5 Conclusion

The paper presents an approach to re-design a passenger interchange node by random utility models. We calibrated nine discrete choice models taking into account attributes able to explain the passenger behaviour by observed flows and generalized least squares technique.

The analysis highlighted which attributes and have a great influence on the passenger behaviour as the waiting time, the number of pedestrian crossings and the walking running time.

Furthermore an ex ante / ex post analysis was carried out in order to design and evaluate measure to incentive modal integration improving perceived quality and transfer facility in walking path. Therefore, the user satisfaction level was determined on paths related to calibrated models in the study area analysed. Results of the analysis highlight as the developed methodology by calibrated model is a good decision support system to appraise measures that the designer can adopt to reduce transfer disutility of passengers.

References

[1] Delle Site P., Epifani C., Filippi F. (1992), "A method for the optimal location, selection and sizing of short-distance transport facilities", *1th Meeting of the Euro Working Group on Urban Traffic and Transportation*, Landshut.

[2] Parizi M. S. & Braaksma J. P. (1995), "An optimum re source utilization plan for airport terminal buildings", *Transportation Research Record 1506,* Washington.

[3] De Barros A. G. & Wirasinghe S. C. (2002), "Optimal terminal configurations for new large aircraft operations", *Transportation Research Part A*, Elsevier.

[4] Correira A. R., Wirasinghe S. C. & de Barros A. G. (2008), "A global index for level of service evaluation at airport passenger terminals", *Transportation Research Part E*, Elsevier.

[5] De Barros A. G., Somasundaraswaran A. K. & Wirasinghe S. C. (2007), "Evaluation of level of service for transfer passengers at airports", Journal of Air *Transport Management*, Elsevier.

[6] Correira A. R., Wirasinghe S. C. & de Barros A. G. (2008), "Overall level of service measures for airport passenger terminals", *Transportation Research Part A*, Elsevier.

[7] Cascetta E. (1998) "Teoria e metodi dell'ingegneria dei sistemi di trasporto", UTET, Torino

Urban intermodality: potentials for connecting the cities' public transport

K. Burckhart[1] & C. Blair[2]
[1]*Institut d'Estudis Territorial, Barcelona, Spain*
[2]*Transportation activist and consultant, Boston, USA*

Abstract

Intermodality is a well-known element in interurban freight and passenger transport, but has not yet received much attention in the intra-urban environment – even though urban intermodal passenger transport systems gain special importance when energy becomes an expensive resource and when global climatic changes awaken the population's environmental consciousness. At the same time, the growing urban population together with separated land uses and low-density housing make mobility a daily trial for society. Intermodality, seen here as a seamless connection of different transport modes, contributes to a more sustainable urban mobility pattern, where each transport mode is used in its most efficient way. This challenges the cities to create intermodal transport systems, usable and useful for the biggest possible part of society. The interconnection of different modes seems to have easy solutions, but its implementation involves complex details, such as accessibility, information integration and urban space management. The present study focuses on different European cities' intermodality schemes. It includes the analysis of all urban transport modes and their interconnections. Factors such as station localization, public transport usage in combination with non-motorized transport modes as well as private vehicle integration in the transportation system are taken into account. As a conclusion, reflections on the present urban intermodality are made and recommendations are given for the future development of intermodal potential in urban environments.

Keywords: urban intermodality, public transport, sustainability, high-speed train.

WIT Transactions on The Built Environment, Vol 107, © 2009 WIT Press
www.witpress.com, ISSN 1743-3509 (on-line)
doi:10.2495/UT090071

1 Introduction

Intermodality, defined as a characteristic of a transport system that allows at least two different modes to be used in an integrated manner in a door-to-door transport chain, is a key element when aiming at sustainable urban mobility patterns [1]. Intermodality has not been a prominent subject in urban transportation; however, increasing environmental concerns and rising petrol prices make the use of the unimodal private car ever more unattractive. This is a unique opportunity to shift travel toward more efficient modes. Good access to bus, tramway or train relies on a variety of transport and intermodality finds its role in offering seamless travel for transport users.

Many studies have focused on freight intermodality, based on the logistics involved in handling goods with different transport modes throughout the entire transport chain [2]. And many projects have addressed passenger intermodality, looking at interregional travel modes, as with the high-speed-train and the airplane [3]. It is therefore thought to be of interest to draw special attention to urban intermodality, which has, so far, been only randomly analyzed [4]. Urban intermodality refers to trip chaining of urban transport modes, such as local public transport, bicycle and trips on foot. It is in the combination of these modes, that efficiency and sustainability are achieved. Growing technological advances and international technology transfer help to make intermodality ever more easy to implement. Despite this fact, important measures have not yet been accomplished and will need collaborations between the many actors involved in the urban transport systems. As claimed by the Green Paper on Urban Mobility [5], intermodality should play a mayor role in today's city and metropolis. In the present research, intermodality is viewed from the local perspective. Firstly, basic aspects of urban intermodality are depicted. Secondly, six European case studies in medium-sized cities help to exemplify the current state-of-the-art of urban intermodality. An intermodal urban connection rating is the outcome of this comparative analysis. In a third step, soft factors on urban intermodality are detailed in best-practice samples. Finally, conclusions are drawn on existing potentials for connecting the cities' public transport.

2 Urban intermodality necessity

The Transport Policy White Paper [6] includes intermodality as a key principle. As stated in its mid-term review 2006 [7] increased emphasis on urban transport in the frame of the preparation of the Green Paper of Urban Transport is laid. The demand for road space continues to grow due to increased car ownership and demand for mobility. The supply of road space and space for parking within cities is, however, finite and increased efficiency of the use of road space through traffic management can give only a temporary respite in the face of growing traffic. Traffic congestion in cities hinders the mobility of people and goods and is increasingly undermining the economic, social and environmental welfare of our cities. Traffic congestion makes cities less pleasant and more expensive places in which to live and work [8,9]. Increasing controls on private car emissions attend to push car travelers toward public transport. Therefore the use of public transport may rise in the next years - more so if transit is characterized by efficiency and interconnection with other transport modes. Intermodality is not a route of a single passenger only, but also a concept and planning principle of co-operation and organization of several modes of transport. Preconditions for true intermodality relate to interconnection and interoperability. Intermodal transport can constitute complex trip chains, which create high demands on the interfaces and operational integration of the transport system. Intermodal passenger transport chains may be an efficient and more sustainable alternative to car transport. Each city has its own characteristics which influence in the use of transport use, including population density, topography, infrastructure and public transport service and last, but not least, local climate. Each of these factors, according to its quality, can be either encouraging or limiting for public transport demand.

The main attributes of a well-functioning urban intermodality can be divided into two subjects: physical and non-physical connection. While a bicycle may be allowed to be transported on the local public bus, the virtual information system may not include maps or routes for the cyclists. In a world with growing urban population and a trend toward low-density housing, intermodal transport chains gain a special importance. In the present study, the introduction of the high-speed-train and its potential positive impact on restructuring the cities was used as the main criterion to choose six medium-sized European cities for analyzing their intermodal situation in form of case studies.

2.1 The interconnection of public transport

In general, urban intermodality depends on urban space management, a conjunction between urban planning (land-use) and transport planning. In European cities, the average modal share is about 50% of urban trips on foot. Walking effort instead of walking distance or walking time is used to represent the utility of walking as access mode to public transport terminals Many studies on public transport have shown that walking is the most natural and important mode to access public transport [10,11]. Walking accessibility to public transport is applied to indicate the quality or performance of public transport service. In recent public transport studies, public transport accessibility is associated with a certain number that is related to walking distance or walking time. A threshold of 400 to 800 meters of walking distance or 10 to 15 minutes of walking time is often applied. The term walking accessibility is based on how much walking effort is needed to access public transport terminal by walking [12]. Here, walkability becomes an important matter. Number of road crossings, ascending steps and conflict points are elements taken into account by the equivalent walking distance [13]. Walkability is a prerequisite to allow intermodality between trips on foot and with public transportation, i.e. Walk & Ride.

While walking is limited to low speed (3-5 km/h) and an inherently small area of coverage, the bicycle (10-20 km/h) can serve a bigger geographical area. In low-density neighborhoods cycling can be a very good feeder-service to public transport (Bike&Ride). Different EU projects (Urbike, MoCUBa, Baltic Sea

Cycling) showed that bike mobility is no longer just an option, but has become a priority in good traffic planning, and, more generally, a valid tool for urban sustainable development [14]. Bike mobility has therefore become a mainstream consideration in urban mobility. Park & Ride (P+R) lots are facilities for (or the act of) transfer between public and private transport. Kiss & Ride refers to the act of picking-up or dropping-off a public transport rider. And Ride & Ride (R+R) characterizes the transfer of passengers between different public transport modes and within a single mode. Other important connecting modes are the taxi and car-sharing services. Ideally, all transport modes are interconnected, not only physically, but also virtually, making possible an intermodal door-to-door trip consultation. A first step towards this integration is the virtual multimodal transport map, where all available transport modes are displayed. The map on urban transport modes by the Barcelona city council may be one example of multimodal transport information [16].

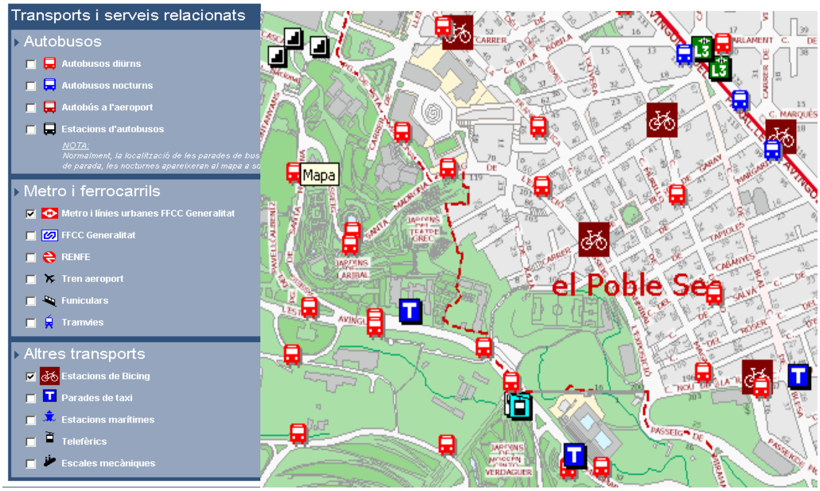

Figure 1: Sample of transport mode information integration.

3 Case studies on urban intermodal connections

Cities with high-speed train connections have been chosen as case studies. The high-speed train (HST) connection signifies an extraordinary investment in railway infrastructure. It is assumed that the introduction of this costly public transport service is accompanied by an efficient connection of its stopping point, the station, with the urban transport system.

3.1 Case study selection

To choose the European case studies, first all isolated HST stations where excluded. Second, a special eye was laid on peripheral stations, located at the edge of the city centers, as they present the challenge to connect a non-centric place to the city. Third, only European medium-sized cities were included in the sample selection. In the end, six stations of three different countries were chosen. Each country includes one centrally located station and one peripheral station (table 1).

Table 1: General case study characteristics.

City	Inhabitants	Station location	HST-connection	Conventional train (trains/day)	HST-train (trains/day)
Mannheim (Germany)	325.000	Central	1991	> 50	168
Kassel (Germany)	194.146	Peripheral	1991	> 50	125
Lleida (Spain)	119.935	Central	2004	< 50	18
Ciudad Real (Spain)	67.401	Peripheral	1992	< 50	25
Lund (Sweden)	101.427	Central	1995	> 50	23
Västerås (Sweden)	130.960	Peripheral	2001	> 50	6

Another factor to take into account is the modal split in the six cities (table 2). First, the lack of data or of up-to-date data was a surprise, as the knowledge of mobility is basic to plan effective actions on the city's transport network. Therefore the data available for Kassel has been transferred to Mannheim, as both cities have similar size and have the same cultural mobility background. At the same time, modal split of Lleida has been copied to Ciudad Real to palliate the lack of data. Despite the fact of dealing with urban environment, the private car share is very high, in most cases representing more than 50%. The public transport share varies slightly between the six cities, being highest in Lund. This high level may be contributed to the important number of students living in the city. Among the non-motorized transport modes, trips on foot reach as much as 35% in the Mediterranean cities. In the central and northern European countries between five and 15% of this percentage is attributed to the bicycle.

Table 2: Modal split in the six case studies.

City	Private car	Public transport	Bicycle	Pedestrian
Ciudad Real (2001)	54%	11%	0%	35%
Lleida (2001)	54%	11%	0%	35%
Kassel (1995)	48%	18%	6%	28%
Mannheim (1995)	48%	18%	6%	28%
Lund (2000)	50%	20%	30%	
Västerås (2005)	53%	12%	35%	

The density in the city is a factor to be aware of when analyzing the urban transport system. In the case of the six case studies, different traditional urban schemes become obvious. The compact Mediterranean city contrasts with the central European cities characterized by lower densities (figure 2).

3.2 Physical connection level analysis of urban public transport

While all of the sample cities have a high quality long distance connection, assured by the high-speed rail, its inner intermodality patterns vary greatly. A

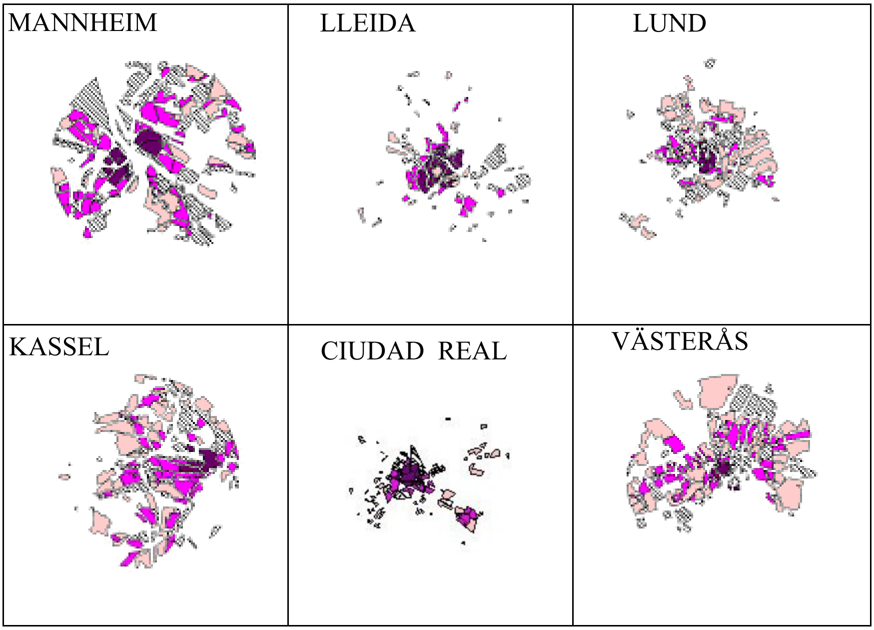

Figure 2: Population density in a radius of 5 km from the HST-station.

comparison of six key intermodal connections provides a picture on each city's weaknesses and strengths regarding intermodal urban transport infrastructure. Apart from the Walk&Ride, Kiss&Ride and Park&Ride, the Ride&Ride concept, referring to intermodal transfer between public transport modes, has been included. For the Bike&Ride interconnection, two categories, the availability of bicycle parking at the public transport stop and the possibility to take the bicycle on the bus or on the tramway, have been distinguished.

For rating, the availability of the intermodal connection has been evaluated in the case of B&R parking, W&R, K&R and P&R with the following rating:

1 = No availability
2 = Availability at HST-station
3 = Availability at main urban public transport stops
4 = Availability at majority of public transport stops

For B&R onboard, the possibility of taking the bicycle onboard is evaluated with

1 = No possibility
2 = Very limited possibility/few services
3 = Some allowance/several services
4 = Allowance on most services

The result from the intermodal connection evaluation provides diverse results (figure 3). The combination of Walk&Ride presents the highest connection level, due to the European character of all six case studies. Walkability to the public transport stops is given and in the best-evaluated case, the city of Lund, sign-posting helps to situate the pedestrians unfamiliar with the area. Bike&Ride facilities exist in most main transport nodes, but only some do offer it in secondary transport stops, like for example in the outskirts of the city. Bike&Ride onboard receives the lowest overall rating in all six cities. The transport of bicycles in or on buses or tramways involves time-consuming maneuvers, so that many transport operators do not allow them except in low demand periods. Park&Ride and Kiss&Ride receive lower ratings, which shows that urban transport stops are not prepared for this intermodality. In some cases, facilities to provide access by private car to public transport stops would be a useful implementation, in order to avoid inner city parking and its correlated emission problems. Regarding Ride&Ride, transfer is physically possible in a seamless way, which contrasts with lacking information, i.e. soft factors, a subject that is discussed further on.

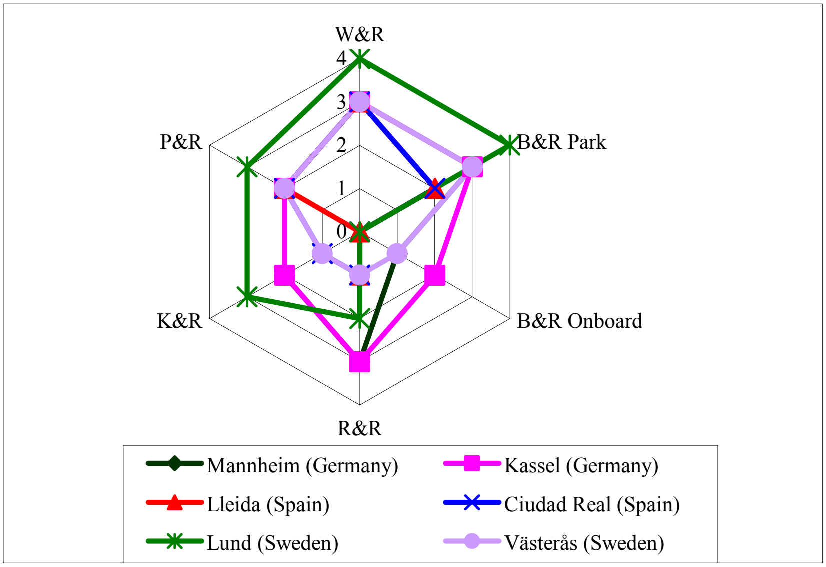

Figure 3: Intermodal urban transport connections.

3.3 Information integration analysis in urban public transport systems

Not only the physical interconnection, but also soft factors such as information are a crucial element when creating a quality intermodal urban public transport system. In developed countries, the Internet has evolved to a practically omnipresent consultation tool. Therefore, information provision through the Internet is considered a main prerequisite. The information integration analysis focuses on information availability at the Internet pages of the six case studies' public transport operators. A rating system is applied, where intermodal information provided by the public transport operator himself is rated with three points. If this information is not provided by the public transport operator or its transport authority, but by third parties (city council, public transport association, taxi association, car-sharing company...) the information integration is rated with one point. Information integration is evaluated for individual intermodal connection (B&R, K&R...) for each of the six case studies (figure 4).

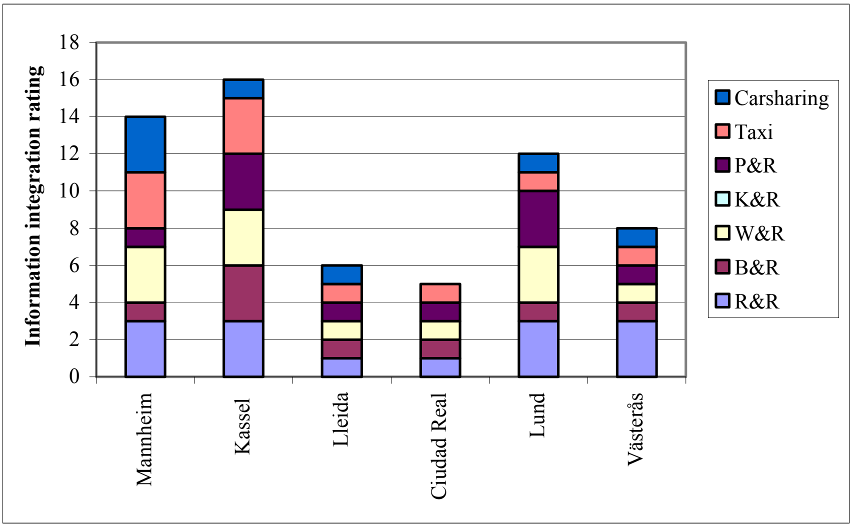

Figure 4: Level of information integration by intermodal connection.

It results that information integration is highest in the two German case studies, where the public transport operators incorporate information on access on foot to the public transport stops, taxi and car-sharing availability, etc. In the Swedish city of Lund, information on walking and car access are included in the public transport companies Internet consultation service. In the other case studies the operators do not include information on connecting transport modes in their Internet pages. Partly information is lacking in these cases because they do not exist, but even the information on its non-existence would be valuable for the potential public transport customer.

4 Conclusions

In the beginning of the present study, it was assumed that the introduction of the high-speed train service is accompanied by an efficient intermodal urban public transport connection. However, the intermodal analysis of physical and information integration have shown that public transport is lacking integration in most of the case studies. The HST-station is a main transport node that deserves a special connection, but urban intermodality has to spread over the entire system. This is the case for the physical as well as the virtual (information) connection.

What of the role of the public transport operator? Is it not to the advantage of the operating company to facilitate access to public transport stops for their clients? Should they not integrate protected bike parking near train stations and allow bikes on buses and trains? This expectation is addressed in the European Strategy for Urban Environment (COM/2005/718) [15], but in reality there is an implementation gap. For cycling to be part of the travel chain pre- and on-trip information becomes important. Allowing bicycles on public transport vehicles may be more complicated, but should always be considered and offered at least in non-peak travel times. Easy access and integrated cycle hire is an additional service to the public transport rider and has been successful in cities like Frankfurt and Munich where the main railway company offers such a service. At the same time, the most desired residential areas are proximate to a well-connected grid offering transport efficiency and connecting many routes and destinations. The potential and power of the Walk&Ride concept for intermodality lies in these two attributes - walkability and public transport connection. In all case studies, the Kiss&Ride concept has received little attention and is statistically not yet fully reflected in urban mobility. An underestimation of its importance in urban intermodality bears at the same time a great potential of improvement. At the same time, Kiss&Ride is an adequate solution for reducing long or inner city private car rides, as it offers an access mode to public transport for those who cannot or do not want to walk or cycle to the public transport spot. Kiss&Ride does not consume valuable urban space, as only a short-parking spot for dropping-off or picking-up is necessary.

As mentioned earlier, intermodality is not a route of a single passenger only, but also a concept and planning principle of co-operation and organization of several modes of transport. The implementation of urban intermodality involves complex details, but often it is not only the hard factor, i.e. infrastructure, but also the soft factors such as pre-trip and integrated transport system information, which are relevant in intermodal urban mobility. Information integration is seen as a mayor prerequisite in order to provide adequate knowledge to the potential public transport user. Further research in the urban intermodality field will have to lay special attention on these soft factors.

References

[1] LINK- European Forum on Intermodal Passenger Travel, www.linkforum.eu
[2] European Commission (2008): Marco Polo – New Ways to a Green Horizon, Brussels.
[3] European Commission (1999): HSR-COMET-Interconnection of the High-Speed-Rail Network.
[4] Ambrosino, D., Sciomachen, A. (2006): Selection of modal choice nodes in urban intermodal networks.

[5] European Commission (2007): Green paper. Towards a new culture for urban mobility, Brussels.
[6] European Commission (2001): White Paper. European Transport Policy for 2010. Time to decide, Luxembourg.
[7] European Commission (2006): Keep Europe Moving. Sustainable mobility for our continent, Mid-term review of the 2001 Transport White Paper, Luxembourg.
[8] European Commission (2004): COST 340, Towards passenger intermodality in the EU. Lessons from history, Brussels.
[9] UITP (2001): Pricing and Urban Mobility. UITP Position Paper, March 2001.
[10] Mitchell, C.G.B. and Stokes, R.G.F. (1982), Walking as a Mode Transport, TRRL Laboratory Report 1064, Transport and Road Research Laboratory, Department of the Environmental, Department of Transport.
[11] Cervero, R. (2001): Factors Influencing Pedestrian Access to Transit, Journal of Public Transport, Vol.7 Issue 3, January, pp. 1-23.
[12] O'Sullivan, S., Morrall, J. (1996): Walking Distances to and from Light-Rail Transit Stations, Transportation Research Record, No. 1538, Transportation Research Board, National Research Council, Washington DC, pp. 19-26.
[13] Walk Score, www.walkscore.com
[14] URBIKE (2006): Bicycle must become a priority for urban mobility. Press release, 19 September 2006, Seville.
[15] Commission of the European Communities (2006): Communication from the Commission to the Council and the European Parliament on Thematic Strategy on the Urban environment, Brussels.
[16] Ajuntament de Barcelona, www.bcn.cat