Passenger Transport Interconnectivity as a Stimulator of Sustainable Transport Development in the European Union

Monika Bak, Przemyslaw Borkowski and Barbara Pawlowska

Abstract The aim of this chapter is to provide the overview of interconnectivity issues in the area of passenger transport in the context of sustainable transport development in the EU. At present the European Transport Networks' role as integrated international networks is compromised by poor interconnectivity. A realistic assessment of intermodal opportunities is a key ingredient to future policy development. In this part the tools and solutions for improvement interconnectivity are also discussed.

Keywords Passenger transport interconnectivity · Interconnection · Sustainable transport

1 Introduction to Passenger Transport Interconnectivity

Effective integration of passenger transport systems requires good interconnection which cannot be guaranteed without the provision of integrated networks and services which are attractive to potential users.

There are no universally accepted official definitions of the terms used for describing the transport of passengers using more than one transport mode;

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however in current literature the words "multi-modality" and "intermodality" are most often used to define a "characteristic of a transport system that allows at least two different modes to be used in an integrated manner in a door-to-door transport chain". Distinction between those two terms is often made in case of goods transport with "multi-modal" indicating possibility of transport unit change whereas "intermodal" addresses transport chains utilizing the same transport unit (but still more than one mode of transport). In passenger transport the rigid distinction between these terms does not exist, but the former term is generally applied.

Consequently, a trip may be defined as being "multi-modal" or "inter-modal" where it uses at least two different modes from origin to destination. Both multi-modality and inter-modality have to consider the existence of connections that allow transfers between different transport modes. In this sense the definition on interconnectivity comes straightforward: interconnectivity is a characteristic of a transport network that allows multi-modal or inter-modal transport. Consequently interconnections are the connections between the infrastructures of the various transport networks (de Stasio et al. 2009).

The topic has particular relevance at the European level because the European Transport Networks' role as integrated international networks is compromised by poor interconnectivity and because the next generation of European transport policies will have to be sensitive to the differences between short, medium and long-term transport markets and the market advantages of each transport mode. In this context, a realistic assessment of intermodal opportunities is a key ingredient to future policy development.

The chapter is based on the results of the project realised in the EU funded 7 Framework Programme—INTERCONNECT (Interconnection between short- and long-distance transport networks) by the team of the University of Gdansk together with partners from five EU countries.

Integrated in the work of the project were the following scientific and technical objectives (Thisgaard et al. 2011):

- To produce quantitative evidence on the current and likely future extent and impacts of poor interconnectivity between long-distance (more than 100 km) and local/regional travel in Europe;
- To provide evidence on key stakeholders perceptions of the underlying causes of the problems and of the applicability of specified solutions;
- To identify and investigate gaps and apparent inconsistencies in the European and national strategic planning concerning interconnection;
- To provide an analysis of evidence on the nature and seriousness of identified barriers to effective interconnectivity;
- To provide an assessment of the effectiveness of available analytical tools for the assessment of problems and solutions in this domain;
- To provide an assessment of the performance of selected policy interventions designed to improve interconnectivity in specific situations;

- To provide evidence on the potential impact of improved interconnectivity on a European scale in particular, though not only, on:
- Decongesting overcrowded transport corridors,
- Encouraging a shift towards the more sustainable transport modes,
- Reduction of Green House Gas (GHG) emissions;
- To provide policy guidance on good practice in implementation of improved interconnectivity;
- To disseminate project findings widely to policy-makers.

In this chapter some results in the mentioned above areas are summarized.

2 Interconnectivity and Sustainable Transport Objectives in EU Transport Policy

Nowadays it is widely acknowledged that facilitating connectivity among modes is crucial for (Sitran et al. 2011):

- Making better use of the existing transport infrastructures;
- Relieving congestion;
- Improving the environmental performance;
- Improving the overall quality of transport operations, thus increasing mobility and influencing passengers' choice.

The optimal and sustainable combination of different transport modes is the basis of the recently introduced concept of co-modality. This is the reason why interconnectivity (and is related term interoperability) is a core theme in the development of the EU transport policy. Together with multimodality and sustainability, interconnectivity is a key word in the design of a comprehensive EU transport policy which is supposed to ensure adequate and efficient accessibility at different levels, that is not only across Member States but also at regional and local level.

The main objective of the INTERCONNECT project was to recommend the solutions aiming for greater efficiency and reduced environmental impact of passenger transport by judicious encouragement of integration, co-operation and, where appropriate, competition in the provision of local connections, paying attention to land, air and maritime modes.

The current part of this chapter gives an overview of EU policy objectives in the field of improving intermodality and interconnectivity of passenger transport in the context of sustainable transport development. For this purpose, those EU policy documents—mainly issued within the last ten years—have been analysed, whose policy objectives or policy measures have a direct impact on passenger intermodality, interconnectivity and sustainability.

The European Commission has put forward in several policy documents the concept of interconnectivity. The policy objectives have been addressed by the EU

through an array of measures, including for instance regulations, funding, standardisation, research or the exchange of best practice. In Table 1 the overview of strategic transport policy documents is presented.

The 1990s saw a gradual but significant development of the interconnectivity issue, which evolved into a major policy goal as stated by the Green Paper on the impact of transport on the environment of 1992 which stressed the need to improve the linkage between the different components of urban journeys (Green Paper on the impact of Transport on the Environment 1992).

A later key development in this respect was marked by the Green Paper on the citizen's network of 1995, where the Commission acknowledged that public transport had to be become more flexible and better suited to the needs of passengers (Green Paper 1995).

A breakthrough in setting the course of the European transport policy occurred in 2001 with the release of the White Paper: European Transport policy for 2010: time to decide of 2001. Interconnectivity and intermodality are viewed as priority aspects for easing travelling conditions and modal transfers, as travellers encounter serious impediments when using different modes of transport for single journeys, namely when the latter involve several transport companies or different means of transport. Moreover, the White Paper also concludes that transferring from one mode to another can be complicated by inadequate infrastructure. Within this framework, the White Paper identified a number of key issues to be addressed, such as (White Paper 2001):

- Integrated ticketing, e.g. encouraging the introduction of integrated systems between modes of transport (air–coach–ferry–public transport–car parks), which may also ensure a greater transparency of fares;
- Baggage handling, e.g. making it easier to check in luggage directly in a station without holding it during transfers to/from the airports;
- Continuity of journeys, which requires integration in land-use and transport planning.

Later, both the Mid-term review of the White Paper of 2006 and the Communication "A sustainable future for transport" of 2009 have stressed the need to further encourage and coordinate actions and investments for making the EU transport systems more cooperative, co-modal and to ensure a better interconnection (Keep Europe moving 2006).

On the one hand, the mid-term review of the White Paper emphasises the structural developments that occurred at EU institutional level with the 2004 enlargement. The enlargement shaped as ever the EU dimension, and the extension of the TEN-T network emerges as valuable and strong determinant in creating more corridors and in linking Europe to its neighbours, while ensuring a Europe-wide internal transport market (Green Paper 2009).

On the other hand, the Communication: A sustainable future for transport emphasises that the optimal functioning of the transport system requires full integration and interoperability of the individual parts of the network, as well as

Table 1 Overview of EU contribution to the interconnectivity and sustainability issue

Document	Editor	Year of publication
The Green paper on the impact of transport on the environment	European commission	1992
The Green paper on the citizen's network	European commission	1995
Interoperable electronic fee collection systems in Europe	European commission	1998
Directive on the interoperability of the trans-European conventional rail system	EU parliament and council	2001
White Paper—European transport policy for 2010: time to decide	European commission,	2001
Trans-European transport network: TEN-T priority axes and projects	European commission	2005
Facilitating the movement of locomotives across the European Union	European commission	2006
Keep Europe moving—sustainable mobility for our continent	European commission	2006
Regulation on rail passengers' rights and obligations	EU parliament and council	2007
Trans-European networks: towards an integrated approach	European commission	2007
Green Paper: towards a new culture for urban mobility	European commission	2007
An action plan for airport capacity, efficiency and safety in Europe	European commission	2007
Directive on the interoperability of the rail system within the Community	EU parliament and council	2008
Proposal for a regulation on the rights of passengers in bus and coach transport	European commission	2008
Community guidelines for the development of the trans-European transport network	European commission	2008
TEN-T: implementation of the priority projects progress report	European commission	2008
Action plan on urban mobility	European commission	2009
Green paper: TEN-T: a policy review	European commission	2009
A sustainable future for transport—towards an integrated, technology-led and user-friendly system	European commission	2009
White paper: roadmap to a single european transport area—towards a competitive and resource efficient transport system	European commission	2011

Note: References to the strategic documents are given in the literature items: (A sustainable future for transport 2009; Action Plan on Urban Mobility 2009; Commission working document 2010; Green Paper on the impact of Transport on the Environment 1992; Green Paper 1995, 2007, 2009; Keep Europe moving 2006; Strengthening passenger rights within the European Union COM 2005; White Paper 2001, 2011)
Source: (Sitran et al. 2011)

interconnection between different (modal) networks. Creating the ideal conditions for making interchanges easier and more accessible is here crucial. This applies to both passenger and freight transport, but it is with respect of the passenger side that the need for better integrating the different modes to make seamless journeys possible emerges with utmost importance (A sustainable future for transport 2009).

A more holistic approach to the achievement of a single, interconnected and efficient transport system has been lined up by the EC in the new White Paper on transport policy released in March 2011. Specifically for the issue related to interconnectivity, in the staff working document accompanying the White Paper, the European Commission stresses that

> The modal mix has to be better adapted to the particular needs of each journey and, in the case of passengers, to the overall travel experience. This will only be possible in a system that is highly integrated, and that is based on a continuous and ubiquitous exchange of information. The use of information technology to optimise all aspects of personal travel and freight transport is likely to become one of the most distinctive traits of future transport systems

(Commission staff working document 2011).

Within the project at the national level 67 policy documents has been reviewed and there has been identified 40 documents, which mentions areas relevant to the intermodality and interconnectivity of passenger transport issues (Sitran et al. 2011). Most of the documents reviewed are from the year 2000 and onwards, and large part of the documents concerning the new member states (NMS). In these NMS documents the mentioning of interconnections are only at a general level and not related to access and egress or to any special modes or terminals/stations. The general picture shows that there is little or close to no focus on interconnections in the policy documents. This lack of focus on interconnections in policy can have some negative effects on the passenger transport between neighbouring states and European wide passenger transport. Missing interconnections between different modes of transport and different layers of transport networks level this would not only have a negative impact on people's ability to access local/regional destinations, but it would also reduce access to European and intercontinental destinations and it would have similar effects for people coming from higher levels of transport networks trying to access local/regional destinations.

This lack of accessibility can potentially have negative effects on the economy and social cohesion, both at local/regional level and at the EU level.

3 Tools for Improvement Interconnectivity

In order to analyse solutions for improvement of the interconnectivity one has to identify the key problems of poor connectivity. They can be enumerated as follows (Bonsall et al. 2010):

- Non provision (or inadequate standard) of the infrastructure for local links;
- Poor design, maintenance or operation of modal interchange points;

- Inefficient procedures for interchange (e.g. delays while waiting for luggage);
- Inadequate provision of local transport services (e.g. no fast public transport from an airport to city centre);
- Local transport services exist but do not serve the needs of connecting long-distance travellers (e.g. time tables are uncoordinated, nearest bus stop requires a long walk);
- Inadequate provision of information;
- Unavailability of integrated tickets (covering the local as well as the long distance parts of the journey).

In the INTERCONNECT project the toolkit is one of the major result of the project. This toolkit refers to 94 potential solutions to the problems of poor interconnectivity experienced by long distance travellers whose journeys require them to use short distance "local" mode(s) to commence and/or complete their journeys. The toolkit comprises[1]:

- A list of 94 potential solutions;
- A brief description of the problems of interconnectivity;
- A discussion of the criteria by which to judge the usefulness of different;
- Text descriptions of each of seven categories of solution;
- Matrices summarising the usefulness of the 94 identified solutions;
- Text descriptions of each of the 94 identified solutions, including examples of their application, references and links to more detailed case studies and sources of information.

A set of assessment matrices which summarise each category of solutions in matrix form, has been developed and the assessment criteria is as follows:

- Indicative cost of implementing the solution;
- Technical feasibility;
- Financial feasibility;
- Organisational/legal feasibility;
- Acceptance by users;
- Other aspects of political acceptability (in addition to expected acceptance by users);
- Impact on users door to door travel time;
- Impact on users door to door travel cost;
- Initial impact on comfort or convenience of the users' journey;
- Any detectable increase in users' safety;
- Any detectable increase in users' personal security;
- Any detectable increased access for people with reduced mobility.

[1] For more detailed information please visit the INTERCONNECT website: http://www.interconnect-project.eu/.

For each solution a rating score is given for each of the assessment criteria. In this way the reader is able to absorb the key characteristics of the solutions in a time effective way.

The toolkit's 94 solutions are organised in the following seven solution categories (as included in Table 2).

The **local link infrastructure** category includes those solutions which seek to address the problem of inadequate infrastructure for the link between an interchange (such as an airport) and the centre of the city which it serves. The question of financial feasibility is very important for many of these solutions. The initial investment by government (local, regional, national or supranational, a special purpose authority, or the private sector, will generally be recouped by usage charges which are met, directly or otherwise, by end users. The assessment of overall financial feasibility is based on a judgement as to whether the initial and ongoing costs could be recouped in this way.

The l**ocal transport services** category includes those solutions which concern improvements to the organisation of local transport services which could be achieved without major investment in new infrastructure.

The category labelled **improvements at the interchange point** includes those solutions which address problems experienced at the modal interchange point (e.g. within airports or at major rail stations or ports). It includes improvements to infrastructure which will facilitate movement within the interchange facility, design details which should make movement easier and quicker, and other interventions designed to make the time spent within the interchange more pleasant or productive. Some of these solutions, e.g. car parks and traveller facilities, may generate revenues, but most do not—except indirectly in so far as they might contribute to the attractiveness of the interchange. Their financial feasibility may thus be an issue.

A special category is included for solutions which concern **check-in and luggage transfer**. Although primarily procedural, all will require some investment in infrastructure and information technology. Even where they do not directly generate additional revenue, the financial case for them may be based on the fact that they may attract additional passengers. Note that, as stated in the introduction, changes to procedures and facilities associated with the long-distance leg of the journey are beyond the scope of this document.

Ticketing and pricing solutions concern the provision of integrated pricing and/or ticketing for the individual components of long distance journeys. The idea being that this will make a multi-leg journey easier to understand, plan and execute. The general justification for providing "seamless" journeys is that it would reduce the effort involved in making such journeys.

A distinct group of solutions involving **marketing, information and sales** was identified and includes branding, the provision of information and new sales channels. The idea being that this will make a multi-leg journey easier to plan and execute and will help users identify and access the most appropriate options for their journey.

Table 2 List of solutions improved interconnectivity

Types of solutions	Solutions indentified
Local link infrastructure	Ferry link
	Maglev link
	Link into general HSR system
	Dedicated HSR link
	Link into heavy rail system
	Metro/s-Bahn link
	Tram link
	Monorail/people mover
	Motorway link
	Park and ride facilities
	Tramtrain or traintram
	Guided bus link
	Segregated bus lanes
	In-road bus lanes
	HOV lanes
	Cycle path
	Improved maintenance and earlier replacement of public transport infrastructure
	Vehicle or service upgrade for increased comfort and convenience
Local transport services	Robust schedules
	Integrated timetabling
	Regular interval timetabling
	Creating hub-and-spoke schedules by adding short 'spokes'
	Increased service frequency or capacity
	Service re-routing
	Direct (shuttle or express) services by rail or bus
	Addition of intermediate stops
	Demand-responsive bus service
	Provision of dedicated shared-ride taxi services
	Link into general bus lines
	Shuttle bus links between different interchange points provision of short feeder flights
Improvements at the interchange point	Additional, conveniently located, car parks
	Convenient positioning of local transport services
	Convenient positioning of taxi services
	Moving walkways
	Elevators and escalators
	Level access to trains and buses
	Visibility axis between modes
	Direct, un-interrupted, logical paths
	Provision of assistance for travellers with reduced mobility
	Tactile guidance systems for disabled
	Improved lighting
	Increase space and comfort at waiting areas
	Provision of services for travellers

(continued)

Table 2 (continued)

Types of solutions	Solutions indentified
	Train information/tickets at baggage claim area of airports
	Multilingual or pictogram information
	Increased provision of staff
	Provision of monitoring cameras
	Cycle facilities at modal interchanges
	Use of charges and subsidies to reduce congestion at the interchange
	Multi-modal information and ticketing booths
Check-in and luggage transfer	At-station passenger check-in for flights
	In-train passenger check-in for flights
	Full check-in and luggage-drop point at airport stations
	Door-to-door luggage transport
	Flight luggage check-in at train station
	Early issue of luggage labels
	Post-flight luggage collection from local train station
	Rfid tagging for luggage
	Self-service luggage check-in and drop-off
Ticketing and pricing	Pre-paid tickets or cards allowing unlimited local travel
	Simple tariff structure for local transport services
	Provision of integrated tickets for local journeys
	Competitive pricing of integrated tickets
	Integrated ticketing for air and rail and within mode
	Pre-booked ticket for parking and public transport
	Integrated ticketing for long-distance rail & local public transport
	Inclusion of local taxi journeys in rail or air tickets
	Smart cards
	Payment via mobile telephone text messages
	Virtual tickets on smart phones
Marketing, information and sales	Common information design guidelines across operators
	Uniform branding and marketing across operators
	Pre-trip marketing of connecting services
	En-route marketing of connecting services
	Pre-journey information about interchanges
	'one stop shop' multi-modal journey planner—national
	'one stop shop' multi-modal journey planne—international
	Local transport ticket sales via internet
	Pricing information and payment systems for international travellers
	Smart phone applications
Enabling solutions	Single strategic authority
	Voluntary partnerships
	Intermodal agreements
	Relaxation of antitrust laws
	Increase competition where little or none exists

(continued)

Table 2 (continued)

Types of solutions	Solutions indentified
	Strengthened independent regulation
	Tendering/franchising/concessioning
	Serial motorway concessions en route to major ports/airports
	Joint management of car parks and serial transport services
	Price regulation for serial rail concessions
	Coordination between local public transport operators and long distance rail providers
	Coordinated policy for management of an interchange's access modes
	System for fair distribution of ticket revenue

Source: (Bonsall et al. 2010)

A final, rather different, category of interventions was identified comprising **enabling solutions** which, while not providing a complete solution to problems affecting end users, seek to facilitate the implementation of more specific solutions by reforming aspects of the operating environment. Many of the impacts of these solutions would come about only indirectly—because some other development is facilitated. These enabling solutions generally involved regulatory or organisational changes.

4 Modelling Interconnectivity

Interconnections between modes could also be analysed in quantitative manner through investigation of the modelling of interconnectivity. Models allow for integration of disperse knowledge that has been gathered through case studies in a systematic way—quantitative whenever feasible—to assess the impact of improving key local and modal interconnections at European level.

The model for interconnectivity assessment calibration is based on using as input data generalised costs obtained from TRANSTOOLS[2] for the different modes and refining these costs based on the knowledge gathered from INTERCONNECT case studies.

Testing of applicability of modelling tools in different situations for number of key nodal points in Europe and at various levels of integration—including different modes of transport allows for creation of meta-model. This final tool indicates what could be the impact on the relative modal shares, if adjusted costs (including interconnectivity issues) were considered. The concept of meta-modelling differs

[2] TRANS-TOOLS ("TOOLS for TRansport Forecasting ANd Scenario testing") is a European transport network model that has been developed in collaborative projects funded by the European Commission Joint Research Centre's Institute for Prospective Technological Studies (IPTS) and DG TREN for purpose of model ling transport systems.

from traditional TRANSTOOLS used widely in transport research and policy making. Traditional transportation modelling approaches are not oriented to deal with interconnectivity and multimodality. Often the definition of "multimodal model" is adopted if the model just covers more than one transport mode, regardless of its capability of dealing with trips composed of different transport modes on multimodal paths. At a general level, the recommended framework to enable the proper modelling—which could been used to determine interconnectivity in multimodal passenger transport has to encompass:(Ulied et al. 2011)

- The use of a network-based representation of alternative routes and modes within the transport model;
- The transport model should employ some form of choice model which estimates the demand on each mode combination/route based on the generalised costs of the different alternatives;
- The generalised cost formulation used in the transport model should include an explicit representation of costs of modal transfer.

The interconnectivity indicators defined and computed by the meta-model fulfil those criteria. The list of 15 indicators used in INTERCONNECT includes (Ulied et al. 2011): respective percentages of uni-modal itineraries, multi-modal itineraries, road uni-modal itineraries, rail uni-modal itineraries, air uni-modal itineraries, road-rail multi-modal itineraries, road–air multi-modal itineraries, rail–air multi-modal itineraries, road–rail–air multi-modal itineraries. Also used are multi-modality rate, defined as the number of different modes used in an itinerary, inter-modality rate, defined as the number of shifts between different modes in an itinerary.

Interconnectivity rate, defined as the number of shifts between different modes or between different services in the same mode, diversity rate, defined as the total length of road, rail and air used in an itinerary aggregated according to an entropy formulation. It reflects the diversity of modes used, has a minimum value of 0 when only one mode is used, and a maximum value of 1 when all modes are used in the same proportion (33%; 33%; 33%). Other indicators are: travel cost, defined as the cost in EUR of an itinerary (dependent on the length of the itinerary, the modes used, the geographic location of the links used and the value of time of users), percentage of travel cost spent in interconnections (city connectors and network connectors) with respect to total travel cost.

Indicators are computed for NUTS3 (counties/districts level), NUTS0 (country level) and globally for Europe. They are determined in relation to itineraries between different NUTS3, reflecting the geographic notion of travel opportunities; they are also calculated in relation to trips in Europe; and they are measured in relation to trip-kilometres. Indicators can be calculated for all trips and for specific travel purposes: business trips, private trips, commuter trips and holiday trips. They can also be calculated for different trip length ranges.

5 Interconnectivity in Europe in the Future

In Europe long-distance travel represents less than 10% of all passenger trips. But if one counts overall distance travelled than those long distance trips rise to almost 30% share. At the same time only 7% of trips use modal combinations of more than one mode, but those trips represent as much as 20% of the total amount of kilometres travelled. Thus multi-modal trips have much higher impact on transport system than uni-modal trips. The pattern of use of different modes shows predominance of road transport with complimentary role of air mode and very limited role of rail. The uni- versus multimodal behaviours are strongly influenced by location. Opportunities for uni-modal trips are lower in the periphery than in central areas. Itineraries from the periphery to all other regions in Europe have to cope with a relatively larger amount of interruptions (interconnections inter mode or intra mode) than itineraries originated in core regions. The important question is how this situation will evolve in the future?

The results of both qualitative and quantitative modelling allow for formulation of possible future scenarios for development in Europe. Three alternative scenarios based on reducing interconnectivity costs could be tested using tools developer within INTERCONNECT. The baseline scenario represents current situation. Scenario A assumes that the cost of all interconnections will be lowered by 50% of today's values. This reduction affects all connections between all transport modes, regardless of the modes (rail connections to airports, road access to airports and rail stations, road access to cities and rail access to cities). Scenario B lowers the cost of all interconnections to zero and Scenario C lowers only the costs of access and egress to rail terminals to zero. The first two aim to measure the overall impact of reducing all interconnectivity costs in Europe, while the third represents an effort to procure modal shift towards more environmentally friendly rail mode. The impacts could be observed on overall EU level, on individual user level and in regard to modal structure of the transport system.

On the EU level overall forecasted costs of passenger transport under those three different approaches produce savings as given in Fig. 1. It is noticeable that while reductions have been achieved in all cases, the rail enhanced scenario does not guarantee substantial savings.

The effects on individuals could be best summarized by changes in trip costs per person. Figure 2 presents modelled results of price change in regard to all three scenarios in division into trip purpose. The most significant changes are observed on vacation trips but also on daily commuter travels. Again rail enhancement only slightly improves overall situation of individual transport user as compared to two other scenarios.

Impact on modal split is simulated on Fig. 3. If costs of travelling are reduced equally the most benefits go to air sector. Also difference between scenario A and B shows that when interconnection cost reductions are higher the positive effect on air is more than proportional.

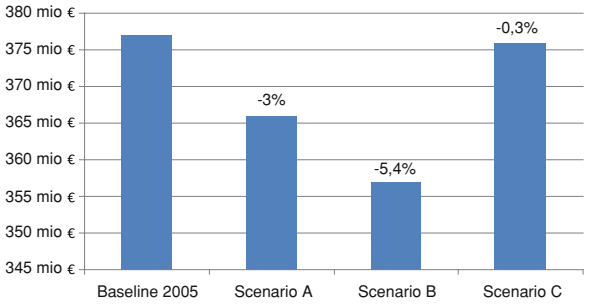

Fig. 1 Evolution of transport costs under different scenarios, *Source*: (Ulied et al. 2011)

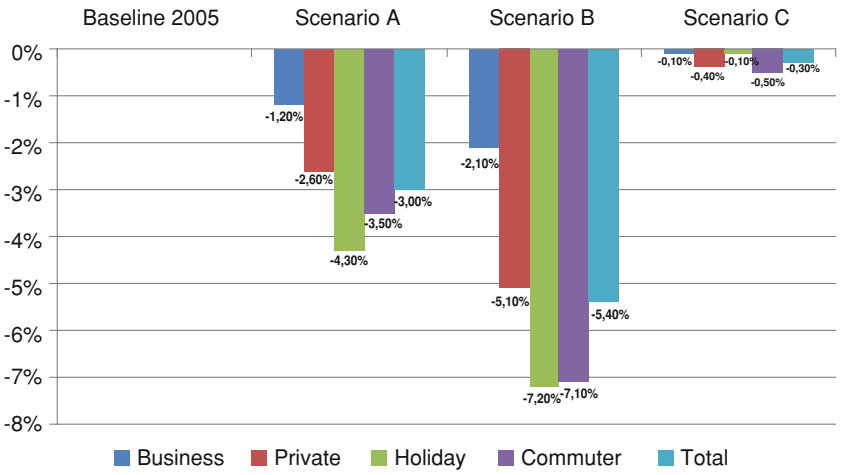

Fig. 2 Cost variations by trip purpose, *Source*: (Ulied et al. 2011)

The relative low value of rail enhanced scenario (from travel cost perspective) is offset by huge reduction of environmental costs under this scenario (see Fig. 4). The results present difficult dilemma for policy makers –improving interchanges only at key rail nodes delivers clean transport and reduces environmental costs but keeps overall transport costs high.

Pursuing balanced improvements of interchanges gives significant savings for users and societies in terms of transport costs but very limited in terms of emissions.

Finally the impact on multimodal travel could be compared to the impact of uni-modal travels. Figure 5 shows evolution of multimodal versus uni-modal share under different scenarios (top figure). Impacts of different scenarios on shifts in modal shares for uni-modal systems (middle figure) could be compared to impacts on multimodal systems (down figure).

When analysing the share of the different transport chains (in terms of trip-kilometres), the number of multi-modal trips increases in all scenarios. Compared

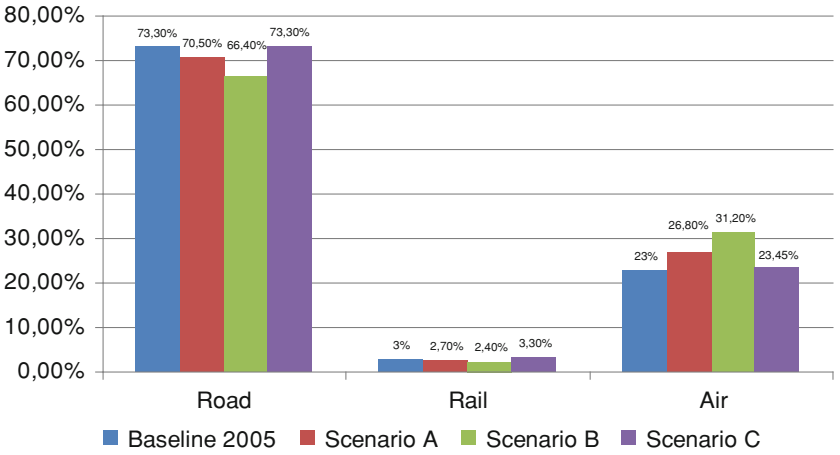

Fig. 3 Impact on modal split (per trip-km), *Source*: (Ulied et al. 2011)

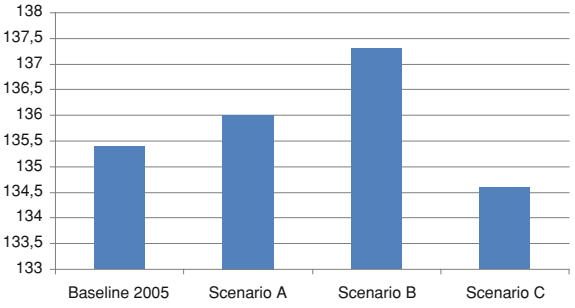

Fig. 4 Impact on GHC emissions (yearly released million tons of CO_2), *Source*: (Ulied et al. 2011)

to base, scenario A produces a 1% increase in the multi-modal trips, scenario B a 2% and scenario C in a 3% growth. This confirms the assumption that making interconnections cheaper results in increasing shares of multimodal travel. Different results apply to the uni-modal trips. In this case both scenarios involving absolute cost reductions (A and B) result in increases of the air uni-modal trips (2 and 4% respectively) and reductions of the road uni-modal trips. The special case—rail scenario (C) gives a 1% increase of the rail uni-modal trips, a 1% increase of the road uni-modal trips and a 2% air decrease. Within the multi-modal trips, for scenarios A and B there is a clear trend towards reduction of the road–rail multi-modal chain, but an increase on all others, in particular on the air–road multi-modal chain but also of the air–rail multi-modal chain. For scenario C, the most significant change is an increase of the tri-modal chains (road–rail–air). The global increase of trips by air mode is a consequence of reducing the higher cost of access/egress to airports, which are more significant than costs of accessing the rail and road networks.

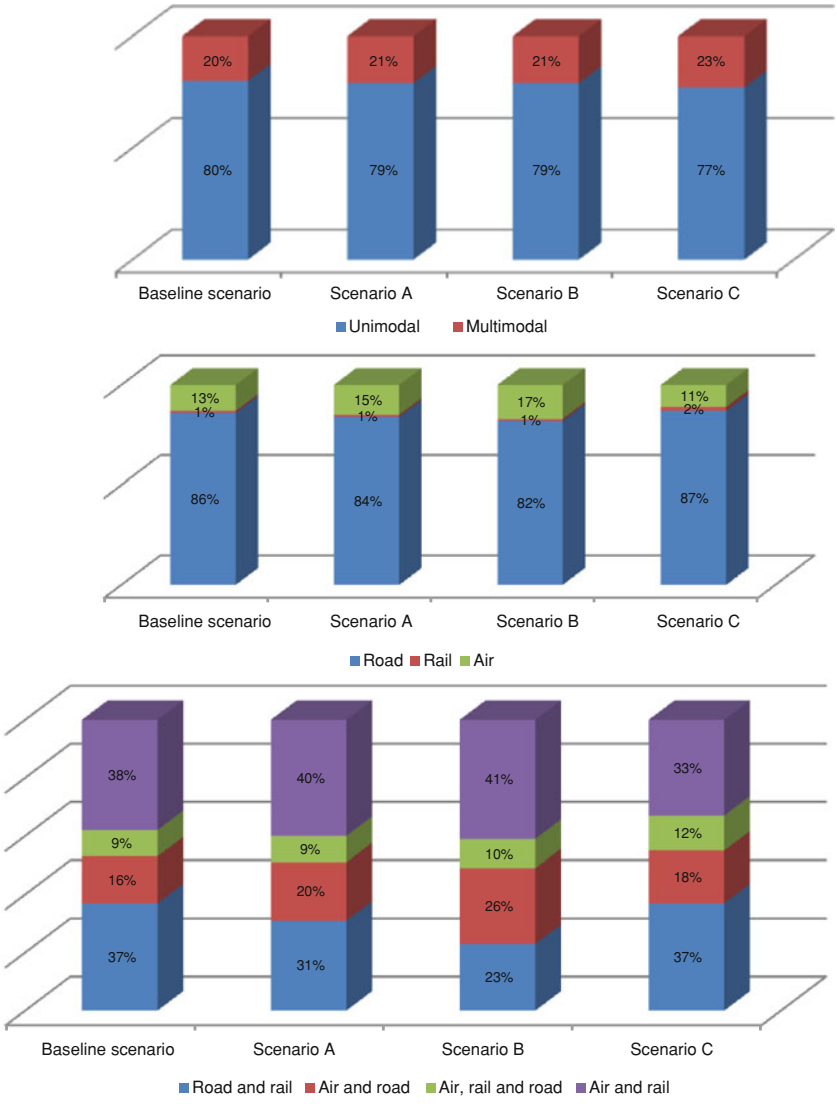

Fig. 5 Modal shifts under interchange cost reduction scenarios. *Source*: (Ulied et al. 2011)

6 Conclusions and Recommendations

The results of the INTERCONNECT project have highlighted the possibilities for the EU to function as a driver for the development of interconnectivity at very different scales. At the strategic level the analysis has revealed that on interconnectivity there is an overall lack of focus in national strategic policies documents,

and that the actual EU strategic policy issues concerning passenger intermodality and interconnections call for a more active role of the EU, and highlight the potential for more formal and authoritative strategic policy decisions binding for the member states, in order to ensure a coherent and cross-national strategic EU policy in passenger interconnections, safeguarding the integration and development of the EU, and ensuring the mobility needs of the EU citizens.

The modelling exercise shows that reduction of costs of interconnection increases the share of multi-modal trips, as expected but the increase is relatively small: But real effect is seen in global transport costs savings. With reductions of 50 and 100% in interconnection costs, transport costs may decrease 3,0 and 5,4% respectively, which translates to a € 11,000 million and € 20,000 million saving per year. Moreover users that capture more benefits from reducing the costs of interconnection are those with lower values of time, like tourists. The reduction of costs of interconnections provides reductions in the global volume of trip-kilometres travelled, implying that more efficient routes are globally chosen. With reductions of 50 and 100% in interconnection costs, volumes of traffic decrease 2,2 and 1.1% respectively. This is a total of 2,600 and 13,000 million passenger-kilometres respectively.

But this overall positive impact on travel costs is offset by increasing environmental burden. The reduction of costs of interconnection causes long-distance traffic CO_2 emissions to increase up to 0,9% (1,9 million tones CO_2) in scenarios with simultaneous reductions of costs of all interconnections, and to decrease 0.5% in scenarios favouring rail.

In general, the present gap between formal and authoritative strategic policy decisions, and the actual EU strategic policy issues concerning passenger intermodality and interconnections highlight the need for an overall and formal strategic EU policy in three strategic areas (Nielsen et al. 2011):

- Physical infrastructure (especially intermodal terminals). There are substantial differences in the quality of the passenger infrastructure in the EU. A terminal for intermodal exchange of passenger cannot be isolated from the development of passenger transport modes, and visa versa. In general an EU policy driving the development of infrastructure and the related intermodality could be a driver for the integration of EU.
- Technology facilitating passenger intermodality. An example is the success of computer reservation systems of the airline industry.
- A similar system covering several or preferably all inter-EU passenger transport modes would be a substantial advantage.
- Policy and legal frameworks facilitating intermodal cooperation. An example is the creation of common EU standards to facilitate technological development and preventing the development of national suboptimal standards, especially concerning passenger ticket, passenger information and passenger reservation systems. Another example is to set-up minimum standards for the intermodal connection terminals important to cross-national passenger movements, and

secondly for interconnections of national importance, thereby creating a feeder system facilitating international passenger mobility.

The INTERCONECT project has documented the need for further research and development on several issues. A few of the most interesting and most promising areas for such endeavours are mentioned in the following (Thisgaard et al. 2011).

Infrastructure planning plays a significant role in the development of interconnections. However, the present tools and knowledge available cannot answer questions on how infrastructure planning as a process in a political system could contribute to an improved interconnection.

Organisational issues have proved to be of importance in the development of interconnection, sometimes leading to success and in other examples leading to failure. A better understanding of organisational behaviour and the structural elements in organising interconnections in complex political and economical structures is needed.

Financial and economic issues have been found to often interact with organisational issues and to create complicated barriers to improved interconnection, as problems at different political, organisational and economic levels need to be solved by actors with conflicting interests. Possibly, a better understanding of such situations could lead to guidance and/or general solutions or models, which could be implemented in the EU.

Intelligent Transport Systems (ITS) and overall the possibilities of using new information technology, mobile- and smart-phones as an active element supporting interconnection, holds a promising potential to become a driver for the development of interconnection. Research and development in this area also has potential for the ITS and IT industry in Europe to develop new products and/or systems to be used and exploited as business opportunities in the rest of the world.

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