FINAL REPORT

Trans-European transport network planning methodology

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TRANSPORT & MOBILITY LEUVEN
DIESTSESTEENWEG 57
3010 LEUVEN
BELGIUM
+32 16 31.77.30
http:\\www.tmleuven.be

AUTHORS:

Griet De Ceuster, TML
Tom Voge, TML
Ming Chen, NEA
Martijn de Kievit, TNO
James Laird, ITS University of Leeds
Andrew Koh, ITS University of Leeds
Carlo Sessa, ISIS
Riccardo Enei, ISIS
Roberto Mascellaro, PWC

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1 Introduction

In February 2009 the European Commission, Directorate general for Energy and Transport (DG TREN), adopted the Green Paper "TEN-T: A policy review – towards a better integrated trans-European transport network at the service of the common transport policy." The Green Paper creates the political framework for this invitation to tender. The policy document concerns a review process of the trans-European transport network policy (TEN-T). Since the first drafting of the TEN-T guidelines in 1996 Europe is now faced with new political, economical and environmental challenges. Against this background the purpose of the TEN-T policy review is to set out new objectives for the future development of the TEN-T policy. In support of the review process a definition of the methodological approach of the TEN-T Guidelines is required. The development of such methodology is subject of this report.

The Trans-European Network (TEN-T) policy is part of the central planning guideline of European transport planning. The objective of the TEN-T policy is to ensure the provision of the EU infrastructure in line with the economic, social and political objectives formulated in the Lisbon Treaty. More specifically, the TEN-T policy is aimed at maintaining current and shaping future multi-modal networks on the territory of the Member States. With the continuing enlargement of the European Union the necessity for a reformed European planning approach became evident. The TEN-T network planning approach developed in this study is aimed at supporting the EU's planning ambitions by providing a methodological backbone to the TEN-T policy.

2 Problem analysis

The objective of the TEN-T policy is to ensure the provision of the EU infrastructure in line with the economic, social and political objectives formulated in the Lisbon Treaty. If Europe is to fulfil its economic and social potential, it is essential to build the missing links and remove the bottlenecks in the European transport infrastructure. Accessibility and cohesion aspects have gained importance with progressive enlargement of the EU. CO2 emissions from transport are high on the agenda.

At the same time, the sustainability of the transport networks in the future should be ensured. The ultimate policy objective of the TEN-T is the establishment of a single, multimodal network covering both traditional ground-based structures and equipment – including Intelligent Transport Systems – to enable safe, sustainable and efficient traffic.

More specifically, the TEN-T policy is aimed at maintaining current and shaping future multi-modal networks on the territory of the Member States. Up to now the planning of the community network has essentially focussed on adding together significant parts of national networks for the different modes and connecting the national borders.

With the continuing enlargement of the European Union, the increasing freight and passenger flows within Europe and with the world, congestion, air pollution, etc. on the one hand and financial constraints at the other hand, the necessity for a reformed European planning approach became evident.

Moreover, the TEN-T Network planning should take into account objectives outside each individual Member State perspective. Therefore a new – top down- approach is needed. The TEN-T network planning approach developed in this study is aimed at supporting the EU's planning ambitions by providing a methodological backbone to the TEN-T policy.

3 Objectives

The objective of this project is to provide the European Commission services with technical and institutional support for the interim period in 2009 on the basis of the European Commission's Green Paper on the TEN-T policy review.

According to the tender specifications, the overall objective and central content of the contract is the definition of a methodological approach of the TEN-T planning network, in particular the "core network" as defined in the Green Paper.

The success criteria of this project are that we provide realistic analyses of transport development options which lead to robust solutions and recommendations and that these are anchored in policies and institutions. This study will:

- Consider the general objectives as described in the Terms of Reference, including the interrelated dimensions of "globalisation and international dimension", "internal market, social and economic cohesion", "territorial cohesion", "sustainable development" and "climate change".

- Consider the specific objectives aiming to achieve a multimodal and interoperable network, as described in the Terms of Reference, including also intelligent transport systems and their potential for future applications.

- Consider the EU transport policy development context and how this could be affected by the solutions sought for a Community-wide TEN-T planning and to exploit the potential of future ITS applications.

- Technical review of the art as well as the European/ international experience on network planning but also analyse the national transport infrastructure planning methodologies in a number of Member States, and the current activities of the Community on sectors such as the social, economic and environmental evaluation of infrastructure projects, the strategic territorial planning, the availability of modelling tools, databases, and of benchmarks and indicators.

- Consider institutional and organisational implications of the new Community-wide TEN-T planning approach, identifying the tools necessary for implementation of conceptual proposals underpinned by the study. A special reference will be made here to the "core network" option for further TEN-T development described in the Green Paper, the results of the related stakeholder consultation and the other three studies undertaken for the policy review of the TEN-T.

4 General approach

The current trans-European transport network lacks backing by a Europe-wide methodological approach. In this report, a top down approach is developed, based on a well defined planning methodology. Both the quality of the infrastructure and the transportation services themselves are expected to meet the highest standards, be it in terms of the connections required for an optimum service or in terms of the reliability and robustness of the connections. The traffic and transportation system need to be tailored to current and future needs.

How should such a core network be defined? It would be quit an achievement if a method was thought up that could avoid the inevitable political discussions about the shape of that network. In theory, a set of mathematical equilibriums could be developed that describe all relations between all transport drives, the European transport system, the impacts on sustainability, and the Commission's goals. A computer could then solve these equations and come up with the ideal transport network. Such exercises have been already done, not only in transport, but also for electricity networks, telecom networks etc. This approach is called the "Network Design Problem (NDP)". It allows determining the optimal investment program, so that the social welfare is maximized, while taking account of the effects of the implemented investment plan on the demand and performance of the transport system. However, the NDP method is not a very practical method for the network design on the European scale.

Alternative approaches are based on link or corridor indicators, where the corridors are then cut off when the value level reached a certain baseline or when it reached a level comparable to those routes with a regional or local function.

We propose to follow a top-down approach, based on linkages between European regions, taking into account the particularities of European geography. This means following a rather geographically than transport demand oriented approach, though in reality the difference is not so big as functional correlations may be assumed, between transport flows and spatial distribution of land use, population and economic activities. Including geographical elements into the methodological approach allows also to include the longer term horizon, and to pay special attention to peripheral regions.

We will follow a stepwise approach to determine the core network on long-distance and border crossing flows. This core network will consists of links, or OD-pairs, to which minimum standards apply, rather than specific road or rail segments.

The question presents itself as to which strategy is the best for the development of a transportation and traffic system that will continue to function efficiently in the future. Widening existing infrastructure for the structural elimination of bottlenecks or constructing entirely new infrastructure is expensive, difficult to fit in, and often undesirable from the viewpoint of community livability. Improved infrastructure does have an influence on mobility of persons and goods, in particular due to its impact on space structure and location quality, but this may be advantageous from an economic view, whereas there is also an impact on the environment.

The spatial structure determines the pattern of activities. These activities lead to a demand for transport. This demand subsequently manifests itself as traffic on the infrastructure. What is new is the addition of the relationship between spatial structure and infrastructure and the designation of the time frames of the various processes.

Not every location requires the same degree of accessibility. Each transportation network is optimally tuned to its own specific function: which destinations does it need to reach, which distances it needs to cover and what does this mean in terms of speed and comfort. A leading principle is that road and rail (and shipping) networks should be developed separately – each with its own quality in terms of speed, price and comfort, strengthening their specific markets. However, there should be co-modality, e.g. that for certain types of goods, regional collection and distribution takes place on road, long-distance transport on rail (or inland navigation).

The proposed method consists of:

1) **Selection and functional classification of nodes and defining a core network on the connection level**
This entails a vision of the overall structure of the network, including, for example, the settlements that need to be connected, the various scale levels required, etc. Current practice often employs a bottleneck approach: problems are solved at the element level. This leads to an approach that follows demand, offering little scope for a well-structured spatial policy.
A transportation network serves to connect access points with one another. It is obvious, therefore, to specify the points to be connected, before planning the connections between these points.
Each network is designed separately, primarily working top-down: from high to low scale level, with a bottom-up feedback mechanism. This is the only way to achieve cohesion between networks at various levels. If a local or regional network is used as the starting point, it becomes very difficult to achieve a coherent national network.
The design must be one of the 'perfect, most desired structure', free from the existing one. The ideal structure functions as a long-term focus.

2) **Quality criteria for the connections (links) in the core network and assessment of missing links**
In order to realise a particular accessibility the function and the desired quality of the connections needs to be clearly defined. Quality implies aspects such as speed, reliability and comfort, but also the pricing concepts that need to be applied. An acceptable relation between use and capacity of the infrastructure is required, though it is in fact separate from the desired quality level. In current practise the capacity approach is too often the primary consideration, while the other quality aspects receive insufficient attention.
In a second phase, the existing network is assessed according to the quality standards. This will lead to a list of underachieving, or even missing links.

3) **Network assessment strategy: ranking (MCA) and evaluating (CBA) projects**
A cost-benefit analysis is the most appropriate tool for the appraisal of network connections. However, on the strategic level, a multi-criteria analysis could be more adequate to quickly scan the possible effects on sustainability.

The design proceeds mainly in **top-down** fashion, using feedback from a bottom up approach. Firstly an ideal network is defined, a network that is neither influenced by the applicable modes of transport nor ‘obscured’ by existing rail or road infrastructure. This is done to obtain a better picture of the function of the infrastructure to be designed. Of course this ideal network may deviate from the existing transport network.

Because the primary function of a network is to offer transport connections between various access points (or nodes), the selection of access points precedes the inclusion of the network links.

A hierarchy in the access points is established (e.g. based on number of inhabitants) and used as a selection criterion. The size of the flows between the various access points can be used to check the selection. The spatial orientation of the various access points is also an important factor influencing the network structure.

5 Selection of nodes and links in the core network

The core network will be build from a step-by-step procedure with a top-down approach, to be able to stable over a reasonably long period. In this sense it is the opposite of the current concept of 30 priority projects, which have in many cases been derived from specific projects proposed by the member states.

In a first step, the relevant nodes need to be define, while in a second step the links are determined to obtain an optimum network configuration. Both nodes and links need to have a high European strategic importance. The next step (next chapter) defines technical parameters and capacity needs for the individual network components, taking into account the specific needs of both passenger and freight traffic on long-distance scale.

5.1. Step 1: Selection and functional classification of nodes in the core network

5.1.1. The European space and selection of zoning systems

The study area is subdivided into nodal areas. The size of a nodal area or zone depends on the level of the subsystem that needs to be designed (an urban system requires smaller areas then a national system). Economic centres will serve as nodal areas. These economic centres consist of large cities including their regional surroundings.

The nodes are therefore to be represented as embedded into a zoning systems of regions covering the whole European space. It is useful to make here reference to a now consolidated framework of data and analyses, using an harmonised zoning system with data available at NUTS2 and NUTS3 levels: the European Spatial Planning Observation Network (ESPON).

The ESPON programme had its origins in the European Spatial Development Perspective (ESDP). The aim was to develop an observatory able to undertake continuous spatial monitoring. ESPON's research has broadened the knowledge basis about territorial structure and trends with a number of projects, whose results are now shown into the ESPON Atlas, mapping the structure of the European Territory at the year 2006 (available at http://www.espon.eu/main/Menu_Publications/Menu_ESPON2006Publications/esponatlas.html). The ESPON study area encompasses 29 countries: the EU 27 plus Norway and Switzerland. The ESPON space covers therefore a total area of 4.7 million km^2 and have about 500 million inhabitants.

When it comes to the choice of the better zoning system to analyse the TENs networks, we should consider mainly two types of impacts expected from large transport infrastructure investments on territorial cohesion across Europe:

- Macroeconomic impacts, focused on direct investments impacts on GDP and employment, which are usually to be detected at national and regional (NUTS2) levels.
- Microeconomic impacts, explained in terms of changes in relative accessibility of regions, usually to be detected at a greater level of territorial detail (NUTS3 regions)

Depending therefore on the purpose of the analysis, the selected nodes of the TEN core network will have to embedded in the context of NUTS2 or NUTS3 zoning systems. The latter is the most frequently used by urban researchers, as NUTS3 regions typically encompass the surrounding commuter settlements of major employment centres. The NUTS Regulation lays down a minimum population threshold of 150 000 and a maximum of 800 000 for the average size of NUTS3 regions in each country. Despite aiming to ensure "that regions of comparable size appear at the same NUTS level, each level still contains regions which greatly differ in terms of area, population, economic weight …" (Eurostat, 2004, p.13). For example, NUTS3 regions range from 19 000 to 5.2 million population, and from just 12 sq.km to 99 000 sq.km (Eurostat, 2004, pp. 24-25), which means that NUTS3 zones may include nodes of very different consistency and attractiveness.

Before discussing in the following section geographical criteria which may be useful to select the nodes of the ideal TEN network, we summarise below the main conclusions of a European Parliament study focusing on the impact of Trans-European Networks on cohesion and employment[1]:

- There are two categories of impact to be considered: those of the construction phase, *via* the multiplier effect of investments, and those of the operational phase, via the changes in the accessibility of the region which may have an impact on the region GDP growth.

- The impact of the construction phase depends heavily on the specialisation of the region. If the region attracting the investments lacks activities in some specific sectors, such as manufacturing of industrial machines, steel, construction equipment, and cannot provide a skilled workforce, the positive spur of investments and consumption may be fairly limited, including only low-value services and some unskilled jobs. Conversely, the impact can spill-over to other regions specialising in those sectors playing a significant role as providers of input for infrastructure building, which can improve their performance most.

- The effects of the operational phase of TEN networks, at least when interpreted mainly in terms of accessibility changes impacts, depend on complex network effects, which can spread well beyond the regions where it is actually the new TEN infrastructure investment. If several infrastructures are completed, the overall impact on a given region is the sum of direct and indirect effects, which may be internal and external to the region and could even go in different directions, compensating each other. These network effects can be detected only using an appropriate European network model, whereas when the impacts are analysed at more aggregate level, i.e. by establishing correlations between the TEN investments and the growth of the GDP in the concerned region, they usually loose importance. According to the EP study, the extent of the impacts produced by the TENs infrastructure invest-

[1] European Parliament, Policy Department Structural and Cohesion Policies, The Impact of Trans-European Networks on Cohesion and Employment, Brussels, June 2006.

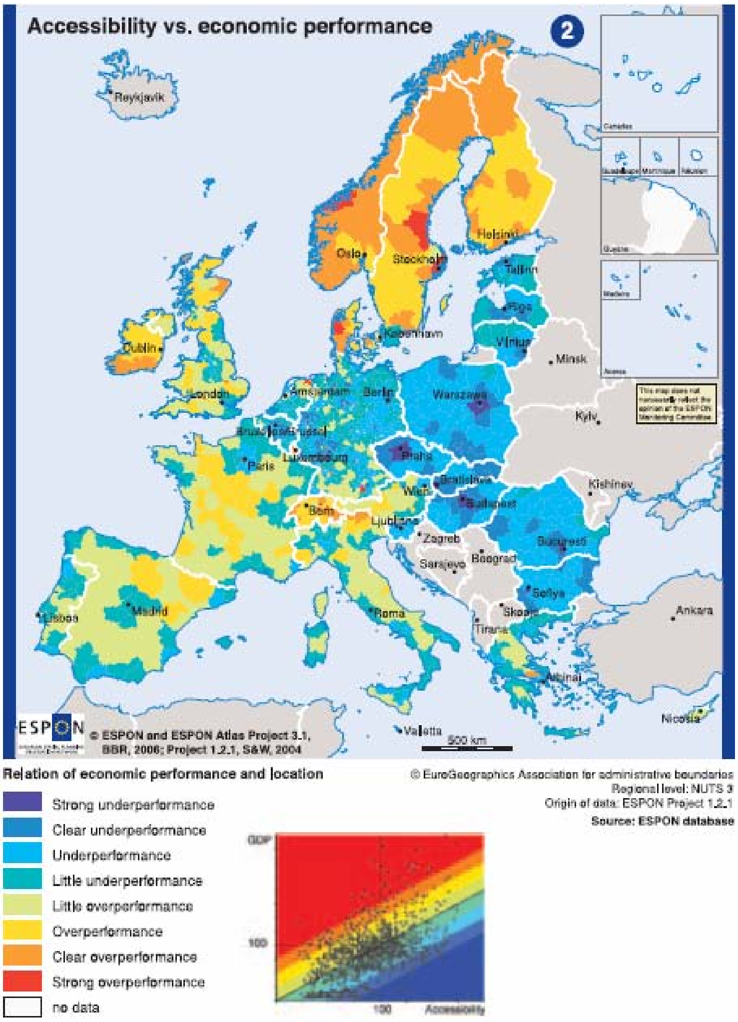
ments – some € 333 billion of total cost of the 30 key TEN projects based on the latest estimation available in 2006 – is usually low during the operational phase. Generally, the magnitudes of the changes in per capita GDP and employment until 2030 does not exceed 2% of the reference values, with only few regions showing over 3% increases. The analysis shown at this regards in the ESPON Atlas confirms that the correlation of good accessibility with economic success is weak, at least when it is analysed by means of regional indicators. The analysis in this case shows that the hotspots of multimodal accessibility are in no way homogeneous economically, and accessibility seems not to be the main factor that determines economic strength and competitiveness. The only reasonable conclusions here are that: 1) the relevant accessibility variations are those in relative, and not in absolute terms, as infrastructure that contemporarily improve the accessibility in different regions may leave their competitiveness unchanged (other regions having improved their accessibility at the same time as well) – and therefore the effects could be less relevant than expected; 2) good accessibility does contribute to potential competitive advantage, but does not by itself guarantee that the potential is realised.

One methodological implication of the above conclusions is that to properly analyse the territorial economic and social impacts of new TEN infrastructures is indispensable to use appropriate European network models and analyses. Such models are usually able to process data and produce outputs using NUTS3 and NUTS2 zoning systems.

Another important conclusion is that the relative improvement of accessibility alone is not enough to decide which nodes are more suitable to be included in the ideal TEN-T core network. The ESPON study 1.2.1 about accessibility (mentioned in ESPON-INTERACT, Accessibility, Transport and Communication Networks – Thematic Study of INTERREG and ESPON activities) looks more closely at the relationship between accessibility and GDP. It is analysed whether the level of GDP can be explained by the level of accessibility or whether there are deviations from this. A typology of NUTS3 regions is constructed by subtracting for each region the accessibility index[2] from the GDP index (both standardised), as it is shown in the map below:

[2] This is more extensively discussed later, in section 5.1.2 below.

Figure 1: Accessibility vs. economic performance



Regions with positive values are labelled as regions over-performing related to their location, while regions with negative values are labelled as under-performing related to their location.

Regions with clear and strong over-performances are primarily located in the four Nordic countries. Apparently, the regional economies here are based on other assets such as skilled labour and technology orientation. Many regions in the Alps and in Ireland and Scotland are also in better economic position than their location would indicate. Also more rural regions in France and Spain have an economic performance that is somewhat better than their location. Regions indicated in blue colours are those in which the GDP index is below the accessibility index. Those regions are not able to fully utilise the economic potential their location within Europe offers. Nearly all regions of the new EU Member States belong to this type. In addition, some regions in Southern Europe are underperforming as well.

The generally accepted idea is simple: more network for better accessibility for more GDP. Nevertheless, reality is more complex: networks generate traffic, and even in a centrally well-served region there are still enclosed zones.

In conclusions, the key findings of the ESPON scenario studies and simulations show that the overall effect of transport infrastructure investments and other transport policies are small compared with those of socio-economic and technical macro-trends, such as globalisation, increasing competition between cities and regions, ageing of the population, shifting labour force participation and increases in labour productivity. Another key result of these studies is that even large increases in regional accessibility translate only into very small increases in regional economic activity. However, this statement needs to be qualified, as the magnitude of the effect seems to depend strongly on the already existing level of accessibility, as:

- For regions in the European core with all the benefits of a central geographical location plus an already highly developed transport and telecommunications infrastructure, additional gains in accessibility through even larger airports or even more motorways or high-speed trains will bring only additional incentives for economic growth.

- For regions at the European periphery or in the new EU Member States, however, which suffer from the remote geographical location and an underdeveloped transport infrastructure, a gain in accessibility through a new motorway or rail line may bring significant progress in economic development. The opposite may happen too, if the new connection opens a formerly isolated region to the competition of more efficient and cheaper suppliers in other regions.

5.1.2. Classification of the zones and functional nodes

Not every economic centre will be awarded with a stop in the TEN network that is being designed. In order to provide access to as many transport users as possible, a ranking of all centres according to their importance is required. Possible ranking criteria are: generation or attraction capacity (long distance trips), function of the centre e.g. regional capital, regional function. Two main criteria are applied:

1) The selection of settlements is based on the urban function and activity patterns.

2) Zones that have a low hierarchy can be graded up based on a **scaling-up principle**. If a zone is located far away from high level zones, it can level up according to territorial cohesion criteria (e.g. improving accessibility). The goal is to provide decent access to the network for remote areas. The settlements that are selected to increase the scaling-up function of the network should be located such that they could contribute most to this accessibility function. The selected nodes should also relatively high in the ranking order, enabling them to add to the connecting function of the network.

In order to define an operational hierarchy of nodes, we may start taking into consideration the classification of urban functional nodes made available for the whole Europe by the ESPON research[3]. This research was boosted by the ESDP, which saw a polycentric settlement structure across the whole territory of the EU as an essential stepping stone towards balanced and sustainable development and as a means to boost Europe's competitiveness in the world.

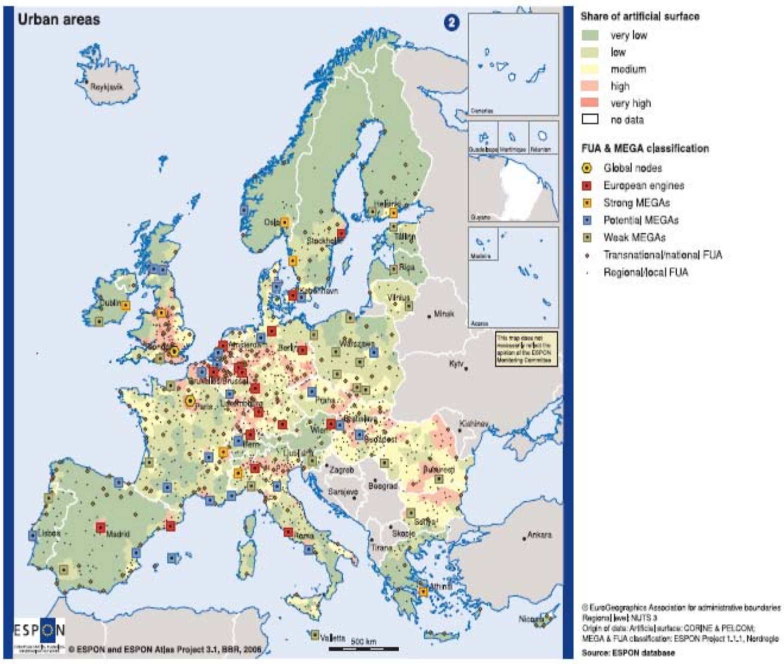
[3] This is visualised in the ESPON Atlas, page 29.

ESPON has delineated functional urban areas (FUAs) across EU 27 countries plus Norway and Switzerland. A FUA consists of an urban core and the area around it that is economically integrated with the centre, e.g. the local labour market. A total of 1 595 FUAs with more than 20 000 inhabitants have been identified on the basis of commuter relations and employment catchments areas. Different in size, they display a great variety of functions and services. Some are of national and/or European significance based on their multi-sectoral orientation, others are the sites of regional, national administrations. Their functional specialisation has been ranked according to their importance in terms of population, transport, tourism, industry, knowledge and decision-making functions – identifying the following hierarchy:

- Metropolitan European Growth Areas (MEGAs)
- Transnational/national FUA
- Regional/Local FUA

The ESPON map of the urban areas is shown below.

Figure 2: ESPON map of the urban areas



The relevant segment of the hierarchy, for the TEN core network design, is that of the MEGAs. As it is shown in the map, MEGAs are divided in five sub-categories according to their relative economic performance and concentration of urban activities:

- **Global nodes**, which based on the ESPON analysis includes only the global cities of London and Paris.
- **European engines**, mostly concentrated in the pentagon area, but including also Stockholm, Copenhagen, Vienna, Rome, Barcelona and Madrid.

- **Strong MEGAs**, mostly outside the existing European core, including capital cities such as Dublin, Oslo and Athens.
- **Potential MEGAs**, including a number of important cities – such as Lisbon, Toulouse, Marseille, Bratislava, Budapest, etc. – across Europe.
- **Weak MEGAs,** including for instance Seville, Genoa, Gdansk, Bucharest, Sophia, etc. These are generally in regions where some economic restructuring and repositioning could help growth prospects, along with better functional connections into wider networks.

One suggestion could be to take this Europe-wide urban hierarchy as the basis for selecting the urban nodes of the ideal TEN core network. As the FUAs are urban regions, these may include within their boundaries different potential TEN nodes, i.e.:

- city centres, and in particular central railway stations which could be the terminal of high speed trains and road rings or tangential urban highways which are connected with the main interurban highways;
- port areas
- airports

Pointing to the MEGAs hierarchy provides a territorial framework in which to embed the nodes of the ideal TEN core network, but still say nothing about how to concretely select the single nodes. In order to identify operational criteria, we need to discuss more in depth two key components for the choice of the nodes, i.e.

- the accessibility of the region, and
- the potential economic vitality of the same region

Accessibility needs to be analysed at and between different spatial scales: there needs to be good accessibility between regions and also within regions. Europe's MEGAs, urban centres and cities need to be inter-connected, but such centres must be accessible from their own hinterland for which they also serve as an access point to further destinations. High Speed Trains are in this respect less problematic, as usually the railway stations are located in the urban centres. Problems of local accessibility are more easily found in air transport. "Airport islands" – i.e. airports with high numbers of flight connections which allow same day return trips in many directions (e.g. Frankfurt, Munich, Brussels, Paris) – are usually connected with fast links to the city centre. But the multimodal accessibility of the neighbouring regions is often considerably lower, and this raises questions about the quality of the inter- and intra-regional transport systems within countries, and their connection to the TEN core network nodes.

A crucial question for the planning of the TEN network, from the territorial point of view, is also to control the "urban implosion" effects usually associated with shrinking travel times between the main urban nodes. Transport innovations are usually first introduced between pairs of large cities between which important flows of people and goods already occur. Such innovations make links between such pairs easier, setting off a cycle of increased contacts and flows. The net effect is to bring larger cities relatively closer to each other. Meanwhile smaller centres becomes relatively (and sometimes absolutely) more remote, a process that can be visualized as an implosion of the larger urban nodes.

The TEN planning methodology should seek therefore the right balance between improving accessibility between the urban nodes – either by providing faster and faster transport services on already existing links of the core network or connecting new urban nodes to this network with new TEN infrastructure and services – and the reduction in the relative accessibility of the smaller nodes. Implosion effects can be reduced if the development of TEN infrastructure and services is carefully coordinated with that of inter- and intra-regional transport systems within countries.

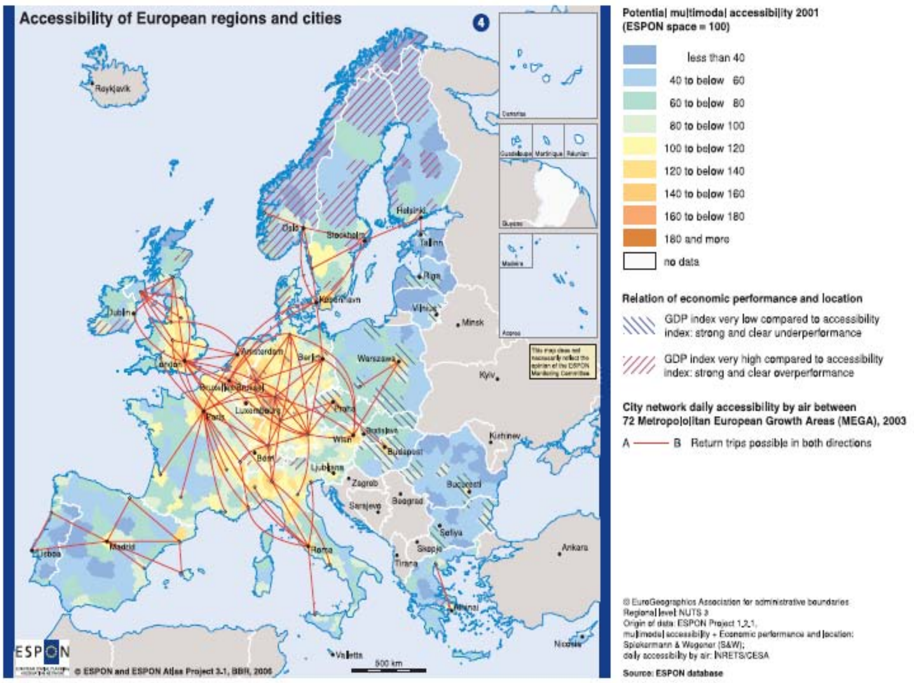
The potential accessibility of the different regions of Europe can be measured using the ESPON multi-modal accessibility indexes. The multi-modal concept acknowledge that in any particular situation accessibility of the urban region from distant origins is the outcome of the use of the best transport mode – airplanes, railway or road – or some combination of them. The regions with the highest multimodal accessibility are usually those that enjoy a combination of important airports together with deeply embedded and strongly inter-connected railway and road networks.

The multimodal index will help therefore to identify the nodes:

- which are already served by a variety of TEN infrastructures (highways, high speed trains, airports), located in the high range of the multimodal index
- which are served by only one fast connection (e.g. airport or highway), located in the medium range of the multimodal index
- which lack of fast connections at all, located in the low range of the multimodal index.

The ESPON Atlas map of multi-modal accessibility is reproduced below, showing the level of potential accessibility of the different regions and the city network of daily accessibility by air for 72 MEGAs in the year 2003.

Figure 3: ESPON Atlas map of multi-modal accessibility



Another important criteria – in particular to decide which less accessible urban regions classified as potential or weak MEGAs should be scaled up in the accessibility ranking by means of new TEN investments –

is the potential economic vitality of the region. Indeed, as discussed in section 5.1.1 above, accessibility per se does not ensure the competitiveness and economic growth of a region if this region is not endowed enough with vital activities.

City economic vitality and competiveness is a complex issue, depending on many factors and dynamics. For many years cities were even identified as the places within Europe facing the greatest economic and social problems. Some commentators viewed cities as remnants of an industrial era when transport costs were high, supply chains were local and people lived close to work. In a post-industrial world of low communication costs, people and firms preferred to locate where property was cheaper, congestion lower and environmental quality higher (Garreau, 1991). However, a contrasting view has emerged recently that identifies cities as sites of renewed economic dynamism and engines of national prosperity (OECD, 2001). They are now increasingly seen as sources of innovation and productivity growth in advanced economies dependent on high order business services, research-intensive universities and firms competing and collaborating through face-to-face contact. Cities are also believed to contain the social infrastructure, amenities and career choices to help countries to attract population, particularly groups with the specialised skills and creative talent required to generate and exploit knowledge, and thereby securing competitive advantage (Florida, 2004). This view of cities can be described as a new conventional wisdom, endorsed at national and European policy levels.

When looking at cities as stand alone entities, population change over a sufficient period of time can be used as a relatively simple indicator of changing urban conditions and city attractiveness, although obviously it does not provide a full picture of urban change. First, population change is an important *consequence* of urban conditions, especially the availability of economic opportunities. Migration is a response to differences in employment or the quality of life between places, even if the process of adjustment is inefficient. Second, population change has also an important influence on urban economic conditions. There is evidence that sheer population size and deep labour pools increase agglomeration economies and productivity (Rosenthal and Strange, 2004). Moreover, shifts in the level of population affect local jobs through demand for consumer goods and services, housing, schools, etc. Changes in working age residents also affect the supply of skills, which may influence mobile investment decisions.

Looking backward to the development of population and urban growth in Europe, Turok (Turok and Mykhnenko, 2007) pointed out the trajectories of European urban population over the period from the 1960s to 2005.[4] The analysis identified 310 cities ranging in size from Bila Tserkva in Ukraine (with 200.000 population) to the Greater London metropolitan area (with nearly 10.6 million). Three clear size bands are apparent from this analysis:

- 145 “small” cities (47% of all) with between 200 000 and 400 000 people;
- 100 “medium-sized” cities (32%) with between 400 000 and 1 million;
- 65 “large” cities (21%) with a population of over 1 million.

The cities and their trajectories in terms of population growth or decline over the whole period 1960 to 2005 have been detected based on the commonsense idea of a continuous built-up area larger than a certain population size (200 000 inhabitants), i.e. a concentrated spatial form of population and socio-economic development. This analysis excludes therefore any region with less than 200 000 inhabitants,

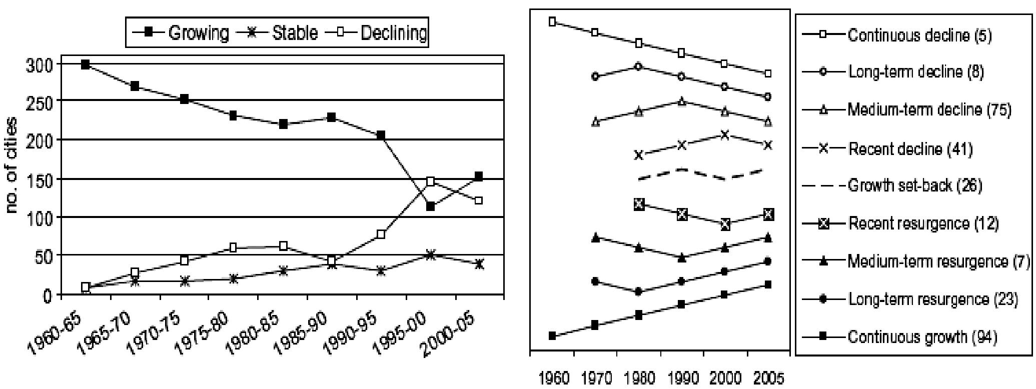
[4] Europe was defined according to the physical meaning of the continent, which is normally taken to include the land area between the Arctic Ocean, Atlantic Ocean and the Mediterranean, Black and Caspian Seas, with the eastern boundary running along the Ural Mountains and the Ural River.

that is considered – at least at the European macro-scale – rural or semi-rural (not urban). It is interesting to note that this is a physical and functional definition (the *de facto* city) rather than an administrative or legal one (the *de jure* city). It covers the continuous or near-continuous territory devoted to land uses such as housing, industrial and commercial activity, transport, education and other public services and spaces. In larger urban areas it is equivalent to the idea of conurbation or metropolitan area. The concern of Turok's analysis was with change in the city as a whole, rather than particular parts such as the core area or the suburban ring. This avoid the possibility of population decline appearing to be a problem where it simply reflects rising incomes or falling households size causing people to choose living at lower densities in the suburbs (i.e. local urban sprawl phenomena).[5]

One possible criteria to select TEN network nodes could be therefore related to the city population size and growth, adopting the definition of the city as a continuous built-up area over 200 000 inhabitants to separate urban from rural regions and pointing to connect first the larger and growing or resurgent cities, i.e. those which show a growing population over a relatively long period or even more recently.

The figure below shows on the left hand the number of cities with a growing, stable or declining population trajectories over the period 1960 to 2005, divided in five years intervals (the stable group include cities with +/- 5% absolute population change between 1960 and 2005). The same figure, on the right hand, shows the nine most common trajectories of individual cities

Figure 4: Development of city population within European Cities



The whole European population trend over the period has been one of first growth and then stability, and this is reflected in the number of growing cities, which has been falling steadily from 1960 until 2000, with a slight recovery in the most recent interval 2000-2005. This trend is mirrored by that of declining cities, which has been increasing until 2000. Concerning the individual trajectories the most common profile, followed by 30% of cities, was continuous growth, whereas there are only 13 cities that have experienced continuous or long-term decline.

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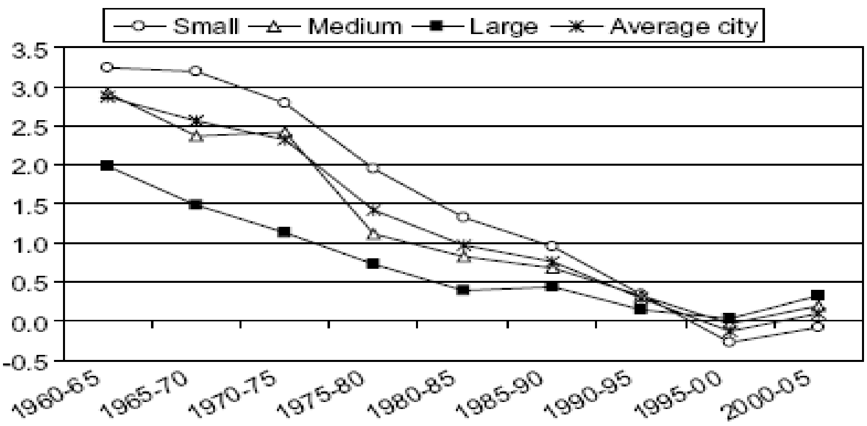
5 In practice the definition was simple to apply in about a dozen of countries where the national statistics agencies provide consistent population figures for spatial units that equate with continuous built-up areas (e.g. "metropolitan agglomerations" in the Netherlands, "census urban agglomerations" in Austria and Greece, etc.). In the other countries the authors had to construct continuous built-up areas by themselves.

Cities of different size tend to show different growth rates. It is indeed well established that large cities have tended to grow more slowly than smaller cities and towns in the post World War II period (Hall et al., 1973; Van den Berg et al., 1982). This was partly because of diseconomies of scale, such as congestion and high property prices, as well as the decline of former dominant industries, physical constraints on land availability and planning restrictions on peripheral urban expansion in many European countries. However, as mentioned above, new urban theories suggest that big cities are now better placed than smaller settlements because of the larger scale of opportunities, amenities, infrastructure and skills available to firms and people.

This seems to be well reflected by the data shown in the figure below, showing the population growth rates for cities of different sizes:

Figure 5: Population growth rates for cities of different sizes, 1960-2005



The growth of all groups of cities slowed dramatically between the 1960s and 1990s. Since the late 1990s the population of European cities has recovered slightly, but growth is still considerably lower than before the late 1990s. Looking at the differences between size bands, during the 1960s small cities expanded at roughly twice the rate of large cities, confirming the received wisdom. Looking back over the four decades, there is a clear evidence of an improvement in the position of large cities relative to smaller cities. However, the absolute improvement in the growth rate of large cities dates back only to the late 1990s.

In conclusion, if we take the cities as isolated entities, we can consider to rank them as candidates for becoming nodes of the ideal TEN network according to their population size and growth as follows:

- First, large cities (over 1 000 000 inhabitants) with a continuously growing or resurgent population
- Second, medium size cities (between 400 000 and 1 000 000 inhabitants) with growing or resurgent population
- Third, and only if this make sense from the geographical perspective – for instance because the small city is on a route between two large or medium cities – small growing cities between 200 000 and 400 000 inhabitants.

However, the complexity of urban development in Europe cannot be fully tackled only by seeing cities as isolated entities.

An alternative approach to that used by Torok's (Torok and others, 2007) to define cities is based on the concept of "functional urban regions" widely used in the context of ESPON research discussed above. These can be very much larger than built-up areas because they include the commuter hinterlands of employment centers, including satellite towns. This is useful concept for capturing the economic interactions between the city and its surrounding territory. However, it is a region and not a city concept.

City regions are specifically not defined in physical or morphological terms; neither are such regions based on administrative units, though administrative units must usually be used to define them. Rather, they are defined on the basis of what Manuel Castells has called the "Space of Flows": flows of people, information, or goods, on a regular basis, for instance daily commuting or weekly shopping (Castells 1989). They are therefore Functional Urban Regions (FURs) that extend beyond the physically built-up area to encompass all the areas that have a regularly daily relationship with a core city.

An important evolution of the city region concept, analyzed recently in the POLYNET study (Hall and Pain, 2006), is the "Mega-City Region", a new urban phenomenon in course of formation in the most highly urbanized parts of the world. This is a new form: a series of anything between twenty and fifty cities and towns, physically separate but functionally networked, clustered around one or more larger central cities, and drawing economic strength from a new functional division of labour. These places exist both as separate entities, in which most residents work locally and most workers are local residents, and as parts of a wider functional urban region connected by dense flows of people and information along motorways, high-speed rail lines, and telecommunication cables. The Mega-City Region arises from a process of extremely long-distance deconcentration from one or more major cities stretching up to 150 kilometres from the centre, with local concentrations of employment surrounded by overlapping commuter fields.

More precisely, in the POLYNET study, Mega-City Regions are defined as aggregations of smaller constituent FURs. These comprise a "core" defined in terms of employment size and density, and a "ring" defined in terms of regular daily journeys (commuting) to the core. The Mega-City Region is then defined in terms of contiguous FURs. The POLYNET study analysed and compared the functioning of eight such regions in Europe: South East England, Belgian Central Cities, the Randstad in the Netherlands, the Rhine-Ruhr and the Rhine-Main regions in Germany, the European Metropolitan Region (EMR) Northern Switzerland, Greater Dublin and the Paris Region.

An interesting forward looking study from Peter Hall (Hall, 2009) presents a perspective of the potential city regions development in Europe until the mid-21st century. At the macro Europe-wide scale, the dominant feature is the contrast between the "Pentagon" – the area bounded by London, Paris, Milan, Munich and Hamburg – with its dense cluster of cities closely networked through air, high-speed train and telecommunication links, and forming the cores of extensive Mega-City Regions (London, Paris, Frankfurt, Luxembourg, Brussels, Amsterdam), and the "regional capitals" in the more peripheral European regions, each dominating a large but less densely populated territory (Dublin, Edinburgh, Copenhagen, Stockholm, Helsinki, Berlin, Vienna, Rome, Madrid, Lisbon, Ljubljana, Budapest, Prague, Warsaw and Tallinn). These latter cities invariably act as regional airport hubs and/or as the hubs of sub-continental high-speed train systems (Madrid, Rome, Copenhagen); they have a wide variety of global service functions, and the larger ones have also spawned extensive surrounding city regions.

In this context, any choice of the ideal TEN network nodes based on population size and growth – the latter as a proxy for economic vitality – must be complemented by a geographic criteria built upon a normative concept of polycentric development to be achieved at a European scale. Accordingly, policy should seek to divert growth from the cities of the Pentagon to more remote growth centers, the intermediate-size gateways cities that proved relatively dynamic in the 1980s and 1990s – not least because several of them (Dublin, Lisbon, Madrid, Athens) received fairly massive aid from EU structural funds. However, while official policy has promoted so far urban polycentric development at the European scale, we can observe a paradoxical outcome at the national scale, with an increasing monocentricity as national political and/or commercial capitals increasingly dominate the picture. As a result, during the coming half-century many of these cities (e.g. Dublin, Madrid, Lisbon, Prague, Budapest, Warsaw, Tallinn) also are likely to develop large surrounding Mega-City regions.

Given this basic fact, as these new extended city regions will develop in the more peripheral areas of Europe, experience from the older-developed mega-city regions (e.g. those analysed in the POLYNET study) suggests to implement a policy of "deconcentrated concentration", guiding decentralized growth, wherever possible, on to selected development corridors along strong public transport links, including high-speed regional metros or even along true high-speed lines. These would not be corridors of continuous urbanization, but rather clustered urban developments, at intervals, around train stations and key motorway interchanges offering exceptionally good accessibility. Some could be at considerable distances, up to 150 km, from the central metropolitan city.

Looking now at the overall picture of the future development of "city regions" in Europe and their transport connection, Peter Hall contends that the main new technological influence is likely to be the development of the high-speed train system, which in Europe will be largely in place in 2010, connecting cities in North West and West Central Europe, in Spain and in Italy – and will be completed during the following decade with linkages through the Pyrenees and the Alps (Hall, 1995, 2009). Extensive experience in Europe and Japan shows that high-speed trains will take about 80-90% of traffic up to about 500 km and about 50% up to about 800 km, and these figures may be even underestimated, as it is shown by the experience of high-speed trains' usage in France (Pepy and Perren, 2006). In addition, given that they have been shown to produce a fraction of the carbon dioxide (CO_2) of equivalent flights, there will be the strongest possible environmental incentive to transfer to them for all but long-haul flights.

Thus, according to the Peter Hall's vision "in Europe, as early as 2020, high-speed trains will connect all the principal cities of Europe from Bari (Southern Italy) right up to Glasgow (Scotland) and Umea (Sweden), and virtually all traffic between city pairs, up to at least the 500 km limit – Madrid and Barcelona, Naples and Milan, Milan and Paris, Munich and Cologne, Cologne and Brussels, Brussels and London, Brussels and Paris, Copenhagen and Stockholm – will go by rail. The longer distance traffic – Southern to Northern Europe, far West Europe to far East Europe, as well, of course, as intercontinental traffic – will largely remain in the air, and a critical planning question will then become the linkages at the airports between the two systems."

Efficient and easy links between high-speed trains and flights already exist at Europe's most advanced airports: Amsterdam, Frankfurt, Paris-Charles De Gaulle. These places are likely to become effectively new urban centers, which will increasingly compete with traditional downtown areas as business hubs and shopping centers. Another likely development closely related to the evolution of high-speed train systems in Europe is that of the regional metro: a network of fast trains connecting small to medium-sized towns, up to 100 km distant, through city centers to towns on the other side (e.g. Copenhagen-Malmoe have built an international system via the new Oresund link, and Switzerland is networking the entire country in this fashion).

In order to conclude our analysis of city regions with the indication of operational thresholds to select the nodes of the ideal TEN network – as we did above in relation to the concept of cities as isolated entities by giving population size and change thresholds – we can exploit the concept of "space of flows" and identify such thresholds based on long-distance travel data, as it is discussed below.

Long-distance travel (LDT) is an important indicator of international economic and social integration. Along with globalization and world-wide economic development, the demand for LDT has been developing dynamically in recent years: only a small share of trips is long distance, but LDT constitutes a high share of total mileage. As a result, LDT accounts for a significant share of worldwide energy consumption and contributes significantly to global greenhouse and other emissions.

Against this background, there is an increasing demand for data in the field of LDT, which can be used to detect in the context of the TEN planning methodology thresholds of transport distances and related traffic flows to decide which nodes would be relevant to link in the ideal TEN core network. However, the availability of data on LDT is often unsatisfactory. Among the reasons for difficulty in surveying LDT is that it is a rare event from the individual perspective and is unevenly distributed in the population (e.g. in France, 30% of long-distance trips are made by 5% of the population).

Several approaches exist to capture LDT, which can be classified in two main methodological categories: household mobility travel diary data, surveying everyday travel (commuting and short trips) and LDT with the same instrument, and specific LDT surveys. The former focus upon everyday travel, typically asking to people: what did you yesterday? (or on longer reporting periods or multiple days). This method captures only a small share of the LDT trips, those which happen to be done in the day before the survey and covering only 1 day (LDT with overnight staying abroad is not included). The concept of LDT surveys generally revolves around this kind of information request: "Tell me about your long-distance travel in the last x-weeks". The general idea here is to focus on LDT but cover a longer period of time instead, which leads to an increased number of long distance journeys. Moreover, long individual-reporting periods provide for the possibility to identify frequent travelers.

Despite some methodological differences, mobility diary surveys with focus on everyday travel are widely standardized, and in many cases they are comparable across countries. This is not the case with specific LDT surveys, which differ significantly in many respects. First, almost every LDT survey applies its own definition of LDT. For this reason it is impossible to rely on published figures that are based on the respective surveys when internationally comparable figures on LDT are being compiled (partial comparability may be achieved in practice only using survey micro-data).

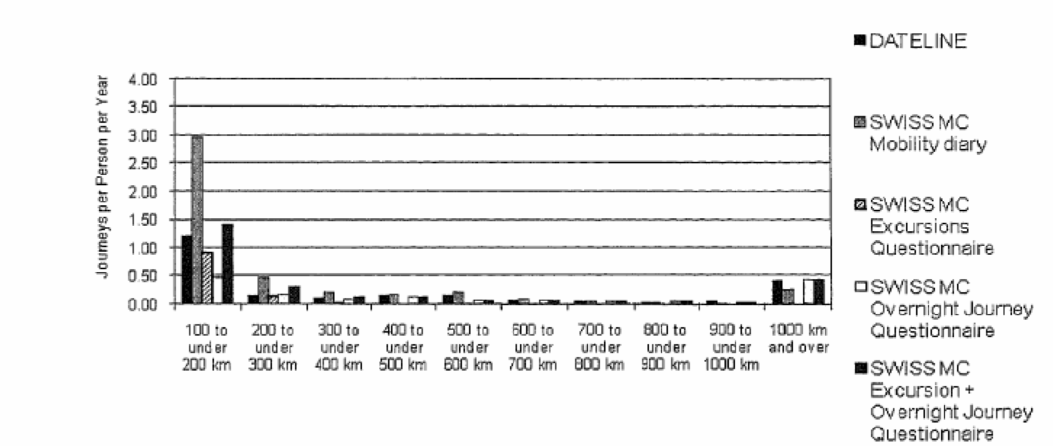
However, for our purposes, we can adopt the definition of "long-distance journeys" given by Eurostat and used in the DATELINE[6] survey: journeys, including outbound trips and return trips, to destinations at crow-fly distances of at least 100 km.

[6] DATELINE stands for Design and Application of a Travel Survey for European Long-Distance Trips Based on an International Network of Expertise. This is the only international LDT survey with the same basic survey design implemented in all countries, although comparability of data is reduced as the survey unit (household, person) and the methodology (postal, telephone) varied from country to country.

The figure below shows, for one emblematic country (Switzerland) the number of long-distance journeys per person per year for different distance segments as computed from different surveys, including also DATELINE as international benchmark survey. The bars in the distance bands represent journeys per person per year from different types of surveys from left to right as follows: DATELINE, national mobility diary survey, and national LDT surveys.

Figure 6: Journey length distribution from selected surveys for Switzerland

Source: Tobias Kuhnimhof and others, 2009



These data – and those computed in the same way for other countries not shown here – show that the mobility diary surveys produce the highest figures for journeys per person per year in the distance segment of 100 to 200 km. Most long-distance journeys fall into this segment. Mobility diary surveys do a better job in capturing medium-distance journeys, up to 200 km, whereas LDT surveys are superior in capturing LTD demand over 400 km.

The better harmonized figures on LDT in Europe, based on the available data, are presented in the table below, showing the LDT demand for 16 European countries. However, LDT demand in the most problematic segment of 100 to 400 km was assessed for only five of them. Among these, the Swedes were the most active travellers.

The other countries (UK, France, Germany and Switzerland) shared a comparable level of LDT. Examination of travel demand beyond 400 km in Southern Europe suggests that the demand of LDT is lower than in the North. The share of LDT business journeys – not shown in the table – was between 6% and 25%, indicating that even though big differences exist, by far the largest part of LDT is private travel.

Table 1: LDT in European Countries (using crow-fly distances)

Source: Tobias Kuhnimhof and others, 2009

Country	Journeys per Person per Year		
	100–400 km[a]	>400 km[b]	Total
Sweden	7.3	1.4	8.7
Great Britain	5.5	0.9	6.4
Germany	5.1	1.0	6.1
France	4.5	1.0	5.5
Switzerland	4.1	0.9	5.0
Finland	[c]	0.9	[c]
Denmark	[c]	0.9	[c]
Ireland	[c]	0.8	[c]
Netherlands	[c]	0.8	[c]
Belgium	[c]	0.8	[c]
Luxembourg	[c]	0.8	[c]
Spain	[c]	0.6	[c]
Austria	[c]	0.6	[c]
Italy	[c]	0.4	[c]
Greece	[c]	0.3	[c]
Portugal	[c]	0.2	[c]

[a]Computed on the basis of national mobility diary surveys.
[b]Computed on the basis of the DATELINE LDT survey.
[c]Not analyzed due to missing NTS data.

The same data have been used to analyse the share of main travel modes in LDT in Europe. The results about the mode of long distance travel (not shown here) confirm the approach to distinguishing between journeys under 400 km, where air travel was negligible, and over 400 km, where air travel took a significant mode share, depending on the geography and situation of the country. With respect to the total mode shares for the countries of Denmark, France, Germany, Switzerland, Sweden and UK, the car was clearly dominant. However, in Switzerland, which is well known for its reliable and easy-to use rail system, the train accounts for nearly one-fifth of all LDT.

Summing up, and taking into consideration both the above LTD data and the insights provided by the Peter Hall's vision of the future of city regions in Europe, we may suggest to consider the following distance thresholds between urban nodes to be connected in the ideal TEN network:

- Between 100 and 200 km for regional metro and fast rail links and motorways, and exceptionally for high-speed trains stops when the city sizes in this distance range are over a certain population threshold (e.g. 400 000 inhabitants);
- Between 200 and 400 km for high-speeds trains connecting couple of densely populated cities (over 400 000 inhabitants).
- Between 400 and 800 km high-speed train routes touching two or three stops maximum may also continue to compete with other transport modes, and in particular with the air mode.
- Over 800 km the dominant mode should be air transport.

Finally, priority may be given to nodes in the countries where the level of LDT per person per year is higher, although the provision of faster links also in the other countries – e.g. in Southern Europe – may help to increase the LDT traffic in those countries as well.

5.1.3. Selection of nodes

The ESPON MEGA's give a good set of nodes, however, possibly not complete. One could star start from the MEGA's, but on the one hand leave out all those, which including their relative peripheries are smaller than 1 million inhabitants. On the other hand, one should add other cities and conurbations, even if they are not included in ESPON's MEGAs.

As a practical approach, one could select these additional nodes according to the trip generation of the node. This is a broadened approach to basing the nodes on solely population.

- In a first step, the total number of nodes has to be set – e.g. based on the desired length of the total core network as stated in annex D.

- In a second step, the total geographical area of Europe can be dived into areas equal in size (km2) by gridding. Also, the total amount of trips is dived into equal parts. For each of these areas, the total trip generation – or potential trip generation – can be calculated with trip generation models (as used in classic transport models as Trans-Tools). The areas that have trip generations larger than the average are selected.

- In a third step, a radius around the each selected city equal to the average trip generation is drawn.

- The remain part of Europe will then be selected in a second iteration (via step 2).

Such a procedure could be developed and tested for both passengers and freight transport. Trip generation models can be found in literature, or could be calibrated on the sport, based on e.g. the FP6 projects on long distance transport KITE and DATELINE, or based on national travel surveys.

Using trip generation models rather than solely population of course complicates the process, but will allow to incorporate special situations as ports and large industry zones (for freight transport) and tourist areas or business districts (for passenger transport). An example is Venice. As a city, it has just some 300 000 inhabitants and therefore would not be a main node. However considering the conurbation consisting of the provinces Venice, Padova and Treviso, the total number of inhabitants is more than 4.5 million, living within a circle of about 40 km or less in diameter. Besides, Venice has 14 million tourists per year, more than any other European city.

5.1.4. Sample procedure

This paragraph contains a simplified example of the above procedure. The calculation has been done on the NUTS2 zoning level, and with population as a proxy for trip generation. A more sophisticated calculation would be on the NUT3 level, or even in a GIS, and would use observed or calculated trip generation, with a focus on long distance transport.

The table below contains the population and area for each NUTS2 zone for 2003, as can be found in Eurostat. In a first phase, all 27 capital zones are selected as a node.

In a second phase, the remaining number of nodes is then distributed over the EU27 according to the number of inhabitants. This is done in several iteration steps. The NUTS2 zone with the largest population is selected and a node is added in that zone and the population allocated to that node is subtracted to that zone. In the second step, again the zone with the largest (remaining) population is selected, a node is allocated and the according population is faded out.

In case the population of a zone is not large enough the population of the surrounding zones is also included. This happens in the latest steps of the process, when smaller and smaller zones become the largest remaining zone. It can also happen that a NUTS2 has a very large population so that it is allocated 2 or even more nodes during the process. This happens for e.g. FR10 Île de France (Paris) which has more than 11 million inhabitants, even with only 100 nodes in EU27.

We have performed this for a set of 100, 150, 200 and 250 nodes. The resulting number of nodes per country can be found the graph below. The actual NUTS2 zone selection can be found in the table below.

A similar calculation should be done, also with more detail, for freight transport taking into account the productivity of the economy, and the intermodal and port transhipment (tons per year).

Table 2: Selection of nodes for each country in EU27

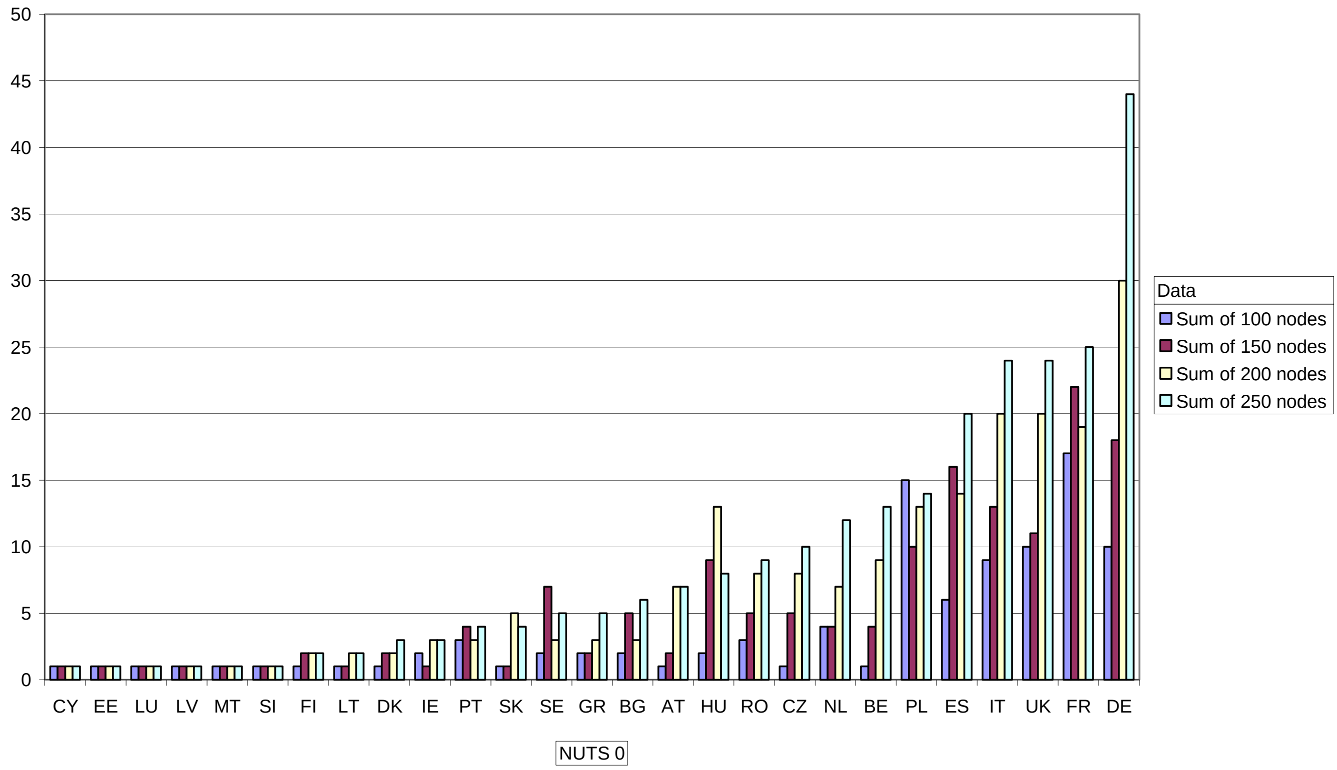


Table 3: Average population (2003) per node

Nodes	Population per node
100	6 449 780
150	3 239 848
200	2 429 886
250	1 943 909

Table 4: Area, population (2003) and selection of nodes for each NUTS 2 zone in EU27

	Region	Area (km2)	Population	Pop. density	100 nodes	150 nodes	200 nodes	250 nodes
AT11	Burgenland	3 966	276 533	70	0	0	0	0
AT12	Niederösterreich	19 178	1 549 695	81	0	1	2	2
AT13	Wien	415	1 583 814	3 819	1	1	1	1
AT21	Kärnten	9 536	559 758	59	0	0	0	0
AT22	Steiermark	16 392	1 190 071	73	0	0	2	2
AT31	Oberösterreich	11 982	1 384 667	116	0	0	2	2
AT32	Salzburg	7 154	520 247	73	0	0	0	0
AT33	Tirol	12 648	681 908	54	0	0	0	0

AT34	Vorarlberg	2 602	355 482	137	0	0	0	0
BE10	Région de Bruxelles-Capital	161	992 041	6 146	1	1	1	1
BE21	Prov. Antwerpen	2 867	1 661 119	579	0	1	2	2
BE22	Prov. Limburg (B)	2 422	802 528	331	0	0	0	0
BE23	Prov. Oost-Vlaanderen	2 982	1 370 136	459	0	2	2	2
BE24	Prov. Vlaams Brabant	2 106	1 027 839	488	0	0	0	2
BE25	Prov. West-Vlaanderen	3 134	1 133 931	362	0	0	2	2
BE31	Prov. Brabant Wallon	1 091	358 012	328	0	0	0	0
BE32	Prov. Hainaut	3 786	1 281 706	339	0	0	2	2
BE33	Prov. Liège	3 862	1 025 842	266	0	0	0	2
BE34	Prov. Luxembourg (B)	4 440	252 295	57	0	0	0	0
BE35	Prov. Namur	3 666	450 395	123	0	0	0	0
BG11	Severozapaden	10 288	521 951	51	0	0	0	0
BG12	Severen tsentralen	18 270	1 180 235	65	0	0	0	2
BG13	Severoiztochen	19 973	1 294 249	65	0	2	1	2
BG21	Yugozapaden	20 306	2 104 208	104	1	1	1	1
BG22	Yuzhen tsentralen	27 516	1 956 913	71	1	2	1	1
BG23	Yugoiztochen	14 648	788 285	54	0	0	0	0
CY00	Kypros / Kibris	5 695	715 137	126	1	1	1	1
CZ01	Praha	496	1 161 938	2 343	1	1	1	1
CZ02	Strední Cechy	11 016	1 128 674	102	0	0	1	0
CZ03	Jihozápad	17 618	1 174 471	67	0	0	1	2
CZ04	Severozápad	8 649	1 123 932	130	0	0	1	0
CZ05	Severovýchod	12 440	1 482 292	119	0	2	1	2
CZ06	Jihovýchod	13 991	1 639 422	117	0	2	1	1
CZ07	Strední Morava	9 123	1 229 880	135	0	0	1	2
CZ08	Moravskoslezko	5 535	1 262 660	228	0	0	1	2
DE11	Stuttgart	10 558	3 985 000	377	1	1	1	2
DE12	Karlsruhe	6 919	2 716 682	393	1	1	1	1
DE13	Freiburg	9 357	2 170 481	232	0	1	1	1
DE14	Tübingen	8 918	1 789 157	201	0	1	1	1
DE21	Oberbayern	17 530	4 169 657	238	1	1	2	2
DE22	Niederbayern	10 330	1 191 476	115	0	0	0	1
DE23	Oberpfalz	9 690	1 088 929	112	0	0	0	1
DE24	Oberfranken	7 231	1 112 655	154	0	0	0	1
DE25	Mittelfranken	7 246	1 703 869	235	0	0	1	1
DE26	Unterfranken	8 531	1 344 300	158	0	0	0	1
DE27	Schwaben	9 992	1 776 465	178	0	1	1	1
DE30	Berlin	892	3 392 425	3 804	1	1	1	2
DE41	Brandenburg - Nordost	15 498	1 170 349	76	0	0	0	1
DE42	Brandenburg - Südwest	13 979	1 412 030	101	0	0	1	1
DE50	Bremen	404	662 098	1 638	0	0	0	0
DE60	Hamburg	755	1 728 806	2 289	0	0	1	1
DE71	Darmstadt	7 445	3 761 749	505	1	1	1	2
DE72	Gießen	5 381	1 065 909	198	0	0	0	1
DE73	Kassel	8 289	1 263 960	152	0	0	0	1

DE80	Mecklenburg-Vorpommern	23 174	1 744 624	75	0	0	1	1
DE91	Braunschweig	8 099	1 665 368	206	0	0	1	1
DE92	Hannover	9 047	2 167 876	240	0	1	1	1
DE93	Lüneburg	15 507	1 692 192	109	0	0	1	1
DE94	Weser-Ems	14 966	2 455 036	164	0	1	1	1
DEA1	Düsseldorf	5 290	5 249 280	992	1	1	2	2
DEA2	Köln	7 365	4 331 419	588	1	1	2	2
DEA3	Münster	6 907	2 625 637	380	1	1	1	1
DEA4	Detmold	6 519	2 069 290	317	0	1	1	1
DEA5	Arnsberg	8 002	3 800 729	475	1	1	1	2
DEB1	Koblenz	8 073	1 527 611	189	0	0	1	1
DEB2	Trier	4 922	513 702	104	0	0	0	0
DEB3	Rheinhessen-Pfalz	6 852	2 016 414	294	0	1	1	1
DEC0	Saarland	2 569	1 064 988	415	0	0	0	1
DED1	Chemnitz	6 097	1 584 776	260	0	0	1	1
DED2	Dresden	7 931	1 683 138	212	0	0	1	1
DED3	Leipzig	4 386	1 081 145	247	0	0	0	1
DEE1	Dessau	4 280	525 207	123	0	0	0	0
DEE2	Halle	4 430	840 160	190	0	0	0	0
DEE3	Magdeburg	11 735	1 183 544	101	0	0	0	1
DEF0	Schleswig-Holstein	15 763	2 816 507	179	1	1	1	1
DEG0	Thüringen	16 172	2 392 040	148	0	1	1	1
DK00	Danmark	43 098	5 383 507	125	1	2	2	3
EE00	Eesti	45 227	1 356 045	30	1	1	1	1
ES11	Galicia	29 574	2 699 955	91	1	1	1	1
ES12	Principado de Asturias	10 604	1 060 177	100	0	0	0	1
ES13	Cantabria	5 321	539 601	101	0	0	0	0
ES21	Pais Vasco	7 235	2 087 972	289	0	2	1	1
ES22	Comunidad Foral de Navarra	10 391	564 608	54	0	0	0	0
ES23	La Rioja	5 045	282 074	56	0	0	0	0
ES24	Aragón	47 721	1 216 127	25	0	0	0	1
ES30	Comunidad de Madrid	8 028	5 573 313	694	1	3	2	3
ES41	Castilla y León	94 225	2 458 637	26	1	1	1	1
ES42	Castilla-la Mancha	79 461	1 790 436	23	0	2	1	1
ES43	Extremadura	41 634	1 061 367	25	0	0	0	1
ES51	Cataluña	32 114	6 492 936	202	1	2	2	3
ES52	Comunidad Valenciana	23 260	4 283 217	184	1	1	2	2
ES53	Illes Balears	4 992	906 266	182	0	0	0	0
ES61	Andalucia	87 599	7 452 598	85	1	2	3	3
ES62	Región de Murcia	11 314	1 232 986	109	0	0	0	1
ES63	Ciudad Autónoma de Ceuta (ES)	19	71 383	3 757	0	0	0	0
ES64	Ciudad Autónoma de Melilla (ES)	13	66 647	5 127	0	0	0	0
ES70	Canarias (ES)	7 447	1 823 402	245	0	2	1	1
FI13	Itä-Suomi	85 172	672 345	8	0	0	0	0
FI18	Etelä-Suomi	45 233	2 557 685	57	1	1	1	1
FI19	Länsi-Suomi	64 647	1 321 583	20	0	1	1	1

FI1A	Pohjois-Suomi	141 541	628 425	4	0	0	0	0
FI20	Åland	1 552	26 257	17	0	0	0	0
FR10	Île de France	12 012	11 131 412	927	2	3	4	5
FR21	Champagne-Ardenne	25 606	1 336 741	52	0	0	0	1
FR22	Picardie	19 399	1 869 386	96	0	2	1	1
FR23	Haute-Normandie	12 317	1 787 319	145	0	2	1	1
FR24	Centre	39 151	2 466 617	63	2	1	1	1
FR25	Basse-Normandie	17 589	1 436 134	82	0	0	0	1
FR26	Bourgogne	31 582	1 612 397	51	0	0	0	1
FR30	Nord - Pas-de-Calais	12 414	4 013 107	323	1	1	1	2
FR41	Lorraine	23 547	2 319 109	98	2	2	1	1
FR42	Alsace	8 280	1 775 390	214	0	2	1	1
FR43	Franche-Comté	16 202	1 130 532	70	0	0	0	0
FR51	Pays de la Loire	32 082	3 312 473	103	1	1	1	1
FR52	Bretagne	27 208	2 977 932	109	2	1	1	1
FR53	Poitou-Charentes	25 810	1 668 337	65	0	0	0	1
FR61	Aquitaine	41 308	2 988 395	72	1	1	1	1
FR62	Midi-Pyrénées	45 348	2 637 957	58	2	1	1	1
FR63	Limousin	16 942	710 645	42	0	0	0	0
FR71	Rhône-Alpes	43 698	5 813 733	133	1	3	2	2
FR72	Auvergne	26 013	1 314 476	51	0	0	0	0
FR81	Languedoc-Roussillon	27 376	2 401 838	88	2	1	1	1
FR82	Provence-Alpes-Côte d'Azur	31 400	4 665 051	149	1	1	2	2
FR83	Corse	8 680	265 999	31	0	0	0	0
FR91	Guadeloupe (FR)	1 705	438 820	257	0	0	0	0
FR92	Martinique (FR)	1 128	390 552	346	0	0	0	0
FR93	Guyana (FR)	83 934	178 347	2	0	0	0	0
FR94	Réunion (FR)	2 520	752 303	299	0	0	0	0
GR11	Anatoliki Makedonia, Thraki	14 158	606 319	43	0	0	0	0
GR12	Kentriki Makedonia	18 811	1 901 930	101	1	1	1	1
GR13	Dytiki Makedonia	9 452	294 830	31	0	0	0	0
GR14	Thessalia	14 037	738 256	53	0	0	0	1
GR21	Ipeiros	9 204	338 028	37	0	0	0	0
GR22	Ionia Nisia	2 307	216 255	94	0	0	0	0
GR23	Dytiki Ellada	11 351	728 083	64	0	0	0	1
GR24	Sterea Ellada	15 550	560 768	36	0	0	0	0
GR25	Peloponnisos	15 491	601 307	39	0	0	0	0
GR30	Attiki	3 808	3 915 912	1 028	1	1	2	2
GR41	Voreio Aigaio	3 836	204 071	53	0	0	0	0
GR42	Notio Aigaio	5 286	301 722	57	0	0	0	0
GR43	Kriti	8 336	598 896	72	0	0	0	0
HU10	Közép-Magyarország	6 919	2 824 754	408	1	1	1	1
HU21	Közép-Dunántúl	11 117	1 113 671	100	0	2	2	2
HU22	Nyugat-Dunántúl	11 329	1 004 328	89	0	0	2	0
HU23	Dél-Dunántúl	14 169	989 408	70	0	0	2	0
HU31	Észak-Magyarország	13 429	1 288 960	96	0	2	2	2

HU32	Észak-Alföld	17 729	1 554 177	88	1	2	2	1
HU33	Dél-Alföld	18 339	1 367 064	75	0	2	2	2
IE01	Border, Midlands and Western	33 252	1 052 684	32	0	0	2	1
IE02	Southern and Eastern	36 545	2 910 981	80	2	1	1	2
ITC1	Piemonte	25 403	4 231 334	167	1	1	2	2
ITC2	Valle d'Aosta/Vallée d'Aoste	3 263	120 909	37	0	0	0	0
ITC3	Liguria	5 422	1 572 197	290	0	0	1	1
ITC4	Lombardia	23 863	9 108 645	382	1	2	3	4
ITD1	Provincia Autonoma Bolzano-Bozen	7 400	467 338	63	0	0	0	0
ITD2	Provincia Autonoma Trento	6 207	483 157	78	0	0	0	0
ITD3	Veneto	18 399	4 577 408	249	1	1	2	2
ITD4	Friuli-Venezia Giulia	7 858	1 191 588	152	0	0	0	0
ITD5	Emilia-Romagna	22 117	4 030 220	182	1	1	1	2
ITE1	Toscana	22 994	3 516 296	153	1	1	1	2
ITE2	Umbria	8 456	834 210	99	0	0	0	0
ITE3	Marche	9 694	1 484 601	153	0	0	1	1
ITE4	Lazio	17 236	5 145 805	299	1	2	2	2
ITF1	Abruzzo	10 763	1 273 284	118	0	0	0	0
ITF2	Molise	4 438	321 047	72	0	0	0	0
ITF3	Campania	13 590	5 725 098	421	1	2	2	2
ITF4	Puglia	19 358	4 023 957	208	1	1	1	2
ITF5	Basilicata	9 995	596 821	60	0	0	0	0
ITF6	Calabria	15 081	2 007 392	133	0	1	1	1
ITG1	Sicilia	25 711	4 972 124	193	1	1	2	2
ITG2	Sardegna	24 090	1 637 639	68	0	0	1	1
LT00	Lietuva	62 678	3 462 553	55	1	1	2	2
LU00	Luxembourg (Grand-Duché)	2 586	448 300	173	1	1	1	1
LV00	Latvija	64 589	2 331 480	36	1	1	1	1
MT00	Malta	316	397 296	1 259	1	1	1	1
NL11	Groningen	2 968	572 997	193	0	0	0	0
NL12	Friesland	5 741	639 787	111	0	0	0	0
NL13	Drenthe	2 680	481 254	180	0	0	0	0
NL21	Overijssel	3 421	1 100 677	322	0	0	1	2
NL22	Gelderland	5 137	1 960 422	382	0	1	1	1
NL23	Flevoland	2 412	351 680	146	0	0	0	0
NL31	Utrecht	1 449	1 152 218	795	0	0	1	2
NL32	Noord-Holland	4 092	2 573 120	629	1	1	1	1
NL33	Zuid-Holland	3 403	3 439 982	1 011	1	1	1	3
NL34	Zeeland	2 934	378 348	129	0	0	0	0
NL41	Noord-Brabant	5 082	2 400 198	472	2	1	1	1
NL42	Limburg (NL)	2 209	1 141 889	517	0	0	1	2
PL11	Lódzkie	18 219	2 607 380	143	2	1	1	1
PL12	Mazowieckie	35 579	5 128 623	144	1	1	2	2
PL21	Malopolskie	15 190	3 237 217	213	1	1	1	1
PL22	Slaskie	12 331	4 731 533	384	1	1	2	2
PL31	Lubelskie	25 114	2 196 992	87	2	1	1	1

PL32	Podkarpackie	17 844	2 105 050	118	2	1	1	1
PL33	Swietokrzyskie	11 691	1 295 885	111	0	0	0	0
PL34	Podlaskie	20 180	1 207 704	60	0	0	0	0
PL41	Wielkopolskie	29 826	3 355 279	112	1	1	1	1
PL42	Zachodniopomorskie	22 896	1 697 718	74	0	0	1	1
PL43	Lubuskie	13 989	1 008 196	72	0	0	0	0
PL51	Dolnoslaskie	19 948	2 904 694	146	1	1	1	1
PL52	Opolskie	9 412	1 061 009	113	0	0	0	0
PL61	Kujawsko-Pomorskie	17 970	2 069 166	115	2	1	1	1
PL62	Warminsko-Mazurskie	24 203	1 428 449	59	0	0	0	1
PL63	Pomorskie	18 293	2 183 636	119	2	1	1	1
PT11	Norte	21 280	3 691 922	173	2	1	1	2
PT15	Algarve	4 990	398 370	80	0	0	0	0
PT16	Centro (PT)	28 179	2 354 550	84	0	2	1	1
PT17	Lisboa	2 865	2 714 614	948	1	1	1	1
PT18	Alentejo	31 484	767 983	24	0	0	0	0
PT20	Região Autónoma dos Açores (PT)	2 322	238 767	103	0	0	0	0
PT30	Região Autónoma da Madeira (PT)	828	241 257	291	0	0	0	0
RO01	Nord-Est	36 850	3 746 330	102	1	1	1	2
RO02	Sud-Est	35 762	2 863 406	80	0	1	1	1
RO03	Sud	34 453	3 368 615	98	1	1	1	1
RO04	Sud-Vest	29 212	2 336 018	80	0	0	1	1
RO05	Vest	32 034	1 951 518	61	0	0	1	1
RO06	Nord-Vest	34 159	2 750 406	81	0	1	1	1
RO07	Centru	34 100	2 548 331	75	0	0	1	1
RO08	Bucuresti	1 821	2 208 150	1 213	1	1	1	1
SE01	Stockholm	6 789	1 850 467	273	1	1	1	1
SE02	Östra Mellansverige	41 415	1 503 423	36	0	2	1	1
SE04	Sydsverige	14 424	1 294 965	90	0	2	0	2
SE06	Norra Mellansverige	69 548	827 067	12	0	0	0	0
SE07	Mellersta Norrland	77 207	372 266	5	0	0	0	0
SE08	Övre Norrland	165 296	508 862	3	0	0	0	0
SE09	Småland med öarna	35 560	796 957	22	0	0	0	0
SE0A	Västsverige	31 108	1 786 781	57	1	2	1	1
SI00	Slovenija	20 273	1 995 033	98	1	1	1	1
SK01	Bratislavský	2 052	599 787	292	1	1	1	1
SK02	Západné Slovensko	14 993	1 863 932	124	0	0	2	1
SK03	Stredné Slovensko	16 256	1 352 452	83	0	0	0	1
SK04	Východné Slovensko	15 733	1 563 882	99	0	0	2	1
UKC1	Tees Valley and Durham	3 046	1 131 373	371	0	0	0	0
UKC2	Northumberland, Tyne and Wear	5 566	1 381 901	248	0	0	0	1
UKD1	Cumbria	6 824	488 513	72	0	0	0	0
UKD2	Cheshire	2 331	986 079	423	0	0	0	0
UKD3	Greater Manchester	1 286	2 513 468	1 955	1	1	1	1
UKD4	Lancashire	3 070	1 421 912	463	0	0	0	1
UKD5	Merseyside	655	1 361 009	2 077	0	0	0	1

UKE1	East Riding and North Lincolnshire	3 658	870 671	238	0	0	0	0
UKE2	North Yorkshire	8 315	755 332	91	0	0	0	0
UKE3	South Yorkshire	1 559	1 267 288	813	0	0	0	0
UKE4	West Yorkshire	2 034	2 089 212	1 027	1	1	1	1
UKF1	Derbyshire and Nottinghamshire	4 788	1 985 662	415	0	1	1	1
UKF2	Leicestershire, Rutland and Northants	4 918	1 571 987	320	0	0	1	1
UKF3	Lincolnshire	5 921	657 843	111	0	0	0	0
UKG1	Herefordshire, Worcestershire and Warks	5 902	1 235 048	209	0	0	0	0
UKG2	Shropshire and Staffordshire	6 203	1 493 308	241	0	0	0	1
UKG3	West Midlands	899	2 575 768	2 866	1	1	1	1
UKH1	East Anglia	12 570	2 190 982	174	1	1	1	1
UKH2	Bedfordshire, Hertfordshire	2 875	1 606 975	559	0	0	1	1
UKH3	Essex	3 675	1 622 403	441	0	0	1	1
UKI1	Inner London	321	2 867 337	8 946	1	1	1	1
UKI2	Outer London	1 263	4 488 017	3 553	1	1	2	2
UKJ1	Berkshire, Bucks and Oxfordshire	5 742	2 099 559	366	1	1	1	1
UKJ2	Surrey, East and West Sussex	5 461	2 559 897	469	1	1	1	1
UKJ3	Hampshire and Isle of Wight	4 174	1 789 678	429	0	0	1	1
UKJ4	Kent	3 735	1 589 252	426	0	0	1	1
UKK1	Gloucestershire, Wiltshire and N. Somerset	7 603	2 170 827	286	1	1	1	1
UKK2	Dorset and Somerset	6 105	1 199 751	197	0	0	0	0
UKK3	Cornwall and Isles of Scilly	3 559	508 412	143	0	0	0	0
UKK4	Devon	6 703	1 082 287	161	0	0	0	0
UKL1	West Wales and The Valleys	13 121	1 860 436	142	0	0	1	1
UKL2	East Wales	7 647	1 058 287	138	0	0	0	0
UKM1	North Eastern Scotland	7 335	436 500	60	0	0	0	0
UKM2	Eastern Scotland	17 987	1 905 800	106	0	0	1	1
UKM3	South Western Scotland	13 033	2 281 100	175	1	1	1	1
UKM4	Highlands and Islands	39 777	432 900	11	0	0	0	0
UKN0	Northern Ireland	14 160	1 696 641	120	0	0	1	1

5.1.5. Grouping of nodes

When building a network planners usually consider only the nodes that have to be connected, i.e. cities or agglomerations. However, it might be an interesting option to introduce extra nodes that make it possible to group nodes, and reduce network length and thus investment costs. This could be useful in, the case of small capital cities, e.,g. in the Western Balkans, where small cities have become capitals. It might not be worthwhile to treat Podgorica, Sarajewo, Pristina and Skopje the same way as Paris or London.

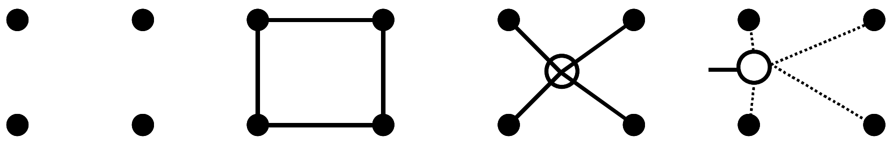
A technique to group nodes, is the use Steiner nodes. The Steiner tree problem is superficially similar to the minimum spanning tree problem: given a set of points (vertices), interconnect them by a network of shortest length, where the length is the sum of the lengths of all edges. The difference between the Steiner tree problem and the minimum spanning tree problem is that, in the Steiner tree problem, extra intermediate vertices and edges may be added to the graph in order to reduce the length of the spanning tree.

These new vertices introduced to decrease the total length of connection are known as **Steiner points**. It has been proved that the resulting connection is a tree, known as the **Steiner tree**.

Such a Steiner tree may then act as an access structure to the new virtual node, while this new node can be treated as a core network node. This is not only suitable for clusters of smaller cities, but also for the case where cities itself are multimodal, e.g. in the case of a large ports or airports.

The impact of these so-called Steiner nodes is illustrated in the following figure.

Figure 7: Application of Steiner nodes



On the left hand side we have 4 nodes that have to be connected. Using only these four nodes a grid network might be a proper solution. Introducing an additional node in or near the center, however, reduces the network length significantly (about minus 30%) while travel times are reduced in some cases and are increased in other. The net effect on investment costs and travel times depend strongly on the demand pattern and the location of the additional node. Finally it is possible to introduce an additional node where a specific road type ends and which is connected to the surrounding cities by links of lower level networks.

5.1.6. Include zoning outside the EU

The network to be designed does not function on its own but must be connected to neighbouring networks at the same scale level. This is why a number of important nodes situated outside the study area need to be included.

Indeed, the changing territorial structure and transport infrastructure needs of Europe cannot be understood without considering its relationship with: 1) the immediate surroundings (neighbouring countries) and 2) the rest of the world.

Integration between the European territory and its neighbouring states is important economically and politically. The countries and regions that constitutes the neighbourhood include the Balkan states, Turkey, and the various countries beyond the eastern border of the EU, as well as the southern Mediterranean countries. They are all very strongly oriented towards Europe in their trade and flight connections.

In order to compare Europe to other world regions in a more global perspective, these have to be defined. This is not easy, and there are no simple and undisputable definitions. Seen from a geo-economic point of view, the world can be thought as a Triad of three major economic poles: North America, Europe and East Asia. Symmetrically to these three major poles – all in the Northern hemisphere – there exist three minor economic poles in the Southern hemisphere: Brazil in South America, South Africa and Oceania. In addition, there are the emerging and increasingly important poles of India and the South East Asia (ASEAN) countries.

The main impacts which affect the planning of the TEN network are related to global trade, business trips or travel for leisure to/from regions outside Europe, whose intensity and directions will affect in particular transport demand at the main transport gateways - mainly airports for passenger traffic and ports for freight transport – which function as access points to the continent. These transport gateways are also the key territorial points where long distance flows of goods and people from/to distant regions need to be connected with the hinterlands.

Changing patterns of global trade and business and leisure trips, related to the growth of new economic leading regions on the global scene – namely China and India from Asia – will produce different pressures on the capacity of the main European ports and airports, which are to be considered while planning new infrastructure.

5.2. Step 2: Selection of the connections in the core network

In the previous section size, accessibility, and economic vitality criteria for the selection of nodes are indicated. In this section the methodology for selecting and defining the connections which will form the core network will be described. This methodology is based on a number of studies performed by TNO on the design of various networks and their nodes (IRVS, ARNO).

The design of the network needs to be done for each transport mode:

- 2 passenger transport networks: road, rail
- 3 freight transport networks: road, rail, shipping (inland shipping and short sea shipping)

Air transport is only concerned at the nodal level (i.e. to include the possibility to connect them to the land modes), not at the (air) network level, since the airport don't require network investments. Pipelines and deep sea shipping are not included in this study. Ferries are included in road transport (further quality details will be given in the next chapter).

The relations between the nodes are **functional relations**, not a physical network. In a next step, quality criteria will be assigned to the function relations, and these qualities can then be compared with what the actual network can offer.

Designing a transportation system is not easily encountered and within the methodology a step-by-step process is described based on the following aspects:

- First structure, then elements
  Start with a perspective on the complete structure of the network, such as which cities need to be connected, which scale levels are distinguished. This can then be followed by a decision on which elements need to be added.

- First the higher scale, then the lower scale
  Networks for every scale are designed independently. For the Ten-T projects this means only projects relevant for the EU-scale need to be selected and fit within the network.
- First ideal, then existing
  The goal of first designing the ideal network is to keep the focus of the network on the quality and the set of goals. Furthermore after identification of necessary changes to the existing network these changes can be prioritized.
- First quality, then capacity
  The desired level of quality needs to be designed clearly, capacity is merely an indicator for the quality and should be considered separately from the quality aspects.

5.2.1. Node hierarchy

For any network system, there is the question whether there should be few or many access points. The more access points, the better its accessibility. This means that a smaller part of the trip needs to be made on the lower scale level (and therefore slower) networks. On the other hand, the quality of connections (how fast, and how reliable from one access point to another) provided by the subsystem is higher when there are few access points. This dilemma plays a major role in the design of public transport networks, but is also becoming more and more important in road and rail networks. In many countries, long distance traffic often encounters congestion near urbanized areas caused by regional or even local traffic, entering and exiting the freeway and frequently causing disturbances in doing so. In general, higher scale level networks have fewer access points – this has to do with the fact that access points are usually found near cities, and fewer cities will be connected to the higher order networks.

We propose to start the design of the network with the distinction of the nodes in a two level hierarchy. In a first approximation, these two level nodes are distinguished based on the ESPON database:
- Level 1 = MEGA (5 classes)
- Level 2 = FUA (2 classes)

However, either level 1 MEGA and level 2 FUA should be better specified, in order to exclude those cities that do not comply with the criteria of size and distance thresholds suggested in in the previous section. According to the latter, the nodes in the ideal TEN network should be selected with the following rules:
- For level 1, direct high speed train links – without intermediate stops – should connect couple of nodes with a population over 400 000 inhabitants each and a distance between min. 200 and max. 400 km. This means that on the selected links more of 800 000 inhabitants will benefit of a connection within a time range of 40 – 80 minutes (assuming a 300 km/hour speed of the trains). In case of large MEGA with more than 1 000 000 inhabitants, these may be connected with a direct high speed train service – without intermediate stops – even if they are located in a larger distance range, let say between min 600 and max 900 km (which means that more than 2 000 000 inhabitants will benefit of a connection within a time range of 120 - 180 minutes).
- For level 2, fast rail links and motorways should connect couple of nodes with a population over 100 000 inhabitants each and a distance between 100 and 200 km.

The desired connections (heart-to-heart) are drawn on the map, according to the following rules:
- First connect level 1 nodes.

- Include level 2 nodes when they are close to an already included connection.

Specific routes do not yet come up at this stage; the map only shows heart-to heart connections. The required network density and acceptable detour factors must be estimated, and acceptable detours examined. When the settlements are connected, these requirements must be met. In this stage natural barriers are not yet taken into account, since the relations identified are only functional relations.

A discussion on the size of the network and the actual number of nodes to be included can be found in ANNEX D: Analysis of freight transport in EU on page 135.

5.2.2. Connecting level 1 nodes

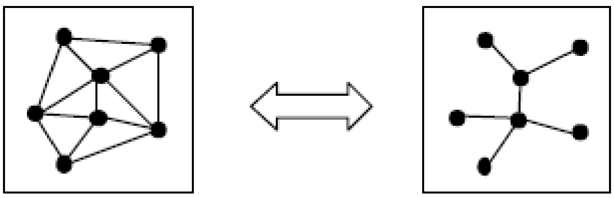
Taking the starting nodes of the core network, its shape would be determined by the most important connections between these nodes, including the periphery of the EU, and continuing towards neighbouring countries. The connections or links should follow main actual or potential long distance traffic flows. For geographical balance and economical equity reasons, no special preference should be given to any particular spatial orientation.

Once it has been established which cities need to be connected, it still has to be decided whether these cities should be connected by direct links or by way of another city. More links means higher quality connections, because there are fewer detours.

However, when it comes to cost savings and minimising the adverse effects on nature and the human environment, the lowest possible network density is desirable. This dilemma is as relevant in individual transport as it is in collective transport.

In fact, there are 2 extreme possibilities:
- A minimal spanning network where every node is connected only to the nearest node.
- A maximal spanning network, where every node is connected to each other node.

Figure 8: Maximal versus minimal network



In reality, a solution in between is ideal. The ideal network can be found by starting with the maximal network (thus the complete OD relation matrix) and then scrapping connections that do not show a functional relationship. In other words look at the map and see where a connection between two outlying nodes can create a connection between several nodes of the same class.

For this connection the detour-factor needs to be taken into account. The detour factor is the ratio between the distance across the network and the straight line distance. To bundle infrastructure, detours make sense, if in a chain of main nodes the routing does not deviate too much from a straight line.

A maximal detour factor can be defined for each scale level. It depends on the speed ratio between two levels. If the detour factor becomes excessive people prefer to make the trip on a lower level network. In the Dutch study the detour-factor used on the national level was 1.4, and the value for the regional scale level was 1.7. For a European scale, the detour factor should preferably be even lower (1.2), since distances are longer and the effect of a detour is high. As a sample, to the functional relation Antwerp – Rotterdam, cities like Breda (as a secondary node) would be connected by creating only a short detour.

The detour-parameter needs to be handled with care however, taking into account the principle that the larger the distance between the two nodes is the lower the detour parameter needs to be. The principle is purely coming from a designer's principle. In reality travellers might accept higher detours if this favours them for another reason (e.g. driving from the Hague to Nice, through Luxembourg because of the cheap gas prices).For passenger transport a certain attractivity factor should be added which enables a higher detour on specific routes. For freight transport the detours can be translated into extra costs and therefore for these functional relations the principle has to be handled stricter.

The relation between the detour and the bundling of connections is a specific aspect to be taken into account. When bundling different relations on one connection, this could result that for a limited number of relations the detour factor could be greater than the respective 1.2 as stated above. As long as the bundling of the relations over one connection doesn't result in a very high increase of the detour factor the bundling of connection resulting in a detour is acceptable.

Connecting two nodes in the first step will not directly take into account existing geographical boundaries. However with the detour factor and the design dilemma presented above the most obvious geographical boundaries, like mountains, rivers or sea, still need to be covered. The basic rule for removing such a barrier will be the basis of existing relations between two nodes and the currently existing unacceptable detour (sometimes combined with not reaching defined quality standards) will create the need for overcoming the barrier and making an investment. If the need for a connection is very high it will get a very high priority on the political agenda as well.

The criterion whether a connection is to be included or not in the European network, is depended on the amount of long distance transport on this connection.

The long-distance transport covers passenger and freight transport over considerable distances of about 100 kilometres or more. This definition implies that long haul excludes purely urban, rural and regional transport, independent of the means of transport.

Long-distance passenger transport comprises:

- Road and rail transport (car, motorcycle, coach, train), which is typically over distances of 100 to 400 km (but can of course be longer, especially for leisure purposes where users are more sensitive to price than journey time).
- Air transport, which starts to become competitive with ground modes at distances of around 250 km or more, although where high-speed rail services exist, this increases the distance at which air travel becomes more competitive.

Passenger long-distance transport within the EU15 – over distances of more than 250 km – is distributed among modes as follows:

- 71.2% road over distances between 250 and 500 km, and 35.1% above 500 km (individual car and bus combined);
- 17.6% rail over distances between 250 and 500 km, and 8.7% above 500 km;
- 7.7% air over distances between 250 and 500 km, and 53.2% above 500 km; and
- 1.7% waterborne above 250 km.

Long-distance freight haulage comprises:

- Road and rail transport (truck, train), which is typically over distances starting at 100 km.
- The use of inland waterways and coastal shipping (particularly for low-value, non-time-sensitive goods).

5.2.3. Adding level 2 nodes

In a second step, level 2 nodes can be added. These level 2 nodes need to be added as good as possible to the existing connections. Most level 2 nodes will already be on a connection, or close to one.

Connecting the level 2 nodes is not just to put a line on the map created in step 1, it also focuses on possible connections with other hierarchical nodes within reach of the route. A good example could be here a connection between Rotterdam and Antwerp, where Breda is a node close to the middle which is in the relation and therefore connected.

When adjusting a connection to include a level 2 node it should be checked that this does not result in unacceptable detours in the network.

Figure 9: Example of an ideal passenger road network for Belgium, with 2 levels of nodes (A and B)

Source: Hans Verbraken, "Tabula Rasa: A new road network for Belgium", Katholieke Universiteit Leuven, 2008

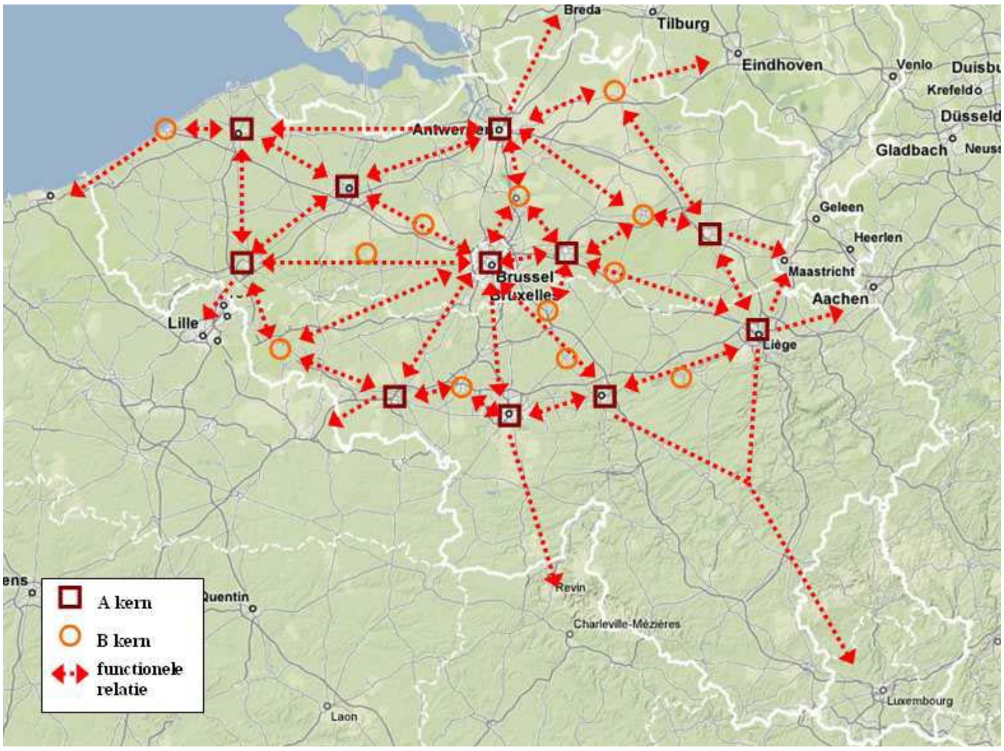


Figure 10: Example of an ideal passenger road network for Florida, with 2 levels of nodes (red and blue)

SOURCE: Ben Immers, Bart Egeter, Rob Van Nes, Transport network planning: Methodology and Theoretical notions, Transportation Engineers' Handbook, Editor: M. Kutz, 2009

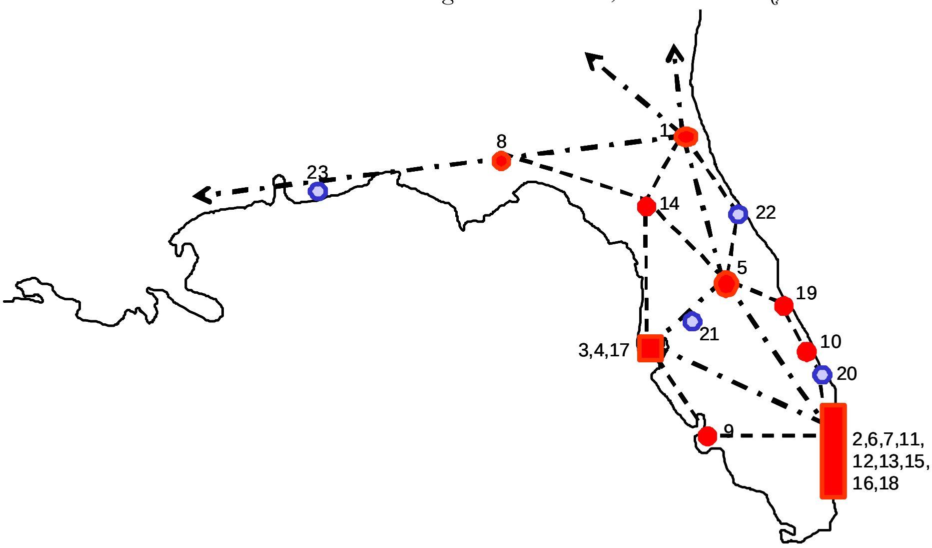
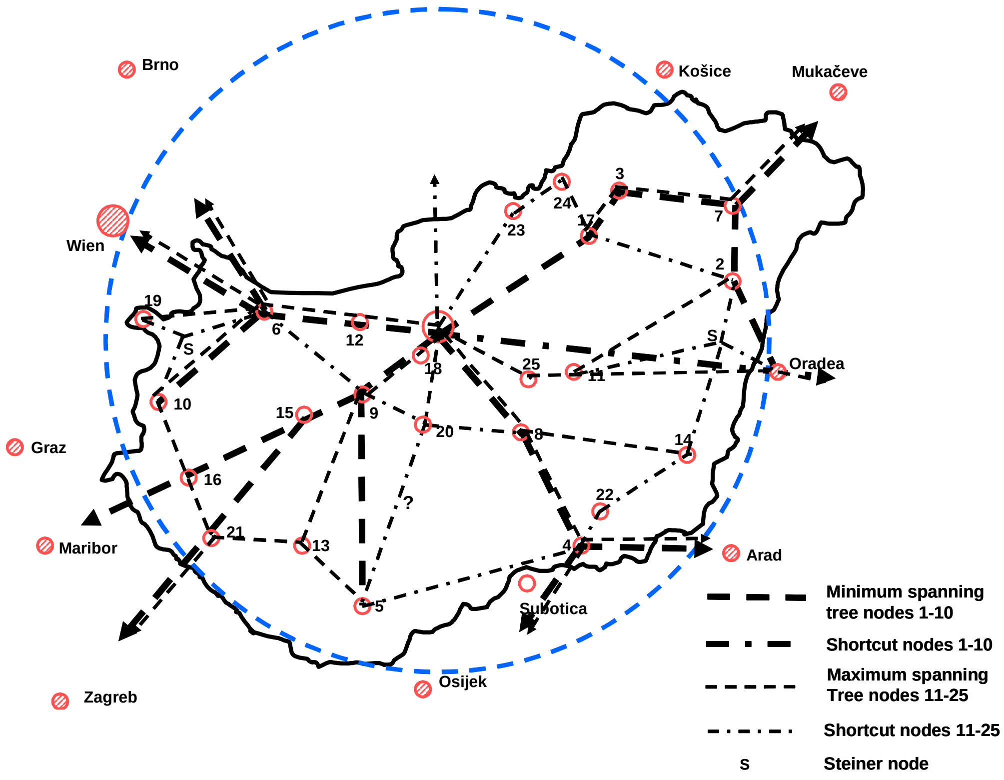


Figure 11: Example of an ideal passenger road network for Hungary, with 2 levels of nodes (red and blue)

SOURCE: Ben Immers, Bart Egeter, Rob Van Nes, Transport network planning: Methodology and Theoretical notions, Transportation Engineers' Handbook, Editor: M. Kutz, 2009



5.2.4. Treatment of corridors

Intermodal corridors

Intermodal corridors can be treated in two ways:

1. Different transportation networks being competitors
2. Different transportation networks being complimentary

In current planning practice transportation networks are often seen as competitors from each other. In the light of this study that would ask for the design of six individual networks which could operate on their own and do not have any relationship with the others. Since this is neither feasible (due to high investment costs for various networks) nor making any sense on the larger geographical scale, the second manner of treating corridors is applied in this document. Especially since relations between nodes are investigated and not the way in which these relations are actually implemented.

Being complimentary requires a whole different set of parameters to be taken into account when designing a network. First of all the concept of intermodality needs to be further investigated (see the next paragraph), secondly linkages between the nodes should be translated from the relational sphere towards real transportation networks. This means that if the relationship between nodes has been established as well as the required quality of this relationship in the design process the combination of the available transportation networks needs to be taken into account. In other words, if for example two nodes are connected by a road and this road doesn't fulfil the existing quality criteria the easy way is to decide to upgrade the road to reach the required quality. If however the quality criteria for passenger traffic are not met, it could also be decided to implement a railroad next to the existing road instead of just upgrading the road. This would create a corridor where both networks are complimentary to each other.

Unimodal corridors

The second perspective often associated with the term corridors is the combination of various OD-relations onto the same stretch of network. In the existing design process the various relations which are relatively close to each other can easily be grouped together into a corridor. Especially since existing networks are not taken into account and new corridors can be designated, if this is creates an improvement for the relations under investigation. The interesting retrospect from the design of corridors is (as already mentioned in the definition) the reduction of pollution affected area. Grouping the environmental pollution coming from the various transportation networks would create a benefit for society as a whole.

5.2.5. Treatment of intermodality, ports and airports

Intermodality can fit in the process in from two perspectives:

1) Existing nodes are shown in the selection of nodes
2) Intermodality is a specific policy purpose

If an existing node is an intermodal node this node will occur in the network and relations for the different transportation networks will start and end here. These nodes can be expanded on intermodality if other (currently not connected transportation networks) are relatively close by and provided that adding this network to the node will add possibilities for the relations. In other words adding a high speed rail link connection to an inland waterway and freight transportation node doesn't make any sense.

If intermodality is a specific purpose the ideal network designs of the three networks for passenger transport and the three networks for freight transport should be overlaid. This creates insight in the potential connecting nodes for the various networks and shows the points where potential of intermodality might be present, but currently is not existing.

5.2.6. Treatment of natural barriers

In the methodology described to connect nodes the detour factor calculation does not distinguish between situations where there are natural barriers (mountains, sea, etc) between the nodes resulting in a detour and situations where there is just a missing link in an undisturbed geography. In the following some examples are described and how this is to be handled in the methodology.

Detour due to sea

If we have a relation between Porto and Le Havre then for land transport a detour has to be made through the Spanish – French border. In the methodology this is handled by only connecting adjacent regions. Then for non-adjacent regions a shortest rout has to be chosen through the connections made between the adjacent regions. In this way for this situation the actual land mode distance is compared with a proper as the crow flies distance.

In case of for instance the Nordic situation also ferry connections should be introduced in the network and regions should be called adjacent also in case a ferry line is available between these regions.

Detour due to meandering rivers

Unlike channels, rivers in many cases are meandering. This implies in some situations that the distance can be over three times as long as the as-the-crow-flies distance. A theoretical solution could be to make a straight channel. The costs are however enormous and very likely to have a negative cost benefit ratio since alternatives are normally available (road, rail).

In principle in the MCA this type of situations will be easily filtered out in a qualitative step.

Detour due to mountains

In mountainous areas detours are also a natural situation. The difference with the situation of meandering rivers is that in this case there is normally no alternative available with a low detour factor. very high since it can open a unique high quality alternative.

Many situations have however already been studied before and have been regarded as not feasible. In the MCA Investments can be very high to make a tunnel. However in some cases the benefits can also be therefore most cases can be filtered out in a qualitative way. For the situations where it could mean a large benefit a more in-depth quantitative analysis will be required.

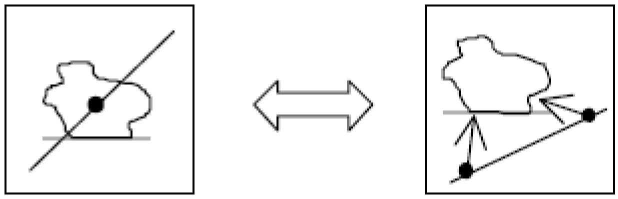
5.2.7. Access structure

For any given transport system, there is the question whether there should be few or many access points, and where they should be located.

The more access points, the better its accessibility. This means that a smaller part of the trip needs to be made on the lower scale level (and therefore slower) networks. On the other hand, the quality of connections (how fast, and how reliable from one access point to another) provided by the subsystem is higher when there are few access points. This dilemma plays a major role in the design of public transport networks, but is also becoming more and more important in road networks. In many countries, long distance traffic often encounters congestion near urbanized areas caused by regional or even local traffic, entering and exiting the freeway and frequently causing disturbances in doing so. In general, higher scale level networks have fewer access points – this has to do with the fact that access points are usually found near cities, and fewer cities will be connected to the higher order networks.

There is also the question of where to situate the access points: one access point in the middle (as is usual for train stations), or one or more at the edges of the built-up area (as is usual for through roads). The first option maximizes the accessibility of the system, but this often leads to 'misuse' of the system by traffic that could use a lower-order network. Also, it may affect liveability in the area. Finally, it undermines the intended differentiation in systems. Although this dilemma plays a role in individual as well as in collective systems, the outcome of the question is different for each type:

Figure 12: Two types of access structures



- Access points for *collective* transport are preferably situated in the middle of urban areas. The main reason for this is that every transfer between subsystems necessitates a physical transfer (change of vehicle) with the associated inconvenience of such transfers. Transfers need to be kept to a minimum, which is why the access points to collective systems should be placed in one central location. This also prevents the use of high level systems for trips that should be made on lower level systems.

- The access points of *individual* transport systems are preferably located at some distance from the settlement: without the need for physical transfers, transition to the underlying road network is practically seamless. Considerations regarding community liveability also favour the location of access points on the periphery of built- up areas. Keeping a certain distance between the settlement and a network access point also prevents use of the network at a lower than intended scale level; the detours become too long.

6 Quality criteria

This chapter describes the quality criteria for each connection. In a second step, we propose a methodology to define the underachieving and missing connections.

6.1. Defining the performance criteria for the core network

This step will describe the performance criteria for the network in terms quality criteria for connections (not for a physical network).

The described TEN objectives will be translated into measurable variables. Threshold values represent desirable or acceptable values of indicators. Identifying threshold values for indicators is both a scientific and political process.

6.1.1. Indicators for measuring the performance of the TEN-T

The EC Treaty provisions (Articles 154-156) continue to be the foundation on which the future TEN-T policy should rest. Seven objectives have been identified.

1) Internal market, social and economic cohesion: For interconnection/ interoperability of national networks objectives, indicators and targets have to be identified considering levels of service (standardisation, accessibility, safety, reliability, quality). Specifically the choice of indicator for economic cohesion needs attention (as proven in the Iason Deliverable 6), where a variety of indicators proved to have contradicting results. Objectives should be formulated which consider the importance of secondary networks.

- Reduce economic and social disparities
- Increase economic competitiveness
- Interconnection and interoperability
- Promote access to networks
- Safety, reliability, quality, level of service

2) Territorial cohesion: The methodology for planning should consider also indicators/drivers that allow the assessment of the capability of a proposed project to improve the territorial cohesion with in a cost-effective way.

- Address territorial disparities
- Deal with consequences of urban concentration
- Counteract polarisation of wealth and population
- Strengthen links and connections
- Promote cooperation between regions

3) Sustainable development: Key issues are limiting vehicle emissions, safety issues, addressing social exclusion, whilst still allowing mobility and freight transport.	• Balance environment, society and economy • Limit vehicle emissions • Improve safety performance • Address social exclusion • Provide mobility and freight transport
4) Specific objectives aiming to achieve a multimodal and interoperable network: In an integrated multimodal context, consistent with that required to support the enlarged single market, effective interconnection between trips will become part and parcel of a growing proportion of passenger and logistics movements. Without a multimodal and interoperable network at the backbone, integration of the single market would become difficult and diluted.	• Enable technical interoperability • Specifically for ITS applications • Ensure policy compatibility • Implement governance framework • Minimise friction costs
5) Climate change: The focus will be here solely on addressing the impact of all modes of transport on climate change in relation to the planning process for the TEN-T network.	• Decrease CO_2 levels and emissions • Minimise land take for infrastructure • Avoid deforestation for infrastructure • Enabling mobility and freight transport • Conform to international legislation (e.g. Kyoto)
6) Globalisation and international dimension: Implications of trends in globalisation (e.g. shifting tradelanes, rising fuel costs). Effect of globalisation on inland networks (e.g. required development of infrastructure connecting the Baltic states) and on maritime transport (e.g. connectivity of ports to other countries, development of inland ports).	• Enable cooperation with Third Countries • Provide efficient supply chains • Implement freight distributions centres and supply chain integration • Coordinate port development with TEN-T • Implement hub/ spoke concept for ports and airports
7) Transport Policy Development: Review of various transport policy documents and analysis of its implications for the TEN-T network. At the moment the Commission is looking into the challenges and opportunities for transport in the long term (20-40 years). In June 2009 a communication on the Future on Transport will be adopted.	• Keep freight moving whilst addressing environmental issue • Develop green, safe, and inclusive transport and mobility • Keep EU at forefront of transport services and technologies • Provide high level of mobility for people and businesses • Avoid bottleneck and provide international connections

6.1.2. Translating the objectives into performance criteria for the network connections

The performance criteria (or "Level of Service") can be defined as the service quality for a given activity. In the specific case of the TEN-T core network, the ambition is to get a transport quality as high as possible on the European scale.

This "quality" is be defined broad, and can be translated into 3 views:

- The view of the society. This boils down to the overall sustainability goals, in their 3 dimensions: economy, environment and social quality.
- The view of the users. They want a fast, cheap and comfortable connection.
- The view of the network owner as the service provider. They want an easy and cheap exploitation, and a large flexibility and interoperability.

For each of the 5 networks (passenger and freight road, passenger and freight rail, and shipping), these criteria need to be translated into performance criteria.

6.1.3. Non-limitative list of performance criteria

This paragraph contains the most important performance criteria to be taken into account when designing a European network

Mean speed

This is the far most important performance criterium of a transport network. How long does a journey on the network take? Since higher level networks generate on average longer trips, they should also need higher average speeds: a motorway is faster than a regional road; an InterCity train is faster than a local train. If this were not so, there would be little point in travelling over higher level networks.

The average travel speed indicates the time needed to travel (or transport goods) on the various networks and can also be determined relatively (in km/hour) thus showing the average speed between origin and destination. This last measurement is used mainly in comparing trips across various distances. It includes:

- Average congestion
- Access time and delays
- Cross-border delays
- Service frequency (in case of public transport, air transport)
- Geographical detours

The speed is calculated preferably on the basis of the resistance of the loaded transport network, so it is necessary to assign an origin-destination matrix to the network. Use of a dynamic assignment model enables realistic travel times to be calculated.

Reliability

This performance criterium describes the ability of the transport network to cope with transport demand peaks. It is thus different from the previous criterium on average speed.

Travel time costs tend to be significantly higher under congested and unpredictable travel conditions. It is suggested by that travel time costs under congested conditions be calculated at 2.5 times that of overall travel time savings.

Reliability includes:

- Congestion on the road network, which can be measure with the 90th or 95th percentile travel times.
- Punctuality in rail and air connections, both at the node level (stations, airports) and on the connection level (e.g. airspace capacity).

To determine the travel time reliability (or robustness) of the network, there are various possibilities that are open, like:

- Calculating the effects of fluctuations in demand and/or supply (e.g., as a result of the occurrence of an incident). By temporarily restricting the capacity of one or more links in a network, the effects of these fluctuations on the quality of the traffic flow can be calculated. This can be measured in the most easy way by volume/capacity ratios, or with days per year where the remaining capacity is limited under a certain threshold.
- A second factor that has a considerable influence on the robustness of a network concerns the traffic load of the 'vulnerable road sections' in the network. As a result of the 'spillback' effect, the tail of a traffic jam can seriously obstruct the traffic flow in other parts of the network.

Environmental hindrance (air quality, noise)

Emissions and noise are mainly a function of the mode, the number of kilometres travelled, and, most important, the characteristics of the vehicle (e.g. Euro-classes). Here it is also assumed that the nuisance level increases as more people experience the interference, therefore there is more interference from traffic in cities than outside of them. However, the readiness to accept might be lower in rural regions, where the impact of a motorway, airport, or a main railway line might be felt more disturbing.

Traffic emits a number of harmful substances. Carbon monoxide (CO), nitrogen oxides (NOx), particulate matter (PM), SOx and volatile organic compounds (VOC) are the main pollutants emitted by motor fuel combustion (primary pollutants). Through reactions in the atmosphere these cause the formation of secondary pollutants (photochemical oxidants, primarily ozone, smog, atmospheric acids, etc.). The size of these emissions depends on various factors like fuel usage, type of fuel, speed, driving cycle, gradient, etc. If we want to take account of all of these factors, this implies a highly complex method of calculation. This level of detail is undesirable in a European network design process and largely not feasible given the absence of required data. A global approach consists of a calculation of the emissions based on the kilometres covered per road type.

Rail, road and aviation are major sources of noise annoyance. To quantify noise nuisance one needs the following data:

- load per stretch of road
- composition of the traffic
- speed of the traffic
- distance of road axis from building facades
- building density (number of premises/residents along the side of the road)

This data helps determine the equivalent noise level which can be compared with the standard (e.g., 55 dB (A) threshold value). If one does not have access to the building density data, one can also use the number of vehicle kilometers (distinguishing between cars and trucks) or passengers and ton kilometers (road and rail) as a starting point.

Climate change

Transport CO2 emissions are the second largest single source of greenhouse gas emissions in the EU, 20 % of total greenhouse gas emissions in 2000. Energy use and climate change are mainly a function of the mode and of the number of kilometres travelled (and of the speed at which vehicles travel). Climate changes impacts can be measure by transport emissions of greenhouse gases by mode and by type of gas, expressed in CO2 equivalent

Landscape

The laying of new rail tracks, roads or widening existing roads can have a significant impact on the landscape, like:

- Slicing through the landscape with the result that valuable landscapes and/or ecosystems are disturbed
- Dividing up areas such that they are subsequently too small to function as a habitat for a species
- Finally roads create a barrier that hinder crossing, for both man and animal.

This effect is difficult to quantify generically; each case will largely have to be examined on its own merits. One way of calculating the effect is to determine which remediation measures (investments) are desirable to retain the original situation.

Safety

As for the criterion safety it is reasonable to assume for individual systems: the higher the scale level, the safer the system.

The safety of a transposition in a network depends on many factors. To ascertain the effects of the proposed network structure on safety, the following calculation can be applied. The kilometres on the network are multiplied by risk factors that indicate the possibility of an accident with (fatal) injury as a function of the distance covered.

As safety in increasing, there is tendency is to measure it in behavioural terms. E.g. in air transport, one can measure it by the number of airproxs and incidents.

Security

Traffic security concerns 3 topics:

- Personal security concerns lowering the risk of assault, theft and vandalism. Such risks can discourage public transport use. Public safety tends to increase with increased community cohesion. In the case of TEN networks, this issue is predominant in intermodal connections as railway stations and airports. However, car drivers also encounter personal security threats, such as car thefts, road rage, and aggressive driving. Security concerns can be addressed by providing visibility and emergency response, and by locating other services and activities within or adjacent to stations, such as vendors and stores, government and commercial offices and police stations.

- Transit terrorism is a threat that harms people both directly, through injury and property damage, and indirectly by creating fear and confusion.

- Goods security concerns mainly smuggling, and goods theft.

It is hard to measure security in indicators. Some existing indicators are the number of vehicle thefts and other vehicle related crimes per inhabitant, and the number of security incidents on public transport per year per inhabitant. The relevance for TEN network design is however small.

Interoperability and harmonisation

TEN-T networks focus, obviously, on long distance transport. This is either interregional or international in nature, thus requiring co-operation between network and service operators in different regions (if they are not the same) and countries, providing interoperability for both passengers and goods transport. Long-distance travel is made more difficult, time consuming or expensive due to issues like different information systems, pricing systems, national regulations, jurisdictions, technical standards and languages. Thus there is a close relationship between long-distance transport and interoperability.

Harmonisation is an issue that affects the user in the same ways as interoperability. E.g. having similar speed limits in each country provides more comfortable and logic transport (with a secondary impact on safer transport).

Interoperability and harmonisation can be taken broad. It includes also:
- Technical aspects as curve radii, gradient, cross-section (number of lanes or tracks).
- Legal regulations (e.g. speed limits)
- Traffic control harmonisation (all modes)
- Harmonisation of operational procedures and practices
- Rollingstock standards
- Rail electrification and track widths

Operational costs

Operation costs can be expressed in euro per km of section, or per unit of operation. Both the network owner as the service provider have operational costs.

Operational costs include:
- Cost of traffic management
- Maintenance costs
- Safety costs
- …

Costs to the user

The costs include the costs of vehicle acquisition, operational costs (fuel cost, parking, …). It can be measure in euro per vehicle-km. The prices of transport services are the result of autonomous market developments such as vehicle and logistics technology, distribution management and location decisions. They are also influenced by government interventions such as taxation, infrastructure provision, regulation, subsidies and spatial planning.

6.2. Analysis of the existing network

An analysis of the existing network will reveal **the degree to which the existing connections function at the desired quality level**. The ideal networks indicate which the desired connections are. The point of this exercise is to pinpoint those existing connections that match the ideal connections maximally and to indicate if the existing connections function at the correct level.

The methodology will focus on unimodal networks and on the inter-modal connections. The methodology to be applied, the requirements and the practical possibilities to apply the method are different for the respective modes. In the following sections the methodologies are described by mode. Here we do not start from the theoretically most advantageous method but turn immediately to the best feasible method. Here the availability of the required data and models at a European scale is taken into account as a prerequisite for the selection of the method.

Eventually, the analysis of the existing network will lead to the identification of possible infrastructure projects. However, some "missing links" will remain, where e.g. a potential corridor is not effective, due to an excessive detour between two points of that potential corridor, not to distant from each other (in relation to the detour).

6.2.1. Road

For road the level of service can only be measure by a confrontation of the long distance and the local traffic with the available road infrastructure capacity. The total traffic on a link is defined as the intensity.

The capacity of a road link is a function of different aspects where the number of lanes is the most important one. The method can be refined by also taking into account the gradient and curvature which have a significant impact on available capacity.

The intensity/capacity ratio is a measure to determine whether a link is in a free flow status or is used at capacity. If the link is at capacity this is called a capacity bottleneck. This is a well know method that does not require further explanation here.

In order to perform this method on needs a proper OD matrix covering all transport flows for passengers and freight at the most detailed level as possible. At the European scale in ETIS-BASE, WORLDNET and TRANS-TOOLS it has been proven that for the EU the NUTS 3 level is possible. What is up to now missing is the local traffic in especially the urban areas. In TRANS-TOOLS this has been solved by pre-loading the network before assignment.

The road network developed in TRANS-TOOLS and WORLDNET is the best available at the moment for modelling exercises like this. TEN-TEC, GISCO and GETIS networks are primarily designed for presentation purposes and originally form the basis for the calculation network that was originally developed in ETIS-BASE and then improved in TRANS-TOOLS, WORLDNET and TEN-CONNECT.

Another type of bottleneck that has to be considered and can not be read from the calculation network are the road conditions. This has also been analysed in for instance TEN-CONNECT. Here aspects as curvature, gradient, safety, Road crossings, passage through densely populated areas, road pavement quality, environmental issues were listed. The methodology to be applied for this type of bottleneck is mainly the collection of already existing information in the countries. In TEN-CONNECT this was proven not to be always available and often the information was not complete.

6.2.2. Rail

An approach for determining the capacity bottlenecks for rail run fairly quickly in data and information availability problems. Where OD data are exiting from ETIS and TRANS-TOOLS the main problem lies in the rail networks. European networks are existing in TRANS-TOOLS but do not contain information on for instance marshaling yards, turning direction at intersections, gradient, number of slots etc. This information is existing but at the national level and is owned by the respective railway organizations. These railway organizations do not want to release this information.

As said this missing information is key for a methodology that can in a reliable way make an assessment of the capacity bottlenecks. For this reason it at this stage it does not make sense to propose a methodology in this direction. For this reason the methodology that is feasible is relying on official publications of infrastructure managers as was also done in the TEN-CONNECT study. Also other information can be derived from these publications.

In the following figure and tables other bottlenecks can be seen. Here we see the different electrification and signalling systems. As can be seen this is a patchwork that restricts the free movement of trains and especially trains with electric locs. This situation favours the use of diesel locs which is given the climate objective not desirable. This type of bottleneck is rather static over time but should be updated when needed.

Figure 13: Different electrification and signalling systems

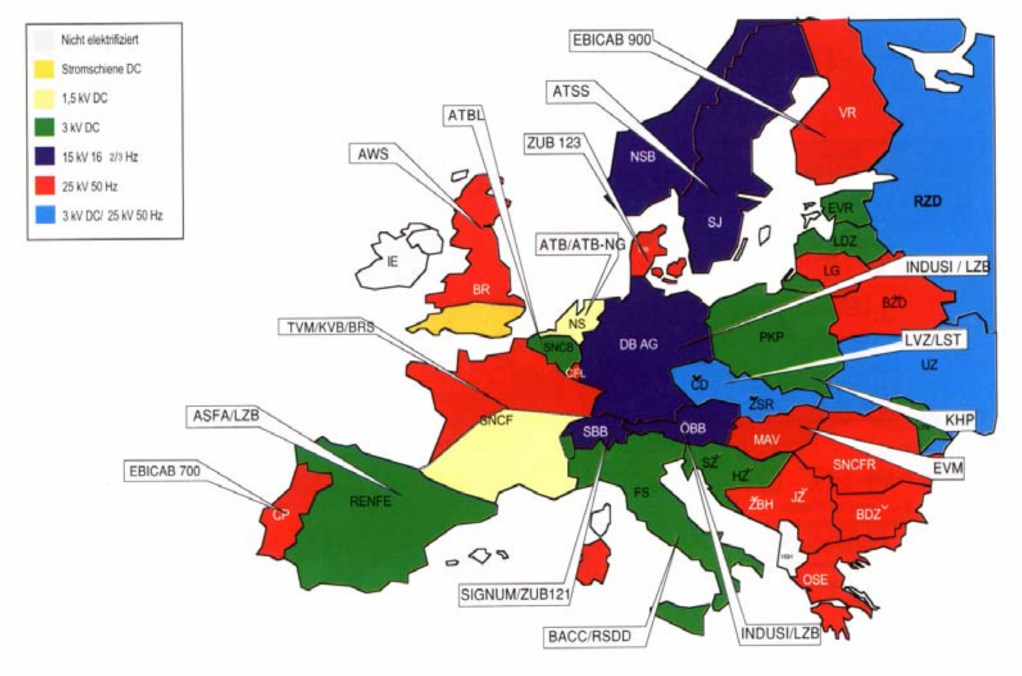


Table 5: Current systems

25 kV / 50 Hertz, AC	15 kV / 16,2/3 Hertz, AC	3000 V DC	1500 V DC	0,75/0,65/1,2 kilovolt DC
Northern France Luxembourg Denmark Finland England (excluding South England), Wales and Scotland Portugal Southern part of Czech Republic and Slovakia Hungary Romania Bulgaria Turkey Balkans (with some exceptions)	Germany Austria Switzerland Norway Sweden	Belgium Spain Italy Poland Slovenia Part of Croatia	Netherlands Southern France	Southern Engeland

Table 6: Safety systems

Country	Safety systems
Netherlands	ATB EG en ATB NG (Alstom)
Belgium	Crocodil, ATBL 1, ATBL 2, TVM
France	Crocodil, KVB, TVM
Spain	ASFA/LZB
Portugal	Ebicab 700
UK and Ireland	AWS (except South part)
Germany	Indusi, PZB, LZB (Siemens)
Denmark	Zub 123
Sweden	ATSS
Norway	?
Switzerland	Signum, Zub 121
Austria	Indusi, LZB
Italy	Bacc, RSDD
Poland	SHP (Adtranz Polen)
Hungary	EVM

In the following table, one can find the different gauge width used in Europe.

Table 7: Gauge width in Europe

1435 mm	1524 mm	1600 mm	1676 mm
England	Russia	Ireland	Spain
Wales & Scotland	Finland	Northern Ireland	Portugal
Netherlands Belgium	Estonia		
France	Latvia		
Germany Denmark	Lithuania		
Norway	Belarus		
Sweden Switzerland	Ukraine		
Austria	Northeast Romania		
Italy			
Poland,			
Hungary			
Czech Republic			
Balkan			
Slovakia			
Romania			
Bulgaria			
Greece			
Turkey			

For railways in addition to the technical bottlenecks also the organisational interoperability bottlenecks should be taken into account. In contrary to for instance road for the rail mode the freedom to make a movements is restricted by time schedules and availability of time slots. The scheduling is performed by the national railway organizations taking into account agreements made at the European level and mutual agreements. In the scheduling in most cases all train movements are interrelated to each other. So passenger and freight trains and different types of domestic and international trains combined take up the available capacity. Furthermore the difference in characteristics and function of the different type of train movements make that scheduling becomes rather complex. For instance where passenger trains make regular stops a freight train preferably does not stop at all. Combining different types of characteristics on one track often takes up much additional capacity. For this reason often the solution is chosen to create infrastructure dedicated for a specific function. HSL is well known but there are also for instance dedicated freight lines or regional lines.

Depending on the country a specific type of movements is dominating. In some countries domestic passenger trains are dominating where in other countries the freight train movements are dominating. Railway companies therefore often give priority to a specific function in the scheduling in order to guarantee optimal quality for the main user group. Differences in priority per country is an additional complication.

For the TEN-T we are merely interested in the long distance international train movements. The actual speed of these trains is depending on the time schedules made. For the base year this can be straightforwardly determined. For a future situation this is not possible. Where the base year situation can be used as an indication on should also take into account the potential for removal of organisational bottlenecks and its expected impact on the scheduled speed.

Where the technical bottlenecks give an indication on the maximum speed on a section the organisational bottlenecks are largely determining the maximum speed on OD level. Even in the case where the trip can take place on a double track that has a deign speed of 150 km/hour the actual speed could well be 40 km/hour. In the methodology the organizational bottlenecks should have a high priority.

The methodology for the organizational will consist of collection of information by desk research and interviews.

6.2.3. Inland navigation

For inland navigation bottlenecks can occur at locks, at Bridges and due to the (fluctuation of the) depth of the river.

In the information available at the European level which is incorporated in ETIS and TRANS-TOOLS no proper information is available about locks and bridges. Information is available about the depth and so called ECMT classification which defines which maximum ship sizes can navigate on a river. The assignment that can be made with TRANS-TOOLS and which has also been applied in for instance TEN-STAC the inland navigation flows are assigned by an all-or-nothing assignment without capacity restrictions. Although insight can be obtained on where the flows will grow there is no proper analysis possible on the bottlenecks.

In national inland navigation models this type of information is available and models are designed to analyse the delays at locks. Generally the national territory is most detailed and up to date where the links across the borders are of lesser quality. In future exercises it might be worthwhile to create a European Network that can be used for modelling.

In commercial software like for instance PCnavigo all required information is available. With this software individual shippers plan their routes taking into account the waiting times at locks and other capacity constraints for a certain ship size. With this software one could create travel time OD's based on current average waiting times at locks. This time matrix then can be used in the assignment module to be used and would add to the quality. Detailed analysis can be done on locations of (potential) bottlenecks using the details in this software.

In an ongoing DGTREN project PLATINA bottlenecks on the inland navigation network are being analysed. Here the required information on bottlenecks is collected from different sources and are largely inventories of observations. On the short term it is therefore advisable to use the PLATINA results as basis and to fine tune it where required.

For a long term methodology the best is to create a proper calculation network and a model that makes optimal use of it. Alternatively the PLATINA approach is the most optimal solution.

6.2.4. Intermodal connections

Intermodal connections are port, airports and inland terminals. Here two different types of bottlenecks can be distinguished; the capacity of the inter-modal connection itself and the access to the networks of the different modes.

Typical for intermodal connections is that they are commercial private organisations. Minimisation of operational costs is essential for being competitive. For this reason the current capacity at an intermodal connection is likely to be as close as possible to the required capacity needed to facilitate the actual throughput. A port using the full capacity is in fact the ideal situation rather than a restricting situation. Generation of over capacity is not an objective here.

In analysis on bottlenecks in a forecasted situation most inter-modal connections will show that capacity is not sufficient. In practise in many cases simple market investments will lead to an increased capacity to facilitate the increased throughput and no bottleneck will occur.

If we look at ports there are different levels at which capacity constraints can occur. For instance:
- capacity of the current lay-out and equipment
- capacity of the current lay-out with maximum equipment
- capacity of the maximum extension of the lay-out with maximum equipment

Capacity has different definitions and interpretations and as a consequence also the capacity constraints. Similar situations can be found for other inter-modal connections.

Another consideration is that if for instance a terminal is at capacity whether this terminal requires additional capacity or another terminal should be opened on a different location.

Finally the data availability at a European scale is limited and definitely not complete.

Conclusion on the capacity of the inter-modal connections is that if this has to be taken into account a consistent definition has to be applied. Furthermore extensive and time consuming data collection would be required to make the calculations.

The other type of bottleneck that has to be analysed is the access to infrastructure of other modes. Here the assessment will be done using the existing infrastructure as described in earlier sections. An indicator can be defined showing which distance can be reached in a certain time from the node for each mode.

7 Assessment at the different strategy levels

Project assessment at strategic network planning level can (and should) be done in two ways:

- Top down: ranking the missing and underachieving links from a European perspective with MCA.
- Bottom up: Member State initiated project appraisal with CBA.

7.1. Using the MCA for infrastructure networks evaluation

On the strategic level, to optimise the efficiency of the core network, by comparing shape, density and modal structure of different variants against the relevant objectives, some kind of **multi-criteria analysis** is the most adequate.µ

Multi-indicators analysis establishes preferences among options (specifically alternative projects candidates for TEN-T funding) reference to an explicit set of objectives that will have to be identified, and for which will be established measurable indicators to assess the extent to which the objectives have to be achieved.

As already premised (cf. paragraph 6.1), and later on developed, the indicators for measuring the performance of the TEN-T projects are the following:

- Internal market, social and economic cohesion;
- Territorial cohesion;
- Sustainable development;
- Multimodal and interoperable network;
- Climate change;
- Globalisation and international dimension;
- Transport policy development.

Each indicator can be declined in sub indicators. For example, the indicator "territorial cohesion" is having reference to the following evaluation sub indicators:

- Address territorial disparities,
- Deal with consequences of urban concentration,
- Counteract polarisation of wealth and population,
- Strengthen links and connections,
- Promote cooperation between regions.

Then, to each sub indicator is assigned a weight depending on its contribution to the overall evaluation expressed by the indicator. Finally the overall evaluation for each project, expressed by the indicator, is calculated by pondering each sub indicator with the respective weight.

One of the most relevant key features of MCA is its emphasis on the subjectivity in establishing objectives and indicators, estimating relative importance weights and, to some extent, in judging the contribution of each TEN-T project to each performance indicator.

The adoption of MCA involves many advantages over informal evaluation not supported by any technical analysis:

- it is an open and explicit methodological procedure;
- there is always the possibility to change the choice of objectives, if felt to be inappropriate, through the intervention of a panel of experts which can modulate again weights of indicators and sub indicators;
- scores and weights, when used, are also explicit and are developed according to established techniques;
- performance measurement can be committed to experts;
- the use of scores and weights provides an audit trail.

The focus of the MCA assessment in such a context will be the evaluation of the different "EU value added" options arising from each project, and the performance criteria will be derived accordingly: for example the capability of the project under examination to improve market cohesion or to promote inter-regional co-operation, etc.

The steps required to undertake this process can be summarised as follows:

1. To weight the different impact categories is the key phase in balancing different or competing objectives against each other, e.g. the relative importance of improving market cohesion benefits when compared to wider social impacts. A number of different approaches are possible for weighting the relative impact categories, e.g.
    - It is possible to use recommended weightings, if any
    - It is also possible to weight different categories using economic values, for example the quantification of the benefits in terms of additional occupancy (value added) vs. major resident population due to polarization effects, based on the unitary costs per additional resident (urbanization costs).
1. The weighting of the different impacts can be undertaken through expert analysis and stakeholder workshops. Such an approach scores the non-quantified impacts and to provide weightings.

From a methodological point of view, it is important to stress that using the approach provided by the MCA model implies, generally, to adopt different views about the relative importance of different attributes of the projects.

In such a case, it must be stressed that differences of this sort are often associated with the views of different groups of stakeholders whose value judgements about what is important in evaluating the projects can vary from each other.

Although applying the MCA cannot in itself usually reconcile what are often fundamental differences at stakes, e.g. environment versus development, it can anyway provide clarifications of where and how the differences in view may affect project evaluations.

In general, it can be said that on some occasions, the MCA approach can provide a basis for discussion in order to find out a better understanding of the multi-facet aspects of the project under examination, helping to trade-off the different pursues of the opera.

7.2. Evaluation of individual projects with CBA

A classical **cost-benefit analysis** is a most appropriate and recognised tool for the appraisal of individual projects.

The Integrated Methodology will synthesise methodologies for Cost Benefit Analysis, e.g. DG REGIO's Guide to Cost-Benefit Analysis of investment projects. With particular reference to estimating the external cost of transport, the methodology will be based on the DG TREN's Handbook on Estimation of External Costs in the Transport Sector. For transport corridors across Europe a new tool – developed as a result of the EU research project GRACE – can be used for the estimation of the external costs. This tool allow to interactively calculate the values of external costs for any given network section (and node) if the EU transport system, for all modes, for all main categories of external costs, i.e. air pollution, global warming, noise, accidents, congestion, wear and tear of infrastructure, and for a wide range of vehicle types. This tool builds upon a number of marginal cost case studies and a generalisation procedure which uses the same methodology as the Handbook mentioned earlier. Furthermore output of the EC EVA-TREN project will be reviewed.

While direct economic impacts like cost savings due to improved operation can be monetised fairly well and with high accuracy, it is in the very nature of many important social and environmental impacts that any assignment of a monetized value is, to a certain extent, subject to individual views, experiences and preferences. This holds for instance for expected spatial structural changes, impacts on health or human life as well as consequences of greenhouse gas emissions for future generations. This may lead to a variety of approaches for assessing transport investments. When choosing among these approaches, some arbitrariness is inevitable, even in the case of a cost-benefit analysis, where this refers to monetizing unit values. With regard to a core network approach there is – until now – no generally recognized procedure existing, to monetise the impacts of accessibility improvements on cohesion and regional economic patterns, although in many cases, as recent findings of economic geography show, these aspects might be most important for the structural development.

7.2.1. Overview

This document distils advice provided by several sources: e.g. DG Regio (2008) and European Commission and European Investment Bank (2007) where more detailed advice is given on general appraisal. In relation to the TEN-T, this note sets forth a framework for Cost Benefit Analysis to be carried out in pursuit of the objectives previously mentioned in this report.

The overarching objective of an economic appraisal of any TEN-T project is to measure the magnitude of the economic impact resulting from the investment. In the economic appraisal, the approach conventionally adopted is a partial equilibrium approach that focuses on the primary impacts incurred by transport users, operators and governments. The basic calculation is summarised below:

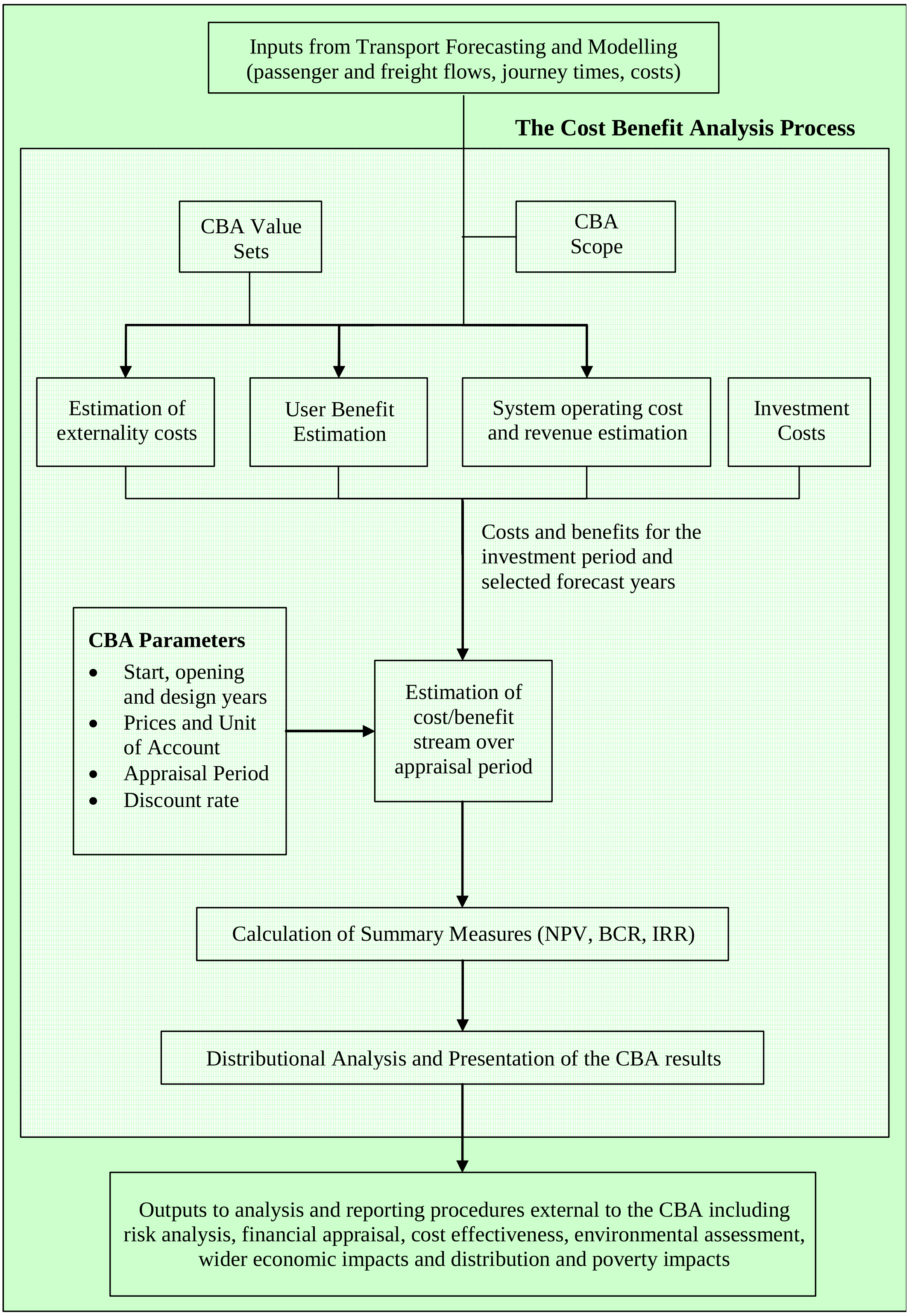
Overall Economic Impact	=	Change in transport user benefits (Consumer Surplus)	+	Change in system operating costs and revenues (Producer Surplus and Government impacts)	+	Change in costs of externalities (Environmental costs, accidents, indirect effects, etc.)	-	Investment costs (including mitigation measures)

This apparently simple calculation can in fact become a quite complex exercise as it becomes necessary to consider:

1. The scope of the appraisal in terms of mode, study area and range of impacts;
2. The calculation of transport user benefits (consumer surplus);
3. The calculation of impacts on transport providers and the government (includes producer surplus and investment costs);
4. Monetary valuation of time and safety;
5. The treatment of environmental impacts, contribution to Global Warming and other externalities.
6. Estimation of indirect effects
7. The mechanics of the process including inputs, project life, discounting, aggregation of benefits and costs, unit of account.

Figure 14 summarises the steps involved in carrying out the cost-benefit analysis for transport infrastructure projects and illustrates that it comprises of a number of distinct stages and that a range of internal inputs are required. The rest of this framework for a CBA document is structured around the elements in figure 14.

Figure 14: Transport economic appraisal



7.2.2. Role of economic appraisal in relation to TEN-T objectives

Appraisal has a crucial role to play in measuring the contribution of projects to the achievement of objectives defined in earlier sections of the note. In table 8, we compare the ability of information arising from a CBA can be used to measure progress towards the aforementioned TEN-T objectives.

It must be borne in mind that there are some objectives which are not easily measured in terms of an economic appraisal primarily because CBA is not designed to deal with such issues and/or the effects cannot be easily monetized. In these cases, multicriteria appraisal (MCA) methods should be used to complement the results of an economic appraisal. Furthermore, and as illustrated in the table above, it is clear that a single CBA output can act as a measure of performance to several TEN-T objectives.

Table 8: Relation of CBA to TEN-T objectives

		Information from a Cost Benefit Analysis						
		Travel Time Benefits	Safety	Global Warming	Noise	Air Pollution	Indirect Effects	Cohesion Indicators
Objectives of TEN-T	Internal market, social and economic cohesion	✓	×	×	×	×	✓	✓
	Territorial cohesion	×	×	×	×	×	×	✓
	Sustainable development	×	✓	✓	✓	✓	×	×
	A multimodal and interoperable network	✓	×	×	×	×	×	×
	Climate change	×	×	✓	✓	✓	×	×
	Globalisation and international dimension	×	×	×	×	×	×	×
	Transport Policy Development	×	×	×	×	×	×	×

✓: Indicates that CBA provides extensive information for monitoring contribution of the project to the objectives of the TEN-T
×: Indicates that CBA provides little information for monitoring contribution of the project to the objectives of the TEN-T

7.2.3. Scope of CBA

Whilst the scope of the Appraisal has been covered by the earlier sections of paragraph 6.1, it is particularly important to bear in mind the following:

Impacts: the measurement of changes in producer and consumer surplus requires the measurement of benefits, revenues and costs to transport operators and users. At a minimum these should include the

investment cost and changes in infrastructure and system maintenance and operating costs, vehicle operating costs, journey times, safety, user charges and operator revenues.
Mode of transport: typically the modes of transport that are considered should include both those that will use the proposed TEN-T infrastructure (e.g. a road) and those from which demand may be abstracted (e.g. rail).
Study area: should be the smallest area that allows for the development of robust results. It should therefore be large enough to capture network effects that include firstly the abstraction of demand from other routes and modes and secondly the impact of competing and complementary schemes that in combination with the project in question may comprise the country's development strategy. It is particularly important to emphasise that if cross-border impacts are expected (e.g. from transit traffic associated with land locked countries) then the study area should be defined so as to incorporate both domestic and international travel.

7.2.4. Transport User Benefits

The essential measure of benefits to users is consumer surplus, that is, the excess of consumer willingness to pay over the cost of a trip. Normally, we are interested in the *change* in consumer surplus resulting from some *change* in the cost of travel brought about by an improvement in transport conditions. Operationalising this in transport poses some practical problems. For most consumer goods the cost of the good (to the consumer) is its price. When it comes to transport, prices and money costs are only a proportion of the composite cost of travel, which in principle also incorporates the time spent by the individual, access times to public transport, discomfort, perceived safety risk and other elements. Therefore price alone is not an appropriate measure of either the cost of travel or the consumer's WTP, instead *generalised cost* is used. Generalised cost is an amount of money representing the overall cost and inconvenience to the transport user of travelling between a particular origin and destination by a particular mode. In practice, generalised cost is usually limited to a number of impacts which when summed comprise the components of user benefit:

1. Time costs (Time in minutes * Value of Time in €/minute);
2. User charges (e.g. fares/tolls); and
3. Operating costs for private vehicles (VOCs)

It is important to note that the components of generalised cost tend to vary by mode. Public transport users (bus, coach, train, air and ferry) will pay a money fare and give up time in order to travel to their destination. Car users and own-account freight users give up time, may be asked to pay an infrastructure access charge or toll, and pay for their own fuel and VOCs. Therefore there is a fundamental difference in the reported user benefits for users of different modes. Additionally, it is important to recognise that Values of Time vary between individuals and even for the same individual, depending on, for example, trip purpose. There is no unique willingness-to-pay for travel time savings. This has consequences for modelling and appraisal, especially for toll roads or urban mass transit, where suitable market segmentation is needed.

The main practical method for measuring consumer surplus is known as the rule of a half (see DG Regio (2008), page 78 for a description of the method). However it must be pointed out that when generalised cost changes are large (comparing a Business-As Usual (BAU) scenario with a policy change), this could potentially cause the rule of a half to produce misleading results (Nellthorp and Hyman, 2001). In this case, the method of numerical integration should be used instead.

Changes in generalised costs are particularly crucial to assess the contribution of the project towards several key TEN-T objectives such as measuring cohesion of the internal market and achievement of a multimodal and interoperable network. The computation of generalised cost needs a calculation of the benefits of time savings, the valuation of which are discussed later.

7.2.5. Impacts on Transport Providers and Government

Although the user benefit analysis will often be the most testing part of the cost-benefit analysis, it needs to be undertaken alongside an analysis of revenues and costs which impact on both the transport providers and the government.

Producer surplus

Cost-benefit analysis is concerned not only with consumer surplus, but with total social surplus. This includes *producer surplus* (PS) as well as consumer surplus. The greatest scope for changes in producer surplus arises from public transport projects or toll road projects, which can affect operators' revenues without having an equal and offsetting effect on operating costs. Producer surplus is defined simply as total revenue (TR) minus total costs (TC):

$$PS = TR - TC \qquad \text{and therefore} \qquad \Delta PS = \Delta TR - \Delta TC$$

It should, however, be noted that there is an implicit assumption here that if the additional demand for this service is associated with reduced consumption of some other goods or services elsewhere in the economy, those goods and services are being priced at marginal cost, so that there is no offsetting or additional change in producer surplus elsewhere. This assumption is a facet of the partial equilibrium approach adopted, as discussed earlier, and whilst usually made is worth making explicit in the interests of transparency.

Revenue forecasts depend on traffic forecasts, and both depend on pricing policy. Therefore it is essential in appraisal that the price policy assumptions on which the traffic and benefit estimates are based are consistent with those used for revenue forecasting. The size of the revenue and user benefit effects, as well as their distribution, depends upon the pricing policy. Although this seems obvious, in many practical situations, the appraisal may be undertaken before the details of the toll or price regime have been finalised, so that provisional assumptions made for the appraisal can turn out to be wide of the mark.

Revenue forecasts will be needed both for the Cost Benefit Analysis and for the assessment of financial sustainability of projects. There may be a trade off in tariff-setting between the desire to maximise social benefits from the project and the imperative to satisfy budgetary constraints.

Maintenance and system operating costs

Proper estimates are also needed of the costs of operating both the infrastructure and the services, which are mode and country-specific. The main items will typically be:

- The costs of infrastructure operation (e.g. signalling/traffic control);
- Maintenance costs (cleaning, minor repairs, winter servicing);
- Costs of renewals (road/rail reconstruction); and
- Changes in the vehicle operating costs of public transport services.

Maintenance costs form an important component of the definition of the Do Minimum scenario (the without project scenario) and should always be included in the definition of that scenario.

Taxation and government revenue effects

Such a project is also likely to involve changes in operating costs for private transport and opposing changes in operating costs for public transport. These changes in costs and revenues need to be shown explicitly in the appraisal.

Investment costs

Typically the investment costs for transport infrastructure projects will be derived from engineering design studies and estimates. A number of adjustments, however, may have to be applied to these engineering cost estimates before they can be included in the appraisal. These adjustments are as follows:

- The cost of *mitigation measures* required by the Environmental Assessment must be included;
- Conversion of the engineering costs to the correct price base and unit of account.

No adjustment is made for the manner in which the project is financed. That is the investment costs used in the appraisal are the same whether or not the project is financed directly by the government or financed through some form of private sector involvement (such as through public private partnerships (PPP) or 'lease-back' arrangements). This is because the costs of financing under PPP or 'lease back arrangements represent a transfer payment from the public to the private sector. As a transfer payment, the profit element of the costs of financing the project will not affect the project's overall economic value (Net Present Value). However, the method of financing will have financial and distributive impacts. It is therefore important that a financial appraisal, comparing the costs and revenues of procuring the project by different methods, is undertaken.

Additionally, whilst not forming part of the investment costs, it is important that user benefits reflect any travel time and cost *delays during construction*. In the case of rail projects on the TEN-T, it is advisable for the appraisal to allow for the effect on traffic and revenues of any disruptions to existing service quality while new schemes are constructed. The treatment of user delays during construction within the appraisal is similar to the treatment of user delays during routine maintenance.

7.2.6. Money Values of Time and Safety

Whilst some benefits and costs within the appraisal are naturally valued in money terms - vehicle operating costs, investment costs for example – others are not and values need to be inferred from relevant evidence. In practice most work has focussed on travel time savings and safety improvements.

Values of time

Attaching a value to time spent travelling is a matter of considerable complexity, however, it is also extremely important for appraising transport infrastructure investments. When valuing time a basic distinction which is usually made between:

- Travel in working time (or "on employer's business");
- Travel in non-working time (usually defined to include all other travel purposes, such as shopping, commuting, education, personal business and leisure); and
- Freight travel time.

The values of time for TEN-Projects can be obtained from HEATCO and its updates. (See for example, DG Regio 2008 page 80 Table 3.1)

Calculation and valuation of safety benefits

Accidents are a leading cause of death and bring about significant social and economic costs. Valuing safety issues is therefore important within the appraisal.

The calculation is a simple multiplication of forecast accident numbers (by severity) with the costs of accidents (by severity). When placing a value on safety, it is important to include both the physical or direct costs of an accident (e.g. damage to property and insurance costs) and casualty related costs (e.g. lost output and human costs). In case no local values are available, the values of accidents disaggregated by severity for TEN-Projects can be obtained from HEATCO and its updates. (see for example DG Regio, 2008, page 81, Table 3.3)

7.2.7. Impacts on the Environment

The environment of a transport project includes the surrounding objects and conditions (natural and man made) as well as the circumstances of human society in that area. Assessment of the impact on the environment is crucial to the contribution of a TEN-T project to the objective of Sustainable Development and Climate Change. This assessment should be carried out to ensure that the environmental implications of decisions are taken into account before the decisions are made. The legal requirement for an environmental impact assessment of projects is founded on European Directive 2003/35/EC of May 2003.

It must be recognised that environmental impacts are handled via a mixture of qualitative, physical and monetary measures. Therefore within the economic appraisal it is considered that the key objectives with respect to environmental impacts are to:

- Firstly, ensure that all environmental impacts are considered within the Environmental Assessment; and
- Secondly, to assign an economic cost to quantified impacts if that cost represents a reasonable proxy for the *Total Economic Value*.
- Thirdly, application of Multicriteria Analysis Methods

For those impacts which can be monetized, HEATCO (2006) establishes values based on the impact pathway approach and stresses that the objective is to value "impacts" and not pressures. HEATCO (2006) recommends the calculation of the following environmental impacts:

Calculation and valuation global warming impacts

The contribution of a project to Global Carbon Emissions has to be reported (DG Regio 2008). The contribution of the project to Global Warming measured in terms of tonnes of Carbon dioxide emitted should be included in the Appraisal. Values can be obtained from DG Regio, 2008, page 80, Table 3.2)

Calculation and valuation air pollution impacts

The following impacts are to be considered

1. Particulate Matter of 2.5 micrometers or less with a distinction between occurrences in built up versus non built up areas.
2. Non Methane Volatile Organic Compounds
3. Sulphur Dioxides
4. Oxides of Nitrogen

In addition to the valuation of these impacts, it is important simultaneously to report the years of life lost (YOLL).

The cost factors and the calculation procedure should follow that given in HEATCO (2006, See for example Section 6.3.3 (pp 103)). External costs which are required for the appraisal can also be obtained from CE Delft (2008).

Calculation and valuation noise impacts

HEATCO (2006) recommends that the reporting procedure for noise impacts should include both the costs and the number of people exposed ("highly annoyed") by the changes in the noise levels. The calculation and reporting procedure should follow that given in HEATCO (2006, See for example Section 6.4.4 (pp 115)). External costs which are required for the appraisal can also be obtained from CE Delft (2008).

7.2.8. Cost Benefit Analysis Parameters

So far the first six boxes of the CBA process detailed in Box 1 have been dealt with. These together give us the investment costs and the operating costs, revenues and user benefits for the base year. This section of the note now addresses issues associated with moving consistently from a single year to the valuation of the project over its whole life.

This involves explicit treatment of forecasting growth over time, numbers of forecast years, accounting issues such as the treatment of inflation and the unit of account, and capital budgeting issues such as discounting. Finally, the summary indicators of value for money need to be briefly considered.

Typical values for the CBA parameters are contained in table 9.

Table 9: Typical cost benefit analysis parameter values

Parameter	Sources
Forecast Years	
Project start year (when works begin)	Project specific
Project opening year (first full year of operation)	Project specific
Design Year	Project specific
Number of forecast years from which CBA is undertaken	Minimum of 2 (e.g. Opening Year and Design Year)
Appraisal Period	40 years (HEATCO 2006)
Discounting	
Discount rate	(HEATCO 2006)
Prices	
Real or Nominal	Real
Unit of Account	Factor prices

7.2.9. Indirect effects and cohesion

Indirect effects

Very often the indirect effects of transport investments on the economy, employment, productivity are the raison d'être of the transport investment – particularly when the transport investment forms part of a regional development programme. These indirect effects however double count transport user benefits unless there is a market failure in one of the markets (other than the transport market). That is if employment levels change and wages do not equal the marginal product of labour in the labour market than an additional welfare benefit to transport user benefits will be felt. Similarly if output expands as a consequence of the transport investment and price does not equal marginal social cost in the goods/product market then an additional welfare benefit to transport user benefits will be felt. The existence of agglomeration externalities also means that wages will depart from marginal cost in areas where these externalities are relevant.

The literature identifies that a number of market failures may be potentially important from a transport cost benefit analysis perspective. These are:

- Agglomeration externalities. Transport investments by increasing the economic mass of a region may increase productivity beyond what would be expected from the time and cost savings alone.
- Imperfect competition. Where the prices of goods and services are higher than marginal cost output is suppressed relative to the case of perfect competition. An expansion of output in the imperfectly competitive case therefore generates an additional welfare benefit.
- Tax wedge effects. The presence of an income tax drives a wedge between the wage received by workers and their marginal productivity. This means that if a transport investment either increases labour supply or re-distributes employment to regions with higher/lower productivity an additional welfare benefit is felt. This is equivalent to the change in tax revenues received by the government.
- Job search costs. Workers are limited in the availability of jobs within commutable distances. For those workers who cannot change residence in search of a job this can result in the presence of search costs. These costs also drive a wedge between the wage received by workers and their marginal productivity. They are of most relevance to transport projects that impact on workers in remote regions or face difficulties in the labour market (e.g. low skilled, ethnic minorities); and
- Involuntary unemployment. The presence of involuntary unemployment implies that the wage is higher than the market clearing wage and employment levels are therefore lower than in the case of perfect competition. In this situation an expansion of employment will generate welfare benefits that exceed the transport user benefits – i.e. an additional welfare benefit will be felt.

Two methods exist to incorporate the economic value of indirect effects in a transport cost benefit analysis: the partial equilibrium approach, as exemplified by DfT (2005), and a more sophisticated general equilibrium approach using SCGE models. To date the partial equilibrium approach has been applied to more projects than the alternative SCGE approach. Conceptually the use of SCGE models is preferable as with the partial equilibrium approach changes induced in other sectors of the economy (the general equilibrium effects) are assumed to have no net social value. However, SCGE models are only in the infancy of their development and as such, are not widely available, with the few in existence typically having been developed in universities. Furthermore simplifications in the representation of labour markets, labour migration, household behaviour, the product market, the land market and the level of industrial disaggregation have to be made. This and the need to interact it with a transport model mean that the application of a SCGE model to the appraisal of a transport improvement is a far from trivial task (Laird, Nellthorp and Mackie, 2005).

The inclusion of indirect effects in an appraisal makes the cost benefit analysis far more onerous. This is for two reasons. Firstly, it becomes necessary to predict the scale and location of the indirect effects. At the very minimum this would require some form of economic impact analysis in the locality of the project, but to capture re-distribution effects a Land Use Transport Interaction (LUTI) model or a transport linked SCGE model will be required. Secondly, the evidence base on the scale of these effects is limited. There may well therefore be the need to re-enforce this evidence base with data on elasticities of productivity to economic mass (needed for analysis of agglomeration impacts), price-cost margins (needed for analysis of imperfect competition effects) and the shadow price of labour (needed for analysis of involuntary unemployment and job search cost effects).

Cohesion

Changes in cohesion are an indirect effect of a transport investment. Cohesion is primarily concerned with the equity of opportunities and wealth across the EU. To include cohesion effects in a CBA there is therefore a need to place social weights on the benefits that accrue to different population segments (e.g. weighting the benefits that accrue to a remote region or low income group higher than those accruing to a rich nation or a high income group). This is inherently difficult to do, and as such is very rarely undertaken in practical CBAs. To ensure that cohesion effects are taken account of in the CBA the CBA framework described here has to be augmented with additional features (for example allocating costs/benefits between regions and/or income groups when reporting the CBA). It also has to be recognised that the measurement of the full equity impacts of a project is difficult not least because it requires a measure of the final impacts (e.g. changes in regional GDP, employment, productivity, etc.).

The IASON project (Integrated Appraisal of Spatial Economic and Network Effects of Transport Investments and Policies) (Bröcker 2004) discussed several indicators to measure the contribution of TEN-T projects to this objective. We repeat the definitions of the indicators below:

- *Coefficient of variation:* This indicator is the standard deviation of regional indicator values expressed in percent of their European average. The coefficient of variation ranges between zero (no variation) and one (extreme polarisation)

- *Gini coefficient:* The Gini coefficient measures the area be tween the accumulated distribution of sorted indicator values and the straight line representing an equal distribution. Like the coefficient of variation, the Gini coefficient ranges between zero (equal distribution) and one (extreme polarisation).

- *Geometric/arithmetic mean:* This indicator compares two methods of averaging among observations: geometric (multiplicative) and arithmetic (additive) averaging. If all observations are equal, the geometric and arithmetic mean are identical, i.e. their ratio is one. If the observations are very heterogeneous, the geometric mean and hence the ratio between the geometric and the arithmetic mean go towards zero.

- *Correlation between relative change and level*: This indicator examines the relationship between the percentage change of an indicator and its magnitude by calculating the correlation coefficient between them. If for instance the correlation between the changes in GDP per capita of the region and the levels of GDP per capita in the regions is positive, the more affluent regions gain more than the poorer regions and disparities in income are increased. If the correlation is negative, the poorer regions gain more than the rich regions and disparities decrease

- *Correlation between absolute change and level*: This indicator is constructed as the previous one except that absolute changes are considered.

Despite of these advances several key points emerge from practical application of these indicators. Firstly it was found that the choice of the indicator is critical in assessing the socio-economic impacts of transport policies and that classifications relying on only one indicator should be avoided. Secondly, it is very possible that the different indicators give conflicting results. In addition, it is particularly important to point out that the contribution of TEN-T to cohesion is at best probably only marginal and would be a function of second order effects of TEN-T investment. We therefore conclude that it is a simple task to assess whether a particular TEN-T intervention supports economic cohesion. Hence in view of the difficulties, attempts to include an indicator of changes in cohesion induced by a TEN-T project would need to be incorporated as part of a multicriteria framework.

7.2.10. Handling risk and uncertainty

Background

Although often treated as synonymous in common parlance, risk and uncertainty are in fact different. Risk is a measure of the probability and severity of adverse effects (Lowrance, 1976). Uncertainty on the other hand is the situation in which the there is an identified set of possible outcomes but the probability of each (outcome) is not known. Hence risk is sometimes referred to as "measurable" uncertainty (Knight, 1921).

The potential sources of errors in appraisal have been identified in earlier research (e.g. Mackie and Preston, 1988) where the authors identified 21 sources of potential risk that can "creep in" to the CBA. Most of these can be summarised into the following categories:

- **Uncertainty in the underlying data.** These sorts of error and risk occur where underlying data is sample based. For example the trip matrix used in the transport model may be based on a set of roadside survey interviews and traffic counts collected on only a few days a year in a number of discrete locations.
- **Uncertainty in inputs.** This for example could occur when there is an incorrect definition of the supply side of the the business-as-usual scenario or the Do Something scenario. Similarly uncertainties in economic and population growth will lead to uncertainties in inputs.
- **Uncertainty in the outputs.** This could for example be caused by a model only approximating true underlying behaviour.
- **Uncertainty in valuation.** This occurs when some valuation related parameters such as value of time or values of safety benefits are uncertain. This can to an extent be addressed by employing the latest guidance on the values to use from authoritative and Commission endorsed sources such as HEATCO. However, even these estimates are not precise – as 95% confidence intervals can range from +/- 30% to +/- 50% in national valuation studies.

There are two particularly important risks that need to be borne in mind in the analysis and interpretation of CBA.

The first is prior political commitment; Mackie and Preston (1998) explicitly mention that "schemes may be difficult to reject because of the degree of political commitment they have accumulated". Put crudely, they are simply "too politically important to fail". Closely related to this point is the risk associated with TEN-T routes that cross boundaries to third countries identified in Sichelschmidt, 1999. The case for co-ordination by a supranational institution may be extended to transport links with third countries, especially in Central and Eastern Europe, in order to secure that these countries do not develop networks that might prove incompatible with each other or with those of the Union, which these countries want to join. We will not dwell further on this as this is outside the scope of our study but it is clearly relevant in terms of future TEN-T policy in that factors beyond direct EU control may influence the return on EU investment.

The other key category, mentioned by Mackie and Preston (1998) under the colourful heading of "Gold plating of the do something/cost overruns", has received much attention and is recognised as a major problem in CBA. This is particularly so in an era when public finances are particularly strained. The work of Flyberg et al (2003, 2004) suggested that "demand overestimation and cost overrun are a common feature of the large infrastructure projects considered". DfT (2006) in the UK has recognised this and issued specific guidance with the aim of ensuring "more realistic and accurate scheme costs estimates to be produced." The conclusion reached by Flyberg et al is that there is a tendency to underpredict costs and overpredict revenues. This tendency has been termed optimism bias.

Methods for dealing with optimism bias

A method for dealing with Optimism Bias in HEATCO is to carry out a sensitivity analysis by raising the costs ("uplift") of the projects by between 22% to 43% (see Table 7.5 in HEATCO(2006), pp 128) depending on whether the project is a road project, a rail project or a fixed link (e.g. bridges) project. If the sensitivity test shows that the project is feasible under the higher costs, then the project appraisal process can continue (HEATCO, 2006, pp 126). If the project which was feasible before the uplifts were applied is no longer feasible, then the cost estimates should be benchmarked against the realised costs of similar projects.

This practice is consistent with the EU funded project EVATREN (2008) and DG Regio (2008). For example, EVATREN (2008) argue that "Although the pattern of costs overrun might seem similar across projects, the causes typically differ. It is not possible to find one single reason for the deviations between ex ante and ex post, different factors occurred for the different case studies. What exactly causes costs overrun is difficult to predict, but for sure the decision making process plays a significant role. The decision process for a large project might take 10 to 20 years, although there are examples of shorter decision processes (around 5 years at minimum), but also longer ones (more than 30 years). In addition to the length of the decision process, one might add around 3 to 5 years for construction and at least 3 to 5 years for "maturation" of the new project implementation."

Practical methods for dealing with other sources of risks

These have been distilled from DG Regio (2008).

Sensitivity Analysis
The simplest form of sensitivity analysis is to employ "what if" analysis to consider this problem. This will allow the decision maker to understand the confidence interval with respect to input variables to which the NPV values are sensitive.

Switching Values
Closely related to sensitivity analysis is to calculate switching values which effectively is asking what value of the uncertain input variable would have to occur for the NPV to become zero. However it is clear that the analysis can quickly get out of hand when there are more than a handful of uncertain variables involved.

Scenario Analysis
Scenario Analysis is a specific form of sensitivity analysis formed by grouping several variables together into for example an "optimistic" or a "pessimistic" scenario. DG Regio (2008) point out that sensitivity/scenario analysis should not be considered as a substitute for Risk Analysis but is only an interim procedure.

Simulation and Risk Analysis
This involves expressing uncertainity about inputs as probability distributions and running this through some form of Monte Carlo pseudo random type of analysis. EVATREN (2008) supports this approach by stating that "**because only by taking into account the probability associated to uncertain aspects it is possible to provide quantitative elements about the robustness of costs and benefits estimations**" and that going beyond sensitivity analysis is critical. While it might appear that the identification of probability distributions for the risky input variables is difficult, in practice the outputs of a risk analysis are often relatively robust to most details of these distributions, apart from mean, standard deviation and any very marked lack of symmetry.

Two issues that are of some practical significance however are firstly that correlation between input variables that are risky will have an impact on the distribution of outcomes. If any input variables are not in broad terms statistically independent of each other, this needs to be recognised, the degree of correlation estimated, and the correlation built into the risk analysis. Secondly this approach can entail extensive model runs which may limit its usefulness in a CBA framework if the underlying traffic model is at all large or complex.

7.2.11. Allocation of benefits and costs between Member States

In this context there are three issues to be considered. The first is to ensure that we have the right valuations, the second is the question of how the benefits are allocated and finally the question of the how the costs are allocated.

The valuations of user benefits and other benefits
In terms of user benefits in the form of travel time savings which are generally the largest component of user benefits, this will be available in "matrix form". In the application of the rule of a half, then the most pragmatic option given in HEATCO and detailed below, would be to use the value of travel time savings (VTTS) consistent with the country of origin. Table 4.4 of HEATCO (2006 page 71) provides examples of how the valuations should be carried out in the case of Cross-Border TEN-T schemes. With regards to passenger traffic, the advice is that since "the majority of the passenger traffic will be related to trips between the nation states,…use of the respective nations' VTTS for trips that originate in that country may be reasonable. In the case of goods traffic, this is more complicated and will depend on knowledge of the nationality of the haulier or the identification of the origins and destinations of the goods. The most pragmatic option is to utilise the VTTS consistent with the country trip origin. For link based benefits that are monetized, such as accident savings, air pollution and noise benefits, these should be based on the

values in the territory in which the savings occur. For example, if an accident saving is made in France then the French values of accident savings should be utilised.

The allocation of benefits between member states
In terms of allocation of benefits it would be most pragmatic to utilise the trip matrix in the absence of a model of the macro-economy – for example a spatial computable general equilibrium model such as CGEurope,

The allocation of costs between member states
The allocation of capital costs between countries for projects with an international dimension is very much a political issue. We will not therefore elaborate further here. However from a Cost Benefit perspective, this allocation is important because the marginal cost of public funds will differ between countries. As a consequence the "social" cost of the project will be sensitive to the allocation of capital costs between countries. This is because the cost of €1 raised through tax revenue differs between countries as member states have different fiscal systems.

7.2.12. Reporting the cost benefit analysis

To aid the decision process described above it is important to present the cost benefit analysis results in a clear and concise form. The key information that should be reported will be:

Initial assumptions and scenario definitions;
CBA parameters including:
- *Start Year, Opening Year;*
- *Discount rate*
- *Price base (e.g. 2002 € real factor prices)*
- *Shadow pricing assumptions*

Summary Measures of social value;
Disaggregated CBA results, highlighting the following distributional issues within the overall costs and benefits:
- *Users' benefits versus net impact on operators;*
- *Shares of user benefits by mode;*
- *Composition of user benefit by item of benefit (Time, VOCs, etc);*
- *Shares of time savings made up by personal travel (in non-working time) and business travel including freight and personal travel in working time;*
- *Shares of international traffic versus domestic traffic in user benefits;*
- *Shares of operator costs and revenue by mode;*
- *Investment costs by group (that is, private operators, national government, financial institutions).*

This disaggregated information could be presented in a range of different formats, some of which are more suitable than others for particular uses of the appraisal outputs. A set of example reporting tables is given below. Such an example table will act as useful starting point for the development of project specific cost benefit analysis reporting table. Such reporting tables are often referred to as *Transport Economic Efficiency* (TEE) tables. Such a disaggregation as presented in these Tables demonstrate clearly the contribution of the entire TEN-T project to the overarching objectives defining of the TEN-T network as defined in earlier sections of this report.

Table 10: Example of table of non work and business benefits

	ALL COUNTRIES/INCOME GROUPS/MODES		COUNTRY 1/INCOME GROUP 1 ROAD		COUNTRY 1/INCOME GROUP 1 RAIL	COUNTRY 2/INCOME GROUP 2 ROAD		COUNTRY 2/INCOME GROUP 2 RAIL
Non Work								
User benefits	**TOTAL**		**Private cars and LGVs**		**Passengers**	**Private cars and LGVs**		**Passengers**
Travel time								
Vehicle operating costs								
User charges								
During construction & maintenance								
NET NON WORK BENEFITS		*(1)*						
Business								
User benefits			**Goods vehicles**	**Business cars & LGVs**	**Passengers**	**Goods vehicles**	**Business cars & LGVs**	**Passengers**
Travel time								
Vehicle operating costs								
User charges								
During construction & maintenance								
SUBTOTAL		*(2)*						
Private sector provider impacts					**Passengers**			**Passengers**
Revenue								
Operating costs								
Investment costs								
Grant/subsidy								
SUBTOTAL		*(3)*						
NET BUSINESS IMPACT		*(4) = (2) + (3)*						
TOTAL								
Present value of non work and business benefits		*(5) = (1) + (4)*						

Table 11: Example of table of public accounts

Country 1	**ALL MODES TOTAL**		**ROAD**	**RAIL**
Revenue				
Operating costs				
Investment costs				
Grant/subsidy payments				
Indirect tax revenues				
NET IMPACT		*(6)*		
Country 2				
Revenue				
Operating costs				
Investment costs				
Grant/subsidy payments				
Indirect tax revenues				
NET IMPACT		*(7)*		
TOTAL Present value of costs (PVC)		*(8) = (6) + (7)*		

Table 12: Example of table of analysis of monetised costs and benefits

Noise impacts		
Air pollution impacts		
Global warming impacts		
Other environmental impacts		
Accidents		
Consumer user benefits		
Business users and providers impacts		
Indirect effects		
Present value of benefits (see notes) **(PVB)**		
Public accounts		
Present value of costs (see notes) **(PVC)**		
OVERALL IMPACTS		
Net present value (NPV)		*NPV=PVB-PVC*
Benefit to cost ratio (BCR)		*BCR=PVB/PVC*
Internal rate of return (IRR)		

Note: This table includes costs and benefits which are regularly or occasionally presented in monetised form in transport appraisals. There may also be other significant costs and benefits, some of which cannot be presented in monetised form. Where this is the case, the analysis presented above does NOT provide a good measure of value for money and should not be used as the sole basis for decisions.

8 Conclusions and recommendations

This report presented a methodology to develop a Trans-European Transport Network based on a top down approach. The method can be used for the design of all types of networks (road, rail, ..). Interaction between different types of networks is implicit in the method. By creating an 'ideal network' separate from the network that is present, a very clear insight is gained into the structure of the network since it is not obscured by the existing situation that has emerged historically, and therefore is not always ideally. By then confronting this ideal situation with the existing situation, weaknesses in the structure come to light.

By reducing the theoretically highly complex design problem to a number of successive design steps or decisions, this methodology provides insight and is applicable in practical situations.

The main further steps that have to be taken are:

Data collection and modelling

ETIS-BASE and TRANS-TOOLS and related projects like WORLDNET and REFIT have managed to come up with a set of data and modelling results that represent the maximum possible given the current data situation in the EU. Recommendations have been provided for the collection of additional data in order to improve future TEN-T assessments. In some cases on an ad hoc basis information has to be collected from the countries (where it is possible and available) to be able to get insights that can not be achieved with the available data and modelling. In these cases the information that will be available will be rather fragmented. For this type of information it is also advisable to set up a structural information/data collection. For some cases the ETIS-PLUS project will make attempts to collect the data.

Design of a functional top-down TEN network

The approach used in the methodology is conceptually very simple. It begins with the formulation of a settlement hierarchy. This is followed by the design of an ideal network that links the settlements with one another. Finally the draft network is compared with the existing network. All this is, in principle, carried out according to a top-down sequence from high to low scale level, with feedback where needed.

In order to apply the design methodology, design parameters are used in the various design stages, such as the criteria for the settlement hierarchy, the distances between access points, design speeds and so on. This systematic approach clearly identifies the introduced parameters. Further research is needed to define the optimal value of these parameters since their influence on the eventual design is of crucial importance.

What is important in this respect is that for each step there is commitment from the stakeholders before the next step is taken. It is, then, most effective when the methodology is used in a workshop-type situation whereby these parties themselves participate in the design process. The result of the methodology is that stakeholders gain a clear picture of the crucial dilemmas and decisions.

Analysis of the current network, including MCA

Analysis of the current network may result per situation in a whole palette of possible recommendations, varying from no action through traffic management, function adjustment coupled to modification of the road design and disentangling or expanding existing connections to the construction of new junctions or new connections. This can be phased in, for instance by first applying traffic management and then in the longer term building new junctions or connections.

ANNEX A: Available tools and information

A.1. Background and objectives

In this annex we elaborate the existing tools for presenting traffic flows and producing traffic forecasts. The transport flows, in form of actual observations or forecasted values, are important inputs to the policy planning process. They create the quantitative basis for defining a core transport network and freight corridor planning. In short, the reliability of traffic flow data and traffic forecasts represents an important criterion in the TEN-T planning methodology.

Models for reproducing traffic flows and making traffic forecasts are an essential tool in understanding the transport patterns. One of the aims was to analyse the results from available models which have been used in different studies on traffic flows and traffic forecasts, such as TEN-STAC, TEN-CONNECT, SASI, ASTRA, WORLDNET and ETIS.

Furthermore, we have included results from the iTREN study which identified key areas for improvement for European models on traffic flows and traffic forecasts, in terms of the model management, structure and methodology. Additionally, we have considered the CGEurope model as developed by the University of Kiel (Germany) as part of the IASON project.

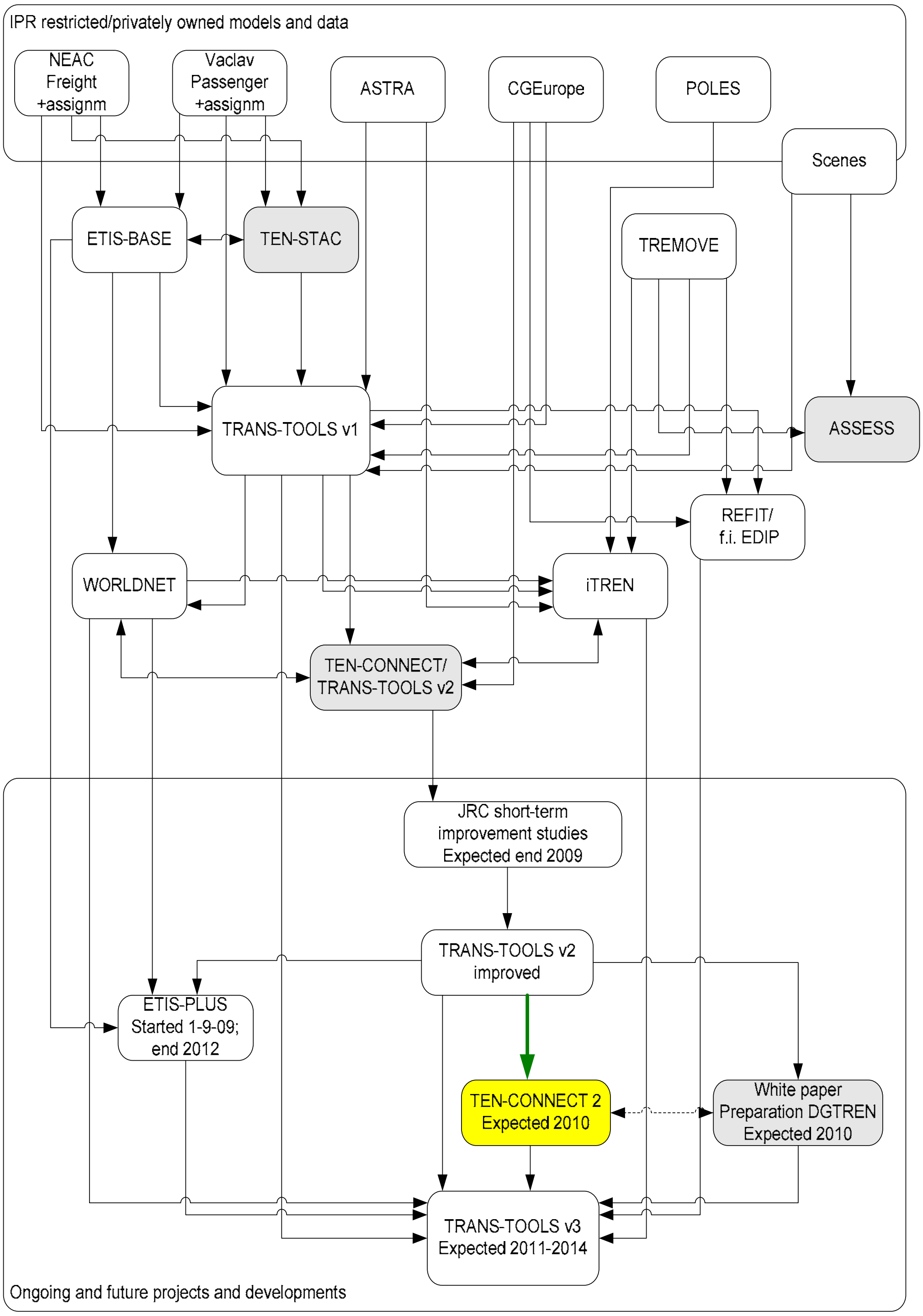
Since many of mentioned projects are interlinked with each other and/or are using input from or updating another project we first give an historical overview of the projects. Then we go in slightly more detail on some lessons learned from ETIS-BASE and TRANS-TOOLS v2 before we make our final recommendations. The methodology as described in the inception report has been adjusted after going into more detail on the actual situation, in order to match better to the actual needs.

A.2. Historical overview on currently available information and models

In this section a historical overview is given on the inter-linkage of the different models and projects mention in the objectives of this study. Since in many cases several projects and models have been input for the development of a new model and this model has been processed further in other projects, the overall story line can be best explained with a figure showing all the interrelationships as shown here below. At the top of figure 15 below, a set of models is shown.

These are well established and specialised models developed and owned by individual organisations. In the middle of the figure, EU initiatives are shown leading to or using largely IPR free models. Much of this work has involved combining the specialised non-IPR-Free models into IPR-Free model suites such as TRANSTOOLS. At the bottom of the figure ongoing or future initiatives are shown including the TEN-CONNECT 2 for which the methodology is developed in this study.

Figure 15: Interconnections between different European models



A.2.1. ETIS process

Traffic modelling can be done at different levels of detail and each level of detail has its own requirements. At the European scale one is confronted with a large variety of data gaps and it is not possible to perform additional data collection from scratch in most studies, where for local issues with a delimited study area this might be possible in some cases. The data gaps also have their consequences for the level of detail that can be taken into account; European models will have to work at a high aggregation level where for local studies one could gather more refined data on which a model can be calibrated.

At the European scale for the data collection the project ETIS-BASE (2002 – 2005) has been performed which is currently being updated and extended by ETIS-PLUS (2009 – 2012). In ETIS-BASE the database for the first pilot ETIS (European Transport policy Information System) was set up. This was a pilot since the only focus was on TEN-T policy. ETIS-PLUS is extending the scope of ETIS-BASE to the general level of transport policy. ETIS has never been made operational as a system especially because of different organisational reasons but also because the software developed in ETIS-AGENT was not flexible enough. In ETIS-PLUS the lessons learned are taken into account and the organisation part is partly covered since the hosting most likely will take place at JRC-IPTS (which still under discussion).

In WORLDNET the freight OD-data of ETIS have been updated to the year 2005. In this project also an important step has been made in the software development since now the ETIS data can be retrieved on-line and also a GIS system has been made where through the internet network information can be up-dated, changed and shared. These developments lead to a promising tool for a sustainable ETIS that will become available after ETIS-PLUS. A new element introduced is also the intercontinental air freight matrix, which has not been present before. Furthermore a detailed database of port demand and supply has been created as well as a more precise method to determine the ton kilometres by sea for intercontinental relations.

A.2.2. TRANS-TOOLS process

The development of the first version of TRANS-TOOLS (2004 – 2006) was mostly based on the ETIS-BASE data. TRANS-TOOLS v2 which was developed in the TEN-CONNECT study (2007 -2009) has used for the freight models updated ETIS freight OD-data for 2005 that were produced by WORLDNET (2007 – 2009). The latest and improved version of the WORLDNET OD data still are being integrated in the improved TRANS-TOOLS v2. For the passenger model in TRANS-TOOLS v2 a new model has been calibrate where one of the sources used is the DATELINE data which were used in ETIS-BASE as reference database but where combined with other source material.

Although TEN-CONNECT was a consultancy project instead of a development project, it was however chosen to produce a new trade model, a new passenger model and some other changes in existing models in TRANS-TOOLS. There were some aspects in TRANS-TOOLS v1 that could be improved by adjustment of this version but it was decided to choose a new direction because of the fact that different partners in the project had no access to the source codes of the TRANS-TOOLS v1. This implied for instance also that the geographical scope of the v1 models could not be extended to Bulgaria and Romania and countries outside the EU.

Not sufficient time was available for a complete elaboration and validation of the model making that currently several gaps and improvements still are being made on the short term in order to make TRANS-TOOLS v2 work properly and have it well documented. The TRANS-TOOLS management board and the peer reviewers have set up a list of short and long term improvements. The short term improvements are expected to be done around the end of 2009 through several smaller dedicated projects organised and financed through JRC-IPTS. At the same time a call has been launched in FP 7 to make a new TRANS-TOOLS v3 using the knowledge of the earlier versions and improve it. This version is however only expected to be finalised by 2014.

A.2.3. TRANS-TOOLS application pilots

Besides the model development of TRANS-TOOLS also model frameworks have been tested in REFIT and iTREN. These pilots that were developed in FP6 have proven to be useful concepts and might be taken up in the next TRANS-TOOLS v3. The applications were developed as a linkage between transport issues and different sustainability issues.

In REFIT TRANS-TOOLS and TREMOVE, which is the DGENV model, have been linked to each other and ad hoc models have been made that produce additional sustainability indicators. The ad-hoc models use the two ‘core models’ as input. One example of an ad-hoc model developed in REFIT is the EDIP model which can determine the impact of transport policy on different economic sectors and in this case particularly the labour market. A broader application of EDIP might be possible in the future. Results of REFIT have been taken into consideration for the internalisation of external costs of DGTREN.

In iTREN the links between transport, energy, environment and economic policy and impacts are studied. In this study TRANS-TOOLS (transport), TREMOVE (environment), POLES (energy) and ASTRA (economy) are combined into one model framework. Due to the difficulties in TEN-CONNECT with TRANS-TOOLS v2 not a complete run of the iTREN could be made but end results of TEN-CONNECT have been used to replace the run with TRANS-TOOLS v2. Overall the iTREN model framework has proven to be a useful concept.

A.2.4. Major European Commission studies

In figure 15 some major impact studies are shown. TEN-STAC was defining the TEN-T and TEN-CONNECT is working on the revision. ASSESS carried out the mid-term assessment of the current white paper. Since the beginning of the nineties the combination of the NEAC freight models and VACLAV passenger model has been used for several TEN-T forecasting studies of DGTREN. Also within the TEN-STAC study this approach was followed.

Also the related project EUNSTAT which was launched just after TEN-STAC was focussing on the expansion of the EU and neighbouring countries was used these models. Due to the proven concepts in the previous projects, these models they were integrated in TRANS-TOOLS v1. Here however the assignment was replaced by a more complex one trying to follow the requirements stated by DGTREN. Also other requirements made that additional models had to be connected, which made the process rather complex and time consuming.

Before the finalisation of the TRANS-TOOLS project also the ASSESS study was conducted. The work was carried out by a different consortium resulting in a different model that was used. The consortium selected gave preference to the SCENES model in combination with TREMOVE. This made that the results were at some points different then what was not long before concluded in TEN-STAC by DGTREN. This illustrated the need for a central model at DGTREN.

At the moment TEN-CONNECT was launched TRANS-TOOLS v1 was ready to be used. However TRANS-TOOLS v1 was covering EU 25 only and TEN-CONNECT required the EU 27 plus neighbouring countries to be considered. This meant that in order to stay close to TRANS-TOOLS v1 a consortium could have been selected offering the use of the basic models underlying TRANS-TOOLS v1. Instead a different consortium was selected that had no choice than to offer a radically changed TRANS-TOOLS since besides some required changes to the models they had to come up with a possibility to cover the additional countries as well.

Since they did not have pre-existing European freight and passenger models this consultancy project ended up to be a model development project at the same time. This has caused time pressure and quick repairs at the end where needed. After the project more time was available to consolidate the TRANS-TOOLS v2 and the TRANS-TOOLS management board and a peer review group have set up a list of matters to be improved.

Here short term solutions have been identified, but so far not implemented, that can potentially make the model run in more simplified, correct and user friendly mode. Also long term solutions have been identified which can be taken into account for the development of the new version of TRANS-TOOLS v3. This overview illustrates the need for a consistent development pathway where clear and coordinated decisions are made on the direction of TRANS-TOOLS developments.

One of the future projects in early 2010 is the assessment of the new White Paper on transport. It should be noted that it is foreseen that for this project the adjusted and improved TRANS-TOOLS v2 will be used. In the TRANS-TOOLS management board (30 September 2009) the required short-term adjustments have been discussed and agreed. Since it will be important that these two studies are consistent., given the lessons described before, it seems logical to align with this methodology and use the improved TRANS-TOOLS v2 as a basis.

A.2.5. Conclusions based on the historical overview

Based on the previous discussion some conclusions can be drawn on the community information on traffic flows and traffic forecasts.

- Although there are different projects that have been producing useful data, information and models there is currently only one central collecting point which is TRANS-TOOLS.
- Experience from earlier DGTREN projects learns that it is useful to have one model suite that is used for different strategic studies; this avoids contradicting conclusions.
- TRANS-TOOLS is still in a development process which should be consolidated in the TRANS-TOOLS v3. Despite some unexpected turns in the development process up to now, at the moment there is an existing TRANS-TOOLS v2 which is on the short term being improved to be working faster and more reliable so there will be a working and available tool.

- It is advised to use TRANS-TOOLS v2 "improved" version (see table 1) as network model for the TEN-T methodology and the White Paper policy document.
- Innovations from WORLDNET on intercontinental freight aviation and maritime transport should if possible be taken on board as well.

A.3. ETIS-BASE information needs for TEN-T

In order to test the information needs for TEN-T policy making and modelling we will have a look at the ETIS-BASE project. In ETIS-BASE the database for the first pilot ETIS (European Transport policy Information System) was set up. This was a pilot since the only focus was on TEN-T policy. For the purpose of this task this is exactly what is needed. In ETIS-BASE different types of data have been distinguished data are needed in TEN-T policy making and the related models.

1. Socio-economic data
2. Freight demand data
3. Passenger demand data
4. European transport network data input
5. Freight transport service and cost data set
6. Passenger transport service and cost data set
7. External effects data set

Within the project the data needs are further specified and this is extensively taken up in the respective reports of ETIS-BASE and will not be repeated here. Data categories 1 – 6 are clearly taken up and covered by TRANS-TOOLS either as input or as result from the models. Data category 7, external effects, was also taken up by TRANS-TOOLS but from the REFIT and iTREN exercises it was learned that a combination with TREMOVE works well. Since TREMOVE is dedicated to environmental effects of transport we also advise in this task to combine TRANS-TOOLS and TREMOVE in the model suite to be used.

A.4. TRANS-TOOLS v2

For a full description of TRANS-TOOLS v2 we refer to the TEN-CONNECT reports. In this section we focus on the foreseen approach by JRC- IPTS to simplify and improve TRANS-TOOLS v2 on the short term.

The overall idea is to create a lighter version of TRANS-TOOLS v2 focussing on the OD-matrices (freight and passenger model), forecasting, mode split and assignment which could be regarded as the core model. This implies that the economy model and logistics model could be disconnected as well as the impact model.

The remaining freight and passenger models will, where needed, be improved. From a comparison exercise done in iTREN it was concluded that the overall TEN-CONNECT freight results, based on TRANS-TOOLS v2 were broadly comparable with those of studies such as TEN-STAC and ASSESS. For the passenger model some remarkable differences were found for the rail transport especially. So where needed the models might be tuned by using elasticities from other models.

The running time of the model is very long (about 5 days) especially due to the assignment routine chosen. Besides this problem the Stochastic user equilibrium model that was used was even if the number of iterations was significantly increased not converging. A more simplified approach will be chosen which is also useful for EU wide analysis. The software was tested and for instance a incremental assignment routine with 10 steps (similar to the approach followed in the VACLAV model only takes less than 1 hour. In case one would like to investigate a specific link or corridor a more advanced method can be chosen.

The exact configuration of the changes to be made is to be determined until the end of this year by JRC-IPTS.

Since the economy model will not be used from TRANS-TOOLS v2 this implies that another model could be selected. For this purpose in the annex several economy models are described and compared. For this the work performed by the IASON project is used. In principle the mentioned models are not IPR free and therefore no clear recommendation can be made since in practice this will depend on the consortium selected to perform the project.

A.5. GIS systems

A.5.1. Needs related to Community databases and information systems

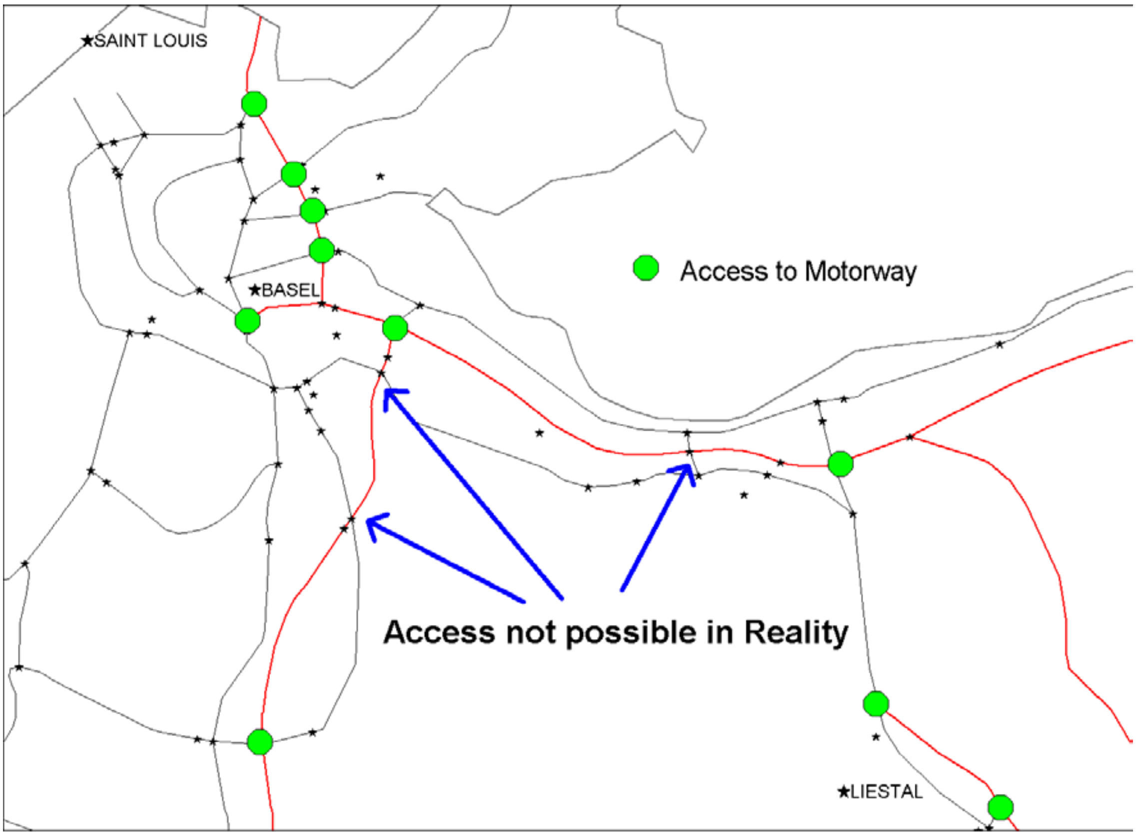
For the TEN-T methodology the need for a database and information system is mainly focussed on the need for a GIS network. This network is to visualise the results of the model calculations but it is also needed for the calculations in the assignment models for the different modes. In addition to this for the monitoring of the TEN-T implementations it is needed to have a system where for instance the investments on the relevant infrastructure can be collected and visualised and where other relevant information can be stored and shared. This last category is out of the scope of this study; our focus in the following will be on the calculation network and the visualisation of the results.

The calculation networks require a good physical interconnectivity between links and a set of link and node attributes that are of influence on route and mode choice. With physical interconnectivity is meant for instance that where links cross and where in practice there is a possibility to turn left or right there should be a node that is common in all connecting links and where a turn is not possible there should not be a node. This is not necessary for networks that are merely meant for visualisation of information in the GIS system; in this case it is only relevant that the links cross and the presence of a node is not really having a specific meaning.

In the following figure an example based on a sample data set for Euroglobalmap (Eurogeographics and also taken up in GETIS for instance) for Switzerland is depicted. All nodes which are marked green provide access to the motorway (red) in reality. In the network model an access to the motorway is also possible at further nodes (blue arrows) which are crossing of the motorway at a different level (bridge or tunnel).

Figure 16: Example of Eurogeographics/ GETIS road network data

Source: ETIS-BASE



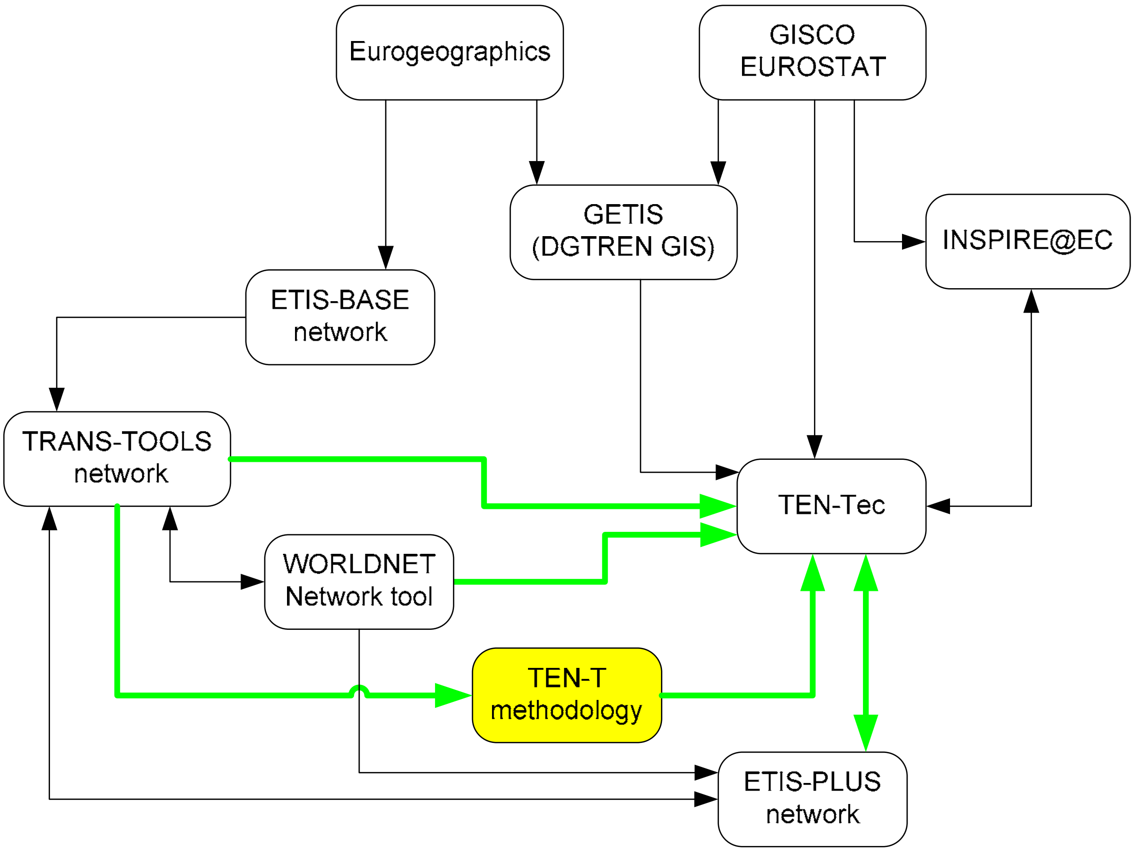
In 'ETIS-BASE D6 Annex report WP 5: ETIS-Database methodology development and database user manual – transport network data V1.1' the specific information needs for a calculation network are described.

Besides this type of calculation network which is needed for all modes, for some modes also a service network is needed since the services provided determines the speed. For instance for the railways a timetable would be needed to explain the travel behaviour but also for instance for ferry lines and aviation. In 'ETIS-BASE D6 Annex report WP6: ETIS-Database methodology application by data set – freight transport services and costs' and 'ETIS-BASE D6 Annex report WP 7: ETIS-Database methodology application by data set - passenger transport services and costs these type of needs are described in more detail.

A.5.2. Community databases and information systems

Different GIS systems and initiatives are existing and available at the Commission. In the following figure the interrelation ships between some important systems are shown. In the figure the black lines indicated the existing or decided relationships between the systems. The green ones indicate the recommended relationships.

Figure 17: Interrelationship important and relevant GIS systems



In the figure above many other data sources that are taken up are in the different systems are not shown since otherwise the figure would become too dispersed. In principle all the systems mentioned are built up from source material coming from different levels of detail. As an example in the following table sources used in the ETIS-BASE network (excluding the services and costs) are shown.

Table 13: Example: Network data ETIS-BASE

Sources
EUROSTAT (GISCO)
EUROGEOGRAPHICS (SABE)
UN-ECE
UIC
National governments
Official Airline Guide (OAG)
Eurocontrol
Tariff database of a consolidator (air tariffs)
Flight booking systems
ICAO-database
EU project results like GETIS and TEN-STAC

So the systems mentioned can be seen as collection point of different source data. The objective of the system is determining which sources are used.

ETIS-BASE, TRANS-TOOLS and WORLDNET have developed a pan European (and even broader) modelling network which will be further improved in ETIS-PLUS and maybe also in other TRANS-TOOLS exercises. The other systems mentioned are mainly focusing on collecting, storing, sharing or visualizing information.

In practice for the TEN-T methodology we have to look only at the latest developments which are TRANS-TOOLS for the calculation networks (on the short term) and TEN-Tec as the collection point for sharing the results. One development that is especially interesting in this respect is the 'worldnetter' which is developed in WORLDNET and which is a tool for sharing the network through the internet but also allowing different users to make improvements or addition to the network comparable with the Wikipedia.

TEN-Tec is under development at moment of writing (report expected 20/10/09) and alignment of ETIS-PLUS with TEN-Tec is requested. TEN-Tec is based on the DGTREN GIS (GETIS) which implies that this network is not suitable for modelilng purposes. However it can be used to share TRANS-TOOLS network calculations.

Since the TRANS-TOOLS network and the WORLDNET tool are not yet incorporated or combined in TEN-Tec it seems the most logical solution to do this in a next stage. One option could be to have two networks parallel to each other. Another option is to connect the two networks so the TRANS-TOOLS results can be transferred to the TEN-Tec network. It can be seen as a task of ETIS-PLUS to have this discussion with TEN-Tec.

A.6. Data availability for key variables in the TEN-T methodology

In the methodology defined, a set of variables is mentioned for which data is required. Some variables mentioned are essential for a short term implementation where others are important for long term improvements in case these data can be made available. The variables are grouped by mode.

The main source of information to be used as concluded from the general assessment is TRANS-TOOLS. For each variable it has been indicated whether this data can be found in TRANS-TOOLS or not. If not then it is indicated that other sources are to be consulted. Mostly data should be collected at a national level and very often it is not to be expected that this can be found for the whole of the EU. In the last case it is indicated that limited country information can be made available.

Important more specific other sources identified are TEN-TEC, TREMOVE, REFIT framework (including TREMOVE) and ETIS-BASE. For some variables the values have been included in the methodology report.

It is foreseen that ETIS-PLUS will collect some of the missing data. The definition of ETIS-PLUS is still ongoing and therefore this is not mentioned by variable. Furthermore the actual delivery for the ETIS-PLUS data will be after 2010.

The results can be found in the following tables by mode.

Table 14: Road

Variables	Type of data		Source
Performance			
road network	network	constructed	TRANS-TOOLS
intensity	link	observed/modelled	TRANS-TOOLS
capacity	link	modelled	TRANS-TOOLS
OD data	relational	observed/modelled	TRANS-TOOLS
road conditions	link	observed	(limited) country information
average speed	link	modelled	TRANS-TOOLS
average congestion	link	modelled	TRANS-TOOLS
access time and delays	link	modelled	TRANS-TOOLS
cross border delays	relational	observed	(limited) country information
geographical detours	relational	derivable	TRANS-TOOLS
External effects			
pollutant emission	geographical/link/aggregate	modelled	TRANS-TOOLS, TREMOVE vehicle-km by mode, vehicle technology by mode
noise emissions	geographical/link/aggregate	modelled	REFIT framework
pollutant concentration	geographical/aggregate	modelled	REFIT framework population in grid or area
noise hindrance	geographical/aggregate	modelled	REFIT framework population in grid or area
CO2 emissions	link/aggregate	modelled	TRANS-TOOLS, TREMOVE vehicle-km by mode, vehicle technology by mode, driving behaviour
accidents by link type	link	modelled	TRANS-TOOLS, REFIT framework
injuries by link type	link	modelled	TRANS-TOOLS, REFIT framework

deaths by link type	link	modelled	TRANS-TOOLS, REFIT framework
Interoperability			
national regulations	geographical	observed	country information
jurisdictions	geographical	observed	country information
technical standards and languages	geographical	observed	country information
technical aspects as curvature, gradients	link	observed	TRANS-TOOLS
Costs			
operational costs network owner	link	observed	(limited) country information
operational costs service provider	network/geographical	observed	(limited) country information
costs of traffic management	network/geographical	observed	(limited) country information
maintenance costs	link	observed	country information, TEN-TEC
safety costs	link/geographical	observed	(limited) country information
user costs	link/geographical	observed/modelled	TRANS-TOOLS
pricing systems	link/geographical	observed	(limited) country information

Table 15: Rail

Variables	Type of data		Source
Performance			
rail network	network	constructed	TRANS-TOOLS
intensity	link	observed/modelled	TRANS-TOOLS
capacity	link	observed/modelled	limited country information
OD data	relational	observed/modelled	TRANS-TOOLS
rail conditions	link	observed	limited country information
technical link speed	link	modelled	TRANS-TOOLS
scheduling	relational	observed	country information, ETIS-BASE
actual OD speed	relational	observed	country information, ETIS-BASE
average congestion	link	observed	limited country information
punctuality in rail connections	relational	observed	limited country information
punctuality in rail nodes	node	observed	limited country information
access time and delays	node	observed	limited country information
cross border delays	relational	observed	country information, ETIS-BASE
service frequency	relational	observed	country information, ETIS-BASE
geographical detours	relational	derivable	TRANS-TOOLS
External effects			
pollutant emission	geographical/link/aggregate	modelled	TRANS-TOOLS, TREMOVE vehicle-km by mode, vehicle technology by mode
noise emissions	geographical/link/aggregate	modelled	REFIT framework
pollutant concentration	geographical/aggregate	modelled	REFIT framework population in grid or area
noise hindrance	geographical/aggregate	modelled	REFIT framework population in grid or area
CO2 emissions	link	modelled	TRANS-TOOLS , TREMOVE vehicle-km by mode, vehicle technology by mode, driving behaviour
accidents by link type	link	modelled	TREMOVE
injuries by link type	link	modelled	TREMOVE
deaths by link type	link	modelled	TREMOVE
Interoperability			
information systems	geographical	observed	national sources
national regulations	geographical	observed	national sources
jurisdictions	geographical	observed	national sources
technical standards and languages	geographical	observed	national sources
technical aspects as curvature, gradients	link	observed	TRANS-TOOLS
traffic control harmonisation	geographical	observed	national sources
rolling stock standards	geographical	observed	national sources

electrification	link	observed	in this study report
gauge width	geographical	observed	in this study report
signalling	geographical	observed	in this study report
safety systems	geographical	observed	in this study report
Costs			
operational costs network owner	link	observed	limited country information
operational costs service provider	link/geographical	observed	limited country information
costs of traffic management	network/geographical	observed	limited country information
maintenance costs	network	observed	country information. TEN-TEC
safety costs	link/geographical	observed	limited country information
user costs	network/geographical	modelled	TRANS-TOOLS
pricing systems	relational/geographical	observed	country information

Table 16: Inland shipping

Variables	Type of data		Source
Performance			
network ECMT classification	network	constructed	TRANS-TOOLS
intensity	network	observed/modelled	TRANS-TOOLS
capacity links	link	observed	national networks
locks	node	observed	national networks
bridges	node	observed	national networks
depth	link	observed	national networks
capacity locks	node	observed	national networks
OD data	relational	observed/modelled	TRANS-TOOLS
bottlenecks	network	observed	national sources
average speed	network	modelled	TRANS-TOOLS
average congestion	network	derivable	
access time and delays	node	observed	national sources
cross border delays	relational	observed	national sources
service frequency	relational	observed	national sources
geographical detours	relational	derivable	TRANS-TOOLS
External effects			
pollutant emission	geographical/link/aggregate	modelled	TRANS-TOOLS, TREMOVE vehicle-km by mode, vehicle technology by mode
noise emissions	geographical/link/aggregate	modelled	REFIT framework
pollutant concentration	geographical/aggregate	modelled	REFIT framework population in grid or area
noise hindrance	geographical/aggregate	modelled	REFIT framework population in grid or area
CO2 emissions	link/aggregate	modelled	TRANS-TOOLS, TREMOVE vehicle-km by mode, vehicle technology by mode, driving behaviour
accidents by link type	link	modelled	TRANS-TOOLS, TREMOVE
injuries by link type	link	modelled	TRANS-TOOLS, TREMOVE
deaths by link type	link	modelled	TRANS-TOOLS, TREMOVE
Interoperability			
information systems	geographical	observed	country information
national regulations	geographical	observed	country information
jurisdictions	geographical	observed	country information
technical standards and languages	geographical	observed	TRANS-TOOLS
Costs			
operational costs network owner	network	observed	limited country information
operational costs service provider	network/geographical	observed	limited country information
costs of traffic management	network/geographical	observed	limited country information
maintenance costs	network	observed	country information, TEN-TEC

safety costs	network/geographical	observed	limited country information
user costs	network/geographical	modelled	TRANS-TOOLS
pricing systems	network/geographical	observed	country information

Table 17: Intermodal connections

Variables	Type of data		Source
location ports	node	observed	TRANS-TOOLS
modes available at ports	node	modelled	TRANS-TOOLS
capacity ports	node	modelled	TRANS-TOOLS
intensity at ports	node	observed/modelled	TRANS-TOOLS
bottleneck at ports	node	observed	limited country information
location terminals	node	observed	ETIS-BASE
modal available at terminals	node	observed	ETIS-BASE
capacity terminals	node	observed	limited country information
intensity at terminals	node	observed	limited country information
bottleneck at terminals	node	observed	limited country information
location airports	node	observed	TRANS-TOOLS
modal available at airports	node	modelled	TRANS-TOOLS
capacity airports	node	modelled	TRANS-TOOLS
intensity at airports	node	observed/modelled	TRANS-TOOLS
bottleneck at airports	node	observed	limited country information
punctuality in air connections	link	observed	limited country information
punctuality in air nodes	node	observed	limited country information

A.6. Conclusions model availability for the TEN-T methodology

In the previous section, the data availability for key variables is described. In this description it is also indicated whether it concerns observed or modeled data and which model can be the source. In this section the focus is shifted to the model requirements for the respective elements of the methodology. Information that should be collected from national sources or that can not be modeled are not considered here.

In table 18 an overview is provided of the modeling activities in the methodology defined and which models are available. TRANS-TOOLS is the reference here and where other models are required this is indicated. In case there are gaps in the available models then solutions are indicated for the short term and long term.

The main models mentioned besides TRANS-TOOLS are TREMOVE, REFIT framework and WORLDNET (which is actually more a database but contains modeling elements to construct the data). Furthermore NEAC and VACLAV are mentioned which have been applied in the TEN-STAC project and are privately owned and maintained by NEA respectively IWW. NEAC and VALCLAV are also connected to other DGTREN modeling activities. For instance in the TEN-T Ports study currently a version of NEAC is used avoiding the current TRANS-TOOLS v2 deficiencies, including: New WORLDNET mode chains, TRANS-TOOLS Freight Modal Split Model (either C or Java version, with option to use

NEAC Freight Modal Split Model), iTREN forecasts (NEAC Freight model is also an option here - Java version), and the NEAC assignment model on the WORLDNET networks. Combinations with TRANS-TOOLS are also which would result in a "TRANS-TOOLS with WORLDNET/iTREN extensions".

In the methodology the nodes and their connections have to be determined. No models are available yet for Europe and will have to be created in the project performing the methodology. For the determination of the nodes alternatively the ESPON result could be used as starting point.

For the calculation of the performance criteria most is being covered by existing models. The main concern is on what could be considered the core of the TEN-T issue knowingly the speed and congestion of the connections. To determine this assignment routines are required for all modes. In TRANS-TOOLS although some short term improvements should be made on the current models in principle the state of the art is included.

For road assignment the major concern is the running time for the stochastic assignment. The convergence of the stochastic element of the assignment is another concern since the stochastic error is sometimes larger than the actual effect of the policy being analyzed. According to the developers short term improvements could be made that would lead to more satisfactory results and running times. Alternatively incremental assignment can be applied with the current TRANS-TOOLS software with some short term adjustments which would reduce the running time considerably and shows stable results without stochastic errors.

Alternatively for the road assignment the VACLAV models is existing. This model has also been applied in the TEN-STAC study and uses incremental assignment with short running times. The advantage of this model is that it contains a lot of detailed knowledge gained in the past 15 years in European infrastructure projects.

Also other commercial software could be made suitable to make the assignments if this would be needed.

For inland navigation also an assignment model is included in TRANS-TOOLS. This model assigns flows by ECMT class for which a subdivision of the flows by ship type is made. The result of the assignment lead to high tonkm where the tons in the OD matrix are correct, which is an indication that short term improvements to the model are required.

With this assignment model eventually a reliable intensity on the inland navigation network can be determined. Congestion however is only possible if proper information would be available at a European scale on the capacity and waiting times at locks. For some countries national networks are existing but not at a European scale and publicly available as TRANS-TOOLS. For the long term it is therefore advised to create an inland navigation network with complete information. Once this network is available a proper model can be made with which the congestion and speed can be determined. For the short term one could rely on national sources in which bottlenecks have been determined.

Table 18: Models required and avaialble for the TEN-T methodology. Information from obeserved data are not included in this list.

Modeling activity	TRANS-TOOLS	Other models	Dedicated development short term	Other quick solutions	Dedicated development long term
Nodes and connections					
Selection of nodes			Develop model	Use ESPON results as basis	
Connections of nodes			Develop model		
Performance criteria connections					
MEAN SPEED					
Average speed and congestion	Assignment models	VACLAV, NEAC; other commercial assignment tools for (mainly for road)	TT Improve running time and flexibility road assignment; TT improve inland navigation current assignment model	congestion iww and rail national sources	TT Improve rail assignment (solve data gaps first); TT improve iww assignment (solve data gaps first)
Geographical detours			simple model based on TRANS-TOOLS networks		
RELIABILITY					
Average punctuality (congestion see 'mean speed')				national sources	Puntuality data collection followed by modeling
ENVIRONMENTAL HINDRANCE					
Pollutant emission by mode	pollutant emission models available	TREMOVE, REFIT framework			
Noise emissions by mode		REFIT framework			
Pollutant concentration		REFIT framework			
CLIMATE CHANGE					
CO2 emissions	CO2 emission model available	TREMOVE			
SAFETY					
Accidents, injuries and deaths by link type and mode	models available for road	TREMOVE, REFIT framework			
INTEROPERABILITY					
'Only observed information'				national sources	
OPERATIONAL COSTS					
'Only observed information'				national sources	
USER COSTS					
User costs by mode	Cost model available	VACLAV, NEAC			
Analysis of the exisiting network					
ROAD					
Intensity, capacity (see congestion 'mean speed')					
OD data	models and data available	VACLAV, NEAC			
RAIL					
Intensity, capacity (see congestion 'mean speed')				national sources	
OD data	models and	VACLAV, NEAC			

	data available				
Technical link speed	assignment models	VACLAV, NEAC			
INLAND NAVIGATION					
OD data	models and data available	VACLAV, NEAC			
Intensity, capacity (see congestion 'mean speed')				national sources	
INTER MODAL CON-NECTIONS					
Intensity at ports	available	WORLDNET, NEAC			
Intensity at airports	available EU flows		TT match WORLNET freight aviation model		passenger extra EU flows to be mod-elled including data issue.

For rail the assignment it is even more complex. Rail assignment with a straightforward combination of nodes and links as is currently available in TRANS-TOOLS gives an indication on the intensity on a corridor. The routing is however not entirely correct since a lot of very influential aspects are missing in the network. Missing in the network is for instance the direction a curve can be made at a junction of links. If for instance a turn to the left is needed but the track only allows a turn to the right this will mean that a detour is required or that the train will have to make a 'head-tail' operation at a suitable location. Furthermore Marshaling yards where time consuming efficiency operation are performed are not included.

For rail besides the technical characteristics of the track the organization is very influential on the actual speed of the OD movements. Schedules are often made with a high priority on a specific function of the railways (national/international, freight/passenger) and a lower on another. This could mean that some functions will have to make use of unfavorable time slots which could mean a longer travel time than would be possible if a free choice of timing would be possible. Schedules are made by national organizations with bilateral or multilateral agreements. This is therefore a quite organic mechanism which is hard to model. It is therefore debatable whether it will ever be possible to model congestion and speed of the railways at a European scale in a reliable way.

So if all technical rail network characteristics would be available a reliable technical speed and technical bottlenecks could be determined with a dedicated and still to be developed model. This could provide an indication on the quality of the network. This then still will be different than the actual OD speed since here the organizational aspect will have to be included. National sources will remain in all cases important to complement the rail analysis.

For all modes the geographical detour can be determined based on the networks available in TRANS-TOOLS. A relatively simple model will have to be developed for this.

For the analysis of the existing network not many additional gaps are identified. Only for aviation some additional effort is needed to get the model complete. In WORLDNET a freight aviation model is developed that has to be added to TRANS-TOOLS. Furthermore the passenger model in TRANS-TOOLS only covers the intra EU passenger flows. A long term improvement therefore is to extend this to the rest of the world where also data problems will have to be solved.

We note that TRANS-TOOLS has been thoroughly assessed in the TRANS-TOOLS management board and by peer reviewers. JRC-IPTS and DGTREN have set up a more complete list of required short and long term improvements for TRANS-TOOLS. In this section we have limited ourselves to the main topics. For other TRANS-TOOLS improvements we refer to the priority list as available at DGTREN.

Finally some words on the forecasting are required. For all model activities in principle a base year and forecasting year situation will have to be calculated. In the iTREN project it has been identified that the energy availability for the transport and other sectors is of great influence on the potential for economic growth. The integrated scenario of iTREN shows that with all climate change measures implemented the economic growth upto 2030 is about 1.5% per year which is less than what we are used to. In case we will not be able to implement all measures taken up in the integrated scenario completely then it is likely that economic growth will be even less. It is important to take these limitations into account also in the redefinition of the TEN-T.

Although the results of iTREN already provide an indication for the selection of the GDP scenarios to be applied it would be best to apply the full iTREN concept. Some technical limitations were still identified in the model suite that would have to be cleared. For instance it turned out that with the current version of TRANS-TOOLS it was not possible in the iTREN model suite to make a full iteration with the other models (ASTRA, TREMOVE and POLES); i.e. a network model is now missing. Some improvements to the TRANS-TOOLS model might solve this problem, but as mentioned earlier alternatively the NEAC and VACLAV model can be used here as well on the short run. Furthermore there are some doubts raised about the POLES model that seems to have problems to handle a limitation of the supply of oil in combination with the lengthy transition process in the transport sector in order to come to a shift to alternative fuels. This last would be a more long term improvement.

ANNEX B: Analysis of objectives to be taken into account by the TEN-T network

B.1. Introduction

The idea of the Trans-European Networks (TEN) emerged at the end of the 1980 in the context of the proposed integrated single market. The Trans-European Network (TEN-T) policy can be considered as the central planning guideline of European transport planning. The objective of the TEN-T policy is to ensure the provision of the EU infrastructure in line with the economic, social and political objectives formulated in the Lisbon Treaty. If Europe is to fulfil its economic and social potential, it is essential to build the missing links and remove the bottlenecks in the European transport infrastructure.

At the same time, the sustainability of the transport networks in the future should be ensured. The ultimate policy objective of the TEN-T is the establishment of a single, multimodal network covering both traditional ground-based structures and equipment – including Intelligent Transport Systems – to enable safe, sustainable and efficient traffic. More specifically, the TEN-T policy is aimed at maintaining current and shaping future multi-modal networks on the territory of the Member States. Up to now the planning of the community network has essentially focussed on adding together significant parts of national networks for the different modes and connecting the national borders.

The new methodology, elaborated in this study, focuses on creating a core network, comprising a geographically defined priority network and a conceptual pillar, which provides the basis for the identification of projects, corridors and network parts. With the continuing enlargement of the European Union, the increasing freight and passenger flows within Europe and with the world, congestion, air pollution, etc. on the one hand and financial constraints at the other hand, the necessity for a reformed European planning approach became evident.

Moreover, the TEN-T Network planning should take into account objectives outside each individual Member State perspective. Therefore a new – top down- approach is needed. The TEN-T network planning approach developed in this study is aimed at supporting the EU's planning ambitions by providing a methodological backbone to the TEN-T policy. As a foundation for this study the minimum requirements of the EC Treaty provision to be taken into account for the planning of the TEN-T network have to be compiled. The later review of tools for evaluation and assessment will have to take this into account and also the final output of the project, the methodology for TEN-T planning, has to be based on this core aims and objectives. Therefore, in this task the background review for this study will be carried out.

For a variety of important and interconnected topics the related aims and objectives will be analysed in view of their relevance for the TEN-T network planning. The main topics covered for this include: internal market, social and economic cohesion; territorial cohesion; sustainable development; specific objectives aiming to achieve a multimodal and interoperable network; climate change; globalisation and international dimension; transport policy development.

Where applicable, reviews of policy documents in the 7 areas listed above will be carried out on 3 levels: EU level, member state level, and third country level. Overlaps, gaps, and discrepancies between documents on these different levels can then be identified. Based on this analysis, core objectives relevant for the planning of the TEN-T network can then be compiled.

The Green Paper states that one of the problems of the previous objectives was that they were rather broad, which made it impossible to meet them fully with the instruments available and which made it difficult to generate effective impacts and visible results. Within this task, special attention will go toward the specificity of the objectives.

The input for this annex consists of various policy documents relating to each of the 7 key areas on EU, member state and third country level. The approach used is based on literature review and desk research on Commission reports, key policy documents, data banks and other sources.

Based on this key objectives within each area relevant for the TEN-T planning process will be identified. At the same time, the possible ways to measure these objectives will be identified. The output will be a deliverable reporting on the outcome of the background review of policy documents.

This deliverable includes separate sections for the 7 key areas and an integrated analysis of the key objectives. The list below shows more detailed task descriptions for the 7 key areas as described above.

- Internal market, social and economic cohesion: For interconnection/ interoperability of national networks objectives, indicators and targets have to be identified considering levels of service (standardisation, accessibility, safety, reliability, quality). Specifically the choice of indicator for economic cohesion needs attention (as proven in the Iason Deliverable 6), where a variety of indicators proved to have contradicting results. Objectives should be formulated which consider the importance of secondary networks.

- Territorial cohesion: The methodology for planning should also consider indicators/ drivers that allow the assessment of the capability of a proposed project to improve the territorial cohesion with in a cost-effective way.

- Sustainable development: Key issues are limiting vehicle emissions, safety issues, addressing social exclusion, whilst still allowing mobility and freight transport. A key enabler here is use of ITS, whereby e.g. capacity gains of the existing network can be achieved, advanced and tailored transport services can be devised, or more fuel-efficient driving patterns can be established.

- Specific objectives aiming to achieve a multimodal and interoperable network: In an integrated multimodal context, consistent with that required to support the enlarged single market, effective interconnection between trips will become part and parcel of a growing proportion of passenger and logistics movements. Without a multimodal and interoperable network at the backbone, integration of the single market would become difficult and diluted. In this context, specific issues about how ITS applications, which range from providing seamless journey planning for all modes through to supporting logistics systems connectivity, can play a major role in the support of an integrated and multimodal network.

- Climate change: The focus will be here solely on addressing the impact of all modes of transport on climate change in relation to the planning process for the TEN-T network. Here again the use of ITS technology will have a large impact in decreasing greenhouse gas emissions from the transport sector.

- Globalisation and international dimension: Implications of trends in globalisation (e.g. shifting trade lanes, rising fuel costs). Effect of globalisation on inland networks (e.g. required development of infrastructure connecting the Baltic States) and on maritime transport (e.g. connectivity of ports to other countries, development of inland ports).

- Transport Policy Development: Review of various transport policy documents and analysis of its implications for the TEN-T network. At the moment the Commission is looking into the challenges and opportunities for transport in the long term (20-40 years). In June 2009 a communication on the Future on Transport has been adopted.

In the following section the results from the desk-based literature review will be described under each of the 7 key policy areas as described above. This will then be followed by a concluding section, which will summarise the key policy objectives relevant for the TEN-T.

B.2. Objectives

B.2.1. Internal market, social and economic cohesion

Strengthening cohesion between regions in the European Union and reducing the economic and social disparities between them is one of the main goals of the European Union. Transport policy is one of the major policy instruments of the European Union to serve this goal in conjunction with the goal to increase the economic competitiveness of regions (Iason D6, p. 92).

One of the major transport policies which covers this goal as well is the trans-European Networks (TEN's). The TEN's, as stated by the EC Treaty, are envisioned to strengthen Europe's internal market, economic and social cohesion for the benefit of all citizens, economic operators and regional and local communities.

This can be established by promoting interconnection and interoperability of national networks and access to such networks. A first step in achieving interconnection and interoperability of national networks is identifying specific objectives, indicators and targets which are preferably collectively supported for these concepts.

This implies that the objectives should consider levels of service such as accessibility, safety, reliability, quality and technical standardization on the TEN-T. Furthermore, the TEN's can only function optimal if they are well connected to the secondary networks providing access to the TEN's.

Therefore, in order to strengthen the internal market, economic and social cohesion an objective should be formulated which considers the aspects like accessibility, safety, technical standardization and the importance of secondary networks. In the planning process these objectives, amongst others, have to be considered.

This objective will be discussed based on an analysis of existing literature that is available from previous and current EC projects and other literature. The projects that will be discussed are Iason, REFIT – EDIP, RAILPAG and the Japanese approach by Hisa Morisugi. For these projects it will be discussed how applicable these are from a practical point of view combined with necessary calculations.

Within the Iason project the SASI model was used to assess 18 different policy scenarios. Accessibility serves as the core concept of the SASI model, comparing accessibility of various regions for different modes of transport. This core concept is straight forward and shows the changes of accessibility for different regions as well as different scenarios. Policy makers are often looking at changes in GDP per capita as result of their policies. This second variable is the main output of the SASI model, where it shows the relative changes amongst regions and not only absolute changes. The two above mentioned indicators bring forward the need to assess the effect on social cohesion of transport policy.

The five indicators used for social cohesion are: coefficient of variation; gini coefficient; geometric/arithmetic mean; correlation between relative change and level; and correlation between absolute change and level. The result of applying these five social cohesion indicators to the calculated transport scenarios reveals a methodological difference in measurement.

This opens the discussion on what effect is wanted when looking at social cohesion, the first indicator tends to signal convergence when actually divergence occurs. For the other four indicators, because the relative difference between regions is used as basis for calculations, policies are indicated as pro-cohesion where this is not necessarily the case. Because of measurement of the relative difference, the relative growth in a rich region is underestimated compared to the growth in a poor region. The differences between these regions might therefore actually be widening, although both are growing.

The primary aim of the EDIP model is to assess the inequality and income distribution effects of the energy and transport related policies. The model focuses on the socio-economic aspects of the policy effects. The EDIP model has broad coverage of different socio-economic types of individuals and households. That allows it to compute the effects of transport and energy policies on different population groups including the five income quintiles, three education levels and ten occupation types.

The model also calculates a set of the inequality and poverty coefficients including the Gini coefficient, the GE family of inequality indexes and the Foster-Green Thorbecke family of poverty indexes. The main drawback of the EDIP model is the fact that the calculation of the effects of transport policy is available on a national level. The SASI model calculated effects on a NUTS-2 level.

Hisa Morisugi has developed a benefit incidence matrix for urban transport improvement. By constructing a socioeconomic model within the framework of the multi regional general equilibrium theory, a matrix for an urban transport improvement project is proposed. This matrix illustrates the relationship between benefit generation and incidence. On this matrix the benefit/loss associated with each sector (household, private firm, absentee landowners, public transport corporation, and government) and associated with each item (transport, land, tax, fare revenue, and project surplus/loss) are indicated clearly, so that the social efficiency and equity of the project can easily be discussed. The idea of this kind of matrix can also be found in the RAILPAG project, which is discussed hereafter.

The RAILPAG (Railway Project Appraisal Guidelines) respond to the need for EU-harmonised procedures for the socio-economic and financial appraisal of rail projects following the latest developments in the sector, especially where supra-national financing is under consideration. Interesting part of this project is the development of a so-called Stakeholder Effects Matrix.

Within this matrix an overview is given (based on amongst other s the result of the CBA) which effects are to be expected for the various stakeholders. These effects are preferably monetised, but if that is impossible effects can also be measured or even simple colour coded. The overview of the various effects for the effected stakeholders creates the possibility for policy makers to see the distribution of effects over stakeholders and discover if "Social cohesion" is affected positively or negatively by the selected transport policy.

The above mentioned methods vary from relatively straight forward calculations to a matrix with effects for affected stakeholders. The calculation methods have the advantage of easy comparison between various scenarios, but also between projects, regions, etc. However these numbers need to have a firm methodological base and need to be understood by the policy maker in order to be used in the correct manner.

The advantage of the matrix methods is that most effects will be put forward into the matrix (especially when various active stakeholders are present) this creates from a societal point of view the best insight in affected stakeholders and effects for social cohesion. Comparison between various projects and scenarios however is a bit tougher since a lot of subjectivity is involved in the matrix methodologies and therefore each of these can easily be manipulated by politicians.

The second question that needs to be answered is the geographical scope of the methodology and for which level effects need to be calculated. The three levels distinguished here are EU level, Member state level, and Third country level. Looking at the methodologies and the different geographical scopes the first two levels can be covered with the straight forward calculations.

For the third country level the stakeholder matrix probably proves to be the best solution, since effects on third countries otherwise need to be estimated and data might not be straight forward available in the same format. For the Ten-T methodology it would be best if both typologies of methods are tried and used once or twice before a final decision is being made for one coherent indicator. This practice is also preferable to gain experience with these indicators and to be able to understand its functionality.

This being said it is recommended, based on the described indicators and analysis above, that for different TEN-T projects different indicators are used:

- EU-wide: Gini Coefficient
- Member State(s): Stakeholder matrix
- EU + Third country: Stakeholder matrix

B.2.2. Territorial cohesion

The concept of Territorial Cohesion has been recognised as a third dimension of Cohesion Policy in the Lisbon Treaty, in addition to social and economic cohesion.
In October 2008 the European Commission adopted a Green Paper on Territorial Cohesion – "Turning territorial diversity into strength", launching a public debate on territorial cohesion and its implications for policies. Between early October 2008 and the end of February 2009, contributions to the public debate have been provided particularly from stakeholders in departments of national government, local and regional authorities, EU institutions, economic and social partners, civil society organisations, academics and citizens, etc.

The Green Paper does not propose a definition of territorial cohesion but shows a broad agreement on the goal and basic elements this topic emerged from the debate. The Territorial Cohesion aims at enhancing a balanced development of all European regions so that they can contribute to the overall competitiveness of Europe. Main concerns for Europe relate to the following issues:

- the need to address territorial disparities, natural and geographical handicaps;
- the negative consequences of urban concentration; and
- the polarisation of wealth and population.

More specifically, certain regions have geographical features which may pose particular challenges with regard to territorial cohesion. According to the ideas arising from the concept of territorial cohesion that there may be intra-regional or supra-national territorial levels which might be relevant for policy intervention, the Green Paper uses different classifications of NUTS3 regions in the analysis of settlement patterns. Among the identified NUTS3 categories there are specific types of regions that can face particular development goals:

- mountain regions, with at least 50% of their population living in topographically defined mountain areas ;
- island regions, defined according to the following criteria: minimum surface area of 1 square km; minimum distance between the island and the mainland of 1 km; resident population of 50 or more; no fixed link (bridge, tunnel or dyke) between the island and the mainland; no Member State capital on the island ;
- sparsely populated regions, with a population density of less than 12.5 inhabitants per square km ;
- border regions: internal border regions eligible for cross-border cooperation under Structural Funds 2007-2013 or external border regions eligible for cross-border cooperation under the Instrument for Pre-accession Assistance (IPA) or the European Neighbourhood and Partnership Instrument (ENPI).

These are not exclusive, and there are other regions with specific features which equally face common challenges, not least coastal zones, which are under pressure from development as well as at risk from global warming, and the outermost regions, which face a number of challenges linked to demographic change and migratory phenomena, accessibility, and regional integration. A literature review and desk research on Commission reports, key policy documents, data banks and other sources has been carried out in order to identify core territorial cohesion objectives for the planning of the TEN-T network and the possible ways to measure these objectives.

The Sixth progress report on economic and social cohesion (European Commission, 2009) provides a synthesis of the state of the public debate on territorial cohesion. Evidences from the consultation suggest that policy responses are needed at different territorial levels (these may vary from deprived urban neighbourhoods to metropolitan areas, from river basins to mountain areas), moving on the following three fronts:

- concentration, achieving critical mass while addressing negative externalities strengthening links between regional policy and other Community policies that contribute to territorial cohesion (environment, transport, rural etc.);
- connection, reinforced link between lagging areas with growth centres through infrastructures and access to services development;
- and cooperation between regions and Member States (i.e. cross-border, trans-national and inter-regional cooperation), working together across administrative boundaries to achieve synergies.

According to this Report, consultation's participants agreed that territorial issues should be better addressed, for instance adopting territorial indicators to better understand territorial trends and developing improved analysis at NUTS3 level.

The Assembly of European Union (AER) contribution to Green Paper on territorial cohesion (AER, 2008) gives further evidence to the relevance of natural or geographical patterns as determinant issues for public policies (EU sector policies - CAP, rural development, transport, energy or research policies, etc., - directly interfere with territorial functions). Remote regions for instance suffer from underdeveloped energy, transportation and communication networks that should be kept in mind when drafting integrated spatial development plans in order to enhance the attractiveness of territories regardless of their geographical or physical particularities.

The AER position suggests that better tools are needed in order to face the principle of territorial balance and the particular problems of peripheral regions: the debate on territorial cohesion gave evidence to the relevance of territorial indicators to understand territorial trends (aspects such as GDP or income per capita are not sufficient to demonstrate the extent of territorial cohesion achieved). In terms of transport policy, improved transport links could allow peripheral regions and islands to overcome to some extent their peripherally and structural weakness (e.g. dependence upon primary industry) through improved links with mainland and central regions.

The World Development Report 2009 - "Reshaping Economic Geography" (product of the staff of the International Bank for Reconstruction and Development and the World Bank, 2009) - introduces the use of three spatial dimensions (density, distance, and division) to describe the geographic transformations that accompany development, affecting economic and social development. Using the concept of market access, spatial dimensions are defined as follows:

- Density indicates the size of economic output or total purchasing power per unit of surface area - say, a square kilometre. It is highest in large cities where economic activity is concentrated and much lower in rural neighbourhoods;
- Distance measures the ease of reaching markets. It determines access to opportunity. Areas far from economically dense centres in a country are more likely to lag;

- Division arises from barriers to economic interactions created by differences in currencies, customs, and languages, which restrict market access. It is most relevant in an international context.

The Report argues that the most effective policies for promoting long-term growth are those that facilitate geographic concentration and economic integration, both within and across countries. Developing nations could reshape their economic geographic well calibrating all available instruments of integration (common institutions, connective infrastructures, targeted interventions): their growth would still be unbalanced, but their development would be inclusive.

The Territorial Agenda of the European Union - Towards a more Competitive and Sustainable Europe of Diverse Regions (agreed on the occasion of the Informal Ministerial Meeting on Urban Development and Territorial Cohesion in Leipzig on 24/25 may 2007) -, among territorial priorities for the development of the European Union, states that "Mobility and accessibility are key prerequisites for economic development of all regions of the EU…". In practice this means that regions having a high accessibility to raw materials, suppliers and markets are in general economically successful regions and improve their competitive position in the global market. If so, transport infrastructure improvement might be an important policy instrument to promote regional economic development.

The European Spatial Planning Observation Network (ESPON) compared the potential multimodal accessibility of regions in 2006 with GDP-PPS per capita in 2006 to better understand if there is a strong connection between high accessibility and economic success of European regions. The main evidences suggest that accessibility seems to be a prerequisite for a good economic development of regions. In relation to potential accessibility and GDP 69% of the regions are in a double positive or double negative situation (i.e. they have GDP and accessibility both above respectively below ESPON average).

The "Territorial State and Perspectives of the European Union" - Towards a Stronger European Territorial Cohesion in the light of the Lisbon and Gothenburg Ambitions (written by experts of the Member States, 2007) - investigates the need for a territorial approach to enhance the development of European regions and constitutes a background document for the Territorial Agenda of the EU. The Report suggests the need to better integrate territorial dimension in the EU policies to create a more coherent approach to territorial cohesion, for instance the EU transport policy should investigate territorial topics such as strengthening trans-European networks, regional and cross-border traffic management, effective, safe, sustainable and multimodal transport links and secondary networks, ICT access and digital literacy, connectivity of rural and peripheral areas, sustainable management of increasing traffic, inland and maritime waterways. In particular, the specific accessibility challenges of mountains, islands and areas of low population density, and their minimum requirements to access global markets are relevant issues to be investigated in order to assess territorial cohesion improvements in the EU. Accessibility describes the relative location of an area and illustrates the development potential of an area in terms of the available transport services and communication infrastructure, therefore can be adopted as a relevant indicator to investigate the territorial aspects of the transport systems.

The Interim Territorial Cohesion Report - Preliminary results of ESPON and EU Commission studies (European Commission, 2004) - summarises the first results of the studies on territorial and urban development initiated by the European Spatial Planning Observatory Network and the EC Directorate- General for Regional Policy. The analysis investigates territorial disparities in the European Union and demonstrates the need for coordination among the various Community policies which have a territorial impact and between those and national policies. The need to enhance territorial cohesion requires cooperation in both horizontal terms (between policies) and vertical terms (between operators and authorities at different geographical levels). In particular, accessibility among the European regions is investigated and evidences from the Report suggest that in terms of means of transport, substantial gaps exist between the centre and the periphery as regards both road and rail transport: investment should therefore concentrate on the development of the Trans-European Transport Network and the secondary transport networks.

The Study "Scenarios, Traffic Forecasts and Analysis of Corridors on the Trans-European Transport Network (TEN-STAC)" has been developed to compare and assess the expected future impacts of various proposed transport infrastructure projects in Europe. Several indicators have been identified, according to the following groups: Economic impacts in the transport sector; Environmental sustainability; Investment cost; General transport relevance; Creation of European value added; Improvement of accessibility; Maturity and coherence of the project. Among "General transport relevance" indicators, the following two examples of peripheral accessibility indicators for the assessment of centrality of peripheral regions and cohesion can be mentioned: 1. Variation of a centrality index for passenger transport in regions identified as peripheral (%); 2. Variation of a centrality index for freight transport in regions identified as peripheral (%).

B.2.3. Sustainable development

The concept of sustainability and sustainable development is high on the political agenda and most, if not all, current policy documents will incorporate the core theories of this. On the highest level this can be defined as development that meets the needs of the present without compromising the ability of future generations to meet their own needs.

In more practical terms this relates to achieving a balance between environmental, societal and economic issues. On a more detailed and specific level applied to the transport sector this has led to the notion of sustainable mobility. Key issues here - again directly relating to the environment, society and the economy - are e.g. limiting vehicle emissions, safety issues, addressing social exclusion, whilst still allowing mobility and freight transport.

The term sustainable transport came into use as a logical follow-on from sustainable development, and is used to describe modes of transport, and systems of transport planning, which are consistent with wider concerns of sustainability. There are many definitions of the sustainable transport, and of the related terms sustainable transportation and sustainable mobility.

One such definition, from the European Union Council of Ministers of Transport, defines a sustainable transportation system as one that:

- Allows the basic access and development needs of individuals, companies and society to be met safely and in a manner consistent with human and ecosystem health, and promotes equity within and between successive generations.

- Is Affordable, operates fairly and efficiently, offers a choice of transport mode, and supports a competitive economy, as well as balanced regional development.

- Limits emissions and waste within the planet's ability to absorb them, uses renewable resources at or below their rates of generation, and uses non-renewable resources at or below the rates of development of renewable substitutes, while minimizing the impact on the use of land and the generation of noise.

Sustainable transport systems make a positive contribution to the environmental, social and economic sustainability of the communities they serve. Transport systems exist to provide social and economic connections, and people quickly take up the opportunities offered by increased mobility. The advantages of increased mobility need to be weighed against the environmental, social and economic costs that transport systems pose.

Transport systems have significant impacts on the environment, accounting for between 20% and 25% of world energy consumption and carbon dioxide emissions. Greenhouse gas emissions from transport are increasing at a faster rate than any other energy using sector. Road transport is also a major contributor to local air pollution and smog.

The social costs of transport include road crashes, air pollution, physical inactivity, and vulnerability to fuel price increases. Many of these negative impacts fall disproportionately on those social groups who are also least likely to own and drive cars. Traffic congestion imposes economic costs by wasting people's time and by slowing the delivery of goods and services.

Traditional transport planning aims to improve mobility, especially for vehicles, and may fail to adequately consider wider impacts. But the real purpose of transport is access - to work, education, goods and services, friends and family - and there are proven techniques to improve access while simultaneously reducing environmental and social impacts, and managing traffic congestion

The EC Transport White Paper from 2001 stresses the need for integration of transport in sustainable development, as Reducing dependence on oil from the current level of 98%, by using alternative fuels and improving the energy efficiency of modes of transport, is both an ecological necessity and a technological challenge.

A complex equation has to be solved in order to curb the demand for transport:

- economic growth will almost automatically generate greater needs for mobility, with estimated increases in demand of 38% for goods services and 24% for passengers;
- enlargement will generate an explosion in transport flows in the new Member States, particularly in the frontier regions;
- saturation of the major arteries combined with accessibility of outlying and very remote areas and infrastructure upgrading in the candidate countries will in turn require massive investment.

To support the package of proposals to be implemented by 2010, which are essential but not sufficient to redirect the common transport policy towards meeting the need for sustainable development, the analysis in the White Paper stresses:

- the risk of congestion on the major arteries and regional imbalance,
- the conditions for shifting the balance between modes,
- the priority to be given to clearing bottlenecks,

- the new place given to users, at the heart of transport policy,
- the need to manage the effects of transport globalisation.

In many areas the key enabler here is the use of Intelligent Transport Systems (ITS), whereby e.g. capacity gains of the existing network can be achieved, advanced and tailored transport services can be devised, or more fuel-efficient driving patterns can be established (eco-driving).

The following is a brief description of ITS which may provide a useful background. Indeed, the construction and operation of transportation systems is being transformed by computers, sensors, and communications technology – collectively called information technology (IT). The application of IT to surface transportation is called "Intelligent Transport Systems" (ITS). ITS provides the ability to gather, organize, analyze, use, and share information about transportation systems.

This ability is crucial to the effective and economical construction and operation of transportation systems and to their efficient use. In particular:

- ITS is being incorporated by manufacturers in "intelligent equipment " that can be installed as part of the transportation infrastructure to gather and disseminate traveller information, control traffic signals and variable message signs, electronically collect tolls, and help manage the system.

- ITS provides vital support in operating transportation systems, including traffic management, pavement monitoring, oversight of system maintenance, and more effectively and reliably managing public transport.

- ITS can store and evaluate archived data about the transportation system that is useful to planners who are evaluating transportation system improvements or to others evaluating safety aspects of the roadway.

- ITS also provides a wide array of in-vehicle technology to improve the safety, productivity, and comfort of road travel. In addition, there is a new focus on using wireless communications to help vehicles and the infrastructure cooperate with each other to enhance safety and the ability to manage the infrastructure well.

ITS can be divided into nine application areas:

1) Traveller Information
2) Traffic Management
3) Demand Management
4) Road Management
5) Advanced Driving Assistance
6) Electronic Financial Transactions
7) Commercial Vehicle Management
8) Public Transport Management
9) Incident and Hazard Response

These ITS applications can produce a plenty of real time data for transport operation and management support. However, only a more limited set could/should be used in practice to provide data useful for feeding the kind of European transport models and indicators databases which could mostly be used for

TEN-T planning purposes. The latter are obviously more aggregated than real time data, both with regard to the geographical scope (i.e. no more detailed than NUTS3 regions) and the time intervals (e.g. yearly or monthly volumes).

B.2.4. Multimodal and interoperable networks

Context

The European Union can be thought of as a “megaregion” (Ross, 2008). It has been recognised (CEC, 2007; CEC, 2009) that the practice of linking up segments of member states’ networks to form the TEN-T is not sufficient for the TEN to meet the desire for economic integration – a goal upon which the creation of the Union was founded. Previous experience suggests that transport planning requires a governance framework that links national, regional and local policies with the aim of building on the capacity and strengths of each individual components such that the whole is greater than the sum of its parts. This is the context, within which the two themes discussed in this section, interoperability and multimodality, fall.

Interoperability

Interoperability can be defined as “the ability of two or more systems or components to exchange information and to use the information that has been exchanged” (IEEE, 1990). Similar definitions can be found in O’Brien and Marakas (2005). However, they tend to focus on interoperability of systems in a technical sense and the most obvious application of technical interoperability is in the field of Intelligent Transport Systems (ITS) e.g. Seymour and Patel (1993). Initiatives such ITS have to be interoperable across the TEN-T network to achieve the objectives of integration across the Europe. Similarly, the 1998 White Paper (CEC, 1998) on infrastructure pricing recognises the need for the interoperability of toll collection systems. Furthermore, in the context of multimodal transport operations discussed later, technical interoperability plays a major role.

In the transport policy context this technical definition of interoperability is narrow. The notion of interoperability can be extended to the need for policy compatibility (e.g. Goulias, 2003). When applied to the TEN-T this means that the framework for policies of individual member states are aligned. Through an alignment of transport policy overall welfare across the EU can be maximised. For example competition for tax and road charge revenue between member states plus the desire of states to maximise the welfare of their residents will lead to sub-optimal pricing structures. Global welfare is maximised if member states cannot discriminate between local and international traffic and the pricing system across states is consistent (De Borger and Proost, 2004; De Borger et al 2005).

If we also consider that the users of transport networks are the ‘pieces of information’ that electronic systems pass between them in the IEEE definition, then we can see that a truly inter-operable pan-European transport network will allow a passenger, a vehicle or piece of freight to pass from one network to another seamlessly. The change in network could be from one national network to another national network, or from say a motorway network to a local road network. If the interchange is between modes, as is discussed below, this is termed multimodal (or intermodal). If a passenger, vehicle or a piece of freight can pass seamlessly from one network to another then we can say that the transport network is truly interoperable.

We would expect the benefits of an inter-operable network to be felt over a much wider area than the narrow focus that many project appraisals take. This is because many appraisals focus on local or national interests, whereas we would expect the benefits of an internationally inter-operable network to be pan-European. For example, inter-operable rail networks allow trains to cross international boundaries. This can allow passengers and shippers of freight to benefit from direct international links without expensive interchanges. A standardisation of road layouts and vehicle technologies can lead to safety benefits, as in modern economies road haulage and private motor vehicles travel across the continent. The benefits of inter-operability can be measured through the standard metrics of time, cost and accident savings plus reductions in environmental externalities. However, interoperability benefits may be difficult to capture in appraisal either due to the wide area over which they occur or due to the difficulty in, say, predicting how accident rates will change in response to consistency in international road and vehicle standards.

Multimodality

Multimodality (or intermodality) is the carriage of people or goods by at least two different modes of transport. Multimodal networks are at the heart of the establishment of the TEN-T. This is because they allow for the flow of people, goods and services in line with the single market enshrined in the EC Treaty. There is a clear parallel between multimodality and inter-operability. This is because intermodality is concerned with the passage of traffic from one network to another in a unimodal sense whilst multi-modality is concerned with the transfer of traffic between modes.

In CEC (1997), a policy framework is provided for Community action in the field of intermodal freight transport. It advocates an intermodal transport system which encourages co-operation between modes and favours competition between operators. For logistical supply chains in the delivery of goods and services the advantages of a network that is truly multimodal increases competitiveness of industries within the EU through reducing the friction costs associated with the movement. It is still recognised though that the biggest missing link to intermodality is the lack of a close connection between sea, inland waterways and rail. Thus, road based modes carry 44% (CEC, 2006) of goods and this continues to rise while the percentage of goods carried by rail and other modes show sign of decreasing. This is partially attributable to the current situation in which friction costs associated with rail and modes other than road are relatively high. Friction costs occur due to the inability of networks to operate harmoniously across member states.

It was remarked in the 2001 White Paper (CEC,2001, pp26) that "Intermodality is of fundamental importance for developing competitive alternatives to road transport. There have been few tangible achievements, apart from a few major ports with good rail or canal links." The 2001 white paper sought to introduce the Marco Polo programme with the idea of improving the sea links and turning multimodality into reality. This has led to the concept of the motorways of the sea concept. It might be useful to look at the TEN-T network using the paradigm of hub and spoke network in that for the transhipment of goods and services across the EU, the nodes in the TEN-T network should play a greater role in supporting intermodal freight terminals in line with the objectives of multi-modality. Intermodal Freight Terminals, or transfer points, are places equipped for the transhipment and storage of Intermodal Transport Units (DG TREN, 2006). They connect at least two transport modes, which usually are road and rail, although waterborne (sea and inland waterways) and air transport can also be integrated.

The benefits of a true multi-modal transport network are a minimisation of interchange costs. These costs are time costs, money costs, inconvenience costs and for freight transport depreciation costs. Interchanges between modes can also exacerbate reliability (or unreliability) costs, as small variations in travel time may mean that a departure slot on the subsequent mode of travel is missed.

Treatment of interoperability and multimodality in appraisal practice

A number of appraisal guidelines have set benchmarks against which other appraisal systems are based on. At an international level these include the World Bank, the European Investment Bank and the European Commission. At a national level the project appraisal methods of the UK and Germany are regarded are often regarded as best practice.

In the World Bank Handbook on Economic Analysis of Investment Operations (Belli et al 1998) and in existing HEATCO guidance (Bickel et al 2006) (an European Commission sponsored method), no specific attention is given to interoperability or multimodality. Part of the reason for this is because of its essential focus on traditional Cost Benefit Analysis. In these appraisals, improvements in integration between multimodal networks or between national networks are implicitly captured within the Present Value of Benefits as changes in time and cost savings. Interoperability if it appears at all in these methods is treated as a constraint on the interventions that are appraised.

This is also the case in Germany and the UK to a certain extent. Both of these national systems employ a framework approach to appraisal. In Germany this includes a Spatial Impacts Assessment. This assessment however is principally made against land use and regional policy objectives rather than an objective of integration between different transport networks. In the UK there is a specific 'integration' objective within the appraisal framework. As part of this there is an assessment of transport integration which has an exclusive focus on multimodality. Consequently, proposals and initiatives that lead to a reduction in "friction costs" as a result of multimodal improvements (for freight) or interchange access and egress times (in the case of passenger journeys) are scored positively under this objective. The improvements in multimodality are measured through changes in generalised costs (time costs, inconvenience costs and money costs).

The Rail Project Appraisal Guidance document (RAILPAG) (European Commission and European Investment Bank, 2007) differs from the above appraisal methods. This is because explicit reference is made to the argument that the cost of an interoperable transport intervention may be higher than one which is not interoperable. One would of course also expect the benefits of the interoperable transport intervention to be higher. RAILPAG therefore advocates that analysts conduct an appraisal of the interoperable intervention and an alternative which is not interoperable. The net additional cost of implementing the interoperable system (that is the additional capital and maintenance costs net of the additional benefits) should be separately identified. The view articulated in the RAILPAG guidance is recognised in Gifford (2005, p108) who notes that "determining the appropriate level of interoperability and spatial integration for a particular network involves complex interactions between the technical difficulty of achieving interoperability, the latent demand for utilizing interoperable systems, and the institutional structure of network providers."

TEN-T planning objective

We propose a single objective, *Transport Integration,* to cover the themes of interoperability and multimodality. This is because they are conceptually similar with multimodality referring to transport integration between modes and interoperability referring to transport integration within modes. Transport Integration lies at the heart of TEN-T policy which has as its aim the objective of facilitating economic integration and trade between member states of the European Union.

For appraisal *Transport Integration* needs to be measured in two ways:

- Friction Costs at Interchanges, which captures improvements in multimodality; and
- Interoperability benefits

These changes in costs should be identified separately from other 'user benefit' elements of the appraisal so that it would be possible to identify clearly the projects which contribute to the fulfilment of this objective. Both of these benefits (friction costs and interoperability benefits) can be measured through changes in generalised costs. In the case of interoperability benefits it may be necessary to compare a scenario with and without an interoperable system to measure the benefits associated with interoperability. This reflects the fact that interoperability of networks and systems is often treated as a constraint in the appraisal all other things being constant.

B.2.5. Climate change

Environmental, issues (usually as part of the concept of sustainable development) are increasingly high on the political agenda. With the large contribution of transport to greenhouse gas emissions, transport is a key factor in addressing climate change. As the concept of sustainability is already covered as part of section 2.3, the focus will be here solely on addressing the impact of all modes of transport on climate change in relation to the planning process for the TEN-T network.

Climate change is a change in the statistical distribution of weather over periods of time that range from decades to millions of years. It can be a change in the average weather or a change in the distribution of weather events around an average. Climate change may be limited to a specific region, or may occur across the whole Earth. In recent usage, especially in the context of environmental policy, climate change usually refers to changes in modern climate.

Anthropogenic factors are human activities that change the environment. In some cases the chain of causality of human influence on the climate is direct and unambiguous (for example, the effects of irrigation on local humidity), whilst in other instances it is less clear. Various hypotheses for human-induced climate change have been argued for many years. Presently the scientific consensus on climate change is that human activity is very likely the cause for the rapid increase in global average temperatures over the past several decades.

Consequently, the debate has largely shifted onto ways to reduce further human impact and to find ways to adapt to change that has already occurred and to implement mitigating measures. Of most concern in these anthropogenic factors is the increase in CO_2 levels due to emissions from fossil fuel combustion. Other factors relevant to transport and infrastructure include land use and deforestation.

Here again the use of ITS technology will have a large impact in decreasing greenhouse gas emissions from the transport sector. This is particularly relevant in view of the concept of sustainable development including the balancing of environmental, economic and societal aspects, i.e. in this context lowering greenhouse gas emissions, whilst at the same time enabling mobility and freight transport, which are key pillars of our modern economy.

This is particularly important in view of meeting the objectives of the Lisbon Strategy. Furthermore, various international agreements (e.g. Kyoto), which in turn have been incorporated into further international policy (e.g. on EU level), as well as national policy have included specific targets for reduction of greenhouse gas emissions. These have to be taken into account when formulating policy advice for the planning process of TEN-T.

As of February 2009, 183 states have signed and ratified the Kyoto Protocol to the United Nations Framework Convention on Climate Change, aimed at combating global warming. The Kyoto Protocol is a protocol to the United Nations Framework Convention on Climate Change (UNFCCC or FCCC), an international environmental treaty with the goal of achieving "stabilization of greenhouse gas concentrations in the atmosphere at a level that would prevent dangerous anthropogenic interference with the climate system."

The Kyoto Protocol establishes legally binding commitment for the reduction of four greenhouse gases (carbon dioxide, methane, nitrous oxide, sulphur hexafluoride), and two groups of gases (hydrofluorocarbons and perfluoro-carbons) produced by "annex I" (industrialized) nations, as well as general commitments for all member countries. As of January 2009, 183 parties have ratified the protocol, which was initially adopted for use on 11 December 1997 in Kyoto, Japan and which entered into force on 16 February 2005.

Under the Kyoto Protocol, industrialized countries agreed to reduce their collective greenhouse gas (GHG) emissions by 5.2% from the level in 1990. National limitations range from the reduction of 8% for the European Union and others to 7% for the United States, 6% for Japan, and 0% for Russia. The treaty permitted the emission increases of 8% for Australia and 10% for Iceland.

Kyoto includes defined "flexible mechanisms" such as Emissions Trading, the Clean Development Mechanism and Joint Implementation to allow annex I economies to meet their GHG emission limitations by purchasing GHG emission reductions credits from elsewhere, through financial exchanges, projects that reduce emissions in non-annex I economies, from other annex I countries, or from annex I countries with excess allowances.

The EU has been taking serious steps to address its own greenhouse gas emissions since the early 1990s. In 2000 the Commission launched the European Climate Change Programme (ECCP). The ECCP has led to the adoption of a wide range of new policies and measures. These include the pioneering EU Emissions Trading System, which has become the cornerstone of EU efforts to reduce emissions cost-effectively, and legislation to tackle emissions of fluorinated greenhouse gases.

Monitoring data and projections indicate that the 15 countries that were EU members at the time of the EU's ratification of the Kyoto Protocol in 2002 will reach their Kyoto Protocol target for cutting greenhouse gas emissions. This requires emissions in 2008-2012 to be 8% below 1990 levels.

However, Kyoto is only a first step and its targets expire in 2012. International negotiations are now taking place under the UNFCCC with the goal of reaching a global agreement governing action to address climate change after 2012.

In January 2007, as part of an integrated climate change and energy policy, the European Commission set out proposals and options for an ambitious global agreement in its Communication "Limiting Global Climate Change to 2 degrees Celsius: The way ahead for 2020 and beyond".

EU leaders endorsed this vision in March 2007. They committed the EU to cutting its greenhouse gas emissions by 30% of 1990 levels by 2020 provided other developed countries commit to making comparable reductions under a global agreement. And to start transforming Europe into a highly energy-efficient, low-carbon economy, they committed to cutting emissions by at least 20% independently of what other countries decide to do.

To underpin these commitments, EU leaders set three key targets to be met by 2020: a 20% reduction in energy consumption compared with projected trends; an increase to 20% in renewable energies' share of total energy consumption; and an increase to 10% in the share of petrol and diesel consumption from sustainably-produced biofuels.

In January 2008 the Commission proposed a major package of climate and energy-related legislative proposals to implement these commitments and targets. These are now being discussed by the European Parliament and the Council of the EU, and EU leaders have expressed their wish for agreement to be reached on the package before the end of 2008.

Furthermore, the Climate Change Act 2008 makes the UK the first country in the world to have a legally binding long-term framework to cut carbon emissions. It also creates a framework for building the UK's ability to adapt to climate change. The Climate Change Bill finished its passage through parliament on 18th November 2008, and was enacted by Royal Assent on 26th November.

The Climate Change Act enhances the UK's ability to adapt to the impact of climate change and establishes that:

- a UK wide climate change risk assessment must take place every five years;
- a national adaptation programme must be put in place and reviewed every five years to address the most pressing climate change risks to England;
- the Government has the power to require public authorities and statutory undertakers (companies like water and energy utilities) to report on how they have assessed the risks of climate change to their work, and what they are doing to address these risks ;
- the Government is required to publish a strategy outlining how this new power will be used, and identifying the priority organisations that will be covered by it;
- the Government will provide statutory guidance on how to undertake a climate risk assessment and draw up an adaptation action plan; and
- the creation of an Adaptation Sub-Committee of the independent Committee on Climate Change in order to oversee progress on the Adapting to Climate Change Programme and advise on the risk assessment.

B.2.6. Globalisation and international dimension

The methodology for TEN-T planning should also take into account the impact of globalization and international dimension. The EC Treaty established that the Community may decide to cooperate with third countries to promote projects of mutual interest and to ensure the interoperability of networks. The fundamental political changes in Europe which took place at the end of the 20th century have dramatically enlarged the common market and augmented the transport flows with neighbouring countries (e.g. Russia) and with the rest of the world. These changes have a particular importance for the transport policies of a number of the European regions (e.g. Baltic region, Mediterranean region, etc.).

Globalisation refers to the ongoing trend in the decrease or elimination of restrictions on exchanges of goods, services, capital, ideas and, to a lesser extent, labour across borders. The result is deeper integration of countries and regions into the global economy. It is one of the main characteristics of economic and social developments over the last 50 years and will remain to be so in the future. This development has been supported by innovations in transport and communication systems such as the use of standard load units.

Currently the economic crises can slow down the growth of globalisation, however the ongoing progress in communication and transport technologies and the economic catching-up of large parts of the world suggests a continuation of this trend. Further the continuing economic integration of the world and the continuous entrance of new players/markets and production locations contributes to increasing trade exchanges and resulting in increasing transport. The emergence of new players would also mean that the focal point of trade flows can change as a result of globalisation.

Globalisation leads to new ways of organising production and distribution, relying heavily on efficient supply chains and consequently to the organisation of the logistic process. Increasing returns to scale give industrial companies a strong incentive to concentrate production in fewer factories. Development in transport costs and logistics allows the enlargement of market areas served from just one distribution point. In many sectors the focus has moved from nationally based production to single locations producing a particular product for the world market.

For national distribution the transport to the final consumer is organised through logistical centres, either on national or continental basis, that provide value added logistics. Concentration of inventory has been another main logistic trend over the last decades. A reduced number of stockholding points can yield a financial benefit much bigger than the additional transport cost they usually cause due to longer trips. This has been facilitated by the decline of international transport costs because carrying capacities have expanded and transport operators could take advantage of larger economies of scale. Other important drivers enabling companies to operate central warehouses are the advances in information technologies and supply chain integration.

In this section we continue with the implications of trends in globalisation for the transport organisation, the change of focus in world trade could mean a shift in trade lanes, the impact of rising fuel costs on globalisation, etc. After that we will describe in detail the past trends in trade development and its expected outcome towards the future. From the development of trade flows we will draw conclusions about the effect of globalisation on inland networks and on maritime transport and port development.

We have in the EU different developments for example the Baltic States and Finland deal with hinterland transport from their ports towards Russia and other non EU European countries. Besides for the connection with non-EU Europe the connections with inland infrastructure (road, rail and limited inland waterway connections). This is different from the Mediterranean area here the port connectivity for ferry connections and other maritime services and land bridge connections via Turkey and Gibraltar are important. In relation to the rest of the World the port development and consequently the hinterland transport is more important for the TEN-T.

The EU is the world's biggest trading power. In 2007, it had a share of 17.4% of world exports and of 19.0% of world imports. The USA imported slightly more (19.1%) while the number two in world exports, China, was still some way behind the EU with a share of 12.2%. Globalisation has helped increasing trade flows in recent years and is expected to continue to do so in the future.

In 2007, the EU 27 imported goods worth 1,459 billion euros. 23% of this total or 336 billion euros have been spent for the import of energy products. In terms of weight, energy products accounted for no less than 61.1% of total imports from countries outside the EU in 2007. Petroleum and petroleum products alone accounted for 37.4% of the total weight of imported goods (61.2% of the weight of all imported energy products). On the export side, energy products accounted for 28.5% of the total weight of all exported goods. Petroleum products alone accounted for 26.7% of the total (94% of all energy product exports). In terms of value, the share of energy products in total EU exports in 2007 was just 5.0%.

An important feature of globalisation has been the ever increasing international trade, firstly with the neighbouring countries and regions and traditional trade partners, secondly increasingly with the emerging new economic blocs further away (first South-East Asian countries and later also with larger countries Brazil, India and China).

International trade, induced by lower barriers to trade and transport costs, has overall increased economic growth and economic welfare because it has allowed for a wider and deeper specialisation in production and has given producers and consumers more choice at more favourable prices. With trade barriers and transport costs (and time) still relatively high, the economic specialisation is mostly based on comparative advantage, namely the relative abundance of basic production factors such as labour and capital.

With somewhat lower barriers and transport costs, this specialisation is strengthened by exploiting comparative advantages in the field of technology and human capital. Finally, with nearly absent barriers and relatively low transport costs, specialisation will also involve intra-industry trade in very similar products, mostly between countries with similar economic structure and level of economic development.

Increasing returns to scale is a critical factor in this kind of international trade: initially, with the production cost advantage of a large "home market" a firm can succeed on foreign markets; however, the larger such a foreign market becomes, the more attractive it gets to locate production in or close to that market instead of exporting to it. Failing to do so could ultimately lead to losing the whole market to local producers as they can exploit economies of scale too, but then without transport costs.

It is clear that the ongoing globalisation will continue to shape the transport patterns into and out of the EU, thereby increasing the volume growth of goods exported from or imported into the EU and enlarging the market area. Foreign direct investments of EU firms in non-EU countries and also re-localisation of existing EU manufacturing industry activities towards countries with a better productivity/labour cost ratio tend to lead to additional transport flows, as the new subsidiary firms have a high tendency to trade with the parental firm. Given the current market size of the emerging economies, it is unlikely that an end to the trend of falling transport costs due to for example rising oil prices would stop globalisation. However it would however affect the shape of international trade and the place of the EU in the global system.

We observed the trends from the past and a possible development towards the future. For this purpose we analyse trade information that gives an indication of exchange of goods of the EU with other parts of the World. The EU has similar figures for import and export, which is explained by the fact that the trade stays within the EU, so exports equal imports.

Relevant for the TEN-T development is the share of trade with the MEDA countries and Non-EU Europe, transport in relation with these areas is carried out with both inland transport modes and maritime. The import and export in relation with other parts of the World (United States, Japan, China, India, Other Americas, Other Asia and Rest of World) is mainly carried out with maritime and air transport.

It is relevant to consider the volume of transport in weight, because this is a measure for the transport performance and gives an idea of an increase in traffic volumes. It can be observed that the EU exports towards MEDA and Non-EU Europe has been growing from 1995 to 2005 and will also grow but at a lower pace in the period 2005-2020.

The EU imports in volume (tonnes) from MEDA have been growing in the period from 1995-2005 but are from 2005 till 2020 more or less stable. From non-EU Europe there was a growth in the period 1995-2005 but is declining in the period 2005-2020. This means that in terms of infrastructure development that flows are more balanced in both directions. In the pas it was that EU imports were always larger than EU exports, causing problems in empty running vehicles (mostly lorries and trains). This also means that in terms of infrastructure development the capacity of inland infrastructure can be adapted to reported figures of growth of physical transport flows.

Notably in the Mediterranean the port and ferry the available port and ferry capacity needs to be adapted towards the trade development with these countries. With respect to imports and exports of the EU to other parts of the World it can be observed that the share of the USA and Japan are declining in the period 2005-2020.

Other areas in the World see their share increasing in this period, notably China will become EU's largest trading partner. It can be observed that measured in value (US$) the growth will be higher than measured in tonnes transport. This means that port capacity will be needed to accommodate the trade flows. The increase of the port capacity needs to go along with the increase of the hinterland infrastructure.

It should be note however that still the largest absolute increase in trade will be within the EU countries, growing from 1618.9 to 1783.7 so increasing with 165 mln tonnes from 2005 till 2020. This is the largest growth in absolute terms. In relative growth it can be observed that the growth in World trade will be take place in relation with China and India.

It can be observed that growth took mainly place in relation with the Western Part of the World, so growing economies were dependent on growth with the West in the period to 2005. After 2005 it can be concluded that growth takes place between India and China. This means that part of the focus of world trade will shift towards the East.

Previously we have seen that the trade flows with the EU-bordering countries (MEDA and non-EU Europe) will become balanced: the EU imports will stabilise, EU exports to these will increase and reach a similar level as the imports. The demand for inland infrastructure capacity connecting to the EU bordering countries will grow along with the trade flows.

So besides a general quality improvement of the connections with these countries the demand for extending the infrastructure is limited to the growth of the trade flows Notably the MEDA countries are dependent on ferry and maritime connections. A large part of the energy product imported from non EU Europe and MEDA will be handled through separate pipeline infrastructure.

As a result of globalisation it is expected that handling though EU ports will increase, as a large part of the trade with countries that integrate fast in the world economy will arrive and leave in the EU by maritime transport. Large intercontinental ports already have high congestion levels and this will increase as a result of further globalisation.

For some of the ports that handle giant containerships the congestion will reach even higher levels. Smaller ports could have spare capacity and will be linked to the main ports trough a hub and spoke system; i.e. the main ports will be related to smaller ports by feeder services. Globalisation will be supported by large container vessels that will lead to lower transport costs as a result of economies of scale. The operation of these large container vessels requires a fast loading and unloading in order to reduce waiting times.

Only a few ports in Europe will be able to handle these large vessels. It is likely that a new hub and spoke system based on the patterns of these large ships will emerge in the EU. The cost of port and terminal lay out is s significant cost element, moreover the hinterland infrastructure to handle the transport flows is far more costly. It would be advisable to undertake some form of coordination with port development and TEN-T planning.

In relation to passenger transport it can be stated that the distance travelled by passenger is likely to increase as a consequence of globalisation, tourism, regional integration and migration which will increase labour and business related mobility, and connected social mobility. In addition the rising incomes, ageing and lower transport costs would increase leisure travel. Large intercontinental airports (hubs) might reach high congestion levels as a result of this. Like for the container market smaller regional airports may present spare capacities and become more integrated through a hub and spoke system.

B.2.7. Transport policy development

Transport policy took some time to emerge. In the nineties, transport mostly concerned infrastructure investments and was still primarily a national subject. The turning point was the development of a common transport policy with the publication of the White Paper in 1985 on the completion of the internal market.

The current European Transport policy was first set out in 2001 when the White Paper 'European transport policy for 2010: time to decide' was published. A revised version of the White Paper was published in the Mid-Term Review in 2006. Both Papers aim for sustainable mobility- allowing greater mobility whilst reducing its negative impacts – by gradually breaking the link between transport growth and economic growth.

On 17 October 2007 the European Commission put forward a package on "Keeping freight moving", which included a actions to promote freight and traffic management, to improve the competitiveness of rail by ensuring lower transit times and increasing rail's reliability and responsiveness to customer requirements and provides a vision and a toolbox for enhancing the performance of ports as essential hubs in Europe's transport system as well as the start towards a European maritime transport space without barriers and a description of the progress made in developing Motorways of the Sea.

On 8th of July 2008 the European Commission put forward a package of new "Greening Transport" initiatives to steer transport towards sustainability. The Strategy as in COM (2008) 435 on the internalization of external costs sets out measures to internalize negative externalities of transport in all modes of transport. It considers all external costs, including climate change, local pollution, noise and congestion.

The Strategy is accompanied by a handbook which outlines a model for the internalisation of external costs. It will serve as a basis for the future calculations of Infrastructure charges. In 2009 the Commission presented the main strategic objectives for the European maritime transport system. The goal is to strengthen the competences of the sector while enhancing its environmental performance. At the moment the Commission is looking into the challenges and opportunities for transport on the long term (20-40 years).

In June 2009 a communication on the Future on Transport has been adopted entitled 'A sustainable future for transport', which states the following policy objectives for sustainable transport:

- Quality transport that is safe and secure
- A well-maintained and fully integrated network
- More environmentally sustainable transport
- Keeping the EU at the forefront of transport services and technologies
- Protecting and developing the human capital
- Smart prices as traffic signals
- Planning with an eye to transport: improving accessibility

More generally it can be said, that from a slow start, the European Union's transport policy has developed rapidly over the past 15 years. The objectives of EU transport policy, from the transport White Paper of 19921 via the White Paper of 20012 to the Mid-Term Assessment: to help provide Europeans with efficient, effective transportation systems that:

- offer a high level of mobility to people and businesses throughout the Union. The availability of affordable and high-quality transport solutions contributes vitally to achieving the free flow of people, goods and services, to improving social and economic cohesion, and to ensuring the competitiveness of European industry.

- protect the environment, ensure energy security, promote minimum labour standards for the sector and protect the passenger and the citizen

  - Environmental pressures have increased substantially and significant health and environmental problems will persist in the future, for example, in the field of air pollution. The promotion of a high level of protection and improvement of the quality of the environment is therefore necessary.

  - Equally, as one of the major energy consumers transport must contribute to ensuring energy security.

  - In the social area, the EU policy promotes employment quality improvement and better qualifications for European transport workers.

  - EU policy also protects European citizens as users and providers of transport services, both as consumers and in terms of their safety and, more recently, their security.

- innovate in support of the first two aims of mobility and protection by increasing the efficiency and sustainability of the growing transport sector. EU policies develop and bring to market tomorrow's innovative solutions that are energy efficient or use alternative energy sources or support mature, large intelligent transport projects, such as Galileo;

- connect internationally, projecting the Union's policies to reinforce sustainable mobility, protection and innovation, by participating in the international organisations. The role of the EU as a world leader in sustainable transport solutions, industries, equipment and services must even be better recognised.

These objectives put the Union's transport policy at the heart of the Lisbon agenda for growth and jobs. They are also longer-term in nature, balancing the imperatives of economic growth, social welfare and environmental protection in all policy choices.

Relatively low and stable oil prices during the 1980s and 1990's led to significant increases in vehicle travel from 1980-2000, both directly because people chose to travel by car more often and for greater distances, and indirectly because cities developed tracts of suburban housing, distant from shops and from workplaces, now referred to as urban sprawl.

Trends in freight logistics, including a movement from rail and coastal shipping to road freight and a requirement for just in time deliveries, meant that freight traffic grew faster than general vehicle traffic. At the same time, the academic foundations of the "predict and provide" approach to transport were being questioned, notably by Peter Newman in a set of comparative studies of cities and their transport systems dating from the mid-1980s.

The British Government's White Paper on Transport marked a change in direction for transport planning in the UK. In the introduction to the White Paper, Prime Minister Tony Blair stated that 'We recognise that we cannot simply build our way out of the problems we face. It would be environmentally irresponsible - and would not work.'

A companion document to the White Paper called "Smarter Choices" researched the potential to scale up the small and scattered sustainable transport initiatives then occurring across Britain, and concluded that the comprehensive application of these techniques could reduce peak period car travel in urban areas by over 20%.

B.3. Conclusion

In the following the key policy objectives relevant for the TEN-T will be summarised for each of the 7 key policy areas, based on the background literature review carried and as described in more detail in the previous section:

- Internal market, social and economic cohesion
  - Reduce economic and social disparities
  - Increase economic competitiveness
  - Interconnection and interoperability
  - Promote access to networks
  - Safety, reliability, quality, level of service

- Territorial cohesion
  - Address territorial disparities
  - Deal with consequences of urban concentration
  - Counteract polarisation of wealth and population
  - Strengthen links and connections
  - Promote cooperation between regions

- Sustainable development
  - Balance environment, society and economy
  - Limit vehicle emissions
  - Improve safety performance
  - Address social exclusion
  - Provide mobility and freight transport

- Multimodal and interoperable network
  - Enable technical interoperability
  - Specifically for ITS applications
  - Ensure policy compatibility
  - Implement governance framework
  - Minimise friction costs

- Climate change
  - Decrease CO_2 levels and emissions
  - Minimise land take for infrastructure
  - Avoid deforestation for infrastructure
  - Enabling mobility and freight transport

   - Conform to international legislation (e.g. Kyoto)

- Globalisation and international dimension
   - Enable cooperation with Third Countries)
   - Provide efficient supply chains
   - Implement freight distributions centres and supply chain integration
   - Coordinate port development with TEN-T
   - Implement hub/ spoke concept for ports and airports

- Transport policy development
   - Keep freight moving whilst addressing environmental issue
   - Develop green, safe, and inclusive transport and mobility
   - Keep EU at forefront of transport services and technologies
   - Provide high level of mobility for people and businesses
   - Avoid bottleneck and provide international connections

ANNEX C: MCA example

C.1. Scoring and weighting the TEN-T projects: the Performance Matrix

The performance matrix, or consequence table, is a standard tool of multi-indicators analysis. In this matrix, each column describes a TEN-T project while each row describes a measurable indicator. The entries in the body of the matrix assess how well each TEN-T project performs with respect to each of the indicators.

MCA techniques commonly apply numerical analysis to a performance matrix in two stages:

1) Scoring: the expected consequences of each TEN-T project are assigned a numerical score on a strength of preference scale for each TEN-T project for each indicator. More preferred TEN-T projects score higher on the scale, and less preferred TEN-T projects score lower. In practice, scales extending from 0.00 to 1.00 are often used, where 0.00 represents a real or hypothetical least preferred TEN-T project, and 1.00 is associated with a real or hypothetical most preferred TEN-T project. All TEN-T projects considered in the MCA would then fall between 0.00 and 1.00.
2) Weighting: numerical weights are assigned to define, for each indicator, the relative valuations of a shift between the top and bottom of the chosen scale. The allocation of the different weights, one of the most delicate step of the MCA, is usually carried out in agreement with stakeholders, and by consulting a panel of experts composed by members with academic and scientific acknowledgements.

Therefore, the starting point for every evaluation through MCA, is the building of the performance matrix as follows:

$$
\begin{array}{c|ccc|c}
 & P_1 & P_2 & P_3 & \\
x_1 & u_{x1}(P_1) & u_{x1}(P_2) & u_{X1}(P_3) & w_1 \\
x_2 & u_{x2}(P_1) & u_{x2}(P_2) & u_{X2}(P_3) & w_2 \\
x_3 & u_{x3}(P_1) & u_{x3}(P_2) & u_{X3}(P_3) & w_3
\end{array}
$$

where:

- P_i represents the TENT-T projects to be evaluated and ranked so to choose the best one;
- x_i are the indicators to which the alternative projects will have to be evaluated (i.e. Internal market, social and economic cohesion, Territorial cohesion, Sustainable development, Specific objectives aiming to achieve a multimodal and interoperable network, Climate change, Globalisation and international dimension, Transport Policy Development);
- $u_{xi}(A_i)$ are the entries in the body of the matrix and express the score of each TEN-T project with respect to each of the indicators. The score is normalized in the range [0,1];

- w_i represents the weights attributed to each indicator in the evaluation process. The allocation is carried out in agreement with the stakeholders, and by consulting a panel of experts with academic and scientific acknowledgements. The vector of weights allows to attribute manifested preferences to the sustainability goals to be pursued.

In synthesis, the performance matrix is a conceptual table in which:

- each column describes one of the TEN-T projects that are being considered;
- each row corresponds to an indicator which is considered important to the comparison of the different TEN-T projects;
- the entries in the body of the matrix assess how well each TEN-T project performs with respect to each of the indicators.

Once assigned scores and weights, there are many different MCA methods to process the basic information and data contained in the performance matrix.

In MCA problems with a certain number of TEN-T projects, each of which is assessed in terms of a given number of indicators, the initial frame of reference is essentially the performance matrix as described previously. For each TEN-T project, with respect to each indicator, this performance information needs to be collected. MCA procedures are distinguished from each other principally in terms of how they process the basic information in the performance matrix.

In the following paragraph is described a particular category of MCA techniques to process the data contained in the performance matrix: the ELECTRE method.

C.2. ELECTRE method

ELECTRE (Elimination et Choix Traduisant la Realite) method is part of a set of techniques called "Outranking methods". ELECTRE is essentially concerned with identifying dominance relations. Synthetically, one TEN-T project is said to outrank another if it outperforms the other on enough indicators of sufficient importance (as reflected by the sum of the indicators weights) and is not outperformed by the other TEN-T project in the sense of recording a significantly inferior performance on anyone indicator. All TEN-T projects are then assessed in terms of the extent to which they exhibit sufficient outranking with respect to the full set of TEN-T projects being considered as measured against a pair of threshold parameters.

An explanation of how precisely ELECTRE method can identify a preferred TEN-T project is given following in this paragraph. ELECTRE method foresees two analytical phases described as follows:

Phase 1: Defining concordance and discordance

The starting point is to define what are termed the concordance and discordance indices and matrices.

The concordance index, c(i,j), can be calculated for every ordered pair of TEN-T projects (i,j) simply as the sum of all the weights for those indicators where TEN-T project *i* scores at least as highly as TEN-T project *j*.

Concordance Index:

$$c_{ij} = \frac{\sum_{k \in I^+_{ij} \cup I^=_{ij}} w_k}{\sum_k w_k}$$

where:

- I^+_{ij} represents the set of indicators to which alternative *i* is better than alternative *j*;
- $I^=_{ij}$ represents the set of indicators to which alternative *i* is equivalent to alternative *j*.

The concordance index expresses the degree of concordance on the fact that alternative *i* is better than alternative *j* .

Therefore, the concordance matrix is built as follows:

Concordance	P_1	..	P_j	..	P_n
P_1	c_{11}		c_{1j}		c_{1n}
..					
P_i	c_{i1}		c_{ij}		c_{in}
..					
P_n	c_{n1}		C_{nj}		c_{nn}

*n: number of TEN-T projects

The discordance index, d(i,j), is a little more complex. If TEN-T project *i* performs better than TEN-T project *j* on all indicators, the discordance index is zero. If not, then for each indicator where *j* outperforms *i*, the ratio is calculated between the difference in performance level between *j* and *i* and the maximum observed difference in score on the indicator concerned between any pair of TEN-T projects in the set being considered. This ratio (which must lie between zero and one) is the discordance index.

Discordance Index:

$$d_{ij} = \frac{\max_{k \in I^-_{ij}} w_k \left| u_{x_k}(A_j) - u_{x_k}(A_i) \right|}{\max_{k \in I} w_k \left| u_{x_k}(A_j) - u_{x_k}(A_i) \right|}$$

where:

- I^-_{ij} represents the set of indicators to which the alternative *j* is better than alternative *i*.

The discordance index expresses the regret in choosing alternative *i* rather than alternative *j*.
Defined in this way, the discordance index is only of real value in later stages of the analysis if indicators are of roughly equal importance. However, it is possible to refine the discordance definition to avoid this difficulty, albeit at the cost of inducing some elements of subjective evaluation. It is the discordance index that captures the notion of a TEN-T project's unacceptability if it records an outstandingly poor performance..

Therefore, the discordance matrix, which quantifies the degree to which alternative *i* is worse than alternative *j,* is the following:

Discordance	P_1	..	P_j	..	P_n
P_1	d_{11}		d_{1j}		d_{1n}
..					
P_i	d_{i1}		d_{ij}		d_{in}
..					
P_n	d_{n1}		d_{nj}		d_{nn}

*n: number of TEN-T projects

Phase 2: Combining concordance and discordance

To bring the two sets of "n x (n – 1)" indices together for all "n" TEN-T projects being considered, the next phase is to define a (relatively large) concordance threshold, T_c, and a (relatively low) discordance threshold, T_d.
A TEN-T project then outranks another TEN-T project overall if its concordance index lies above the chosen threshold value and its discordance index lies below the threshold value.

In synthesis, in order to determine which is the most promising project and which are the alternatives been outranked, the outranking relationship is expressed by the following condition:

$$i \text{ outranks } j \text{ if and only if } (c_{ij} \geq T_c) \text{ and } (d_{ij} \leq T_d)$$

Therefore, the set of all TEN-T projects that outrank at least one other TEN-T project and are themselves not outranked contains the promising TEN-T projects for this problem. If the set is too small, perhaps even an empty set, it can be expanded by appropriate changes to the concordance and/or discordance thresholds. Similarly, if the set is too big, it can be made smaller.

As already premised in the context of MCA, the main concern voiced about the outranking approach is that it is dependent on some rather arbitrary definitions of what precisely constitutes outranking and how the threshold parameters are set and later manipulated. However the assignment of weights and the determination of appropriate thresholds is usually made by a group of relevant stakeholders, to which can be added the support of a panel of experts. The vector of weights obtained allows to attribute manifested preferences to the sustainability goals to be pursued.

In synthesis, ELECTRE method requires TEN-T projects to be specified, their performance to be assessed on a series of indicators and indicators to be assessed through the assignment of weights in order to express their relative importance.

In the next section we provide an example of the application of the ELECTRE method.

C.3. Example of ELECTRE method application

We suppose to compare three projects (P_1, P_2, P_3) over three evaluation dimensions (or indicators), namely, Territorial cohesion, Sustainable development and Climate change. As previously permitted, each indicator is declined in different sub indicators.

In order to make the example easier to be understood, the weights assigned to each indicator are equal to 1.00: this is equivalent to say that all the sustainability indicators "worth" the same.

On the basis of random numbers, the performance matrix is consequently built as follows:

Indicators	Projects			Weights
	P_1	**P_2**	**P_3**	
Territorial cohesion	0.55	0.90	0.57	1.00
Sustainable development	0.78	0.85	0.78	1.00
Climate change	0.78	0.96	0.54	1.00

The concordance index, which expresses the degree of concordance on the fact that alternative *i* is better than alternative *j*, is calculated as in the following example:

$$C_{12} = \frac{\Sigma(0 + 0 + 0)}{\Sigma(1 + 1 + 1)} = 0$$

Our concordance matrix, built by evaluating comparatively three alternative projects over three evaluation indicators is the following one:

Concordance	P_1	P_2	P_3
P_1	-	**0.00**	0.67
P_2	1.00	-	1.00
P_3	0.33	0.00	-

The discordance index, which quantifies the degree to which alternative *i* is worse than alternative *j*, is calculated as in the following example:

$$d_{12} = (|0.90 - 0.35|)/(|0.90 - 0.35|) = 1$$

Consequently, our discordance matrix is the following one:

Discordance	P_1	P_2	P_3
P_1	-	1.00	0.08
P_2	0.00	-	0.00
P_3	1.00	1.00	-

We assume as concordance and discordance thresholds, the average values of the concordance and discordance indices (contained in the respective matrices), therefore:

$$T_c = 0.33 \text{ and } T_d = 0.34$$

In order to determine which TEN-T project is the most promising, we adopt the outranking relationship previously introduced:

$$P_2 \text{ outranks } P_1 \text{ if and only if } c_{21} \geq T_c \text{ and } d_{21} \leq T_d;$$

analytically:

$$P_2 \text{ outranks } P_1 \text{ because } 1 \geq 0.33 \text{ and } 0.00 \leq 0.34.$$

The outranking matrix can be consequently built as follows:

Outrankings	P_1	P_2	P_3	Score	Ranking
P_1	-	0.00	1.00	1.00	2
P_2	1.00	-	1.00	2.00	1
P_3	0.00	0.00	-	0.00	3
N. of outrankings	1.00	-	2.00		

From the above matrix can be easily inferred that:

the winning TEN-T project is P_2.

In fact, project P_2 constitutes the "nucleus" of not outranked alternatives, while the remaining alternatives P_1 and P_3 are respectively outranked once and twice.

C.4. The case of the Lyon-Turin high speed rail connection (No. 5 TEN-T Corridor)

In this section is presented the case of the Lyon-Turin high speed rail connection which is particularly relevant as regards to the weight of the indicators for each TEN-T project under evaluation. More specifically, MCA has been already used in the context of No. 5 TEN-T Corridor in order to select the most appropriate option to be funded between two different hypotheses.
In the Lyon-Turin case study the MCA has been implemented as fundamental support tool of the decision process. In particular MCA has supported the decision process, by providing transparency and consistency in choosing the weights to be assigned to each indicator openly and are shared and available for discussion.

The Lyon-Turin rail link is part of the railway axis 'Lyon-Trieste-Divača-Koper-Divača-Ljubljana-Budapest-Ukranian border', included in the list of the 30 Priority Projects (it is the "No. 5 corridor", connecting Lisbon to Budapest) of the TEN-T network. The project is considered an important east-west link crossing the Alps between Lyon and Turin and between Italy and Slovenia. In particular, one of the major expectations behind the project is that it will be able to absorb part of the continuing growth of traffic flows between the south-east, central part and south-west part of Europe. Furthermore, due to the significant increase in rail freight capacity that will be achieved, there is the expectation of improving the modal shift in the sensitive mountainous regions against the road transport. The project involves four Member States: Hungary, Slovenia, Italy and France.

The Lyon-Turin rail link raises interesting issues at least for two reasons:

- **institutional reasons,** i.e. the timely implementation of the project needs an effective cooperation between the Italian and French infrastructure managers and rail operators on the common Franco-Italian border crossing section. In such a way, the Lyon-Turin rail link can be considered as a test case for intra European cooperation in cross-border infrastructure projects. In fact, it is only through a clear and unequivocal communication about works and interoperability issues on the common Franco-Italian link that the rail project can be effectively implemented. The common Franco Italian section consists of the links with the historic line closest at both ends to the border, near St. Jean de Maurienne in France and Bussoleno/Bruzzolo in Italy. From the beginning it was clear to Italy and France that a common structure was necessary to enable a coordinated approach on the Base Tunnel. For this reason, the Lyon Turin Ferroviaire (LTF), a 50-50% daughter of Réseau Ferré de France (RFF) and Rete Ferroviaria Italiana (RFI), was created in 2001;
- **methodological reasons**, to the extent that the particular social and political context of the Lyon-Turin rail link, described in the next section, has made the recourse to the MCA an interesting TEN-T project.

The social and political context of the Lyon-Turin rail link (common Franco-Italian section).
The social and political context of the common Franco-Italian rail link section is complex and difficult to manage. In fact, the new infrastructure rail link (a 52 km long tunnel across the Alps from Saint-Jean-de-Maurienne to the lower Susa Valley), despite its being located by larger traits under the level of the

ground, it affects valleys and mountainous areas with a delicate ecosystem, rich of water and with presence of human settlements. After the strong opposition of the citizens of the Valley of Susa (in which the international tunnel should exit) a dedicated institutional level was established (the 'Observatory for the rail link Turin – Lyon') to promote an inclusive process of involvement of the local stakeholders. The Observatory started to operate in 2006.

Initially, the LTF and RFI, involved in the Observatory, proposed a new path in the Valley of Susa. This path was designed in order to respect the environmental sensitivity of the territory and the interoperability constraints, making the best use of as much existing infrastructure as possible. According to the new path defined in June 2008 the international tunnel would exit at Susa, where an international station (the Val di Susa International station) should be built.

On 28th of June 2008 the Observatory found an agreement on the basic path, the 'Agreement of Pracatinat'. Even though the Agreement of Pracatinat was not adhered to by all local representatives in the Observatory, the Observatory continued its technical work with the representatives of all interested parties over the reporting period. In particular, a set of different local variations to the Pracatinat path, have been discussed with the stakeholders.

Through a continuing process of careful technical discussions, in which all representatives of the territory have been involved, the revision of the Pracatinat path has finally been carried out. The procedures, including the definitive design of the path, the environmental impact assessment, the tendering of the works for drilling the tunnel, etc. are under preparation and at the time being (end of January 2010), the definitive path has been outlined and the procedure that will lead in 2013 to start the construction of the rail link has been prepared.

It's important to stress that the MCA has been an important component of the overall process. The following example shows the type of indicators used for raising consensus among the stakeholders.

Indicators	Sub indicators	Weighting factors Pracatinat/ TEN-T project1	Weighting factors Pracatinat/ TEN-T project2	Weights for category/ TEN-T project1	Weights for category/ TEN-T project 2
Natural environment	Impacts on natural landscapes	6.4%	5.6%	25.7%	22.3%
	Volume of land occupied	6.4%	5.6%		
	Hydro geological risks	12.9%	11,1%		
Human environment	Impacts on urban landscape	9.7%	11,1%	35.5%	50.0%
	Interconnection with existing infrastructure	-	5.6%		
	Working time for construction	9.7%	8.3%		
	Human health risks	-	11.1%		

Indicators	Sub indicators	Weighting factors Pracatinat/ TEN-T project1	Weighting factors Pracatinat/ TEN-T project2	Weights for category/ TEN-T project1	Weights for category/ TEN-T project 2
	(asbestos)				
	Impact of Rail noise	9.7%	8.3%		
	Building damaged	6.4%	5.6%		
Functionality	Maintenance	9.7%	8.3%	19.4%	16.6%
	Security	9.7%	8.3%		
Costs	Investment costs	6.5%	5.6%	6.5%	5.6%
Socio-economic aspects	Local impacts of investment	6.45%	2.75%	12.9%	5.5%
	Local activities to relocate	6.45%	2.75%		
		100%	100%	100%	100%

The involvement of the stakeholders has been decisive for the selection of the topics to be considered and the related indicators on the basis of which the MCA has been carried out.

It can be observed that the selected topics and indicators have been weighted with different values depending on the TEN-T project to be considered, due to the different characteristics of the TEN-T project under examination compared to the “Pracatinat” reference path. For example, the health risks was null in the TEN-T project 1, but high in the TEN-T project 2, due to possible pollution by asbestos.

The allocation of the different weights, one of the most delicate step of the MCA, has been carried out in agreement with the stakeholders.

C.5. Conclusions

The Lyon-Turin case study shows that the MCA may be implemented as a tool of decision support. Its role has been in fact to enhance decision maker understanding, not to prescribe decisions. The application of the MCA approach has provided transparency and consistency to the decision. Weights and resulting scores are attributed and assessed openly and are shared and available for discussion. The weights applied to different attributes reflect the value judgements of the decision making group, but again are explicit and transparent and so open to reasoned debate.

The adoption project of the MCA approach has made available the understanding of the consequences, in terms of a ranking of alternatives, of adopting different views about the relative importance of different attributes within the MCA model. Differences of this sort are often associated with the views of different groups of stakeholders whose value judgements about what is important in influencing choice of alternatives vary from each other. Although applying the model cannot usually reconcile what are often fundamental differences, it can provide clarification of where and how the differences in view affect project rankings and, on some occasions, can provide a basis for discussion of compromise solutions, which meet the concerns of one stakeholder group without seriously jeopardizing the wishes of others.

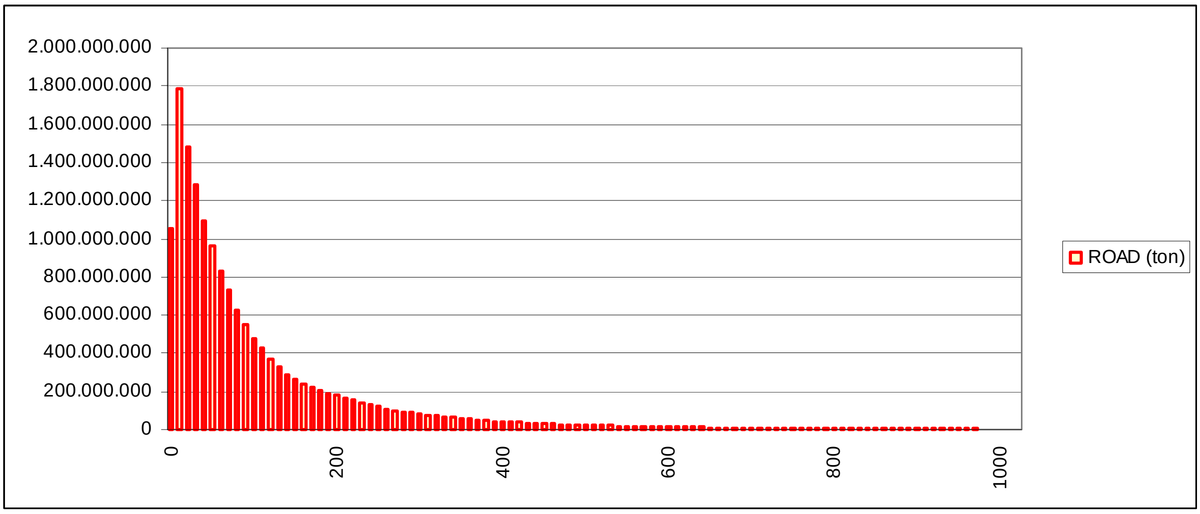
ANNEX D: Analysis of freight transport in EU

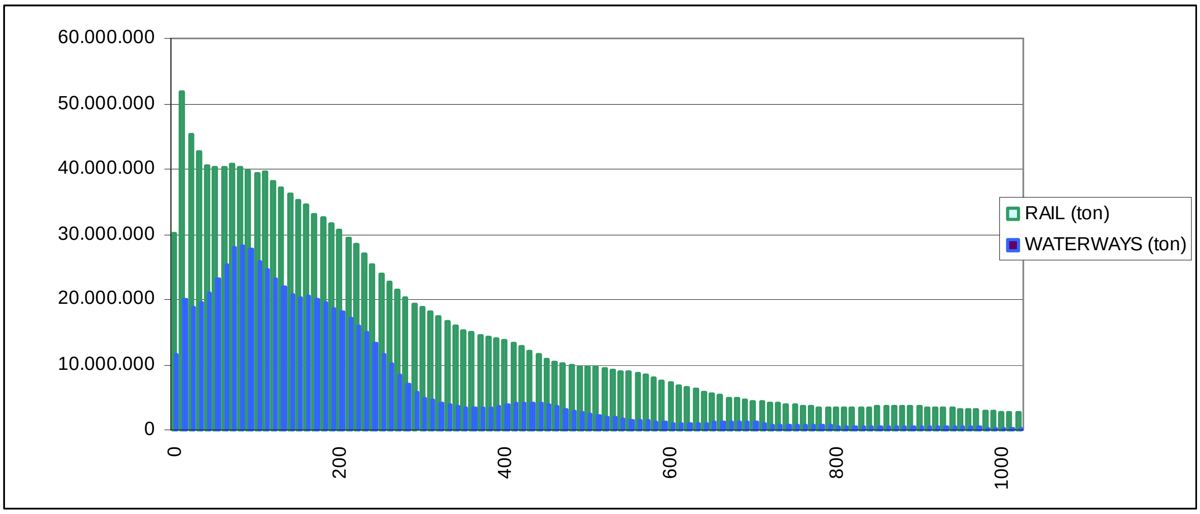
D.1. Freight transport volumes and distances

The figures below give an overview of the tonnes transported by distance in EU27, for 2005. The source is the Trans-Tools model, which data is based n the ETIS database.

Logically, most goods are transported at a fairly low distance, especially for the transport by road. Goods transported via trains and inland ships travels higher distances.

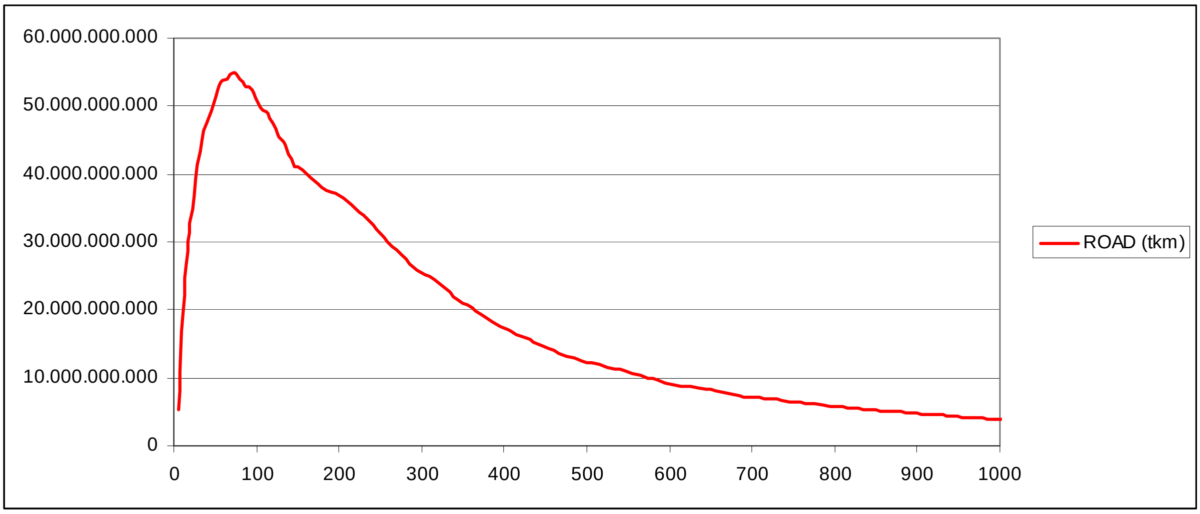
Figure 18: Tonnes by distance, interval of 10 km, Trans-Tools, 2005

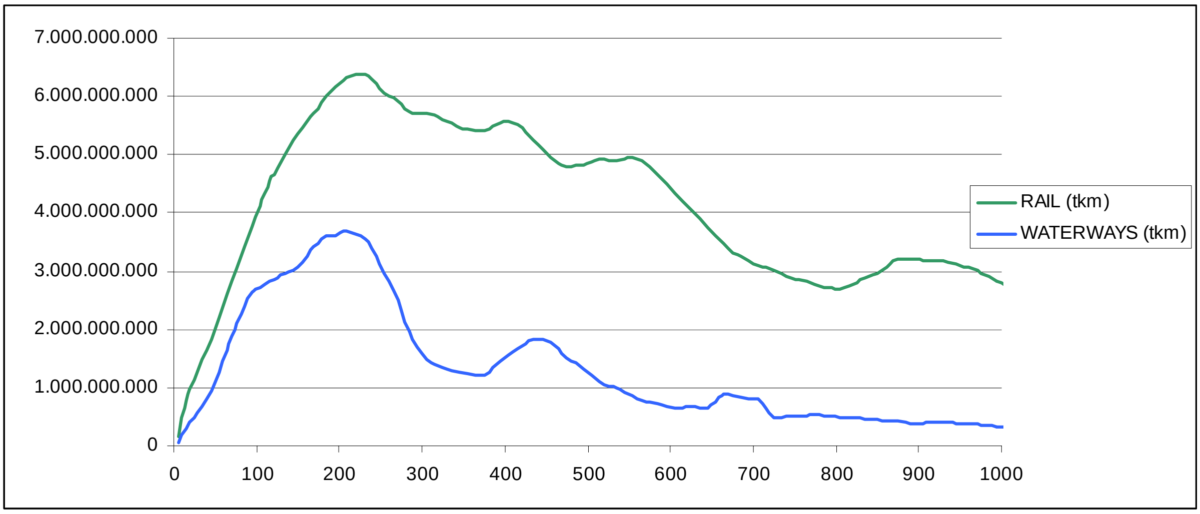




We converting the tonnes into ton-km, the graph show similar differences between road, rail and inland shipping.

Figure 19: Tonne-km by distance, interval of 10 km, Trans-Tools, 2005





The median distance of the tonne-km transported in Europe is 270 km for road transport. This means that half of the tonne-km are transported less than 270 km, half more than 270 km. If you see a truck driving, changes are 50% that it will drive more than 270 km. It does not mean that half of the tonnes are transported more than 270 km, this median distances is much shorter. Long distance transport is weighted higher when analysing tonne-km than just tonnes.

Table 19: Median distances in 2005 (Trans-Tools)

Network	Median distance
Freight road	270 km
Freight rail	775 km
Inland shipping	290 km

The median distance for inland shipping is lower than for rail transport, although the goods types are about the same. The reason is that the inland shipping network is relatively small: it basically consists of The Netherlands and Belgium area on one hand, and the Rhine-Danube corridor on the other hand.

The tables below show the freight transport versus the population and area in Europe. Road freight transport is the most used mode, with 3 889 tonne-km per inhabitant.

Table 20: The EU27 population and area in 2007 (Transport in Figures 2009)

Population	495 578 000 inhabitants
Area	4 323 000 km2
Population density	115 inh/km2

Table 21: The EU27 freight transport in 2007 (Transport in Figures, 2009)

Mode	Tonne-km	Tonne-km/inhabitant
Freight road	1 927 400 million	3 889
Freight rail	452 200 million	912
Inland shipping	141 100 million	285

D.2. Freight transport networks

The table below shows the "size" of the transport networks in Europe. The total length of the current TEN-T roads, including ordinary roads yet to be upgraded, was approximately 98.500 km in EU27 in 2005. Assuming, the networks have a perfect triangular shape, the TEN-T road network would have a distance between the junctions (or nodes) of 203 km. In realty, the network is of course more dense in certain areas (e.g. Belgium) than in other areas (e.g. Sweden).

Each "node" of the TEN-T network serves about 3 million people in an area of 65 243 km2.

The total railway network is about twice as dense as the motorway network. In 2005 the TEN-T railway had a total length (conventional and high-speed lines) of about 97 600 km, which is about half of the total rail network, and has approximately the same size as the road TEN-T network.

The inland waterway network is very irregular: it is very dense in Belgium and The Netherlands, and on the Rhine-Danube corridor, and almost non-existing elsewhere.

Table 22: The EU27 transport networks in 2007

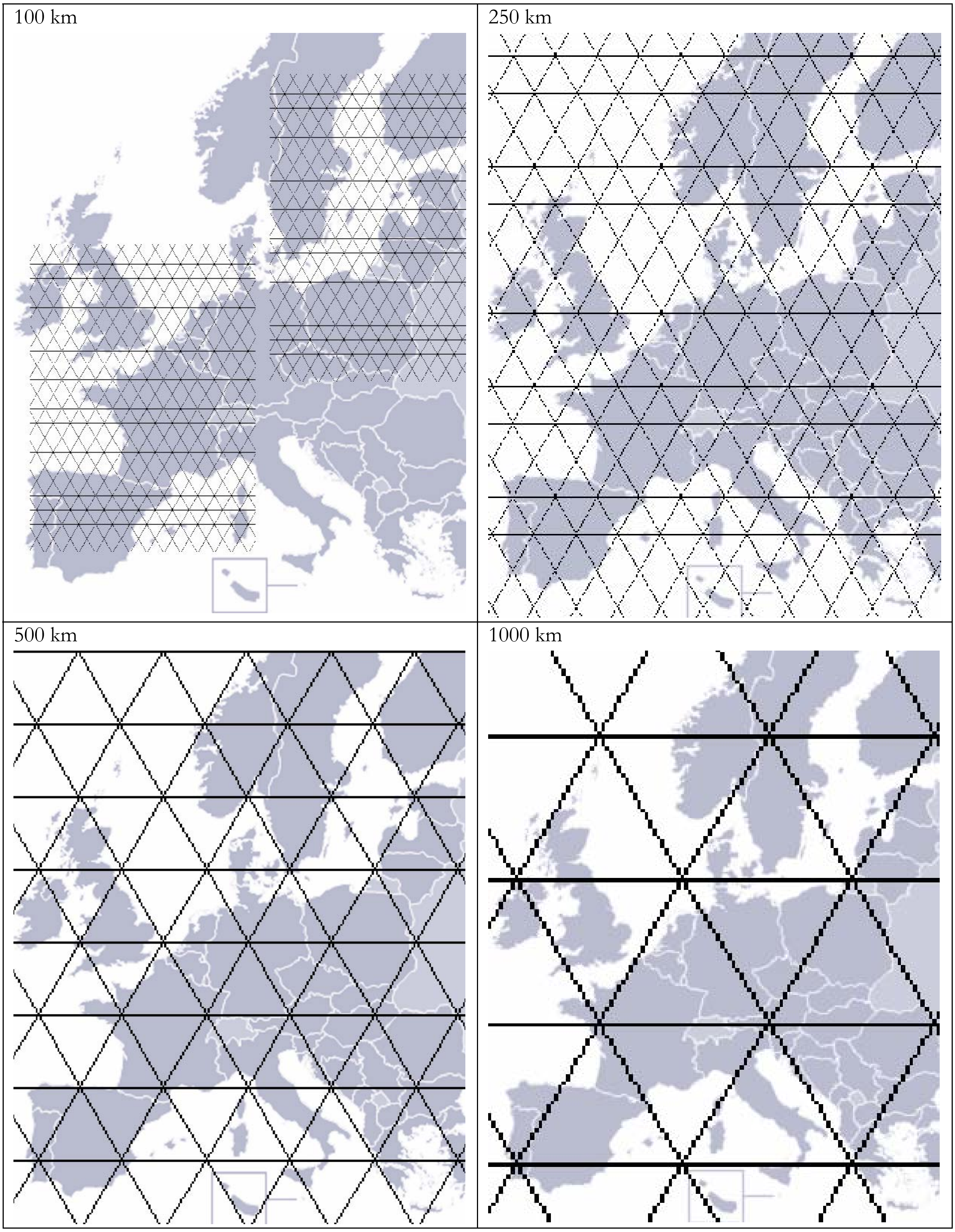
Source: Transport in Figures 2009

	Length (km)	Triangular distance (km)	Inhabitants/km
Road network (all)	5 000 000	4	99
Road TEN-T network	98 500	203	5 031
Road motorway network	63 000	317	7 866
Railway network (all)	215 900	92	2 295
Rail TEN-T network	97 600	205	5 078
Navigable inland waterways	43 000	464	11 525

	Nodes	Inhabitants/node	Area/node (km2)
Road network (all)	417 354	1 187	10
Road TEN-T network	162	3 059 676	65 244
Road motorway network	66	7 479 400	26 690
Railway network (all)	778	636 858	5 555
Rail TEN-T network	159	3 116 364	27 185
Navigable inland waterways	31	16 055 024	140 050

The following maps show an impressing of networks with a density of 100, 250, 500 and 1000 km.

Figure 20: Triangular grids



D.3. Infrastructure scenarios

This section shows what the impact of different network densities would be. Logically, increasing the network density (lowering the network distance) will lead to a smaller population per node, thus incorporating smaller regions and cities to the "European" network. As stated in the section above, the road TEN-T network has now an average mesh size of 203 km with a node size of 3.0 million inhabitants, the rail TEN-T network of 205 km with a node size of 3.1 million inhabitants.

Figure 21: Inhabitants per node (y-axis) versus triangular distance in km (x-axis)

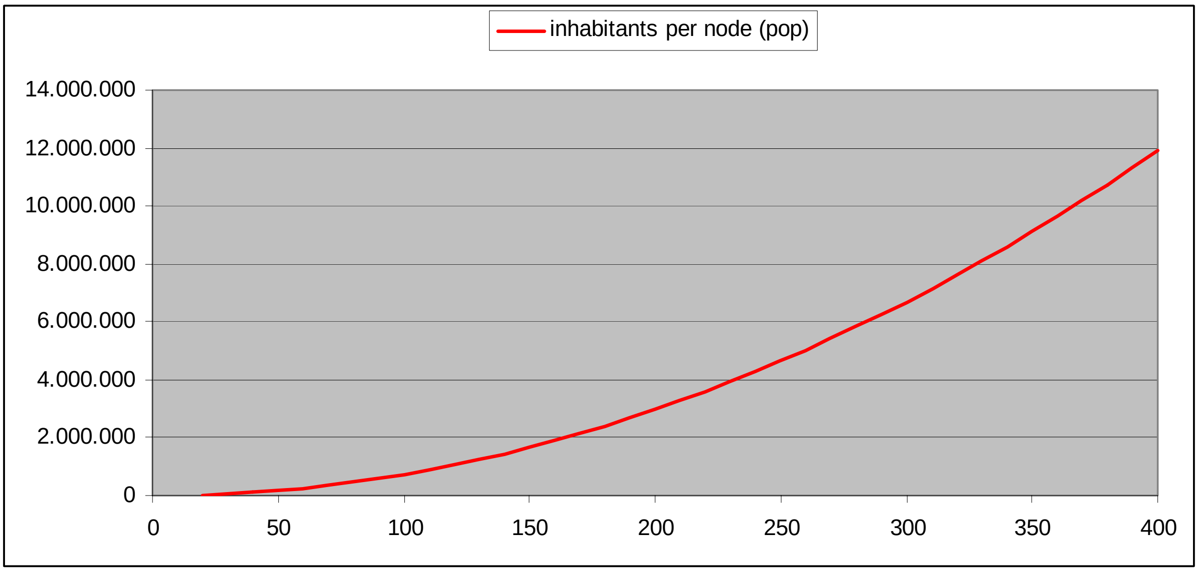
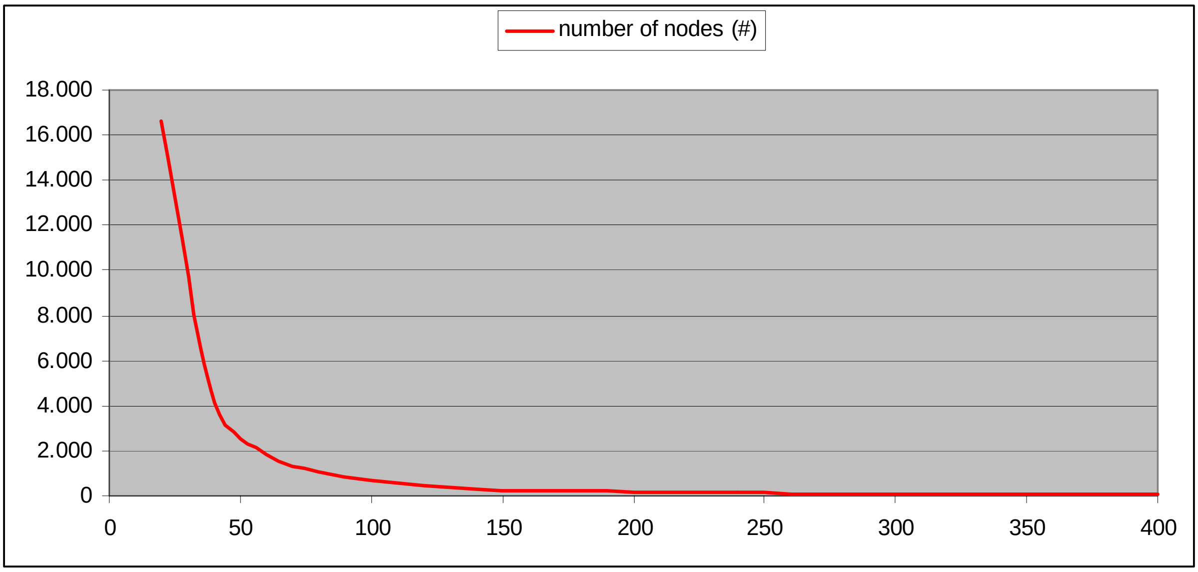
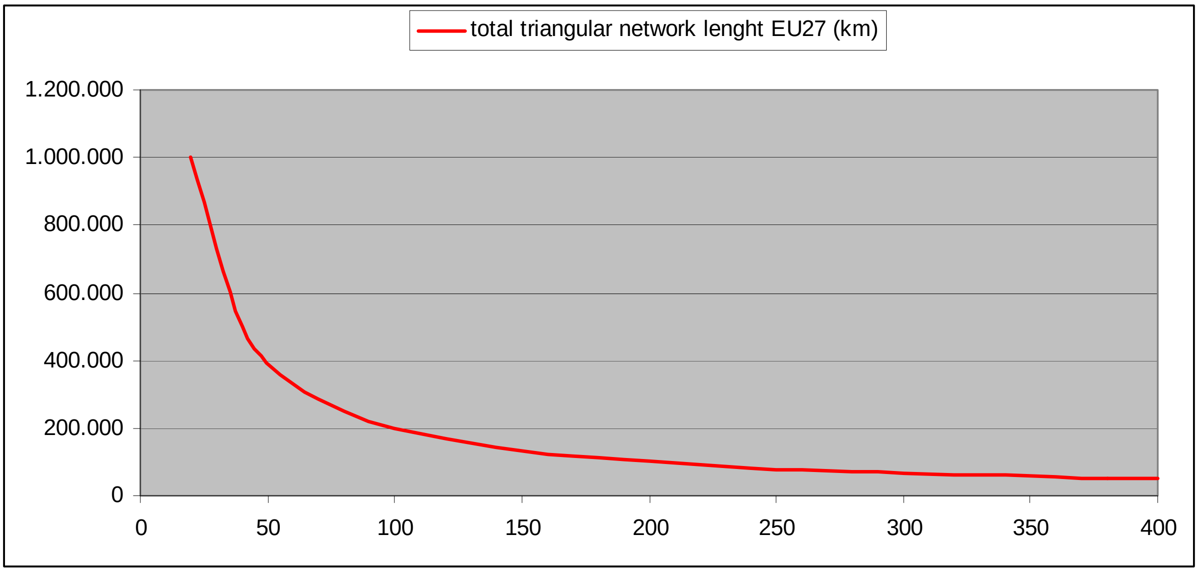


Figure 22: Number of nodes (y-axis) versus triangular distance in km (x-axis)



As shown in the next figure, increasing or decreasing the mesh size of the network will also lead to a larger or smaller network length, which may affect financing and standardisation of transport networks.

Figure 23: Total triangular network length in km (y-axis) versus triangular distance in km (x-axis)



The figures and table below represent the (freight only) traffic on the network, assuming different network sizes. If the current freight road traffic (1 927 400 million tonne-km in 2005) would be loaded to a network with a mesh size of 100 km, the traffic on such a "European" road would be about 7.5 million tonne-km transported per km of road. Assuming a load factor of 10 tonnes per truck, this is 0.75 million trucks. About 77% of the traffic would be on the high level network, thus 23% on the underlying networks – assuming that all long distance transport would drive on the high level network wherever possible.

Similar calculations have been made for other network sizes with mesh distances of 200, 300 and 400 km. And similar calculations have been made for rail and inland shipping is also added. As one can see, with similar network sizes, rail transport gets a larger share of transport on the high level network compare to road transport. This is because rail transport has a larger median transport distance. The current TEN-T networks hav a mesh distances of about 200 km (both for rail and road).

Note that these calculations assume an equal population (and transport) density in EU27. In reality, given an average network density, some areas of Europe will have more nodes and links than others.

Table 23: The EU27 transport networks in 2007

triangular network dimensions				
distance between triangular nodes (km)	**100**	**200**	**300**	**400**
area per node (km2)	6 495	25 981	58 457	103 923
inhabitants per node	744 593	2 978 370	6 701 333	11 913 481
number of nodes	666	166	74	42
total triangular network length EU27 (km)	199 671	99 835	66 557	49 918
triangular network traffic				
tonne-km road per km road	7 467 318	11 553 194	13 406 047	13 827 603
tonne-km rail per km rail	2 070 968	3 787 571	5 195 286	6 334 402
tonne-km shipping per km inland waterways	556 428	876 265	1 034 959	1 086 572
% tonne-km road per node	77%	60%	46%	36%
% tonne-km rail per node	91%	84%	76%	70%
% tonne-km shipping per node	79%	62%	49%	38%

Figure 24: Yearly tonne-km (2005) for road, rail, inland shipping (y-axis) versus triangular distance in km (x-axis)

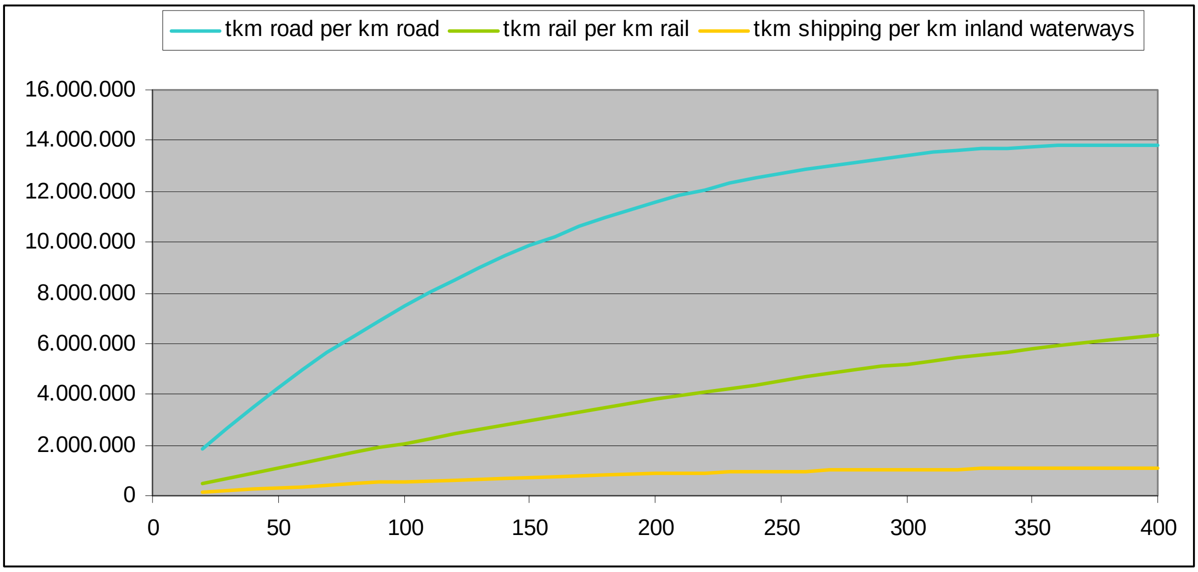
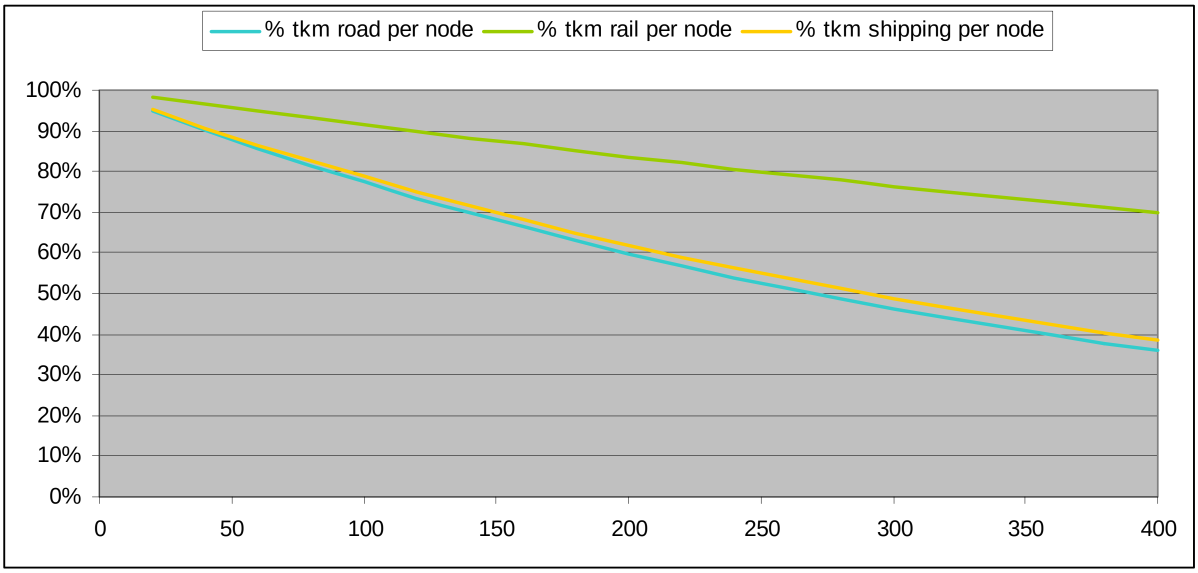


Figure 25: Share of tonne-km (2005) for road, rail, inland shipping on the triangular network versus triangular distance in km (x-axis)



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