made of concrete.

Bicycles are actually a very important complementary mode (as everywhere in the Netherlands). The system connects at several stops with the existing rail networks (both national rail and the Amsterdam underground network).

Future developments: high quality bus routes are to be introduced in other parts of the Amsterdam region. In the future, a conversion to light rail might become necessary, depending on how patronage will develop.

### Description

#### **Infrastructure (first route only):**

Length: 41 km. Dedicated infrastructure: 70% / 80% with several viaducts and underpasses and a tunnel under an airport runway, 5km on the A9 motorway (use of emergency lane permitted in case of congestion).

In order to minimize the maintenance costs, the surface of the bus way was made of concrete (which costed around 20% more to construct than an asphalt surface).

Spacing : 1900 m in average ; 4 P+R (1820) , P+B at every station; platform height: 30cm.

#### **Buses :**

Common diesel articulated buses with a dedicated livery (red and grey), 100% low floor.

#### **ITS tools :**

<b>For passengers</b> (visual and vocal information)	at station	Dynamic information
	on board	Dynamic information; PT card can be credited
<b>For drivers</b>	AVM system with CCTV	

<b>For regulator</b>	
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**Identification :**

<b>On the bus</b>	Common buses with a dedicated livery and the logo “Zuidtangent”
<b>On the running ways</b>	Not specific but well protected and signalised
<b>At the stations</b>	Specific stations

Cost and Financing sources if available (in €)

Infrastructure : 6,5 M€ / km in average

Some results (first route only)

**Ridership :** 32 000 passengers per day on an average working day, heaviest loadings in Hoofddorp: 13.500 passengers per day (both directions).

**Headways :** 6 min (7h – 19h) ; **Schedule span :** 24h. ; **Regularity :** high level of regularity.

**Commercial speed :** > 35 km/h ; **Accidents :** 20 / 40 events / year

Success factors / Strengths

Successful concept: high commercial speed, high service frequency, high flexibility, high reliability  
Result: patronage higher than estimated, increase of PT use (+47%) within 3 years (each year : + 10 / 15 %)

Barriers / weaknesses / Points to monitor

Subsidence of bus way: physical guidance at some stops blocked; concrete surface less comfortable than asphalt, weather protection at stops not satisfactory (roofs at stops removed after problems during storm)

Slippery surface at stops, fare evasion, implementation of ITS delayed for some years

Lessons learnt

BHLS can only be successful if the concept is uncompromised; Maintaining high quality means continuous effort from all parties. In particular, much attention is needed to maintain the quality of infrastructure.

BHLS is able to increase the share of PT; the choice for BHLS with proven technology has been the right one!

Strategy in term of system component choice

	1	2	3	4	5
<b>Running ways</b>	lateral ROW mostly ( C )	ROW two directions mostly (B)	ROW with some grade separated crossings (B+)	strategic part ROW (A)	strategic ROW (A) with passing lanes (high capacity)
<b>Stations</b>	Not upgraded	upgraded only (accessible)	upgraded with dynamic information	idem 3 with a specific design	idem 4 with ticketing machines and CCTV
<b>Vehicle</b>	common bus (1)	common bus (CNG, Biofuel, hybrid...)	Trolleybuses	with a specific design	guided buses (specific fleet)
<b>ITS</b>	None	some priority at traffic lights	AVMS (priority at quite all crossings)	idem 3 + dynamic information	idem 4 + no ticket selling by drivers
<b>Route identification</b>	None	specific station	specific colour of the fleet	specific station & buses, ROW contrasted	Strong identification (logo, specific system design)

(1) : can be a standard, articulated, bi-articulated, bus or coach)

References and contacts for further details

Institute : Stadsregio Amsterdam ; Contact : Pim Kuipers, p.kuipers@stadsregioamsterdam.nl

*The original specific design of the station replaced by new stations, because of high maintenance costs and a few design flaws (slippery surface, poor protection against unpleasant weather conditions).*



### 7.1.13 The scheme developed in Almere - NL



*The Right of Way arriving at the rail station, connection with Amsterdam*

**Country:** Netherlands; **Region / city:** Almere; **Type of route:** bus network into a medium dense area

#### Background / Context

At the 70ties, the new city Almere (currently 186 000 inhabitants) has been planned as a town for commuters to Amsterdam. The master plan (1972) was innovative and forecasted a bus network on dedicated lanes, in coherence with all urban areas (not dense, around 800 per km<sup>2</sup>) and well connected with all rail stations; the mobility planning policy was based on these statements:

- Reducing motor car dependency for reasons of traffic safety and environment
- Facilitating car use, not stimulating but also not frustrating cars
- Stimulating bicycle <5 km (now a market share by over 30%)
- Stimulating public transport ≥ 5 km (now around 190 bus trips per inhabitant and per year)
- A bus stop within 400m of every home (at that moment 300m was usual) with fast connections
- City development planning, urbanism and public transport planning intertwined.

8 bus lines form this BHLS network (brand name: "MAXX"); the commercial speed stays very high (28 km/h) and reliable. Bus stops are located centrally in neighbourhoods. Bus routes connect neighbourhoods directly with each other and are feeding at all railway stations. The cycle network is also connecting the neighbourhoods directly with each other. For motor cars traffic between neighbourhoods is only possible via main roads outside the neighbourhoods. The BHLS network design is based on few lines with few transfers, high frequencies and few stops. Average distance between stops is 600 meters. Priority at all crossings is efficient, with an obligation of a moderate speed, not more than 45km/h. Spacing stays wide as bicycle is well used, with P+B at all stops. The dynamic information system is on progress, and will be implemented at all stops.

Due to pavement rutting problems, the pavement at station is built with concrete, as some section as well.

#### Description

##### **Infrastructure :**

For the 8 'Maxx' city lines, 11 regional lines and several night lines, 58 km, line 1: 17.2km.

A high percentage of freestanding bus ways: 99 % - no sharing with bicycle.

Priority at all road crossings while using pre-signalling for drivers. Main roads are crossing on a different level.

Structure: concrete at all stations

Distance between stops : > 600m ; some P+R ; and lots of P+B, almost at all stops.

**Buses :** Diesel bus standard and articulated, EEV-norm ; ticket purchase on board possible, manual ramp, entrance at all doors.

##### **ITS tools :**

<b>For passengers</b> (visual and vocal information)	at station	dynamic information to be introduced in 2011, network map and departure times at all stops
	on board	Next stops , direction, connecting buses and trains, points of interest

<b>For drivers</b>	AVM system without dynamic information
<b>For regulator</b>	Priority at all road crossings

#### **Identification :**

<b>On the bus</b>		no
<b>On the running ways</b>	no	
<b>At the stations</b>		The main stations

#### Cost and Financing sources if available (in €)

**Infrastructure cost** : no data, construction integrated with this new city development.

#### Some results

**Ridership** : Line 1: 16 000 trips/day - 1500 trips at rush hours - 2004-2009 + 5% each year (bus network)

**Headways**: 7 - 30 min

**Schedule span**: 5h - 2h00 (21h)

**Regularity** : 91,4 % (2010) - very good level, CEN standard, a bus on time arrives at H-1min, H+3min.

**Commercial speed** : 24 km/h peak/ 25 km/h off-peak (line 1)

#### Success factors / Strengths

One of the best example of coherence urbanism/ transport in Europe.  
High speed, high protection of the Right of Way, a perennial system.  
A strong intermodality, with the rail station, with cycling as well.  
A very good regularity, priority at all road crossings, with a speed limit for buses.

#### Barriers / weaknesses / Points to monitor

The identification by the buses themselves seems to be rather low, however the network remains simple, so that there is no need to have a specific fleet, that is always more expensive.  
Ticket purchased on board possible at drivers; however, policy is focused on presale to reduce delay on stops.  
Security may be a problem around freestanding busways with no other parallel traffic.  
Road safety at footpath and cyclepath crossings.

#### Lessons learnt

The strength of the freestanding busway, with a strong intermodality with the rail network, for improving the attractivity.  
No need to have a specific fleet for the BHLS lines into a simple network.

#### Strategy in term of system component choice

	1	2	3	4	5
Running ways	lateral ROW mostly ( C )	ROW two directions mostly (B)	ROW with some grade separated crossings (B+)	strategic part ROW (A)	strategic ROW (A) with passing lanes (high capacity)
Stations	Not upgraded	upgraded only (accessible)	upgraded with dynamic information	idem 3 with a specific design	idem 4 with ticketing machines and CCTV
Vehicle	common bus (1)	common bus (CNG, Biofuel, hybrid...)	Trolleybuses	with a specific design	guided buses (specific fleet)
ITS	None	some priority at traffic lights	AVMS (priority at quite all crossings)	idem 3 + dynamic information	Idem 4 + no ticket selling by drivers
Route identification	None	specific station	specific colour of the fleet	specific station & buses, ROW contrasted	Strong identification (logo, specific system design)

(1) : can be a standard, articulated, bi-articulated, bus or coach)

#### References and contacts for further details

Institut: City Almere ; Person contact : Walter Brands - wbrands@almere.nl

### 7.1.14 The scheme developed in Twente - NL



*Twente region, a beautiful section, always with an efficient and wide cycling lane along the route*

**Country** : Netherlands ; **Region / city** : Twente ; **Type of route** : urban route into a low dense area

#### Background / Context

The whole project has been launched in the whole wide urban area (500 000 inhabitants) with lots of small cities, of which Enschede, Hengelo, and Almelo are the main important ones.

The density remains very low, between 400 up to 1500 inhabitants/km<sup>2</sup>.

A bus-based network is planned with 50 km in total, 30 are already on service with almost 90 % of dedicated lanes, as a wide space is available, but not always.

The modal share by bicycle stay very high, like everywhere in NL, 50% (15% between 7 and 15km).

A very good intermodality (The Dutch “HOV” concept requires the need of a network approach with all modes) is observed with the rail network and bicycle mode (often P+B at stops).

The concrete has been preferred for all pavement, for providing a good contrast and for decreasing the maintenance cost (around + 20% in investment). Innovative switch point (with reversible directions) in the infrastructure lay-out due to lack of width in street profile (trade-off!).

Stations offer a good level of comfort, with a dynamic information. After some ten years, good results have been observed: a higher ridership (+30% on working days, +70% on Saturdays), then a better cost coverage (+47%), a decrease of the operating cost (-5% in average due to the higher speed). 20 days per years with bad weather, buses are really congested as bicycle is no more convenient. Unique selling point of the concept (according to Twente): red livery of the whole fleet and reliability.

Line 2 and 3 are the 2 specific HOV lines in Enschede, there are more HOV lines in Twente, in this sheet we limit ourselves to these two.

#### Description

##### **Infrastructure :**

Line 2:26km; line3:15km , opened in 2000 and 2006.

A high percentage of dedicated lane: 80% (line 3)

Structure: concrete along the whole route - + 30% on cost (for having less maintenance).

Distance between stops : 600m ; 1 P+R (219) ; P+B at all stops.

**Buses :** Diesel bus standard, not identified; ticket purchase on board possible. 2 Hybrids will be tested on line 2)

##### **ITS tools :**

<b>For passengers</b> (visual and vocal information)	at station	Waiting time
	on board	Next stops , direction
<b>For drivers</b>	SABIMOS system, 1 <sup>st</sup> AVM system in Holland	
<b>For regulator</b>	Camera inside vehicle	

##### **Identification :**

<b>On the bus</b>		no
<b>On the running ways</b>	By contrast	
<b>At the stations</b>		HOV stops are distinctive from regular lines

#### Cost and Financing sources if available (in €)

Infrastructure cost : 3 M€ / Km.

### Some results

**Ridership** : Line 2: 1318 trips/day ; Line 3: 1250 trips/day (5 lines are in the corridor)  
**Headways**: 10 - 30 min (12buses per hour at some section)  
**Schedule span**: 6h - 0h15 (18h15)  
**Regularity** : Line 2 : 94,7 / 96,4 % ; Line 3: 97,4 / 97,6 % (very good level, CEN standard)  
**Commercial speed** : Line 2: 20,5 Km/h ; Line3 : 27 Km/h  
**Accidents** : 2 small events /year

### Success factors / Strengths

Intermodality with train, bike;  
 A very good regularity, central dedicated lane with priority at all crossings;  
 Contrast of infrastructure, with a great design.  
 Operating cost: - 5 % (due to a better average speed).  
 Modal shift: additional trips : 20% from cars ; 80% from bike.  
 Ridership increase before / after : week days:+30% Saturday: + 70%.

### Barriers / weaknesses / Points to monitor

The identification by the buses themselves seems to be rather low.  
 However the network remains simple, and then stays actually readable without a complete identification of the structured lines with a specific fleet.

### Lessons learnt

The strength of the dedicated lane, with a strong intermodality with the rail network, for improving the attractiveness. The complementary between cycling and an attractive bus system (big modal shift from cycling). No need to have a specific fleet for the BHLS lines into a simple network.

### Strategy in term of system component choice

	1	2	3	4	5
Running ways	lateral ROW mostly ( C )	ROW two directions mostly (B)	ROW with some grade separated crossings (B+)	strategic part ROW (A)	strategic ROW (A) with passing lanes (high capacity)
Stations	Not upgraded	upgraded only (accessible)	upgraded with dynamic information	idem 3 with a specific design	idem 4 with ticketing machines and CCTV
Vehicle	common bus (1)	common bus (CNG, Biofuel, hybrid...)	Trolleybuses	with a specific design	guided buses (specific fleet)
ITS	None	some priority at traffic lights	AVMS (priority at quite all crossings)	idem 3 + dynamic information	Idem 4 + no ticket selling by drivers
Route identification	None	specific station	specific colour of the fleet	specific station & buses, ROW contrasted	Strong identification (logo, specific system design)

(1) : can be a standard, articulated, bi-articulated, bus or coach)

### References and contacts for further details

Institut : T&T - Regio Twente ;  
 Person contact : Patrick Zoontjes policy advisor - P.Zoontjes@regiotwente.nl



*Access control*

*connection with the rail station*



### 7.1.15 Junqueira / 24 de Julho Corridor - Lisbon



**Country :** Portugal ; **Region / city :** Lisbon Metropolitan Area (2,8 million inhabitants) /Lisbon city (500,000 inhabitants)

**Type of route :** Bus and Tram corridor

#### Background / Context

At Lisbon, we can't say that there is a BHLS system, in the terms which this system is usually defined. Meanwhile, there exist in the bus network many of the components which are associated to a BHLS. We choose one the most significant corridors in Lisbon, which is shared by trams (modern and traditional tramways), buses and taxis.

This corridor was conceived essentially to guarantee an efficient service in line 15 of modern tramways. However, this line was equipped with only 10 tramways, a quantity not enough to respond to the demand in this axis. That's the reason why in this segment there is a mixed traffic with bus lines and traditional tram lines.

#### Description

##### **Infrastructure :**

Length: 4.8 km (81% dedicated, 19 % mixed traffic) - shared with tramways and taxis

Width of bus lanes: two ways 6 / 7 m

Average station spacing: 400m

Road crossings: 9 at grade intersections, with no priority

##### **Buses :**

Type and number of vehicles: no dedicated fleet; different buses (articulated and standard) and tramways (articulated and traditional) lines running into the corridor

Enforcement control vehicles

##### **ITS tools :**

<b>For passengers</b> (visual and vocal information)	at station	Destination / waiting time / disturbances
	on board	Next stop (only on a few vehicles)
<b>For drivers</b>	AVL system with advance / delay information	
<b>For regulator</b>	Security control system in all vehicles	

##### **Identification :**

<b>On the bus</b>		No specific identification
<b>On the running ways</b>	No specific contrast, only a very frequent "BUS" painted on the pavement	
<b>At the stations</b>		No distinction

#### Cost and Financing sources if available (in €)

No data.

#### Some results

**Ridership :** 27 000 passengers per day in all lines that go into the corridor

**Headways :** 2 minutes (average headway cumulating all lines)

**Schedule span:** daily service: 5h00 - 24h00; Night service: 0h00 - 5h00

**Regularity :** data available for the whole bus network

**Commercial speed :** In Junqueira corridor, average speed from 14 km/h to 16 km/h

**Accidents :** The parking of the cars became more disciplined, the safety increased, the number of cars in the bus lanes decreased.

### Success factors / Strengths

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Potential demand with correspondence in Train, Boat, Metro and Tram Interfaces not only for commuters as well as for the residents ridership. It serves school, commercial, services and touristic areas. In what concerns to the car drivers, we verify a strong respect for the non use of the corridor by them. Besides, there exist enforcement teams that provide the surveillance of the corridor.

After the implementation of the reserved bus lane in Junqueira, the parking of the cars became more disciplined, the safety improved, the number of cars in the bus lanes decreased and the speed of our lines increased.

### Barriers / weaknesses / Points to monitor

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The fact of having a mixed traffic with bus lines, modern tram lines and traditional tram lines is a handicap in the efficiency of the corridor, because it generates a loss of time in bus stops. It would be more useful to have only one typology of vehicles, with high capacity, than the mix of different kind of vehicles.

This corridor is opened to taxis, although it is not allowed to stop for boarding or alighting of passengers.

The corridor is composed by segregated lanes and a common used segment. In the eastern side (Lisbon City Center) it finishes in a traffic light, in a square with many people and many cars moving. This discontinuity of the corridor and a non existence of priority at traffic lights generate losses of efficiency, with traffic congestions.

In the segments where there is no physical separation, there are a few crossroads, with a high level of accidents. Also, in the "24 de Julho" bus lane, there were already some accidents with taxis.

### Lessons learnt

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The most important findings to be done in this corridor should be the complete segregation of the bus lanes and give priority at traffic lights in the crossroads.

In what concerns to comfort and accessibility, all stops should be elevated to keep the kerbs at the same level of the buses and trams.

One lesson that was learnt in the process is that it is very much difficult to succeed such a project when there is a "divorce" between the operator and the municipality. That's why is so urgent that the Lisbon Metropolitan Transport Authority becomes into action.

In spite of all this, it is better to have buses and trams mixed in the corridor than having buses outside mixed with general traffic.

### References and contacts for further details

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Institut : CARRIS - Companhia Carris de Ferro de Lisboa

Person contact : António Araújo - [antonio.araujo@carris.pt](mailto:antonio.araujo@carris.pt) - 351 21 361 3101 or Carlos Gaivoto - [cgaivoto@imtt.pt](mailto:cgaivoto@imtt.pt)



## 7.1.16 The TVRCAS – Castellón - Spain



Country: Spain

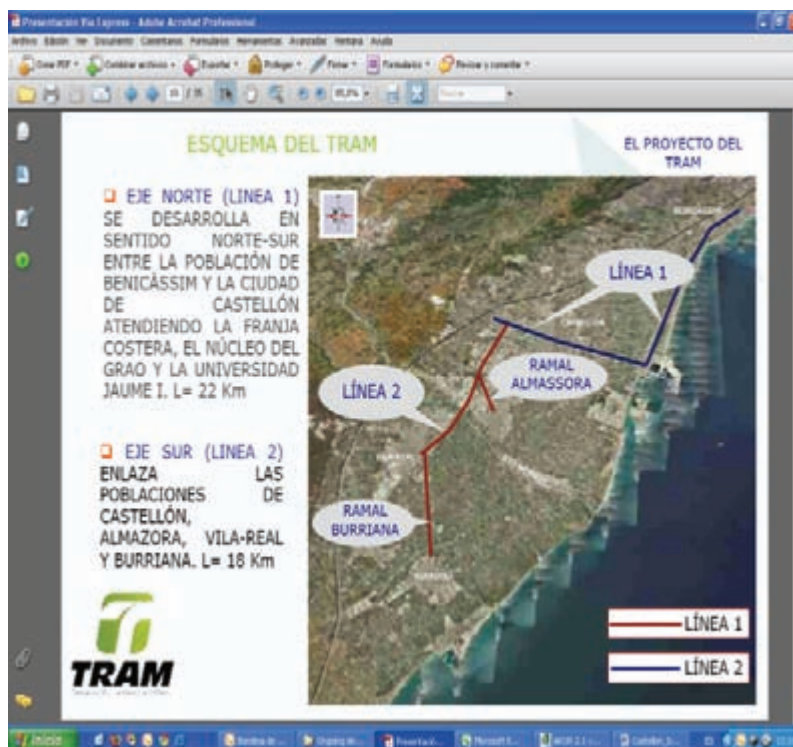
City: Castellón

### Background / Context

Castellón is a Spanish city located in the east of Spain. It has a population of 177.924 inhabitants, with a surface of 107 km<sup>2</sup>. In Castellón, 16% of the trips are made by public transport.

The new system, called TVRCAS, is part of a Master Plan from the Regional government - “Consejería d’Infraestructuras I Transport”, with the objective of promoting the metropolitan public transport.

The Master Plan included two lines, with a total length of almost 42 km., 22 km for line 1 and 20 km for line 2.



In June 2008, 2 km of line 1 (see in light blue in the second picture) were opened.

### Description

#### Infrastructure :

Length: 2037 meters (no length shared with pedestrians)

Width of platform: one way: 3,65 m / two ways: 7,15 m

Average station spacing: 509 m. (5 stops)

Road crossings: 100% at grade intersections (Signal priority for the BHLS)

#### Buses:

Type: three Civis Cristalis with optical guidance

Length: 12 M

Capacity: Civis: 74-78 in total.

ITS tools:

For passengers:	NA
For drivers:	NA
For regulator:	NA

Identification:

On the bus:	Different vehicles with distinctive colours
On the running ways:	Red asphalt
At the stations:	Distinctive design, brand and colours (Tram type)

#### Cost and financing infrastructure

Investment cost: 22M€ the running ways

Vehicles cost: 2,5 M€

Project financed by the Regional Government

#### Some results

Ridership: 3200 passengers/ day in ordinary week day, 1600 pass./day in off-holiday period

Headways: 5 min. in peak / 15 min. in non-peak

Schedule span: 7-22 h. (15 h.)

Regularity: 98%

Commercial speed: 18 km/h

Accidents: none, 2 incidents dealing with pedestrians crossing the running way, at square and other intersections.

#### Success factors / Strengths

Improvement of travel time: are better than car's.

#### Barriers / weakness / points to monitor

As it is not a complete line, initial objectives cannot be achieved.

#### Lessons learnt

Hard to answer when the project is just partially implemented BHLS is a more efficient solutions than tram in small-medium urban areas.

#### References and contact for further details

Person contact: Leonardo Mejías Almendros

Télefono: 96 386 76 28



Optical guidance system fruitful for achieving regular gaps at dockings



The specific station for this line

### 7.1.17 The bus line 16 – Gothenburg - Sweden



**Country** : Sweden ; **Region / city** : Gothenburg (530 000 inhabitants); **Type of route** : urban route

#### Background / Context

After a mobility master plan adopted in 1999, a network of 4 structuring “BHLS” lines has been decided, mostly for economical reasons. Indeed the efficiency of the bus network got down step by step, with a PT market share of 28%, considered as a low level in comparison of other important cities.

The line 16 was operated into the most important corridor and is one of these 4 BHLS routes. The decision to proceed has been taken in 2001; the end of works in 2004 comes after the year of opening into service in 2003 with some difficulties, as the operator had the pressure from politicians and costumers to start the service.

During the studies, a debate raised about the system choice, tramway versus a bus-based system, due to the high potential of capacity of this corridor. For cost and timeline reasons, bi-articulated buses were chosen for this route.

This structuring network is well connected to the rail station.

#### Description

##### **Infrastructure :**

Length: 16,5km ; Dedicated lanes: 45% ; central implementation

Spacing: 700m

Specific stations, P+B at some stations

##### **Buses :**

Bi-articulated buses identified

Manual ramp on 17cm kerb height, managed by the driver (very few wheelchairs)

##### **ITS tools :**

<b>For passengers</b> (visual and vocal information)	at station	Dynamic information (waiting time)
	on board	Dynamic information (next station, terminus)
<b>For drivers</b>	AVM system	
<b>For regulator</b>	AVM system	

##### **Identification :**

<b>On the bus</b>	yes	Numbers follow tram lines; routes on same map as tramway – specific blue and white colour
<b>On the running ways</b>	not	
<b>At the stations</b>	no	However separated stops from other buses

#### Cost and Financing sources if available (in €)

Investment cost: data not available (no calculation per line).

57% of the operating cost is covered by fares.

#### Some results

**Ridership** : 25 000 trips / day (65 000 into the trunk section with line 16 – around 8 lines)

**Headways**: 3 - 5 - 10 min

**Schedule span**: 20h (23h week end)

**Regularity** : 75 % of passengers having a bus within 30 seconds early to 3 minutes delayed.

**Commercial speed** : 21 km/h (in off peak the bus necessarily don't stop at every stop)

**Accidents** : data not available per line, very few events in buses, less than in tram.

Success factors / Strengths

Visible, understandable, identity : the structuring routes are presented on the same map as the tramway. Passenger information; intersection priority; vehicle size; frequency.

An easier process than for a tram.

Drivers have no tickets to sell. For security reasons they should have no money. For time saving reasons they shall also not deal with ticketing.

Barriers / weaknesses / Points to monitor

Not enough bus lanes, problems of regularity. This line is getting to be crowded at peak hours.

The implementation process decided requested to open the line before the infrastructure works were finished. Difficulties have been observed to get the infrastructure space for the project and to decrease the number of stops (there are at least four stops too many).

CNG buses reliability was not enough at the beginning (now most buses are powered by diesel).

Lessons learnt

For such project, the political will stays very important.

Strategy in term of system component choice

	1	2	3	4	5
Running ways	lateral ROW mostly ( C )	ROW two directions mostly (B)	ROW with some grade separated crossings (B+)	strategic part ROW (A)	strategic ROW (A) with passing lanes (high capacity)
Stations	Not upgraded	upgraded only (accessible)	upgraded with dynamic information	idem 3 with a specific design	idem 4 with ticketing machines and CCTV
Vehicle	common bus (1)	common bus (CNG, Biofuel, hybrid...)	Trolleybuses	with a specific design	guided buses (specific fleet)
ITS	None	some priority at traffic lights	AVMS (priority at quite all crossings)	idem 3 + dynamic information	idem 4 + no ticket selling by drivers
Route identification	None	specific station	specific colour of the fleet	specific station & buses, ROW contrasted	Strong identification (logo, specific system design)

(1) : can be a standard, articulated, bi-articulated, bus or coach)

References and contacts for further details

Institute : Västtrafik AB - the Public Transport Authority in the area of Region Västra Götaland

Person contact : Magnus Lorentzon magnus.lorentzon@vasttrafik.se



### 7.1.18 The trunk bus network - Stockholm



**Country** : Sweden ; **Region / city** : Stockholm - 8 466 persons/ km<sup>2</sup> (inner-city), PT market split rate: 36% - **Type of route** : inner-city bus structuring network of 4 lines.

#### Background / Context

Stockholm city area represents 1.9 million inhabitants, and 50% of the Swedish trips concern this area. There is a traffic congestion charge in Stockholm (around 2.50€ to access the city centre). The Swedish accessibility policy requires that all public buildings and services should be totally accessible for impaired within 2010.

The trunk network restructuring began in 1992, after political agreements concerning local infrastructure and investments. The average bus speed was previously 13 km/h and the objective was to achieve 18 km/h with a much better quality (by a whole “system” approach).

Four lines (One abandoned) were strengthened and given easy numbers to remind: 1-4. Although the traffic agreement broke down in 1998, Stockholm municipally (the inner part of Greater Stockholm) and SL decided to carry on. They shared the costs 50% each. These four lines carried between 24 000 and 35 000 passengers/day and now it is between 33 000 and 57 000, at an average speed of only 15 km/h.

More than a half of the new passengers came from the metro, and 5% from the car.

This trunk network is designed for the inner-city.

#### Description

##### **Infrastructure :**

Length : 40 km for the 4 lines – dedicated lanes not very contrasted : 30% (often central, shared partially with secondary lines)

Average station spacing: 400 – 500 m (before 200 m)

Station: red concrete or asphalt pavement for identification

A very good intermodality with the metro network (connection with 8 metro stations)

**Buses** : specific blue articulated buses for all these 4 lines – 46 seats /120 passengers in total (4pers/m<sup>2</sup>).

manual ramp for wheelchairs ;

##### **ITS tools :**

<b>For passengers</b> (visual and vocal information)	at station	Direction, Waiting time,
	on board	Terminus, next stops
<b>For drivers</b>	Advance, delay	
<b>For regulator</b>	Control room, AVM system	

##### **Identification :**

<b>On the bus</b>		Number of the line 1 to 4 (the most capacitive) – blue colour
<b>On the running ways</b>	Not really	

<b>At the stations</b>	Red colour of the concrete pavement – dynamic information
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#### Cost and Financing sources if available (in €)

7 MSEK / km (0,7 M€/km)

#### Some results

**Ridership** : 163 000 (4 lines : 40 000 per line in average) ridership increase before / after : + 60%

**Headways**: 4 – 10 min

**Schedule span**: 5h30 - 0h30 (19h)

**Regularity** : Severe regularity problems due to lack of infrastructure measurements/capacity but also driver and trip scheduling.

**Commercial speed** : 15 – 18 km/h

**Accidents** : no data available per line

#### Success factors / Strengths

**The whole “system” approach**, even if the objectives in term of infrastructure were not be achieved.

**The good identification** of the system (blue buses) with a better level of service (frequency and higher schedule span) can provide a higher ridership (+60%), even if the infrastructure was not totally dedicated.

**The passenger information**, “real time” at all stops, and on board.

**The intersection priority**, even if and the crossings were not all prioritized by the city due to car traffic.

**The accessibility** for the elderly and handicapped people.

#### Barriers / weaknesses / Points to monitor

**Stockholm has no wide streets**: they are between 18 up to 30 m. this causes problem when you try to introduce a bus lane. There are a lot of other wishes upon a street. For ex. Trees, cafés, bicycle lanes, car traffic lanes, loading place and so on. If you could satisfy all the needs the street would have to be about 42m wide.

**The Trunknetlines did not reached the target of 18km/h in peak hours**. In order to achieve this target there must be a way of dealing with the public transport as a priority issue from the top of the political level all the way down to the planners. There must also be an acceptance that car-traffic can be reduced in certain streets or in bigger areas.

#### Lessons learnt

To succeed in this kind of project it is necessary to have a firm support from the politicians and from the Town servants. There must also be a close working group where representatives from both Public Transport and the Town participate.

The information system at all stops is a key-component indispensable for a structuring network.

#### References and contacts for further details

**Institut**: AB Storstockholms Lokaltrafik (SL) /Stockholm PTA;

**Person contact**: Per Ekberg, per.ekberg@sl.se

**Institut**: Bjerkemo Konsult - Lund ;

**Person contact**: Sven-Allan Bjerkemo: bjerkemo.konsult@swipnet.se





## 7.1.19 The structuring network – Jönköping - Sweden



**Country** : Sweden; **Region / city** : Jönköping , 125 000 inhabitants – PT share : 22% (city centre)  
**Type of route** : Line 1, 2 and 3 : the 3 bus lines forming the new bus structuring network with some feeder lines



### Background / Context

The city is in the middle between the three biggest Swedish cities : Stockholm, Göteborg and Malmö. It is build around three lakes. In the city centre there is lack of space, so it's complicated to deal with both transportation and urbanism. Those 10 last years, the city built a new bridge over one lake, so that more space was liberated for housing, trade and services. A new high-speed railway and station are planned.

This new master plan has integrated a hierarchy of bus network, two main BHLS lines (the yellow and the red) that crosses now the centre since 1996. A third line (green) started in 2001 to complete this network. ITS has been integrated on these 3 lines since 1997 (waiting time for next departure at stops, priority at all crossings).

Line 1 (red) and line 2 (yellow) were opened 1996. Line 3 (green) was opened afterwards as a complement. The success story is the comprehensive package of all measures taken.

There was a need to reconstruct the old network (with a hierarchy among the lines that leads to some transfers) and turn a negative trend in demand for PT. There was also a need for modal shift in the city centre as it is narrow and need more space for pedestrian zones. Today 53 improvements are planned to twice the PT trips.

### Description

#### **Infrastructure :**

Length : Line 1: 13.4 km; Line 2: 11,5km; Line 3: 14,3km

Dedicated lane : 7% - shared partially with bicycle – priority at all road crossings

Average station spacing : 440 m

Crossings : 3 grade separated


**Buses** : New articulated kneeling low floor buses with 4 doors for fast boarding and alighting – no specific design – all powered by bio-gas today. 16 – 17 cm kerbstone height – manual ramp for wheelchairs.

#### **ITS tools :**

<b>For passengers</b> (visual and vocal information)	at all stations	Destination, waiting time (the 2 following busses)
	on board	Next stop, terminus
<b>For drivers</b>	AVL – priority at all crossings (efficient)	
<b>For regulator</b>	AVL, control centre, CCTV partly	

#### **Identification :**

<b>On the bus</b>	Not really	New, painted low floor buses, small logo at the front and side
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<b>On the running ways</b>	No identification (contrast very low)	
<b>At the stations</b>		Always large, well visible stop signs, logo, real time displays

#### Cost and Financing sources if available (in €)

Cost of the infrastructure : 2,6 MSEK / km (around 0,26 M€/km)

#### Some results

**Ridership** : 18 000 trips per day (for 3 lines)

**Headways**: 10 – 30 min per line ; **Schedule span**: 4h20 - 01h (21h)

**Commercial speed** : 21 - 23 km/h ; **Regularity** : no data ; **Accidents** : no data

**Ridership increase** : 6% from cars - 5% from biking and walking - 1% from special T - 13% new trips

#### Success factors / Strengths

Introduction of the City Bus system gave radical changes in the bus network, New low floor 4 door articulated buses, Bus stops with real time information, Infrastructure and Bus priority: **a coherent “system” approach**.

The city of Jönköping has invested in infrastructure where needed, especially in high quality bus stops and a bus priority signal system. These investments have been successful and a need for improving medium speed and keep regularity with 10 minutes intervals between the buses.

Jönköping had one of the first real time information systems in Sweden. It has been improved in three steps and has today a high functionality.

There is a need for articulated or bi-articulated buses in peak hour on all lines - also in off peak for lines 1 and 3. City council has decided to work for a double market share of PT which means that even more bus capacity will be needed in future – or some part of the system has to be transferred into a tram system.

#### Barriers / weaknesses / Points to monitor

It was taken as one big step in June 1996 and caused a lot of opposition in local media. The process started three years earlier and included study tours to other European cities like Almere and Essen. Two years were used for planning and political acceptance which made it easier to resist the media storm.

#### Lessons learnt

The project has learnt that there is need for:

**Partnership**: Many actors were involved in the process. There is a need for coordination and understanding.

**Political confirmation**: Investments in public transports has to be valid for a long period. There is a need for political decisions and confirmation to be sure that there will be a holistic solution and that all goals will be achieved.

**There must be enough time for planning**: There is a need to find ideas and best practice and transfer it in local conditions.

**Continuous improvement**. Turn the project into a process.

#### References and contacts for further details

**Institut**: Jönköpings Länstrafik AB ; **Person contact** : Thomas Adelöf: thomas.adelof@jlt.se

**Institut**: Bjerkemo Konsult - Lund

**Person contact**: Sven-Allan Bjerkemo: bjerkeremo.konsult@swipnet.se



## 7.1.20 The trolleybus line 31 - VBZ Zurich



**Country:** Switzerland

**Region / city :** Zurich **Type of route :** High-capacity, Urban

### Background / Context

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Zurich is the largest city of Switzerland, as well as the economic and financial engine of the country. With a population of about 380'000 inhabitants (metropolitan area around 1 million) Zurich is a mixed hub for railways, roads and air traffic. Its airport and railway station are the busiest in the country. Public transport services in the urban area are provided by a combination of high capacity commuter trains (S-Bahn services), a dense tram network and a number of complementary bus services varying in capacity. In general, quality of public transport in Zurich is very high, with clean, modern vehicles, and comfortable, reliable and punctual services. Line 31 is a major trolley bus line of the network, carrying more passengers than some of its tramlines. It is a radial line using double-articulated vehicles, which serves four S-Bahn stations, as well as the main train station. Diverse urban areas are served, including the city center, residential, and previously industrial areas (where the potential for further development exists). The use of large vehicles in Line 31 as of 2007 was the result of a study that focused on current and future demand, as well as on the quality of the service for the passengers. Line 31 is provided with different types of priority at all intersections and along the route, dynamic and static in-vehicle information, low-floor modern vehicles, central dedicated lanes along parts of the line, high frequency services and one park-and-ride facility. The use of a 25 m vehicle has reduced the difference between bus and tram in a city where the tram network is the backbone of the majority of trips.

### Description

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#### **Infrastructure:**

Length: 11 km  
Stations served: 28 (4 S-Bahn stations + Zurich main railway station)  
Average station spacing: 414 m  
Road Crossings: 23 at-grade intersections


#### **Buses :**

Type: 17 Double-articulated trolley buses – Hess Light tram 3  
Length/Width/Height: 24.7 / 2.55 / 3.45 m  
Capacity: Technical max. capacity: 202 (4 pass./m<sup>2</sup>)  
Rated output: 2 x 160 kW (+ 50 kW emergency power)  
Doors / ramps: 5 / 2  
Empty / full weight: 24 / 38 Ton

### **ITS tools :**

<b>For passengers</b> (visual and vocal information)	at station	Ticket vending machines, static schedules, topological and zonal maps in every stop. At larger stops real-time information displays. Audio announcements in case of disruptions or changes in service at every station.
	on board	Real-time information displays: next/ final stop with travel time, disruptions or changes in service, special events, connection status at next stop with waiting time. Audio announcement: next stop, disruptions or changes in service.
<b>For drivers</b>	AVL, automatic priority request at all crossings, cameras at back of bus for safety	
<b>For regulator</b>	AVL, CCTV in some vehicles, radio and emergency button contact with driver.	

### **Identification :**

<b>On the bus</b>		On front and side of buses. Marketing is for entire system, it is creative, fun and the VBZ brand is strong and recognized.
<b>On the running ways</b>	Bus lanes are clearly marked; overhead catenaries help to follow the line path.	
<b>At the stations</b>	Concrete surface and clear marking of the bus stop.	

### Cost and Financing sources if available (in €)

Cost coverage of service: around 64% for all system. Cost of one vehicle: around 1 Mio €. Single ride 3€, 24h ticket 6€. Discounts and season tickets are available and savings compared to single tickets are significant.

### Some results

**Ridership** : demand in peak hour: 1300 pass. / direction. Around 14'000 per day.

**Headways**: 7.5 min from 6 am to 8 pm

**Schedule span**: 5:30 to 00:30 (19 h)

**Commercial speed** : around 19 km/h

### Success factors / Strengths

Public transport in Zurich enjoys ample support by the population and has a very positive image. Priority for public transport is a key element in the city. Planners have good relationships with traffic engineers and are able to work cooperatively on improvement projects. Zurich developed a unique approach that applies an active approach (priority is provided only when a public transport vehicle is present) to all the traffic signals in its network. The payment system (proof of payment or self service fare collection) considerably accelerates boarding and alighting times, thereby reducing dwelling times at stations. Vehicle characteristics such as low-floor, improved interior circulation spaces and multiple wide doors make the service faster, more comfortable and more accessible.

### Barriers / weaknesses / Points to monitor

Public transport in Zurich is rather slow when compared with other cities. This is mainly due to the short distance between stations, and the density of the network. At some critical points, conflicts between public transport vehicles occur due to restricted space. Zurich is a tram city and bus services enjoy lower levels of recognition by the population. Construction sites can seriously impact services.

### Lessons learnt

The high quality transport system in Zurich is not the result of one single measure, but rather the implementation of a number of measures that complement each other and have a greater effect than that which they could individually achieve. Public support is critical to implement measures in favour of public transport. Network planning, infrastructure allocation and service characteristics must be designed to meet conditions in public areas, serve all social groups including elderly, poor and disabled while minimizing unnecessary negative impacts.

### References and contacts for further details

Person contact : Nelson Carrasco Telephone : +41 44 633 3087 - nelson.carrasco@ivt.baug.ethz.ch

### 7.1.21 The Fastrack scheme in Kent Thameside - UK



**Country :** United Kingdom ; **Region / city :** Kent Thameside **Type of route :** Structuring network in a new urban area

#### Background / Context

The Fastrack transport concept was developed through a partnership between Kent County Council, Arriva, and the Kent Thameside partners. Kent Thameside (population 175 000, 2010 and expected to rise to 216 000 by 2021) has huge development potential, which will bring up to 50,000 new jobs and 30,000 new homes to the area over the next 20 to 30 years. The traffic impacts of this level of development were to be mitigated by developing a high quality, attractive public transport system. Fastrack was designed to meet the challenge.

Fastrack is designed as part of the overall Public Transport Network in the area and integrates with railway and current bus services. Fastrack is designed to connect with the majority of existing and new developments in Dartford and Gravesham. Services are provided through a network of express routes on which only Fastrack services will be allowed to run.

The design of the network allows for expansion in the future, the ultimate network of 40km will have 75% dedicated or priority lanes for Fastrack services. Launched in 2006, Fastrack utilizes a variety of measures including dedicated traffic free sections of busway, bus priority on the non-segregated sections of highway, high quality bus stops and infrastructure, dedicated low emission vehicles, off bus ticketing, and investment in branding and marketing.

The Fastrack network is currently split into 2 routes described below.

Arriva operates Fastrack through 2 different types of operating contract. Partnership working was the key to this relationship with local planning authorities clear about how the bus network is to develop in the future and seek appropriate developer contributions to fund infrastructure and operation of services.

Arriva invested significant time in driver training with regular evening events held to build an enthusiastic and engaged driver workforce. Ticketing is provide through the use of roadside ticket machines to aid in boarding times with the network split into zones to simplify the process. Arriva initially trialed their mobile ticketing on Fastrack and has subsequently been rolled out across the UK.

#### Description

##### **Infrastructure :**

Route A consists of 10km (2.5km busway, 2km bus lanes, 5.5km on-street). This section serves a 107 Ha mixed use development site which proposes 1,500 new homes and 7,500 new jobs. The developer, Prologis, has entered a 17 year agreement to operate and fund this service which provides free travel to residents, free travel for employees, and introduction of RTI screens within every new home.

Route B consists of 15km (5.5km busway, 4km bus lanes, 4.5km on-street) This section links Dartford to Gravesend with local links to Bluewater and Ebbsfleet International Station. This operating contract was led by Kent County Council based on a commercial arrangement with vehicles funded by the Council The contract included a number of performance targets with robust monitoring.

##### **Buses :**

Diesel standard buses, CCTV, plug and WIFI, identified, single deck.

**ITS tools :**

<b>For passengers</b> (visual and vocal information)	at station	Interactive kiosks, limited web access & email
	on board	Next stop, destination, display for transfers information (Train to London,...)
<b>For drivers</b>	Fastrack control centre which is used to monitor the buses together with all the bus stops – CCTV	
<b>For regulator</b>		

**Identification :**

<b>On the bus</b>	yes	Logo, colour,
<b>On the running ways</b>	RoW well protected	
<b>At the stations</b>	yes	Logo, specific design, comfort with Internet access

Cost and Financing sources if available (in €)

Infrastructure : 5 M€ / Km – Private Public Partnership for 17 years.

Some results

**Ridership** : Route B, 6000 trips / day ; modal shift from the car: 19%.

**Headways**: 10 - 15 min

**Schedule span**: 5h30 - 23h (17h30)

**Regularity** : 97,5% between 1m early & 5m late (Traffic commissioner target) ; Availability: 99,52%

**Commercial speed** : 18 Km/h

Success factors / Strengths

Flexibility of the structuring bus-based network, all along its development, with always the same target of a great quality of service (regularity).

Barriers / weaknesses / Points to monitor

The coming crisis can slow down the perspectives of the whole network, that justifies the choice of a flexible system.

Lessons learnt

The strength of a complete and strong system approach.

The interest of the flexibility of a BHLS that can be developed according to the city development.

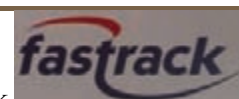
Strategy in term of system component choice

	1	2	3	4	5
Running ways	lateral ROW mostly ( C )	ROW two directions mostly (B)	ROW with some grade separated crossings (B+)	strategic part ROW (A)	strategic ROW (A) with passing lanes (high capacity)
Stations	Not up-graded	upgraded only (accessible)	upgraded with dynamic information	idem 3 with a specific design	idem 4 with ticketing machines and CCTV
Vehicle	common bus (1)	common bus (CNG, Biofuel, hybrid...)	Trolleybuses	with a specific design	guided buses (specific fleet)
ITS	None	some priority at traffic lights	AVMS (priority at quite all crossings)	idem 3 + dynamic information	idem 4 + no ticket selling by drivers
Route identification	None	specific station	specific colour of the fleet	specific station & buses, ROW contrasted	Strong identification (logo, specific system design)

(1) : can be a standard, articulated, bi-articulated, bus or coach)

References and contacts for further details

Person contact : David George (Kent Thameside) , David.George@kent.gov.uk  
Kevin Hawkins (Arriva) :



## 7.1.22 The guided bus system - Cambridge



*The concrete guided way along a station*

**Country :** United Kingdom ; **Region / city :** Cambridge ;  
**Type of route :** peripheral route connecting several areas

### Background / Context

The Cambridge Guided Busway project has been designed to connect the key centres of Cambridge, Huntingdon and St Ives (769 000 inhabitants in Cambridgeshire within a low density, from 200 up to 1000 Inh/km<sup>2</sup>). The decision to use a guided busway centred on the need for segregation, to aid enforcement, width restrictions, ride quality, drainage, and ecological issues.

The guided busway will total 25km in length as part of a 40km wider network incorporating on road busways. The total cost of the scheme is estimated at £116.2 million, with a target construction cost of £87 million. The funding is made up of £92.5 million of government funding from the Department for Transport with the remaining £23.7 million from developer funds.

The construction contract was originally intended for completion in January 2009. The intention at the time of letting the contract was to open both the northern (St Ives to Cambridge) and southern (Cambridge rail station to Addenbrooke's Hospital and the Trumpington Park and Ride site) sections at the same time. Since the contract was let, it became increasingly clear that delays in scheme delivery would be encountered and the contractor has experienced delays in completing the programme. Cambridgeshire County Council has been working with the contractor to try to speed up delivery in the hope that at least part of the overall scheme could be made available for public use. Currently the expected date for completion is late 2011.

Two bus operators have already entered into the quality partnership agreement to operate on the busway. All costs and risks are borne by the operators including the purchase of the vehicles. Operators have entered into the partnership for a period of 5 years which includes the payment of an access charge to use the busway, the revenue from this charge will be directly targeted to maintenance of the busway.

### Description

#### **Infrastructure :**

The construction of the busway utilised pre-cast concrete beams (similar to the Essen construction) due to the superior ride quality achieved. The beams used varied in length between 10m and 15m with pad foundations. The part "RoW" is located between urban poles (57% of the total length), accessible only for buses (no sharing).

Distance between stops: 2500m (on guideway) - around 400m into urban poles.

Stations: ticketing machine, CCTV, dynamic information, bike parking (290), and some P+R (1700).

#### **Buses :**

**D**iesel specific guided standard Single Deck and Double Deck, manual ramp for wheelchairs.

### ITS tools :

<b>For passengers</b> (visual and vocal information)	at station	Dynamic information, waiting time
	on board	Dynamic information
<b>For drivers</b>	AVM system with CCTV	
<b>For regulator</b>		

### Identification :

<b>On the bus</b>	yes	Several operators
<b>On the running ways</b>	self enforcement for the guideway	
<b>At the stations</b>	yes	Same comfort and services

### Cost and Financing sources if available (in €)

Infrastructure: within a PPP ( 3,4 M€ / km).

Access will be charged to operators and provide revenue (£500 000) a year which will cover maintenance and the operation of the control center.

### Some results

**Ridership** : 20 000 by 2016 expected

**Headways**: 20 - 30 min (several lines)

**Schedule span**: no data

**Regularity** : no data

**Commercial speed** : 60 km/h along the guideway expected.

### Success factors / Strengths

This scheme is not yet operational however its strengths can be highlighted as:

exclusive and well protected bus lanes

reliable infrastructure, as it is in concrete

high level of station with a strong intermodality with cycling, rail, P+R

### Barriers / weaknesses / Points to monitor

Problems of quality during the infrastructure construction phase. This resulted in a huge delay in starting operations.

The first year in operation will provide an opportunity to evaluate the scheme.

### Lessons learnt

The first year in operation will confirm any lessons to be learnt. This scheme seems to conform to an integrated efficient "system" approach.

### Strategy in term of system component choice

	1	2	3	4	5
Running ways	lateral ROW mostly ( C )	ROW two directions mostly (B)	ROW with some grade separated crossings (B+)	strategic part ROW (A)	strategic ROW (A) with passing lanes (high capacity)
Stations	Not upgraded	upgraded only (accessible)	upgraded with dynamic information	idem 3 with a specific design	idem 4 with ticketing machines and CCTV
Vehicle	common bus (1)	common bus (CNG, Biofuel, hybrid...)	Trolleybuses	with a specific design	guided buses (specific fleet)
ITS	None	some priority at traffic lights	AVMS (priority at quite all crossings)	idem 3 + dynamic information	Idem 4 + no ticket selling by drivers
Route identification	None	specific station	specific colour of the fleet	specific station & buses, ROW contrasted	Strong identification (logo, specific system design)

(1) : can be a standard, articulated, bi-articulated, bus or coach)

### References and contacts for further details

Institut : Cambridgeshire County Council

Person contact : Bob Menzies, bob.menzies@cambridgeshire.gov.uk



## 7.2 Acronyms

AVMS: Automatic Vehicle Monitoring System	LCC: Life Cycle Cost
BHLS: Buses with a High Level of Service	LRT: Light Rail Transit
BRT: Bus Rapid Transit	MC: Management Committee
CBA: Cost Benefit Analysis	PPP: Public Private Partnership
CCTV: Closed-Circuit TeleVision	PTA: Public Transport Authority
DPI: Dynamic Passenger Information	RoW: Right of Way
EBSF: European Bus System of the Future	RTI: Real Time Information
GHG: Green House Gas	STSM: Short Term Scientific Mission
HVAC: Heating Ventilation and Air Conditioning	WG: working group
ITS: Intelligent Transport System	WP: Working Package
KPI: Key Performance indicators	

## 7.3 Glossary of technical terms and concepts<sup>69</sup>

### 7.3.1 Terms related to the infrastructure

**Asphalt:** the term asphalt is often used as an abbreviation for asphalt concrete. Asphalt is a sticky, black and highly viscous liquid or semi-solid that is present in most crude petroleum and in some natural deposits. Asphalt is composed almost entirely of bitumen.

**Bike & Ride (B+R):** facility for interchanging between bicycle and public transport (i.e. getting to stops by bike, leaving it there and continuing the journey by public transport).

**Bus bulb:** where a section of sidewalk extends from the curb of a parking lane to the edge of an intersection or off-set through lane. This creates additional space for passenger amenities at stations, reduces street crossing distances for pedestrians, and eliminates lateral movements of buses to enter and leave stations.

**Dedicated lane (or designated, or reserved lane):** a lane reserved for the exclusive use of transit vehicles. Dedicated lanes can be located in different positions relative to the arterial street and are classified accordingly:

- One-way lateral or concurrent flow curb: next to the curb, used by buses to travel in the same direction as the adjacent lane.
- Contra flow Curb: located next to the curb, used by transit vehicles to travel in the opposite direction of the normal traffic flow.
- Bilateral lanes.
- Two-way lateral lanes.
- Median lane: within the centre of a two-way street. It can be one-way axial or two-way axial.

They are protected at different levels:

- by official marking or a simple difference in colour or texture; the lane is easily physically accessible to other vehicles that can cross it easily.
- by a higher kerb that can be driven over at a very low speed (it allows a flexible use of the dedicated space).
- By using a system that cannot be driven over by vehicles.

They can be shared with certain categories of identified vehicles like taxis, bicycles...

**Exclusive bus lane (or exclusive ROW):** dedicated lane that is physically inaccessible along a whole section, even to pedestrians and bicycles, with grade separated road crossings (with viaduct, tunnel,...).

**Flexible dedicated lanes:** lanes not always dedicated, they can be reversible (dedicated for one direction at the morning, for the other direction at the afternoon), dedicated during a while, when the bus is announced (intermittent bus lanes developed in Lisbon),...

**High Occupancy Vehicle (HOV) Lane:** A lane designated for use by cars with more than one passenger only, including buses. HOV lanes are often used on motorways.

**Infrastructure categories<sup>70</sup>:** Category A, B or C, as presented in chapter 3.3.

<sup>69</sup> Inspired from the BRT guidelines released by the FTA (USA) and completed from other EU glossaries.

**Kiss & Ride (K+R):** dropping or picking up PT passengers by private car.

**Intermodality:** the quality of connection between the existing different transportation modes for a door-to-door transport chain.

**Mixed flow lanes:** when a BHLS is operated into the general traffic.

**Park & Ride (P+R) :** a facility for transfer between public and private (cars) transport. These parking fares are included into the PT fares.

**Passing lane:** an additional lane for vehicles in service to pass one another. Bus pullouts and passing lanes at stations are two primary ways to enhance passing capability for a BHLS system (integration of express routes).

**Platform layout:** platform design with respect to vehicle accommodation. The three basic options are the single vehicle length platform, the extended (i.e., multiple vehicle) platform with un-assigned berths, and the extended platform with assigned berths.

**Queue jumper:** a designated lane segment or traffic signal treatment at signalized locations or other locations where traffic backs up. Transit vehicles use this lane segment to bypass traffic queues (i.e., traffic backups). A queue jumper may be shared with turning traffic.

**ROW (Right of Way):** all type of infrastructure tools that give the priority at PT vehicles.

**Road crossing:** junction between the running way and other street or roads. It can be:

- a fully grade-separated crossing for an exclusive lane,
- an at-grade road crossing.

**Route structure:** how stations and running ways are used to accommodate different vehicles that serve different routes.

**Running way:** the space within which the vehicle operates. For BHLS systems, the running way can be dedicated, exclusive or in mixed traffic.

**Running Way Segregation:** level of segregation, or separation, of BHLS vehicles from general traffic. A fully grade-separated exclusive transitway for BHLS vehicles represents the highest level of segregation, followed by an at-grade transitway (second highest); a designated arterial lane (third highest); and a mixed flow lane (lowest).

**Rut (roads):** a rut is a depression or groove worn into a road or path by the travel of wheels. Ruts or rutting can be removed by upgrading the road surface.

**Slant kerbs:** kerbs that facilitate the dockings as they have a slope of around 60° allowed the bus sticking the kerb when stopping.

**Station:** term adopted for BHLS (and mostly for full BHLS, with high capacity), as it should be strongly designed and cannot be displaced or moved, for any reason ... as for a LRT or tram station. All passengers should find the station at the same location, exception can be seen, rarely.

**Station spacing:** the distance between stations that impacts passenger travel times and the number of locations served along the route.

**Stop, or bus stop:** term adopted for common buses, as they stay more flexible and can often and easily be displaced or moved, for several reasons such as road works, market, special events,...

**TOD (Transport Oriented Development):** strategy that allows to co-finance big interchanges by private and public funds while organising the urban development around these areas (from USA and Canada trends).

### 7.3.2 Terms related to the rolling stock

**Capacity of Vehicle:** the maximum number of seated and standing passengers that a vehicle can safely and comfortably accommodate (comfort level below 3 or 4 passengers per m<sup>2</sup>).

**Dual-Mode Propulsion:** a propulsion systems that offers the capability to operate with two different modes, usually as a thermal engine and electric (e.g., trolley) mode.

**Low-floor bus:** a bus designed with a complete or partly low floor (approximately 32 / 34cm from pavement at door thresholds), that allows to provide accessibility for wheelchairs and pushchairs. One door at minimum should be equipped with a ramp (manual or electric) according to the EU rules (directive 2001/85/EC).

**Low-entry bus / coach :** A vehicle of which the front door is accessible.

**Multiple-Door boarding:** passengers are allowed to board the vehicle at more than one door, which speeds up boarding times. This typically requires off-board fare collection.

**Vehicle Guidance System:** a system used to guide automatically the bus or to steer it on running ways while maintaining speed. These may be magnetic, optical. The optical requires markings painted on the pavement; the magnetic requires magnets into the pavement, non visible. The guidance can be mechanical, by a track or lateral kerbs (side-to-side to keep buses within a specified right-of-way).

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<sup>70</sup> From Professor Vukan R. Vuchic – “Urban Transit systems and technology” – version 2007  
Awarded “Doctor honoris causa” du CNAM.  
[http://ww1.cnam.fr/mediascnam//Conferences/2011/110310\\_HonorisCausa\\_VVuchic.html](http://ww1.cnam.fr/mediascnam//Conferences/2011/110310_HonorisCausa_VVuchic.html)

### 7.3.3 Terms related to operation, ITS and product branding

**Automated Passenger Counter (APC):** technology that counts passengers automatically when they board and alight vehicles. APC technologies include treadle mats (registers passengers when they step on a mat) and infra-red beams (registers passengers when they pass through the beam).

**Automated Vehicle Monitoring System (AVMS):** technology used to monitor bus locations on the street network in real-time. Two operating strategies are observed, schedule-based or Headway-based (when the frequency is below around 5 / 10 min).

**Barrier enforced Fare Payment System:** a fare collection system (process) where passengers pay fares in order to pass through turnstiles or gates prior to boarding the vehicle. This is done to reduce vehicle dwell times.

**Barrier-free Proof of-Payment (POP) System:** a fare collection system (process) where passengers purchase fare media before boarding the vehicle, and are required to carry proof of valid fare payment while on-board the vehicle. Roving vehicle inspectors verify that passengers have paid their fare. This is done to reduce vehicle dwell times.

**Branding (or Branding elements):** the use of strategies to differentiate a particular product from other products, in order to strengthen its identity. In the context of BHLS systems, branding involves the introduction of coherent elements among the 3 sub-systems (buses, station, use of distinct visual markers such as colour, logos, name...) that identify for passengers a distinguish service performance or a route from other transit services.

**CCTV (Closed-Circuit TeleVision):** security technology that use video cameras to transmit a signal and pictures to a specific place, on a limited set of monitors. CCTV equipment may be used to observe the operation from a central control room.

**Dwell Time:** the time associated with a vehicle being stopped at a station for the boarding and alighting of passengers. BHLS systems intend to reduce dwell times to the extent possible, through such strategies as platform height, platform layout, vehicle configuration, passenger circulation, and the fare collection process.

**Driver Assist and Automation Technology :** form of technology that provides automated controls for BHLS vehicles. Examples include collision warning, precision docking, and vehicle guidance systems.

**Fare Structure:** establishes the ways that fares are assessed and paid. The two basic types of fare structures are flat fares (same fare regardless of distance or quality of service) and differentiated fares (fare depends on length of trip, time of day, and/or type of service). We observe off-board or on-board payment, pre-board fare-collection

**Frequency of service:** number of vehicles per hour.

**Headway:** time between running vehicle.

**Intelligent Transportation Systems (ITS):** advanced transportation technologies that are applied to improve transportation performance, i.e. to provide improved travel information.

**Level of service (LOS):** measures the quantity of the service as it is planned (frequency, capacity, operating span...) – a High level of Service needs to offer a high quality (see chapter 3.5 2 and 3.6.1).

**Pay on-board system :** a fare collection system (process) Passengers pay fares onboard the vehicle at the fare-box, or display valid fare media to the bus operator.

**Quality of service:** measures the gaps observed between the planned service and the service really provided (regularity or punctuality, reliability, comfort, accessibility,...) - reference to the EU standard EN 13816.

**Reliability:** “one minus the probability of failure”. However, in PT systems failure is complex and hard to define (Km lost usually, events per 100 000km,...).

**(Travel time) reliability:** consistency in travel times, measured from day to day for the same trip.

**(PT service) reliability:** can be understood in different ways:

“variability in performance measured over time”

“variability of service attributes and its effects on traveler behavior and on transport agency performance”

“schedule adherence and keeping schedule related delays to a minimum”.

**Service span:** the period of time that a PT service is available to passengers. Examples include all day service and peak hour only service.

**Station and lane access control:** allows vehicle access to dedicated BHLS running ways and stations with variable message signs and/or gate control systems.

**Ticket vending machine:** a fixed machine that accepts a combination of cash, stored value media, and credit cards to dispense valid tickets

**Transfer time:** the time associated with a passenger waiting to transfer between particular transit vehicles. The network design determines where passengers need to make transfers.

**Transit signal priority:** adjustments in signal timing to minimize delays to buses at traffic lights. Priority techniques involve adjustments of signal timing after a bus is detected (i.e., changing a red light to a green light, extending the green time, shorting the red time).

**Turnstale:** a possible device of a gate control system that turns and control each passenger getting into a closed station, after validating its payment.

**Variable Message Sign (VMS) :** a sign that provides flashing messages to its readers. The message posted on the sign is variable and can be changed in real-time.

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- Lloyd Wright (Guest ed.) - Built Environment “Bus Rapid Transit: a public transport renaissance” – vol36 n°3 – 2010.

Web sites dealing with BHLS or BRT issues:

- <http://www.brtuk.org> : a UK website managed by an association of professionals
- [www.gobrt.org](http://www.gobrt.org) : Bus Rapid Transit Policy Center of USA.
- [www.nbrti.org](http://www.nbrti.org) : the national BRT Institute of USA
- [www.bhns.fr](http://www.bhns.fr) : the French "Bus à Haut Niveau de Service" web site (French Language).
- <http://www.chinabrt.org/> : the China web site, collecting information of BRT from the world.
- <http://www.brt.cl> : the web site of the new Volvo Centre for Excellence on BRT, established at the Universidad Catolica de Chile in Santiago.
- <http://www.embarq.org> : the web site of the association "Embark", held in Washington, dealing with sustainable cities in developing countries (often working for the world bank).
- <http://www.sibrtonline.org/> : the web site of the latin-american BRT trends
- <http://www.globalride-sf.org/> : the web site of “accessibility for all” on PT all over the world (e.g. on BRT)

## 7.5 CD content

- 1- Memorandum of understanding (MOU)
- 2- Outputs of each workshops organised by the COST group
- 3- BHLS description and photos
  - Templates and guidelines used for BHLS descriptions
  - Abstracts of BHLS descriptions
  - Full descriptions of BHLS
  - Photographs of the BHLS visited
  - The “master data base” file: all the main data collected from all BHLS descriptions
- 4- Final report and drafts set up by the COST group
  - The final report (pdf file)
  - Full version drafts from some WGs
  - Analysis report from the COST group
- 5- Short Term Missions reports (set up by the COST group)
- 6- Dissemination
  - Articles
  - Leaflets
  - Minutes – presentations in external conferences
  - External analysis reports - Books

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