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D2.2 Key intermodality factors

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LIST OF ABBREVIATIONS

Abbreviation	Description
CCTV	Closed-circuit television
D	Deliverable
EU	European Union
IES	Intermodal Exchange Station
IMTI	Integrated Multimodal Travel Information
NTS (UK)	National Travel Survey United Kingdom
PERS	Pedestrian Environment Review System
PPP	Public Private Partnership
PTALS	Public Transport Accessibility Levels
TfL	Transport for London
TVE	Transport Visioning Event
WP	Work Package
UIC	International Union of Railways
UK	United Kingdom

ABSTRACT

In the first phase of the City-Hub project information from (European) research projects, policy documents, case studies and interviews with stakeholders have been collected and reviewed to understand what defines interchange quality. These state of the art results have been presented at the first City Hub workshop. At this event experts and stakeholders in the field validated the identified key interchange elements in different focus group sessions (the so-called “transport visioning events”). This deliverable reports the state of the art review (previously documented in Deliverable 2.1) and the identified key intermodality factors which have been validated in the workshop.

The state of the art review indicates that no interchange is the same, and that the success of an interchange depends on many factors including the position in the network, the urban environment, the modes involved and the legislation that is in force. Developing or designing interchanges is an intensive and complex process that involves different stakeholders. These stakeholders have different perspectives and different interests. This also leads to different priorities. The City-HUB project starts from a holistic approach taking into account these different perspectives and including all elements affecting the quality of an interchange.

A crucial element in providing successful multi modal interchanges is understanding the requirements of the users, both existing and potential travellers. A transfer is generally an unwanted interruption of a journey. Common elements that are important to travellers and affect their travel behaviour are perceived time and costs, travel time, reliability, convenience, comfort, security and accessibility. Various measures and facilities are available that enhance the quality of interchanges for users. Intermodal integration of modes (e.g. availability of secured bicycle stands), passenger services (e.g. integrated ticketing, way-finding, availability of shops) and design aspects (e.g. short distances between transport modes) are all important. It is crucial to understand that needs differ between types of users. The efficiency of an interchange matters most for frequent users and commuters. Such travellers should be able to proceed quickly between traffic modes without facing many barriers. Integrated timetables, concise information and good signage will support this. People with limited mobility or disabilities will benefit from facilities that support them with travelling. Interchanges may also be important places for businesses and retailers to locate. It makes sense to achieve balance in functional diversity and different user groups to avoid mono-functionality and social exclusion.

Transport operators use interchanges, and are in many cases involved in or responsible for their management and operation. Operability includes considerations of service coordination, integrated services (e.g. ticketing), maintenance and safety. Coordination of different modes also requires co-operation between different stakeholders. An interchange will benefit from appropriate, inclusive and on-going administration, and urban management arrangements that can take care of future alterations and changes, while monitoring operations.

This deliverable also shows that policy makers aim for more sustainable urban transport in the future. Interchanges are considered an important element in the transport networks, however national policies usually focus on modes themselves rather than their integration at nodes.

Various policy instruments can be used by policy-makers to provide for the implementation of accessible urban multi-modal transport systems and interchanges. With the instrument chosen having implications on what happens in practice. During project decision making financing and user benefits are key elements to consider for policy makers. Management and coordination are essential during the entire process before and during operation. A visionary lead is also helpful in the coordination and communication between different stakeholders.

The perfect interchange does probably not exist. However, the state of the art review shows that key elements for a successful interchange nowadays include efficient coordinated processes and management, accessibility for all, convenience and safety in use for all types of travellers, and addresses sustainability in design. These key intermodal factors have been validated in terms of completeness and relevance with interchange experts and practitioners. The participants confirmed that management of stakeholders (particularly relevant for larger interchanges where many stakeholders are involved and processes tend to be more complex), comfort, safety and accessibility are currently the key elements for successful interchange operation and design. In addition, information provision at interchanges should not be neglected and is an important service. Sustainability was less important.

1 Introduction

Urban public transport is considered as an important alternative to car transport and as such is an important element in the sustainable transport policies of urban policy makers. Interchanges are an important element that should facilitate seamless travel. Urban interchanges are subject to several analyses initiated by the European Commission due to the growing interest in the development of urban areas, the growing urbanisation trends, population characteristics as well as other socioeconomic targets; among others these could involve reducing car-dependencies, improving quality of life (hence decreasing the noise and emission effects of traffic but also enhancing social inclusion), improving transport system efficiency, developing better business models and other sustainability targets. The importance of well-designed interchanges in achieving these targets is obvious.

Interest in the quality of urban passenger interchanges in Europe has been growing since the beginning of this century and this has resulted in several European research studies. The project Guide (Group for Urban Interchanges Development and Evaluation) in 2000 was probably one of the first studies to identify existing European research and practices concerning urban interchanges. It highlighted that an interchange is an inescapable feature of public transport and assessed best practices in terms of functional specification and design. The project set the scene with the definition of distinct aspects of interchanges that were found to be of relevance for a seamless public transport system (such as accessibility, facilities, image and information provision). At the same time, the MIMIC project (1999) focused on considering the barriers to intermodality from the different perspectives of users, local authorities, and transport operators. Later the study “Towards Passenger Intermodality in the EU” (2004) was commissioned to create the basis for an EU work plan in the field of passenger intermodality. Key issues affecting interchanges were classified under the following three domains:

- Context or framework conditions (e.g. policy framework, legislation);
- Products and services linked with networks and interchanges (interoperability, ticketing, timetables, etc.); and
- Implementation (coordination and cooperation, resources, etc.).

In addition, several European projects have developed frameworks for evaluating interchanges, focusing mainly on the users’ perspective. Examples include the KITE project (2009a, 2009b and 2009c) and the PIRATE project (1999).

This shows that much has been done in the field of urban transport interchanges and knowledge development. In addition to the European studies, also on a national guidelines level, best practices and legislation have been developed to improve interchanges and maintain quality levels at a certain standard. The challenge is then to realise an end product that satisfies the interests of all stakeholders involved. City-HUB brings together results from research projects, academic articles and policy papers starting from these different stakeholder perspectives and a new holistic approach.

WP2 establishes the City-HUB project. It sets the scene and provides a solid basis for the project as a whole. The aim is to identify key intermodal factors that characterise a successful interchange starting from the holistic City-Hub approach. An interchange is a place where the traveller transfers between modes and where multiple parties are involved in the design and operation of the hub. This therefore means that multiple stakeholders are involved, who may have different objectives and different perspectives on what is a good interchange. This deliverable provides an overview of results from both theory/policy (Task 2.1) and practice (Task 2.2), identifies key factors and reports about the validation of these results (Task 2.3).

We have slightly modified the approach as originally described in the Description of Work, starting from the stakeholders' perspective to identify important elements from each of the different perspectives. An optimal interchange, i.e. one that satisfies all of the requirements of each of the stakeholders, will probably never be realised in practice. However, using the different perspectives relating to the design and operation of interchanges, we will address many elements. WP2 also reports about good practice examples. Results from these case studies will be used to illustrate and emphasize the importance of the different elements (see Annex A). In many cases, research literature about best practice focuses on one, or more, specific elements that makes a case study successful. Knowledge gathered from the available literature, together with interviews with an interchange operator and/or a transport operator (e.g. with Dutch Railways, to confirm specific elements, or clarify certain issues) form the basis for the information that is used in this report.

The outcomes will offer new insights into the promotion of complementarity and coordination between the different transport modes and their operators and users. They will additionally allow better understanding of the level of success in certain cases and enable an initial list of key intermodal factors to be defined. These factors have been validated at the workshop with key international experts (Task 2.3), where results from the review were discussed. Based on the above, a conceptual framework of key intermodal factors is derived in this D2.2. This framework will be used to assess the five pilot case studies with the aim of defining good practice, barriers and opportunities (Task 2.4). The output of Task 2.4 is a report with recommendations for the development of the City-HUB model (D2.3).

The figure below brings all of the tasks and their milestones together. The first two tasks retrieved information from existing literature and good practice cases (see also Annex A for an overview, note that these are different from the City HUB case studies) related to urban interchanges. This constitutes the basis for the WP2 outputs and is documented in this deliverable (and D2.1). In addition, also key indicators have been defined in an experts' workshop (Task 2.3). Based on these a data collection template will be generated and applied in five pilot European case studies (City HUB case studies, Task 2.4). The conclusions from the case studies will serve as inputs into the analysis of the organisation of interchanges in terms of their operational functionality, management (WP4) and so on, as well as to the City-HUB model which will be designed in WP5.

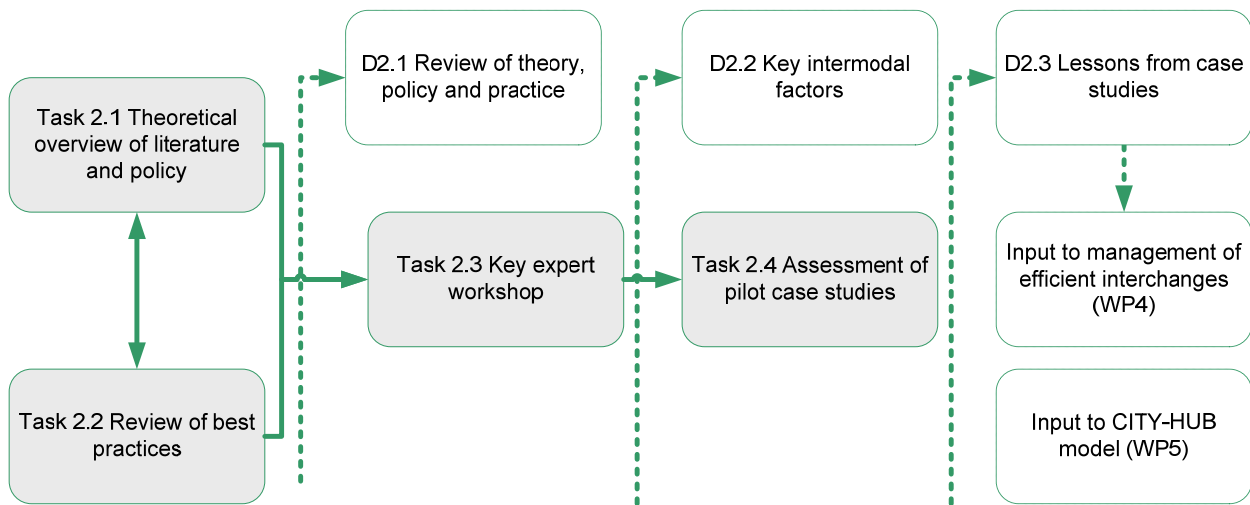


Figure 1: Workflow for WP2

This deliverable is structured as follows. Chapter 2 defines the framework for the analysis and gives scope to the work to be carried out. Chapter 3 presents results from research literature about the quality of an interchange from the perspective of the traveller. Chapter 4 presents results from the operators' perspective, while chapter 5 is devoted to the policy perspective. Chapter 6 reports about the workshop validation. This starts with the main outcomes from the review carried out in chapters 3 to 5 that were input to the workshop (all participants of the workshop received this information in advance (D2.1)), and outcomes of the workshop. Chapter 7 summarises and identifies the validated key interchange elements. The annex provides additional information about good practice cases (which are also mentioned throughout the text).

2 City-HUB Framework

The City-HUB project applies a holistic approach to the analysis and understanding of urban transport interchanges. Urban interchanges are as places where people transfer between one or more public transport modes (such as train, bus, metro, and tram stations). This report focuses on larger interchange stations (and not airports or single bus stops) although this does not mean that the findings will not apply to these types interchanges or stops. The report not only considers specific mobility issues, but also technology, economic, land use planning and social elements. This latter element is specifically important because it addresses the issue of providing mobility services to specific user groups such as the disabled and the elderly: i.e. enhancing social inclusion. The following figure outlines this approach:

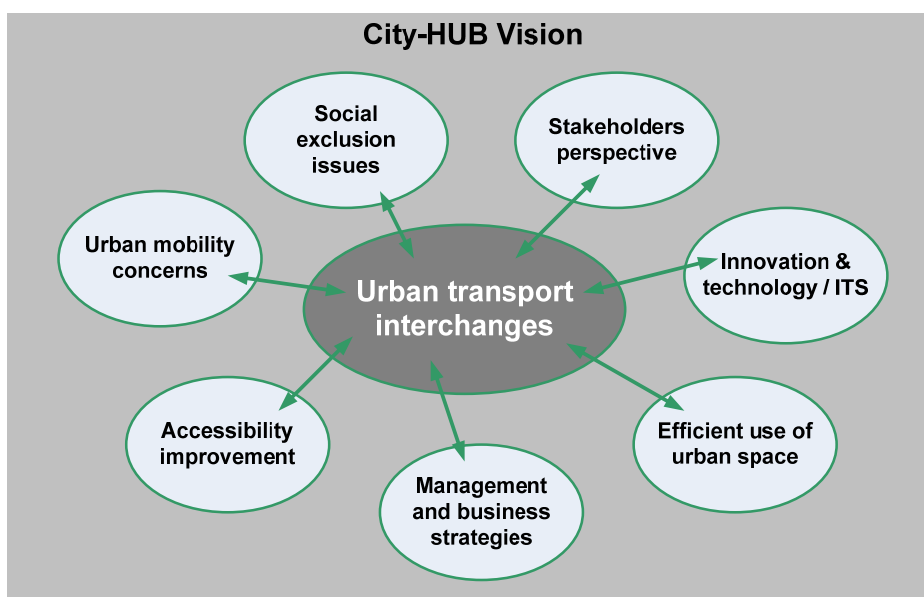


Figure 2: City-HUB Approach

Figure 2 shows that an interchange brings together different elements and involves multiple stakeholders. There are interrelationships between these different elements. Social inclusion may, for instance, be enhanced by improved accessibility for the disabled. Of course, the intention of a good interchange will generally be to improve the quality of public transport services and support seamless door-to-door travel. But nowadays an interchange is more than just a simple node in a network; it has many elements. Research literature shows that the benefits of urban interchanges relate to time savings, better use of waiting times, urban integration, and improved operational business models (Di Ciommo, 2002). This also links to the above figure where, besides accessibility improvements, management, and innovation, an efficient use of interchanges is also depicted. The City-HUB project aims to develop an integrated model which embraces the different aspects of an interchange in order to reduce the barriers to the use of public transport, improve the quality and propose a new business model.

To derive recommendations for interchanges, and to identify key interchange factors from practice and literature, we need to answer the question as to what is considered to be high

quality or good practice. Therefore, based on a large set of literature reviews and discussions with a few key experts (both within and outside the City-HUB consortium), this report will define a set of elements that are crucial to support seamless travel at interchanges and essential to establish high quality.

The KITE project (KITE, 2009b) has also studied good intermodal exchange practice. With this project rightfully pointing out that the design of an optimal interchange depends on the local framework, specific local circumstances and local behaviour. This makes it hard to generalise findings: best practice in Madrid may not be a best practice in Oslo for instance. Nevertheless consideration of the individual circumstances of an interchange can generate some basic recommendations for others. Secondly, it is clear that the definition of an optimal service depends on individual opinions: a high quality urban transport interchange will be different for passengers/travellers (even depending on the type of traveller), transport operators and society (KITE, 2009b). These groups seem to be the main stakeholders involved, with society represented by the national, regional or local government. There are common interests between the groups, but there may also be conflicting interests which have to be considered within the recommendations for the key interchange factors. The groups will have different objectives when using an interchange, and will have different demands for an optimal design. This deliverable will use these three different perspectives as the framework for analysis. This will be outlined in section 2.1 below.

2.1 Three perspectives

The present analysis attempts to provide a holistic view of the interchanges by exploring the views from three different perspectives:

- The interchange users (travellers);
- The operators and owners of the interchange; and
- The government.

The design and management of an interchange brings all these stakeholders together. A good interchange obviously benefits from good management and efficient interaction between these stakeholders. This issue will be addressed under the operators' perspective which needs to manage the interchange, and the policy perspective. Both need to cooperate and to communicate with one another. Decision making and the financing of interchanges will also be an issue for governments, and not only for the operator. Below we will briefly describe the different perspectives. The following chapters will outline the main elements for these perspectives, illustrated with examples from good practices in Europe and elsewhere.

2.1.1 Interchange users

Passengers' requirements depend on their mobility needs, but generally the benefit can be expressed in time respectively cost savings and convenient travelling (economists used to express this as generalised costs). This relates to efficient changes between modes, but also to comfort. Not only do mobility services facilitate seamless travel (such as bicycle stands, parking

lots, bus lanes, etc.). At interchanges travellers also usually need to wait and spend time. When services are offered, or shops are located at the interchange the quality of the time to spent waiting may improve. Comfort is nowadays a very important element of a trip, as well as the perception of security and reliability. This leads to several additional services at public transport interchanges besides the transport function itself. Many studies have identified important interchange elements for travellers, also making a distinction between the types of travellers. Commuters generally want to travel as quickly as possible, whereas leisure travellers tend to have fewer problems with longer waiting times at interchanges. Improving accessibility for persons with reduced mobility is also an important urban transport policy objective nowadays (see for instance Actions 3 and 5 of the Action Plan on Urban Mobility of the EC (2009) and the issue of service quality and passengers' rights in the White Paper on Transport (EC, 2011)). Accessibility needs depend on the type of disability. Interchange accessibility and social exclusion aspects are important and as such have been identified as an important element within City-HUB project. Chapter 3 will provide an overview of literature results on interchange elements that are important to travellers, and defining quality from their perspective.

Of course, transport operators also use the interchange. Bus companies use the roads, bus lanes and other facilities at the interchange to bring and collect people. The same holds for operators of metro, tram and train services. Usually (national) standards apply for the construction of physical infrastructure, depending also on the sizes of rolling stock. Interactive discussions will take place in the design phase between different stakeholders in order to construct an optimal interchange.

2.1.2 Operators

An interchange may be operated and managed by different organisations. Railway stations in the Netherlands for instance are operated by ProRail, the company that is also responsible for management of the rail network. But interchanges may be large and consist of different elements: a bus terminal, a rail terminal and access to the metro and tramways. This means that also different operators may be involved. For instance in the Lille Europe station management, the SNCF and Transpole are responsible for station operations and bus public transport respectively. In addition, regional transport authorities may also often be involved in interchange management and operation, with responsibilities for specific parts (e.g. urban public transport connections such as bus and tram stations). A joint venture of different stakeholders is often created to manage the entire interchange and coordinate processes.

The operator of an interchange (the organisation that is responsible for the day to day management) aims, in the first place, to achieve complete satisfaction of the requirements of the different users (the travellers and transport operators) and transport authorities (when involved). The operator also needs to take into account the requirements of the (central or local) government: they may therefore face certain restrictions on activities. The legal framework and local circumstances will affect the daily operation of an urban transport interchange. However, generally the operator aims to manage a cost-effective terminal with the challenge being to find a balance between the different needs from users and society (KITE, 2009b).

2.1.3 Policy and governance: society

Governments are usually considered as institutions that focus on the welfare of their citizens. Economists argue that when markets fail, welfare is not optimal which gives reasons for governments to intervene. Transport is such a market where governments often intervene. A common objective nowadays is to deliver a more sustainable transport system, with public transport being considered to be an important element in this. Not only to provide an alternative to the car from an environmental and efficiency perspective, but also to provide transport for the socially less advantaged groups. Interchanges are an important element of the public transport mode and should contribute to the quality, speed and comfort that is needed to compete with the car. A sustainable transport system should be efficient, clean, safe and comfortable. The European White Paper (2011) emphasised that a competitive transport system should be realised with an important role for collective transport. The integration of different passenger modes is important to provide seamless multimodal door-to-door transport.

Cost-benefit analyses have now developed into a common tool that assesses the contribution of different investment alternatives to welfare of a region or a country. Investments in interchanges may also be assessed by analysing the contribution to the economy and the society as a whole. This means that both the direct and indirect effects are important to governments. Besides modal split effects (resulting from travel time gains) that may be realised by a good interchange (although more probably depends on the quality of the public transport service in general), environmental effects, safety effects and effects on the labour and housing markets are also relevant. It is important also not to forget that these effects depend not only on the design and facilities of an interchange itself, but also on supporting policies such as limited or paid car parking near the interchange.

Interchange costs are also important to society. The outcomes of a cost-benefit analysis are affected by the way the interchange is financed. A public-private partnership may be feasible for instance, as we have seen for many transport infrastructure initiatives. Related to this is the business model that is applied; are urban transport interchange fees applied to users and how are revenues generated? Furthermore commercial activities at an interchange (e.g. shops) may generate revenues which may accrue to the operator or investor in the interchange and may cover operating expenses.

Governments also use legislation to realise objectives. Interchange operators have a certain level of flexibility in how they operate, however they need to obey the legal framework that is in place. In many countries national or regional governments have developed a legal framework that sets standards, for instance for accessibility of certain groups to prevent social exclusion and improve safety. In addition, spatial planning laws and environmental legislation are both in place which interchange developers and operators must obey. Larger interchanges are nowadays often part of large redevelopment programmes within cities, which means that a wider range of legislation than only public transport is important.

A final element is that different levels of government may be involved in interchange design and management. This can affect processes and decision making. Multiple levels of governments may be involved depending on the scope of the interchange. Besides national, regional or local

governments (municipalities), also regional transport authorities may be involved in transport policy making (in metropolitan areas such as Amsterdam, or Transport for London in London). In many cases the impact of governments goes further as transport operators are partly or completely owned by public bodies.

3 Interchange Users

Passengers' decision making processes or perceptions are complex and much influenced by their own personal characteristics and needs. This stream explores the research findings on the user's perspective. It is important to understand them in order to be able to provide better services and prioritise actions for improvement. Interchanges are used by many passengers and understanding their point of view is essential for the efficient management of existing interchanges or stations as well as for improving infrastructure design in the future (Monzon et al, 2013). Interchanges are the 'principle shop window' for the public transport system and as such the impression they give will be a major influence on perceptions of public transport (GUIDE project, 2000). Travellers seem to have different priorities depending on their age, purpose of travel and mode chosen. This particularly affects those with mobility impairments whose priorities may include additional factors to others travellers. However, there are also differences in needs between users and non-users (potential users) of interchanges, and men and women (PIRATE, 1999).

This section explores what research into travel behaviour tells us about the underlying factors that influence travel choices, and their specific implications for interchange; introducing the concept of the 'interchange penalty'. It then discusses interchange issues specific to each mode, and from these define a set of fundamental user requirements for a good interchange. Finally, it considers methods for assessing how well an interchange performs against each of these requirements, identifying some methods used for carrying out such a quality assessment.

There are a range of different types of interchanges varying in size from small rural stations to large urban transport hubs. This report focuses on larger, urban interchanges but not exclusively on transport hubs. The location of an interchange can be at the base of any mode of public transport, for example, bus, coach, metro, tramways; however they are primarily found at railway stations and secondarily in stations for other modes: buses, ports, etc.

3.1 Drivers of travel behaviour

A crucial element of providing successful multi modal interchanges is to understand the requirements of the users, both existing and potential new ones, and the factors that influence their modal choices. In the literature these factors are categorised in a number of different ways, but the following are very commonly discussed (Hine and Scott, 2000; Paulley et al., 2006):

- Travel and waiting time;
- Convenience and reliability;
- Comfort;
- Costs (fares, fuel price etc.); and
- Security (or safety).

Below we will discuss important items, and expand by identifying modal specific issues, accessibility and other movement related issues that define quality for the user.

3.1.1 Travel time and waiting time

Travel time includes not only the time spent on the move (in vehicle) but all travel time from leaving the origin of the journey to arriving at the destination. For multi-modal journeys, this could include waiting at a bus stop, travelling on a bus to the railway station; waiting at the railway station; travelling on a train; and then travelling from the destination train station to the final destination. In multi stage journeys waiting time can account for a significant fraction of the total travelling time. As missed connections can turn short delays into long ones, people often make an allowance for this in their estimate of journey times. Travel time is closely related to the users' perception of time as the use of travel time can depend on how much value travellers place upon it. This in itself is influenced by factors such as the level of income and the number of activities an individual has to do. This is important because people want to be productive with their time, however this can be limited by their choice of mode.

Whilst waiting at a bus stop either at the beginning of a journey or to reach their final destination, there is a limit to the activities a traveller can undertake due to the typical necessity to remain standing; this makes it difficult to use a laptop for example. However, it is possible to use a smart-phone for business or leisure, checking emails or making phone calls and it is also possible to read for business/ leisure. Depending on different users' preferences, their value of this time will also vary. As bus journeys tend to be relatively short, and often disturbed by the movements of others, users are often reluctant to use their laptops, thus limiting their perceived productivity. At a station the facilities available will govern how productively users can spend their time. Retail and eating facilities give users the opportunity to buy food and browse shops before their onward journey; and seated areas with Wi-Fi access provide users with an opportunity to work or browse the internet. On longer train journeys, seats with tables and plug sockets enable travellers to use laptops.

Compared with cars, it seems that public transport users have more opportunities to use their journey time productively while drivers are restricted to making phone calls using hands free equipment depending on the legal restrictions and thus cannot make use of their ICT equipment.

Until recently, travel time has been considered as the cost paid by individuals, and society, in order to benefit from activities at their destination (Lyons et al, 2007). However, this assumption is now being challenged as research suggests that journey time by public transport (notably rail) is increasingly being considered a positive benefit. ICT has a big part to play in this as it provides travellers with the opportunity to make full use of their travel time via laptops and smartphones (Lyons & Urry, 2005). Train passengers report using their time for activities such as leisure reading; working or studying; sleeping; talking to other passengers; and listening to music. Which of these activities people participate in appears to depend in part on the journey purpose but also upon the duration of the journey, with working and studying more frequently reported on longer journeys and by business travellers or commuters. This is due to the need for setting up and packing away work related activities; therefore on journeys of less than fifteen minutes, work is unlikely to take place with the exception of checking emails and making short phone calls.

It is how users feel they have used their time that is more significant than the actual activities themselves. Different people can perceive the same activity as varying in productivity. For example, reading for leisure can be viewed as a way to 'kill time' or as an opportunity to read when other situations do not allow it (such as a busy home life). Lyons & Urry (2005) reported that three quarters of passengers in their study considered their travel time not entirely wasted whilst 33% of first class passengers claimed they had made very worthwhile use of their time. However, the majority of those with laptops and mobile phones, admitted to not using them. The literature suggests while that ICT is considered more likely to improve the use of travel time for younger people. However, it is difficult to say whether ICT has enhanced productivity or simply substituted another activity. It is important to note that other uses of travel time are considered to have value to individuals, beyond those solely related to paid work. As noted earlier, time spent reading on a train can be considered time usefully spent by someone whose home life otherwise allows little time for it.

There is some research evidence to support the idea that people have a 'travel time budget', which not only limits the total amount of time people are prepared to spend travelling, but also implies that people prefer to have a minimum amount of travel. Metz (2008) argues that, across the world, people's average travel time per day has remained fairly consistently at about an hour. Reasons for this include both the need to allow time for other activities, such as childcare, shopping, leisure etc, balanced against a social need to travel. The implication for wider transport planning is that time savings for individual journeys arising from improved transport systems do not necessarily result in reduced total travel time, as there is a 'rebound effect' in which the time savings from one journey are used to increase travel elsewhere. In the context of interchange, the implication is that other uses can be made of travel time, whether work related, social or leisure, this time would not count towards the individual's travel time budget, so would increase their willingness to undertake that journey.

Planning also has a significant role in how transport users spend their time since it provides an opportunity for users to decide before the journey what activities they may wish to partake in to improve the productiveness of their travel time. In general, planning is linked to journey duration with people tending to plan for long or infrequent journeys rather than short or frequent ones. The more planning, the more likely travel time will be used productively. It is assumed that commuters do not plan as much as others because they have a travel routine, and have a packed bag or suitcase, which is not viewed as planning in advance.

Although most literature focuses on train journeys, it can also be applied to other forms of public transport such as buses, trams and underground rail systems. Although these journeys tend to be shorter, ICT still provides the opportunity to use time productively through activities such as checking emails or conducting quick phone calls.

3.1.2 Convenience and reliability

Convenience and reliability are often given as the main factors influencing travel behaviour after time and cost. This includes not only reliability and frequency of services but also the number of interchanges required as part of a journey, particularly longer ones (Balcombe et al, 2003). The convenience of multi-modal travel refers to travel information, integrated ticketing (see below)

etc, whereas comfort (discussed below) refers to the availability of facilities at interchanges and making the time spent at interchange pleasant and useful.

Travellers often perceive that cars are much more convenient because they provide door to door transport; multimodal transport requires more effort, including physical effort (walking longer distances, use of stairs, carrying luggage etc) possibly higher expenditure and generally take longer; and that interchanges involve waiting periods when the use of cars often does not (providing there is no traffic congestion on the roads).

For elderly people and those with disabilities, inconvenience is a considerable deterrent, with excessive walking distances to each transport mode and within interchanges being an issue. At interchanges, the elderly are less willing to accept changing platforms because it is inconvenient with their reduced mobility, and it is often not possible for them to determine prior to the journey whether lift facilities are available. People with luggage also have a similar concern as their luggage can act to reduce their mobility. Interchanges can involve several places where luggage handling is necessary which can dissuade people from using multimodal transport (Wardman & Hine, 2000).

For business travellers, with the aim of arriving at their destination as quickly as possible, interchanges are often considered an inconvenience as they involve waiting periods that can be avoided by cars. These people have a higher value of time and a greater desire or need to be productive with it.

Clearly, when considering the risk of missed connections, and how that risk is perceived, the punctuality and reliability of each stage in the journey makes a big difference to people's willingness to attempt the journey. Bus travel is commonly perceived to be less reliable than rail travel, which may have the effect of reducing people's willingness to use buses as the first stage of the journey, if arriving on time is considered to be important (Hine and Scott, 2000). Not surprisingly, even in the Netherlands where there is a high level of bus use to stations, buses are less likely to be used as access for business journeys than for leisure (Brons et al, 2009). However, this may not only be the result of perceived reliability, but also the image of buses being a less smart way to travel. In Madrid, following the construction of an Intermodal Exchange Station (IES) at Avenida de América, more people used multimodal transport because they no longer had to wait for buses in the street, but could look around shops instead. The IES also improved the look of the surrounding area, encouraging more people to use it (Vassallo et al, 2012).

Even within the rail network punctuality is perceived to be a barrier to meeting connections. It is worth noting that in the UK the rail industry's punctuality targets are based on times of arrival at the final station, and have the result that trains recorded as being 'on time' are possibly still late enough to miss connections at intermediate stations (Crockett et al, 2004).

3.1.3 Comfort and security

Comfort refers to the availability of facilities at interchanges and making time spent there pleasant. Comfort and security also influence people's decisions about how they travel. Lyons &

Urry (2005) offer the explanation that people prefer travelling in their cars to public transport because being in their car is close to being in a place of dwelling, where people feel comfortable and safe. Within a car it is possible for the users to behave almost freely as they would in their home, whereas on public transport, behaviour is in part governed by the etiquette of being in a public place. Within a car it is possible for the driver to control the sociability of the environment, such as conducting a business call via hands free facilities or listening to the radio in a private environment.

Public transport is usually viewed as less comfortable than cars are, due to factors such as uncomfortable (or lack of) seating, inadequate shelter, a lack of privacy, poor lighting and overcrowding etc. Shelter and seating are a higher priority to people travelling for leisure or those without time pressures. Getting a seat on transport modes is especially important for people when making longer journeys.

Users have a lower perceived value of time when they have access to more comfortable and attractive facilities. Shelters offering weather protection or where all round visibility is available, increase people's feelings of security and in turn their comfort (CfIT, 2000). Plaza de Castilla in Madrid is one particular example of an interchange with this specific requirement in mind with a large marquee joining two separate passenger areas to prevent passengers' exposure to the elements (Consortio Regional de Transportes de Madrid (CRTM), 2010). Comfort is particularly important for the elderly, those with disabilities and those with children. Facilities close to boarding areas are preferred. Similarly, by providing people with access to points of interest such as shops and places to eat while they wait at the interchange lowers their value of time and makes them feel more comfortable and reduces boredom.

Comfort is also linked to the stress or anxiety people feel at interchanges, such as the discomfort experienced in overcrowded areas. Overcrowding can cause people stress as it can make it difficult to move around an interchange, increasing confusion about which way to travel and increasing the risk of missing connections. People feel more comfortable in well-lit areas because they feel safer and have the opportunity to use their time productively or enjoyably for example, reading for leisure. The need to use interchanges also causes stress and discomfort particularly for people with reduced mobility or luggage as there is the possibility of physical exertion that they are uncomfortable with or the risk that they will not be able to make a connection. This discomfort is higher for short connection windows.

Security is closely linked to comfort and is a concern, particularly for unaccompanied females and older users, and especially when it is dark. Female users perceive walkways and tunnels at interchanges as being less secure than platforms and booking halls and therefore when travelling at night, this could be a consideration (London Transport, 1997). Passengers also have concerns about crime and overcrowding at busy interchanges, feeling they may be more at risk. However; they also feel at risk when interchanges are overly quiet or located in isolated areas. Coccia et al (1999) identified four main types of fear expressed by users in terms of security:

- Physical attack and sexual assault;
- Theft of cars, car parts and car radios;

- Theft of bicycles and bicycle parts; and
- Vandalism to vehicles and buildings.

The significance of these issues in terms of affecting travel behaviour depends on the levels of staffing and lighting at interchanges. The presence of staff is a major factor in increasing a passenger's sense of personal safety, with unstaffed stations often used less as a result. Interesting examples of interchanges with good security include Antwerp Central Station and Gare do Oriente, Lisbon which have in built police control centres as part of their design (KITE project, 2009a).

3.1.4 Generalised cost and value of time

Transport modelling usually seeks to predict transport user behaviour on the basis that they will try to minimise the overall cost to themselves. However, it is necessary to take account of a wider range of factors than just the out of pocket costs- fares, fuel etc. Travel time also has a value to the user and, as discussed previously, there are other more subjective factors which affect modal choice and are not straightforward to consider quantitatively. For this reason transport economists use methods to express these influences as if they were also costs to the user. The concept of 'Generalised Cost' is used, which is the total cost to the user when monetary values are applied to time and other impacts on the user.

For more subjective factors, and the cost of journey time, research techniques such as 'willingness to pay'¹ are used to try to give monetary values so that they can be included in Generalised Cost. Hence, the cost to the user of a journey, as measured by Generalised Time, will vary with the value they attach to time, comfort, how they can use their time, as well as with the direct out of pocket costs.

A related concept, which is particularly helpful in the context of interchange, is Generalised Time. Generalised Time is a measure of total journey time in which actual travel times for different stages of the journey are weighted by the users' perceived values of time. This is important because, in a multi-modal journey, the value that users allocate to the stages that involve interchange between the different modes: e.g. time taken to walk to bus stops, time spent waiting; time used walking between a bus stop and a railway platform and time spent waiting within the interchange. When interchange involves more than one mode, considerations also have to be given to the implications of different timetables, ticketing systems and information provision (Wardman and Hine, 2000).

¹ The willingness to pay is the maximum amount a person would be willing to pay, sacrifice or exchange in order to receive a good or service, or to avoid something undesired, such as pollution, or, in this case, travelling time.

As a result:

- Time is valued differently for different stages of the journey, for different journey purposes and by different groups of people. Waiting time and interchange time have a higher value than travelling time. Figure 3 shows this in terms of beneficial time, whereby time is more useful on a train journey for example than whilst waiting at an interchange.
- Travelling time is perceived differently for different stages of the journey, with waiting time consistently over estimated (RSSB Topic Note on Integrated Transport, 2009).

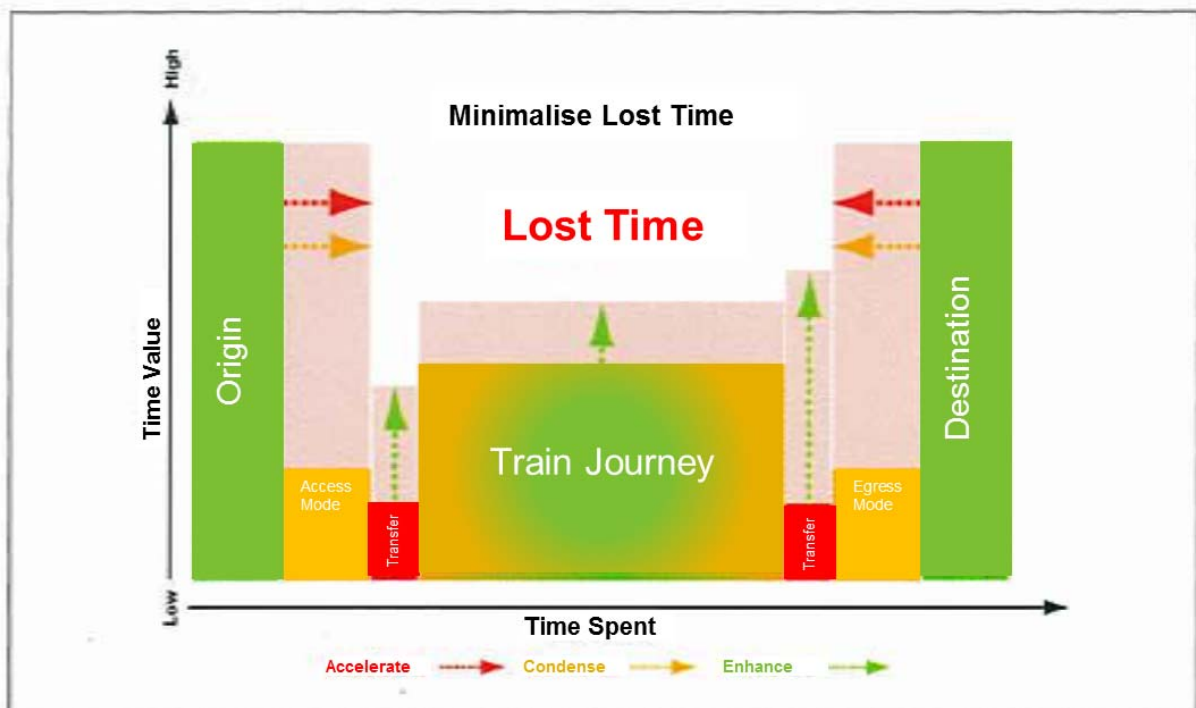


Figure 3: Value of time at different parts of the journey (van Hagen, 2010)

As a consequence, journey time as measured by Generalised Time involving interchange can be addressed at three levels:

- Reducing actual travelling time through improved vehicle speeds and reduced transfer times.
- Reducing the risk factors associated with unreliable travel times through better connections and improving information.
- Reducing the perceived cost of travelling time by enabling people to use their time more productively and providing them with more comfortable surroundings.

Time spent at interchanges is perceived by the user to last longer than travelling time (or be of less use as shown in Fig. 3). Methods taken to enhance the interchange experience reduce the perceived cost, thereby cutting total Generalised Time (and hence the Generalised Cost) without

having to make any actual time savings. Methods to reduce the interchange penalty can therefore be more cost-effective in decreasing the total Generalised Cost of a journey, and hence influencing traveller decisions, than efforts to speed up transport services themselves (RSSB, Topic Note for Integrated Transport, 2009). Therefore, identifying measures to reduce the interchange penalty should be a key element of the City Hub model.

3.1.5 The interchange penalty

The 'interchange penalty', the greater value of time attached to waiting and interchange, represents a barrier to 'seamless journeys' and to changing modes. Research literature suggests that the interchange penalty (also known as 'transfer barrier') dissuades people from making use of multi-modal transport, particularly between different forms of public transport (Wardman and Hine, 2000; Hine and Scott, 2000; McDonald et al, 2003; Crockett et al, 2004 and Preston et al, 2006). This interchange penalty comes about as a result of the extra time required to make a connecting journey, for example waiting at a bus stop, which is tied heavily to the risks of missing a connection, and the perceived hindrance associated with the perceived inconvenience and discomfort of the interchange. This penalty is observed in through higher values of time, or less use that people assign to waiting, walking and delays in comparison with in-vehicle time; and the overestimates of total travel time that people give when asked to estimate how long different stages of their journey take. This is made worse when people have nothing to do, with time at the interchange passing two to three times slower in this case (Van Hagen, 2012). In the Netherlands, the Dutch Railways are focusing in on addressing the issue of the interchange penalty, primarily through the enhancing of users' time at the interchange. This is achieved through improving their experience through amenities such as shops and making the interchange a more enjoyable place to be with infotainment available and visual stimuli such as lighting, art and greenery (Van Hagen & Martijnse, 2009).

The interchange penalty applies both to train-to-train connections and train-to-non train connections; however the literature focuses more on the former, with interchange times between modes not being fully considered (Wardman, 2001). In current UK passenger demand forecasts, for example, forecasting methods are not able to indicate how improvements to interchange between modes will affect passenger numbers (RSSB Topic Note on Integrated Transport, 2009); however an example from the Netherlands, the redevelopment of s-Hertogenbosch station resulted in an increase in passenger numbers from 26,800 in 1996 to 40,100 in 2002 following the new station opening in 1998 (Van Hagen & Peek, 2003). This redevelopment was based on three strategies to address the interchange penalty: to accelerate (reduce the waiting time); condense (reduce access and egress times by locating facilities closer to interchanges); and enhance (make the interchange a more attractive place to users). Another example is that of Moncloa in Madrid. Here, measures have been taken to specifically reduce the waiting time, and access and egress times (HERMES, 2011).

3.1.6 Reducing the risk of interchange

The interchange penalty can be regarded as a measure of the perceived risk attached to journeys by public transport. This can be viewed in terms of risk assessment². For example, the likelihood of missing a connection is connected to the punctuality and reliability of the previous stage. The consequences of this could include:

- Arriving when a station is empty and feeling unsafe; and
- Being late at the final destination e.g. missed appointments; or having less time there; thus making the journey less valuable to the user.

However, there may also be consequences for later stages of the journey, which can result in:

- Missing more connections, increasing the delay to such a much greater extent than would likely occur when driving;
- Missing trains for which advance purchase tickets have been booked, resulting in the user facing additional fare costs; and
- Having to use taxis for later stages of the journey, adding extra costs.

Lowering the risk of interchange, even without changing the actual timetabled journey time, still improves how people perceive their journey time, and so may encourage modal shift without transport operators having to increase average vehicle speeds. Brons et al (2009) suggest that increasing frequency of bus services is likely to have a greater effect than trying to reduce travel time to stations by bus. Some examples of measures that reduce the perceived and actual risk of interchange, and hence the interchange penalty include:

- Providing detailed information on different travel options at the final destination to travellers prior to their onward journey so they can plan ahead;
- Better timetabling information including real-time information and options at the final station so that travellers have the option to alter their plans during the journey;
- Secure and sheltered cycle parking to lower the risk of theft;
- Protection for travellers using booked or otherwise time restricted tickets from losing validity or incurring penalty fares in the event of missed connections caused by delays earlier in the journey; and
- Guaranteed connections, especially for end of the day services

Put simply, avoiding or reducing the negative impacts of lost time, i.e. making time more productive or fulfilling, is just as important as a saving in travel or waiting time.

² Risk is the likelihood of an event multiplied by the severity of its impact.

3.1.7 Modal specific issues at interchanges

For journeys to be seen as door to door, they need to be accessible, both physically and financially. User satisfaction with accessibility to stations has not increased as much as overall journey satisfaction; thus the importance of improving accessibility is now high. Continuous improvements are required, and at a higher rate, to increase or even maintain the numbers of people using interchanges (Brons et al, 2009). Currently, people still view interchanges as a barrier to using multimodal transport due to poor facilities, a lack of synchronisation between different transport modes, and restricted ticketing and therefore are less inclined to use it. This was highlighted in the EU funded MIMIC project (1999).

Research from the Netherlands suggests that improving access facilities at interchanges such as: connections between the transport modes; capacity of car parks; and guarded and unguarded bicycle parking increases the propensity of people to use sustainable transport for access. Rietveld (2000) argues that the whole journey is important, with the bicycle being a popular access mode as it avoids the need to wait at bus, metro and tram stops. It is also argued that investments in higher speeds between rail stations need to be balanced by investments in local accessibility to stations, as the further people live from a station, particularly over 3.5km, the less inclined they are to travel by train even when high speed rail is available.

Givoni & Rietveld (2007a) emphasised the importance of reducing distances from the station, not in a physical sense by opening new stations, but in the real and perceived sense of travel time. By this they meant improving public transport service frequencies to stations. They suggested that people who use rail less frequently are more likely to feel the benefits of such improvements. A survey by Passenger Focus (2010) found that access, egress and interchange improvements were more important for lower income households and those who use public transport less often. This may reflect wider accessibility difficulties facing low income groups which are part of the wider problem of social exclusion (Department for Transport, 2003).

Access and egress are the stages that present the greatest challenge from an end to end perspective for multimodal transport systems. Generally, people tend to choose their access mode based on convenience (ATOC, 2011). The mode of transport used to access or egress a station invariably depends on the distance of the origin or destination away from the station. Generally, for short distances there is a trade-off between cycling and walking and for longer distances public transport use is higher (Givoni & Rietveld, 2007b). Infrequent travellers and business users tend to use car more often as an access mode. Table 1 gives some examples that affect the interchange penalty in terms of access and egress (excluding in-trip requirements for example when changing trains).

Table 1: User requirements accessing and egressing interchanges

Mode	Access	Egress
Walking	Require: short distances from origins; direct routes from origins; easy/ safe crossings; secure routes (well-lit, CCTV monitored etc)	Require: short distances to destinations; direct routes to destinations; easy/ safe crossings; secure routes (well-lit, CCTV monitored etc); information on walking routes

Cycling	Require: relatively short distances from origins; direct routes from origins; easy/ safe crossings; covered/secure cycle parking close to interchange; cycle repair shop; on-train/bus cycle carriage	Require: relatively short distances to destinations; direct routes to destinations; easy/ safe crossings; covered/secure cycle parking at destination; cycle hire at interchange; information on cycle routes
Cars	Require: low-cost parking close to interchange; direct routes from parking to interchange; information on public transport services at interchange	Require: information on public transport services to destination; information on walking/cycle routes to destination; cycle hire at interchange
Bus/ other public transport	Require: close proximity of bus stands to interchange; easy/ safe access to interchange	Require: close proximity of bus stands to interchange; easy/ safe egress from interchange; information on walking/cycle routes to destination; cycle hire at interchange

Research into access was the focus of research in the Netherlands (Brons et al, 2009) and is also the focus of the UK Station Travel Plan pilots. The UK Rail Travel Survey report (DfT, 2008) provides information on the modal share of travel to stations, i.e. access, but not egress. However, when considering door-to-door journeys we must also consider the egress mode at the destination, which should not be assumed to be the same as the access mode, but may affect the choice of access mode, or indeed whether to make the journey by rail at all. Brons et al (2009) point out that even if housing is located very close to a station, rail will still not be used for commuting if workplaces are not also located conveniently for rail travel.

Getting to and from the railway station is an integral part of travelling by train; research has indicated that if getting to the rail station proves inconvenient potential rail passengers will often choose to make their whole journey by car, increasing congestion on the roads and adding to transport's carbon footprint (Passenger Focus, 2011).

Findings from past research on access to railway stations and on the inconvenience associated with the need to change vehicles during a journey (transfer) all indicate that the accessibility of the railway station can be a factor in determining if rail is chosen as a travel alternative (Hine and Scott, 2000; Krygsman et al., 2004; Wardman and Hine, 2000; Wardman and Tyler, 2000). Woldeamanuel and Cyganski (2011) found from a German Mobility Panel that people tend to use public transport more regularly when they are satisfied that the accessibility to it is good.

Passengers' satisfaction with the rail journey is partly the result of their satisfaction with the access facilities provided to them and, therefore, improving the quality of the access to the railway station is likely to increase rail use. The quality of access facilities was found by Givoni and Rietveld (2007a) to be even more important for infrequent rail passengers, indicating that improving the access to the rail network has the potential to increase their use of rail and can attract new passengers.

3.1.8 The role of integrated ticketing in reducing barriers to interchange

Monzon et al (2013) highlight that alongside time; cost is one of the most significant factors influencing people's decision to use public transport. The young and old tend to prefer saving money over time, particularly bus users. Business users on the other hand are less influenced by monetary cost. One way of addressing the cost barrier is by introducing integrated ticketing. This is an important component of integrated transport as it generally reduces cost and interchange time together because users do not have to buy an additional ticket for each stage of their journey; this in turn lowers the generalised cost. Users find it more convenient and often easier to use as they just buy one ticket for the completed journey and this reduces uncertainty about fares. It also raises awareness of alternative modes of transport, reduces dwell time when boarding buses, reduces queuing times at station gates and ticket offices and reduces ticketless travel.

In Europe, countries are increasingly introducing integrated ticketing systems in order to encourage people to use public transport. Within the EU initiative CIVITAS II (2005-2009) different measures were implemented in which innovative ticketing and payment systems for public transport were developed in order to increase the attractiveness of this transport mode and to increase the share of travellers using this mode in a range of cities across Europe (CIVITAS, 2010). Countries in Western Europe, such as France, Germany, Italy, Netherlands, Spain and the UK have had some integrated ticketing facilities for decades now. For example the Netherlands introduced the 'Strippenkaart' ticketing system in the 1980s and the UK introduced the London Travelcard also in the 1980s, so the concept of integrating transport ticketing to promote its use has been around for many years. The 'Strippenkaart' ticketing system has been replaced by the OV-chipcard which is electronic.

The most familiar integrated ticketing schemes at the moment are all-mode travelcard schemes, such as those that have been available in London for many years and, more recently, in other conurbations in the UK. Local transport add-ons to rail tickets are also available, with tickets to London zones available for many years but more recently the Plus-Bus scheme now provides a bus add-on in many towns across Britain (Palmer et al, 2011). These are very helpful for those using local public transport in the egress mode but, as rail tickets are not available on buses, are not so helpful for journeys starting with a bus stage. They are however, available by phone and online.

'Smart card' ticketing potentially offers greater flexibility in multi-operator and multi-modal ticketing (for example, the 'Sube-T' card in Madrid), increasingly making use of mobile phones to make bookings and carry out the transaction at ticket gates. This is already taking place in Stockholm and Helsinki through the use of SMS messages that are turned into machine readable tickets (KITE, 2009c). Through such methods, which can be linked to real-time passenger information, many of the informational and perceived barriers to the use of public transport can be reduced. Preston et al (2006) reviewed integrated ticketing systems as part of a study on user needs, and report evidence that integrated ticketing, like travel information, can help to encourage modal shift. The European Commission Smartcards Study Consortium (2011) reviewed the situation in relation to the development of smart card fare payment systems across

Europe (Fig.4. illustrates significant locations where smart card ticketing systems are currently in operation). They looked specifically at the benefits these bring to regular travellers and also the perceived and actual barriers to irregular travel, which smartcards can address. Smart ticketing brings a number of benefits to the user that traditional paper-based ticketing cannot necessarily deliver and is perceived to be a lot more reliable, convenient, faster and easier to use. Tariff structures such as ‘Pay As You Go’ can deliver greater flexibility for all users, not just those who use public transport on an irregular basis. Operational benefits include a decrease in dwell times at bus stops, faster transactions and less cash-handling which has increased the safety for bus drivers and other on-board staff. The flexibility provided by smart-ticketing can be used to personalise travel costs by providing user specific zonal based fares, tailored to their most frequent journeys, removing the need for pre-defined zonal systems. Again, reducing the level of cash handling improves the personal safety of passengers on public transport.

Integrated smart products in particular, such as pre-pay with capping, can allow people to use public transport networks in much the same flexible fashion that they might use the road network if they were a car user. Thus decisions about routes and timings can be made dynamically throughout the day in response to changing circumstances and without any concern about wasted expenditure on a suddenly redundant ticket (DfT, 2009).

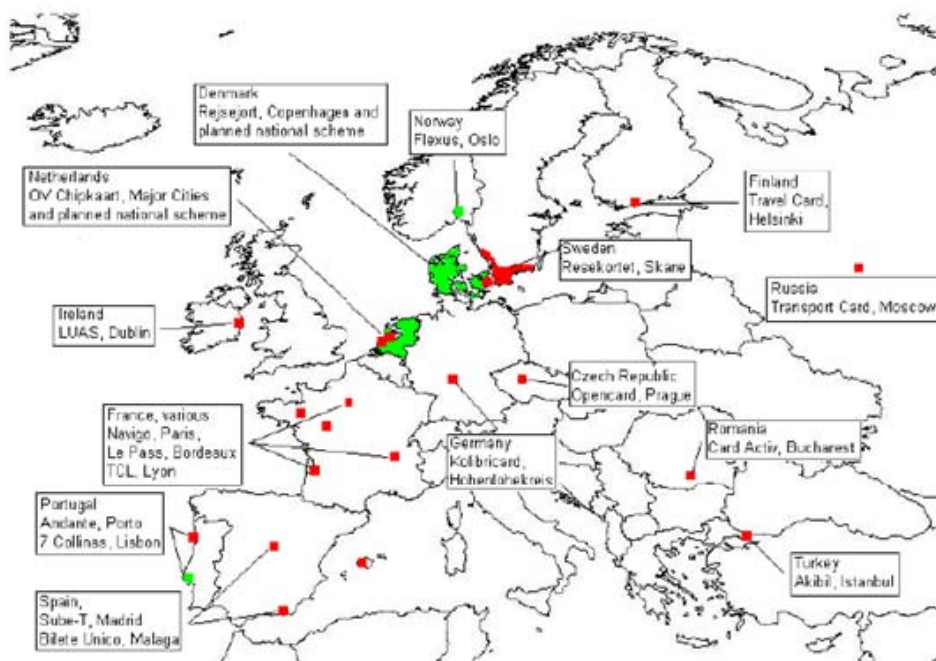


Figure 4: Smart ticketing schemes from around Europe (source: DfT, 2009)

Although the plastic Smartcard is a well-established media, there are other technologies such as contactless banking cards and mobile phones, which can potentially be used as a Smartcard, and which have the potential to significantly influence the future of ticketing for public transport.

3.1.9 Accessibility

The previously discussed factors affecting behaviour have provided a context for the main focus of this report: accessibility. Accessibility is important because it provides a key mechanism by which issues related to user perception of time and cost can be addressed, thus encouraging greater use of public transport. Many factors that people have listed as likely to increase their use of public transport at interchanges are connected to accessibility (Passenger Focus, 2011). Improved accessibility reduces not only the interchange time period but also the travel time of the whole journey and improves usefulness of time as well. Improvements in access can be a very cost effective way to improve perceived journey time.

It is not just large transport facilities and interchanges that persuade people to use other means of transport to the car, but also access to facilities such as cycle racks and bus stops near to the interchange. Some examples of the types of facilities that are useful to travellers and therefore may influence their decision to use an interchange are shown in Box 1. This includes best practice examples from across Europe.

Although satisfaction with accessibility has increased slightly over the last decade, for example in the Netherlands and in Germany (Brons et al, 2009; Woldeamanuel and Cyganski, 2011), it has not increased as much as the overall satisfaction with public transport. The importance of accessibility has increased over time. The combination of these developments has resulted in a steady increase between 2001 and 2005 of the negative impact of accessibility on the overall satisfaction with rail travel. While it is encouraging that the satisfaction with access is improving over time (the mean satisfaction score for each year is statistically different from that of other years) the higher importance passengers assign to this dimension means continuous improvements are required and at a higher rate (Brons et al, 2009).

Box 1: User facilities within interchanges (taken from the INTERCONNECT Project³)

User facilities at interchanges

Additional, conveniently located car parks

Example: To be found on many railway stations all over Europe. The Karlsruhe Central Railway Station is notable because its car park is located underneath the station.

Convenient positioning of local transport services

Example: Convenient positioning of local public transport can be found on many railway stations all over Europe. The Karlsruhe Central Railway Station is notable because the access / egress to tramways (directly in front of the station) are totally separated from the private car park. The recently constructed Leeds Bus Interchange, adjacent to Leeds train station, represented a significant improvement for many bus users in Leeds.

Convenient positioning of taxi services

Example: Prominent positioning of taxi stands can be found on many railway stations and airports all over Europe.

Moving walkways

Example: Most major airports in Europe have at least one moving walkway. For example, in

³ See: http://www.interconnect-project.eu/images/stories/deliverables/ic_d3_1_final_v1.1.pdf

Manchester, moving walkways are used to improve connectivity between Manchester Airport railway station and the Airport terminal buildings.

Elevators and escalators

Example: Elevators / escalators exist in most transport terminals

Level access to trains and buses

Example: Use of ramps for boarding and alighting trains is becoming common-place, particularly in countries such as Britain, where it is required by law. A programme of platform-height alterations has been undertaken across various parts of the London Underground and at selected British railway stations. Use of 'Kassel' curbs, or other raised curb designs, has been made in a number of locations, including the Leeds Guided Bus system and the Karlsruhe tramtrain.

Visibility axis between modes

Example: Railway station Amsterdam Duivendrecht, Frankfurt Airport long distance railway station to terminal 1.

Direct, un-interrupted, logical paths

Example: Many interchange points have such a layout. Railway station Amsterdam Duivendrecht is mentioned in one of the sources reviewed.

Provision of assistance for travellers with reduced mobility

Example: For rail, assistance is often available with prior arrangement, and a national system of disabled passenger rail assistance exists throughout the UK. However, the 'mode-specific' assistance sometimes breaks down where there is an interchange but the two modes are not immediately co-located. The "Bahnhofsmission" has existed to offer assistance to passengers at large train stations in Germany for more than 100 years.

Several European train operators offer assistance to passengers. The service offered by Deutsche Bahn is detailed on its website.

Tactile guidance systems for disabled

Example: Tactile guidance systems are standard in several countries such as the UK. Furthermore, new build stations tend to be equipped as standard e.g. the stations of the Karlsruhe TramTrain system, the recent interchanges of Madrid.

Improved lighting

Example: From the literature reviewed, the lighting at the rail station in Bern, Switzerland has been identified as an example of good practice.

Increased space and comfort at waiting areas

Example: When luggage/ mail transport was ceased in Germany some 20 years ago, the layout at some main stations of the German railway network was changed: The separate platforms for luggage / mail feed to trains were removed in favour of moving the tracks in a way that the passenger platforms could be made wider.

Provision of services for travellers

Example: Services for travellers are offered more or less at every interchange point. What distinguishes "good" examples from the mass is often the layout and arrangement of these services in the interchange. Good examples identified in the literature include Zurich Central Station and Madrid Atocha station.

Provision of monitoring cameras

Example: Numerous interchanges are equipped with monitoring cameras.

Cycle facilities at modal interchanges

Example: Amsterdam Central railway station and the Osterport railway station in Copenhagen are

well known examples of stations equipped with such bike facilities.

Multi-modal information and ticketing booths

Example: Transport for London's six travel information centres: Liverpool Street, Piccadilly Circus, Euston, Victoria, Heathrow Terminal 123, and King's Cross.

3.1.10 Movement

Interchanges are dynamic environments with people wanting easy access to a range of transport modes and having to cater for a range of users with different mobility and disability levels means that there is the potential for conflict. This is particularly the case when movement is restricted (for example at small interchanges or as a result of overcrowding) with people walking at different paces and in different directions. A good design layout of an interchange has sufficient space that it allows people to each walk at their own desired pace without adversely impacting others around them.

People intuitively dislike crowded spaces and prefer to avoiding bodily contact with others, thus crowded spaces usually make people feel less comfortable. However this depends on the cultural background of the country; that makes people feel more or less uncomfortable or frustrated by crowded spaces.

Fruin (1971) created an index, known as the Fruin Index that indicates different levels of crowding in public places (shown in Fig. 5) ranging from free circulation to a complete breakdown in traffic flow. Doorways and access points are a particular problem area as they act to channel pedestrians moving in opposite directions into a reduced space. It was suggested that the physical dimensions of the human body should be used as a basis for designing public spaces. It needs to be taken into account that users are invariably carrying personal items and therefore would prefer even more space for security reasons than they would without them.

Overcrowding is a particular problem in urban agglomerations such as South-East England, Benelux, The Ruhr region and the Po Valley. The numbers of commuters in Europe using public transport are increasing as people wish to avoid road congestion, and therefore movement is becoming increasingly reduced at peak travel times.

Crowding results in significant reductions in pedestrian convenience as movement speeds are restricted, due to a loss of freedom to manoeuvre within the traffic stream. Since convenience is a significant factor in decision making, significant overcrowding is likely to reduce people's propensity to use interchanges, or at the least, increase their value of time. In Madrid, the interchanges have undergone mobility simulation studies to ensure that movement around them is safe and comfortable for the user (Consortio Regional de Transportes de Madrid (CRTM), 2010).

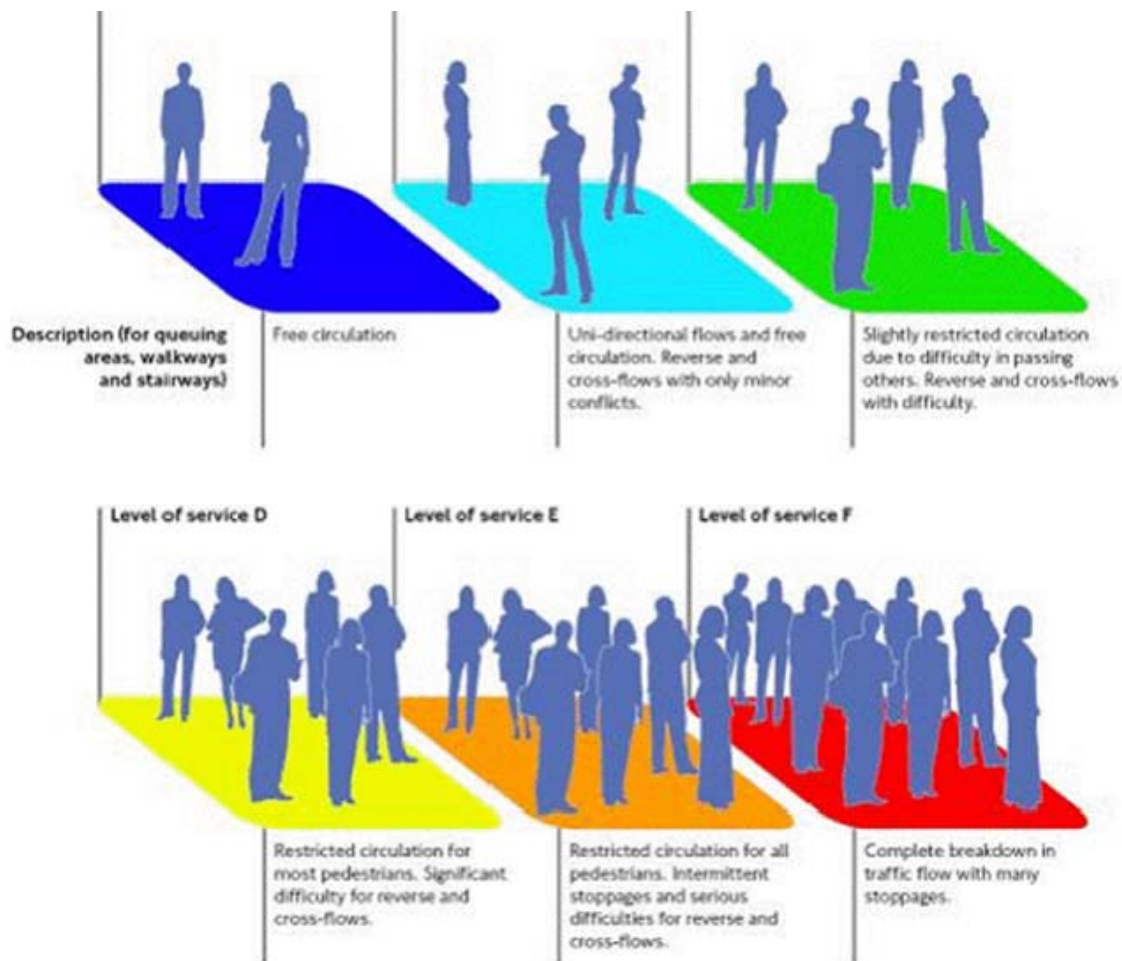


Figure 5: Level of Service Illustrations for Walkways (Network Rail, 2011a)

In the UK Transport for London has developed a methodology for assessment pedestrian comfort, which is used, amongst other things, to gather baseline information to inform the design of transport interchanges, where high pedestrian flows often occur⁴.

3.1.11 Social inclusion and mobility

Public transport is crucial for people living on a low income or with disabilities who do not have a car available to them. It provides them with access to facilities such as employment opportunities; public services such as health and education; retail facilities; recreation and leisure facilities; and friends and relatives. Poor access to transport services can often compound the problem of living on a low income. Through factors such as this, mobility has an influence over people’s quality of life (Bannister and Bowling, 2004). The MOBILATE structural equation model in particular found that out of the home mobility has a large impact on the quality of life amongst the elderly in Europe (Mollenkopf et al, 2005). Thus transport disadvantage (i.e. having a lack of accessible transport) can increase social exclusion (Delbosch and Currie, 2011).

⁴.www.tfl.gov.uk/assets/downloads/pedestrian-comfort-guidance-technical-guide.pdf

The EU Matisse Project (2003) identified 6 aspects of transport that are important to users. An absence of any of these can result in social exclusion:

- Mobility level: the ability to travel, affected by access to a car, bike ownership, or disability which means the user requires assistance.
- Accessibility: physical accessibility at all journey stages and interchanges including over time as well as space.
- Affordability: the scale and nature of the cost relative to means (i.e. costs/income ratio).
- Awareness: information provision, mentoring and tutoring on travel opportunities.
- Assurance: confidence and control in ability to make journeys and wider horizons, affected by transport reliability issues, personal and road safety fears etc.

Delbosc and Currie (2011) found in their study that the people who reported lowest well-being faced both transport disadvantage and unemployment or low social support.

Door-to-door transport including interchanges enables easier access to these facilities and with integrated ticketing, the cost is reduced. Also, across Europe, people are being offered 'travel training' aimed at older people, disabled passengers or persons with learning difficulties to help remove the uncertainties that people have and get them familiar with how to use public transport, including buying tickets, where to find timetable information prior to the journey and real time information when at an interchange (Cré et al, 2008 in the NICHES + projects). Munich, Germany is a particular example of where public transport training is taking place (AENEAS, 2011).

It is important for interchanges to have strong access facilities for people with limited mobility or disabilities. By providing for disabilities, good design of the pedestrian and transport environment will also be of benefit to people with small children, people carrying heavy shopping or luggage, people with temporary accident injuries and older people (GUIDE project, 2000). This will become increasingly important as in the coming years Europe faces dramatic demographic changes with the share of older people rising in all societies. This will likely lead to an increase in the number of people with impairments related to mobility requiring better access to public transport facilities such as interchanges. This was highlighted in the EU NICHES+ project by Cré et al (2008). This older generation will be made of the Baby Boomer generation, who are healthier and wealthier than those before them and more dependent on cars. Therefore they will be more inclined to use cars over public transport unless public transport in the form of interchanges is accessible and provides a reasonable level of service (Currie and Delbosc, 2010).

There are two primary barriers for people with disabilities: informational barriers and physical barriers. In terms of information, the unpredictability of the journey experience, particularly when an interchange is required is a significant problem (TfL, 2012). The impact of disruptions on disabled passengers can be greater than others as alternative route options may be more limited. Accurate and reliable real-time information tailored to the needs of disabled people is therefore vital, as is information prior to the journey. This can give users information not only about their journey, but also the facilities available to them at an interchange and whether

facilities such as lifts or escalators are out of service, thus enabling them to prepare and reducing unpredictability and concern about using interchanges. Audiovisual assistance systems such as those indicating arrivals of buses and trains are available in different technologies in cities such as Madrid, Prague, Dresden and Linz but are still not very well spread throughout Europe (Cré et al, 2008 in the NICHES+ project). Information online can also be used by those whose first language differs to that of the main residents, encouraging tourists and international residents to make use of multi modal transport also. Physical barriers for people with disabilities are primarily related to boarding and alighting of public transport modes at interchanges and crowding within each of the three interchange zones, restricting movement. As the main mode of transport for many disabled people is walking (or in a wheelchair), improvements are required to improve access outside the interchange through measures including clearing obstacles and tactile paving. This will not only enhance the interchange experience but improve the whole journey. A number of interchanges in Europe are notable for their barrier free access and tactile design for users with reduced mobility. These include Berlin railway station, Gare do Oriente in Lisbon, and Linz Central station, Moncloa in Madrid (KITE project, 2009a; HERMES, 2011).

In the UK, the Department of Transport provides a set of 'inclusive mobility guidelines' (2005) for people with locomotion; sight; hearing; reaching, stretching and dexterity; and learning disabilities. These suggest that at the interchanges themselves, people with visual and aural impairments should have access to well-lit areas with high contrast, large print timetables, pictograms and signage; and improved public address systems and enhanced customer service. The guidance also outlines specifications for physical design for people with locomotion difficulties (people who are in a wheelchair or use walking aids); these include:

- Width of walkways;
- Design of steps/stairs;
- Signage;
- Height of buttons/machines;
- Lifts;
- Ramps;
- Platform facilities;
- Flooring;
- Shelters; and
- Pedestrian facilities outside the interchange, e.g. road crossings, paving, bus stop flags, way finding signage.⁵

However by contrast, in the Netherlands, facilities for people with disabilities are lacking due to a combination of these users only making up a fraction of the total travellers using interchanges and the expense that fitting such facilities would cost to travel operators. Thus this is not a

⁵ For more details, see:

https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/3695/inclusive-mobility.pdf

priority. Other parts of the world are taking an opposing view by investing in the retro fitting of existing public transport infrastructure and the provision of new, accessible infrastructure to enable access for people with physical impairments (including the elderly). Australia is one such example (Currie and Delbosc, 2010).

3.1.12 Way-finding and passenger information

It is important to have good signage within interchanges to enable people to quickly locate where they need to be for their connecting mode of transport. At bus, tram or underground/metro stops, there should be clear directions to where connecting services can be found and the same should be applied at railway stations where information should also be available about connecting bus services and taxis (CfIT, 2000). Clear signs for pedestrians regarding platform numbers, services and facilities are required to enable users to find their way in the shortest time period possible, reducing the interchange penalty. The larger or more complex the interchange is, the greater the signing requirements of the user (Coccia et al, 1999). Information provides the following benefits to multi-modal travel:

- Assisting the planning of journeys;
- Supporting the promotion of public transport by raising awareness of alternatives; and
- Helping the traveller to reduce the risks of travelling and manage the consequences of delays that occur during the journey.

Examples of information systems include:

- Telephone call-centre services;
- Online rail journey planners, which is essentially single modal but is increasingly providing information about transport services available at stations;
- Multi-modal planners such as Transport Direct and TfL's online service for London;
- Real time information, e.g. the Real Time Passenger Information (RTPI) system in Ålborg, Denmark; MOBITRANS in Nantes, France, bus and metro system in Madrid (Palmer et al, 2011); and
- Live mobile updates, e.g. text messages, enabling travellers to know, for example, when the next bus is expected before starting their journey or even on route as available via iPhone.

A range of different information services have been identified and reviewed for Rail Research UK (Preston et al, 2006, Crockett et al, 2004). They conclude that these developments are promising and cite research showing that such services have the potential to encourage modal shift. However, this is another aspect of multi-modal travel that is not currently fully taken into account in the transport models used for passenger demand forecasting, making it more difficult to develop a business case for investment in improved information. Further research is needed to quantify the impacts of information systems on passenger demand so that forecasting methods can take it into account. It will be necessary to ensure that information and journey planning services are designed and targeted to meet the needs of different users and journey purposes, in particular those who are not currently public transport users.

Information provision also plays an important role in 'smarter travel' behavioural change programmes, such as workplace travel plans and personalised travel planning. Smarter travel measures have been found to deliver significant modal shift, with reductions of car use of over 10% commonly achieved, even where no significant changes have been made to transport infrastructure or services (Cairns et al, 2004). Earlier studies suggest that the largest changes are in local journeys, with significant increases in walking and bus use, however this suggests that smarter travel has a role to play in encouraging these modes for travel to stations as part of longer distance journeys (Palmer et al, 2011).

3.1.13 Journey planning and real time information

The quality of integrated multimodal travel information (IMTI) desired by travellers varies throughout the pre-trip, wayside and on-board stages of a journey. The key factors are time savings (travel and search time) and effort savings in the form of physical, cognitive, and affective effort (Grotenhuis et al., 2007).

Prior planning is crucial nowadays for users of public transport, more so those using the interchange when travelling for leisure. Having information before travelling makes the user more comfortable with their choice of journey, reducing stress and lowering their value of time at the interchange when changing transport modes. It also means they are able to plan any spare time they have at the interchange to their own needs. Grotenhuis et al (2007) found within a sample of Dutch travellers, where young persons made up a substantial share, that the pre-trip stage turned out to be the favourite stage to collect IMTI when planning multimodal travel. This service is not really available for car journeys. Online information is the dominant type used by people to decide on the best route for them prior to the journey and in general it is perceived to provide more reliable up to date information about timetables and fares rather than paper leaflets available at stations. It means users no longer need to ask members of staff at an interchange and thus saves time within the journey itself. Prior planning is of benefit to all modes of transport from walking and cycling to bus and rail and enables people to become comfortable with the idea of using an interchange, making them more likely to do so.

The most readily available information useful for planning prior to travel is of rail with most travel operators offering this service online. The website of the German national railways has a very convenient route planner that covers almost the entire European railway network (and beyond), as well as bus, metro, and ferry connections in Germany.⁶ This enables the user to easily view different connection options and book the whole journey saving time and often money including deciding on waiting times at different interchanges. ATOC (2011) found that up to 60% of passengers in the UK plan rail in advance of their actual journey using online information. Users are able to view all their possible timetable and fare options, a station map, station facilities and often have access to onward travel information on rail journey booking websites, usually for buses.

Obtaining information about bus services prior to travel gives users the ability to view their likely waiting times before the journey. Invariably bus timetables do not provide information about

⁶ <http://www.bahn.com/i/view/GBR/en/index.shtml>

other travel options. However, they do provide information about access on individual bus routes, whether buses have low easily accessible floors for the disabled or people with small children and luggage or wheelchair access. It is also possible to obtain information about whether bus routes have Wi-Fi availability on board and accept smart card tickets, giving users information in advance about how they can use their time and how they can purchase tickets. In general, it is less likely that users will be able to purchase tickets for single or return journeys in advance, (this is why smart card or integrated ticketing is of benefit) however it is possible for frequent travellers to purchase longer term tickets ranging from weekly through to annual depending on the operator.

For cycling and walking, prior planning is particularly important for assessing how long to leave for journeys to and from an interchange. For cycling it is particularly important to find out whether the interchange being used has cycle parking facilities and whether these are secured or unsecured; which services offer cycle access on board for those who wish to use their own bicycle for both access and egress; and which interchanges offer bicycle hire. For both walking and cycling journeys, users need to plan their route to the interchange, requiring a route map. In London, Transport for London offer a walking journey planner service, whilst in Madrid, the journey planner offered by CRTM combines public transport options with walking routes and maps⁷. This allows for people to become comfortable with their chosen route beforehand, seeing where cycle and footpaths are and noting whether there are any areas nearby that would make them feel unsafe such as alleyways or busy roads that require crossing since these act as a barrier to walking (CIHT, 2000). The user can explore different possible routes depending on the time of day they are planning to take their journey and whether they are travelling alone or in a group. This is increasingly possible with services such as Google Street Maps where people can see photo images of where they may be walking or cycling. If people do not feel they can comfortably access the interchange on foot they are unlikely to do so, instead either using a car to travel to the interchange or just using a car for the entire journey.

Availability of comprehensive real time information (before the journey is made, at the start of the journey and during it) is vital to increase the attractiveness of multimodal journeys (CfIT, 2000). Real time IMTI at interchanges is important to users as it helps the traveller to catch the right vehicle whilst on-board travellers are most concerned about punctual arrival at interchanges in order to make connections (Grotenhuis et al., 2007). IMTI provides users with information about connections to other transport modes, current delays and in large stations, the fastest services to a range of destinations; allowing users to make quick decisions about their onward journey. This is particularly important to commuters and those users travelling for business, for whom time is a significant factor. Real time information screens on platforms, such as those in Linz (KITE project 2009a), also impact upon user perceptions of reliability, security, customer service and effort, giving users an improved image of rail as a mode of transport (Crockett et al, 2004).

As the use of mobile technology has increased, users are increasingly able to view real-time information on their way to the interchange if their access mode enables them to, for example on the bus or walking within areas that have internet access available. The advantage of this type of service is that users can tailor it to themselves, showing only the information they need (ATOC,

⁷ http://www.ctm-madrid.es/servlet/IdiomaServlet?xh_IDIOMA=2

2011) and by having this available to them, users can have the information they need before they even reach the interchange, significantly cutting time spent at the interchange.

3.2 Assessing the quality of interchange

Following on from the passenger requirements identified, it is necessary to establish approaches to design and assessment of interchanges.

The Network Rail (2011b) design and evaluation framework for station zones (see Fig. 6) can be used as a basis for designing interchanges that encompass not only railway stations, but also bus, coach and metro stations with an emphasis on increasing the usefulness of users' time.⁸



Figure 6: Interchange zones (source: Network Rail, 2011b)

As shown in the diagram, an interchange can be divided into three key zones. A typical user experience at an interchange might consist of:

- Arriving by bus outside the entrance of a railway station in the 'Access and Interchange Zone'.
- Moving into the 'Facilities Zone' via walkways.
- Spending time in the 'Facilities Zone' purchasing a ticket for the onward journey; checking journey information; visiting the retail and catering outlets; and making use of the public convenience facilities.
- Moving to the 'Platform Zone' via walkways.
- Using time in the 'Platform Zone' to check emails remotely and check journey information before boarding a train for the onward journey.

⁸ An alternative framework is used in the NODES project, whereby instead of having three zones to an interchange, there are two: a fast area and a slow area. The fast area is where the changing of modes takes place and the slow area is where the majority of facilities are located.

Assessment can include assessment and guidelines related to mobility, movement or general passenger satisfaction. Crossrail recently undertook an assessment of Ilford station on the outskirts of London, covering both site and movement analysis with the aim of improving it as an interchange (Crossrail, 2012).

In the UK, the government has a general set of standards or indicators regarding quality of interchanges (shown in Fig.7).⁹ It focuses on the key factors of: the connections, information and facilities that should be available to passengers at an interchange. The aim of the passenger interchange assessment is to identify in broad terms the extent to which particular indicators would change following implementation of a particular strategy or plan together with the number of passengers affected. The passenger interchange assessment should include intermodal interchange, including interchange between public transport modes (such as bus-train) and between public and private modes (such as park and ride by bus or train).

There are a number of different interchange design and assessment tools that can be used to address the issue of accessibility in terms of user requirements. These cover general guidelines for interchanges as well as aspects of pedestrian walking routes around interchanges, movement within interchanges and inclusive mobility. The nature of the passenger use of the interchange should have an influence on how it is designed, because much of the design process will be concerned with compromises between conflicting objectives, depending on which factors different groups of users give greater priority to (GUIDE project, 2000). It is important to use these tools to design interchanges that are no longer viewed as a barrier to multimodal transport, in order to encourage more people to use them. Leemans & Ivkovic (2011) have developed a particular toolkit for the design and or renovation of major interchanges, breaking the design process into three different categories: Architecture, infrastructure and interchange station's urban context; Equipment and human interaction; and Human engineering of the space.

⁹ <http://www.dft.gov.uk/webtag/documents/expert/pdf/unit3.7.1.pdf>

Passenger Indicator	Poor standard	Moderate standard	High standard
Waiting environment	Old, uninviting, uncomfortable, non-existent or poorly-lit waiting room.	Some comfortable waiting rooms, but improvement or upgrades still needed.	New, inviting and comfortable well-lit waiting room.
Level of Facilities	Terminal old and needing upgrade. No or very poor buffet. No other facilities available.	Some good facilities, but others needing replacement or upgrade.	Modern terminal, good buffet and/or other facilities available
Level of information	No announcements, partial timetables, absence of automatic displays or information office.	Full timetables and announcements, no automatic displays or information office. Information level could be improved.	Frequent announcements, full timetables, automatic displays, information office.
Visible staff presence	No visible staff presence for most of the time the terminal is open.	Staff presence visible at some times terminal is open.	Staff presence visible at all times terminal is open.
Physical linkage for next stage of journey	Physical linkage impossible without use of more than one bridge or subway. Need to change to a physically separate terminal.	Physical linkage possible with use of a single bridge or subway. No need to change to a physically separate terminal.	Physical linkage possible without use of bridge, subway or changing to a physically separate terminal.
Reliability of connection	Timetable largely un-coordinated. High risk of missing connections.	Some timetable coordination but still a moderate risk of missing connections.	Timetable coordinated or guaranteed either within or between modes to minimise risk of missing connections.

Figure 7: Recognition of Low and High Standards for Interchange Quality (source: DfT, 2003)

In terms of inclusive mobility, as previously mentioned, the UK government also has in place a set of guidelines regarding accessibility for people with disabilities at public transport facilities¹⁰. These can be used in the assessment and design of interchanges to improve them in line with passenger needs.

The PERS assessment tool¹¹, as well as pedestrian comfort surveys, can be used to identify opportunities to improve pedestrian walking routes and public spaces, in order to provide a better pedestrian environment, for example around interchanges, thus encouraging people to walk more. The tool has previously been used as part of an assessment of Ilford station, to inform the early design process of a redevelopment of the station¹². PERS has been widely used in London for assessing the quality of the pedestrian environment and identifying priority issues that need to be considered in the detailed design stage of schemes.

The Fruin Index can also be used to apply standards to interchanges in terms of the movement of people and overcrowding in and around interchanges, as can a similar overcrowding

¹⁰ <http://www.dft.gov.uk/webtag/documents/expert/pdf/unit3.7.1.pdf>

¹¹ https://www.trlsoftware.co.uk/products/street_auditing/pers

¹² <http://www.cityhub.imet.gr/Default.aspx?tabid=101>

management chart developed by the RSSB¹³. PTALS (Public Transport Accessibility Levels) have also been used for London to measure accessibility to the Public Transport network or network density (Transport for London, 2010).

The European NODES project is currently looking in depth at the design and assessment of interchanges in terms of their fulfilment of user requirements. This particular project highlights the importance of the image of the interchange, its architecture and atmosphere and how good design can have an impact on user volumes.

Other examples of assessment tools include:

- The Station Travel Plans that have been developed in the UK involve conducting a 'site audit' to assess the quality of access and interchange, to identify barriers to sustainable modes and help prioritise where improvements can be implemented. A Site Audit template has been developed which is used to assess things like the availability and quality of cycle parking, public transport information, information on walking routes etc., and the quality, comfort and security of waiting areas.¹⁴
- Service quality assessment methods have been developed for airports, which has transferable experience that could be applied to more conventional transport interchanges.¹⁵
- Transport Scotland has a service quality assessment framework for assessing the quality of stations, amongst other things.¹⁶

3.3 Conclusions

Transport research provides a theoretical basis for understanding the requirements of interchange by applying the fundamental drivers of travel behaviour, and understanding how people perceive time both while travelling and during interchange. This leads to the conclusion that the act of changing modes is of itself a barrier, known as the interchange penalty. Using this knowledge a set of requirements and measures for reducing the interchange penalty for good interchange can be identified, and a variety of methods can then be used for assessing interchange against indicators based upon these requirements.

The main aspects that are important to users of multimodal transport are time and cost. However, travellers do not perceive time as having the same value throughout a journey, for example, regarding time spent waiting as equivalent to a longer period of time spent on the move. Many different factors, including individual preferences and circumstances, such as whether people feel comfortable, or can use time productively, affect how people value time. In transport planning these different factors are brought together in the concept of 'Generalised Time' in which time for different stages of a journey is weighted according to the value of time that is perceived by transport users. Generalised Time and the costs of travel can be combined

¹³ See here for more details:

http://www.rssb.co.uk/SiteCollectionDocuments/pdf/reports/research/CIRIA_GuidanceOnCrowding.pdf

¹⁴ Available from www.stationtravelplans.com/

¹⁵ See for example www.airportservicequality.aero

¹⁶ See www.transportscotland.gov.uk/rail/rail-franchise/service-quality

together to calculate the Generalised Cost of a journey, enabling the overall ‘costs’ to the user of different journey options to be compared on an objective basis. The factors that affect the value attached to time, as well as the more easily defined costs, govern whether people are willing to use interchanges, through their perceptions of travel using interchanges. Users, particularly those who do not use interchanges frequently, consider there to be a high interchange penalty as a result of travelling to the interchange and then waiting at the interchange for their connection. However, this does not have to be the case with good real time information services, and comfortable and attractive waiting facilities also help to reduce the interchange penalty. A fundamental consequence of the interchange penalty is that measures to allow people to make better use of time, or to spend it in greater comfort, can be more cost-effective in reducing the generalised cost to travellers than measures to reduce journey times.

One of the main factors that can be assessed in an effort to reduce perceived time spent at the interchange is accessibility, both physical and information. The importance of this to users has increased over the last few years and has a significant role in determining whether people are likely to use multimodal transport. There are a number of aspects of accessibility that are important to different users. Mobility and movement is important to people with disabilities or children or who have luggage, whilst facilities at the interchange, such as car parking, and routes to and from interchanges, for walking and cycling are important for people who wish to use the interchange on a regular basis.

Having identified the factors that define the user requirements we can consider how these can be assessed using quantitative /semi-quantitative methods, so that design can be improved and performance measured for operational management. Various tools exist such as pedestrian audit tools, accessibility measures, measures of journey time and reliability, quality of services etc, these are summarised in Table 2 below. As the GUIDE project (2000) points out, although it is good to understand general user perspectives of interchanges, it is important to remember that all interchanges are individuals in terms of their user groups and their specific function, thus they will require different design considerations to be made. These factors are therefore an important part of the development of the City Hub model.

Table 2: Key interchange factors from a user’s perspective

Driver of travel behaviour	Measure/ indicator	Best practice example	Zone/ Time
Travel time	Connection times, e.g. waiting time until next bus	Station Travel Plan site audit	Access & Interchange Zone, Facilities Zone and Platform Zone Pre-journey, In-journey
Reliability	Punctuality, proportion of services run	Data collected by regulatory bodies e.g. UK Office of Rail regulation http://www.rail-reg.gov.uk	In-journey
Convenience	Frequency of services, distance to the interchange	Station Travel Plan site audit	Facilities Zone and Platform Zone

Comfort	Variety of facilities at the interchange	Station Travel Plan site audit Service Quality audits and surveys	Facilities Zone and Platform Zone
Security (or safety)	Number of people and around the interchange, number of staff	Gare do Oriente, Lisbon and Antwerp station both have police control centres as part of their design Station Travel Plan audit Service quality audits and surveys	Access & Interchange Zone, Facilities Zone and Platform Zone
Accessibility	Fruin index, distance to the interchange, facilities for bicycles, cars, pedestrians	PERS/ CERS reviews of access to Ilford Station Station Travel Plan site audit	Access & Interchange Zone
Movement	Fruin index Pedestrian comfort surveys	Madrid interchanges- mobility simulations are carried out to ensure movement is safe and comfortable for users TfL has a pedestrian comfort index as part of its package of pedestrian tools	Access & Interchange Zone, Facilities Zone and Platform Zone
Wayfinding and passenger information		Station Travel Plan site audit	Access & Interchange Zone, Facilities Zone and Platform Zone Pre-journey

4 Transport Operators

Transport operators consist of the public transport service providers that use interchanges and in many cases also operate and manage the infrastructure. However, it should be emphasized that there are different models in managing an interchange. Regional public transport authorities may also be involved in operation and management. Transport operators may therefore have different responsibilities in different occasions. The GUIDE (2000) project identified two models: the conventional urban interchange organisation where transport operators own the space which is related to all operations and the 'Airport' model where the interchange space is owned by one manager who is responsible for the passengers safety, security etc., while operators are only responsible for loading/unloading.

As transport operators are among the most important stakeholders in interchanges, they are usually involved from the very beginning when it comes to interchange planning and design. Transport operators focus on the satisfaction of the interchange passengers (e.g. harmonised schedules of all modes to shorten travel times), taking however into consideration the legal restrictions, societal requirements (well-being of passengers and sustainability of the interchange), the local politics and the cost effectiveness (KITE, 2009b). Their attributes focus on the operability of:

- Station operations (efficiency, movement);
- Management and maintenance;
- Safety and accident prevention;
- Security (personal, protected environment);
- Fares and ticketing; and
- Revenue generation.

Effective planning, management and operation of stations are essential to realising a positive outcome for users and operators. Operability includes considerations of service coordination, operating costs integrated ticketing, maintenance, safety and servicing. Station managers and transport operators are primarily measured on service performance, customer satisfaction and patronage levels. Depending on whether it is a commercial organisation, they seek to optimise revenues while minimising operational costs. Below we will address these elements from the perspective of the operator and consider which are important when defining successful interchanges.

4.1 Station operations

Station operations involve the aspects of allocating the necessary spatial capacity for the station functions, integrating the different modalities, improving delivery accessibility and storage, as well as providing additional facilities (Network Rail, 2011a).

Spatial capacity intends to establish, by effective planning, that the station can meet its current and prospective needs in terms of operations and services.

The *coordination of different modalities* aims at creating efficient connections by engaging local transport operators, prioritising access to the interchange, coordinating information and designing efficiently the modal movements (seamless/ easy change of mode). This was indicated as one of the most important factors for attractive transport in SPUTNIC (2009). The HERMES (2011) project focused on the barriers to efficient intermodal transport, highlighting that the lack of cooperation among operators was mainly due to the different ticketing systems, the lack of incentives for operators and disintegrated tariff systems.

Moreover, HERMES (2011) confirmed the following issues for improving the *interoperability of modes* from the transport operators' perspective; the main identified barriers were design issues (i.e. inadequate infrastructure) and the coordination and planning issues (i.e. inadequate infrastructure and so on), as well as financial issues.

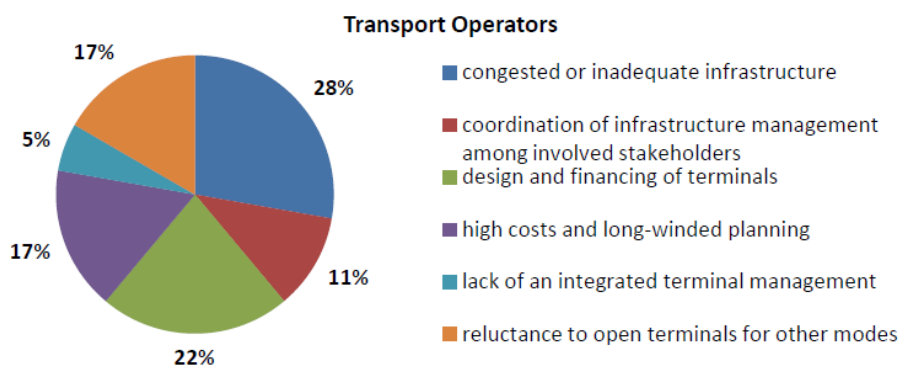


Figure 3: Problems in interoperability of modes from Transport operators' perspective (Source: HERMES, 2011)

In addition, HERMES explored the intermodality issues from the infrastructure managers' perspective. Here, the most important barriers were design and financing, followed by the lack of coordination among public authorities and further administrative and regulatory constraints, especially from the operators' perspective. For that matter, the managers supported that in 60% of the cases cooperation failed due to the lack of coordination among operators, followed by 25% which failed because of different ticketing and tariff systems. In addition, merely one third of the (investigated) operators had agreements for information services and time synchronisation.

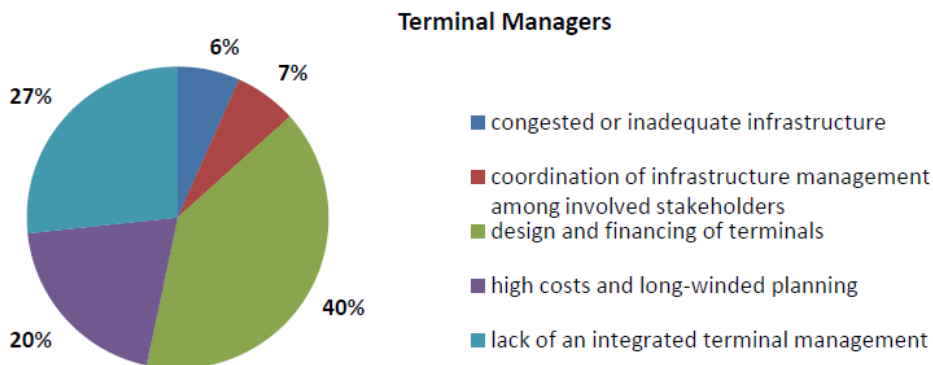


Figure 4: Problems in interoperability of modes from Terminal managers' perspective (Source: HERMES, 2011)

SPUTNIC (2009) analysed thoroughly the different aspects of interoperability and the integration of public transport and concluded by developing a three-step approach. However, the successful implementation of an integrated scheme would demand strong commitment from different parties up to funding schemes and other support mechanisms.



Figure 5: Interoperability and integration of public transport approach (Source: SPUTNIC, 2009)

Delivery accessibility and *storage* should also meet current and anticipated future needs and integrate appropriately to the interchange passenger flows; for example, minimising and controlling the interaction between services and waste activities.

4.2 Management and maintenance

Management of interchanges involves amongst other issues, the establishment of the rights and responsibilities of stakeholders and the facilitation of station maintenance and cleaning (Network Rail, 2011). An effective organisational framework for operations and planning is a priority for infrastructure managers as station facilities are shared among different actors. For example, each mode of transport manages its own space, while the commercial activities (shops, restaurants etc.) are concessions to intermediates. Priority topics for interchange management

are the engagement of local stakeholders to ensure coordinated maintenance and other responsibilities for public spaces and access routes, the formulation of standards for interchange activities, and the effective management of deliveries. Furthermore, interchange managers should maintain the minimum hygiene standards and facilitate to the best possible extent the transition of passengers. In this way, the managers provide for the comfort and ease of travel of passengers. Safety and security is also included in the management priorities and forms a separate category (see 4.3 below).

Interchange management is also an important element of the interchange best practice guidelines developed by Transport for London (TfL, 2009). These guidelines have been developed to encourage cooperation and coordination between those organisations involved in designing, implementing and managing London's interchange facilities with the aim of providing improved levels of services for passengers. The work suggests the use of interchange facility management agreements when interchange facilities are owned, managed or served by more than one organisation (which is often the case). The organisations involved should agree the cooperative procedures and describe these in agreements. This identifies interfaces between all parties involved in managing and serving the interchange including external bodies (e.g. fire brigade). It also establishes clear responsibilities and provides unambiguous accountabilities for the tasks that are required to ensure that the interchange operates successfully. The scope of the management agreement will depend upon the scale and complexity of the interchange, but could include arrangements about cooperation in different zones, information provision, ticketing and hours of operation.

Management may also require monitoring of passengers needs. Public consultation is then a useful tool to understand the viewpoints of the interchange user. For example, Transport for Great Manchester (GMPTE) commissioned a questionnaire (see figure below) in order to define user needs but also to ask Trafford Council to grant permission to build a new bus station and other improvements at Altrincham.

Your views on the proposed new Altrincham Interchange
Please go to www.gmppte.com/haveyoursay or fill in this form, enclosing additional sheets if needed.

Q1. For each of the following aspects of the proposed scheme please rate the importance of the proposals to you. **Please tick only one box per question.**

a) **Improved bus passenger waiting area**
 Not important Less important No view Important Very important

b) **Combined bus, Metrolink and rail ticket and information office**
 Not important Less important No view Important Very important

c) **New fully accessible toilets including baby changing facilities**
 Not important Less important No view Important Very important

d) **New pedestrian footbridge connecting all four rail platforms and linking to the Oakfield Road development**
 Not important Less important No view Important Very important

e) **Narrowing of Stamford New Road to improve pedestrian environment and crossing facilities**
 Not important Less important No view Important Very important

f) **Reconfiguration of taxi pick-up point**
 Not important Less important No view Important Very important

Q2. Please identify which two of the following four issues are most important to you when using the interchange. **Please tick two boxes only.**

Cleansing and removal of litter Maintenance of facilities Availability of accurate travel information Staff presence within the interchange

Q3. Please identify which two of the following four issues are most important to you in the design of the new interchange. **Please tick two boxes only.**

The look and feel of the facility Provision of public toilets Security measures eg. CCTV cameras Retail opportunities eg. Cafe, newsagents

Figure 6: Public consultation survey for upgrading the Altrincham interchange (Source: GMPTE, 2010)

Feedback from customers about interchanges was also undertaken in the case of a Sydney (Australia) ferry interchange in order to assess additional facilities installed to main ferries in order to serve daily travellers needs, like Charge Bars. Charge Bar is equipment for mobile charging while travelling, allowing customers to conveniently charge a range of mobile phone and tablet devices at no cost while in transit. Furthermore, Sydney Ferries' offer free WiFi¹⁷ service and there have been over 250,000 free WiFi sessions since its launch in 2010.

4.3 Safety and security

The safety aspect encompasses two main elements:

- The design of the interchange in order to minimise the potential for accidents, conflicts and collision; and
- The compliance with all the relevant safety and emergency standards.

For the first element, the spaces and facilities in interchanges should be designed considering the minimisation of obstructions and the maximal use of space, the level of conflict between vehicles and pedestrians but also the pedestrian flows, the position of ancillary equipment (in places where it does not disturb passenger flows), low speed limits for vehicles etc. The second element refers to the compliance with emergency exits, emergency lighting, fire alarms, fire

¹⁷ http://www.itnews.com.au/News/217357_railcorp-to-trial-free-wifi-at-circular-quay.aspx

fighting equipment and evacuation plan. Appropriate forms of safety should be applied for impaired persons, as well as other sensitive groups.

The security aspect integrates the following features: the assessment and minimisation of risks from man-made threats, crime prevention, the design of usable and secure facilities, and the use of additional means (like CCTV) to monitor the interchange for illegal activities and crowd management.

Recently also the threat of terrorism has become an important issue for operators. The policy perspective of this is addressed in chapter 5, however there is clearly also a responsibility for the operator. Whilst efforts undertaken by public transport companies across EU and the world have been irregular, many operators have in recent years increased their safety and security arrangements, reacting to the potential threat from terrorist attacks. Although every urban transport network is unique in its size, complexity and the threats it faces, common elements of security efforts undertaken are still observable. A range of new security devices were implemented or existing arrangements upgraded in many public transport systems:

- Electronic employee ID targets and vehicular gates at entrance points;
- Metro-rail fibre optic networks for video recording devices;
- Programmable intrusion equipment to alert police of unauthorized intrusion;
- Closed-circuit TV and motion detection alarms;
- Personal protection equipment, training and satellite telephones for employees;
- Expansion of chemical emergency sensors;
- Bomb-resistant containers; and
- High-visibility uniformed patrols at vulnerable stations with explosive detection dogs or devices.

National authorities, international organisations and private sector associations alike support these endeavours with advice, training and guidance material, including handbooks.

4.4 Fares & Ticketing

The GUIDE (2000) project indicated that fares and ticketing policies have a great impact on the increase of public transport use. Multi-modal tickets and other integrated ticketing systems (not separate tariffs for different modes) have a strong impact on passenger demand. Monzon et al (2013) indicated that ticketing is a very significant factor for choosing a travel pattern among different groups (by age, by trip purpose but also by interchange). In fact, this was the dominating factor for almost all case studies, differing substantially from the others (for example, in the case of Av America in Madrid, the price accounted for 47.4% of the total followed by comfort with 16.3%) except from Zaragoza bus where time spent and comfort scored higher and in Lyon where time spent was equally important to the price.

The SPUTNIC project (2009) investigated the importance of an integrated ticketing system and documented the results of the VVO (Verkehrsverbund Oberelbe) survey in 1998, where integrated ticketing was not yet implemented. The interviewees indicated that if there was one ticket for all means of transport that would make public transport more attractive. The same was concluded in the case of integrative fares for several public transport operators. PWC (2011) in its study for Scottish railways came to the same conclusion. Estimating the costs and benefits of ticketing schemes, PWC estimated that the benefit to cost ratio could be from 14.7 to 19.7 (for the different schemes) reaching to a Net Present Value of 543 million pounds for 60-year horizon.

In Sydney, Australia, in the Circular Quay Station, located in the Central Business District began installing in 2012 new ticket barrier gates on ferry wharves in order to improve ticketing services and standardise gates across gated wharves and gated CityRail stations. Moreover three gates (Circular Quay, Manly and Darling Harbour) installed a new Customer Message Display. The new gates are designed to be quicker, easier and safer for customers and staff, and pave the way for the implementation of smartcard ticketing, scheduled to roll out to ferry customers from late 2012.

4.5 Revenue generation

Well designed and accessible interchanges that are frequently used are interesting for many businesses. Businesses want to locate in direct proximity to large public transport interchanges which are characterised by high intermodal and international accessibility. These intermodal nodes are also attractive to retailers and other commercial activities. Examples include large grocery shops at stations and the development of meeting locations. This generates possibilities for station owners and managers to generate revenues from renting space. Revenue generation from interchange activities could lead to a significant funding stream to support its maintenance and operation costs. For larger developments the creation of land for offices and housing other constructions are usually developed, including public private partnerships (see also chapter 5 on financing issues). Revenues may then be dedicated to the consortium that invests in the redevelopment.

The example of Tokyo Central station shows synergy between stakeholders (JR East and Mitsubishi group) and the revenue potential from other sources than transport. There are three operators/ administrators at Tokyo Station: JR East, JR Tokai and Tokyo Metro (Railway Company). The renovation plan of the Tokyo Station is developed in collaboration with local stakeholders; for example, the Mitsubishi group and the Mitsui group. The Mitsubishi group purchased the 'air rights' above the Tokyo station which enabled them to increase the floor area ratio and design and construct the Tokyo Building. The assets JR East has acquired through the air rights have been invested in the preservation and restoration of the Marunouchi Station Building, which serves also as a location for offices, restaurants, shopping etc. The administration and operation of retail and services inside the station area is handled by the JR East and JR Tokai.

Another example of successful revenue generation comes from the Linz central railway station (BOKU, 2011), this time as the result of businesses operation in the station. The development of a multifunctional interchange resulted in an increasing demand but also new uses for the interchange (see figure below). The average expenses on non-transport related goods per person were estimated around 9.80€, adding up to 180,000€ per workday at the railway station.

Purposes to visit the new pt node (multiple answers allowed)

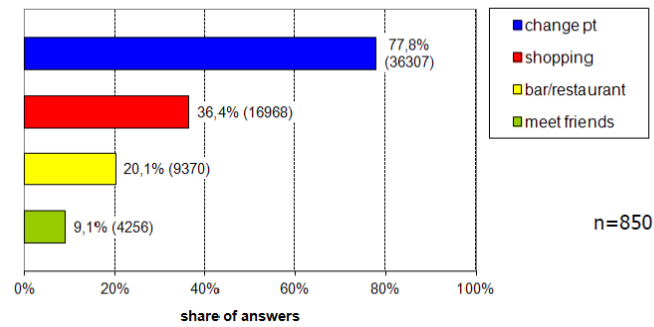


Figure 7: The example of Linz interchange (BOKU, 2011)

5 Policy and Governance

A government that promotes sustainable urban transport usually considers efficient public transport as an important instrument in realising that strategy. Interchanges are considered as an important element to facilitate seamless travel and intermodal transfers, and are crucial to any public transport system at the local, regional or national level. An efficient interchange that is safe, accessible, and sustainable in operation and design is probably an objective for all governments. The question then arises how governments realise this, and how they develop a policy framework where successful, cooperative multimodal operations can take place. This is difficult in a situation where public and private stakeholders are involved who obviously have different interests.

There are various policy instruments that can be used by policy-makers to provide for the implementation of accessible urban multi-modal transport systems and interchanges. With the instrument chosen having implications on what happens in practice. Policy documents, for example white papers, can be implemented through legislation (laws), regulation, fiscal policy, public investment decisions, or through issuing guidance. The first section will deal with these issues and provides a policy review. Investment decisions and the use of cost benefit analyses will be discussed separately. This gives information about the welfare impacts of interchanges. Also the financing of these investments is an issue when it comes to creating successful interchanges.

In recent years also sustainability of interchanges is a relevant objective, both in design and operation. The TfL guidelines (TfL, 2009) define sustainability as an important element of efficiency. Sustainable interchange design can make places work better, mitigate against climate change, add value to an interchange enhancement business case and meet with the needs of people who want to use the interchange now and into the future. Finally, safety of interchanges has become an important policy issue, especially after the attacks in Madrid and London. For each of the elements, recommendations for successful interchanges can be formulated.

5.1 Policy review

As indicated above, various policy instruments can be used to provide for the implementation of accessible urban multi-modal transport systems and interchanges. Legislation and regulation are more directive, requiring conformance and certain actions to be undertaken. Guidance however may provide policy and procedural advice that is based on legislation but will more discretionary allowing for flexibility and innovation.

Fiscal policy involves using taxation, fuel duty and other such instruments to influence decision making, but is less relevant to interchanges. Public investment decisions directly affect the type of schemes that are implemented and can be targeted to achieve particular policy aims.

A review of policy instruments in place across Europe related to accessible urban multi-modal transport systems and interchanges suggests that various levels have been implemented.

In 2009, the European Commission adopted the Action Plan on Urban Mobility (EC, 2009). This proposes 20 measures to encourage and help local, regional and national authorities in achieving their goals for sustainable urban mobility. Of these 20 measures, several have specific implications for accessible urban multi-modal transport systems and interchanges. 'Action 4 – Platform on passenger rights in urban public transport' for instance aims to put a set of ambitious voluntary commitments in place, including quality indicators, commitments to protect the rights of travellers and of persons with reduced mobility as well as commonly agreed complaint procedures, and reporting mechanisms. For 'Action 5 - Improving accessibility for persons with reduced mobility' the Commission will work with Member States to achieve full compliance with obligations set out in the United Nations Convention on the Rights of Persons with Disabilities by including the urban mobility dimension in the EU Disability Strategy 2010-2020 and by developing appropriate quality indicators and reporting mechanisms. Article 9 of the Convention states that "*Parties shall take appropriate measures to ensure to persons with disabilities access, on an equal basis with others, to (...) transportation, both in urban and in rural areas*". Through 'Action 6 — Improving travel information' the Commission will support the development of national and regional multimodal journey planners, and links between existing planners, with the ultimate aim of providing users with a public transport travel portal at EU level on the internet.

A review of policy instruments in a number of European countries (namely Spain, Hungary, Norway, Greece, Netherlands, UK, Finland, France and the Czech Republic) suggested that few have national or regional policy/legislation etc. specifically targeted towards accessible urban multi-modal transport systems and interchanges. Instead countries generally have a range of policies/legislation etc. at both national and regional levels which, although not specific, nevertheless relate to the planning and design of accessible urban multi-modal transport systems and interchanges. These sorts of policies/legislation etc. include, for example, those relating to accessibility for the mobility impaired to transport systems (such as in France), quality and safety standards on public transport (such as in the Czech Republic), and public transport operations, including developing multi-modal transport (such as in Greece). In Hungary, the national level 2008-2020 'Integrated Transport Development Strategy' highlights the importance of the improvement of intermodality in urban areas, while at a regional level the 'National Development Plan – Regional Operational Programme for Central Hungary' (2007-2013) provides EU funding for the planning and construction of interchanges and adjoining park and ride, as well as bike and ride, facilities. In the UK, the topics of urban multi-modal transport systems and interchanges are covered by various policy instruments (see Box 2).

Box 2: Examples of policies related to accessible urban multi-modal transport systems and interchanges in the UK

Transport White Paper 1998

Improving interchange was identified in the Government's White Paper "A New Deal for Transport" (1998) as a key factor in achieving truly integrated transport. Prior to receiving funding and approval from central government all projects must satisfy an assessment using NATA (the New Approach to Transport Appraisal). Transport appraisal is carried out to provide input to efficient policy development and resource allocation across government and covers all new and extended interchanges. An Appraisal Summary

Table (AST) brings together all the data into a form that decision-takers can use. Five objectives for transport policy were set, including one covering integration. The transport interchange sub-objective (part of the integration objective) assesses whether the proposed strategy is likely to affect passengers beneficially.

Transport White Paper 2011

In 2011 the Department for Transport issued the Transport White Paper “Cutting carbon, creating growth: making sustainable local transport happen white paper: The government’s vision for a sustainable local transport system that supports the economy and reduces carbon emissions”. It enables local authorities and Passenger Transport Executives (in the main conurbations) to fund improvements to rail services and facilities, such as new stations, interchanges and improved access. The White Paper recognises that the ‘end-to-end’ journey concept is about making the entire journey experience, from door to door, better for passengers.

The Disability Discrimination Act 2005 (DDA 2005)

The Disability Discrimination Act (2005) builds on the previous version from 1995. It makes it unlawful to discriminate against a disabled person (i.e. to treat them less favourably than it treats or would treat others; and it cannot show that the treatment in question is justified). This requires that the disabled are not discriminated against in the provision of transport services and that vehicles, e.g. railway carriages, are accessible. . The 1995 Act sets accessibility standards for taxis. It also makes provision for the construction, use and maintenance of regulated public service vehicles i.e. buses. The Secretary of State must approve the use of a vehicle for passenger transport under the terms of the DDA 1995.

Access for all’ station improvement fund

In 2011 the UK Government and rail infrastructure operator established an ‘access for all’ funding programme to provide step-free access at 39 stations across the country. Bids were submitted by rail operators in partnership with local authorities, and the funding was used to provide lifts, new pedestrian bridges and other accessibility improvements.

Local Sustainable Transport Fund

As part of the 2011 Local Transport White Paper, the UK Government created the Local Sustainable Transport Fund (LSTF) to help improve transport links. The LSTF enables local authorities the freedom to develop targeted packages that address the particular problems in their areas, including urban transport interchanges. The purpose of the LSTF is to enable local authorities to effectively tackle the problems of congestion, improve the reliability and predictability of journey times, enable economic investment, revitalise town centres and enhance access to employment. It aims to bring about changing patterns of travel behaviour and greater use of more sustainable transport modes.

Local Transport Plans

Local Transport Authorities in England are required to submit a Local Transport Plan (LTP) under the Transport Act (2000), as amended by the Local Transport Act (2008). A LTP should cover two elements: strategy and implementation. Possible measures that LTAs can adopt include schemes to improve signing, travel information, ticketing and ease of interchange.

Station Travel Plan

A Station Travel Plan (STP) is a management tool for improving access to and from a station and mitigating local transport and parking problems, supporting sustainable growth in rail patronage and the strategic objectives of the rail industry. The STP is jointly agreed and delivered by the rail industry, local authorities, other stakeholders and the local community working in partnership. Station Travel Plans (STPs) are a tool that brings together such initiatives into a coordinated package. Their application is being encouraged by the government as well as the industry.

The UK DfT is developing a 'Door to door' strategy, which is expected to advocate STPs as a tool for delivering more seamless journeys where interchange is involved.

Within Spain, one of the three countries reviewed considered to have specific national level policy, the national policy context is characterised by a legal framework centred on accessibility issues, with its 2009 'Strategy for Sustainable Mobility' supporting the development of multi-modal transport systems for travellers in order to exploit the potential of all modes of transport. In Norway, although there is no policy document specifically on accessible urban multi-modal transport systems and interchanges, one focus of the Norwegian National Transport Plan (2010-2019), which is the central document for the transport sector in Norway, is accessibility and securing accessibility to important interchanges for multi-modal transport. In the Netherlands the national government is heavily involved in the design, development and management of seven major interchanges, with interchanges, such as those usually part of a large spatial planning programme, involving the redevelopment of an entire city area. Notably each of these three countries has taken a different policy approach and indeed none have a specific policy document covering the topic.

It is unclear from the review undertaken whether there would be benefits to be gained from countries implementing specific national (and/or regional) policy/legislation etc. on accessible urban multi-modal transport systems and interchanges, or whether it is acceptable, or even better, for countries to consider these issues separately in a range of, sometimes non-transport specific, policies/legislation etc. at the national (and/or regional) level. The fact that few of the countries reviewed have specific policies in place makes it difficult to assess the impact of these in comparison with the effects of having a range of different non-specific policies which cover the general issues. What is probably important however is having national (and/or regional) guidance which brings together the various requirements concerning accessible urban multi-modal transport systems and interchanges which can then be used by the various stakeholders involved to help guide the design and operation of new or upgraded facilities to ensure that they are as efficient as they can be.

The review suggested that six of the countries already have specific guidance at a national level (these being Finland, Hungary, Netherlands, Norway, the UK and Spain). For example:

- In Finland guidance on the Service Level of Public Transport produced by the Finnish Transport Authority also contains guidance on multi-modal transport and park and ride.
- In 2012 the Hungarian Road Society published its 'Intermodal Public Transport Interchanges (Planning and Assessment Guidelines)'. The main aim of this new national guidance was to help the planning and preparation of intermodal interchange projects across the country and to support a multidisciplinary planning approach that took into account aspects such as urban development, design and the economy.
- Since 2005, the 'Strategic Masterplan for Infrastructure and Transport' in Spain (PEIT, Plan Estratégico de Infraestructuras y Transporte, 2005-2020) has presented the integration of different modes of transport as the main objective in achieving a more efficient and accessible transport system. In addition, since 2012 the Plan de Infraestructuras, Transporte y Vivienda (PITVI), 2012-2025, has considered multi-modal transport systems and transport

accessibility as a relevant objective for regional planning and urban infrastructures. The PIVIT includes two main strategic transport planning tools orientated to increase accessibility by improving the multi-modal transport system: the reinforcement of door to door multi-modal transport systems and the integration of intermodal transport fares and organisation of transport information in a multi-hub portal system.

- In Norway the Public Road Administration has produced an instruction manual covering the design of both interchanges and streets ('Universal design in road and streets' Handbook 278, published 2011). Other relevant manuals include 'Adaption for public transport on road' (Handbook 232, published 2009) and 'Electronic ticketing' (Handbook 206, published 2011).
- In the UK, the Department for Transport's 'Inclusive Mobility: a guide to best practice on access to pedestrian and transport infrastructure' (2005) sets out standards for the design of facilities and services in the pedestrian environment and in transport related infrastructure: bus stations and stops, airports and railway stations, for example.

In addition to this, six countries (Greece, Finland, Hungary, France, the UK and Spain) were all identified as also having guidance at a national (or regional and local) level which relates to accessible urban multi-modal transport systems and interchanges. This review indicated that there is already a fairly high level of guidance available for use by those developing or improving interchanges. The effectiveness of this guidance in influencing design and operations, however, is not known.

5.2 Cost and benefits of interchanges

Identifying the cost and benefits of investments and assessing the contribution to social welfare is now common practice before policy decisions are taken. Various tools are available such as cost benefit analysis and multi-criteria assessments. We will focus here on cost-benefit analysis and its application to interchanges, and not enter the discussion about which method to apply.

Cost-benefit analyses have now developed into a common tool to assess the contribution of different investments or project alternatives to the welfare of a region or a country. Investments in interchanges can be assessed by governments to analyse the contribution to the economy. This means that both the direct and indirect effects are important to governments. Besides modal split, effects that may be realised by a good interchange (this probably depends more on the quality of the public transport service in general), are also environmental effects, safety effects, and effects on the labour and housing markets. We should not forget that impacts not only depend on the design and facilities of an interchange itself, but also on supporting policies, such as paid car parking near the interchange. The scope of the interchange project is therefore very important for the outcomes of the analysis. Interchange (re-)developments are also often part of large restructuring plans of city areas which involve new spatial planning and the construction of offices and houses. The cost benefit analysis then becomes very complex with many effects to be taken into account. The Amsterdam South Axis project in the Netherlands, for instance, is a redevelopment project around the train station Amsterdam South. This interchange is reconstructed as part of a large spatial planning project which includes more road lanes, more railway tracks and a change in land use (allowing offices and houses to be built on top of the

infrastructure). The cost benefit analysis for this project focused, however, on the main effects on the land market, the attraction of new employment and the transport effects resulting from travel time gains (Besseling et al., 2005). The effects of the interchange redevelopment itself have not been included, probably because of the minor importance compared with the other effects.

Box 3: The case study of Madrid

Madrid (case study analysis of Avenida de America)

In Spain, the city of Madrid has promoted the use of public transportation by the adoption of different measures. The construction of intermodal exchange stations has been one of the most prominent investments to improve the physical connection between metropolitan bus services and the subway system. Vassalo, Di Ciommo and Garcia (2012) evaluated the effects of such an interchanges in Madrid on the affected stakeholders: travellers, operators, interchange managers, the government and the urban environment (people living near the interchange). The authors apply a welfare perspective that has been applied to the Avenida de America interchange in the city of Madrid. The financial analysis shows that public subsidies are not needed to have interchange constructions or redevelopments realised.

The analysis of the case study of the Avenida de America compares costs with benefits. The main benefits result from the travel time gains for metropolitan and urban buses (between 3 and 7.5 minutes per trip). This leads to travel time savings for both travellers and bus operators. Although the authors conclude that this has resulted in an increase in bus demand, it is not clear whether the users have given up car use (which may lead to environmental benefits as well). Transportation fares did not change. The bus operators have to pay a fee for using the interchange to the owner of the interchange (IES concessionaire). The reduction in operating costs compensates for the fees. The benefits for the concessionaire are not only these fees, but also parking revenues and the commercial rents from shops. In sum, the implementation of this interchange has a positive welfare outcome. It is concluded that it is a win-win strategy with the interchange being financed by private capital only.

The Madrid case study shows that costs and financial effects are important for welfare. However, a new interchange may also induce other effects that make the assessment more complex but should be included when an adequate policy decision is required. Dutch guidelines for interchange assessment (see SEO, 2006) recommend including transfer time changes (which will be different for different types of users), travel time changes (depending on the types of problems that will be solved by the new interchange), and improved reliability. In addition, social security effects and comfort effects should be included and monetised by using traveller satisfaction surveys and the time spent at interchanges. This tries to capture the quality perception of existing and newly attracted travellers. Clearly, also environmental effects of the interchange (energy efficiency) and indirect impacts on the labour and housing market should be included but were not discussed in these guidelines (but are included in the general CBA guidelines for transport infrastructure investments, the so called OEEI guidelines for the Netherlands).

5.3 Financing of interchanges

Costs are also important to society. Financing of transport infrastructure is in many countries a public responsibility. Depending on the type of infrastructure and the responsibility, this may be the national, regional or local government. Interchange investments usually involve multiple

stakeholders and potentially also multiple financiers. For instance the redevelopment of the station in Delft (province of South Holland) in the Netherlands (Sporzone Delft project) has been funded by the national government (ministry of Infrastructure and Environment), the municipality of Delft, the province of Zuid Holland and two regional authorities (the Hague and Rotterdam). A covenant has been signed by all of these partners to ensure that the other parties have one organisation to communicate with when it comes to this project. Transport operators may also be involved, which are in many cases also publicly owned.

However, private partners may also be involved in the funding of transport infrastructure, with the toll roads in France and Italy well known examples. Also when it comes to interchanges public private-partnerships may be established to bring in extra funding (public budgets are usually limited) and the innovativeness of the private sector. Policy makers are then looking for ways to involve the private sector in managing and financing new and existing infrastructure. Perhaps the most popular mechanism is the concession approach where the responsibility for construction, maintenance and operation of the infrastructure is transferred to the private consortium, in exchange for a user fee (Di Ciommo et al., 2009 and Lopez-Lambas and Monzon, 2010). The Madrid case study (discussed previously) shows that this approach can also be applied to the construction of intermodal interchanges. The Spanish concession law is applicable to every type of public works. It is possible to fund intermodal exchange stations without public money. Clearly there must be a sufficient level of demand that creates benefits to all stakeholders involved.

The PPP transit project has analysed the organisational, legal and economic factors that influence the creation and success of PPP projects for urban rail interchanges (PPP-Transit project, 2002). This project studied various case studies (in Europe and the US) by conducting interviews with actors involved. Interchanges seem to be attractive infrastructure for public private cooperation because of possibilities with property development and land rents (proximity of public transport services makes urban development more attractive and provides added value). The external circumstances under which the projects came into existence varied in many aspects – such as associated legislation and public strategies – as did the projects themselves. Similarly, the different roles of the public and private actors lead to varying degrees of involvement and commitment. However, the experiences and processes permitted the project to formulate some recommendations relating to form, process and effects of public private partnerships. It appears that partnerships can be successful, but that good preparation and communication is important. PPPs can offer a very useful tool for realising public transit related urban development which the public bodies might not realise on their own. But it has also to be kept in mind that they do have potential disadvantages and the forging of such partnerships should thus carefully considered on a case by case basis.

5.4 Policy management and coordination

Another issue to consider is the involvement of governments in interchange design and development. Multiple levels of governments may be involved depending on the scope of the interchange. It may not always be clear who manages and is responsible for the project. Related to this is the level of cooperation and coordination between different governments and

stakeholders involved. The project “Towards passenger intermodality in the EU (2004) has identified key issues of passenger intermodality for framework conditions and implementation issues. Policy consistency and clear institutional structures in operations and management are two of those key elements.

This is an issue in the Netherlands for instance, where the management of public transport is a local or regional issue. The national government is involved in the transport between the nodes, but not at the nodes, unless it affects the development of the interchanges of national importance (e.g. Rotterdam port and Schiphol airport and seven major station projects). It is not always clear which type of government is involved and takes the lead in processes. This is important for efficient coordination and management. A visionary lead seems to be a key precondition for successful interchange development and management, in particular when multiple private and public stakeholders are involved in the development.

5.5 Sustainability of interchanges

Sustainability is an important policy aim in society nowadays, with the concept being included in design and evaluation frameworks for urban interchanges (see e.g. Network Rail, 2011 and TfL, 2009). Interchanges should deliver value for money and provide a positive economic, social and environmental impact. Social and economic elements have been addressed before in this report, we focus here on energy efficiency and environmental friendly operations. The impacts of an interchange upon the environment may fall into two categories: construction effects and design effects. The construction or redevelopment of an interchange can have consequences on land take and disrupt visual settings. The operation stage may cause noise, vibration and air pollution. The impacts of design for the environmental should be included in cost benefit assessments, but are difficult to monetise in many cases. Sustainable design may be costly, and in the end it is a trade-off between environmental and economic priorities that will affect the interchange project.

There are many guidelines developed for sustainable design (Network Rail, 2011 and TfL, 2009). Questions that should be answered by developers include: is the interchange future-proof, are materials high quality and sustainably sourced, and is it as energy efficient as possible. Guidelines and standards are available to be applied. Innovative examples include the Vauxhall bus interchange in the UK where roof design includes 168 solar panels producing a third of the bus station’s energy needs (TfL, 2009) and Rotterdam Central Station which has the largest photovoltaic roof as part of the station upgrade.

Box 4: The case studies of Vauxhall and Rotterdam Central Station

Vauxhall Bus Interchange (UK, source TfL website)

The upgrade to Vauxhall Interchange opened in 2004 and accommodates upwards of 30 million interchanging passengers each year. The interchange upgrade aimed to improve pedestrian and cyclist access and transfer between, bus, London Underground and rail. This was achieved by the inclusion of direct access from the bus interchange to the underground station removing street level passenger/vehicular conflicts, improved pedestrian crossings and walkways. Congestion was also reduced by a

redesign of bus access routes, removing them from the gyratory system.

Sustainability was a significant consideration in the new bus station design, with the roof incorporating two cantilevered arms covered in 168 technologically advanced solar panels, enabling the interchange to produce a third of its own electricity. The result is a striking, contemporary structure, which formed the focal point of an extensive regeneration programme for the area. The twin arms extending from the bus interchange create a prominent local environmental feature and project a positive image for Public transport.

The interchange is compact with short movements required between modes. Movement spaces are generally clear and uncluttered with information and street furniture situated away from desire lines. A good staff presence, visible CCTV and an operations room situated prominently within the bus interchange achieve a good sense of security.

Rotterdam Central station (Netherlands, metro, bus, train, tram)

Rotterdam Central Station is currently being renovated. The station sees 110,000 travellers per day, and is an important national and international transport node. The redevelopment of the public transport terminal is part of a bigger programme which also includes spatial redevelopment that should attract national and international businesses. The Rotterdam Central project has been jointly facilitated by the Municipality of Rotterdam, ProRail, the Ministry of Infrastructure and the Environment, the Dutch Railways and Rotterdam City Region.

The public transport terminal has an innovative design where passageways and platforms will be connected by glass bridges that allow the use of daylight. It also allows travellers to see trains departing and arriving. Various forms of public transport will be connected under one roof. Also a separate bicycle storage facility will be developed below the main square of the station (with a capacity of 5190 secured places). The station's square will connect Rotterdam Central with the city centre where only pedestrians and cyclists are allowed.

Sustainability has been an important element in the design phase. About one third of the glass roof will be equipped with solar cells. This provides energy for 100 households on a yearly basis. The rainwater on the roof will be diverted via a separate system. Rotterdam Central will also apply heat and cold storage, which improves the energy efficiency performance of the station.

There are also assessment tools available that measure how sustainable an existing station or station design is. For instance, the SusStation project aims to deliver and promote a new generation of sustainable railway stations and has developed an assessment tool to support interchange operators, transport authorities or other involved governments in designing sustainable interchanges (French, 2012). This particular assessment tool includes five themes: energy, environment, health, quality of use and future value. Each of these five elements has four or five subthemes which are rated on a scale from 1 to 10 (very good) to identify strengths and weaknesses.

5.6 Safety at interchanges

Safety of interchanges goes beyond the security of passengers only (as addressed in chapter 3). Mass surface transportation moves millions of passengers each day, in distributed networks making them very difficult to secure against terrorist attacks. They are by their nature open environments, designed to move a high volume of passengers quickly to their destinations.

Consequently they are less protected and regulated than other forms of transportation, such as air travel. This makes them easy and attractive targets for terrorist attacks.

The threat of terrorism and the urban transport security gained tragic recognition in EU policy after the Madrid bombings on the 11th March 2004. The European Council's Declaration, adopted two weeks later, acknowledged the fight against terrorism and the full implementation of the European Security Strategy of 2003, as a matter of urgency, and called for a long-term strategy to address all the factors which contribute to terrorism.¹⁸ With regard to specific measures to protect transport, the European Council called for the "strengthening of the security of all forms of transport systems, including through the enhancement of the legal framework and the improvement of prevention mechanisms". This includes work to develop further EU transport security standards, in coordination with relevant international organisations and third countries.

However, security is not simply about terrorism or attacks on passengers. Security in a transport context seeks to prevent acts of unlawful interference against passengers, freight or the transport infrastructure. Security should give users confidence that they can use transport. Transport – and thus transport security - has also an important international dimension: in order to ensure security within the country it may be necessary for transport security to be performed outside this country before a journey to the EU commences.

Recently, the EU has published a working paper on transport security (EC, 2012) where it considers what can be done at the EU level to improve transport security. Particularly in areas where putting in place common security requirements would succeed in making Europe's transport systems more resilient to acts of unlawful interference. Whilst there are European security requirements in the aviation and maritime sectors, such requirements do not exist for land transport. It suggests creating an Advisory Group on Land Transport Security. This working paper complements the Commission's 2011 White Paper on Transport which identified the creation of a land transport security advisory committee as one of the priorities of EU transport policy. This is also underlined in the Commission Communication "The EU Internal Security Strategy in Action: Five steps towards a more secure Europe" which states that there is scope, and justification, for a more active European approach to the broad and complex area of land transport security, and in particular to the security of passenger transport. In parallel, the EU Counter-Terrorism Coordinator has repeatedly drawn attention to the terrorist threat to transport security, and identified the value of EU action in promoting higher standards and better coordination.

Safety is not only an issue of governments of course. In chapter 4 we have already highlighted actions taken by operators to improve safety. And there is a role for communication and information to travellers. This is clearly a topic which requires good coordination between the different stakeholders. Involvement in an early stage is recommended.

¹⁸ The European Council's Declaration on Combating Terrorism, 25 March 2004 (07906/04). Available at: <http://www.consilium.europa.eu/uedocs/cmsUpload/DECL-25.3.pdf>

6 Validation workshop

Several workshops¹⁹ will be organised during the City-HUB project, with members of the stakeholders' advisory group, expert reference group, and case study reference group and other (local) stakeholders being invited. They will be used to disseminate findings, encourage discussion on particular topics, and include the views of participants into the project.

The first workshop was held in March 2013 in Budapest, Hungary. At that time the results from the state of the art review (as presented in the Chapters 3, 4, and 5 of this report) were available and ready to be disseminated to a wider audience. But the most important objective of the workshop was to validate our findings with the experts:

- Did we miss anything in the state of the art review (validation on completeness)?
- Have we identified the key interchange factors (validation on importance)?

Prior to the workshop the participants received the programme and Deliverable 2.1 with the state of the art review and a draft list of the key interchange factors that had been identified. This information is summarised below in section 6.1 and was presented to the participants at the start of the workshop. After this introduction we held three transport visioning events (TVE) using the focus group technique (see Deliverable 7.1 (Stakeholder consultation guidelines) of the City-HUB project (Keseru et al., 2013) for more details about this technique, the advantages and its application within the project) and allocated participants to each of the sessions (based on their expertise/background). Focus group discussions are useful to collect data and reach consensus about specific issues. The City-HUB focus TVEs were led by two moderators in a group interview format with one rapporteur. The themes of the three different visioning events were selected based on the structure applied in the state of the art review:

- The users perspective;
- The policy perspective;
- The managers/operators perspective.

This chapter reports the main outcomes of the TVEs, particularly in relation to the key interchange factors. We refer to Deliverable 7.2 (Summary report on the transport visioning events at the stakeholder workshops²⁰) for more details about the workshop (participants, presentations, programme, etc.). Section 6.1 provides a summary of main results (as described in D2.1) that were presented to the workshop participants before the start of the focus group sessions. Section 6.2 provides the key outcomes of the TVEs.

¹⁹ A workshop is a stakeholder engagement event with typically 20-60 participants addressing a particular topic, including an interactive element (brainstorming or focus group sessions).

²⁰ A first draft report is available for the first workshop in Budapest, which will be part of D. 7.2.

6.1 Summary input to transport visioning events

The state of the art review provided an overview of important elements that together define interchange quality. No interchange is the same, and the success of an interchanges depends on many factors, including its position in the network, the urban environment, the integration between modes, and the legislation that is in force. Developing or designing interchanges is an intensive and complex process that involves different stakeholders. These stakeholders have different perspectives and different interests which in turn lead to different priorities. The City-HUB project starts from a holistic approach taking into account these different perspectives and including all elements affecting the quality of an interchange.

This review is structured along the perspectives of the three main stakeholders involved: the traveller, the operator/manager, and the policy perspective. Obviously, the definition of an optimal service or operation depends on opinions of these different stakeholders, but there are also common elements. Every stakeholder, for instance, benefits from a safe interchange. In general, it can be concluded that the facilities, characteristics and services are important to the travellers' perception of interchange quality, but that also aspects concerning the optimal and successful implementation process (dependent on the organisational, legal and institutional framework and the cooperation between stakeholders) at interchange terminals are essential in reaching high quality design.

A crucial element for providing successful multi modal interchanges is to understand the requirements of the users, both existing and potential. These needs are different depending on the type of users. However, all users benefit from a safe, reliable and comfortable interchange with short waiting times and the availability of a set of passenger services. People with limited mobility or disabilities will benefit from facilities that support them with travelling and enhance the accessibility of an interchange.

Transport operators use interchanges, and are in many cases also involved in, or responsible for their management and operation. Coordination of different modes also involves the cooperation between different stakeholders. An interchange will benefit from appropriate, inclusive and ongoing administration and urban management arrangements that can take care of future alterations and changes, while monitoring operations.

The state of the art review also indicates that different levels of government are involved in designing, managing and operating interchanges. In most cases regional and/or local governments cooperate with operators and interchange managers, but it is not necessarily the government who takes the lead in processes on interchange design and development. Governments have different options to intervene and realise interchange objectives. Before projects are constructed an assessment of cost and benefits can be carried out to understand the economic, social and environmental consequences. The legal and regulatory frameworks are also crucial for the development of high quality services to ensure that a minimum level of facilities is available to minority groups. It probably depends on local circumstances as to which type of governance is best.

Key interchange factors

Based on the state of the art review, key factors have been identified that are most important to the quality of interchanges. The following list was drafted by the project and provided as input into the focus group sessions at the workshop.

- **Process coordination and management**

The design, development, and operation of an interchange involves different stakeholders with different interests making the process complex. This requires careful coordination in order to operate efficiently and meet all the passenger needs.

A business model may be helpful from the start of the interchange project which clearly defines roles, responsibilities, and objectives. The main stakeholder should coordinate the partnership with others, do justice to all interests and make optimal use of the resources. A visionary leader is helpful in the role of the project champion. Assessments of cost and benefits, financing options and interchange facility agreements are useful tools to investigate options and support cooperative procedures.

- **Accessibility to all**

Accessible interchange design is about making places easier to use for everybody – including those with reduced mobility. This includes disabled people, those in wheelchairs or otherwise older people, young children and their carers, people with heavy baggage and those with bicycles. Legal requirements in many countries are in place to ensure that disabled people are not discriminated against. However, in practice it is probably also an issue of priority to operators and interchange managers to do more than the minimum required. Usually these extra facilities are expensive and not very often used, which may decrease their importance to decision makers.

An interchange travel plan may be useful in order to assess accessibility in general. This is a management tool for improving access to and from a station and mitigating local transport and parking problems, supporting sustainable growth in urban public transport patronage, and the strategic objectives of the industry.

- **Quality to the traveller**

An integrated approach should ideally address multiple issues to ensure that the demands of different types of travellers are satisfied and that they will return for their next trip. Elements that improve quality include short transfer times, integrated ticketing, actual and reliable travel information, and easy way-finding.

- **Safety**

People should also feel safe and secure at interchanges. This is an important element that should be addressed in interchange design.

- **Interchange design**

Interchange design is important and affects the quality elements of policy makers, users and operators. High quality design of interchange elements, such as buildings and paving, should create added value to the image of an interchange, enhance the quality of time spent and the perception of safety. Well designed interchanges create places that people enjoy and want to use with a friendly ambiance. Coherence and hierarchy in information delivery, interior elements and interchange services improves the travelling experience. Innovate design ideally should also address the sustainability of interchanges and fit within the urban environment (usually in city centres). Design should also facilitate short distances and accessibility, and be open, legible and permeable both within the interchange facility and the wider interchange zone.

6.2 Outcomes of the TVE focus group discussions

The City-HUB state of the art findings were explained to the workshop participants at the beginning of the workshop. This was followed by an introduction to the TVE sessions and aims of these sessions. Participants were allocated into one of three following TVEs based on expertise and interest:

- A. Transport operators' and managers' viewpoint;
- B. Policy and governance viewpoint; or
- C. Users (or travellers) viewpoint.

Each of the groups had 10-15 participants with each session having two moderators to initiate and steer the discussions, and one rapporteur to note down what was said. After the TVE sessions (about 90 minutes duration) results were presented by the rapporteurs at a plenary session and main conclusions were drawn.

Session A: Transport operators and managers viewpoint

Various issues that are important for good interchange management and operation were discussed, supported with evidence from practice (e.g. in Budapest). A key issue for interchange managers is the provision of reliable and clear information to travellers (travel information and way-finding). Other important intermodality factors included accessibility (in particular for travellers, although this may have less priority amongst operators) and security (managers should develop interchanges that give a secure feeling to travellers). We should not forget that priorities may be different between countries (e.g. security is considered less of an issue in Greece). Clearly, good centralised management is needed to ensure that these issues are included in daily interchange operations. The participants agreed that a public body should be involved in interchange management. Cooperation between public and private parties is probably best. An organisational model with different responsibilities can work, but one stakeholder should take the lead and coordinate processes.

Session B: Policy and governance viewpoint

Chapter 5 of Deliverable 2.1 (policy and governance) was used as starting point for the discussion. Participants agreed that all relevant governance issues were addressed in the chapter.

The discussion was structured along the four main issues in relation to the governance perspective as identified in Deliverable 2.1: processes, financing, sustainable design and spatial planning, and safety/security. There is a difference in the relative importance of these to policy makers; processes and management of stakeholders are considered very relevant, as is the security of travellers. Sustainable design and financing is considered to be of less importance, but this can change over time and differ amongst countries. It depends on the local context and legislation which management/governance model is most appropriate and successful: there is no one size fits all solution. Sometimes multiple stakeholder involvement in interchange management works without a clear governance model; successful management may occur when stakeholders accept a 'natural' leadership by an undisputed third coordinating party. Safety at interchanges is an important issue (what to do in case of emergency?) but in many cases not well managed due to different and unclear responsibilities. An action plan on safety which clearly defines roles and responsibilities (of fire department, policy, government etc.) is recommended.

Session C: Users viewpoint

This session discussed the key issues for interchanges that facilitate all users' demands. The link was made to the design of questionnaires to identify attitudes and perceptions of travellers when using an interchange. The participants agreed that interchanges should be accessible to all users, including the disabled, the elderly and foreign tourists. Information provision is an important element for creating good levels of accessibility. Clear and understandable information should be provided on a website (to visit before the journey takes place to plan the trip), and also at the interchange itself (e.g. way-finding). The perception of safety by women was also an highlighted.

Summary

The outputs of the three TVEs (users, operators/managers and policy perspectives) confirmed that the review addressed all of the important elements of an interchange. The participants indicated that management of stakeholders (particularly relevant for larger interchanges where many stakeholders are involved and processes tend to be more complex), comfort, safety (safe feeling of traveller, but also security in case of emergency) and accessibility are currently the key elements for successful interchange operation and design. In addition, information provision at interchanges is considered to be an important element of interchange services. New technologies should be used to improve way-finding at interchanges and give reliable information about travel times. Sustainability of design was considered to be of less importance by the stakeholders.

7 Conclusions

In the first phase of the City-Hub project information from (European) research projects, policy documents, case studies and interviews with stakeholders have been collected and reviewed to understand what defines interchange quality. These state of the art results have been presented at the first City Hub workshop. At this event experts and stakeholders in the field validated the identified key interchange elements in different focus group sessions (the so-called “transport visioning events”). This deliverable reports the state of the art review (previously documented in Deliverable 2.1) and the key intermodality factors which have been validated with the workshop.

State of the art

This deliverable is structured based on the perspectives of the three main stakeholders involved: the traveller, the operator/manager, and the policy perspective. Much research has been devoted to the quality of the public transport chain and the role of urban public transport interchanges within that chain. This is as a result of the importance that policy makers give nowadays to good public transport, which should provide a reliable alternative for single car use. Interchanges are increasingly recognised as an important element in the quality of a public transport trip. Previous research has addressed passenger intermodality, developed criteria and indicators for good quality, assessed best practices and provided guidelines for improving the quality of interchanges. It appears that the design of an optimal interchange depends on local framework and individual circumstances making it difficult to generalise findings. However, the state of the art overview, presented in this deliverable, shows that, elements which affect the quality of an interchange can be identified. Obviously, the definition of an optimal service or operation depends on opinions of the different stakeholders, but there are also common elements. Every stakeholder, for instance, benefits from a safe interchange station. In general, it can be concluded that facilities, characteristics and services are important to the travellers’ perception of interchange quality, but that also aspects concerning the optimal and successful implementation process (dependent on the organisational, legal and institutional framework and the cooperation between stakeholders) at interchange terminals are decisive to reach a high quality.

A crucial element for providing successful multi modal interchanges is to understand the requirements of the users, both existing and potential new users. A transfer is generally an unwanted interruption of the journey. Common elements which are important to travellers and which affect their travel behaviour are perceived time and costs, travel time, reliability, convenience, comfort, security and accessibility. Various measures and facilities are available that enhance the quality of interchanges to users. Intermodal integration of modes (e.g. availability of secured bicycle stands), passenger services (e.g. integrated ticketing, way-finding, availability of shops) and design aspects (e.g. short distances between transport modes) are all important. It is important to understand that needs differ between the different types of users. The efficiency of an interchange matters most for example for frequent users and commuters. Such travellers should be able to proceed quickly between traffic modes without facing many

barriers. Integrated timetables, concise information and good signage will support this. People with limited mobility or disabilities will benefit from facilities that support them with travelling. Interchanges may also be important places for businesses and retailers to locate. It makes sense to achieve balance in functional diversity and different user groups to avoid mono-functionality and social exclusion.

Transport operators use interchanges, and are in many cases also involved in, or responsible for their management and operation. Operability includes considerations of service coordination, integrated services (e.g. ticketing), maintenance and safety. Coordination of different modes also involves the cooperation between different stakeholders. An interchange will benefit from appropriate, inclusive and ongoing administration and urban management arrangements that can take care of future alterations and changes, while monitoring operations. Stakeholder involvement and public consultation should be part of interchange operation. Safety is an important element, even more so after the station attacks in London and Madrid. Operators have to comply with existing legislation, but usually do more to increase security levels.

This deliverable also indicates that policy makers aim for more sustainable urban transport in the future. Interchanges are considered as an important element in the transport networks, although national policies usually focus on the modes rather than their integration at nodes. Interchanges are usually left to regional or local governments, and involve cooperation with operators and interchange managers. It may not always be the government who takes the lead in interchange design and development. However, the government should represent the citizen and make sure that welfare is included in decision making. During various stages of the interchange development governments can intervene. Before projects are constructed an assessment of cost and benefits can be carried out to understand economic, social and environmental consequences. The legal and regulatory frameworks are also crucial for the development of high quality services to ensure that also a minimum level of facilities is available to minority groups. It probably depends on local circumstances which type of governance is best.

Validation of key interchange factors

Based on the previous review results, a set of key interchange factors were identified. A successful interchange is characterised by efficient coordinated processes and management, provides accessibility for all, is convenient and safe in use for all types of travellers, and has a sustainable interchange design. These key intermodal factors have been input for discussion at the first City-HUB workshop. The aim was to validate our findings on completeness and relevance with experts and practitioners. Outputs of the three focus groups (users, operators/managers and policy perspectives) confirmed that the review has addressed all of the important elements of an interchange. The participants indicated that management of stakeholders (particularly relevant for larger interchanges where many stakeholders are involved and processes tend to be more complex), comfort, safety/security and accessibility are currently key elements for successful interchange operation and design. In addition, information provision at interchanges is considered to be an important element of interchange services. New technologies should be used to improve way-finding at interchanges and give reliable information about travel times. Sustainability was considered to be of less importance.

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Annexes

Annex A: Overview of good practice case studies

Good practice case studies can be found everywhere; however in many cases it is difficult to understand why a certain case is being considered to be successful. The following list is indicative and contains case studies that are mentioned in this deliverable and have a certain element of best practice. For more information about the case studies please refer to the report and the references provided.

Case study	General description	Why best practice
Moncloa Interchange	One of the intermodal exchange stations in Madrid where bus and metro services come together	Example of public private partnership that worked well. No public money was needed for the funding of this new interchanges. Travel time gains produced lower costs to bus operators which covered the fee to be paid for using the interchange. Fares did not change for travellers. Attracted more travellers.
Linz Railway station Masterplan	The main railway station in Linz, where bus, metro and rail operate	Changing a railway station into a multimodal and multifunctional transport node including coordinated city development (successful cooperation among stakeholders) resulted to increasing demand and revenue generation.
Rotterdam Central Station	Central station in Rotterdam (Netherlands) connect bus, train, tram and metro (110.000 travellers/day)	The renovation of Rotterdam Central Station makes use of innovative urban design which takes energy efficiency into account.
KITE examples (Berlin)	Berlin Hauptbahnhof connects the urban railway, buses and is additionally an international railway hub.	Increased security, way finding, passenger information, and provision of services.
KITE examples (Antwerp)	Antwerp Central connects the urban railway, tram, buses and is additionally an international railway hub.	Increased security, way finding, passenger information, and provision of services.
Vauxhall interchange station	Interchange station between bus, London underground and rail in the UK	Renovation improved accessibility levels in general. A sustainable design was key and resulted in improved energy efficiency.
Circular Quay Interchange, Sydney	Interchange railway station incorporating also bus and ferry activities	Its proximity to much of the Sydney Central Business District and its intermodal function as a bus, train and ferry interchange make it an ideal ferry terminal and an important part of the public transport network.
Ashford International station, Kent	International railway hub, train and bus connections	The station is considered as a best practice regarding the urban planning issues. The location of the station was chosen strategically before the opening of the Channel Tunnel and the availability of through Eurostar trains from London and Paris or Brussels.

Manchester Piccadilly Station	Rail, light rail, metro	Well interconnected means of transport.
UIC (Tokyo station, Japan)	Rail, metro, intercity bus terminal	A good practice due to their business scheme for revenue generation.
Kwun Tong, Hong Kong	Rail, minibus and bus	Good practice in terms of stakeholders engagement in all the processes for the renovation of the station.
Stratford Station, UK	Rail, bus	This is good practice from a design perspective. It is an open station, legible (use of lighting and supporting information) and permeable both within the interchange facility and the wider interchange zone.
Den Bosch, NL	Rail, bus	This is a good practice from a policy perspective for the redevelopment of the station resulting in an increase in passenger numbers. The redevelopment was based on three strategies to address the interchange penalty.
King's Cross, UK	London Underground, main line and international rail, bus services	This is good practice from a design perspective. Movement paths within the interchange facility are largely direct and clear with good sight lines and little clutter. Spatial management is good with mixed use spaces arranged to either side of movement spaces, decision points are relatively clear with minimal advertising or other distractions. Much of the station environment is step free with lifts, where needed, located on desire lines. A visible staff presence, combined with pedestrian and retail activity promotes a sense of safety and security.
Finsbury Park, UK	Bus, London Underground, mainline rail	This is good practice from a design perspective. The area has good natural surveillance. Finally, interchange between Underground lines in the same direction is excellent with passengers offered a direct step free route between adjoining platforms.
Canary Wharf, UK	London's Dockland's Light Railway (DLR)	This is good practice from a design/ construction perspective: high quality materials, design incorporating the natural light, clear movement paths from entrance to platform. It also provides a good staff presence combined with CCTV, good natural surveillance and lighting achieves a positive sense of personal security. Finally, operational and passenger amenities are located to the edges of the central movement spaces and access to surrounding office and retail amenities is integrated into the design of the station.

Annex B: Policy questionnaire

The City HUB project has reviewed policies (from countries across Europe and beyond) related to accessible urban multi-modal transport systems and interchanges. This has been done by circulation of a policy review form amongst the partners. TRL has asked all partners to kindly answer the following questions in relation to policies in their country. The answers have allowed to undertake a comprehensive policy review of which results have been used in this Deliverable 2.1.

Policy Review Form

Date:

Reviewer:

Country:

Question 1: Do you have a policy at national level specifically on accessible urban multi-modal transport systems and interchanges?

- Yes
- No

If yes, please provide details of this policy, including the title of any legislation, documents and the date it was published. In addition, any information (from reviews or research) about the effectiveness of the policy would be much appreciated.

Question 2: Do you have guidance at national level specifically on accessible urban multi-modal transport systems and interchanges?

- Yes
- No

If yes, please provide details of this guidance, including the title of the guidance and the date it was published. In addition, any information (from reviews or research) about the effectiveness of the guidance would be much appreciated.

Question 3: Do you have a policy at regional level specifically on accessible urban multi-modal transport systems and interchanges?

- Yes
- No

If yes, please provide details of this policy, including the title of any legislation, documents and the date it was published. In addition, any information (from reviews or research) about the effectiveness of the policy would be much appreciated.

Question 4: Do you have guidance at regional level specifically on accessible urban multi-modal transport systems and interchanges?

- Yes
- No

If yes, please provide details of this guidance, including the title of the guidance and the date it was published. In addition, any information (from reviews or research) about the effectiveness of the guidance would be much appreciated.

Question 5: Do you have policies at national (and/or regional) level which although not specific nevertheless relate to accessible urban multi-modal transport systems and interchanges, for example by providing the context in which such developments are taken forward?

- Yes
- No

If yes, please provide details of these policies, including the title of any relevant documents and the date it was published.

Question 6: Do you have guidance at national (and/or regional) level which although not specific relate to accessible urban multi-modal transport systems and interchanges?

- Yes
- No

If yes, please provide details of this guidance, including the title of any relevant documents and the date it was published.