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TRACC
Transport Accessibility
at Regional/Local Scale and
Patterns in Europe

Applied Research 2013/1/10

Inception Report | Version 30/07/2010

This report presents a more detailed overview of the analytical approach to be applied by the project. This Applied Research Project is conducted within the framework of the ESPON 2013 Programme, partly financed by the European Regional Development Fund.

The partnership behind the ESPON Programme consists of the EU Commission and the Member States of the EU27, plus Iceland, Liechtenstein, Norway and Switzerland. Each partner is represented in the ESPON Monitoring Committee.

This report does not necessarily reflect the opinion of the members of the Monitoring Committee.

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This basic report exists only in an electronic version.

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1 Introduction

The ESPON project TRACC (Transport accessibility at regional/local scale and patterns in Europe) aims at taking up and updating the results of existing studies on accessibility at the European scale, to extend the range of accessibility indicators by further indicators responding to new policy questions, to extend the spatial resolution of accessibility indicators and to explore the likely impacts of policies at the European and national scale to improve global, European and regional accessibility in the light of new challenges, such as globalisation, energy scarcity and climate change.

The Transnational Project Group (TPG) for the ESPON project TRACC consists of the following seven Project Partners:

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This report is the Inception Report of the TRACC project and was developed shortly after the commencement of the research work. The Inception Report is the main planning document for the project. It contains a detailed overview of the research approach and methodology to be applied in the project and its breakdown into individual research tasks. The report contains a first review of the main literature on European accessibility studies and a first assessment of available data sources for network and socio-economic data. The Inception Report informs also about the selection of case study areas that will be used to calculate regional/local accessibility. The report closes with a chapter containing detailed project planning.

2 Objectives

Accessibility is the main 'product' of a transport system. It determines the locational advantage of an area (i.e. in ESPON a region, a city or a corridor) relative to all areas (including itself). Indicators of accessibility measure the benefits households and firms in an area enjoy from the existence and use of the transport infrastructure relevant for their area.

The important role of transport infrastructure (i.e. networks and transport services) for spatial development in its most simplified form implies that areas with better access to the locations of input materials and markets will, *ceteris paribus*, be more productive, more competitive and hence more successful than more remote and isolated areas.

However, the impact of transport infrastructure on spatial development has been difficult to verify empirically. There seems to be a clear positive correlation between transport infrastructure endowment or the location in interregional networks and the *levels* of economic indicators such as GDP per capita. However, in most countries this correlation may merely reflect historical agglomeration processes rather than causal relationships effective today.

Attempts to explain *changes* in economic indicators, i.e. economic growth and decline, by transport investment have been much less successful.

The reason for this failure may be that in countries with an already highly developed transport infrastructure further transport network improvements bring only marginal benefits. A different situation can be observed in some regions of the new EU member states where the lack of modern infrastructure (motorways, high-speed trains) is still a major barrier to economic development and where the rapid increase of freight flows by road on the main transport corridors between western and eastern Europe was not followed by new road, rail or multimodal transport investment.

While there is uncertainty about the magnitude of the impact of transport infrastructure on spatial development, there is even less agreement on its direction. It is debated whether transport infrastructure improvements contribute to spatial polarisation or decentralisation. From a theoretical point of view, both effects can occur. A new motorway or high-speed rail connection between a peripheral and a central region makes it easier for producers in the peripheral region to market their products in the large cities, however, it may also expose the region to the competition of more advanced products from the centre and so endanger formerly secure regional monopolies.

These developments have to be seen in the light of changes in the field of transport and communications which will fundamentally change the way transport infrastructure influences spatial development. Several trends combine to reinforce the tendency to diminish the impacts of transport infrastructure on regional development:

- An increased proportion of international freight comprises high-value goods for which transport cost is much less than for low-value bulk products. For modern industries the *quality* of transport services has replaced transport *cost* as the most important factor.

- Transport infrastructure improvements which reduce the variability of travel times, increase travel speeds or allow flexibility in scheduling are becoming more important for improving the competitiveness of service and manufacturing industries and are therefore valued more highly in locational decisions than changes resulting only in cost reductions.

- Telecommunications have reduced the need for some freight transports and person trips but they also increase the demand for transport by their ability to create new markets.

- With the shift from heavy-industry manufacturing to high-tech industries and services other less tangible location factors have come to the fore and have at least partly displaced traditional ones. These new location factors include factors related to leisure, culture, image and environ-

ment, i.e. quality of life, and factors related to access to information and specialised high-level services and the institutional and political environment.

On the other hand, there are also tendencies that increase the importance of transport infrastructure:

- The introduction of totally new, superior levels of transport such as the high-speed rail system create new locational advantages, but also disadvantages for regions not served by the new networks.

- Another factor adding to the importance of transport is the general increase in the volume of goods movements (due to changes in logistics such as just-in-time delivery) and travel (due to growing affluence and leisure time).

Both above tendencies are being accelerated by the increasing integration of national economies within the European Union and by the continuing globalisation of the world economy.

Key policy questions

In this situation the project is to address the following key policy question from a European point of view:

- What are the differences between accessibility at three different levels (regional, European and global) considering the four modes road, rail, water and air?

- What is the link between accessibility at the different levels and for different modes of European regions and their economic development? How has this link changed over time? Does the strength of this link differ across the EU?

- What could be the territorial impact of rising energy prices on the future developments of road, rail, water and air transport?

- What could be the impact of various transport scenarios on climate change, access patterns and economic development?

In addition the project is to look into the regional dimension of accessibility often neglected in previous studies of accessibility:

- What does regional accessibility/connectivity look like at the regional level? For example, how many jobs/people can be reached in 45 minutes travel time (by road or by train), how many city centres can be reached by flying out in the morning and returning in the evening?

- In which type of regions is the level of European accessibility very different from their regional accessibility?

From a research point of view, the following key research questions are to be addressed:

- What is the accessibility of European regions for travel by different modes (road, rail, air) at the European level?

- What is the accessibility of European regions for air travel at the global level?

- What is the potential of intermodal travel, in particular the combination of high-speed rail and air?

- What would be the impacts of different policies to make rail more competitive on the modal share of travel and travel accessibility?

- What would be the impacts of different policies to make rail and water more competitive on the modal share of freight transport and freight accessibility?

- What are the most favoured urban centres and most disadvantaged regions with respect to travel accessibility (island, mountain areas)?

Project objectives

From these key policy and research questions the main objectives of the project are derived:

- to take up and update the results of existing studies on accessibility at the European scale using most recent available network and socio-economic data,

- to extend the range of accessibility indicators by further indicators responding to new policy questions and further developing the quality and validity of the existing indicators,

- to extend the spatial resolution of accessibility indicators by calculating, besides European accessibility, also global and regional accessibility,

- to explore the likely impacts of available policies at the European and national scale to improve global, European and regional accessibility in the light of new challenges, such as globalisation, energy scarcity and climate change.

Geographical coverage of all analyses should be according to the project specification NUTS-3 or equivalent regions in all countries participating in the ESPON 2013 Programme plus ideally the EU candidate countries Croatia, FYR Macedonia and Turkey and the other countries of the Western Balkans Bosnia and Herzegovina, Serbia, Montenegro, Albania and Kosovo.

When calculating accessibility indicators transport connections to destinations outside the study area are to be considered. When calculating European accessibility, also links to destinations in neighbouring countries, such as Belarus, Moldova, Russia and Ukraine, are to be considered, and when calculating global accessibility, links to destinations in all world regions.

3 Conceptual framework

In this section first an introduction into the state of the art of calculating accessibility indicators is given showing the major dimensions of accessibility, the most frequently types of accessibility indicators and important extension of these. Based on this conceptual framework, the research concept of the project is outlined.

Accessibility: dimensions

Accessibility indicators may be sensitive to the following dimensions: origins, destinations, impedance, constraints, barriers, type of transport, modes, spatial scale, equity and dynamics. These dimensions are summarised in Table 1.

Origins

Accessibility indicators are calculated for areas such as regions or cities. From a pure semantic point of view, an area is called accessible if it can be easily reached from other areas. However, in practice a reverse view is used: an area is called highly accessible if many attractive destinations can be reached from it in a short time. In that sense the area can be considered the origin of trips to destinations of interest. In both perspectives the notion of accessibility is closely linked to movement, and so it matters who moves. Different actors such as business travellers, tourists or commuters are attracted by different destinations and have different travel preferences and travel budgets. By the same token different firms have different views of destinations as purveyors, customers or other firms and require different transport services depending on the kind of goods they ship. Accessibility indicators therefore have to be calculated with different types of actors or transport users in mind.

Destinations

Different actors are attracted by different destinations. Business travellers find their clients most likely in city centres. Tourists are attracted by tourist attractions such as beach resorts, mountains or historical towns. Commuters are interested in job opportunities. Consumer-oriented firms want to reach their customers, whereas business-oriented firms deliver their goods and services to other firms. Accessibility indicators therefore have to be calculated with respect to different destinations such as economic activities, population or tourist attractions.

Impedance

Simple accessibility indicators consider only transport infrastructure in the area itself, expressed by measures such as total length of motorways or number of railway stations, or in the vicinity of the area, expressed by measures such as access to the nearest nodes of interregional networks like motorway exits, intercity stations, freight terminals or airports. More complex accessibility indicators distinguish between destinations in the area itself and those in other areas. The effort needed to overcome that distance is measured as spatial impedance. Spatial impedance is calculated as a function of distance or time or money or a combination of the latter two (generalised cost). There are two different approaches:

- *Euclidean distance*. If no transport network is considered, geographical or Euclidean distance between areas is taken as spatial impedance: Origins and destinations are assumed to be concentrated in nodal points in the centre of the areas called centroids, so distances between the centroids are calculated. In this case other attributes such as travel time, travel cost, capacity, congestion, convenience, reliability or safety have no meaning. The mean length of internal trips in the origin area is estimated as a function of its size.

Table 1. Dimensions of accessibility

Dimension	Comments
Origins	Accessibility indicators may be calculated from the point of view of different population groups such as social or age groups, different occupations such as business travellers or tourists or different economic actors such as industries or firms.
Destinations	Accessibility indicators may measure the location of an area with respect to opportunities, activities and assets such as population, economic activities, universities or tourist attractions. The activity function may be rectangular (all activities beyond a certain size), linear (of size) or non-linear (to express agglomeration effects).
Impedance	The spatial impedance term may be a function of one or more attributes of the links between areas such as distance (Euclidean or network distance), travel time, travel cost, convenience, reliability or safety. The impedance function applied may be linear (mean impedance), rectangular (all destinations within a given impedance) or non-linear (e.g. negative exponential).
Constraints	The use of the links between areas may be constrained by regulations (speed limits, access restrictions for certain vehicle types of maximum driving hours) or by capacity constraints (road gradients or congestion).
Barriers	In addition to spatial impedance also non-spatial, e.g. political, economic, legal, cultural or linguistic barriers between areas may be considered. In addition, non-spatial linkages between areas such as complementary industrial composition may be considered.
Types of transport	Only travel or only freight transport, or both, may be considered in the analysis.
Modes	Accessibility indicators may be calculated for road, rail, inland waterways or air. Multimodal accessibility indicators combine several modal accessibility indicators. Intermodal accessibility indicators include trips by more than one mode.
Spatial scale	Accessibility indicators at the continental, transnational or regional scale may require data of different spatial resolution both with respect to area size and network representation, intra-area access and intra-node terminal and transfer time.
Equity	Accessibility indicators may be calculated for specific groups of areas in order to identify inequalities in accessibility between rich and poor, central and peripheral, urban and rural, nodal and interstitial areas.
Dynamics	Accessibility indicators may be calculated for different points in time in order to show changes in accessibility induced by TEN projects or other transport policies, including their impacts on convergence or divergence in accessibility between areas.

- *Network impedance*. If one or more transport networks are considered, the travel time or cost along the minimum path between areas over the network(s) are taken as spatial impedance between the areas. Besides distance, link attributes such as travel time, travel cost, capacity, congestion, convenience, reliability or safety may be considered. Origins and destinations are assumed to be concentrated in the centroids, and the centroids are linked to the nearest network node by non-network access links. The mean length or travel time or cost of access links and internal trips in the origin area is estimated as a function of the size of the area as above.

If the assumption that origins and destinations of areas are concentrated in their centroids is abandoned, additional access links are estimated between the micro locations of origins and destinations in the areas and their centroids.

Constraints

The use of the links between areas may be constrained by regulations (speed limits, access restrictions for certain vehicle types of maximum driving hours) or by capacity constraints (road gradients or congestion). It is relatively straightforward to take account of regulation constraints when calculating accessibility. Speed limits can be directly converted to link travel times. Regulations on maximum driving hours can be converted to a barrier at the link on the minimum path where the maximum driving time is exceeded. Taking account of capacity constraints when calculating accessibility is more difficult since it requires the consideration of link capacity and network flow characteristics. To restrict the use of certain links by certain vehicle types (e.g. of Swiss transalpine roads by 40-ton lorries) is only possible if different lorry types are distinguished in the accessibility model. To take account of road congestion would actually require a full-scale traffic assignment model, something rarely available when calculating accessibility. As a workaround sometimes time penalties are assigned to links passing through urbanised areas.

Barriers

In addition to spatial impedance also non-spatial, e.g. political, economic, legal, cultural or linguistic barriers between areas may be considered:

- Political barriers are, for instance, national boundaries with delays at the borders for passport control, visas, customs declarations, etc. Significant reductions of barriers between countries of the European Union have been achieved through the Schengen Protocol. However, movement of people from immigration countries across the external boundaries of the European Union has become more restricted.

- Economic barriers are customs, tariffs and other fees imposed on the exchange of goods and services between different countries. Due to the Maastricht Treaty, economic barriers between EU countries have been greatly reduced.

- Legal barriers are non-tariff restrictions imposed on movement of people and goods between countries through different standards, safety regulations, legal provisions, employment restrictions, etc.

- Cultural barriers are invisible barriers discouraging the exchange of people or goods because of different traditions, values, life styles and perceptions at two sides of a border between or within countries.

- Linguistic barriers are invisible barriers discouraging the exchange of people or goods across a border between countries or regions with different languages.

By the same token, non-spatial linkages between areas may be considered. For instance, economic exchange between regions with complementary industrial composition will be more intensive than it is to be expected form their distance and size. Barriers may also be expressed as

negative linkages. For instance, exchange of people and goods between regions with the same culture and language will be more intensive than between regions with different cultures and languages.

Types of transport

The majority of accessibility indicators are expressed in terms of travel. However, if origins and destinations are economic activities (firms or employment), clearly exchange of goods and services is intended. Accessibility for freight transport is explicitly addressed where freight transport is explicitly modelled. Advanced freight accessibility indicators take account of freight-specific terminals such as intermodal terminals or ports or freight-specific modes such as inland waterways. There are to date only few studies on freight accessibility.

Modes

Network-based accessibility indicators may be calculated for road, rail, ferry, inland waterways or air and can be unimodal, multimodal or intermodal: Unimodal accessibility indicators consider only one mode. Multimodal accessibility indicators are aggregates of two or more unimodal accessibility indicators. Intermodal accessibility indicators consider trips by more than one mode taking account of transfers between modes. Among the accessibility indicators reported in the literature, intermodal accessibility indicators are rare, except for rail and maritime freight transport where the start and end of a trip is assumed to be by road..

Spatial resolution

Origins and destinations are located in *areas* representing regions or cities. However, accessibility indicators can be calculated only for *points*, which are defined either by geographical coordinates (when calculating Euclidean distance) or as network nodes (when calculating network impedance). It is therefore not useful to classify accessibility indicators as area-oriented or nodal. All accessibility indicators are nodal, and if accessibility indicators for areas are required, some generalisation is needed.

The most common generalisation is to assume that all origin and destination activities are concentrated in nodal points in the centre of the areas called centroids. This generalisation is acceptable if the areas are small or if only the accessibility of the city centres is of interest in the study.

However, there are important issues of spatial equity concerned with the decline of accessibility with increasing distance from network nodes. If accessibility is represented as a continuous three-dimensional surface, the nodes of the (high-speed) networks are 'mountains' representing, for instance, high-speed rail stations in the city centres, whereas the areas away from the network nodes are 'valleys' representing the 'grey zones' with low accessibility between the network nodes. Accessibility indicators that are to show not only the 'mountains' but also the 'valleys' need to be more spatially disaggregate.

The most straightforward way of calculating more disaggregate accessibility indicators is to increase the number of areas. This is, however, frequently not possible because high-resolution socio-economic data are not available.

Another way to calculate spatially disaggregate accessibility indicators is to disaggregate the socio-economic data from large areas to much smaller uniform raster cells or pixels probabilistically using land cover information from geographical information systems or remote sensing images as ancillary information. By calculating accessibility indicators for each of these pixels, quasi-continuous accessibility surfaces showing not only the 'mountains' of high accessibility but also the adjacent 'valleys' of low accessibility can be created. As with larger areas, estimates of

non-network travel times or cost between pixel centroids and nearest network nodes need to be made.

Equity

Issues of spatial equity arise with respect to differences in accessibility both within and between areas:

- At a regional scale, the decline in accessibility from centroids or network nodes to interstitial areas affects decisions on the linkage between interregional and intraregional transport networks.

- At a European scale, spatial equity is related to the territorial cohesion objective of the European Union to reduce disparities in income between regions. To analyse territorial cohesion, accessibility indicators may be calculated for specific groups of regions or cities to identify inequalities in accessibility between rich and poor, central and peripheral, urban and rural, nodal and interstitial areas.

In addition, accessibility indicators can be used to study peripherality. The political and economic significance of peripherality issues has grown as a result of the enlargement of the European Union by the accession of the new member states in central and eastern Europe. A peripheral region is a region which is distant in terms of travel time and travel cost from opportunities, activities or assets existing in other regions – in short, a peripheral region is characterised by low accessibility. Accessibility indicators are conditioned by a number of factors. Transport networks cover the territory of the European Union unevenly and differ in relevance with respect to the requirements of individual regions, partly due to the fact that the regional division of labour and social stratification has been adapted to differences in accessibility.

This implies that accessibility indicators which may be highly relevant to core regions might be of secondary relevance for peripheral regions. This has implications for policy-making: the priorities for improving accessibility are likely to differ between peripheral and core regions. However, even if the interests of peripheral regions were given more weight in European transport policy, it is unlikely that the locational disadvantage of peripheral regions will ever be completely compensated by transport infrastructure. To analyse the difference between accessibility due to 'pure' geographical position and accessibility in transport networks, accessibility indicators based on Euclidean distance may be used as benchmarks against which improvements in network accessibility can be measured.

Dynamics

Accessibility is not static. Accessibility based on Euclidean distance changes with the distribution of socio-economic variables. Network-based accessibility changes both with socio-economic variables and with transport networks or levels of service of transport. To analyse the dynamics of accessibility, accessibility indicators can be calculated for different points in time, for instance to show changes in accessibility induced by TEN projects or other transport policies. By comparing the spatial distribution of accessibility with and without the projects or policies, it can be assessed whether the projects or policies would lead to convergence or divergence in accessibility between areas. A critical issue here is to apply meaningful measures of convergence and divergence, as commonly used cohesion indicators measure only relative and not absolute differences between distributions. However, with appropriate cohesion indicators, accessibility analysis can be used to monitor and forecast the achievement of cohesion goals of the European Union.

Generic accessibility indicators

In this section a classification of accessibility indicators is proposed that encompasses a great variety of possible indicators in three generic types.

In general terms, accessibility is a construct of two functions, one representing the activities or opportunities to be reached and one representing the effort, time, distance or cost needed to reach them:

$$A_i = \sum_j g(W_j)\, f(c_{ij})$$

where A_i is the accessibility of area i, W_j is the activity W to be reached in area j, and c_{ij} is the generalised cost of reaching area j from area i. The functions $g(W_{ij})$ and $f(c_{ij})$ are called *activity functions* and *impedance functions*, respectively. They are associated multiplicatively, i.e. are weights to each other. That is, both are necessary elements of accessibility. A_i is the total of the activities reachable in areas j weighted by the ease of getting from i to j. It is easily seen that this is a general form of potential, a concept dating back to Newton's Law of Gravitation. According to the Law of Gravitation, the attraction of a distant body is equal to its mass divided by its squared distance. The gravity model of regional science is somewhat more general, it states that the attraction of a distant location is proportional to its size (e.g. population) weighted by a decreasing function of its distance.

In the context of accessibility, the 'size' are the activities or opportunities in areas j (including area i itself), and the 'distance' is the spatial impedance c_{ij}. The interpretation here is that the greater the number of attractive destinations in areas j is and the more accessible areas j are from area i, the greater is the accessibility of area i. This definition of accessibility is referred to as destination-oriented accessibility. In a similar way an origin-oriented accessibility can be defined: The more people live in areas j and the easier they can visit area i, the greater is the accessibility of area i. Because of the symmetry of most transport connections, destination-oriented and origin-oriented accessibility tend to be highly correlated.

However, the generic equation of accessibility above is more general than the gravity model. Different types of accessibility indicators can be generated by specifying different forms of functions $g(W_j)$ and $f(c_{ij})$:

- *Travel cost*. If only destinations of a certain kind, e.g. cities beyond a certain size, are considered (the activity function is rectangular), and the impedance function is travel time or travel cost itself (i.e. the impedance function is linear), the accessibility indicator is total or average travel cost to a predefined set of destinations.

- *Daily accessibility*. If only destinations within a certain travel time are considered (the impedance function is rectangular), and the destinations are taken as is (the activity function is linear), the accessibility indicator measures the number of potential destinations (customers, business contacts, tourist attractions, etc.) that can be reached in a given time, e.g. a day.

- *Potential*. If the impedance function takes travel behaviour into account, i.e. the diminishing inclination to travel long distances (the impedance function is nonlinear, e.g. exponential), the accessibility indicator is a potential indicator. The activity function may take account of agglomeration effects or economies of scale (i.e. may be nonlinear, e.g. a power function).

Table 2 shows the most frequent specifications of $g(W_j)$ and $f(c_{ij})$ for the three types of accessibility indicator, where W_{min} and c_{max} are constants and α and β parameters:

Table 2. Accessibility indicators

Type of accessibility	Activity function $g(W_j)$	Impedance function $f(c_{ij})$
Travel cost Travel cost to a set of activities	$W_j \,\begin{vmatrix} 1 \text{ if } W_j \geq W_{min} \\ 0 \text{ if } W_j < W_{min} \end{vmatrix}$	c_{ij}
Daily accessibility Activities in a given travel time	W_j	$1 \text{ if } c_{ij} \leq c_{max}$ $0 \text{ if } c_{ij} > c_{max}$
Potential Activities weighted by a function of travel cost	W_j^α	$\exp(-\beta c_{ij})$

Travel cost

This indicator is based on the assumption that not all possible destinations are relevant for the accessibility of an area but only a specified set. This set may, for instance, consist of all cities over a specified size or level of attraction W_{min}. The indicator measures the accumulated generalised travel costs to the set of destinations. In the simplest case no distinction is made between larger and smaller destinations, i.e. all destinations in the set get equal weight irrespective of their size and all other destinations are weighted zero (the activity function is rectangular). In many applications, however, destinations are weighted by size (the activity function is linear). The impedance function is always linear, i.e. does not take into account that more distant destinations are visited less frequently.

Travel cost indicators are popular because they are easy to interpret, in particular if they are expressed in familiar units such as average travel cost or travel time. Their common disadvantage is that they lack a behavioural foundation because they ignore that more distant destinations are visited less frequently and that therefore their values depend heavily on the selected set of destination, i.e. the arbitrary cut-off point of the W_j included.

Daily accessibility

This indicator is based on the notion of a fixed budget for travel, generally in terms of a maximum time interval in which a destination has to be reached to be of interest. The rationale of this accessibility indicator is derived from the case of a business traveller who wishes to travel to a certain city, conduct business there and return home in the evening. Maximum travel times of three to five hours one-way are used. Because of its association with a one-day business trip this type of accessibility is often called 'daily accessibility'.

The daily accessibility indicator is equivalent to a potential accessibility (see below) with a linear activity function and a rectangular impedance function, i.e. within the selected travel time limit destinations are weighted only by size, whereas beyond that limit no destinations are considered at all. Daily accessibility indicators, like the travel cost indicators above, have the advantage of being expressed in easy-to-understand terms, e.g. the number of people one can reach in a given number of hours. However, they also share their disadvantage that they heavily depend on the arbitrarily selected maximum travel time beyond which destinations are no more considered.

Potential accessibility

This indicator is based on the assumption that the attraction of a destination increases with size *and* declines with distance or travel time or cost. Therefore both size and distance of destinations are taken into account. The size of the destination is usually represented by area population or some economic indicator such as total area GDP or total area income. The activity function may be linear or nonlinear. Occasionally the attraction term W_j is weighted by an exponent α greater than one to take account of agglomeration effects, i.e. the fact that larger facilities may be disproportionally more attractive than smaller ones. One example is the attractiveness of large shopping centres which attract more customers than several smaller ones that together match the large centre in size. The impedance function is nonlinear. Generally a negative exponential function is used in which a large value of the parameter β indicates that nearby destinations are given greater weight than remote ones.

Indicators of potential accessibility are superior to travel cost accessibility and daily accessibility in that they are founded on sound behavioural principles of stochastic utility maximisation. Their disadvantages are that they contain parameters that need to be calibrated and that their values cannot be easily interpreted in familiar units such as travel time or number of people. Therefore potential indicators are frequently expressed in percent of average accessibility of all areas or, if changes of accessibility are studied, in percent of average accessibility of all areas in the base year of the comparison.

Extensions

There is a large number of extensions of the above generic accessibility indicators. Three of them will be addressed in this project:

Multimodal accessibility

All three types of accessibility indicator can be calculated for any mode. At a European scale, accessibility indicators for road, rail and air are most frequently calculated. In most studies accessibility indicators were calculated for passenger travel only; there are to date only few studies calculating freight accessibility indicators. Differences between modes are usually expressed by using different generalised costs taking into account travel time, travel distance and convenience of travel. In addition, there may be a fixed travel cost component as well as cost components taking account of network access at either end of a trip, waiting and transfer times at stations, waiting times at borders or congestion in metropolitan areas.

Modal accessibility indicators may be presented separately in order to demonstrate differences in accessibility between modes. Or they may be integrated into one indicator expressing the combined effect of alternative modes for a location. There are essentially two ways of integration. One is to select the fastest mode to each destination, which in general will be air for distant destinations and road or rail for short- or medium-distance destinations, and to ignore the remaining slower modes. Another way is to calculate an aggregate accessibility measure combining the information contained in the modal accessibility indicators by replacing the generalised cost c_{ij} by the 'composite' generalised cost

$$\bar{c}_{ij} = -\frac{1}{\lambda} \ln \sum_m \exp\left(-\lambda\, c_{ijm}\right)$$

where c_{ijm} is the generalised cost of travel by mode m between i and j and λ is a parameter indicating the sensitivity of travellers to travel cost. This formulation of composite travel cost is superior to average travel cost because it makes sure that the removal of a mode with higher cost (i.e. closure of a rail line) does not result in a – false – reduction in aggregate travel cost. This way of

aggregating travel costs across modes is theoretically consistent only for potential accessibility. No consistent ways of calculating multimodal accessibility indicators for travel cost and daily accessibility exist.

Intermodal accessibility

A further refinement is to calculate *intermodal* accessibility. Intermodal accessibility indicators take account of trips involving two or more modes. Intermodal accessibility indicators are most relevant for logistic chains in freight traffic such as rail freight with feeder transport by lorry at either end. Intermodal accessibility indicators in passenger travel involve mode combinations such as Rail-and-Fly or car rentals at railway stations and airports. The intermodal generalised cost function consequently contains further additional components to take account of intermodal waiting and transfer times, cost and inconvenience. The calculation of intermodal accessibility indicators requires the capability of minimum path search in a multimodal network.

Regional accessibility

Intermodality is also an issue when calculating *intra-area* or regional accessibility. Most accessibility studies so far have concentrated on the accessibility of cities, i.e. network nodes which are assumed to represent the whole metropolitan area or even a larger region. This presents two problems:

- Accessibility indicators calculated for network nodes ignore that accessibility is continuous in space. The decline of accessibility from the central node (centroid) of a region to smaller towns and less urbanised parts of the region is not considered.

- The quality of the interconnections between the high-speed interregional and the low-speed local transport networks cannot be taken into account. Yet the ease of getting from home or office to the nearest station of the high-speed rail network or the next international airport may be more important for the accessibility of a location than the speed of the long-distance connection from there.

In addition the estimation of access times from locations within the area to the centroid as well as of travel times between locations within the area itself ('self-potential'), which greatly influence the accessibility of an area, increases in difficulty with spatial aggregation. There have been numerous proposals for approximate solutions to the problem of 'self-potential'. Most of them concentrate on the selection of an appropriate fictitious 'internal' distance or travel time estimated as a function of the radius of the area. A really satisfactory solution of the problem of calculating intra-area accessibility requires high-resolution data on the spatial distribution of activities in the region. If also the quality of the intraregional transport network and its connection with the long-distance interregional networks are to be assessed, detailed information on the intraregional road and public transport networks and the transfer possibilities at railway stations and airports are required.

Research concept

The project will be based on and extend the state of the art of accessibility analysis in Europe presented in the previous sections:

- It will take up and update the results of existing studies on accessibility at the European scale using most recent available network and socio-economic data.

- It will extend the range of accessibility indicators by further indicators responding to new policy questions and further developing the quality and validity of the existing indicators.

- It will extend the spatial resolution of accessibility indicators by calculating accessibility indicators for both the global and the regional scale.

- It will explore the likely impacts of available policies at the European and national scale to improve global, European and regional accessibility in the light of new challenges, such as globalisation, energy scarcity and climate change.

To achieve this, the research in the project will be divided into seven Tasks:

- Task 1: Methodology/indicators
- Task 2: Network and socio-economic data
- Task 3: European accessibility: travel
- Task 4: European accessibility: freight transport
- Task 5: Regional accessibility
- Task 6: Impacts of accessibility
- Task 7: Policy implications

With this concept the project starts from the standard accessibility indicators developed in ESPON 1.2.1, 1.1.1, 2.1.1 and 1.1.3 and the recent Accessibility Updates and extends these to first freight accessibility and global accessibility and then to the regional/local level of intraregional accessibility in regional case studies. By exploring several alternative ways of calculating regional/local accessibility indicators and comparing them with European accessibility indicators, the added value of more detailed accessibility indicators will be assessed.
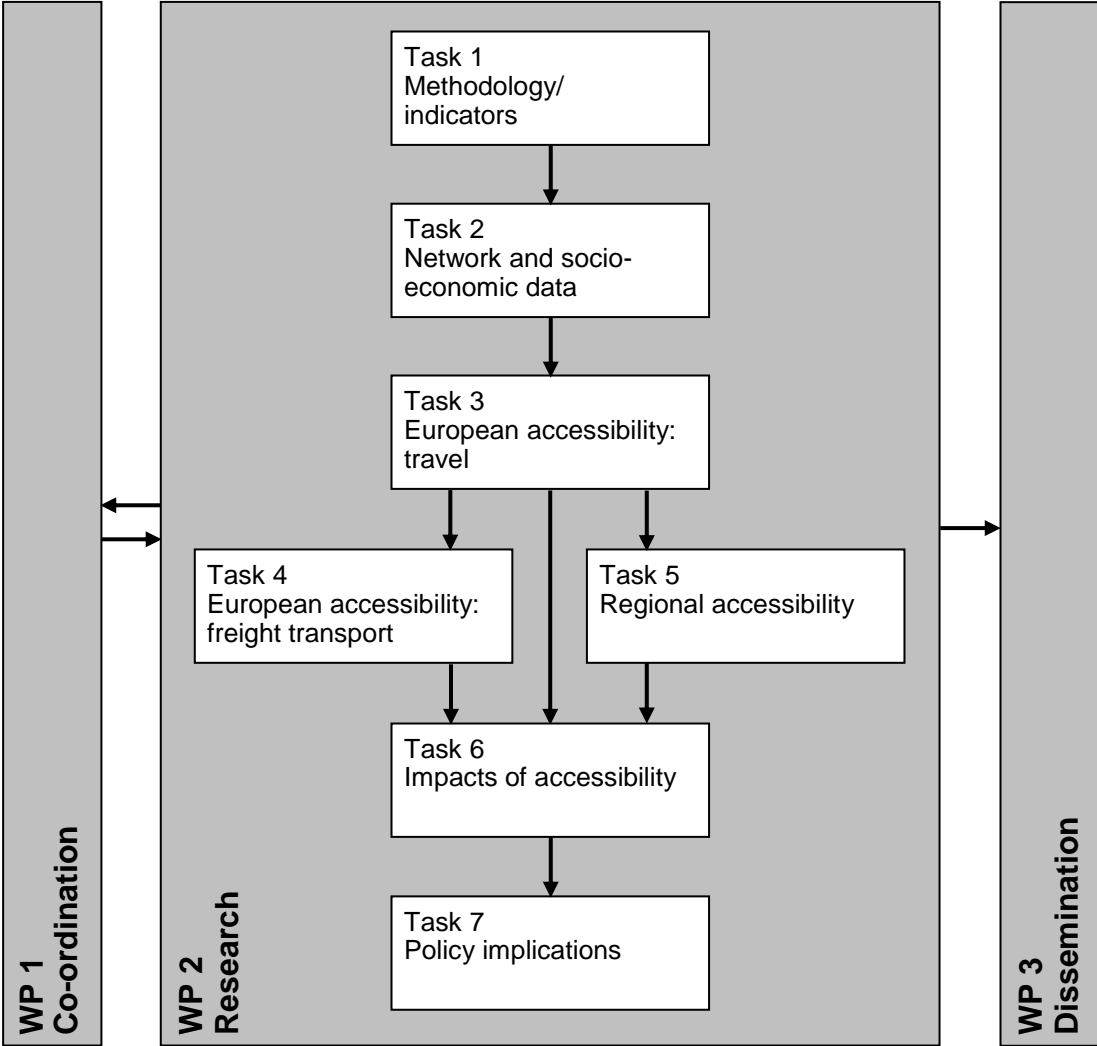
The expected results of the project will be

- a consistent set of European network and regional socio-economic data
- a database of various accessibility indicators at NUTS-3 level
- evidence on the relationship between accessibility and regional development (GDP per capita, energy consumption and greenhouse gas emissions by transport)
- case studies of regional accessibility in different types of regions
- exploratory research on Europe-wide regional accessibility
- policy-relevant findings, policy conclusions and suggestions for further research

Geographical coverage of the analyses will be NUTS-3 or equivalent regions in all countries participating in the ESPON 2013 Programme plus the EU candidate countries Croatia and FYR Macedonia and the other countries of the Western Balkans Bosnia and Herzegovina, Serbia, Montenegro, Albania and Kosovo and larger regions in neighbouring countries and the rest of the world. Smaller areas will be used in the regional case studies (see Chapter 7).

Figure 1 shows the Work Packages and Tasks of the project and the main linkages between them.

Figure 1. Work Packages and Tasks

4 Research approach

This chapter describes the research activities of the project in detail. For each of the seven Tasks the key research questions, the methodology and the expected results are given. Each Task is further broken down into Subtasks.

4.1 Methodology/indicators

There are numerous notions of accessibility. Accessibility is a very complex concept that has multiple dimensions, such as origins and destinations, spatial impedance, constraints and barriers, types of transport purposes and transport modes, spatial scale, equity and dynamics (see Table 1). In consequence, there is a huge variety of accessibility indicators addressing these dimensions in very different ways for different scientific or policy purposes.

The objective of the first Task of the project is therefore to review the existing methods and indicators for different types of transport, transport modes and spatial scales, to improve the methods to measure European accessibility by calculating other indicators than potential accessibility and to extend them by calculating not only European travel accessibility as done so far but also freight accessibility and global and regional accessibility.

Task 1 Methodology/Indicators

The Task will start with a thorough review of the state of the art of accessibility research. There are several Europe-wide accessibility models available, and there exist an even larger number and variety of accessibility models at the regional and local scale. There is a vast range of journal articles and research reports on how to measure accessibility at different spatial scales, for different types of travel and transport and by different travel and transport modes. Based on this review, this Task is to define the methodology of the project.

The following key research questions will be addressed:

- What is the state of the art of accessibility modelling at the global, European and regional scale?
- What is the state of the art of existing models to forecast the impacts of accessibility changes on regional economic development?
- How can existing ways of measuring accessibility be improved?
- What are feasible options to integrate different transport modes into intermodal accessibility indicators?
- What are innovative ways of measuring accessibility at different spatial scales?
- What can be considered as a core set of accessibility indicators for ESPON?

Subtask 1.1 European and global accessibility models and indicators

There are several Europe-wide accessibility models available. Only few of them address accessibility in a global context. This Subtask will review existing accessibility models at the European and global scale. The review will categorise existing models with respect to methods and indicators structured along the different dimensions of accessibility. First conclusions on the usability of the analysed methods and indicators for the project will be drawn.

Particular attention will be paid to earlier work on European accessibility in the Study Programme on European Spatial Planning (SPESP) and in previous ESPON projects 1.2.1, 1.1.1, 2.1.1, 1.1.3 and the recent Accessibility Updates.

First results of this review are summarised in Chapter 5 of this report.

Subtask 1.2 Regional and local accessibility models and indicators

There exist an even larger number and variety of accessibility models at the regional and local scale. This Subtask will review accessibility models at the regional and local scale. The review will categorise the models with respect to methods and indicators structured along the different dimensions of accessibility. First conclusions on the usability of the analysed methods and indicators for the project will be drawn.

Subtask 1.3 Models to forecast the impacts of accessibility on regions

Accessibility is an important location factor for households and firms and so influences regional development. Accessibility also affects the demand for transport and hence energy consumption and greenhouse gas emissions. Methods to forecast the impacts of transport infrastructure investments and other transport policies to improve accessibility and regional economic performance are therefore of high relevance for policy making. This Subtask will review existing models that address the relationship between transport infrastructure investments and other transport policies on accessibility, regional economic development, energy consumption and greenhouse gas emissions by transport and make recommendations for the modelling of scenarios in Task 6.

Subtask 1.4 Core set of accessibility indicators

This Subtask will draw conclusions from the reviews in the previous Subtasks to define a core set of accessibility indicators to be implemented in the project. A set of criteria for the selection of accessibility indicators for the core set will be developed addressing issues such as theoretical relevance, policy relevance, comprehensiveness and feasibility. Specific attention will be given to the improvement of accessibility indicators developed in earlier ESPON projects.

Expected results

The results of this Task will include overviews on the state of the art of accessibility research from the global to the local scale and of assessing the impacts of accessibility improvements on regional development, energy consumption and greenhouse gas emissions by transport. This will lead to a proposal for of a set of core accessibility indicators for the ESPON Programme, which will be implemented in the subsequent Tasks.

4.2 Network and socio-economic data

The calculation of accessibility indicators and the modelling of regional impacts of accessibility improvements require network and socio-economic data. Transport networks data are needed for road, rail, water and air networks, for both passenger travel and freight transport. The network data must contain the necessary attributes for the calculation of the accessibility indicators defined in Task 1, must have the necessary geographical coverage and spatial resolution and must describe the network evolution in past years and in the form of scenarios of the further development of the *Trans-European Transport Networks* (TEN-T) and the national outline plans in future years to allow the analysis of the dynamics of accessibility and the impacts of transport infrastruc-

ture investments and other transport policies on accessibility and regional development, energy consumption and greenhouse gas emissions.

In addition accessibility models require regional socio-economic data of the study area in the needed sectoral, spatial and temporal resolution to be used as destinations in the models.

Task 2 Network and socio-economic data

At the European level several transport network databases exist that might be used for this project. At the regional level the Project Partners have access to regional transport network data that can be used as starting points for the regional case studies.

The objectives of this Task are to evaluate existing network and socio-economic databases in the light of the requirements for the calculation of the accessibility indicators defined in Task 1 and to compile appropriate databases for the subsequent Tasks. Key research questions in Task 2 are:

- Which existing European network data can be used for the project, and which additional network data will have to be collected?

- Which existing socio-economic data can be used for the project, and which additional socio-economic data will have to be collected?

- Which regional transport network databases exist at Project Partners, and to which degree do they need to be enhanced to meet the project requirements?

- Which statistical data are at hand at Project Partners, and which alternative data sources need to be investigated to set up a comprehensive database for the individual regional case studies?

- What is the data situation in the EU candidate countries and in Western Balkan countries both with respect to transport network data and statistical data at regional level, allowing extension of the Europe-wide models to include these countries in the analysis?

Following these research questions, Task 2 is subdivided into four subtasks:

Subtask 2.1 European network data

This Subtask will review available European network databases, such as TRANS-TOOLS, Eurostat GISCO/DG Move, ESRI's Digital Charts of the World (DGTW), OpenStreetMap (OSM), Navteq, TeleAtlas, OAG and the network data of the Project Partners. First, it will develop evaluation criteria for the assessment of network databases, such as general data availability, available modes, spatial coverage, network density and network topology, actuality and temporal dimension (past and actual years), information on travel times, speeds and/or costs, data format, price and legal restrictions, model requirements and flexibility, and whether the database contains also past and future network states. Second, based on this evaluation, decisions about the network database(s) to be used and/or developed in Subtask 2.3 will be made.

Specific attention will be given in this Subtask to the data situation in the EU candidate countries and Western Balkan countries, whether or not the assessed network databases also cover these countries.

The outcome of this Subtask is an overview about existing European network databases and an evaluation of their potentials for being used for the Europe-wide passenger travel and freight transport modelling in Tasks 3 and 4. A recommendation will be given which database shall be used and implemented in the European wide travel and freight modelling.

During the evaluation process the Project Partners will strive to harmonise the used databases as far as possible across all models, but, following the different model requirements, the database

shall also be customised to the models as far as needed. Data harmonisation is needed in order to ensure comparability of the model results later on.

Subtask 2.2 Socio-economic data

This Subtask will review the availability of Europe-wide socio-economic data to be used as destinations for the calculation of the accessibility indicators defined in Task 1, such as population, employment or GDP per capita, in the required sectoral, spatial and temporal resolution and will make recommendations for developing the project database of socio-economic data in Subtask 2.3. The actual list of required socio-economic data on the one hand depends on the model requirements of the Europe-wide accessibility models and on the other hand is subject to the innovative accessibility indicators identified in Task 1. For innovative accessibility indicators, raster-based representations of activities, e.g. population, will be developed.

Similar to the network databases, the socio-economic data need to be harmonised for all models to allow comparisons of results and indicators, with respect to the spatial resolution (i.e. NUTS level), the temporal dimension (base year, past years/time series, future horizons/projections), data definitions and data units.

Specific attention will be given also in this Subtask to the data situation in the EU candidate countries and Western Balkan countries, whether or not the required socio-economic data are available in these countries in the required spatial and temporal disaggregation. Special concern will be given to the spatial level for which the data are available, as this level should ideally match the spatial level of the models applied in the European member states.

Subtask 2.3 European network and socio-economic data

Based on the review in Subtasks 2.1 and 2.2, this Subtask will compile the network and socio-economic data necessary for the accessibility and impact modelling at the global and European scale. The data will cover all countries participating in the ESPON 2013 Programme plus the EU candidate countries Croatia and FYR Macedonia and the other countries of the Western Balkans Bosnia and Herzegovina, Serbia, Montenegro, Albania and Kosovo plus larger regions in neighbouring countries and other parts of the world, as far as the data availability allows to include these countries.

Subtasks 2.3 will also pre-process the collected data in a way to forward standardised, harmonised and complete datasets to the models. In agreement with the model requirements of Tasks 3 and 4, the data will be forwarded to the models in the agreed data format and data structure.

Subtask 2.4 Regional network and socio-economic data

This Subtask will compile the network and socio-economic data for the regional case studies once the case studies have been selected. The data will cover road, rail and water networks as well as population, work places, etc., and major transport nodes, such as long-distance railway stations, airports, seaports and logistics centres in the case study regions.

Most of these data are already available with the Project Partners, however, certain data gaps and data insufficiencies will be identified in this Subtask, and alternative data sources will be approached to enhance existing data.

In certain cases it might become necessary to contact national data providers to clarify legal issues, i.e. to obtain permission to use the data in the framework of ESPON TRACC.

Unlike the network and socio-economic data to be used for the Europe-wide modelling, which should be harmonised as far as possible, there will be no centralised and harmonised database

for all regional case studies, but, reflecting the individual character of each case study, there will be individual databases for each case study or macro region compiled by the Project Partners. Nonetheless it will be important to harmonise the regional case studies to some degree, i.e. in terms of the spatial resolution used (for instance, NUTS-5 level), the spatial extent and the set of indicators calculated, to allow for comparisons of results.

Expected results

The final outcomes of this Task are network and socio-economic datasets customised for all accessibility and impact modelling in this project at all scales addressed based on the comprehensive overview and assessment of available network and socio-economic databases.

At the European scale the databases will be harmonised as far as possible across all models, while at the regional scale there will be individual databases for each case study.

Task 2 will also provide an overview about data availability in the EU candidate countries and Western Balkan countries, helping to address the question whether or not the Europe-wide models can be extended to these countries.

Several databases to be used for the development of the internal project databases may be subject to intellectual property rights. This is particularly likely for the transport network databases. Most of them may be legally used in the project. However, to what extent the network databases compiled in the project may become part of the overall ESPON database will be subject to further investigation.

4.3 European accessibility: travel

Fast and reliable travel over long distances has become the signature of modernity and one of the essential prerequisites for the competitiveness of regions and regional economic development. In a globalised world, international gateways, such international airports have become origins and destinations of equal importance as the locations of central business centres of global cities.

Because of this, transport has continued to grow faster than GDP per capita. In particular road transport, because of its efficiency and flexibility, has grown much faster than transport by rail and is today the fastest growing source of energy consumption and greenhouse gas emissions of all sectors of human activity. Only air travel, in particular long-distance intercontinental trips, has experienced similar growth rates.

European transport policy therefore has to find a tradeoff between promoting accessibility for travel in the interest of quality of life and competitiveness and at the same time making travel more sustainable in the interest of energy conservation and the achievement of greenhouse gas reduction targets.

Task 3 European accessibility: travel

This Task is to provide the knowledge needed for making rational policy choices for this tradeoff. For this the following research questions are to be answered:

- What is the accessibility of European regions for travel by different modes (road, rail, air) at the European level?

- What is the accessibility of European regions for air travel at the global level?

- What is the potential of intermodal travel, in particular the combination of high-speed rail and air?

- What would be the impacts of different policies to make rail more competitive on the modal share of travel and travel accessibility?

- What are the most favoured urban centres and most disadvantaged regions with respect to travel accessibility (island, mountain areas)?

The method for calculating travel accessibility indicators will start from the potential accessibility indicators with population and GDP as destination activities. developed and applied in ESPON 1.2.1, 1.1.1, 2.1.1 and 1.1.3 and the recent Accessibility Updates for ESPON.

In those studies the potential accessibility indicator for road, rail, air and multimodal travel was calculated for the years 2001 and 2006. The first part of the calculation of European travel accessibility will be to calculate this type of potential accessibility indicator for the year 2011 based on updates of the networks and the accessibility model used previously (Subtask 3.1). This allows the comparison of the development of European accessibility over a period of ten years.

Then, these standard accessibility indicators will be extended in three directions:

- First, the critique on the standard potential accessibility indicator, i.e. that each region is represented only by a centroid, will be addressed by using instead of centroids a raster representation of population based on the EEA population grid as destinations in the accessibility model. The appropriate size of the raster cells will have to be determined; reasonable sizes might range between 2.5x2.5 km and 10x10 km. This refined accessibility model will be run with the same networks as before, i.e. the model will provide raster-based potential accessibility patterns for the years 2001, 2006 and 2011. The results of this disaggregate accessibility approach will be compared with the standard centroid-based indicators to assess the advantages of having more spatial detail with the disadvantage of higher computation efforts. This extension will be part of Subtask 3.1

- Other types of accessibility indicators than potential accessibility, such as intermodal accessibility (road/air and rail/air), daily accessibility (number of population reached in one day) and average travel time/distance to major destinations (see Chapter 3) will be calculated and their explanatory power and policy-relevance compared with those of the standard potential accessibility. Intermodal accessibility indicators will require an intermodal network database, for average travel time/distance and daily accessibility special software will be developed (Subtask 3.2).

- Global accessibility indicators measure accessibility to destinations in other continents outside Europe by air, but also selected road and rail connections to Asia. It will be examined whether potential accessibility or simpler connectivity indicators are more appropriate. The indicators will consider travel time and travel cost to the nearest airport and waiting times and political, cultural and language barriers at borders (Subtask 3.3).

Geographical coverage of the analysis are NUTS-3 or equivalent regions in all countries participating in the ESPON 2013 Programme plus the EU candidate countries Croatia and FYR Macedonia and the other countries of the Western Balkans Bosnia and Herzegovina, Serbia, Montenegro, Albania and Kosovo (see Chapter 7). When calculating European accessibility, also destinations in neighbouring countries, such as Belarus, Moldova, Russia, Turkey and Ukraine will be considered, when calculating global accessibility, destinations in all world regions.

The analysis will be performed using the most recent available network and socio-economic data (see Chapter 7). Where possible accessibility data from previous ESPON projects (ESPON 1.2.1, ESPON 2.1.1 and the latest Accessibility Update for ESPON) will be included and updated

It will be examined to what degree policies to change the parameter of accessibility, such as transport network improvements, in particular high-speed rail connections, continued European integration or rising transport costs due to taxation, road pricing or higher fuel costs will influence the patterns of travel accessibility.

The results of the different accessibility indicators will also be used to develop typologies of European and global accessibility patterns..

Subtask 3.1 European travel accessibility

This Subtask will calculate potential travel accessibility by road, rail and air and multimodal accessibility to destinations in Europe and neighbouring countries. The indicators will consider travel time and travel cost and waiting times at borders and political, cultural and language barriers. As an alternative to centroid-based also raster-based accessibility indicators taking account of the intraregional distribution of population will be tested. It will be examined to what degree policies to change these parameters, such as transport network improvements, in particular high-speed rail connections, continued European integration or rising travel costs due to taxation, road pricing or higher fuel costs will influence the patterns of travel accessibility.

Subtask 3.2 European travel accessibility measured by other indicators

This Subtask will calculate further indicators of travel accessibility other than potential accessibility by road, rail and air to destinations (population and GDP) in Europe and neighbouring countries, such as

- average travel time/distance to major destinations
- daily accessibility (number of businesses reached in one day)
- intermodal accessibility (road/air and rail/air)

These indicators will consider travel time and travel cost and political, cultural and language barriers at borders. It will be examined to what degree policies to change these parameters, such as transport network improvements, in particular high-speed rail connections, continued European integration or rising transport costs due to taxation, road pricing or higher fuel costs will influence the patterns of travel accessibility.

This Subtask will also provide a platform for innovation and experiments with new types of accessibility indicators and advanced ways of visualisation of results. As such new types of indicators basically require the same input data as more traditional types of indicators, the additional effort focuses less on data issues but on concepts, ideas and experiments, i.e. the specification and implementation of such new indicators will be part of the process.

Subtask 3.3 Global travel accessibility

This Subtask will calculate intercontinental travel accessibility to destinations (population and GDP) in other continents outside Europe. The most relevant mode will be air, but also road and rail connections to Asia, such as the Trans-Siberian Railway and the Bosphorus Bridge, will be considered. It will be examined whether potential accessibility or simpler connectivity indicators are more appropriate. The indicators will consider travel time and travel cost to the nearest airport and waiting times and political, cultural and language barriers at borders. It will be examined to what degree policies to change these parameters, such as transport network improvements, in particular high-speed rail connections, continued European integration or rising transport costs due to taxation, road pricing or higher fuel costs will influence the patterns of travel accessibility.

Expected results

The results of Task 3 will be a unique set of standard and new accessibility indicators implemented for the European territory. These indicators will show the development of accessibility patterns in Europe for the last decade and for possible future situations. The accessibility pattern

will be transformed into European and global accessibility typologies. The results will be presented in maps of the ESPON territory and the Western Balkan showing the spatial distribution of the different travel accessibility indicators by road, rail, air and combinations of these modes at the global and European level.

4.4 European accessibility: freight transport

One of the elements that have shaped globalisation in the recent decades is the decline of freight transport costs. This has allowed companies to outsource several phases of the production chain at different scales: regional, national and international. Because of this fragmentation of the value chain, freight transport has become the fastest growing type of transport. In particular freight transport by road, because of its efficiency and flexibility, has grown much faster than freight transport by rail and waterways and is today the fastest growing source of energy consumption and greenhouse gas emissions of all sectors of human activity. Only freight transport by air, in particular on long-distance intercontinental connections, has experienced similar growth rates.

Fast and reliable freight transport from production to markets has therefore become one element of regional competitiveness and economic development. International gateways, such as seaports and airports have become origins and destinations of equal importance as the locations of production and consumption. In brief: accessibility for freight transport has become more and more significant. At the same time, much less attention has been devoted in the literature to produce freight accessibility indicators.

Task 4 European accessibility: freight transport

This Task of the project is aimed at producing accessibility indicators for freight that take into account specific features of goods movement such as:

- Terminal operations can explain a significant share of travel time (especially for some commodity groups).

- Many non-road consignments are actually intermodal.

- In some cases borders are less easily permeable than for passengers.

In the following, the main methodological aspects that will be dealt with are presented. The methodology is introduced with reference to the different accessibility indicators that will be considered: European accessibility measured as potential accessibility, European accessibility measured by other indicators and global accessibility.

Subtask 4.1 European freight potential accessibility

This subtask will calculate freight accessibility for selected commodities by road, rail, water (inland waterways and short-sea shipping) and air to destinations in Europe and neighbouring countries.

As a first step, general criteria will be defined, such as:

- Which elements should define the impedance function of the potential accessibility?

- Which elements should define the attractiveness of destinations?

- Which different commodity types should be adopted?

- How to deal with intermodality?

- How to compute a multimodal accessibility index?

With respect to impedance, the first choice to be explored will be whether to use travel time or travel cost or both, i.e. generalised cost as impedance. For better sensitivity of the impedance term to alternative conditions (e.g. increase of energy cost, transport policies like road charging) both cost and time might be separated. In particular, terminal costs and times should be explicitly considered, but also travel costs could be split into more elements where possible and relevant. For instance, in case of lorries, time components could include onboard time, waiting time at borders and resting times due to maximum number of driving hours, whereas cost components could distinguish energy cost and toll cost. Also times and costs of loading and unloading could be part of generalised costs.

As destinations alternative measures will be considered including GDP per capita, number of jobs, number of productive units, etc.

A segmentation into different commodity types should reflect differences with respect to impedance or destinations. For instance, travel time could be very different for different types of goods. One criterion for segmentation could be handling categories (i.e. bulk, container, general cargo).

Intermodality is a 'natural' condition of most non-road freight consignments. In many cases rail transport means combined transport (rail and road). Maritime and air freight are also linked to land transport from/to ports and airports. Impedance for non-road modes will therefore be calculated as impedance of mode chains adding time and cost between zone centroids and terminals whenever relevant.

For multimodal accessibility index, the first candidate will be the composite cost defined in Chapter 3. Alternative measures will be considered if interesting suggestions of other approaches will be found.

The approach selected will depend both on theoretical and practical considerations. On the theory side the outcome of Task 1, in which methods and indicators will be reviewed, will provide relevant information and suggestions. On the practical side the availability of data and the effort needed to combine them will play a key role in designing and approach that is both rigorous and not too ambitious or disproportionate for this project.

Once these methodological issues will be sorted out, the further step will consist of collecting the data required for computing the accessibility indicators. Here the results of the review f data availability in Task 2 will be relevant. The TRANS-TOOLS model is expected to be a major source of information for times and costs for different modes although its data could need some integration from other sources. Namely, TRANS-TOOLS does not simulate air freight transport nor ports and intermodal terminals are explicitly coded in the network. Also a sound methodology to reflect changes in travel time and cost will be established.

Subtask 4.2 European freight accessibility measured by other indicators

This Subtask will calculate further indicators of European freight accessibility for the same modes considered for the potential accessibility indicators. Alternative indicators should be useful to emphasise specific aspects of accessibility and to monitor specific policy aspects. It might well be that different indicators will be relevant for different modes of transport.

Examples of other alternative indicators that might be produced are:

- Number of regions that can be reached in 24 hours (relevance: all modes but maritime);

- Number of jobs or productive units that can be reached in 24 hours (relevance: all modes but maritime);

- Number of jobs or productive units that can be reached within legal driving time with just one driver (relevance: road);

- Weight of non-distance related components (e.g. loading/unloading, waiting time at customs) on overall generalised cost (relevance: all modes)

- Availability of alternative modes to reach destinations (or terminal, like ports) within a certain time threshold (relevance: multimodal, maritime);

The final list of other indicators to be provided will be made in the light of data availability.

Subtask 4.3 Global freight accessibility

This Subtask will calculate intercontinental freight accessibility to destinations in continents outside Europe. Obviously it will not be possible to calculate global accessibility indicators for all European regions to all non-European destinations. Therefore relevant origin/destination pairs will be selected, for instance major overseas terminals.

It will be examined whether potential accessibility or simpler connectivity indicators are more appropriate. The concepts and definitions developed for European accessibility in Subtask 4.1 will provide a starting point, but additional methodological and data availability issues will be addressed about measuring times and costs for overseas routes (e.g. cost and time for transhipment at ports) and attractiveness of destinations (e.g. is GDP of destinations more suitable than the amount of trade? If trade is preferable, should it be measured in value or quantity?). Answering this kind of questions will allow to select the indicators for freight global accessibility.

Freight global accessibility will mainly concern maritime and air transport, although road and rail could enter in the analysis for specific destinations. For instance, road freight could be considered for destinations in the Middle East or North Africa, while it will be explored whether significant rail freight service between countries participating in the ESPON 2013 Programme and countries outside Europe exist or might exist such so accessibility by rail is worth to be computed.

A specific analysis on global accessibility will be carried out for intermodal freight accessibility of the hinterlands of the European ports. This analysis will use the strategic model SIMPORT developed by MCRIT that was used to investigate the relative competitiveness of the port of Barcelona, and more in general of Mediterranean ports, in relation to trade coming from outside Europe, mostly from the emerging markets in Asia.

Expected results

The results will be presented in maps of the ESPON territory showing the spatial distribution of the different freight accessibility indicators computed for the various modes and with reference to the different types of accessibility (European potential accessibility, European accessibility measured with other indicators, global accessibility).

First, the indicators will provide an overview of the current situation of the ESPON territory with respect to freight accessibility, answering questions, such as:

- What is the accessibility of European regions for freight by different transport modes?

- What is the accessibility of European regions for freight at the global level?

- What are the most favoured and most disadvantaged regions with respect to freight accessibility (urban centres, island, mountain areas)?

Second, the indicators will allow to measure the impact of alternative scenarios on regional accessibility. Scenarios can include policies such as transport network improvements, reductions of transhipment times, road pricing as well as exogenous trends like continued European integration or higher resource energy costs.

4.5 Regional accessibility

Global and European accessibility are important location factors for firms and working and leisure travel of people. However, for the daily life of citizens regional/local accessibility to jobs, services and public facilities, may be more important than global or European accessibility. On the other hand, to get access to long-distance and international transport services, travellers have to rely on local and regional transport networks. Accessibility, as social and economic development factor, nowadays depends on the regional connection to long-distance transport and communication networks as well as to the physical or geographic distance to large economic centres.

Task 5 Regional accessibility

The objective of this Task is to measure and analyse accessibility at the regional scale for different types of regions in Europe. The following research questions are to be addressed:

- What specific access conditions to long-distance and international transport networks exist in the European regions? How are accessibility and connectivity at the regional/local level, i.e. which activities can be reached in typical daily travel times?

- What are characteristic patterns of regional/local accessibility, i.e. accessibility to different travel modes and what are key infrastructural bottlenecks and barriers at the regional level for long-distance trips?

- How does accessibility by public transport compare to accessibility by road at the regional/local level?

- What would be the advantage of including intermodal accessibility indicators in the analysis of regional/local accessibility as well as including regional/local indicators in the European accessibility measures?

- In which type of regions is the level of European accessibility similar or different to their intraregional accessibility, i.e. are regions with good European accessibility able to translate it into good intraregional accessibility?

Subtask 5.1 Typology of regional accessibility patterns

A review of accessibility studies at the intraregional scale will be performed to find characteristic patterns of accessibility at the regional/local scale. Due to the expertise and geographical distribution of the Project Partners, accessibility studies will be analysed in all ESPON member states, with special emphasis to the macro regions selected for the case studies.

The literature review will cover different types of spatial development areas, such as urban, semi-urban and rural areas, but also islands and mountain regions, remote regions, and different kinds of economically based areas such as tourist, service, industrial or post-industrial centres, etc.

Based on the accessibility patterns found, a typology of regional/local accessibility will be defined that will be used to characterise the different accessibility patterns in different types of regions.

Subtask 5.2 Selection of regional case studies

A number of case study areas at macro regional level (NUTS-0 or NUTS-1) will be selected in this subtask for analysis. The selection criteria to be developed will assure a good geographic coverage of macro regions from Northern Europe to the Mediterranean and from peripheral regions to regions in the European core.

Within each macro region, specific areas will selected (at NUTS-3 or NUTS-2 level) for a detailed analysis of regional/local accessibility patterns. The selection of these case study regions within the macro regions will ensure that different types of regions with different accessibility patterns cover the whole diversity of Europe. Selected case studies will include mountain areas, islands, archipelagos, central and remote rural areas, urban centres within rural landscapes, highly populated metropolitan regions, tourist areas, transborder regions, etc.

A first selection of macro regions and case study regions has already been made. The selection process and the selected regions are described in Chapter 6 of this report.

Subtask 5.3 Case studies on regional accessibility patterns

This Subtask will analyse the accessibility patterns in the selected case study regions, linked to integrated territorial policymaking practice at the regional level. Based on the definitions of accessibility indicators in Task 1, the selection of accessibility indicators calculated in the regional case studies will be harmonised to achieve as comparable outputs as possible.

Each regional case study will consist of three main parts.

- First, a qualitative assessment of territorial and transport infrastructure plans affecting the case study area (at regional, national and EU levels) will be undertaken. The analysis will be done also in relation to the 2010-2020 Transport White Paper and TEN revision.

- Second, qualitative analyses of the regional transport system with respect to existing access points, bottlenecks, and physical barriers will be done.

- Third, the accessibility indicators computed at NUTS-5 level for the macro regions (e.g. endowment, peripherality, connectivity, potential accessibility, level of service) will be analysed in more detail for each case study area. Part of the analyses will be a comparison of accessibility by car and by public transport as well as intermodal transport opportunities.

Subtask 5.4 Europe-wide modelling of regional accessibility

This Subtask will introduce an alternative way to calculating regional accessibility. Based on network and raster-based population databases covering all Europe, it will calculate accessibility indicators at the regional scale for all regions of the ESPON Space. These indicators will mainly be based on car travel. Examples for such Europe-wide indicators at the regional scale are travel times to the next airports or to intercity or high-speed rail stations or the number of persons or workplaces that can be reached within a certain maximum travel time, e.g. within 30 or 60 minutes. The regional accessibility indicators so derived will be compared with the regional accessibility indicators calculated in the regional case studies.

The connection of a given place within a region to networks can be measured in terms of distance, time or generalised cost to get access to network entering nodes and the potential utility that these entering nodes or terminals may deliver to travellers (e.g. measured as the amount of people or the market accessible for daily round-trips, say shorter than 3.5 hours door-to-door). Indicators based on this concept have been applied at European and regional level during the last twenty years using the Indicator of Connection (ICON) complementary to other concepts and methods that will be reviewed in Subtask 5.1.

The mathematical formulation of ICON was defined as simple, flexible and intuitive as possible in order to make it easily applicable and understandable by decision makers. For each network i=1...n, i.e. rail network, airport network, port network, etc., a network-specific value of ICON is calculated. These partial values are summed up in proportion to their relative contribution to transport endowment. The relative proportions (p_i) can be adjusted in relation to the economic

value added of each transport sector or, in a first approach, estimated according to the current modal split. The aggregated value of ICON is then:

$$iCON = \sum_{i=1}^{i=N} p_i iCON_i$$

The main advantage of this formulation is the intuitive meaning of the ICON aggregated value, which is not an abstract index but a measure dimensionally equivalent to each partial ICON value or weighted access time to a network expressed in hours or minutes. On the other hand, the weighted addition is consistent with the strategic and long-term assessment aim of ICON, since it assumes independence between the contributions of each network to the regional endowment. Deficits in a given network resulting in high values of ICON reduce development opportunities.

Subtask 5.5 European vs. regional accessibility

This Subtask will compare the regional accessibility calculated in the regional case studies with those calculated by the method developed in Subtask 5.4 and with the European accessibility calculated in Tasks 3 and 4.

Differences between these and the likely causes of these differences will be analysed to find out which types of region follow the general European accessibility pattern and which types of regions need to be given particular attention due to a mismatch between European and regional accessibility.

Expected results

This Subtask will provide an updated view on regional and local accessibility patterns in Europe. It will result in a typology of regional/local accessibility patterns in different types of regions.

The main delivery of the Task will be the reports on the regional case studies with harmonised analyses of regional/local accessibility. In addition, regional accessibility indicators calculated by the raster method developed in Subtask 5.4 will be presented for NUTS-3 or equivalent regions in all countries participating in the ESPON 2013 Programme plus the EU candidate countries Croatia and FYR Macedonia and other countries of the Western Balkans Bosnia and Herzegovina, Serbia, Montenegro, Albania and Kosovo.

Finally the results of the comparison between the regional accessibility calculated by different methods and between regional accessibility and European accessibility will be presented. All results will be visualised in maps showing the main accessibility patterns.

4.6 Impacts of accessibility

The important role of accessibility for regional development is one of the fundamental principles of spatial economics. In its most simplified form it implies that regions with better access to the locations of input materials and markets will, ceteris paribus, be more productive, more competitive and hence more successful than more remote and isolated regions.

However, the relationship between accessibility and economic development is more complex. There are successful regions in the European core confirming the theoretical expectation that accessibility matters. However, there are also centrally located regions suffering from industrial decline and high unemployment. On the other side of the spectrum the poorest regions, as theory would predict, are at the periphery, but there are also prosperous peripheral regions, such as the Nordic countries. To make things even more difficult, some of the economically fastest growing regions are among the most peripheral ones, such as some regions in the new EU member states.

Accessibility is therefore a central policy variable for spatial policy at all spatial levels from the European to the regional scale. Policies to improve regional accessibility by transport infrastructure investments belong to the most effective policies to stimulate regional competitiveness and economic development. But because more transport also means more energy consumption and greenhouse gas emissions, accessibility also has an ambiguous character.

European transport policy therefore has to find a tradeoff between promoting accessibility for passenger and freight transport in the interest of competitiveness and at the same time making transport more sustainable in the interest of energy conservation and the achievement of greenhouse gas reduction targets.

Task 6 Impacts of accessibility

This Task of the project is to provide the knowledge needed for making rational policy choices for this tradeoff taking not only accessibility itself but also its wider socio-economic and environmental impacts into account. For this the following research questions are to be answered:

- How is accessibility related to regional economic development, employment, energy consumption and greenhouse gas emissions by transport?

- What will be long-term scenarios of European transport policy with respect to transport infrastructure improvements and other transport policies, such as taxation or road pricing?

- What will be the impacts of long-term scenarios of European transport policy on accessibility, regional economic development, energy consumption and greenhouse gas emissions by transport?

- What will be the impacts of rising energy prices on the future development of transport and hence accessibility, regional economic development, energy consumption and greenhouse gas emissions by transport?

Subtask 6.1 Accessibility and regional development

This Subtask will analyse the relationship between different types of accessibility as calculated in Tasks 3 and 4 and regional economic development in terms of economic development (GDP) and the environment (energy consumption and greenhouse gas emissions). Particular attention will be given to the most favoured regions (urban centres) and most disadvantaged regions (islands and mountain regions) and whether the gap in income between these types of regions tends to increase or be reduced. The analysis will review the state of the art of theory development (see Chapter 3) and recent literature on existing accessibility studies (see Chapter 5).

Subtask 6.2 Long-term scenarios of European transport

This Subtask will identify long-term scenarios of European transport policy in terms of transport infrastructure investments and other transport policies, such as taxation and road pricing, and assumptions about future developments in vehicle technology and alternative fuels and fuel price increases. A business-as-usual scenario will assume the implementation of the Trans-European Transport Networks (TEN-T) priority projects. Alternative policy scenarios will assume faster or delayed implementation of the TEN-T projects in combination with different taxation and road pricing policies and different assumptions about vehicle technology, alternative fuels and fuel prices. Key assumptions of scenarios developed in other EU projects, such as ADAM or ITREN-2030 will be considered.

Subtask 6.3 Spatial impacts of European transport scenarios

The Europe-wide regional economic model SASI (Socio-economic and Spatial Impacts) (Wegener and Bökemann, 1998; Wegener, 2008) will be used to forecast the likely impacts of the policy scenarios defined in Sub-Task 6.2. The SASI model was applied in several EU projects, such as IASON (Bröcker et al., 2004), ESPON 2.1.1 (Bröcker et al., 2005), ESPON 1.1.3 (2006), ESPON 1.4.4 (Spiekermann et al., 2007), AlpenCorS (Spiekermann and Wegener, 2005) and STEPs (Fiorello et al., 2006).

The SASI model is a recursive simulation model of socio-economic development of regions in Europe subject to exogenous assumptions about the economic and demographic development of the European Union as a whole and transport infrastructure investments and transport system improvements, in particular of the trans-European transport networks.

The model differs from other approaches to model the impacts of transport on regional development by modelling not only production (the demand side of regional labour markets) but also population and migration (the supply side of regional labour markets). The sectoral production functions of SASI include production factors (some of them delayed) representing regional capital, labour market potential, economic structure, sector-specific accessibility indicators and soft location factors, such as research and development and quality of life.

The geographical coverage of the model includes all countries participating in the ESPON 2013 Programme plus the EU candidate countries Croatia and FYR Macedonia and the other countries of the Western Balkans Bosnia and Herzegovina, Serbia, Montenegro, Albania and Kosovo (see Figure 2). The spatial dimension of the model is established by subdividing these countries into 1,330 NUTS-3 or equivalent regions and connecting these by road, rail and air networks. When calculating European accessibility, also destinations in neighbouring countries, such as Belarus, Moldova, Russia, Turkey and Ukraine are considered, when calculating global accessibility, destinations in all world regions.

The target year of the simulations is 2031. The temporal dimension of the model is established by dividing time into periods of one year duration. By modelling relatively short time periods both short- and long-term lagged impacts can be taken into account. In each simulation year the seven submodels of the SASI model are processed in a recursive way, i.e. sequentially one after another. This implies that within one simulation period no equilibrium between model variables is established; i.e. all endogenous effects in the model are lagged by one or more years.

The transport networks used by the SASI model originated in the trans-European transport network GIS database developed at the Institute of Spatial Planning of the University of Dortmund, and now maintained and further developed by RRG (2010). The strategic road, rail and waterways networks used by the SASI model are subsets of this database, comprising the trans-European networks specified in Decision 1692/96/EC of the European Parliament and of the Council (European Communities, 1996) and amended in Decision 884/2004 (European Union,

2004), further specified in the TEN Implementation Report (European Commission, 1998) and the revisions of the TEN guidelines provided by the European Commission (1999; 2002a; 2003a) and by the European Communities (2001), information and decisions on priority projects (European Commission, 1995; 1999; 2002b; 2003b; 2004; European Union, 2004), on the TINA networks as identified and further promoted by the TINA Secretariat (1999, 2002), the Helsinki Corridors as well as selected additional links in eastern Europe and other links to guarantee connectivity of NUTS-3 level regions. The strategic air network is based on the TEN and TINA airports and other important airports in the remaining countries and contains all flights between these airports and reflects the state of air travel in 2006.
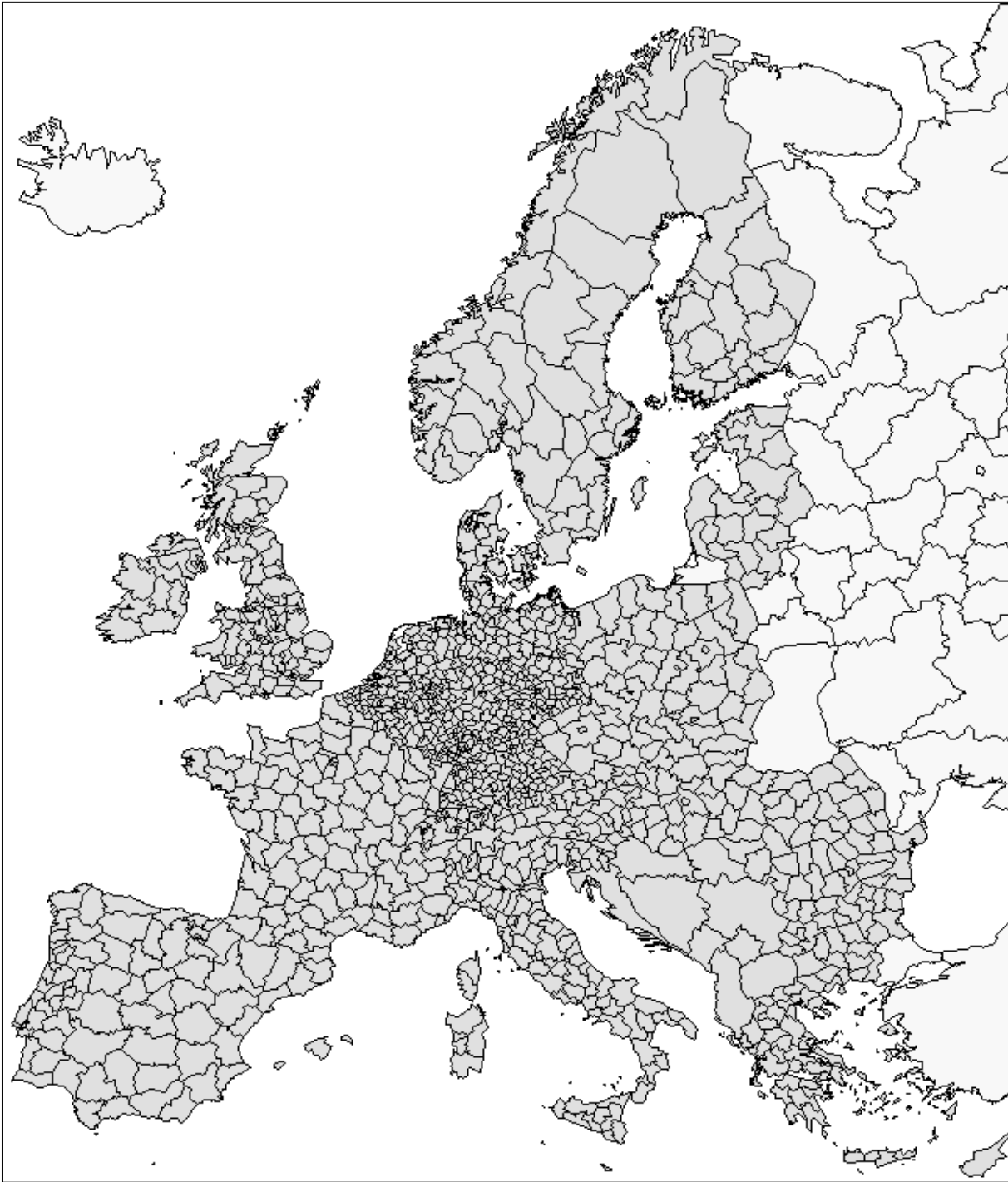
Figure 2. The regions of the SASI model in Europe

Figure 3 visualises the structure of the SASI model.
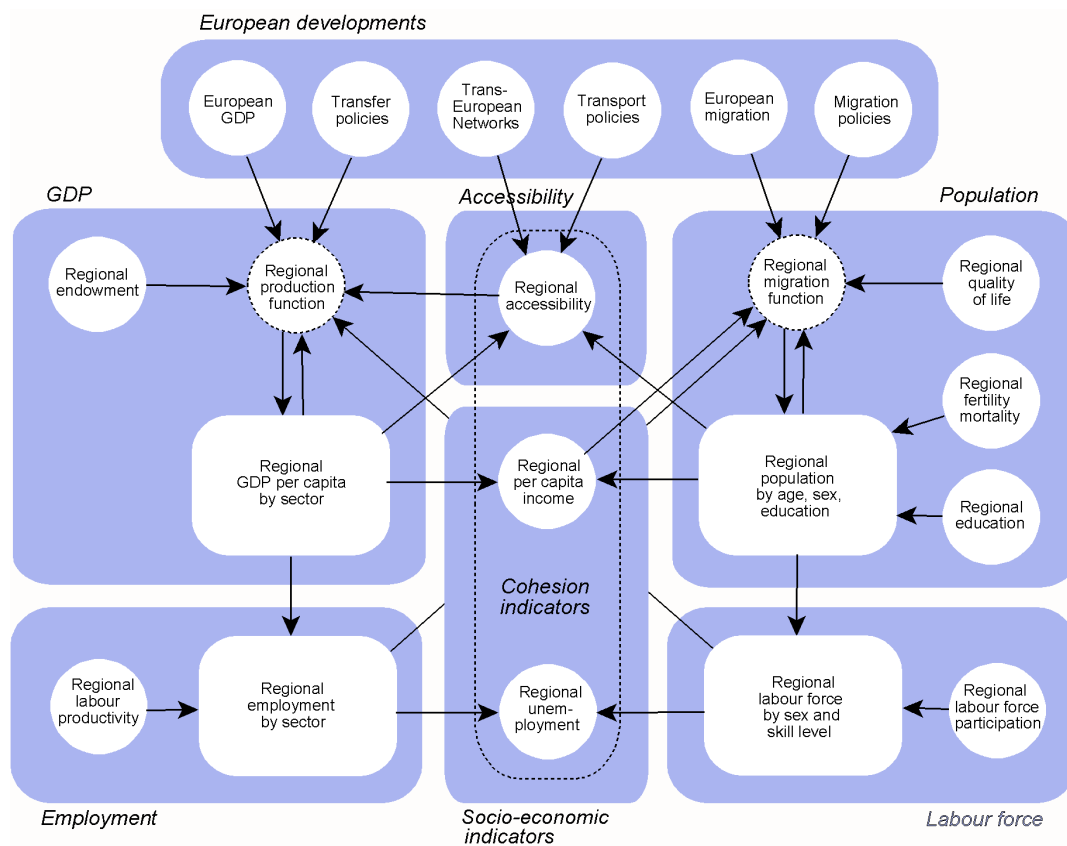
Figure 3. The structure of the SASI model

The SASI model has six forecasting submodels: *European Developments*, *Regional Accessibility*, *Regional GDP*, *Regional Employment*, *Regional Population* and *Regional Labour Force*. A seventh submodel calculates *Socio-Economic Indicators* with respect to equity and cohesion:

- The *European Developments* submodel processes exogenous assumptions about the wider economic and policy framework of the simulations, such as (i) the performance of the European economy as a whole, (ii) net migration across Europe's borders, (iii) transfer payments by the European Union via the Structural Funds and the Common Agricultural Policy or by national governments to support specific regions, (iv) European integration in terms of lowering barriers between countries, such as border waiting times and political, cultural and language barriers and (v) the development of trans-European transport networks (TEN-T) in policy scenarios, i.e. time-sequenced programmes for addition or upgrading of links of the trans-European road, rail and air networks or other transport policies, such as taxation or road pricing.

- The *Regional Accessibility* submodel calculates regional accessibility indicators expressing the locational advantage of each region with respect to relevant destinations in the region and in other regions as a function of the generalised travel cost needed to reach these destinations by the strategic road, rail and air networks.

- The *Regional GDP* submodel calculates regional economic development by production functions incorporating various accessibility indicators as additional production factor for six economic sectors: agriculture, manufacturing, construction, trade/transport/tourism, financial services and other services.

- The *Regional Employment* submodel calculates regional employment by industrial sector derived from regional GDP by industrial sector and regional labour productivity.

- The *Regional Population* submodel forecasts regional population by five-year age groups and sex through natural change (fertility, mortality) and migration.

- The *Regional Labour Force* submodel calculates the regional labour force derived from regional population and regional labour force participation partly endogenously affected by changes in job availability or unemployment.

- The *Socio-economic Indicators* submodel calculates equity or cohesion indicators describing the distribution of accessibility and GDP per capita across the regions. Cohesion indicators are macroanalytic indicators combining the indicators of individual regions into one measure of their spatial concentration. Changes in the cohesion indicators predicted by the model for future transport policies reveal whether these policies are likely to reduce or increase existing disparities in accessibility and GDP per capita between the regions. In the SASI model five cohesion indicators are calculated: (i) coefficient of variation, (ii) Gini coefficient, (iii) geometric/arithmetic mean, (iv) correlation between relative change and level and (v) correlation between absolute change and level.

In each simulation period the seven submodels are processed sequentially a shown in Figure 4:
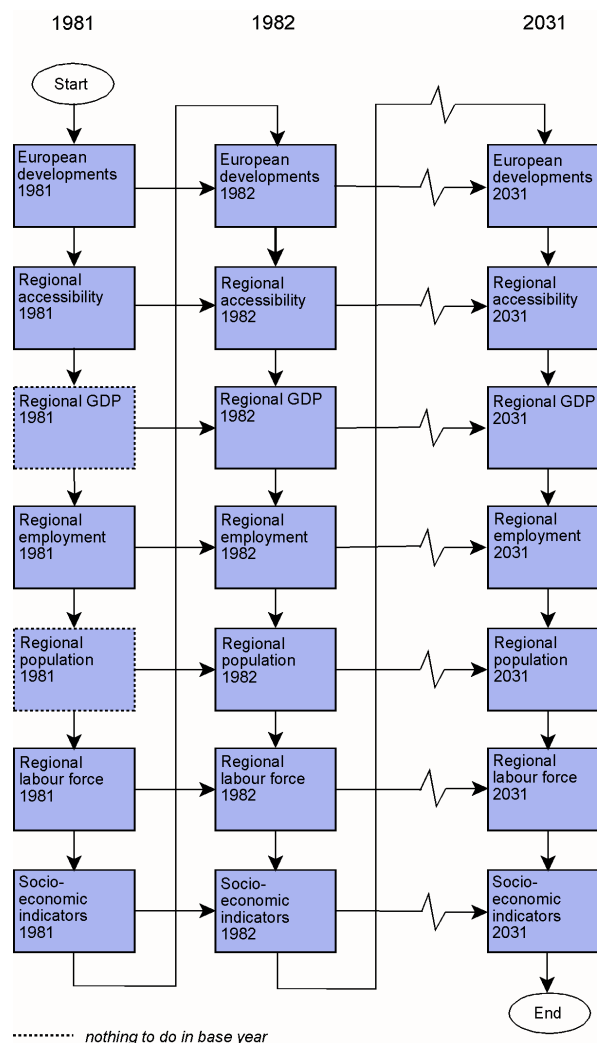
Figure 4. The sequence of submodels in SASI

A more detailed description of the SASI model, its data requirements and output indicators is available in Wegener (2008).

Model development

For application in the present project the SASI model will be extended by a simple model of long-distance passenger and freight transport in order to calculate basic environmental indicators, such as energy consumption and greenhouse gas emissions of transport.

The network and socio-economic data of the model will be updated by the most recent available network and socio-economic data. Where possible, data from previous ESPON projects (ESPON 1.2.1, 1.1.1, 2.1.1. and 1.1.3 and the recent Accessibility Updates will be used (see Chapter 7.2).

The system of regions will be converted to the latest 2006 NUTS-3 classification (Eurostat, 2007) and equivalent regions in non-EU countries, including a higher spatial resolution in the candidate countries Croatia and FYR Macedonia and the other countries of the Western Balkans Bosnia and Herzegovina, Serbia, Montenegro, Albania and Kosovo. Turkey will continue to be treated as an external region (see Chapter 7.4).

The target year of the simulations will continue to be 2031. However, it will be examined whether an experimental extension of the simulations until 2050 will be feasible.

Expected results

For each region of the study area the model forecasts the development of accessibility and GDP per capita, employment and population and energy consumption and greenhouse gas emissions of transport.

In addition cohesion indicators expressing the impacts of transport infrastructure investments and transport system improvements on the convergence (or divergence) of accessibility and socio-economic development in the regions of the European Union are calculated.

The results will be scatter diagrams of the relationship between accessibility and economic development and environmental indicators and time series diagrams and maps showing the development over time and spatial distribution of accessibility, GDP per capita, energy consumption and greenhouse gas emissions by transport.

4.7 Policy implications

Accessibility is a prerequisite for economic competitiveness and quality of life in European regions. There exists a broad consensus between European policy documents, from the European Spatial Development Perspective (1999), the White Paper on European Transport Policy (2001), the Territorial Agenda of the European Union (2007), the Green Paper on Urban Mobility (2007) to the Green Paper on Territorial Cohesion (2008) that improvement of accessibility is a major objective of European spatial policy.

However, there are goal conflicts involved. If mainly the transport corridors between the major agglomerations are improved, this may be good for the global competitiveness of Europe as a whole but may increase the differences in accessibility between the core centres and peripheral regions. Conversely, if mainly transport links to and between peripheral regions are improved, that may reduce their disadvantage but may retard the growth of the European economy as a whole. Moreover, each new infrastructure will tend to attract more traffic and so accelerate the growth of energy consumption and greenhouse gas emissions by transport, if transport technologies and market regulations remains the same.

Task 7 Policy implications

It is the objective of this Task to create awareness of this goal conflict of European transport policy and provide guidance for rational tradeoffs between the conflicting goals of competitiveness, territorial cohesion and environmental sustainability.

Subtask 7.1 Policy-relevant findings

This Subtask will summarise the findings of the project in relation to the goals of the European Union competitiveness, territorial cohesion and environmental sustainability for different types of regions, such as urban areas, rural areas, mountain areas, islands, coastal areas and outermost regions, and their development opportunities and policy options taking account of the cohesion policy orientations as expressed in the Community Strategic Guidelines on Cohesion 2007-2013 and the Fourth Report on Cohesion. The summary will be based on the accessibility analyses of Tasks 3 and 4, the case studies of Task 5 and the model scenarios of Task 6.

The *Community Strategic Guidelines on Cohesion 2007-2013* (2005) represent a framework which the member states and regions are invited to use when developing national and regional programmes, in particular with a view to assessing their contribution to the objectives of the European Union in terms of cohesion, growth and jobs. A central element of the guidelines is the assumption that transport infrastructure is a necessary condition for economic and employment growth in the Union, having a direct impact on the attractiveness of regions for businesses and people. Territorial accessibility is therefore perceived as an enabler of economic prosperity.

The Fourth Report on economic and social cohesion (2007) supports of the spirit of the Community Strategic Guidelines, and argues that in order to improve the crucial aspects of economic and social cohesion and the development of quality employment, it is essential to ensure complementarity between the Union's cohesion policies and other Community policy areas, in particular transport, but also macroeconomics and other services.

The report states how improved accessibility tends to create new job opportunities for rural as well as urban populations. Improving the accessibility of regions to the fullest extent requires not only investment in the main routes, but also in secondary networks and public transport to ensure that local areas are properly connected. But positive effects will be captured only as long as populations have the necessary education and skill levels. The potential advantages from improving accessibility therefore depends on the competitiveness of the regions concerned and some regions are liable to lose out as they become more open to competition from elsewhere.

It is an objective of this subtask to check results from Tasks 3 and 4, the case studies of Task 5 and the model scenarios of Task 6 against these general policy assumptions.

Subtask 7.2 Policy conclusions

This task will evaluate the policy instruments available to the European Union and its member states to maintain and improve the different types of regional accessibility in order to draw as much benefit for regional development from accessibility with the smallest possible negative implications for territorial cohesion and the environment and formulate policy conclusions which can stimulate and enlighten the ongoing political discourse on transport and accessibility policy for decision makers, experts and the wider public.

The European Common Transport Policy (CTP) is an essential component of the political project of the European Union. However, transport infrastructure has been considered a common political area of the European Union only since the Maastricht Treaty of 1992, when the concept of trans-European transport networks was introduced for the first time, with a special emphasis on interconnection and interoperability of the diverse national networks.

The TEN-T policy (to be updated during 2011) is intended to increase the co-ordination in the planning of infrastructure projects by the member states. Although there has been progress towards the Common Transport Policy (CTP) objectives of eliminating infrastructure bottlenecks through the TEN-T programme, progress has been relatively slow, partly due to the scale, complexity and cost of the projects. Most of the 30 TEN-T priority projects involve large amounts of investment, especially rail projects. According to the CTP Evaluation (EC 2009), substantial progress has been made towards meeting the objective of the CTP of creation of a competitive internal market for transport services by liberalisation of the transport market. Market opening has been very successful in the air sector, and there are signs that market opening in the rail sector is starting to bring some success. In other sectors, further reforms are required to fully implement liberalisation.

The White Paper on Transport of the EU is the document of strategic reflection providing the conceptual and philosophical framework for the CTP. Successive versions of this document have had substantial influence on EU, national and regional policies. While the first White Book of 1992 set the objective to liberalise the transport markets, the second White Book of 2001 proposed the a massive modal change from road to rail to combat climate change. Today, the objective of decoupling economic growth from mobility growth has proven its complexity according to the mid-term revision of the White Book in 2006. The communication by the European Commission in 2009 triggering the debate for the 2011 White Book revision proposed that the CTP should pursue an integrated sustainable, safe and comfortable, globally accessible and efficient transport system focussing on technology development, management improvement and infrastructure investment on those links providing the highest returns to European mobility, regional development and territorial cohesion.

Subtask 7.2 will confront the CTP, TEN-T policy and the Transport White Paper with the capacity to maintain and improve the different types of regional accessibility, to formulate conclusions to contribute to the ongoing political discourse on transport and accessibility policy, the redefinition of TEN-T policy and the new Transport White Paper in 2011.

The policy conclusions will be differentiated by type of region. Special attention will be given to peripheral and most isolated regions, such as island or mountain regions. The 4th Report on Cohesion relates accessibility conditions in these regions to their level of wealth: *islands*, where accessibility often constitutes a particular problem because their size of population is in many cases too small to support a reasonable level of infrastructure and basic services; *ultra-peripheral regions*, which have among the lowest levels of GDP per head in the EU (with the exceptions of Madeira and the Canary Islands); *mountain areas*, which being extremely diverse in terms of socio economic trends and economic performance, are threatened by international road traffic when they are highly accessible, but tend to depopulate and to show poor indicators when they are difficult to access.

Policy recommendations for the new EU member states will take into account the different phase in economic development of the new member states compared with the old member states, which may justify a policy primarily promoting improvements of accessibility of their capital cities during a transition period following the phase strategy of spatial development proposed in ESPON 1.1.3. As stated by the *Community Strategic Guidelines on Cohesion 2007-2013*, infrastructure investment needs to be adapted to the specific needs and level of economic development of the regions and countries concerned.

Subtask 7.3 Further research needs

In the final Subtask, avenues for further applied research on the theme of accessibility at the global, European and regional scale with respect to data needs and required methodologies will be formulated.

5 Review of existing accessibility studies

Over the last decades a vast number of accessibility studies addressing European core-periphery issues have been published. This chapter extends earlier reviews (Rietveld and Bruinsma, 1998; Wegener et al., 2001). It starts with short summaries of prominent European accessibility studies and compares these along the dimensions of accessibility identified in Chapter 3 and with respect to equity and cohesion and gives an outlook on national and regional studies to be examined in later phases of the project.

5.1 European accessibility studies

There is a growing number of accessibility models addressing Europe-wide accessibility. This section briefly introduces European accessibility models developed in the last three decades and classifies them and compares the accessibility indicators they produce by applying the dimensions of accessibility presented in Chapter 3. The dimensions equity and dynamics will be discussed separately. The order of the models presented is chronological.

Keeble et al. (1982, 1988) in a project for DGXVI of the European Commission analysed economic core-peripherality differences between the regions of the Community and investigated whether any differences can be explained by relative location. For this purpose, they developed a gravity potential model with regional GDP as destination activity and road distance costs as impedance. The results were expressed as economic potential index and presented in maps as contour lines.

Törnqvist had already in the 1970s developed the notion of 'contact networks' based on the hypothesis that the number of interactions with other cities by visits such as business trips is a good indicator of the position of a city in the urban hierarchy. Based on this, Cederlund et al. (1991) and Erlandsson and Törnqvist (1993) calculated daily accessibility indicators of European cities expressed as the number of people that can be reached from a city by a return trip during a work day with four hours minimum stay using the fastest available mode (*outbund* accessibility).

The *Bundesforschungsanstalt für Landeskunde und Raumordnung* (Lutter et al., 1992, 1993) in a study for DG Regio of the European Commission calculated the accessibility of NUTS-3 regions in the then twelve member states of the European Community as average travel time by intermodal transport (road, rail, air) to 194 economic centres in Europe. In the same study they used also other destinations such as the next three agglomerations, the next high-speed train stop or the next airport. In addition, they calculated a daily accessibility indicator expressed as the number of people that can be reached in three hours using the fastest connection. Modes considered included road, rail and air with and without planned infrastructure investments (new motorways, high-speed rail lines and more frequent flight connections).

Bruinsma and Rietveld (1993) calculated the population potential of European cities with similar results as Keeble et al. (1982; 1988) once again demonstrating the spatial correlation between economic and population centres.

Spiekermann and Wegener developed three-dimensional surfaces of daily and potential rail accessibility for Europe using raster-based GIS technology (Spiekermann and Wegener, 1994; 1996; Vickerman et al., 1999), road and air accessibility were added later (Schürmann et al., 1997; Fürst et al., 2000). The quasi-homogenous accessibility surfaces were achieved by subdividing Europe into some 70,000 square raster cells of 10 km width and calculating accessibility indicators for each raster cell with respect to all other raster cells. Population of raster cells was estimated by allocating the population of NUTS-3 regions to raster cells with the help of a hypothetical negative-exponential gradient of population density around population centres. Access travel time from each raster cell to the nearest network node was approximated using an airline travel speed of 30 km/h.

Chatelus and Ulied (1995) developed several accessibility indicators for the evaluation of trans-European networks at the level of NUTS-2 regions in the EU15 plus Norway. One of them, the FreR(M) indicator, measures the average cost to reach a market area of a certain population size by lorry. The impedance term is generalised road transport cost including cost of the driver's time, cost per kilometre and a fixed cost component. The CON(T) indicator accumulates population of NUTS-2 regions of EU15 plus Norway and Switzerland reachable within a maximum travel time of three hours by any combination of car, rail and air with transfer times between modes explicitly considered. The CON(T) index was used to assess transport infrastructure scenarios with respect to competitiveness, cohesion and sustainability. The FreR(T) index is a freight accessibility indicator expressing the size of the market that can be reached in a certain travel time, e.g. the population that can be reached overnight or in 12, 36, 60 or 84 hours by the fastest connection using road, rail or combined traffic with driving time restrictions for lorry drivers observed.

Gutiérrez et al. (1996) and Gutiérrez and Urbano (1996) calculated average travel time by road and rail from about 4,000 nodes of a multimodal European transport network to 94 agglomerations with a population of more than 300,000 with and without planned infrastructure improvements. Road travel times included road and car ferry travel times modified by a link-type specific coefficient and a penalty for crossing nodes representing congested population centres. Rail travel times included timetable travel time plus road access time and penalties for changes between road and rail (60 minutes), rail and ferry (180 minutes) and change of rail gauge between Spain and France (30 minutes).

Copus (1997, 1999), in studies for the Highlands and Islands European Partnership Programme and for DG Regio of the European Commission developed peripherality indicators for NUTS-2 and NUTS-3 regions based on road-based potential measures of the Keeble type. The model takes account of different average speeds for different classes of road, realistic ferry crossing and check-in times, EU border crossing delays and statutory drivers' rest breaks. Accessibility is presented as a peripherality index derived as the inverse standardised to the interval between zero (most central) and one hundred (most peripheral).

In a report for the Study Programme on European Spatial Planning of DG REGIO, Wegener et al. (2001) proposed reference indicators describing the geographical position of European NUTS-3 regions. Besides geographical, physical and cultural indicators, three accessibility indicators were proposed. The first two measure accessibility by road and rail to population, the last one accessibility by air to economic activity (expressed by gross domestic product, or GDP). Accessibility to population is seen as an indicator for the size of market areas for suppliers of goods and services and accessibility to GDP as an indicator of the size of market areas for suppliers of high-level business services. Accessibility is presented as percent of European average accessibility.

Schürmann and Talaat (2000) produced an index of peripherality for the Third Cohesion Report of the European Commission (2001) with a geographical information system. Potential type indicators are calculated for passenger and freight transport by road using GDP or population or labour force as destination activity. Travel times for lorries were computed separately from car travel times to take account of speed limits for lorries, delays at borders and ferry ports and statutory drivers' rest periods. The indicators are calculated for NUTS-3 regions and for equivalent regions of the candidate countries and Norway and Switzerland. The indicators were aggregated to NUTS-2, NUTS-1 and NUTS-0 regions. The peripherality index is presented in two ways: either standardised on the European average (as in Wegener et al., 2001) or to an interval between zero and one hundred (as in Copus, 1997, 1999).

In 2004 a research team led by Nordregio (2004) in a project for DG Regio analysed the socio-economic situation of mountain areas in the EU and potential accession and other countries. The study analysed different accessibility indicators, among them population potential, airline distances to national capital cities and the next three cities with more than 100,000 inhabitants, ac-

cess to airports, universities and hospitals. Two spatial levels were used: All indicators were calculated at municipal level and then aggregated to mountain areas. First all indicators were standardised at the European average, but also at the respective national averages. Access to public facilities was initially calculated as shortest travel time by car to the nearest facility and then converted to the proportion of population at more than one hour from the nearest facility.

Another study by Nordregio (Gløersen et al., 2006) analysed the accessibility of peripheral, sparsely populated regions in Finland, Norway and Sweden in the European Union. Due to their extremely peripheral location, these regions rely on transport hubs such as airports and seaports; therefore number of destinations and frequency of services of flight and ferry connections were analysed. In addition, access to universities and hospitals was analysed as the proportion of population living within 60 minutes from these facilities.

In a study for the Directorate-General for Internal Policies of the Union of the European Parliament (European Parliament, 2007) a 2.5x2.5 km raster system for the entire European Union plus Norway and Switzerland was used to calculate a comprehensive set of road potential accessibility indicators to population, GDP and service facilities, such as airports, high-speed train stations, universities and hospitals. The results at raster level were aggregated to NUTS-3 and NUTS-2 level, and indicators, such as number and proportion of population within 60 minutes travel time were derived and mapped.

Spiekermann and Schürmann (2007) updated the accessibility indicators for road and rail used in several ESPON projects and EU documents with 2006 network data. More recently, the work was extended to air and multimodal accessibility.

Comparison

The European accessibility models reviewed above yield a wide range of approaches with respect to various dimensions of accessibility. They differ in many respect, but there are also some commonalties (see Table 3):

- More than half of the models use potential type indicators, the remaining models use travel costs or daily accessibility indicators. A few models are able to calculate more than one type of indicator.

- The origins for which accessibility indicators are calculated are usually NUTS-2 or NUTS-3 centroids, very few studies have a more detailed representation of space.

- The destination activities are usually population or GDP for potential type accessibility indicators and a pre-defined set of agglomerations for the travel cost indicators. For daily accessibility indicators both population and public facilities, such as airports, high-speed train stations, universities or hospitals are used as destinations.

- Nearly all models use travel time as impedance term, only few models apply travel costs or a combinations of both as generalised cost.

- Only few models consider constraints on the impedance term. Models that consider freight transport use statutory drivers' rest breaks as constraints.

- Only few accessibility models consider barriers, such as waiting times at national borders. Only Keeble et al. use trade barriers, such as tolls.

- Nearly all accessibility models are based on passenger travel, only few models consider freight transport.

- Half of the models consider one mode only, in most cases road. The other models have networks for different modes, however, only two use intermodal travel times

Table 3. Dimensions of European accessibility models

Authors	Indicator type	Origins	Destinations	Impedance	Constraints	Barriers	Type of transport	Modes	Spatial scope
Keeble et al. (1982; 1988)	Potential	NUTS-2 centroids	GDP in NUTS-2 regions and other European countries	Road distance	-	Sea crossings, trade barriers	-	Road	EU9 EU12
Cederlund et al. (1991) and Erlandsson and Törnqvist (1993)	Travel time, Daily	Cities	Cities	Travel time	-	-	Travel	Fastest mode	EU12
Lutter et al. (1993)	Travel cost, Daily	NUTS-3 centroids	194 centres next 3 agglomerations, airports etc.	Travel time	-	-	Travel	Road, rail air, intermodal	EU12
Bruinsma and Rietveld (1993)	Potential	Cities	Cities	Travel time	-	-	Travel	Air	EU27+2
Spiekermann and Wegener (1994, 1996)	Daily, potential	10 km raster cells	Population in 10 km raster cells	Travel time Travel cost	-	-	Travel	Rail	EU27+2
Chatelus and Ulied (1995)	Travel cost, Daily	NUTS-2 centroids	Population in NUTS-2 regions	Travel cost	Statutory drivers' rest breaks	-	Travel freight	Road, rail air intermodal	EU15 +2
Gutierrez and Urbano (1996)	Travel cost	4,000 nodes	94 agglomerations	Travel time	Congestion in urban areas	Change of rail gauge	Travel	Road rail	EU12

Table 4. Dimensions of European accessibility models (continued)

Authors	Indicator type	Origins	Destinations	Impedance	Constraints	Barriers	Type of transport	Modes	Spatial scope
Copus (1997, 1999)	Potential	NUTS-2 / NUTS-3 centroids	GDP, population, labour in NUTS-2/3 regions	Travel time	Statutory drivers' rest breaks	Border delays	Travel	Road	EU15+2+12
Wegener et al., (2001)	Potential	NUTS-3 centroids	Population and GDP in 10 km raster cells	Travel time Travel cost	-	Border delays	Travel	Road Rail Air	EU15
Schürmann and Talaat (2000)	Potential	NUTS-3 centroids	GDP, population, workforce in NUTS-3 regions	Travel time	Statutory drivers' rest breaks	Border delays	Travel Freight	Road	EU15+12
Nordregio (2004)	Daily	Municipality Mountain area	Municipality Facilities	Travel time	-	-	Travel	Road	EU27+2+5
Gløersen et al. (2006)	Daily	Municipality	Airports Seaports Universities Hospitals	Travel time	-	-	Travel	Road Air Ferry	EU27+2
European Parliament (2007)	Potential	Raster cells 2.5x2.5 km NUTS-3 NUTS-2	Population GDP Airports HSR stations Universities Hospitals	Travel time	-	-	Travel	Road	EU27+2
Spiekermann and Schürmann (2007)	Potential	NUTS-3 centroids	NUTS-3 population	Travel time	-	Border delays	Travel	Road Rail Air	EU27+2

Equity and cohesion

Table 4 summarises the main results of the accessibility models with respect to spatial disparity and its changing patterns over time.

It can be seen that all European accessibility studies expose the existing core-periphery pattern of accessibility in Europe and all indicate that over time the gap in accessibility between core and peripheral regions has increased.

A distinction can be made between potential and daily accessibility. Whereas potential accessibility has improved in the former cohesion countries in southern Europe and increasingly also in the new member states in central and eastern Europe, daily accessibility, in particular where business trips are concerned, has increased mainly in central regions with good air connections.

Table 4. Equity and dynamic statements of European accessibility models

Authors	Spatial disparities	Changing pattern through time
Keeble et al. (1982; 1988)	Core-periphery pattern	Disparities in accessibility have increased in past periods
Cederlund et al. (1991) and Erlandsson and Törnqvist (1993)	Core-periphery pattern	Disparities in accessibility have increased in past periods
Lutter et al. (1993)	Existing, but scope depends on destination activities considered	Travel time benefits for peripheral regions, daily accessibility increases in central regions
Bruinsma and Rietveld (1993)	Core-periphery pattern	Increasing disparities in accessibility
Spiekermann and Wegener (1994, 1996)	Clear core-periphery pattern plus clear centre-hinterland disparities in all European countries	Increasing disparities induced by TEN
Chatelus and Ulied (1995)	Clear core-periphery pattern	Decreasing disparities
Gutierrez and Urbano (1995, 1996)	Clear core-periphery pattern	Decreasing disparities induced by TEN
Copus (1997, 1999)	Clear core-periphery pattern	Dynamics not considered
Wegener et al., (2001)	Different core-periphery patterns for different transport modes	Increasing or decreasing disparities is an outcome of the indicator
Schürmann and Talaat (2000)	Clear core-periphery pattern for road transport	Improvements mainly for EU candidate countries
Nordregio (2004)	Great disadvantage in accessibility of mountainous regions	Increasing disadvantage of mountainous regions
Gløersen et al. (2006)	Great differences in accessibility between core and periphery	Increasing peripherality of remote regions
European Parliament (2007)	Great differences in accessibility between core and periphery	Increasing peripherality of remote regions
Spiekermann and Schürmann (2007)	Great differences in accessibility between core and periphery	Cohesion improving in relative terms but declining in absolute terms

Another important distinction can be made between whether changes in accessibility are measured in relative or in absolute terms. Whereas in relative terms (e.g. in percent) accessibility has improved more in the peripheral regions, in absolute terms accessibility in the core regions in western Europe has continued to grow more.

Assessment

An overall assessments of accessibility models is difficult. The general tendency is that none of the models is really able to serve all purposes:

- Most models focus on personal transport and ignore freight transport although freight transport might be more relevant for peripheral regions. Spiekermann and Neubauer (2002) in their review of European accessibility studies found only two out of ten studies dealing with freight accessibility. However, empirical work has shown that road accessibility by using car or trucks is very high correlated and that car accessibility can be used as a proxy for truck accessibility.

- Most models do only have an implicit relation to certain sectors of the economy, i.e. by concentrating on personal transport the models are closely related to the service sector and neglecting that transport has differential relations with different sectors (see Vickerman, 1999).

- Following that, the reality of the business environment in peripheral rural areas is hardly represented in the European accessibility models.

- Some models, those working with travel cost indicators, support the case for public investment in infrastructure by demonstrating increased cohesion. Other models, mainly of the potential type, are much more cautious or even forecast increased regional disparities as outcome of transport infrastructure investments.

To conclude, despite the vast range of models, there is currently no model presented in the literature that would match all requirements for the different dimensions. Models that are superior in a certain dimension are behind in others. There is no model available that would be able to calculate accessibility for a spatially detailed representation of pan-Europe for personal and freight transport for all transport modes including multi- and intermodal trips for different indicator types and destination activities and that has a database that allows assessments for different points in time, i.e. past, current and future accessibility patterns.

5.2 National and regional accessibility studies

The number and diversity of accessibility studies at the national and regional level in European countries is even larger than those Europe-wide studies.

In national and regional studies of accessibility other origins and destinations become relevant. If a balanced polycentric urban system is a goal of national spatial planning, accessibility of cities at the second or third level of the urban systems are of interest. In countries with stagnant or declining populations, the provision of minimum standards of basic services of general interest in peri-urban or rural areas are quickly becoming a problem of high political importance. This makes accessibility studies with local public facilities as destinations, such as schools, food shops, doctors and pharmacies, an important future field of applied research.

It is beyond the scope of work in the short period until the Inception Report to undertake a full review of such studies in all countries of the ESPON space.

Reviews of existing studies in the macro regions in which case studies will be conducted will be undertaken in conjunction with the case study regions (see Chapter 6).

6 Selection of regional case studies

Global and European accessibility are important location factors for firms and working and leisure travel of people. However, for the daily life of citizens regional/local accessibility to jobs, services and public facilities, may be more important than global or European accessibility. Task 5 of the TRACC project is therefore concerned with regional accessibility (see Chapter 4.5). A major part of Task 5 is the development and execution of a broad set of regional and local case studies in order to gain systematic knowledge on accessibility patterns in different types of regions throughout Europe.

This chapter presents the process of selecting appropriate regional case studies as well as a brief introduction to the selected case study regions.

6.1 Selection process

The case study areas to be selected for regional accessibility modeling within TRACC should cover a wide range of different types of regions in different parts of Europe. In addition, one of the technical objectives is that the methodologies to be implemented in the case study regions should be as similar as possible in order to allow a comparison of the resulting accessibility patterns, i.e. should not be disturbed by artefacts induced by methodological differences.

However, the comparison of regional and local accessibility pattern in different parts of Europe would be difficult if the case study regions would be limited to a single NUTS-3 region, i.e. such accessibility patterns would have to be compared without having information on regional accessibility in the surrounding regions of the case study region.

In addition, there are data constraints which are mainly related to network data. It is currently impossible to set up a harmonised network database for Europe, in particular for public transport, from which subsets could be extracted for regional case studies. Consequently, regional case studies have to be developed from existing regional network databases.

Based on these considerations the TRACC project performed a pragmatic process for the selection of case study regions:

- First, a set of macro regions at NUTS-0 or NUTS-1 level was compiled for which Project Partners have already a fairly good database for accessibility modeling (see Chapter 7) and which at the same time represent very different parts of Europe.

- Second, within each macro region a number of case study regions at NUTS-2 or NUTS-3 level were identified which represent very different types of regions within the macro region.

During the quantitative parts of the case studies, the regional accessibility models will ideally be run for the macro region at NUTS-5 level with harmonised indicator definitions to provide overall knowledge on the regional accessibility pattern in the different macro regions. Based on this framework the case study areas will be analysed and discussed in more detail. By doing it this way, the different case study areas will be comparable all over Europe.

The selection process resulted in a good geographic coverage of macro regions from Northern Europe to the Mediterranean, from eastern parts of Europe to western parts and from peripheral regions to central core regions (Figure 5). Each Project Partner is responsible for one macro region resulting in seven macro regions in total. The selected macro regions form an arc stretching from the far North almost down to Gibraltar. The chosen macro regions are the EURAM transborder region along the Mediterranean coast in Spain and France, Northern Italy, Bavaria in Germany, Czech Republic, Poland, Scandinavia and Finland.

Figure 5. Selected macro regions for case studies.

Within each macro region between three and six case study areas for in-depth analysis were selected. The selection results in a good distribution of about in total 30 case study areas over different types of regions ensuring the study of different kinds of territorial typologies with different mobility patterns associated. Case study areas include mountain areas, islands, archipelagos, fjord regions, remote and central rural areas, urban centres within rural landscapes, functional urban areas of lower importance, highly populated metropolitan regions, touristic winter and summer areas, transborder regions.

Table 5 presents the selected macro regions and the case study areas by giving brief characteristics of the areas. A more detailed presentation of the selected regions follows in Section 6.2.

Table 5. Selected macro regions and case study areas

Macro region	Case study areas	Characteristics
EURAM Mediterranean Arc Euroregion	Andorra Pyrénées-Orientales / Girona Barcelona Alacant Menorca	Andorra is a small independent mountain country enclave with complex topography but important accessibility requirements due to primary tourist industry targeted to Spanish and French visitors. Pyrénées Orientales / Girona is selected to study accessibility at a transborder region between France and Spain. Barcelona is selected as being representative of major European metropolitan regions. Alacant is selected as primary tourist region in Europe located on a coastal area. Menorca is selected as a sparsely populated island with an important floating population in summertime. Being a biosphere reserve, Menorca needs to make compatible accessibility with environment preserving.
Northern Italy	Milan urban area Piacenza province La Spezia province City of Parma	Milan has been chosen as being representative of major European metropolitan regions. Piacenza case study will measure accessibility in a province structured by radial lines centred in the capital and crossed by major corridors at trans-regional level. La Spezia case study is interesting to analyse accessibility in a dense costal area with difficult mountainous characteristics, with intense port activity and growing tourism industry. Parma case study is chosen to study accessibility in detail at urban level. The case study will consider all modes, from car and public transport, to cycling and walking.
Bavaria	Munich region Nuremberg region Allgäu region Donau-Wald region	The Munich region will give insights into accessibility patterns in a large urban area with a monocentric spatial structure. The Nuremberg region will provide knowledge about accessibility patterns in a medium-sized urban area with a polycentric spatial structure. The Allgäu region in the south-western parts of Bavaria includes parts of the Alps and its foothills will depict accessibility patterns of rural and mountainous areas. The Donau-Wald region in the eastern parts of Bavaria will provide findings concerning the accessibility situation of rural areas.

Table 5. Selected macro regions and case study areas (continued)

Macro region	Case study areas	Characteristics
Czech Republic	Prague other case study areas to be defined	The capital city of Prague is currently one of the most dynamic and successful regions of Central Europe. Remaining NUTS-2 regions in the Czech Republic can be placed in four groups: catching up regions with the EU average (South West region and Central Bohemia), low-moderate economic growth regions (South-East region and North-East region), lagging (Central Moravia) and declining (Moravia-Silesia and North-West region).
Poland	Warsaw region Dolnośląskie Zachodniopomorskie (or Pomorskie) Małopolskie	Warsaw is developing very fast while its road accessibility is poor; it will change in 2012 after the realization of the A2 motorway section to Warsaw. Dolnośląskie is chosen due to the lack of motorways, but the good railway connection to Warsaw and excellent accessibility to European core areas. Zachodniopomorskie (or Pomorskie) will be studied for their interest due to the existence of ports, regional airports, fragmented motorway sections and foreseen accessibility changes in the next decade. Małopolskie includes the tourist destinations of Kraków (relatively good accessibility) and Poland's most popular mountain resort Zakopane (poor accessibility).
Scandinavia	Tromsø Trondheim Lillehammer Oestersund Falun Oerebro	Tromsø and Trondheim represent both 'Fjord Norway' with a specific topographic situation between the sea and the mountains. They are regional service centres, with extremely low population density around. Lillehammer is chosen as a representative example of a winter sports resort in 'mountain Norway' Østersund and Falun/Borlänge are selected as typical Swedish examples of regional cities, both covering water areas and extensive forest areas, but with distinct urban settlements in between. Oerebro is selected as a major centre within a number of other medium-size towns in the heart of Sweden with good connections to the major agglomerations in Sweden.
Finland	Lapland Oulu region Helsinki region	Lapland is chosen as a representative case of extreme periphery in the European context, substantially different to other rural regions in the rest of Europe. Oulu region is chosen as representative of a competitive growth centre located high up in the north, showing the contrast between different kinds of regional types, i.e. relatively developed urban and scarcely populated peripheral areas. Helsinki is an illustrative example of high and good quality accessibility in spite of the physical remoteness in relation to the rest of Europe.

6.2 Macro regions with case study areas

This section provides a brief presentation of each macro region selected with the target areas for in-depth analysis. Each presentation includes a territorial and socioeconomic characterisation of the case study and its transport infrastructure together with the reasons for the selection.

EURAM regional case study

The macro region

The Mediterranean Arc Euroregion, the EURAM, covers Spanish and French crossborder regions, and Andorra. It is stretching over three different states, contains some autonomous communities, about 10 regions and departments, several hundred counties, and about 2,000 municipalities. It has more than 1000 km of coastal areas, mountain regions with highs up to 3,000 m, four islands, highly populated metropolitan regions with densities up to 15,500 inh./km², and sparsely populated rural areas with densities below 10 inh./km².

Between 1998 and 2008, the EURAM population increased by 20 % up to 14.2 million inhabitants and the number of jobs by 2.1 million (50 %). Approximately 13 % of the EURAM population are now foreigners, most of them attracted to fill job vacancies generated during the period of strong growth of 3.5 % GDP per year between 1997 and 2007, but a significant number were also attracted by the climate and quality of life of the region. About one in every five immigrants to the EURAM is from another EU-25 nation, and in some places the proportion stands at one in every three, similar to the level found in the American Sunbelt.

The present territorial organisation of the EURAM involves a large number of jurisdictions and a complex distribution of responsibilities and resources between administrations. This introduces rigidities and inefficiencies in the public sector: on the one hand it hinders the attainment of scale economies in the supply of public services and, on the other, the difficulties of reaching consensus under very different political agendas often create insurmountable obstacles to carry out major strategic projects.

The spatial structure

The population in the EURAM region is heavily concentrated along the coastal fringe along the Mediterranean Sea. The three main agglomerations in the EURAM region are Barcelona's (5 million inhabitants), Valencia's (1.8 million inhabitants) and Alacant-Elx (0.8 million inhabitants).

Barcelona's metropolitan region concentrates some 5 million inhabitants which represents about 70 % of the population of Catalonia autonomous community in only 10 % of its territory. The metropolitan region of Barcelona is composed of seven counties and 800 municipalities, and it includes 18 cities with more than 50,000 inhabitants, only 7 with more than 100,000 inhabitants The municipality of Barcelona itself has 1.6 million inhabitants.

Valencia's metropolitan region concentrates some 1.8 million inhabitants, representing 35 % of its autonomous community population, while Alacant-Elx metropolitan region holds 760,000 inhabitants. Both regions together accommodate 50 % of the region's population in 10 % of its territory.

The Balearic insular region is composed of four islands, Majorca, Minorca, Eivissa and Formetera, and has 1.1 million inhabitants. It is a heavily frequented summer destination (as many other EURAM coastal regions), having its transport and service infrastructures prepared for some 10 million visitors yearly.

The department of Pyrénées-Orientales has 437,000 inhabitants. Its head city Perpignan houses the largest fruit and vegetables market in Europe, managing some 1.5 million tonnes of products yearly, and constituting an important logistics centre connected to air and to sea modes.

Andorra is an independent state in the heart of the Pyrenees with 85.000 inhabitants. It is located at a high between 800 m and 3,000 m. Population is mainly settled in two narrow river valleys between mountains. Being a major tourist, leisure and commercial centre oriented to both Spanish and French visitors, it registers important flows of visitors, mostly by car (some 25,000 vehicles across its borders daily), and therefore transport infrastructures is a major concern.

Socioeconomic portrait

The EURAM has an important industrial tradition. The sector is characterised by the presence of some multinational firms attracted during the 1980s and 1990. But it is essentially composed of a broad network of small and medium-sized family firms in mature sectors, sometimes constituting sectoral clusters such as ceramics, footwear, textiles, toy industry, furniture, or agri-food. The relocation of some major multinational industrial firms may be inevitable; nonetheless, de-industrialisation of the territory is a major political objective in the mid-term.

Agriculture accounts for 2 % of EURAM's GDP and employs 2 % of its active population. Nevertheless, the agro-food industry is of considerable importance in the EURAM, producing 15 % of Spanish food exports and hosting some of the largest food production, transformation and distribution firms of Spain. Agricultural land in the EURAM has a trend to decrease in extension.

With 60 million visitors per year, Spain ranks second only to France as the world's leading tourism destination. Some 30 million visit the EURAM regions every year (15 million in Catalonia; 10 million in Balearic Islands; 5 million in Valencia). Tourism is expected to evolve towards the provision of additional services related to education and training, health and wellbeing, sport and leisure and cultural and business activities, and constitutes a strategic sector in the EURAM.

After the present downturn, the construction sector should slowly recover in the EURAM, although growing at a slower pace than in the past decade. In 2004, Spain's six leading building firms had a joint turnover of around 35 billion Euros, threefold increase with respect to 1999. The construction sector is in a process of business diversification towards other economic sectors such as concessions and infrastructure management, which account now in many cases for up to 50 % of their business turnover. Most of these major firms are immersed in a process of growing internationalisation.

Transport aspects

Mobility for both passengers and freight in the EURAM will continue to grow in the future with the pace of economy. Urban trips motivated by factors other than work and medium to long-distance travel will increase and become more variable throughout the day and the territory, while international and intercontinental travel may undergo exponential growth. In 1981, 28 % individuals living in the Barcelona urban region worked outside their home municipality. By 2001 this percentage had risen to 47 %; forecasts indicate that this figure will rise to 60 % by 2026.

The long distance road corridors of the EURAM comprise essentially the Mediterranean axis along the coast (integrated by two parallel motorways), three axes linking the cost to Zaragoza (from Barcelona, Tarragona and Valencia) and two axes linking the coast to Madrid (from Valencia and Alacant). All these axes are served by motorways, and some of them are tolled. Road capacity in these corridors has already difficulties in fulfilling demand needs in many sections, notably around metropolitan areas. Particularly during peak tourism seasons some motorway and trunk road sections reach congestion levels that are unacceptable.

Within ten years, the Spanish high-speed train network has become one of the most developed in the world, together with those of France and Japan. There are many new sections being built across the Iberian peninsula and, following the inauguration of the Barcelona-Madrid line in 2008, it is expected that by 2012 the line connects to France in Perpignan. The missing stretch from Perpignan to Montpellier may not be connected, however, until after 2020. In the Community of Valencia, the three provincial capitals will be both interlinked and connected to Madrid by the HST in five years. The continuity of the high-speed Mediterranean corridor along the EURAM would be ensured with a new Tarragona-Castelló section which is not scheduled yet.

The explosion of low-cost companies has led to a sharp rise in air traffic in the EURAM, linked to the increase in tourism. Air traffic in the EURAM rose from 56 million passenger in 2000 to 87 million passenger 2007. In 2007, Barcelona handled around 33 million passenger, Palma 23 million passenger and Alacant 9 million passenger. The global traffic growth has benefited some regional airports such as Girona, whose traffic has increased since 2000 by 644 % up to 5 million passenger. The current capacity of the EURAM airport system, taking planned extensions into account, is globally sufficient in the short and medium terms. Spanish airports are managed by a public entity, Aena, with a centralized model.

The port of Valencia currently leads the container traffic in the Western Mediterranean with 3.6 MTEU in 2008 (+20 % compared to 2007), while the port of Barcelona handled 2.6 MTEU (+0 % compared to 2007). While other competitive hubs like Algeciras or TangerMed are better located geographically on the Suez-Gibraltar route, the ports of Barcelona-Tarragona and Valencia-Sagunt still offer excellent opportunities to become maritime gateways for Southern Europe. Pursing this strategy, all major ports in the Mediterranean basin are currently undergoing extensions or planning them to capture a higher share of Asian imports to Europe, which are currently handled by 75 % in the ports of Northern Europe.

If the EURAM is to become the Mediterranean's logistic gateway of Europe, the Mediterranean corridor to Central Europe should be able to accommodate far greater flows of goods. The provision of competitive rail services might contribute to reduce the pressure on motorways. Despite public support, however, railways play a modest role in goods transport in the corridor. Rail network is scarcer than in central Europe, while new lines require important investments due to difficult topographies and heavily populated environments.

Expected results

Accessibility analysis will be performed in the EURAM region in a NUTS-5 resolution. Accessibility runs will include accessibility to road and rail networks, to airports and ports. Results will provide an image of accessibility in a coastal corridor confined between sea, and hilly unpopulated hinterland areas. It will also provide contrast between different kinds of region types such as mountainous, metropolitan, sea-side, and scarcely populated areas. More specifically,

- Andorra will provide insight on accessibility in a small independent mountain country enclave with complex topography but important accessibility requirements due to primary tourist industry targeted on Spanish and French visitors.

- Pyrénées Orientales / Girona will study accessibility in a transborder region.

- Barcelona will show accessibility in the most important urban agglomeration in the EURAM

- Alacant will provide knowledge on accessibility in a coastal region focused on international tourism.

- Menorca case-study will analyze accessibility in an island, which being a biosphere reserve, needs to make compatible accessibility with environment preserving.

Northern Italy regional case study

The macro region

The area the case studies belong to is located in the north-western part of Italy across three regions: Lombardia, Emilia Romagna and Liguria. Northern Italy case study will deal with four different case studies corresponding to the Milan urban area, to the province of la Spezia, to the province of Piacenza and to the city of Parma.

The Milan urban area (corresponding to two NUTS-3 regions) consists of the Provinces of Milan and Monza-Brianza. It has a total area of about 2,000 km², with a total population of about 3.9 million inhabitants: In terms of population it is part of the leading metropolitan area in Italy and fifth in Europe. More than 1.3 million people live in the city of Milan, the core of the area.

The Piacenza Province (NUTS-3 region) is placed on the north-south corridor linking the city of Milan with the rest of the Peninsula (Florence, Rome, Naples, etc.). The location makes the Province especially influenced by the city of Milan, in terms of historical and economic aspects. The province has about 288,000 inhabitants with a total area of 2,589 km².

Parma is one of the main cities in the Italian region of Emilia-Romagna (NUTS-2 region), capital of the Province of Parma (NUTS-3 region). The area is characterized by flat countryside, bounded west and east by two minor rivers marking the separation from the neighbouring provinces of Piacenza and Reggio Emilia. Parma is placed on the North-south corridor linking the city of Milan with the rest of the Peninsula. The city has about 180,000 inhabitants over a total area of 261 km².

The Province of La Spezia (NUTS-3 region) is one of the four provinces of Liguria Region (NUTS-2 region). The province has an area of about 881 km², and a total population of 223,503.

The spatial structure

The case studies in the macro region cover different types of land structures. Milan Province is a flat and densely populated metropolitan area. In the Province of Piacenza flat countryside, hills and small mountains alternate. Most of the people live in the capital city while the rest of the Province is characterised by sparsely populated rural areas and small towns. Parma is a medium size town surrounded by a low density peripheral area gravitating around the main centre. The Province of La Spezia is characterized by diverse geographical areas: first, the gulf and the seaside, the hills around the Magra valley (Val di Magra) and the hinterland mountains crossed by various valleys. Like in all Ligurian provinces, land area is characterized by mountains and hills, while plains are statistically undetectable. Less than one half of population lives in the capital city while the rest is concentrated in many towns with rural characteristic, most of which is located in hilly areas or foothills.

Socioeconomic portrait

The four case studies belong to Northern Italy, which is largely the most developed and rich macro region in Italy. In particular, Milan is the most important economic area at Italian level with more than 300,000 firms located (corresponding to about 42 % of the activities in the Lombardia Region and 6 % of the Italian firms) generating nearly 10 % of the Italian GDP. Beginning with 1970s, the heavy industrial production decreased making room for the growth of services and tertiary activities, particularly if qualified and with high value added. 15 % of Italian firms related to the high-tech sectors resulting in about 30 % of employment in such sectors are located here. During the 1990s technologic progress and global economy modified the traditional structure of the production which is based now on a wide network of small firms together with a slight number of medium firms. Currently, most of the firms and jobs are related to the service sector (about 69

%), while the industrial sector covers about 28 % and agriculture 2 % only. Nevertheless, the high level of mechanisation and productivity of the agricultural sector gives it an important role in the economy of the area despite the low number of jobs.

The economic structure of the Piacenza Province is primarily based on the industrial tradition of the area, developed by small and medium-sized firms mainly focused on manufacture products (including about 33 % of people working in the Province). Other important activities for the economy of Piacenza are related to trade, services and construction sectors (respectively 22 %, 11 % and 10 % of workers).

Parma economy stands on the ground between all the Italian cities for the significant interpenetration between agriculture and industry. Parma farmers (located in the Province) produce food for industrial purposes: tomatoes, peas and sweet corn for canning, milk for the dairy industry, the first among others the production of Parmigiano Reggiano cheese and Prosciutto di Parma (Parma ham). The mechanical industry of the area of Parma is the national leader in the production for industrial processing of agricultural commodities: equipment for the canning industry, milk processing system, etc. In addition, two large multinational food companies are located in Parma and its surroundings. Also, several large chemical and pharmaceuticals multinational companies are located in Parma.

The economic structure of the La Spezia Province developed thanks to the Naval Military base, located there since the second half of the nineteenth century. The gradual disengagement made by the Navy in the area which begun in the eighties and is still ongoing has caused a critical period for La Spezia economy, impacting negatively also on demographics aspects. Currently, many efforts are still ongoing to promote new economic growth in different sectors: many military areas have been converted for civil use, especially in the field of yachting, strongly in expansion in this period and tourism is becoming a key point of the economy of the Province of La Spezia. In terms of value added, agriculture accounts for 2 % while services sector covers more than 80 % of the total amount; the residual part is in charge of the industrial sector.

Transport aspects

Transport infrastructures and services are generally well developed in Northern Italy, despite the high population density coupled with many small firms and residences spread all over the territory generate a large amount of transport demand that gives rise to congestion problems.

For this reason, especially in the Province of Milan additional road infrastructures are planned for the next future, namely:

- the Brebemi motorway, linking the city of Milan to Brescia via Bergamo;

- the "Pedemontana" motorway, connecting the A4 motorway from Dalmine to the Malpensa airport crossing the provinces of Lecco, Monza and Como;

- the Outer Ring Road in the eastern part of Milan, planned to relieve the traffic on the A1 motorway directed towards the A4 motorway and vice versa.

Demand is largely concentrated around the city of Milan. More than 800,000 trips enter in the city every day, mostly concentrated during morning peak hours (about 27 % between 8 a.m and 9 a.m.). Most of the trips attracted from the city are made by private car (60 %), while train and bus are used for 21 % and respectively 8 % of the trips. The railway network is quite extensive and is managed by different entities: the Ferrovie dello Stato and Le Nord (in the northern area of Milan). The extra-urban rail system is pivoted around the Milan Central Station and Milan Cadorna Station. Three airports (Linate city airport, Malpensa and Orio al Serio) serve the metropolitan area.

The Province of Piacenza is located in a strategic place on the North-South corridor linking the city of Milan with the rest of the Peninsula (Florence, Rome, Naples, etc.). Nevertheless, it could be considered strategic on the West-East corridor as well, being on the road corridor linking Turin and Liguria region with Brescia and the Eastern part of Italy bypassing the Milanese pole. Therefore, the city of Piacenza in particular can be considered a strategic railway and motorway junction. The Province does not have an airport on its territory: the nearest are those of Parma and Milan.

The city of Parma is the pivot of local mobility and passengers commuting to or within the city predominantly use private transport modes (about 59 % cars, 7 % motorcycles), while public transport modes are used for about 16 % of the commuting trips (12 % by bus, 4 % by train). Bicycles are used for more than 10 % of trips. For the connection with external regions, Parma is well served by motorway and rail networks. A small airport (about 70,000 passenger/year) is also existing providing several national (and few international) connections for passenger transport.

The Province of La Spezia is crossed by two main motorways: motorways A15 connects the province to Parma, while motorway A12 links La Spezia to Genoa and Livorno. As well, there are two railway lines on the territory of the La Spezia Province: the line from Parma to La Spezia and the line from Genoa to Rome.

The Province does not have an airport on its territory: the nearest ones are those of Genoa and Parma.

Expected results

For each of the four cases studies a multimodal transport model is available. The four models have been developed independently, with specific features as far as elements like demand segments, transport modes etc. are concerned. Nevertheless all models provide results on transport generalised cost and attractiveness for a zoning system at NUTS-4 level or lower (within for the municipalities of Milan, Piacenza, Parma and La Spezia) and for origins and destinations outside the areas of the case studies. These elements will be available for producing accessibility indicators at the local level.

Bavaria regional case study

The macro region

The Federal State of Bavaria is located in the southern parts of Germany. With an area of about 70,500 km², Bavaria is the largest NUTS-1 region in Germany. With a total population of 12.5 million people it is the second largest state of Germany, only the high-density state of North Rhine-Westphalia has more inhabitants. Bavaria consists of seven NUTS-2 regions, 96 NUTS-3 regions and 2056 municipalities (LAU-2 regions).

In the macro region of Bavaria there are very different types of regions included ranging from a high-density monocentric agglomeration and medium-sized polycentric agglomerations via semi-urban surroundings of the agglomerations to rural structures with small and medium-sized cities which include also mountainous areas, in particular the Alps.

Spatial structure

Munich is the capital of Bavaria and the largest city with a population of more than 1.3 million in the municipality and about 2.5 million in the agglomeration. Nuremberg with about 0.5 million inhabitants and Augsburg with 250,000 inhabitants follow next, but are clearly smaller in size. There are only five more cities with a population of slightly more than 100,000. Two thirds of the

population live in small and medium-sized cities and rural areas of less than 20,000 inhabitants per municipality.

Consequently, the spatial structure of the macro region of Bavaria is very heterogeneous. The agglomerations of Munich and Nuremberg are major centres in a more urbanised arc starting in the north-west of Bavaria and running through the two agglomerations towards the south. From this arc towards the outer boundaries of Bavaria, the regions are getting less dense, more rural and peripheral. In terms of area size, rural areas are dominating the macro region of Bavaria.

Socio-economic portrait

Bavaria is considered to be one of the most successful regions of Germany during the economic transformation in the last decades. Since World War II Bavaria developed from an agrarian economy to a high-tech economy with a concentration of modern industries in and around the larger cities. GDP growth rates of Bavaria were usually higher than for Germany as a whole. Compared to the average GDP (in PPS) of EU 27 the index for Bavaria is about 135. Unemployment rates in Bavaria are the lowest in Germany and currently little above 4 percent. Consequently, Bavaria has experienced steady population increases during the last decades which are based on a positive migration balance, in particular also with all other German states.

Transport aspects

As most German regions, the macro region of Bavaria is very well served by the national motorway network in which major investments have been made during the last decades. Within Bavaria, a mesh-like motorway structure with only very few remaining gaps is connecting the different parts of the state. Several motorways lead to other parts of Germany as well as to international destinations such as Prague, Vienna or via the Brenner motorway to northern Italy. The motorway network is amended by a dense system of national and state roads connecting also small and medium-sized towns.

The public transport network is based on a relatively dense rail network system composed of high-speed train services and regional and local train services. However, as in other parts of Germany, the rail services in Bavaria were reduced in rural areas whereas agglomerations partly saw investments in new infrastructure and services. The rail network is amended by tram and underground networks in the agglomerations and by a dense bus network serving small and medium-sized cities and rural areas. However, the frequency of many bus lines serving rural areas is rather low so that some areas are only served in connection with bus transport of pupils to school

Less important for the analysis of regional and local accessibility patterns are the air and waterway connections of Bavaria. The Munich airport located more than 30 km northeast of the city centre is one of the major German airport hubs and serving many national, international and intercontinetal destinations. Though located far away from the sea, Bavaria is well integrated into the European inland waterway system. Via the navigable rivers of Main flowing into the Rhine and the Danube and the connecting Main-Danube-Canal Bavaria has waterway links to ports located at the North Sea as well as at the Black Sea and the eastern parts of the Mediterranean Sea.

Expected results

The accessibility model will be set up for the entire macro region of Bavaria. Modes addressed are road and public transport. The road network includes all roads including all residential streets. The public transport network is derived from the public transport time table covering all public transport services in Bavaria including all rail, underground, tram and bus services. The raster

model will be run for a raster representation of the Bavarian territory. For this, Bavaria was disaggregated into some seven million raster cells of 1 ha in size. Population was also disaggregated to these raster cells.

The accessibility model for the Bavarian macro region will be able to compute a wide variety of accessibility indicators to be specified in the course of the TRACC project. Results can be presented for the raster level and can be aggregated to municipalities. Results will be presented for the whole macro region, but in more spatial detail also for some selected specific types of regions. For this, four zoom-in case study areas within the macro region of Bavaria are foreseen:

- The Munich region will give insights into accessibility patterns in a huge urban area with a monocentric spatial structure.

- The Nurenberg region will provide knowledge about accessibility patterns in a medium-sized urban area with a polycentric spatial structure.

- The Allgäu region in the south-western parts of Bavaria including parts of the Alps and its foot-hills will depict accessibility patterns of rural and mountainous areas.

- The Donau-Wald region in the eastern parts of Bavaria will provide findings concerning the ac-cessibility situation of rural areas.

The accessibility analysis for the case study macro region of Bavaria and the zoom-in case studies will provide understanding of regional and local accessibility patterns for a variety of regional types including large agglomerations, urban-rural settings, rural areas and mountain areas. By having a precise representation of road and public transport networks, the differences of accessibility pattern for the two modes of transport in the different types of regions will become visible.

Czech Republic regional case study

The macro region

The Czech Republic is a landlocked country situated in Central Europe. Its area comprises the historical territories of Bohemia, Moravia and a part of Silesia. It shares borders with Poland (762 km), Germany (810 km), Austria (466 km) and Slovakia (252 km). The capital city is Prague. The area covers 78,864 km² (21st position in Europe) with a population of 10.3 million (12th in Europe). The average density of population is approximately 130 inhabitants/km². The Czech Republic is located between two mountain systems. The western and central parts of the country include the Czech Highlands, the eastern part is formed by the Carpathian mountain range.

The spatial structure

The Czech Republic can be divided into lower (municipalities) and higher (regions) territorial self-government units. In 1997, a constitutional act established higher territorial self-government units (the regions), which did not correspond to the regional demarcations valid between 1960 – 1989. However, this act did not regularise the organisation or the structure or competences of bodies at the regional level. Therefore the regional system functioned at the beginning only formally (de iure). The state administration and self-government started to work at the regional level as late as the autumn of 2000 (de facto). It means since the year 2000 the Czech Republic has the new administrative structure - 14 Regions (NUTS-3).

Municipalities administer their territories within the framework of independent competence. Besides, they execute delegated competences on behalf of the state. Within their self-competence, all municipalities and towns have equal rights and obligations. Execution of the

delegated competences depends on the size of the municipality and the territory it administers. Municipalities are divided into three groups, according to the scope of delegated

- Municipalities with the basic range of the transferred competency – of which there were 6 249 municipalities as at the 1st January 2008.

- Municipalities with authorised municipal offices – 388 municipalities whose municipal offices exercise transferred competency, especially in the domain of offences, construction administration and agricultural land resources.

- Municipalities with extended powers – 205 municipalities, which exercise in their territory the largest range of the transferred competency especially in the domain of issue of passports, driving and trading licences, waste management, transport and road management etc.

Besides these in the Czech Republic, there are some municipalities with registry offices (900), with construction offices (722) and with tax offices (223). It is obvious that the recent structure of state administration is complicated and too complex for its inhabitants.

The Czech Republic is characterised by a fragmented structure of its settlements, with a historically given high number of municipalities. As was mentioned above there is a great number of municipalities in the Czech Republic of which only a minor part can be regarded as towns based on international standards. Nonetheless the urban areas play an important role in the development of the entire regions. From the functionality viewpoint, the following urbanised areas can be identified: Prague agglomeration, East-Bohemian agglomeration, North-Bohemian conurbation, Liberec – Jablonec nad Nisou, Plzeň, České Budějovice, Karlovy Vary, Ostrava agglomeration, Brno agglomeration, Central-Moravian conurbation, Zlín.

With regards to the potential for further development, the Czech spatial development policy defines 12 main development areas. Far more frequent requests are made for zoning changes in the following areas because they are centres for international or nationwide businesses: Prague, Ostrava, Brno, Hradec Králové – Pardubice, Plzeň, Ústí nad Labem, Liberec, Olomouc, Zlín, České Budějovice, Jihlava and Karlovy Vary. These development areas are linked by 11 development axes.

Socioeconomic portrait

Regional development and differences in the Czech Republic are strongly influenced by a unique position of Prague in the Czech economy. The capital city of Prague (NUTS-2 region) is currently one of the most dynamic and most successful regions of Central Europe. Prague is a key administrative centre in the Czech Republic and has a modern services economy, specialising in financial services and activities related to tourism. As the largest city by far in the Czech Republic, it is also the location of the main national companies and the principal bodies concerned with scientific research and education. Prague has become a favoured destination for foreign banking activity during the transformation period and holds this position to present time. Prague belongs among the five wealthiest regions in the whole European Union. At the same time Prague is the wealthiest regions from the new members EU. On the other hand Prague has also number of serious problems typical for high metropolitan regions as for example disrupted environment, transport problem (traffic jam), pollution, criminality etc.

The remaining NUTS-2 regions in the Czech Republic can be placed in four groups.

- Regions with strong economic growth that are catching up with the EU average: South-West (Jihozápad) and Central Bohemia (Střední Čechy)

- Regions of low-moderate economic growth: South-East (Jihovýchod) and North-East (Severovýchod)

- Regions lagging because of very slow growth: Central Moravia (Střední Morava)

- Declining regions: Moravia-Silesia (Moravskoslezsko) and North-West (Severozápad)

Czech NUTS-2 regions are always made up of two or three NUTS-3 regions. NUTS-2 regions are only statistical units without self-government and responsibility. On the other hand NUTS-3 regions (kraje) play a key role in the regional development.

Transport aspects

Due to its position in Central Europe, the Czech Republic is well-advantaged to make the most of its good transport accessibility. The country is indeed covered with a dense network of railways and roads, but it does not always meet the standards expected from transport.

Since 1990 the shares of the various modes of transport have transformed substantially, in relation with a general transformation of the society and the country's accession to the EU. The greatest decline in performance, and the volume carried, was noted by the railway, by public road transport (passenger), and water transport. On the other hand, transport by heavy trucks over 12.5 tonnes increased substantially, as well as individual passenger and air transport. The performance of all the transport modes with a negative impact on the environment increased.

Expected results

Accessibility analysis will be performed in the Czech Republic for a NUTS-5 resolution. Accessibility analysis will include time accessibility (rail and road) to airports and important economic settlement centres as well (which will be chosen). These analyses will provide images of accessibility in different types of Czech regions (urban and metropolitan regions, rural, mountain and periphery regions etc.), the final selection of case study areas within the macro region still has to be made. Analysis could also show the accessibility in these types of regions to main services (health, schools, administrative services etc.).

Poland regional case study

The macro region

Poland is a country located in Central Europe. It covers an area of 312,685 km² that makes Poland the ninth largest country in Europe. Since the beginning of the 1990s population of Poland has remained rather constant in size and equals about 38.1 million people (ranks eighth in Europe and sixth in the European Union).

The territory of Poland has been divided into arbitrary 6 NUTS-1 regions (regiony) and 66 NUTS-3 subregions (podregiony) for statistical purposes. The 16 NUTS-2 units correspond to the 16 voivodships (województwa). The voivodships are divided into 379 NUTS-4 districts or counties (powiaty) including 65 cities with powiat status. The powiats are further subdivided into 2478 NUTS-5 municipalities or communes (gminy). The gmina is the basic unit of the country's territorial structure. The gmina, powiat and voivodship councilmen as well as mayors of rural gminas, mayors of urban gminas and mayors of major cities are elected in general, equal, direct election.

The northern border of Poland runs partly (about 440 km) along the Baltic Sea coast. Poland shares the rest of the border (3511 km) with its 7 neighbouring countries including, since 2004, 1908 km of internal EU border (since 2007 within the Schengen zone border) with Germany, Czech Republic, Slovakia and Lithuania and, since 2007, about 1163 km of new Eastern Schengen border with Ukraine, Belarus and Russia. The Sudety Mountains are located on the

Polish-Czech border and the Carpathian mountains are along Poland's border with Slovakia. However, the majority of the country is a lowland.

The spatial structure

The Polish urban system is characterized by a polycentric structure. In comparison with other European countries' urban systems, the capital of Poland (Warsaw) is less dominant in the Polish urban hierarchy. Population of Warsaw is about 1.7 million people (only 4.5 % of the total population of the country). Besides Warsaw, the population of Kraków, Łódź, Wrocław and Poznań is more than 500.000 inh. and in 12 other cities population exceeds 200.000 inh.

The NUTS-2 population density differs from 59 persons per km² in north-eastern Poland (Warmińsko-Mazurskie and Podlaskie voivodships) to more than 200 persons per km² in the south-central of a country (217 persons per km² in Małopolskie and 377 persons per km² in Śląskie voivodships). The average population density in Poland is about 122 persons per km².

Socioeconomic portrait

During the last two decades Polish GDP has expanded rapidly and Poland climbed up the ranks to the sixth in the EU in terms of real GDP (PPS-based). The Polish economy avoided a decline in GDP during the financial crisis and has created in the EU the highest GDP growth in 2009. However, the restructuring of heavy industry and agricultural sector after 1989 led to the higher rate of unemployment (20 % of the economically active population without job in 2002-2003). In the following years the situation has improved and the unemployment rate decreased to the level of 9.5 % in 2008. However, due to the financial crisis, it has increased once again to 11.9 % in 2009 (in the Warmińsko-Mazurskie voivodship still exceeds 20 %).

Poland's large internal market of 38 million consumers could help in being more independent of world economy than the rest of Eastern European countries. However, as early as 1995, 70 % of Polish export was directed to EU members (particularly to Germany).

The GDP structure is formed mainly by the service sector (65 %), followed by the industry (32 %) and agriculture (3 %). The overemployment in agriculture (about 15 % of the workforce), particularly in the eastern parts of the country, still remains an obstacle to modernisation.

Spatial structure of industry in Poland has its roots in the time when Poland was partitioned by the Prussian, Austrian and Russian empires. The western and southern parts of Poland became more industrialized than the central and eastern ones (with exception of metropolitan areas and Świętokrzyskie voivodship). Despite the strong decline of coal mining and metallurgy in terms of employment, the main industrial part of Poland remains industry conurbation of Upper Silesia voivodship. The automobile industry has developed to a considerable extent in the south-western Poland but most of the headquarters and foreign direct greenfield investments are located in Warsaw and its surroundings or in the other largest metropolitan areas.

For several years Poland has experienced a large amount of emigration to the UK and Ireland where 1 million Poles outnumber the other Eastern Europeans.

Transport aspects

Before 1989 the Polish transport system was characterized by freight traffic flows in the east/west direction between Soviet Union and GDR and in the north/south direction between Polish harbours and the Upper Silesian coal region. After 1989 the decline in freight transport and the rapid increase in the private mobility and the motorization rate (much faster than GDP growth) led to more than 400 motor vehicles per 1000 inhabitants in 2008. In spite of this process, the 1990s

was the decade of further delay in major decisions concerning transport infrastructure investments. After 2000 Poland is making up for the lost time being in the process of the biggest national motorway construction program in Europe.

The traffic is particularly concentrated in high population density areas – the Upper Silesia region and Warsaw. The highest traffic is observed on the international roads: existing motorway sections of the A4, A2 and A1, on E-75 (Upper Silesia-central Poland section) on E-77 (from Gdańsk through Warsaw to Kraków) and on E-67 from (Wrocław through Warsaw to Polish-Lithuanian border). The main transit road is the route from Germany through Poznań and Warsaw to the Baltic States.

Poland suffers from lack of proper railway infrastructure. The large decrease of technical speeds on many railway lines led to the modal shift from rail to road. According to the government's plan Polish high speed railway will run from Warsaw to Poznań, Wrocław and Łódź (Y line) in 2020.

Poland's regional airports are catching up with the country's main airport in Warsaw after the accession to the EU (nearly 55 % of all 20.8 million passengers in Polish airports flew through regional ones in 2008). The main flight destinations are UK and Germany.

The harbour cargo operations, which are decreasing in recent years, are concentrated in Gdansk and Gdynia (Pomorskie voivodeship), and on a smaller scale also in Szczecin and Świnoujście (Zachodniopomorskie voivodeship).

Expected results

Accessibility analysis will be performed in Poland on the NUTS-5 level (isochronic accessibility measure to main cities, road and railway networks, airports and ports) and on the NUTS-4 level (road and railway potential accessibility). The results of the accessibility study will provide a knowledge base on important difference in accessibility results obtained from European and national perspective, particularly in case of south-western part of Poland (lack of motorway and good railway connection to Warsaw and excellent accessibility to European core). The following in-depth case studies are planned:

- Warsaw is developing very fast while its road accessibility is poor; it will change in 2012 after the realization of the A2 motorway section to Warsaw.

- Dolnośląskie is chosen due to the lack of motorways, but the good railway connection to Warsaw and excellent accessibility to European core areas.

- Zachodniopomorskie (or Pomorskie) will be studied for their interest due to the existence of ports, regional airports, fragmented motorway sections and foreseen accessibility changes in the next decade.

- Małopolskie includes the tourist destinations of Kraków (relatively good accessibility) and Poland's most popular mountain resort Zakopane (poor accessibility).

Scandinavia regional case study

The macro region

While the countries of Norway and Sweden will be considered as the macro region, there will be three regional case studies in each of the two countries: Tromsø in the far North and Trondheim represent 'fjord Norway', with their specific topographic situation between the sea and the mountains in the backyards. Both cities represent regional centres offering all public and private services, with extremely low population density around. The cities of Tromsø and Trondheim itself experiences population increases over the last decade on the expense of population losses in the

regions around. Lillehammer is chosen as a representative example of a winter sports resort in 'mountain Norway' with linear settlement structures along the valley, and mountain areas around. Lillehammer, being the regional centre in the heart of the mountains, also offers a wide range of public and private services; unlike Tromsø and Trondheim, there is quite a large number of small villages and second home areas in the hills around Lillehammer, leading to quite big differences between summer and winter residents.

Østersund and Falun/Borlänge are selected as typical Swedish examples of regional cities, both covering water areas and extensive forest areas, but with distinct urban settlements in between. Both cities represent the regional centre for public and private services and facilities, with only small villages in their hinterland, and a remote location in the national context. Both case study area experienced population losses over the last decade. Örebro is selected representing a major centre in the heart of Sweden, in between the great lakes of Vänern and Hjälmaren, with good transport connections to both Stockholm in the East and Gothenburg in the south-west, and with a stable population. Unlike the other two Swedish examples, there are a number of other medium-size towns and centres in rather close proximity to Örebro (for instance, Arboga, Eskilstuna, Linköping, Karlskoga).

The spatial structure

From a European perspective, Norway and Sweden are considered as peripheral regions with extremely low population densities, long distances, low density of transport infrastructures, extensive forest areas and barren lands. From a regional perspective, there are, though, important differences in the settlement structures of these regions, and also the major modes of transport differ widely.

Earlier studies on the Nordic countries revealed very distinct settlement patterns in the Nordic countries (Gløersen et al., 2006). The example given is that within a 50 km radius cities might have the same population potential and overall population density, however, based on very different types of settlement structures. While in the example of Mikkeli (Finland) basically all the territory is populated except for water areas with extremely low number of residents per 1x1 km grid cell, in case of Östersund (Sweden) there is a clear distinction between the extensive urban area, with partly very high numbers of residents per 1x1 km grid cell, and no residences in the surrounding wilderness; finally due to the difficult topographic situation with fjords and mountains around Tromsø (Norway) only few places along the fjords and valleys are populated, while the other barren land remains unpopulated. Such very different settlement structures in the Nordic countries will result in different accessibility patterns, which will be analysed in this case study.

Transport aspects

The main modes of transport differ significantly between the case study regions. While all Swedish case study areas are well embedded into railway and national road networks, connecting the cities in all directions, only Trondheim and Lillehammer in Norway have rail access, but with only one (Lillehammer) or two (Trondheim) rail links. Even though only Örebro has direct connection to motorways, the Swedish major road networks can be considered as rather dense with a even higher density of complementary secondary roads, compared to the Norwegian ones, where there are only few major routes, connecting through the valleys, which almost lack any secondary roads, in consequence of the difficult topographic conditions. In turn, the regional airports of Trondheim and Tromsø play a major role in the Norwegian airport system, so as all airports in Norway, with a very high number of daily flights to Oslo and other destinations. Flights to these destinations are, moreover, subsidised by the Norwegian government to ensure accessibility of these remote areas. The cities of Östersund,

Falun/Borlänge and Örebro also have airports, but with less importance (in terms of number of flights and destinations served).

Expected results

The accessibility model will be set up for the entire macro region (i.e. Norway and Sweden), including road, railways, ferry and flight connections and tramways and subways. The spatial base level will be a 1x1 km raster grid, for which travel times and accessibilities will be calculated. The raster results will then be aggregated to municipality level. Based on this overall computation, the analysis will zoom into the six regional case study areas to reveal small-scale local and regional accessibility patterns. The results will be compared not only between the six case studies, but also to the other parts of the macro region.

Finland regional case study

The macro region

Finland is the eighth largest country in Europe in terms of area and the most sparsely populated country in the European Union. Around 5.4 million people live in Finland, with a majority being concentrated in the southern part of the country. Situated in the Fennoscandian region of Northern Europe, it is bordered by Sweden, Norway and Russia, while Estonia lies to its south across the Gulf of Finland. Finland is a country of thousands of lakes and islands (almost 200.000 lakes and 200.000 islands), mostly flat with few hills, being its highest point the Halti at 1.324 metres in the northern tip of the country. In addition to the harsh climate, the amount of population and economic activities have remained low due to the fact that the topography of the region poses serious challenges to accessibility.

The selected case study areas will provide insight on the Helsinki metropolitan area, the Lapland region and the Oulu region.

The spatial structure

Around 5.4 million people live in Finland, with a majority being concentrated in the southern part of the country. The Greater Helsinki concentrates 25 % of the country's population, including three cities with more than 100,000 inhabitants (Helsinki, Espoo and Vantaa). Other major cities in the region are Tampere (210,000 inhabitants), Turku (175,000 inhabitants), Oulu (140,000 inhabitants), Jyväskylä (130,000 inhabitants) and Lahti (100,000 inhabitatns). There are no other cities other than these with more than 100,000 inhabitants.

The Helsinki metropolitan region, roughly corresponding to the NUTS-3 level region of Uusimaa, consists of 18 municipalities with a totall population of around 1.4 million people, making it the most densely populated region in Finland. Most of the population lives in the capital city of Helsinki and its three immediate neighbour cities. Due to being located at the coast along the Gulf of Finland, the region encompasses a large number of islands of different sizes, but they do not have any significant demographic role. Generally, the population density decreases fast as one moves away from the city of Helsinki. The main transport corridors of course make exceptions to this.

The Oulu region consists of ten municipalities located within the NUTS-3 region of Northern Ostrobothnia, located in the mid of Finland on the shores of the Bothnian Bay. Oulu, the main municipality of the region, has a population of about 140.000 inhabitants, making it the most populous city in Northern Finland. The region is characterised by a single and relatively small urban centre surrounded by rural areas. The population density drops rapidly as one moves away

from the city of Oulu, and large areas in the region are totally unpopulated. Settlements have concentrated historically at the coast and at the mouths of rivers, a pattern which remains even today, although a distinctive semi-urban area has been formed around the city of Oulu.

The NUTS-3 region of Lapland is the northernmost region of Finland, being a vast region constituting almost a third of the entire country but housing only 180.000 inhabitants, a half of which is concentrated in the three biggest population centres. This signifies that most of the region is extremely sparsely populated, and indeed, large areas of the region are totally unpopulated. The region of Lapland consists of overall 21 municipalities, which differ significantly both in their area and population. The largest population centres are located in the south-western part of the region, positioned mostly at the mouths of the great rivers running into the Bothnian Bay. The northern parts of the region are extremely sparsely populated with only small local centres.

Socioeconomic portrait

Helsinki's metropolitan region is Finland's major political, educational, financial, cultural and research centre. Approximately 70 % of foreign companies operating in Finland have settled in the Helsinki region. The employment rate in the region is high: 63 %, which is considerably higher than in the rest of the country (57 %). Indeed, the region is more than self-sufficient in jobs. Currently less than one percent of the population work in agriculture. Industry and services account for 18.6 % and 80.8 % of the workplaces, respectively. The share of the industry has been in constant decline for several decades, which is compensated by the growth in services-related activities. The region accounts for about 35 % of the entire GDP of Finland. The GDP per capita is over 46,000 € which is 135 % of the national average.

Most of the people in the Oulu region work either at the service sector (75 %) and industrial sector (24 %). Traditionally the economy of the region has relied on the wood-processing industry, which has benefited from the location close to the rivers. The relative importance of the traditional industry has been in constant decline, and has been replaced especially by high-technology industry. However, the industries have suffered from the economic downturns during the past decade, resulting in relatively high unemployment (14.5 %), which is four percentage units higher than the national average, especially among young people. However, related to the fact that the age structure is tilted towards younger generations, which can be regarded as a potential socioeconomic advantage for the region. The population of the region has been in constant increase for a long period of time, due to immigration from the peripheral areas of Northern Finland, but also the result of a high birth rate. Specifically, the population growth has been strongest in the neighbouring municipalities of Oulu, and Oulu itself.

The region of Lapland is generally considered to be one of the least developed and most peripheral parts of Finland, where many socioeconomic problems are apparent. For example, the unemployment rate is several percentage points higher than the national average, and is the second highest among the NUTS-3 regions of Finland. Generally, the population of the region is in steady decline, and the age structure is becoming increasingly older. The population of the region peaked in 1993, but since then the amount of population has decreased by almost 20 000 people. The negative trend has affected the entire region, except for the regional capital and certain individual population centres benefiting from the expanding tourism industry. While 6 % of the population work in the agricultural sector, 14 % do so in industry and construction, and services account for the major share of the sources of livelihood. Tourism in particular has become an important form of economic activity during the past few decades. Although the role of industry has been in slow but steady decline, two paper mills and a large steelworks operate in the south-west corner of the region.

Transport aspects

Due to its position as the capital of Finland since early 19th century, Helsinki and the surrounding region is well connected to the rest of the country by roads, railways and air traffic. Especially the railway network has been designed to connect Helsinki efficiently to the regional centres around the country. The region includes the main international airport of Finland, located remotely from Central Europe, while serving as an important connection hub between Europe and East Asia. The most important port of Finland is also located in the region as well. In addition to very busy freight traffic, there are passenger ferries operating mostly to Stockholm in Sweden, and Tallinn in Estonia. Domestic passenger traffic by the sea is, however, almost non-existent.

The Oulu region, In spite of being located far from the main populated centres of Finland, and extremely far away from Central Europe, can be considered to be relatively well accessible, at least in the national context. Finnish fast speed trains operate to Oulu, but the current condition of the railway and the congestion of the route reduce the actual benefit of the high-speed traffic. The shortest travel time from Oulu to Helsinki is 6 hours by train. Railway connections are also provided to many other regional centres especially in the south, but not at very short intervals. The Oulu region is also located advantageously with respect to the road network, as the most important highway running from Helsinki up north through the entire country run through the Oulu region. The region has the second biggest airport in Finland by passenger volume. Port of Oulu is one of the busiest harbours within the Bothnian Bay, but it only handles freight traffic.

Lapland has significantly varying conditions accessibility and transport conditions within the region. The south-western part of the region is well connected to the rest of Finland by the road, railway and air connections. The eastern and northern parts of the region, however, are almost solely accessible by road. Two big harbours are located in the industrialised south-west part of the region, serving the needs of the heavy industry. Unlike any other region in Finland, Lapland has transborder connections to three other countries, but the low amount of population in the northern regions of Sweden and Norway is a limiting factor to the volume of economic interaction. Connections to Russia are relatively limited.

Expected results

Accessibility analysis will be performed at least at NUTS-5 resolution; the use of more accurate resolutions is an option. Accessibility runs will include accessibility by road and rail, possibly also including airline connections.

The case of Helsinki region is an illustrative example of high and good quality of accessibility in spite of the physical remoteness. The typologies associated with this case study include at least urban and semi-urban areas, in the northern context.

The Oulu region in Northern Finland represents the case of a competitive growth centre located high up in the north. The region is particularly interesting from the accessibility point of view in the sense that the urbanised area is closely surrounded by deeply rural and peripheral areas.

The region of Lapland represents a case of extreme periphery in the European context. The importance of the accessibility in this kind of periphery should be taken in to account, due to the difference in remoteness when compared to the rural regions in the rest of Europe, and also the remoteness in the local habitation structure and infrastructure. The accessibility of these regions remains a relatively unstudied question.

7 Assessment of data situation

In the initial project phase the current data situation with respect to trans-European transport network databases and socio-economic data has been assessed and evaluated. The availability of the required input data for the accessibility models is crucial for the overall success of project.

7.1 Network data

Several Europe-wide transport network data sources were identified that potentially could be used for Europe-wide or regional modelling in ESPON TRACC:

- ESPON local data (ESPON LD)
- ESRI´s Digital Chart of the World (DCTW)
- Eurostat GISCO/DG Move
- Navteq
- OAG
- OpenStreetMap (OSM)
- RRG GIS Database
- TeleAtlas
- TRANS-TOOLS
- Eurogeographics (not included here because of too late arrival of information)

The list of network data comprises open ('free of charge') datasets (ESRI´s Digital Chart of the World, OpenStreetMap), project datasets (ESPON local data, TRANS-TOOLS), European Commission datasets (Eurostat GISCO/DG Move), as well as databases of commercial data vendors (Navteq, OAG, RRG GIS Database, TeleAtlas). The databases were assessed by evaluation criteria developed in the project (Table 6). The criteria reflect the potential of the network data for European accessibility travel and freight modelling. Table 7 provides the assessment results.

Concerning the available *modes*, most of the datasets comprise road and railways; only TRANS-TOOLS and TeleAtlas and RRG provide flight and waterway networks. Freight terminals are only provided by RRG, TRANS-TOOLS and (to some extent) OSM. OAG, as a special data source for aviation only provides flight networks.

The *spatial coverage* of the databases is generally good, except for the ESPON Local Data, which only comprises the Czech Republic, Hungary, Romania and Slovakia, and the GISCO networks and do not provide data for the Western Balkan and east European countries. Data for North Africa, as required by the freight model, are included in all data sources except for the ESPON LC, GISCO and RRG networks.

The *network density*, however, is very different. ESPON Local Data, Navteq, OAG and TeleAtlas can provide high network density, including all network links and nodes. OpenStreetMap provides generally high network densities in Western Europe, but in other parts the density is poor in rural areas. The RRG GIS Database covers all trunk roads, but secondary roads only for selected areas, whereas it contains all railways and all navigable waterways in Europe. DCTW, GISCO and TRANS-TOOLS cover only major links resulting in a rather low network density.

Five data sources come with built-in *network topologies* (GISCO, Navteq, RRG, TeleAtlas, TRANS-TOOLS), whereas ESPON Local Data, DCTW and OSM do not provide network topologies; consequently, the topology would need to be established.

Most of the data sources provide the network data for an actual year (Navteq, OAG, OSM, RRG, TeleAtlas), for other networks this information is not available (ESPON Local Data, GISCO, TRANS-TOOLS). A *temporal dimension*, i.e. network evolution over time, however, is only available with the RRG GIS Database.

Table 6. Criteria for the evaluation of Europe-wide transport network data

Criterion	Comment
Modes: road, rail (incl. stations), air (incl. airports), waterways, ferries (incl. ports)	For the Europe-wide accessibility modelling all four modes indicated are required. In addition, specific types of facilities such as intermodal freight terminals are needed for freight modelling, and functional connector links are required to link the centroids to the networks, and to link intermodal networks with each other.
Spatial coverage	The dataset needs to cover all countries of the ESPON space, plus EU candidate countries plus countries of the Western Balkan. Furthermore, external zones of the accessibility models cover Eastern European countries (Belarus, Moldova, Ukraine, Russia). For the freight model even countries in Northern Africa are included as external zones.
Network density	The networks need to have a certain density which is sufficient to connect all NUTS-3 region centroids. At least all trunk roads, all railway lines and all navigable waterways and ferries need to be included, as well as all scheduled flights in Europe. The minimum network density required is the density used in accessibility potential modelling for ESPON projects 1.2.1, 1.1.1, 2.1.1, 1.1.3 and the recent Accessibility Updates.
Network topology	In order to avoid time-consuming procedures in which usually errors in the database would be detected, the datasets should already include built-in network topologies, i.e. a correct topology between the links and nodes of a network.
Actuality	The databases need to have sufficient actuality (2008-2011). Older reference years cannot be used. Some accessibility indicators as the potential accessibility need to be calculated for 2011.
Temporal dimension	In order to assess the impacts of transport policies, scenarios of future transport infrastructures until 2030 or 2050 need to be available in the networks, based on the TEN-T and national outline plans. The SASI model covers also a backcasting period starting in 1981, requiring network input data in five year intervals from 1981 onwards to the present.
Attributes: link types, lengths, travel times (rail), speed limits, degree of urbanization (road), frequency (ferries, flights), IATA codes (airports), costs, capacities	All links in the networks need to have at least attributes providing information on link lengths, link speeds (either average speed, or maximum speed), for rail and flight networks even timetable travel times are needed. For ferries and flights information on service frequencies is required as well. Based on this information, minimum paths based on travel time can be computed by the accessibility models. Ideally, also cost and capacity information is provided with the networks. Capacities, however, can often be deduced from link types.
Data format	In order to facilitate a smooth integration of the network database, the data should already be available in a GIS format (like ArcView shapefile, MapInfo tab file etc.). Raster formats or ASCII formats cannot be used.
Price	Ideally the dataset should be usable free of charge by ESPON TRACC. High data costs may be an exclusion criterion for the dataset.
Legal restrictions	Any other legal restrictions that need to be considered.
Continuity	Previous ESPON projects (1.2.1, 1.1.1,, 2.1.1, 1.1.3 and the recent Accessibility Updates) already generated a number of accessibility indicators, where ESPON TRACC is expected to update these indicators. In order to enable reliable comparisons of the updated indicators with the previous ones, input data with similar characteristics should be used to ensure continuity without artefacts.
General data availability	Some datasets may, for any reasons, generally not become available to ESPON, even if they comply with all requirements.

Table 7. Evaluation of network datasets

Criteria	ESPON LD	DCTW	GISCO [8]	Navteq	OAG	OSM	RRG	TeleAtlas	TRANS-TOOLS
Mode[1]									
Road	+	+	+	+	--	+	+	+	+
Rail	+	+	+	+	--	+	+	+	+
Flights	--	--	--	--	+	--	+[2]	--	+
Water	--	--	--	--	--	--	+	--	+
ILC [9]	--	--	--	--	+	+	+	--	+
Coverage									
ESPON candidates	[3]	+	+	+	+	+	+	+	+
Balkan	--	+	+	+	+	+	+	+	+
East Europ	--	+	--	+	+	+	+	+	--
Africa (N)	--	+	--	+	+	+	--	+	--
Network density	high; all roads and railways	Low; only trunk roads & major railways	Low; only trunk roads & major railways	high; all roads and railways	high: all scheduled flights	different; in cities all net-works, in rural parts only major infra-structures	different: all railways, all trunk roads, in selected areas also secon-dary roads	high; all roads and railways	medium. all major infra-structures; secondary missing.
Network topology	not available, need to be build	not available, need to be build; pro-blems with connectivity.	available	available	not required	not available, need to be build; pro-blems with connectivity.	available	available	available
Reference year	n.a.	2008	n.a.	actual year	actual year	actual year (depending on community)	actual year	actual year	n.a.
Temporal dimension	no	no	no	no [4]	no	no	every year since 1950	no [4]	no
Attributes:									
Speed	--	--	--	+	+	--	+	+	+
Time	--	--	--	+	+	--	+	+	+
Costs	--	--	--	+	+	--	--	+	+
Capacities	--	--	--	+	+	--	+	+	+

Table 7. Evaluation of network datasets (continued)

Criteria	ESPON LD	DCTW	GISCO [8]	Navteq	OAG	OSM	RRG	TeleAtlas	TRANS-TOOLS
Data format	Shapefile geodatabase	shapefile	shapefile	shapefile	Web [5]	shapefile	Shapefile, geodatabase	shapefile	shapefile
Price	free	free	n.a.	high	free [7]	free	free [6]	high	free
Continuity	compiled in other ESPON project, but no acc calc	---	internal EC usage (DG Move)	---	---	---	used to calculate previous ESPON acc indicators	---	used in various research projects
Data availability	yes	yes	Currently not avail., later WMS service	only upon licensing	huge efforts for data gathering from website	yes	yes	only upon licensing	yes

1 modes: required are routable modal networks, not just background layer.

2 flight network data collected by S&W in a previous study; however, flight networks tightly integrated into RRG GIS Database.

3 network data only available for Czech Republic, Hungary, Romania, and Slovakia.

4 upon request past years could be licensed separately

5 data to be extracted from website

6 free usage within ESPON TRACC project, since RRG is project partner

7 free when data manually compiled from website; otherwise license fee to be paid

8 information provided by Sorin Andrei (DG Move) on TENtec at a GIS Experts Meeting in Brussels, 7 July 10 (Andrei, 2010)

9 ILC = Intermodal logistics centre (intermodal terminal, freight village)

Relevant speed, time, cost and capacity *attributes* required for accessibility calculations can only be provided by half of the databases (Navteq, OAG, RRG, TeleAtlas, TRANS-TOOLS), whereas the other ones are missing any such information. Information on capacity, however, can also be approximated from the link type fields (if available).

All databases offer the network data in a GIS *format* (ArcView shapefiles or Geodatabase). Except for Navteq and TeleAtlas, all databases can be used for free in ESPON TRACC. However, the GISCO datasets are currently not available, but at a later point in time GISCO/DG Move will make the networks available as WMF service. Navteq and TeleAtlas data, as being two commercial data vendors, need to be licensed for any usage. License fees depend on the actual scope of usage, however, they can be generally considered as very high.

The RRG GIS Database and also the TRANS-TOOLS data have already been used in several research projects, ESPON projects and consultant projects for various DGs of the European Union; the RRG data, moreover, have already been used to compute the previous ESPON potential accessibility indicators, that way ensuring continuity if used in ESPON TRACC.

In Table 8 the detailed findings are evaluated. It is concluded that the TRANS-TOOLS database should be used for modelling of European freight accessibility in TRACC, if necessary complemented with additional information from the RRG GIS Database, whereas for modelling Europe-wide accessibility travel the RRG GIS Database should be used (enriched with latest data for flight networks). OSM and the ESPON Local Data may also provide additional information to TRANS-TOOLS and RRG GIS Database. The TRANS-TOOLS network database is currently being updated and improved in the project ETIS+ with respect to the addition of international terminals, improved interconnections between modes, and network topology of ferry lines and airlines.

Table 8. Summary of network database assessment

Data source	Pros	Cons	Conclusions
TRANS-TOOLS, RRG	Free of charge, full coverage, all modes, required data formats, at European level sufficiently dense, already used in modelling, speed / cost / time info avail., network topology ok, RRG temporal, flexible	At regional level road networks not dense enough	TRANS-TOOLS to be used as base network for freight modelling, RRG to be used as base network for travel modelling. RRG to complement TRANS-TOOLS with missing information
OSM, DCTW, ESPON Local Data	Free of charge, full coverage (except ESPON Local Data), road and rail modes, required data formats, OSM and ESPON Local Data sufficiently dense	Network topology problems, no info on speed / cost / time, no TEN info, no temporal dimension, no flight and waterway networks	OSM and ESPON Local Data to complement existing network data for regional case studies, DCTW not to be used
Navteq, TeleAtlas, OAG	Full coverage, all modes except flights (Navteq, TeleAtlas), complete networks, topology ok, speed / time available, actuality	No temporal dimension, commercial datasets, high prices, legal restrictions, no flexibility due to internal formats	Navteq & Teleatlas not to be used due to price and legal restrictions
GISCO / DG Move	Free of charge, full coding of TEN networks, full coverage except Western Balkans, road and rail modes, sufficiently dense for Europe-wide modelling.	Currently not available, several required attributes not available	Currently data cannot be used

7.2 Socio-economic data

Potential data sources for the socio-economic data needed for the accessibility models are

- ESPON Database
- Eurostat Regio database
- National Statistical Offices
- Urban Audit
- Data at hand with project partners

First, existing data from the ESPON database will be investigated. If ESPON cannot provide certain datasets, the Eurostat Regio database or the National Statistical Offices will be reviewed. Data from the Urban Audit and data available at the Project Partners may complement the data collection.

The socio-economic data for the different models and analyses will be harmonised as much as possible in order to avoid situations where different indicator results are tracked back to different input data. Harmonisation will be done with respect to the following aspects: main data groups, spatial level, spatial coverage, reference year(s) and temporal dimension.

Main data groups

Main data groups to be collected for the accessibility models include population data (total, by sex and by age groups), employment (total and by sector), GDP (absolute, per capita), and number of productive units and number of workplaces. Depending on the indicator selection in Task 1, other data groups may be added if required in order to calculate certain types of accessibility indicators.

In addition, the SASI model to forecast impacts of transport policies requires additional simulation data, which can be grouped into base-year data and time-series data (see Chapter 4.6).

Base-year data describe the state of the regions in the base year of the simulation (1981). Regional base-year data provide base values for the regional GDP submodel and the regional population submodel as well as base values for exogenous forecasts of changes in regional educational attainment and regional labour force participation. Required base year data include

- Regional GDP per capita by industrial sector in 1981
- Regional labour productivity (GDP per worker) by industrial sector in 1981
- Regional population by five-year age group and sex in 1981
- Regional educational attainment in 1981
- Regional labour force participation rate by sex in 1981
- Regional quality-of-life indicators in 1981

Time-series data describe exogenous developments or policies defined to control or constrain the simulation. They are either collected or estimated from actual events for the time between the base year and the present or are assumptions or policies for the future. Time-series are defined for each simulation period, which are five year intervals from 1981 onwards. All GDP data are converted to Euro of 2006. Some of these data are required at European level, some at national level and some at regional (NUTS-3) levels, as follows:

- European data (34 countries)
  - Total European GDP by industrial sector, 1981-2031
  - Total European net migration, 1981-2031
- National data (34 countries)
  - National GDP per worker by industrial sector, 1981-2031
  - National fertility rates by five-year age group and sex, 1981-2031
  - National mortality rates by five-year age group and sex, 1981-2031

- National educational attainment, 1981-2031
- National labour force participation by sex, 1981-2031
- Regional data (1,330 NUTS-3 regions)
  - Regional endowment factors, 1981-2031
  - Regional transfers, 1981-2031

Spatial level

The statistical data for the accessibility models are to be collected at NUTS-3 level according to the latest 2006 NUTS classification (Eurostat, 2007) for the 'internal' zones of the models; if required, data for NUTS-2, NUTS-1 or NUTS-0 levels can be aggregated from there. For the external zones (see paragraph on spatial coverage below), data at country or macro region level will be sufficient.

In order to calculate new innovative accessibility indicators, some of which may be calculated at raster level, relevant statistical data at raster (grid) level are required. Because raster data are usually not available from official statistics, two approaches can be chosen to derive a raster database: first, statistical data from NUTS-3 level may be disaggregated by using actual land uses as side information, or second, existing grid data from ESPON or from the European Environmental Agency (EEA) can be used. The actually needed variables at raster level depend on the selected set of innovative indicators and the data requirements to compute them, which will be one output of Task 1.

The updated accessibility indicators will be calculated for the latest 2006 NUTS-3 classification. The SASI model, being the model used to assess the impacts of transport investments in Task 6, is currently being updated to this NUTS classification.

For the SASI model, in addition some data groups need to be collected at European and national level, respectively (see above).

Spatial coverage

Both, accessibility travel and freight models as well as the SASI model cover the ESPON space, i.e. EU27 plus Norway and Switzerland, as internal zones. The regions of the EU candidate countries Croatia and FYR Macedonia and of other countries of the Western Balkans will be included as internal zones (see Chapter 7.4). Other European countries of Eastern Europe are treated as 'external' zones for the models. Additionally, the freight model also considers countries in North Africa as external zones.

Reference years and temporal dimension

One of the main outputs of Task 3 will be the update of the existing potential accessibility indicators to the year 2011. Thus, the required base data for 2011 need to be collected in 2011. Another reference year will be constituted by the freight model (Task 4) for which the year with the latest available data, 2008, will be used. The socio-economic model (SASI model) to be used to assess the spatial impacts of accessibility (Task 6) works with network data in intervals of five years starting in 1981, i.e. empirical time series data for this period are required as well. Most of these time series data are due to previous model applications, already available at the Project Partners, but need to be converted to the latest 2006 NUTS classification.

In order to assess the impacts of European transport policies and infrastructure projects, a forecast horizon is set to 2031 for the passenger travel and freight accessibility models. Another forecasting horizon for the freight model and the SASI model may me set to 2050.

ESPON database

The ESPON database available to all ESPON projects will be the main database for the socio-economic data. The ESPON database is subdivided into six themes (directory names of the CD-ROM in italics)

1. *Basic* statistical data for the ESPON space at NUTS-3 level
2. *Grid* data for the ESPON space and the EU candidate countries and Western Balkan (disaggregated socio-economic data on GDP, unemployment and active population)
3. *Historic*al statistical data for the ESPON space, based on older NUTS classifications
4. *Local data* (statistical and geographical) for Bulgaria, Czech Republic, Hungary, Romania and Slovakia at municipality level
5. Basis statistical data for the *neighbour*ring EU candidate countries and Western Balkan at NUTS-3 level
6. *World* data: geographical datasets.

The required datasets will be extracted from these themes, and compiled and processed in the format required by the Europe-wide models.

Apart from the statistical data, the ESPON database also includes geographical boundaries for the different NUTS levels (NUTS-3, 2, 1, and 0), for different NUTS versions, which can be used for data illustrations and mapping. The he ESPON database provides also pre-processed mapkits and map layouts in ArcGIS format at different scales and with different extent (ESPON Space, ESPON Space and candidate countries, global mapkit, and local mapkit), which are to be used by all ESPON projects.

7.3 Regional data

Whereas for the Europe-wide modelling (Tasks 3, 4 and 6) NUTS-3 has been identified as the appropriate spatial resolution, the regional case studies to be conducted in Task 5 will work at finer spatial resolutions (NUTS-5, raster). Thus, small scale regional data need to be collected. Because of the different scope, extent and character of the case studies, no overall regional case study database will be developed, but individual databases for each macro region will be set up in the responsibility of the Project Partner in charge of the case study. Usually there will be several case studies per macro region, so that there will be one case study database developed per partner concerned.

Most of the required data is already available at the Project Partners, and can be used within ESPON TRACC. Table 9 summarise the available data and data sources for the individual case studies.

Concerning the network data, apart from some necessary database updates, in general networks for all required modes are already available in GIS format at sufficient detail. Concerning the statistical data, for most case studies data are already available with high resolution (i.e. municipality level, raster level); however, in several case some data are missing, or are available at higher spatial level only. Each Project Partner will be responsible to collect and update the data necessary for the regional case studies, at the required spatial scale.

It will have to be checked whether two Europe-wide available raster datasets, i.e. the EEA population grid and the ESPON grid data, can be used as one harmonised data source for the case studies in relation to socio-economic data.

Table 9. Available data for regional case studies

Macro region	Network data	Statistical data
EURAM trans-border region (Spain, France, Andorra)	*Contents:* Networks for 2010 for road, rail, ferries, air, ports and seaports available. *Source:* TRANS-TOOLS database, updated with interconnecting links. *Data format:* ArcView shapefile, Bridges	*Contents:* - Population, NUTS-3 (2006), NUTS-5 (2010) - Number of workplaces, NUTS-3, 2006 - GDP (Mio EUR), NUTS-3, 2006 - Air passenger by main airports, 2009 - Air passenger transport, NUTS-3, 2010 - Modal split, travel, NUTS-0, 2007 *Sources:* INE, Eurostat *Data format:* Dbase
Northern Italy	*Contents:* Network data for 2009 (Milan), 2004 (Piacenza), 2005 (Parma) and 2006 (La Spezia) for road and rail, bike, motorbike and metros (Milan), including interchange links at stations and parkings. *Sources:* TRT *Data format:* MapInfo, ArcGIS *Remarks:* Data available only for Milan, Piacenza, Parma and La Spezia provinces plus surrounding areas. Own estimates for capacities, partly manually coded links. Another ArcGIS layer for Milan available with even higher network density. Road mode includes car and public transport (busses).	*Contents:* - O/D trip matrix by mode, NUTS-5, sub-NUTS-5, 2009 (Milan), 2004 (Piacenza), 2005 (Parma), 2006 (La Speizia) *Source:* Modelling estimations *Data format:* ASCII *Remarks:* Estimated data based on a sample survey and on modelling results.
Bavaria (Germany)	*Contents:* Full road, rail and public transport networks (busses, trams, subway) for Bavaria for 2009. *Sources:* ATKIS, Public Transport timetables with additions through S&W. *Data format:* ArcView shapefiles, ASCII *Remarks:* Network data comprise a complete representation of road and public transport networks for Bavaria, i.e. all roads that can be used by cars are included and the public transport network is based on a complete public transport timetable.	*Contents:* - Population, NUTS-5, 2008, also disaggregated to 100x100 m raster - Services of general interest (education, health care, public administration), exact locations, 2008 *Source:* Miscellaneous *Data format:* Excel, ASCII, ArcView shapefile

Table 9. Available data for regional case studies (continued)

Macro region	Network data	Statistical data
Czech Republic	*Contents:* Two network datasets available (1:500 000 and 1:150 000) for road, rail and air for 2006 for the whole of the Czech Republic. Road and rail attributes include, inter alias, road number, length and category. *Sources:* ArcČR500 (1:500,000), CEDA 150 (1:150,000), Road and Motorway Directorate of the Czech Republic. *Data format:* ArcView shapefile, Geodatabase, ArcInfo coverage *Remarks:* Data not fully updated, several errors in network topology.	*Contents:* - Public transport supply, NUTS-3, 2001-2008 - Number of cars, NUTS-3, 2001-2008 - GDP, NUTS-2/3, 2001-2008 - Active population, NUTS-2/3, 2005-2008 - Unemployment, NUTS-3, 3002-2008 - Net domestic/foreign migration, NUTS-3, 2001-2008 - Urban/rural population, NUTS-3, 2001-2008 - Foreign direct investments by sectors, NUTS-3, 2007 - Production by sector, NUTS-3, 2008 - GVA, NUTS-3, 2008 - Public investments, NUTS-3, 2008 - Land use data by class, NUTS-3, 2001-2008 - Number of operating firms, NUTS-3, 2008 - Household consumption of goods/services, NUTS-3, 2008 - Regional budgets, NUTS-3, 2008 - Compensation of employees, NUTS-3, 2008 - Commuting flows between NUTS-3, 2008 - Group of environmental data, NUTS-3, 2008 *Source:* Czech Statistical Office, Ministry of Finance, Ministry of Internal Affairs, Ministry of Transportation *Data format:* Excel, dbase
Poland	*Contents:* Network data for 2009 available for the whole of Poland for roads, railways, inland waterways incl. ports and seaports, and air, density optimised for voivodships. Road attributes include road number, length, category, number of lanes, width, condition and congestion. Rail attributes include technical speeds and lengths. *Sources:* IGSO PAS, General Directorate for National Roads and Motorways of Poland, Voivodship Road Administrations, PKP Polish Railway Lines JSC *Data format:* MapInfo *Remarks:* Rail speeds not precise and for 2008 only; process triggered to obtain train timetable times for 2010 as NUTS-3 matrix.	*Contents:* - GDP/GVA, NUTS-2/3, 1999-2007 - Population (total, by age, by sex), NUTS-5, 1995-2009 - Employment, NUTS-2, 2000-2009 - Employment, NUTS-5, 1995-2009 - Land use data, NUTS-3, 2000-2006 - Many other data, NUTS-5 *Sources:* IGSO PAS, Central Statistical Office of Poland. *Data format:* Excel, dbase

Table 9. Available data for regional case studies (continued)

Macro region	Network data	Statistical data
Scandinavia (Norway, Sweden)	*Contents:* Full road network data for 2009 provided by the Norwegian and Swedish road authorities, including speed limits and road categories. Otherwise, RRG GIS Database to provide full railways, air, inland waterways and shipping networks including ports and seaports for 2010. *Sources:* Norwegian Road Authority, Swedish Road Authority, RRG *Data format:* ArcView shapefile, geodatabase	*Contents:* - Population by age group/sex, 1x1 km grid, 2000/2010 - Built-up areas, 1x1 km grid, 2000/2010 - Employment by sector, 1x1 km grid, 2000 - Labour market centres, 1x1 km grid, 2000 - Population, municipalities, 2000 - Ports, exact location, 2010 - Airports, exact location, 2010 - Major hospitals, exact location, 2010 - Universities, exact location, 2010 - Railway stations, exact location, 2010 - Tram and subway stations, exact location, 2010 *Sources:* Statistics Norway, Statistics Sweden RRG GIS Database *Data format:* ArcView shapefile, geodatabase, dbase
Finland	*Contents:* Network data for entire Finland for roads (2008), railways (2007), inland waterways, ports and seaports (2008), airports (2010) and ferries/shipping routes, plus border crossing points (2009). *Sources:* Finnish Transport Agency (Digiroad & railways), Finnish Port Association, Finavia, Finnish Customs. *Data format:* ArcView shapefiles, geodatabase. *Remarks:* Airport locations are available, but no attribute or connectivity information is attached.	*Contents:* - Population, 1x1 km grid, 1970, 1980/1990/2000/2005-2008; municipalities 1951-2007 - Population by sex/age groups, 1x1 km grid, 2003/2007 - Education, 1x1 km grid, 2002/2006 - Income, 1x1 km grid, 2002/2006 - Households, 1x1 km grid, 2002/2006 - Sources of livelihood by 17 sectors, 1x1 km grid, 2002/2006 - Employment, 1x1 km grid, 2001/2005 - Built-up areas, 1x1 km grid, 1970/1980/1990/2000/2005 *Source:* Statistics Finland *Data format:* Shapefile

7.4 EU candidate countries and the Western Balkan

In order to include the EU candidate countries and the countries of the Western Balkan as internal zones for the Europe-wide accessibility models, both network data and socio-economic data at a sufficient regional subdivision are required. In order to work with socio-economic data in GIS, also appropriate region boundary layers are required. The ESPON 2013 Database project assessed the data availability in these countries (Angelidis, 2010). Following is a brief overview of the data situation with respect to these two data groups.

Network data

Both the RRG GIS Database and the TRANS-TOOLS database include network data for these countries with sufficient network density from a European perspective (see Chapter 7.1). It still needs to be checked whether all region centroids are connected properly to the network. If this is not the case, individual network links will have to be added.

Regional subdivision

In order to include these countries into the models, a regional subdivision corresponding to the NUTS-3 regions in the EU countries needs to be available. The ESPON 2013 Database project (Angelidis, 2010, 4) confirms that Turkey, Croatia and FYROM already adopted the NUTS classification, including the NUTS-3 level, while the rest of the countries are currently in the process of adoption, where existing administrative divisions can easily be associated with respective NUTS levels. Table 10 provides an assignment of these divisions to the NUTS system.

Table 10. Corresponding NUTS levels in EU candidate countries and Western Balkans

Country	NUTS equivalent territorial divisions		
	NUTS-1	**NUTS-2**	**NUTS-3**
Albania	Country	Country	12 prefectures
Bosnia and Herzegovina	Country or FBiH, RS, Brsko districtx	FBiH, RS, Brsko districtx	10 cantons
Croatia	Country	Regiia	Counties
FYROM	Country	Country	Statistical regions
Kosovo	Country	Country	Country
Montenegro	Country	Country	Country
Serbia	Central Serbia, Voivodina	Central Serbia, Voivodina	21 districts
Turkey	Regions	Sub-regions	Provinces

The draft version of the *ESPON Space and candidates mapkit* developed by the ESPON 2013 Database project (Zanin et al., 2010) includes shapefiles for the equivalent NUTS classification in these countries; however, as partly 'non-official' boundaries were used (Angelidis, 2010, 6), it still needs to be investigated whether or not these shapefiles can be used in ESPON free of any legal restrictions.

Socio-economic data

Most of the required socio-economic data at country level are already available at Project Partners. At regional level (i.e. NUTS-3), the ESPON 2013 Database project made a rough assessment of the data availability (Angelidis, 2010, 33ff; see Table 11 for full overview) , revealing

(i)   a very good availability of population data (total population, by sex, by age groups, by educational attainment) for different points in time
(ii)   a lack of household data
(iii) a lack of land use data and data on buildings and dwellings
(iv)   a fairly good availability of data on employment, unemployment and active population, however, some of these data not more recent than 2000 or 2001 or even early or mid 1990s
(v)   partial availability of GDP data

The lack of statistical land use data may be alleviated by using the CORINE land use data at raster level, which is available for the Western Balkan countries (EEA, 2010). A lack of other statistical data may also be compensated by the 'experimental' ESPON grid data (Milego and Ramos, 2010), which provides raster data on GDP, active population and unemployment for all countries of the ESPON space, plus the EU candidate countries and countries of the Western Balkan. These grid data can either be used to disaggregate available datasets from the national level to the NUTS-3 level, or the grid data can directly be aggregated to the NUTS-3 level.

Conclusions

The data situation in the EU candidate countries and Western Balkan countries with respect to transport networks, administrative boundaries and basic socio-economic data can be considered as generally good enough to include equivalent NUTS-3 regions of these countries as internal zones into the accessibility models and the SASI model, even though for some data groups data processing and data estimations will have to be done.

While the Western Balkan countries are located in Europe and are already surrounded by European Union member states, an inclusion of Turkey raises some other fundamental methodological questions: If Turkey would become a full internal zone of the accessibility model and the SASI model, countries in the Caucasus, countries in the Arab world (Near East and Middle East), and also Russian regions in central Asia would have to become 'external zones', as they have direct boundaries with Turkey or because important transport routes are directly linked to Turkey. In consequence, this would require to include these countries as external zones into the model (at least at national level), and to collect all required data for them as well. Also, as most parts of Turkey are located in Asia, the accessibility models will become inter-continental models, exceeding the European territory. As this is not feasible in the time available in the project, the Turkish regions will not become internal zones of the accessibility model and of the SASI model, but will be included as external zones with higher spatial detail than so far.

Table 11. NUTS-3 data availability in EU candidate countries and Western Balkan Countries (Angelidis, 2010, 33ff, simplified)

Data - Indicators	Albania	Bosnia-Herzegovina (1)	Croatia	FYROM	Serbia	Montenegro	Kosovo (2)	Turkey
NUTS-3 equivalent region	12 Prefectures	3 Districts (FBiH, RS, and Brsko)	21 Jupanija	8 Statisticki Regioni / SR	Districts	1 (total country)	7 Districts-	81 ILLER
Population census years 1985 - 2008	1999, 2001	1991	1991, 2001	1991, 2002	1991, 2002 (3)	1991, 2003	1991	1985, 1990, 1997, 2000 (4)
Total population	1989, 2001c	1991, 1995, 2001 -2002 2007 (FBiH)	1991, 1995, 2001, 2002 -2008	1991, 2002	1991, 1995, 2002, 1998-2005.	1981, 1991, 2003	1981, 1991, 2006, 2007	1990, 2000
Population by sex:	2001	1991, 2000-2003, 2007 FBiH)	1991,1995,2001 2008	1991, 2002	1991, 1995, 1998-2007	1981, 1991, 2003	1991, 2006, 2007	1990, 2000
Population by age group	2001	1991, 2000-2003 2007 FBiH)	1991, 2001	1991, 2002	1991, 1995, 1998-2005.	1991, 2003	1991, 2006, 2007	1990, 2000
Population by sex and age group	2001	1991	1991, 2001	1991, 2002	1991, 1995, 1998-2005	1991, 2003	1991	1990, 2000
Population per education level	2001	1991	1991, 2001	1991, 2002	1991, 1995, 1998-2005,	2003-2008, 2003	1991	1990, 2000
Total active population	2001	1991, 2007	1991, 2001 2002	1991, 2002	1991, 1995, 2002	1991, 2003	1991	1990, 2000
Active population by sex	2001	1991, 2007	1991, 2001	1991, 2002	1991, 1995, 2002	1991, 2003	1991	1990, 2000
Number of employed per sons	2001	1991, 2007	1991, 2001	1991 2002	1991, 1995, 1998-2006, 2002, 2006	1991, 2003, 2004-2007	1991	1990, 2000
Number of unemployed persons	2001	1991, 2007	1991, 2001	1991, 2002	1991, 1995, 1998-2006, 2002, 2006	1991, 2003, 2004-2007	1991	2000, 2004- 2007
Employment per primary, secondary, tertiary sector	2001	1991, 2007	1991, 2001	1991, 2002,	1991, 1995, 1998-2006, 2002, 2006)	1991, 2003, 2004-2007	1991	1981-2001
GDP		2005-2007 (FBiH)		2004-2006		2000-2004	no data	1990, 2000

1 Federation of Bosnia and Herzegovina (FBiH), Republic of Srpska (RS), and Brsko District
2 Under UN Security Council Resolution 1244

3 Census not carried out in Kosovo and Metohia.
4 Turkey: 1997 only housing, 2000: only population census

8 Project planning

8.1 Detailed timetable

The detailed and updated timetable of the TRACC project for the three Work Packages Co-ordination, Research and Dissemination is presented in Table 12.

8.2 Work towards Interim Report

The Interim Report is due six months after the delivery of this Inception Report. Project work will mainly concentrate on Tasks 1, 2 and 5, which are mainly reviews and preparatory work for the latter accessibility analyses at global, European and regional/local scale.

Work in Task 1 *Methodology and Indicators* includes the continuation and finalisation of the review of European and global accessibility studies as well as the reviews of applied models and indicators at the regional/local scale, a review of models to forecast the impacts of accessibility on regions and the elaboration of a proposal for a core set of accessibility indicators to be applied in TRACC.

Work in Task 2 *Network and Socio-economic Data* includes the continuation and finalisation of the review of European network data and socio-economic data as well as work on the implementation of European network and socio-economic data and work on the implementation of network and socio-economic databases for the regional case studies.

Work in Task 5 *Regional Accessibility* will be devoted to reviews of the results of regional and local accessibility studies leading to a typology of regional accessibility patterns. In addition, the selection of regional case study regions will be finalised and the work on these case studies will commence.

In addition, preparatory and planning work for Tasks 3, 4 and 6 will commence. However, proper work on these tasks will start after the delivery of the Interim Report.

All Project Partners will be involved in the work towards the Interim Report. There will be one TPG meeting scheduled for late November or early December 2010 to discuss findings achieved so far and to prepare for the Interim Report.

8.3 Use of existing ESPON results

The TRACC project will take advantage of existing ESPON results. Particular attention will be paid to earlier work on European accessibility in the Study Programme on European Spatial Planning (SPESP) and in previous ESPON projects 1.2.1, 1.1.1, 2.1.1 and 1.1.3 and the recent Accessibility Updates. As described in Chapter 4, the TRACC project will use the main accessibility indicators developed in those projects, in particular the potential accessibility indicator and will update these to the year 2011.

In addition, the TRACC project will be an intensive user of the ESPON database as well as of the ESPON typologies developed by other ESPON projects. It will have to be found out whether the TRACC project might also benefit of results of other projects such as the ones on globalisation, on services of general interest or on attractivity of regions and cities.

8.4 Distribution of research tasks among partners

Table 13 shows the distribution of research tasks among project partners by indicating for each Subtask the leading Project Partner and the degree of contributions (major, small or none) of other Project Partners to that Subtask.

Table 12. Timetable of project activities

Tasks	Subtasks	2010				2011				2012			
0 Co-ordination	Co-ordination	M		M		M		M	M				
1 Methodology and indicators	1.1 European and global accessibility models and indicators	▢											
	1.2 Regional and local accessibility models and indicators		▢	▢									
	1.3 Models to forecast the impacts of accessibility on regions		▢										
	1.5 Core set of accessibility indicators		▢										
2 Network and socio-economic data	2.1 European network data	▢											
	2.2 Socio-economic data		▢										
	2.3 European network and socio-economic data			▢	▢								
	2.4 Regional network and socio-economic data			▢									
3 European accessibility: travel	3.1 European travel accessibility					▢	▢	▢					
	3.2 European travel accessibility measured by other indicators					▢	▢	▢					
	3.3 Global travel accessibility						▢						
4 European accessibility: freight transport	4.1 European freight accessibility					▢	▢	▢					
	4.2 European freight accessibility measured by other indicators						▢	▢					
	4.3 Global freight accessibility						▢	▢					
5 Regional accessibility	5.1 Typology of regional accessibility patterns		▢										
	5.2 Selection of regional case studies		▢										
	5.2 Case studies on regional accessibility patterns			▢		▢	▢	▢					
	5.3 Europe-wide modelling of regional accessibility						▢	▢					
	5.4 European v. regional accessibility							▢					
6 Impacts of accessibility	6.1 Accessibility and regional development					▢	▢						
	6.2 Long-term scenarios of European transport					▢	▢						
	6.3 Spatial impacts of European transport scenarios					▢	▢	▢					
7 Policy implications	7.1 Policy-relevant findings						▢						
	7.2 Policy conclusions						▢						
	7.3 Further research needs						▢						
8 Dissemination	Dissemination	R		R				R	R				

M	Meetings
R	Reports

Table 13. Research tasks and Project Partner responsibility

Tasks	Subtasks	S&W (LP)	Prf UK (PP2)	RRG (PP3)	Mcrit (PP4)	FOGIS (PP5)	TRT (PP6)	IGIPZ PAN (PP7)
0 Co-ordination	Co-ordination	Lead	Small	Small	Small	Small	Small	Small
1 Methodology and indicators	1.1 European and global accessibility models and indicators	Lead			Major			
	1.2 Regional and local accessibility models and indicators	Lead	Major	Major	Major	Major		Major
	1.3 Models to forecast the impacts of accessibility on regions	Lead						
	1.4 Core set of accessibility indicators	Lead	Small	Small	Small	Small	Small	Small
2 Network and socio-economic data	2.1 European network data			Lead	Major			
	2.2 Socio-economic data			Lead				
	2.3 European network and socio-economic data	Major		Lead	Major		Major	
	2.4 Regional network and socio-economic data	Major	Major	Lead	Major	Major		Major
3 European accessibility: travel	3.1 European travel accessibility	Lead						
	3.2 European travel accessibility measured by other indicators	Lead		Major				
	3.3 Global travel accessibility	Lead						Major
4 European accessibility: freight transport	4.1 European freight accessibility				Major		Lead	
	4.2 European freight accessibility measured by other indicators				Major		Lead	
	4.3 Global freight accessibility						Lead	Major
5 Regional accessibility	5.1 Typology of regional accessibility patterns	Major	Major	Major	Lead	Major	Major	Major
	5.2 Selection of regional case studies	Small	Small	Small	Lead	Small	Small	Small
	5.3 Case studies on regional accessibility patterns	Major	Major	Major	Lead	Major	Major	Major
	5.4 Europe-wide modelling of regional accessibility			Major	Lead			
	5.5 European v. regional accessibility				Lead			
6 Impacts of accessibility	6.1 Accessibility and regional development	Lead					Major	
	6.2 Long-term scenarios of European transport	Lead			Small		Small	
	6.3 Spatial impacts of European transport scenarios	Lead						
7 Policy implications	7.1 Policy-relevant findings				Lead			
	7.2 Policy conclusions	Major			Lead	Major		Major
	7.3 Further research needs	Major			Lead	Major		
8 Dissemination	Dissemination	Lead	Small	Small	Small	Small	Small	Small

Lead	Task leader with major contribution
(dark grey)	Major contribution
(light grey)	Small contribution

8.5 Barriers for project implementation

A potential barrier for project implementation for research projects dealing with accessibility indicators is always the availability of proper network data. However, as shown in Chapter 7, the project is in a very good situation with respect to Europe-wide as well as to regional network data. In consequence, the TPG does not see any major barriers for the implementation of the TRACC project.

8.6 Deliveries and outputs envisaged

The TRACC project is expected to disseminate its results to the wider political and scientific audience. To do so, there are a couple of formal requirements such as the different project reports and the presentations at ESPON seminars and there will be a couple of other opportunities to present results of the TRACC project.

Interim Report

The Interim Report will be due nine months after the start of the project. It will reflect the research concept laid down in the Inception Report and the conclusions from the feedback from the Sounding Board. The report will include preliminary and final results, such as

- a finalised review of European and global accessibility models and indicators
- a finalised review of regional and local accessibility models and indicators
- a finalised review of models to forecast the impacts of accessibility on regions
- a proposal for a core set of accessibility indicators
- a finalised review of European network data
- a finalised review of socio-economic data
- the implementation of European network and socio-economic database
- the implementation of regional network and socio-economic databases
- a typology of region accessibility patterns
- the final selection of regional case studies

as well as a detailed plan for the planned research during the next year of the project towards the draft Final Report.

Draft Final Report

The Draft Final Report will be due 21 months after the beginning of the project. The report will take into account the feedback on the Interim Report from an ESPON seminar and the Sounding Board. The report will include the following draft results:

- European travel accessibility indicators
- European travel accessibility measured by other indicators
- global travel accessibility indicators
- European freight accessibility indicators
- European freight accessibility measured by other indicators
- global freight accessibility indicators
- results of the regional case studies
- long-term scenarios of European transport
- spatial impacts of European transport scenarios

The Draft Final Report will consist of an executive summary and a scientific report supported by diagrams, tables and maps.

Final Report

The Final Report will be due five months after the Draft Final Report. It will be a revision of the Draft Final Report on the basis of comments received and the final results achieved in the research.

ESPON events

The project team will present the research concept and preliminary and final results at the internal and external ESPON Seminars which take place twice a year as well as at other ESPON events organised by the ESPON CU or the ESP Network or at events such as the DG REGIO Open Days.

These dissemination activities will be planned in close co-operation with the ESPON CU to avoid overlap with activities organised in Priority 4 of the ESPON 2013 Programme "Capitalisation, ownership and participation: capacity building, dialogue and networking".

Conferences

The Project Partners will use every opportunity to present and discuss the research concept and preliminary and final results at scientific conferences. Given the theme of the project, transport accessibility and regional development, the Project Partners plan to give presentations on the project at the following international conferences:

- World Conference on Transport Research (WCTR)
- Congress of the European Regional Science Association (ERSA)
- International Conference of the Regional Studies Association (RSA)
- Congress of the Association of European Schools of Planning (AESOP)

and at national conferences with similar focus. In addition it can be expected that Project Partners will be invited to give presentations on the project not only at academic workshops or seminars but to wider audiences and the general public.

Papers

The Project Partners will publish the results of the project in scientific journals and books during and after the project.

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