TEN-STAC:
SCENARIOS, TRAFFIC FORECASTS AND ANALYSIS OF CORRIDORS ON THE TRANS-EUROPEAN NETWORK

D6 Deliverable Part I

TRAFFIC, BOTTLENECKS AND ENVIRONMENTAL ANALYSIS ON 25 CORRIDORS

TEN STAC

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- COWI
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Partners

NEA Transport research and training, project co-ordinator (The Netherlands),
Professor Marc Gaudry at the University of Montreal (Canada) and University of Strasbourg (France)
COWI, A/S (Denmark)
PWC, PriceWaterhouseCoopers (Italy)
TINA, Transport Infrastructure Needs Assessment (Austria)
IWW, Institut für Wirtschaftspolitik und Wirtschaftsforschung (Germany)
NESTEAR, Nouveau Espaces de Transport en Europe
Applications de Recherche (France)

Mkmetric, Gesellschaft für Systemplanung mbH (Germany)
HERRY, Traffic Planning/Consulting (Austria)
IVT, Institut für angewandte Verkehrs- und Tourismusforschung e.V. (Germany)

CETE, Centre d'Etudes Techniques de l'Equipement (France)
University of Tours (France)
Professor Jan Burnewicz at the University of Gdansk (Poland)
Professor Andrès Lopez Pita, Director of CENIT, Centre d'Innovació del Transport (Spain)
Experts from all CEEC countries

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EXECUTIVE SUMMARY

In the TEN-STAC project, a uniform and consistent framework has been developed to compare and assess the expected future impacts of various proposed transport infrastructure projects in Europe. The year chosen for the assessment and comparison is the year 2020.

The infrastructure projects considered within TEN-STAC include the list of priority projects (see COM(2003) 564). When speaking of "project appraisal" and "impacts of projects" one generally refers to answers to the following questions:

- ⇒ What will be the changes in the size, composition, modal split and spatial distribution (routing) of future transport flows as a consequence of the realisation of the infrastructure project(s)?
- ⇒ What are the changes in the use of transport infrastructure networks as a consequence of the realisation of the infrastructure project(s)?
- ⇒ What are the benefits for the economy and society of the changes in transport flows and network use of the realisation of the infrastructure project(s)?
- ⇒ What is the dimension of these benefits for the society compared to the costs for the realisation of these projects?

A part of the work in the TEN-STAC project consists in working out these questions in more detail and proposing an indicator set that is capable of answering such questions. These indicators are applied to all of the projects to be assessed, in a way that the measurements of indicators are comparable across projects.

An appraisal of the relative merits of different infrastructure projects from a European perspective being applied within TEN-STAC, can not be done by collecting all individual (national) cost-benefit assessment studies, taking from these studies the projected performance and starting the comparison. Even if such studies reported the same type of indicators and used similar time horizons, this would be a misleading procedure, because the studies are usually based on a number of (economic, political, technological) assumptions. These assumptions may differ significantly across the studies.

A first step in the analysis of projects is the grouping of sub-sections in priority projects. This concept intends to capture the first and most obvious linkages between individual priority project sub-sections. So a priority project in TEN-STAC is a set of strongly interrelated infrastructure project sub-sections on a part of a (modal) infrastructure network.
E.g. various sub-sections on railway line (line upgrading, tunnels etcetera) or a river (locks, bridges, dredging works etcetera).

In order to measure the *net* impacts of priority projects, it is necessary to filter out all changes in transport flows which can be expected to occur in the future (in 2020) but which are not directly causally connected to a specific priority project. This filtering out of "noise" has been attempted in various ways:

- By defining a uniform economic and political environment for the year 2020 in which all project and the societal and economic effect of those projects will be examined (only the additional or incremental impacts of the priority projects will be investigated);
- By including in the scenarios for 2020 the effects of other (White Paper) policies and the effects of already decided up priority projects (avoiding "double counting" and attributing other policy impacts to priority projects);
- By looking at the impact of the combined sub-sections in a priority project, as well as the individual sub-sections.
- By looking at the marginal impacts of sub-sections and at the impact of the priority project in a) the situation where all other priority projects are implemented and b) when none of the other priority projects are implemented.

The priority project appraisal in TEN-STAC has been performed in a standardised way and from a European perspective. Although land-use data or details at the regional level were taken into account for the modelling of transport, not every specific peculiarity of individual infrastructure sub-sections could be processed. Therefore, the results of the TEN-STAC study have to be interpreted in such a way that they reflect the priority project performance at an aggregated level. More specifically it is important to realise that the TEN-STAC study is an additional study and does not replace other studies on infrastructure projects, which are capable of taking into account further peculiarities at regional and local level.

Looking at the list of the priority projects to be investigated, one discovers that there are various types of priority projects / sub-sections on the list: priority projects / sub-sections already under construction and to be completed in the next years and priority projects / sub-sections still to be decided upon. In order to be able to better concentrate the efforts on the priority projects / sub-sections that are still in the planning stage, two infrastructure scenarios were designed.

The two scenarios are based on the same assumption regarding the political and economic developments, and differ only in the assumptions made with respect to the realisation of infrastructure projects. These scenarios are called the "Reference 1 scenario", and the "Reference 2 scenario". The Reference 1 scenario aims to measure in an aggregated way the combined impacts of the sub-sections that are already finalised (sub-sections with a completion date between 2000 and 2002).

The Reference 2 scenario is similar to Reference 1, but additionally includes sub-sections to be completed in the period 2003 - 2007. This scenario is intended to form the proper reference situation for the assessment of priority projects still to be decided upon. So the analysis of the two reference scenarios provides information for the assessment of the sub-sections to be finalised in the period 2003 – 2007.

The priority projects are assessed as follows: 6 priority projects are completely assessed in the Reference 1 and Reference 2 model runs, project P15 Galileo is not considered. For the other 22 priority projects, one scenario has been defined, in which the assumption is made that all priority projects have been realised, this is called the "all projects scenario". Sensitivity analyses were carried out to assess of the impact of each individual priority project and sub-sections.

Major deviations between the "all projects scenario" and the impact from the sensitivity analyses take place for strongly interrelated priority projects. Notice that deviations may go either way depending on whether the relationship with the other priority projects is positive (mutually strengthening) or negative (in case of high overlap). A technical but straightforward impact allocation method was worked out by which made it possible to assign impacts on priority project level to the sub-sections in a consistent manner.

Accompanying measures for stimulating the use of rail freight transport were also included in the model runs. This was not considered to be a real deviation from the principle (adhered to throughout TEN-STAC) to clearly separate infrastructure from other policy impacts, since these accompanying measures primarily concerned the rail services to be developed on the new infrastructure (and were therefore not really infrastructure independent policies).

Based on forecasts for the economic developments in the year 2020 and the transport economic/policy of the Phase 1 baseline scenario, priority projects and sub-sections were investigated on a whole range of impact indicators. These indicators aim to measure (respectively per priority project and sub-section) key impact variables. The impact variables chosen and applied to project assessment within TEN-STAC, has been derived from Article 19 of the European Commission (COM(2003) 564 final) publication. From this document, analysing the text of the Article, the following indicator groups were derived and defined:

- Economic impacts in the transport sector
- Environmental sustainability
- Investment cost
- General transport relevance
- Creation of European value added
- Improvement of accessibility
- Maturity and coherence of the project

Each Indicator group in TEN-STAC consists of one or more indicators that intend to capture various aspects of the criterion under which they are grouped.

Of course in selecting indicators one has not only to consider the specific criterion that an indicator has to measure, but also a number of practical and statistical considerations, like for example availability and measurability of data. So in deciding how to measure and which indicator to select, one has to weigh various practical and theoretical objectives.

Main findings

One of the main findings consists of the modal shift from road to alternative modes of transport. The modal shift from road to rail generated by the implementation of the priority projects in the Reference 2 scenario (projects to be finalised in the period 2003 – 2007) is 22 million tonnes, when compared to the Reference 1 scenario.

The total combined modal shift potential for all 22 priority projects / 72 sub-sections (however, the priority projects not addressing freight transport are not considered for freight assessment) that are still in the planning stage (realisation later than 2007) is estimated to be 107 mln tonnes. This modal shift potential was measured as the total additional increase in freight volumes (for all other modes of freight transport) compared to the Reference 2 scenario. This means that when all priority projects of the list were to be realised, approximately 107 mln tonnes additional freight volumes would be shifted from road freight transport to other modes of transport.

The size of the shift potentials is very modest compared to the forecasted size of total road freight transport volumes in Europe in 2020 (this is expected to amount to approx. 6,200 mln tonnes). This figure however is much more impressive when compared to the forecasts of the volume of international road freight transport in 2020 (which is approx. 1,200 mln tonnes). Since to a large extent modal shift is an international phenomenon, it is believed that the latter comparison is more relevant.

So the TEN-STAC study confirms that infrastructure is important and very relevant for modal choice.

When comparing the shift potentials forecasts in TEN-STAC with the shift potentials as reported in individual country cost-benefit assessments, it is generally found that the individual country estimates are much higher than the forecasts in TEN-STAC. Differences vary per project but on average one could say that the size of TEN-STAC estimates is approximately 30-50% of the reported national figures. This large gap between forecasts can be explained by the factors like overlap between projects, the filtering out of impacts of other policies like e.g. infrastructure pricing policies in TEN-STAC, differences in the assumptions on which the forecasts are based.

Of course it has to be admitted that the level of detail of country-specific studies generally is much higher, and that possibly the TEN-STAC team missed some interesting "local" opportunities for modal shift. However against this it could again be argued that the modal shift generally is not a local phenomenon at all. Furthermore missing "some opportunities for modal shift" is by far not sufficient to explain the extent of the gap between the forecasts.

Comparing the sum of all individual priority projects outcomes with the variant that all priority projects are implemented simultaneously indicates that generally priority projects more tend to complement each other than that there is rivalry between them. Although there certainly are examples of rival priority projects, most of the priority projects increase the size of the modal shift in the "all projects" variant. The total additional boost of implementing all priority projects is approx. 20 mln tonnes. So it appears that there is an increasing return to scale.

As may be expected just looking at modal shift opportunities, projects in the geographic and economic centres of the Europe score highest. Priority projects in peripheral regions generally appear to have a limited modal shift potential. The majority of the priority projects are rail transport related but also the two water related corridors show sizeable modal shift potentials.

For describing the methodologies applied for the generation of performance data for quantitative impact variables, the impact criteria can be subdivided into four groups:

- Impact criteria based on transport impedance matrices (e.g. potential changes in travel times, centrality)
- Impact criteria based on transport flows on the corridor (e.g. share of international traffic)
- Impact criteria based on transport flows in the whole transport sys1tem (e.g. modal split, environmental indicators)
- Impact criteria independent from modelling results (e.g. appraisal of project planning status)

The estimation of performance data for *impact criteria based on transport impedance matrices* does not require the application of the transport models, as no transport demand reaction is considered. The impedances are derived from the infrastructure measures implemented in the network models.

For the assessment of a priority project's impact on criteria based on transport impedances following two situations are compared: the situation in which all sub-sections in all priority projects are realised besides the sub-section under evaluation, and the situation in which the sub-section under evaluation is realised, together with all other sub-sections belonging to the priority project.

Impact criteria based on transport flows on the project, e.g. the total transport volume or the share of international transport demand, can be retrieved directly from the assignment results. Impact criteria belonging to this type are raised for each corridor without a comparison to a reference case. The calculation of performance data for *impact criteria based on transport flows in the whole transport system* – thus covering all modes, like criteria related to modal split or environmental criteria, requires the analysis of all traffic flows of all modes. In a first step the assignment results are generated at the level of priority project.

For these assignment runs the assumption is made that all sub-sections belonging to the priority project under consideration are implemented. The changes in transport flows and related impact criteria have to be assessed at priority project level. Hence the assignment results at priority project level have to be transferred to the sub-section level. For this task the following procedure is applied:

1. In a first model run, underlying the assumption of the implementation of all sub-sections on a priority project, all relations are stored, which are routed via the specific sub-section i being part of a corridor. This results in a set of sub-section-specific O/D relations, which are routed via the specific sub-section.
2. A routine identifies all sub-section-specific O/D flows from step 1 on the other networks for the situation that the priority project is implemented, as well as for all assigned traffic flows in the reference situation.
3. With all transport flows relevant for the sub-section under consideration being identified, both for the situation “with” the sub-section and the reference situation “without” it, the dimension of impacts caused by all transport flows concerned by the sub-section, can be measured.

In order to avoid double-counting of effects, the performance results at sub-section level are compared and adjusted to the performance results at priority project level.

Performance data for *impact criteria independent from modelling results*, like qualitative appraisal of a priority project’s contribution for an intermodal transport system or appraisal of the project planning status, are generated by expert judgements. The expert judgements are largely based on further available information on the corridor from different sources, mainly from European or national level.

1 INTRODUCTION

1.1 General background

This report describes the results of the evaluation of the priority projects, as requested by the task 3 in phase 2 of the TEN-STAC project.

The priority project appraisal has been performed in a standardised way and from a European perspective. Although the geographical scope of the analyses has been addressed more in detail than in Phase 1, e. g. by taking into account land-use data or details at the regional level for modelling transport, the present study is not able to take every specific peculiarity of an infrastructure project into account. Hence the results have to be interpreted in a way that they reflect the priority projects' performance from a European perspective, so that the TEN-STAC study does not replace further studies on infrastructure projects, which are capable of taking further peculiarities at regional and local level into account.

The structure of this report is as follows:
In chapter 2 the scope of the analyses is given: a short description of the reference scenarios, the infrastructure projects and the indicators is given.

Chapter 3 goes into detail in the definitions and calculation methods of the indicators. In chapter 4 the transport flows in the reference scenarios are presented.

Chapter 5 presents the overall results of the "all projects scenario". Chapter 6 presents the results by priority project. Each priority project is described extensively, followed by maps of the relevant transport flows and a table of indicators.

Given the volume of the report it has been printed in two parts:
Part 1: Chapter 1-4
Part 2: Chapter 5-6

1.2 Terminology

Due to the ambiguity of terminologies used for the denotation of transport infrastructure sections and transport infrastructure measures, the terminologies applied for addressing these notions are defined in the present paragraph.

"Priority Project"

Priority projects have been defined around 29 main axis in Europe (see (COM(2003) 564 final) and most of these priority project are transport infrastructure project. Hence, a priority project stands for an infrastructure part of the (planned or existing) Trans-European Network.

"Sub-section"

A sub-section represents a sub-set of a priority project and is defined by the EU document (COM(2003) 564 final) and further considerations within the TEN-STAC project. In most cases a priority project consists of several sub-sections. The sub-sections denote those transport infrastructure parts, which are subject to analyses within TEN-STAC.

"All projects scenario"

This is the scenario where it is assumed that all priority projects are realised in year 2020. Networks models have been built according to the infrastructure assumptions considered for each priority project.

2 SCOPE OF THE ANALYSES

2.1 Approach for the assessment of priority projects

The scope of the analyses is not anymore the detailed analysis of the 25 corridors in order to identify bottlenecks and priority projects as initially planned, but the detailed analysis of the priority projects.

The methodology applied for priority project evaluation in TEN-STAC phase II is determined by the perception of infrastructure projects as part of transport infrastructure corridors. This perception is in line with the European Commission's view on transport infrastructure investments, as described in the Commission document on amending decision no 1692/96/EC on Community guidelines for the development of the trans-European transport network (COM(2003) 564 final).

This general approach of perceiving the transport infrastructure projects assessed as part of a transport corridor is reflected by the methodology applied for priority project evaluation in TEN-STAC phase II. Some performance criteria are raised directly at priority project level and for each sub-section, whereas other performance criteria are raised for the sub-section seen as a part of a priority project.

The appraisal methodology has been performed in a standardised way and from a European perspective. Although the geographical scope of the analyses has been lowered, e.g. by taking into account land-use data or lowering the regional level for modelling transport, the present appraisal scheme is not able to take every specific peculiarity of a sub-section or project into account. Hence the results have to be interpreted in a way that they reflect the sub-sections' performance from an European perspective, so that the TEN-STAC study does not replace future studies on infrastructure investments, which are capable of taking further peculiarities at regional and local level into account.

The sub-sections to be finalised after year 2007 have been analysed at individual level in Phase II, while sub-sections to be finalised in the period 2003 – 2007 have been evaluated at an aggregated level. Two reference infrastructure scenarios have been developed for the Phase II of the TEN-STAC: a Reference 1 scenario and a Reference 2 scenario. The purpose of these two infrastructure scenarios is to measure in an aggregated way impacts of those priority projects planned to be finalised in 2007 and, secondly, to have a reference situation for the assessment of the priority projects to be finalised after 2007. The first objective is achieved by comparing the impacts between the Reference 1 and the Reference 2 scenario. The reference situation for the assessment of the priority projects to be finalised after 2007 is represented by the Reference 2 scenario.

Finally, one scenario incorporating all 29 priority projects has been considered, the “All projects scenario”. This scenario is considered for the assessment of impacts at the level of priority projects and related sub-sections.

For the assessment of the Reference 1, Reference 2 and the “All projects scenario”, the following assumptions are made:

- Socio-economic & general policy measures as in all 3 scenarios of Phase I.
- Road charges as in the TREND+ scenario of Phase I.
- The scenarios differ with respect to the infrastructure assumptions.
- Accompanying Measures for freight rail related to the rail sub-sections to be assessed.

The priority projects and the related sub-sections are assessed by several impact variables, which are embedded in a common multi-criteria evaluation scheme. According to the generation of performance data for impact variables the impact criteria can be subdivided into four groups:

- Impact criteria based on transport impedance matrices (e.g. potential changes in travel times, centrality)
- Impact criteria based on transport flows on the sub-section (e.g. share of international traffic)
- Impact criteria based on transport flows in the whole transport system (e.g. modal split, environmental indicators)
- Impact criteria independent from modelling results (e.g. appraisal of project planning status)

The priority projects’ sub-sections have been evaluated based on the impact assessment of the “All projects scenario”, thus when it is assumed that all priority projects are realised.

Because the impact estimated for an individual priority project / sub-section is in fact a cumulative impact of all priority projects, a sensitivity analysis has been carried out by estimating the impact of individual priority project. For the assessment of the priority projects to be finalised after 2007, a model run for each priority project has been carried out.

2.2 Transport infrastructure assumptions for the reference scenarios

The infrastructure assumptions for the **Reference 1 scenario** can be summarised as follows:

- Sub-sections with a finalisation date between 2000 and 2002 (see Table 2.1),
- Information from UIC on rail infrastructure improvements between 2000 and 2002.

Table 2.1 *Sub-sections to be finalised in 2002 (included in the Reference 1 scenario)*

Priority project	Priority Project name	Sub-sections	End date	Sections	Sub-section start date	Sub-section end date
P01	Railway line Berlin-Verona/Milano-Bologna-Napoli-Messina	Berlin/Ludwigsfede - Halle/Leipzig	2002	P01 D Berlin/Ludwigsfede - Halle/Leipzig	1991	2002
		Fortezza – Verona	2002	P01 I Fortezza – Verona	1992	2002
P08	Multimodal link Portugal/Spain-rest of Europe	Sevilla-Lisboa motorway	2001	P08 Road Lisboa - Sevilla (Spainish part)	1998	2001
				P08 Road Lisboa - Sevilla (Portuguese part)	1998	2001
P09	Railway line Cork-Dublin-Belfast-Stranraer	Conventional rail link Cork-Dublin-Belfast-Larne-Stranraer	2001	P09 IRL Conventional rail link Cork-Dublin-Belfast-Larne-Stranraer	1989	2001
P10	Malpensa	Malpensa Airport	2001	P10 I Malpensa Airport (Milan)	1995	2001
P11	Öresund fixed link	Fixed rail/road link between Denmark and Sweden	2000	P11 Fixed rail/road link between Denmark and Sweden	1992	2001

The **Reference 2 scenario** consists of following basic items:

- Infrastructure assumptions of the Reference 1 scenario,
- Sub-sections finished / planned to be finished between 2003 and 2007 (see Table 2.2),
- The Gotthard/ Simplon base tunnels.

Table 2.2 *Sub-sections to be finalised between 2003 and 2007 (included in the Reference 2 scenario)*

Priority project	Priority Project name	Sub-sections	End date	Sections	Subsection start date	Subsection end date
P01	Railway line Berlin-Verona/Milano-Bologna-Napoli-Messina	Nürnberg-München	2006	P01 D Nüremberg-München	2000	2006
		Verona-Napoli	2007	P01 I Verona – Bologna	1989	2006
				P01 I Bologna – Firenze	1996	2007
				P01 I Firenze – Roma	1970	1992
				P01 I Roma – Napoli	1994	2004
		Milano-Bologna	2006	P01 I Milano – Bologna	2000	2006
P02	High-speed railway line Paris-Bruxelles/Brussel-Köln-Amsterdam-London	Channel tunnel-London	2007	P02 UK London Channel South (Fawkham/Chériton)	2000	2007
				P02 UK London Channel North (ST Pancras/Ebbsfleet)	2000	2007
		Bruxelles/Brussel-Liège(-Köln)	2007	P02 B Branche Est: Brussels – Liège	1997	2007
		Bruxelles/Brussel-Rotterdam-Amsterdam	2007	P02 B Branche Nord: Antwerp – NL Border	1998	2007
				P02 NL B border – Rotterdam – Amsterdam (Bruxelles – Antwerp not included)	2000	2006
		Koln – Frankfurt [1]	2004	P02 D Koln – Frankfurt	1990	2004
P03	High-speed railway lines of south-west Europe	Madrid-Barcelona-Figueras	2005	P03 E Madrid – Barcelona – Figueras	1998	2005
P04	High-speed railway line east	Paris-Baudrecourt	2007	P04 F Paris – Metz/Baudrecourt - Luxembourg.	2002	2007
		Metz-Luxembourg	2007			
		Saarbrücken-Mannheim .	2007	P04 D Saarbrücken -Mannheim	2003	2007
P05	Betuwe line	Betuwe line	2007	P05 NL Betuwe	1998	2007
P07	Motorway route Igoumenitsa/Patra-Athina-Sofia-Budapest	Via Egnatia	2006	P07 EL Via Egnatia	1994	2006
		Nadlac-Sibiu motorway (branch towards Bucuresti and Constanta) .	2007	P07 RO nadlac - Sibiu	2004	2007
P08	Multimodal link Portugal/Spain-rest of Europe	Railway line Lisboa-Faro	2004	P08 P Lisboa-Faro	2000	2004
		Coruña-Lisboa motorway	2003	P08 Road Coruna - Lisboa (Spanish part)	2000	2003
				P08 Road Coruna - Lisboa (Portuguese Part)	2000	2003
P14	West coast main line	West coast main line	2007	P14 West Coast Main Line	1994	2007

A comparison of impacts between the Reference 1 and Reference 2 scenario allows assessing the impacts of those sub-sections, which are already in the construction phase or have been finalised. Furthermore, the Reference 2 scenario represents the reference situation for evaluating the impacts of the remaining sub-sections, which are grouped in 22 priority projects.

The assumptions for the Reference 1 scenario are summarised by Figure 2.1 and Figure 2.2. The Reference 2 scenario infrastructure assumptions can be found in Figure 2.3 and Figure 2.4.

For the road network the following type of roads are distinguished:

- Motorways
- Dual carriageway roads
- Other roads

For rail the following type of lines are distinguished:

- CL: conventional line
- NL: new line
- UL: upgraded line

New lines dedicated only to high-speed rail (when the project description has mentioned this) have been assumed of being closed for freight trains.

Figure 2.1 *Reference 1 road network*

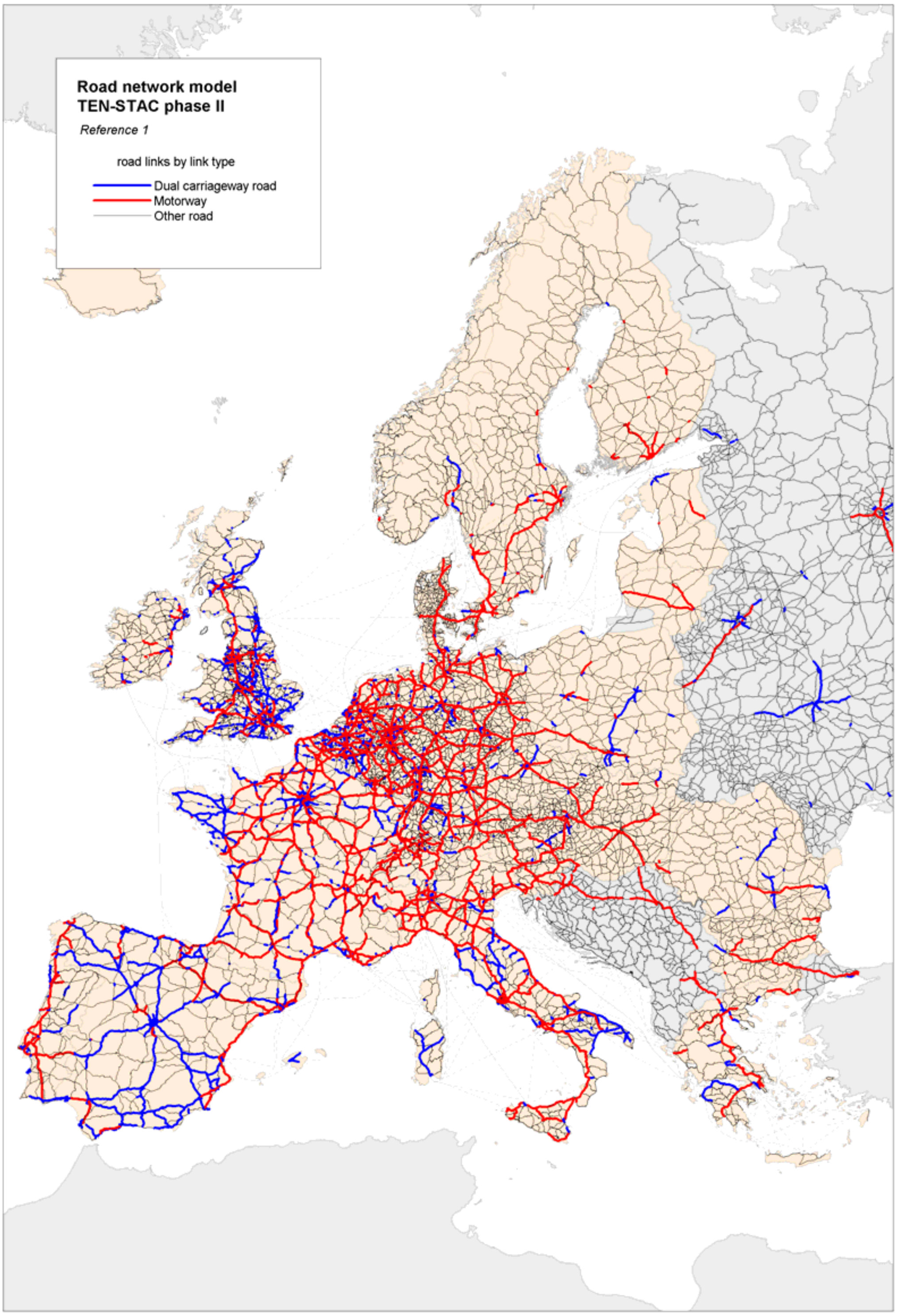


Figure 2.2 *Reference 1 rail network*

Figure 2.3 *Reference 2 road network*

Figure 2.4 *Reference 2 rail network*

2.3 Transport infrastructure assumptions for the priority projects

In the “all projects scenario”, the assumption is made that all the priority projects are finalised, meaning that this scenario consists of the infrastructure assumptions of the Reference 2 scenario and all sub-sections finalised after 2007. In the map in Figure 2.5 and Table 2.3, all sub-sections to be finalised after 2007 are presented by priority project.

With respect to the sensitivity analysis, when the effect of each individual project has been identified, the infrastructure assumptions of each high priority project are considered individually in the priority project scenario, in addition to the Reference 2 infrastructure assumptions.

Table 2.3 *Sub-sections to be finalised after 2007 (included in the “All projects scenario”)*

Priority project	Priority Project name	Sub-sections		Sections	Sub-section start date	Sub-section end date
P01	Railway line Berlin-Verona/Milano-Bologna-Napoli-Messina	P01.1	Berlin & Halle/Leipzig-Nürnberg	Domestic	1994	2008
					1996	2012
		P01.2	München-Kufstein-Innsbruck-Brenner	Internat	2010	2015
					2003	2009
					2007	2015
		P01.3	Rail/road bridge over the Strait of Messina	Domestic	2005	2015
P02	High-speed railway line Paris-Bruxelles/Brussel-Köln-Amsterdam-London	P02.1	Liège - Aachen - Koln	Internat	2001	2007
					1996	2007
P03	High-speed railway lines of south-west Europe	P03.1	Lisboa - Badajoz - Madrid	Internat	2006	2011
		P03.5	Aveiro - Salamanca	Internat		
		P03.6	Lisboa - Porto	Domestic		
		P03.2	Barcelona-Figueras-Perpignan-Montpellier-Nimes	Internat	2004	2008
					2003	2015
					2007	2010
		P03.3	Madrid-Vitoria-Irun/Hendaye - Bordeaux	Internat	2002	2010
					2008	2010
					2010	2020
		P03.4	Bordeaux-Tours	Domestic	2008	2015
P06	Railway line Lyon-Trieste/Koper-Ljubljana-Budapest-Ukrainian border	P06.1	Lyon-Mont-Cenis-Torino-Milano	Internat	2007	2015
					2006	2016
					2003	2011
					2003	2008
		P06.2	Milano - Venezia	Domestic	2005	2011
					2003	2017
		P06.3	Venezia - Ljubljiana - Budapest	Internat	2003	2015
					2007	2015

Priority project	Priority Project name	Sub-sections		Sections	Sub-section start date	Sub-section end date
					2006	2015
					2006	2015
P07	Motorway route Igoumenitsa/Patra-Athina-Sofia-Budapest	P07.1	Pathe: Patras - Athen section	Domestic	1998	2008
		P07.2	Athen - Greek/Bulgarian border - Kulata - Sofia	Internat	2003	2010
P08	Multimodal link Portugal/Spain-rest of Europe	P08.1	Railway line Coruña-Lisboa-Sines	Internat	2003	2010
					2001	2010
		P08.2	Railway line Lisboa-Valladolid	Internat	2003	2007
					2003	2010
		P08.3	Lisboa-Valladolid motorway	Internat	2001	2010
					2004	2010
		P08.4	New Lisboa airport	Domestic (?)	2000	2015
P12	Nordic triangle railway line/road	P12.1	Road and railway projects in Sweden (including Malmo and Stockholm Tunnels)	Domestic	1996	2015
					2000	2015
		P12.2	Vaalimaa - Helsinki-Turku motorway	Domestic	2003	2010
					2004	2015
		P12.3	Railway line (Helsinki-) Lahti-Vainikkala and other railway projects in Finland	Internat	2004	2014
		P12.4	P12 Railway line Kerava - Lahti	Domestic	2003	2006
P13	UK/Ireland/Benelux road link	P13.1	UK/Ireland/Benelux road link (UK sections) [1]	Domestic	1996	2010
					1996	2010
P16	Freight railway line Sines-Madrid-Paris	P16.1	New high-capacity rail link across the Pyrenees	Internat	2013	2020
		P16.2	Railway line Sines-Badajoz .	Domestic (?)	2005	2010
P17	Railway line (Paris-) Strasbourg-Stuttgart-Wien-Bratislava	P17.1	Baudrecourt-Strasbourg-Stuttgart with the Kehl bridge as cross-border section	Internat	2010	2015
					2010	2015
		P17.2	Stuttgart-Ulm	Domestic	2004	2012
		P17.3	München-Salzburg , cross-border section	Internat	2002	2015
					2005	2015
		P17.4	Salzburg-Wien	Domestic	1990	2012
		P17.5	Wien-Bratislava , cross-border section.	Internat	2004	2010
P18	Rhine/Meuse-Main-Danube inland waterway route	P18.1	Rhine-Meuse with the lock of Lanaye as cross-border section	Internat	2006	2010
					2005	2019
		P18.2	Vilshofen-Straubing	Domestic	2008	2013
		P18.3	Wien-Bratislava cross-border section	Internat	2006	2015
		P18.4	Palkovicovo-Mohàcs	Domestic	2007	2014
		P18.5	Bottlenecks in Romania and Bulgaria .	Domestic	2002	2011
					2004	2011
		P18.6	Inland waterway Seine - Scheldt	Internat	n.a.	2020

Priority project	Priority Project name	Sub-sections		Sections	Sub-section start date	Sub-section end date
P19	High-speed rail interoperability on the Iberian peninsula	P19.1	Madrid-Andalucia	Domestic	2001	2010
		P19.2	North-east	Domestic	2001	2010
		P19.3	Madrid-Levante and Mediterranean	Domestic	2001	2010
		P19.4	North/North-west corridor, except Vigo-Porto	Domestic	2001	2010
		P19.6	Vigo-Porto	Internat		
		P19.5	Extremadura	Domestic	2001	2010
P20	Fehmarn Belt railway line	P20.1	Fehmarn Belt fixed rail/road link	Internat	2007	2014
		P20.2	Railway line for access in Denmark from Öresund	Domestic	2007	2015
		P20.3	Puttgarden - Hamburg - Hannover/Bremen	Domestic	2007	2015
					2010	2015
P21	Motorways of the sea	P21.1	Motorway of the Baltic Sea	Internat	n.a.	2010
		P21.2	Motorway of the sea of western Europe	Internat	n.a.	2010
		P21.3	Motorway of the sea of south-east Europe	Internat	n.a.	2010
		P21.4	Motorway of the sea of south-west Europe	Internat	n.a.	2010
P22	Railway line Athina-Sofia-Budapest-Wien-Praha-Nürnberg/Dresden	P22.1	Railway line Greek/Bulgarian border-Kulata-Sofia-Vidin/Calafat	Domestic	2010	2015
		P22.2	Railway line Curtici-Brasov (towards Bucuresti and Constanta)	Domestic	2005	2010
		P22.3	Railway line Budapest-Wien , cross-border section	Internat	2004	2010
					2004	2010
		P22.4	Railway line Brno-Praha-Nürnberg , with NürnbergPraha as cross-border section.	Internat	2003	2015
					2012	2015
P23	Railway line Gdansk-Warszawa-Brno/Bratislava-Wien	P23.1	Railway line Gdansk-Warszawa-Katowice	Domestic	2005	2015
		P23.2	Railway line Katowice-Brno-Breclav	Internat	2004	2010
					2002	2010
		P23.3	Railway line Katowice-Zilina-Nove Misto n.V. .	Internat	2005	2010
					2005	2010
P24	Railway line Lyon/Genova-Basel-Duisburg-Rotterdam/Antwerpen	P24.1	Lyon-Dijon	Domestic	2010	2018
		P24.6	Dijon-Mulhouse-Mülheim	Internat	2006	2010
					2006	2015
		P24.2	Genova-Milano/Novara-Swiss border	Domestic (?)	2005	2013
					2003	2010
		P24.3	Basel-Karlsruhe	Domestic (?)	1987	2015
		P24.4	Frankfurt-Mannheim	Domestic	2006	2012
		P24.5	Duisburg-Emmerich & "Iron Rhine" Rheidt-Antwerpen .	Internat	1997	2009
					2004	2010
P25	Motorway route Gdansk-	P25.1	Gdansk-Katowice motorway	Domestic	2003	2010

Priority project	Priority Project name	Sub-sections		Sections	Sub-section start date	Sub-section end date
	Brno/Bratislava-Wien	P25.2	Katowice-Brno/Zilina motorway , cross-border section	Internat.	2003	2010
					2003	2010
					2003	2010
					2003	2010
		P25.3	Brno-Wien motorway , cross-border section	Internat	2003	2010
					2003	2010
P26	Railway line/road Ireland/United Kingdom/continental Europe	P26.1	Road/railway corridor linking Dublin with the North (Belfast-Larne) and South (Cork) [2]	Domestic	2003	2010
		P26.2	Road/railway corridor Hull-Liverpool	Domestic	2003	2020
		P26.3	Railway line Felixstowe-Nuneaton - Crewe - Holyhead	Domestic	2003	2012
					2003	2008
P27	"Rail Baltica" line Warsaw-Kaunas-Riga-Tallinn	P27.1	Warsaw-Kaunas	Internat	2008	2010
		P27.2	Kaunas-Riga	Internat	2010	2014
		P27.3	Riga-Tallinn	Internat	2012	2016
					2012	2016
P28	"Eurocaprail" on the Brussels-Luxembourg-Strasbourg railway line	P28.1	Brussels-Luxembourg-Strasbourg .	Internat	2007	2012
P29	Railway line of the Ionian/Adriatic intermodal corridor	P29.1	Railway line of the Ionian/Adriatic corridor	Domestic	2006	2012
					2009	2014

[1] *It is assumed that P13.1 will include as remaining projects only UK sections (the motorway Cork - Dublin - Border with NIRL is the road link of P26.1).*

[2] *The rail link of P26.1 is the further modernisation of the link developed within P09 Railway line Cork-Dublin-Belfast-Stranraer*

Figure 2.5 *Sub-sections to be finalised after 2007 (included in the 'all projects scenario')*

The following assumptions have been made with respect to the priority projects subject to analyses within TEN-STAC:

1) Sub-section P12.5, Malmo and Stockholm city tunnels, is considered together with and as part of sub-section P12.1, Road/ rail projects in Sweden.
2) P13.1, UK/ Ireland/ Benelux road link, includes only UK sections. Irish sections are considered in P26.1, Road/ rail corridor linking Dublin with the North and the South.
3) The sub-section Lisboa/ Porto – Madrid of P03 is replaced by the following parts:
   - Lisboa – Madrid via Badajoz (2010), not to be opened for freight,
   - Aveiro – Salamanca (2015),
   - Lisboa – Porto.

A few priority projects and sub-sections feature overlapping links, i.e. links, which belong to two different priority projects and sub-sections. However, in order to avoid double counting and methodological difficulties due to the possibility of the same link being considered within the scope of two different sub-sections, for most of the overlapping links a clear allocation has been made. Most of the overlapping sections can be found in Spain due to priority project P19, interoperability of the Spanish high-speed rail network. The allocation of links to sub-sections does not have an impact on the network models, but relates only to the generation of the performance data. Hence within the networks models the overlapping links are considered within all sub-sections, in which they appear.

For the generation of performance data however, they are dealt with in the scope of only one sub-section. The allocation of the concerned links to sub-sections is documented in Table 2.4.

Table 2.4 *Allocation of overlapping links to sub-sections*

Priority project	Priority Project name	Sub-sections		Allocation of overlapping sections
P03	High-speed railway lines of south-west Europe	P03.1	Lisboa - Badajoz - Madrid	
		P03.2	Barcelona-Figueras-Perpignan-Montpellier-Nimes	
		P03.3	Madrid-Vitoria-Irun/Hendaye - Bordeaux	
		P03.4	Bordeaux-Tours	
		P03.5	Aveiro - Salamanca	
		P03.6	Lisboa - Porto	
P08	Multimodal link Portugal/Spain-rest of Europe	P08.1	Railway line Coruña-Lisboa-Sines	Sines-Ermidas considered within P16.2
		P08.2	Railway line Lisboa-Valladolid	Lisboa-Entroncamento-Pampilhosa-Porto considered within P08.1
		P08.3	Lisboa-Valladolid motorway	
		P08.4	New Lisboa airport	
P16	Freight railway line Sines-Madrid-Paris	P16.1	New high-capacity rail link across the Pyrenees	
		P16.2	Railway line Sines-Badajoz .	
P17	Railway line (Paris-) Strasbourg-Stuttgart-Wien-Bratislava	P17.1	Baudrecourt-Strasbourg-Stuttgart with the Kehl bridge as cross-border section	
		P17.2	Stuttgart-Ulm	
		P17.3	München-Salzburg , cross-border section	
		P17.4	Salzburg-Wien	
		P17.5	Wien-Bratislava, cross-border section.	
P19	High-speed rail interoperability on the Iberian peninsula	P19.1	Madrid-Andalucia	
		P19.2	North-east	Madrid-Valladolid-Irun considered within P03.3
		P19.3	Madrid-Levante and Mediterranean	
		P19.4	North/North-west corridor, except Vigo-Porto	New line Aveiro-Salamanca considered within P03.5
		P19.5	Extremadura	New line Madrid-Badajoz-Lisboa considered within P03.1
		P19.6	Vigo-Porto	Project considered within P08.1
P28	"Eurocaprail" on the Brussels-Luxembourg-Strasbourg railway line	P28.1	Brussels-Luxembourg-Strasbourg .	Metz-Strasbourg considered within P17.1

The sub-sections P19.5 and P19.6 are completely dealt within the framework of other sub-sections (P03.1 and P08.1).

The infrastructure scenario representing the assumptions of the reference scenarios together with those for the priority projects is called “all projects scenario”. The network models corresponding to “all projects scenario” with all 29 priority projects implemented are displayed in Figure 2.6 and Figure 2.7.

Figure 2.6 *Road network with all 29 priority projects implemented*

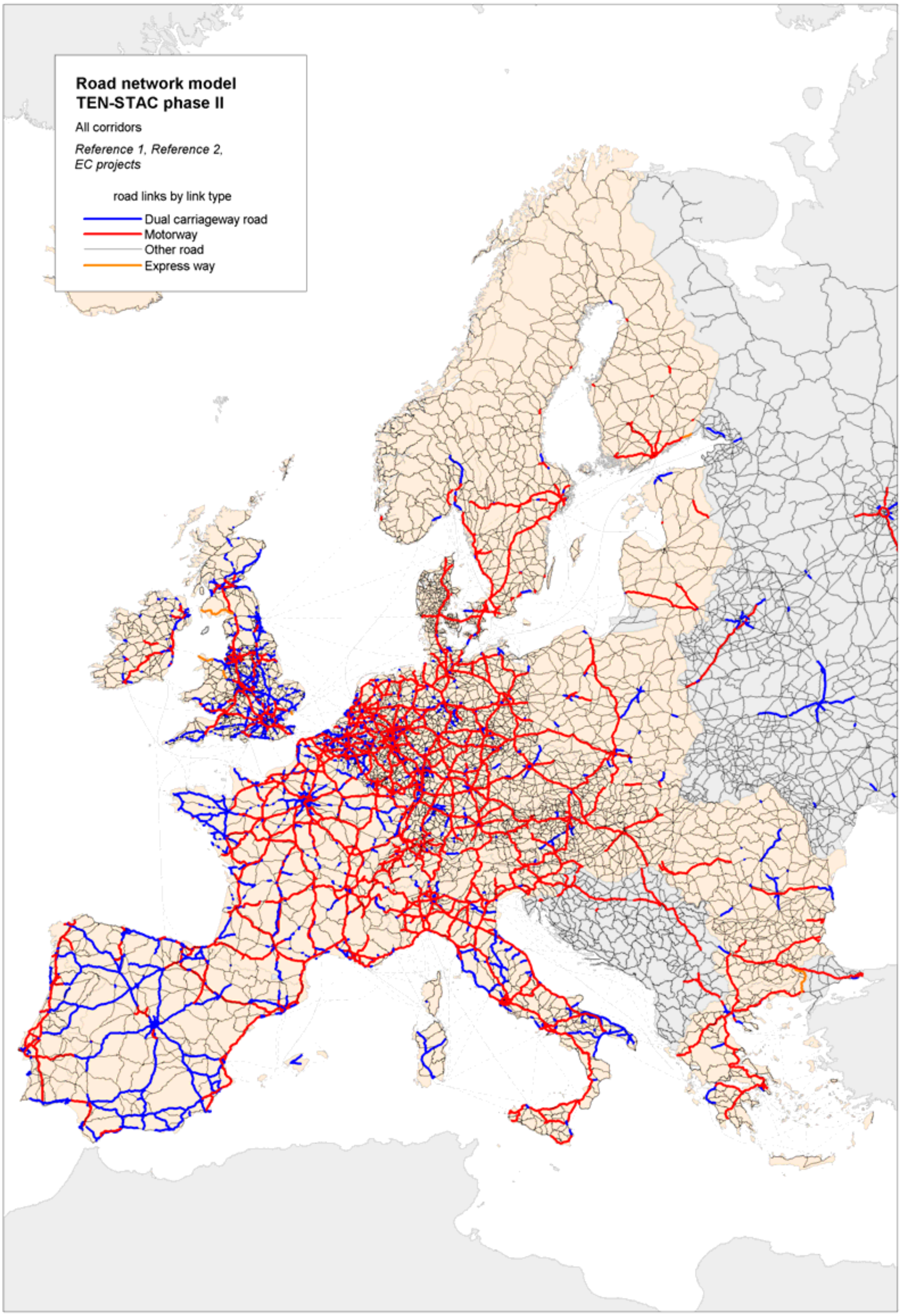
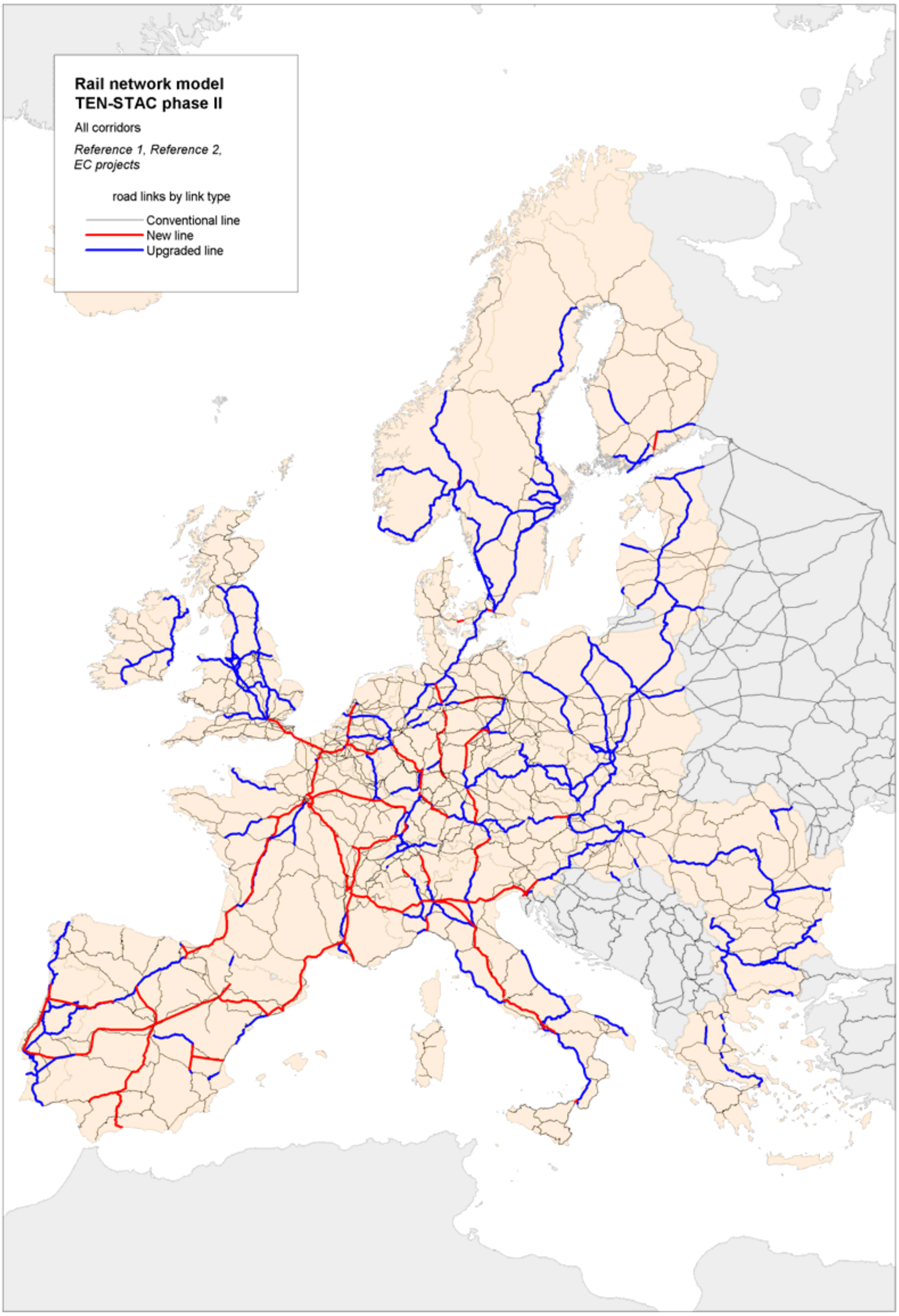


Figure 2.7 *Rail network with all 29 priority projects implemented*



2.4 Selection and definition of impact criteria

The impact variables applied for priority project assessment within TEN-STAC phase II is based on the Commission's proposal made on 1 October 2003 (see COM(2003) 564 final), Article 19. The relationship between the criteria mentioned in this proposal and the impact variables defined in TEN-STAC is illustrated by Table 2.5.

Table 2.5 *TEN-STAC group of indicators*

Criterion as specified in COM 2003/564, Art.19	Corresponding group of STAC indicators
(a) (priority projects) aim to eliminate a bottleneck or complete a missing link on a major route of the trans-European network, in particular projects which cross natural barriers;	**ECONOMIC IMPACTS IN THE TRANSPORT SECTOR**
(b) (priority projects) are on such a scale that long-term planning at European level brings high added value;	**CREATION OF EUROPEAN VALUE ADDED** **GENERAL TRANSPORT RELEVANCE**
(c) (priority projects) provide significant added value in facilitating the mobility of goods and people between Member States, including contributing to the interoperability of national networks;	
(d1) (priority projects) demonstrate, in terms of the overall project, potential socio-economic profitability and other socio-economic advantages	**INVESTMENT COST** **CREATION OF EUROPEAN VALUE ADDED**
(d2) (priority projects) demonstrate, a commitment on the part of the Member States concerned to carrying out the studies and evaluation procedures in time to complete the work in accordance with a date agreed in advance;	**MATURITY AND COHERENCE OF THE PROJECT**
(e) (priority projects)contribute to the territorial cohesion of the European Union by integrating the networks of the new Member States and improving connections with the peripheral regions;	**ENVIRONMENTAL SUSTAINABILITY** **IMPROVEMENT OF ACCESSIBILITY**
(f) (priority projects) contribute to sustainable development of transport by improving safety and reducing environmental damage caused by transport, in particular by promoting a modal shift towards railways, intermodal transport, inland waterways and maritime transport.	**ENVIRONMENTAL SUSTAINABILITY** **MATURITY AND COHERENCE OF THE PROJECT**

In the next step these indicators have been made operational for the TEN-STAC assessment task and defined as shown in Table 2.6 and Table 2.7 hereunder.

Table 2.6 TEN STAC Phase II indicators; Cost-benefit analyses

Objective	Indicator	Ind.#	Unit of measure
ECONOMIC IMPACTS IN THE TRANSPORT SECTOR			
IMPROVEMENT OF ROAD LEVEL SERVICE	Changes in time costs caused by road congestion	1	Mln. € / year
REDUCTION OF TRAVEL TIME	Changes in monetary value of the reduction of passenger travel time	2a	Mln. € / year
		2b	passenger * hour / year
	Changes in monetary value of the reduction of freight travel time	3	Mln. € / year
ENVIRONMENTAL SUSTAINABILITY			
GLOBAL WARMING	Change (in monetary value) of the transport contribution to global warming	4a	1000 € / year
		4b	Mln. kg CO2 / year
ATMOSPHERIC POLLUTION	Change (in monetary value) of the NOX transport emission	5a	1000 € / year
		5b	Mln. kg NOx / year
	Change (in monetary value) of particulates' emissions of transport	6a	1000 € / year
		6b	Mln. kg particulates / year
TRANSPORT SAFETY	Variation on monetary value of accidents	7	Mln. € / year
INVESTEMENT COST			
INVESTMENT COST	Total project costs	8	Mln. €

Table 2.7 *TEN STAC Phase II indicators; Non-monetised impacts*

Objective	Indicator	Ind.#	Unit of measure
GENERAL TRANSPORT RELEVANCE			
TOTAL TRAFFIC VOLUME ON THE PROJECT	Total passenger traffic on the project section	10	Mln. passengers / year
	Total freight traffic on the project section	11a	Mln. tons / year
		11b	Mln. tons / year
		11c	Bln. ton km /year
INTERMODALITY	Quantitative appraisal of the project's contribution for an intermodal transport system	12	Mln. tons
CREATION OF EUROPEAN VALUE ADDED			
DEVELOPMENT OF INTERNATIONAL PASSENGER TRAFFIC	Share of international passenger traffic on total traffic on the project	13	%
	Volume of international passenger traffic on the project	14	Mln. passengers / year
DEVELOPMENT OF INTERNATIONAL FREIGHT TRAFFIC	Share of international freight traffic on total traffic on the project	15	%
	Volume of international freight traffic on the project	16	Mln. tons / year
INTEROPERABILITY	Reduction of passengers waiting time at borders for international traffic	17	-
	Reduction of freight waiting time at borders for international traffic	18	-
	Length of networks becoming interoperable because of the project	19	-
IMPROVEMENT OF ACCESSIBILITY			
PASSENGER ACCESSIBILITY	Variation of the STAC centrality index for passenger transport	20	%
FREIGHT ACCESSIBILITY	Variation of the STAC centrality index for freight transport	21	%
PERIPHERAL ACCESSIBILITY	Variation of the STAC centrality index for passenger transport in regions identified as peripheral	22	%
	Variation of the STAC centrality index for freight transport in regions identified as peripheral	23	%
ENVIRONMENTAL SUSTAINABILITY			
MODAL REBALANCING	Volume of road freight traffic shifted to rail, IWW or sea transport	24	Mln. t·km / year
	Volume of road and air passenger traffic shifted to rail	25	Mln. passenger·km / year
LEVEL OF CONCERN: TRAFFIC TRANSFER	Transfer of traffic from infrastructure lying in sensitive zones to the projected infrastructure	26	% of road traffic transferred from sensitive areas
LEVEL OF CONCERN: DISTANCE	Percentage of the length of the project lying in a sensitive area	27	% length
LEVEL OF CONCERN: EMISSIONS	Changes of inhabitants' level of concern caused by emissions of NOx and particulates	28a	% NOx
		28b	% Particulates
LEVEL OF CONCERN: PROXIMITY	Synthetic appreciation of the proximity of the project from specially protected areas (SPAs) or densely populated areas	29a	Proximity of the project from SPA (km)
		29b	Number of inhabitants living in the zone traversed by the project
MATURITY AND COHERENCE OF THE PROJECT			
DEVELOPMENT OF THE PROJECT	Appraisal of the project planning status	30	-
INSTITUTIONAL SOUNDNESS	Qualitative appraisal of the project's compliance with national plans	31	-
COHERENCE OF THE PROJECT	Qualitative appraisal of the project's coherence with main international traffic corridors	32	-

3 A METHODOLOGY APPLIED FOR THE GENERATION OF PROJECT-SPECIFIC PERFORMANCE DATA

3.1 Methodology for generation of performance results

This chapter describes first the methodology of estimating the impact of implementing the infrastructure assumptions at the level of each priority project and related sub-sections in the case of "all projects scenario", thus under the assumption that all priority projects are realised in 2020.

Secondly, the methodology of estimating the impact of implementing the infrastructure assumptions at the level of each priority project and related sub-sections in case of individual priority project scenario(s), to be further considered for the sensitivity analysis, is presented.

3.1.1 Generation of performance results – all priority projects realised

Impact criteria based on transport impedance matrices

The estimation of performance data at the level of priority projects and related sub-sections is based on the "all projects scenario" model run.

The impedances are derived from the infrastructure measures implemented in the network models.

For the assessment of a sub-section's impact on criteria based on transport impedances, a top-down approach is applied that distributes the effects of differences between the "all projects scenario" and Reference 2 scenario, in a first step to the level of priority projects, and in a second step to the level of sub-sections:

$$\Delta_i^X = \frac{X_i^{P\_all\_w}}{\sum_{i(i \in j)} X_i^{p\_all\_w}} \cdot \Delta_j^X \,, \quad \text{with}$$

$$\Delta_j^X = \frac{X_j^{P\_all\_w}}{\sum_{j} X_j^{p\_all\_w}} \cdot \Delta_{P\_all}^X \qquad \text{and} \qquad \Delta_{P\_all}^X = X^{P\_all} - X^{ref2}$$

where:

$\Delta_{P\_all}^X$	"Global" impact of the "all projects scenario", in reference to performance for impact criterion X
Δ_j^X	Impact of the "all projects scenario" on priority project j, in reference to performance for impact criterion X

Δ_i^X	Impact of the "all projects scenario" on sub-section i, in reference to performance for impact criterion X
X^{P_all}	Performance of indicator X in the "all projects scenario"
X^{ref2}	Performance of indicator X in the Reference 2 scenario
$X_j^{P\_all\_w}$	Performance of indicator X in the "all projects scenario" without priority project j
$X_i^{P\_all\_w}$	Performance of indicator X in the "all projects scenario" without priority project j, but with sub-section i (with sub-section i belonging to priority project j)

Impact criteria based on transport flows in the whole transport system
The calculation of performance data for impact criteria based on transport flows in the whole transport system (thus covering all modes), like criteria related to modal split or environmental criteria, requires the analysis of all traffic flows, for all modes, purposes and segments.

Also for this group of impact criteria, a top-down approach is applied that distributes the effects of differences between the "all projects scenario" and the Reference 2 scenario in the first step to the level of priority projects, and in the second step to the level of sub-sections.

The following method is applied:

First those O/Ds that are routed via a sub-section in the loaded network of the "all projects scenario" are identified. Each selected sub-section-specific O/D is retraced, both in each loaded network of the "all projects scenario" and in each loaded network of the Reference 2 scenario. By a comparison of flow pattern of the sub-section-specific selected O/Ds between the "all projects scenario" and the Reference scenario, a "global" impact value is determined for the impacts of the "all projects scenario", which is subsequently distributed to the level of priority projects and sub-sections:

$$\Delta_i^X = \frac{\Delta_i^{sOD,X}}{\sum_{i(i\in j)} \Delta_i^X} \cdot \Delta_j^X \quad \text{, with}$$

$$\Delta_j^X = \frac{X_j^{sOD,X}}{\sum_j \Delta_j^X} \cdot \Delta_{P\_all}^X \qquad \text{and} \qquad \Delta_{P\_all}^X = X^{P\_all} - X^{ref2}$$

where:

$\Delta_{P\_all}^X$	"Global" impact of the "all projects scenario", in reference to performance for impact criterion X

Δ_j^X	Impact of the "all projects scenario" on priority project j, in reference to performance for impact criterion X
Δ_i^X	Impact of the "all projects scenario" on sub-section i, in reference to performance for impact criterion X
X^{P_all}	Performance of indicator X in the "all projects scenario"
X^{ref2}	Performance of indicator X in the Reference 2 scenario
$\Delta_j^{sOD,X}$	Impact of the "all projects scenario" on the selected O/Ds of priority project j, in reference to performance for impact criterion X
$\Delta_i^{sOD,X}$	Impact of the "all projects scenario" on the selected O/Ds of sub-section i, in reference to performance for impact criterion X

The approach applied is visualised by Figure 3.1.

Approach for eliminating double counting

The approach for generation of performance data for impact variables based on transport flows in the whole transport system as described above implies the possibility of double counting: If a certain O/D tackles more than one sub-section of a priority project, the problem of double counting arises, with the O/D, their routing through the network and the subsequent environmental assessment being analysed for each sub-section individually. In order to overcome this pattern the sub-section-specific assessment is combined with the assessment at priority project level:

The corrected performance index for sub-section i on priority project j, $(X_i)'$ is calculated as follows:

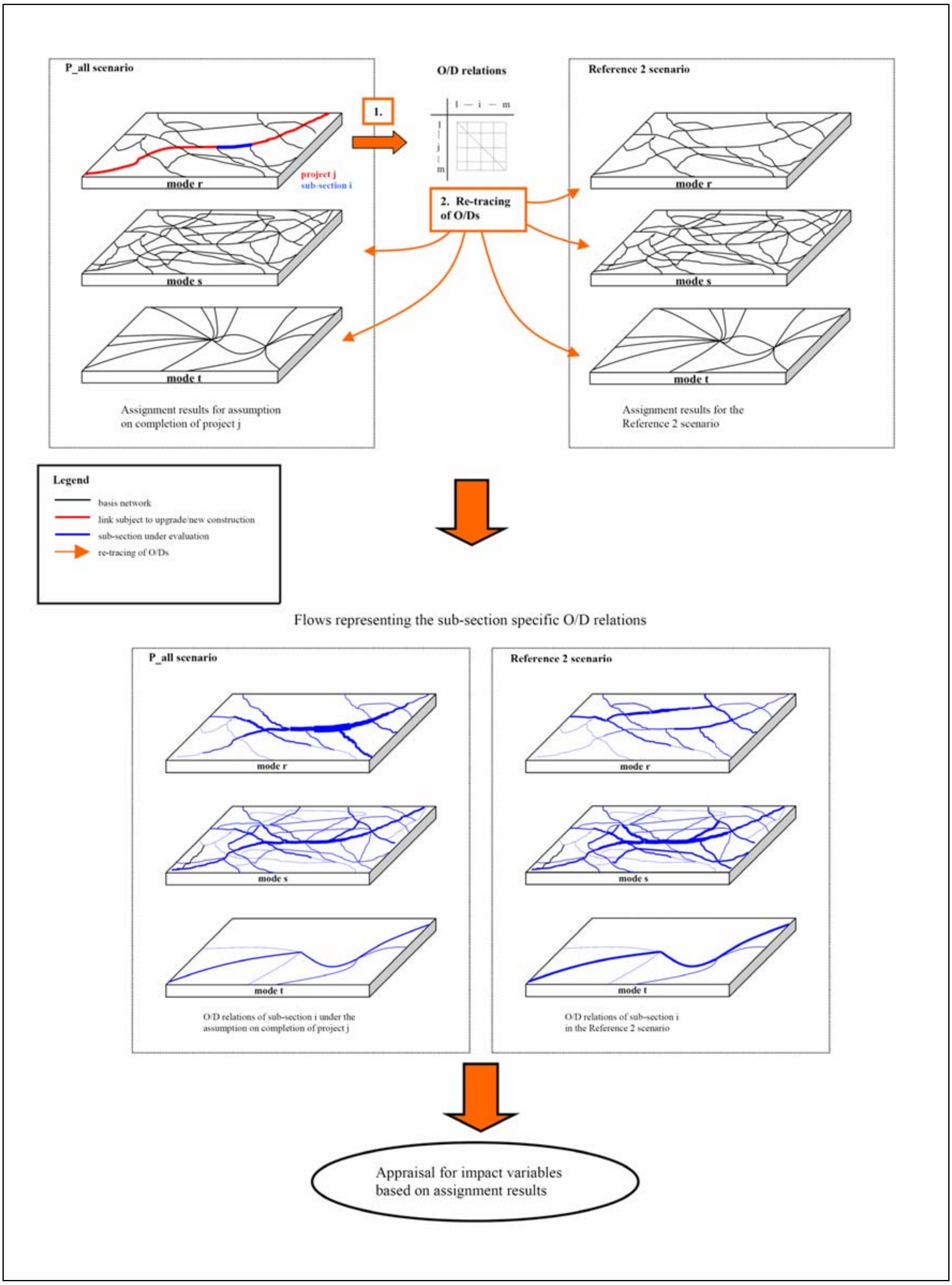
$$(X_i)' = \frac{X_i}{\sum_i X_i} \cdot X_j \quad ,$$

with:

X_i performance value of impact variable X for sub-section i, belonging to priority project j

X_j performance value of impact variable X for priority project j

Figure 3.1 *Organisation of generation of performance data for impact variables based on the whole transport system ("all projects scenario")*



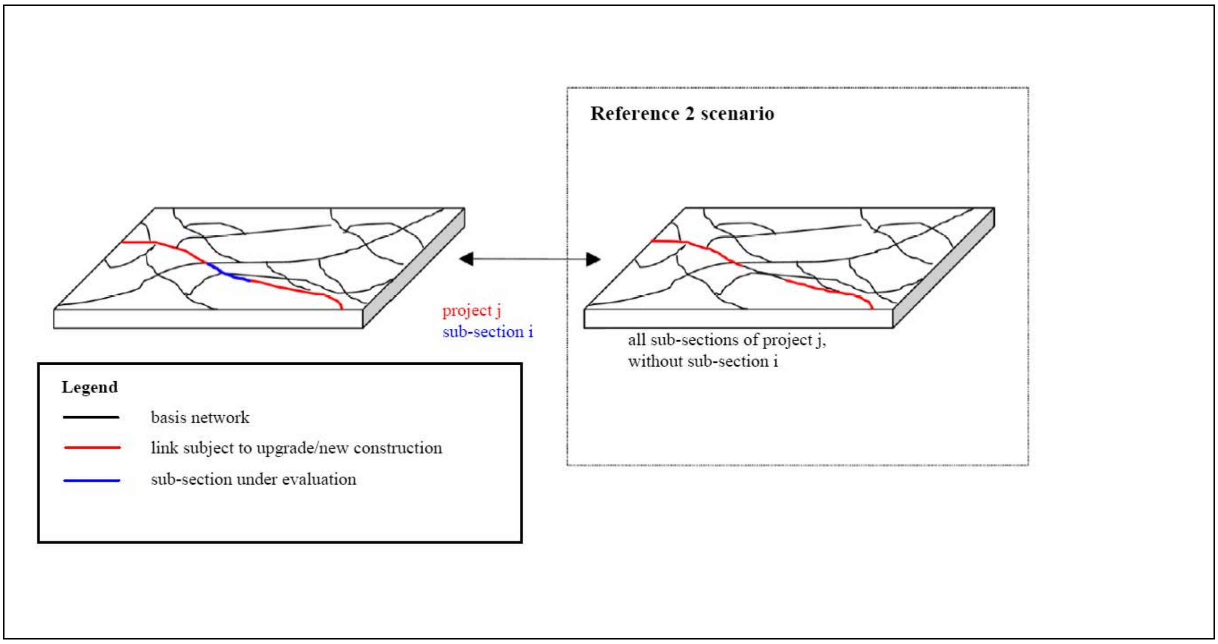
3.1.2 Generation of performance results – individual priority project implementation

Impact criteria based on transport impedance matrices

For the assessment of a sub-section's impact on criteria based on transport impedances, the following two situations are compared: the situation in which the sub-section i is realised, together with all other sub-sections belonging to the priority project j, and the situation in which all sub-sections on priority project j are realised besides sub-section i (see Figure 3.2).

Examples for impact criteria are indicators referring to changes in (potential) travel times or to centrality.

Figure 3.2 *Reference case for assessment of sub-sections for criteria based on impedance matrices*



Impact criteria based on transport flows on the sub-section

Impact criteria based on transport flows on the sub-section, e.g. the total transport volume or the share of international transport demand, can be retrieved directly from the assignment runs of transport modelling. Impact criteria belonging to this type are raised for each sub-section without a comparison to a reference case.

For the estimation of these indicators one model run for each priority project is required.

Impact criteria based on transport flows in the whole transport system

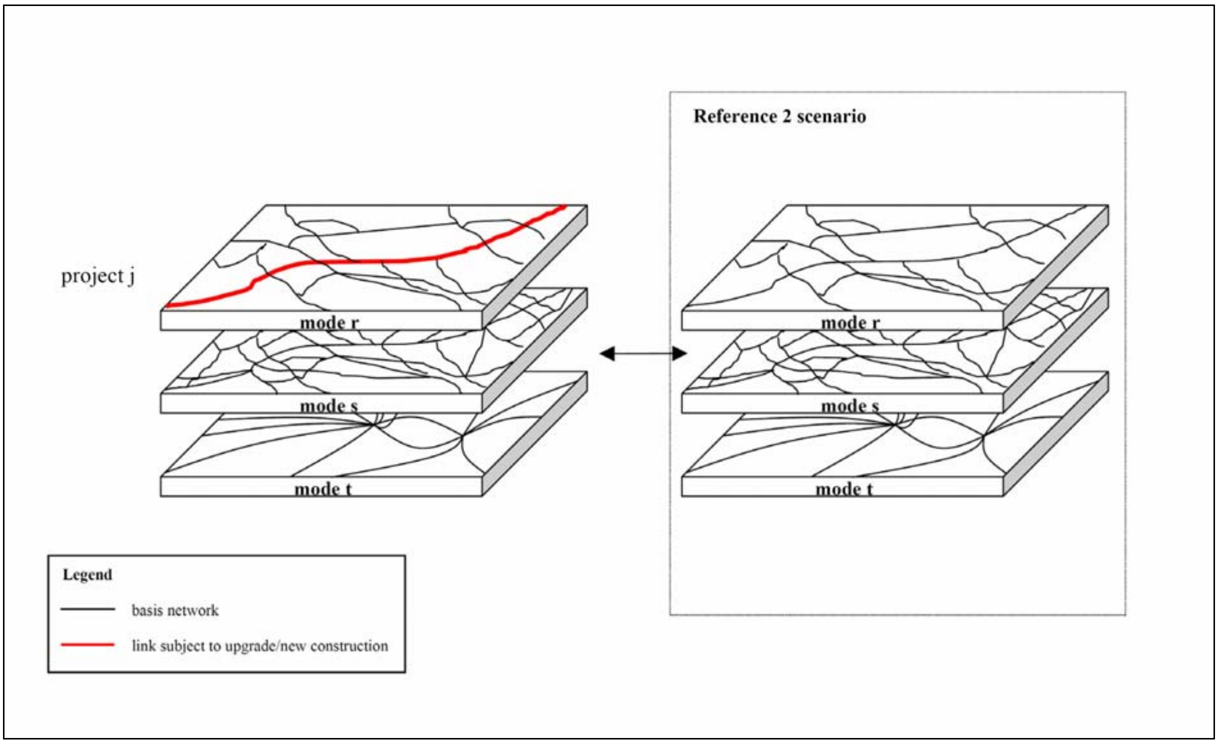
The calculation of performance data for impact criteria based on transport flows in the whole transport system (thus covering all modes), like criteria related to modal split or environmental criteria, requires the analysis of all traffic flows, for all modes, purposes and segments.

The assignment runs are generated at priority project level, with individual assignment runs for each priority project. For these assignment runs the assumption is made that all sub-sections belonging to the priority project under consideration are implemented.

This approach results in 1+22 model runs for assignment:
Infrastructure assumptions for the reference situation: Infrastructure scenario of the Reference 2 scenario.
Infrastructure assumption for priority project j (j= 1, ..., 22): Infrastructure scenario for the Reference 2 scenario plus infrastructure assumptions for priority project j.

Figure 3.3 illustrates the scope of the assignment runs for this approach for a priority project j (the red network links indicate the assumption of completion of the link in terms of upgrade/ new construction).

Figure 3.3 *Assignment runs for impact criteria based on transport flows in the whole transport system*



The changes in transport flows and related impact criteria have to be assessed at the level of sub-sections. Hence the assignment results at priority project level have to be transferred to the level of sub-sections.

For this task the following procedure is applied:

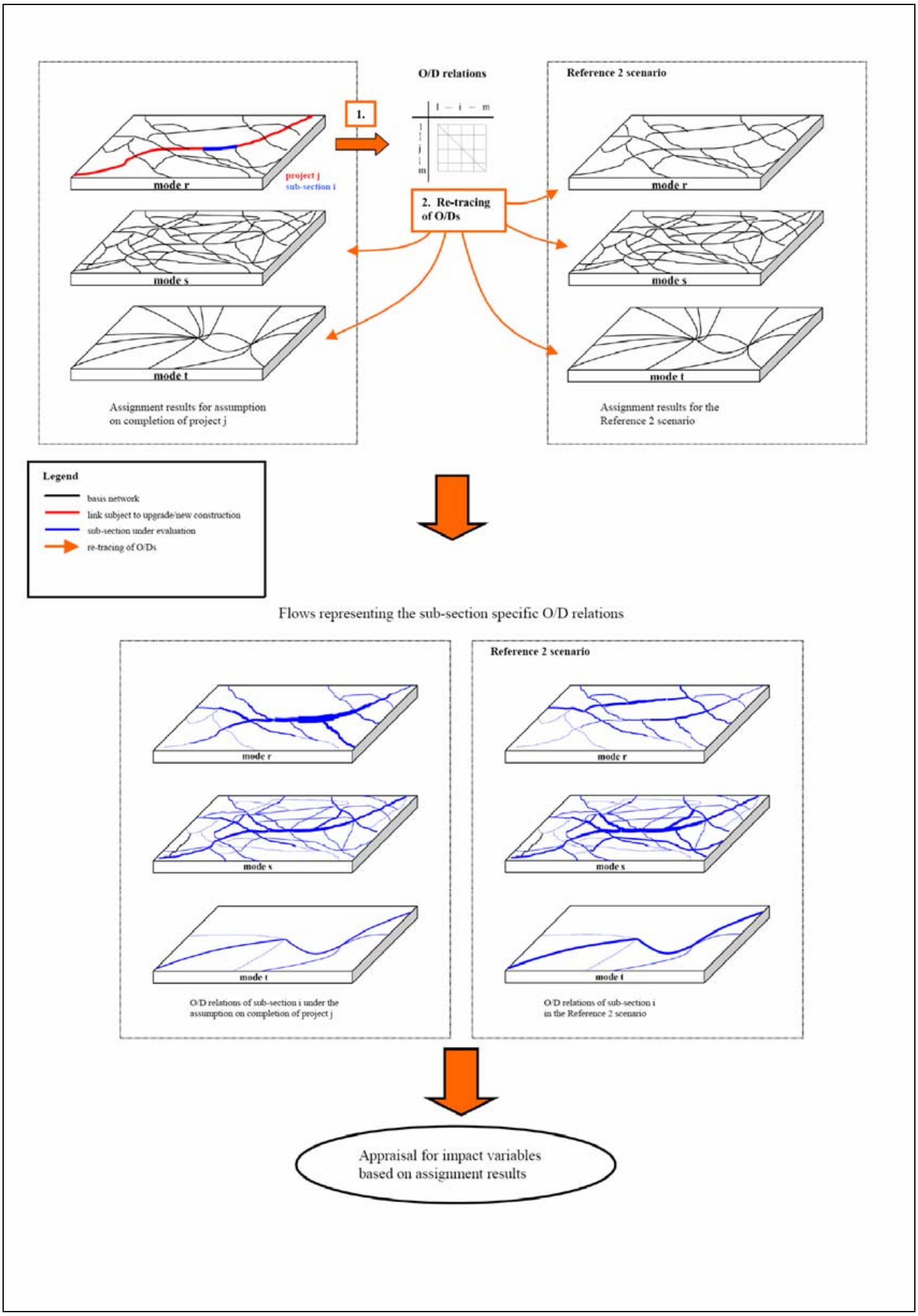
1. In a first model run, underlying the assumption of the implementation of all sub-sections i on priority project j, all relations are stored, which are routed via the specific sub-section i being part of priority project j. This results in a set of sub-section-specific O/D relations, which are routed via the specific sub-section.

2. A routine identifies all sub-section-specific O/D flows from step 1 on the other networks for the situation that priority project j is implemented, as well as for all assigned traffic flows in the loaded networks of the Reference 2 scenario.

3. With all transport flows relevant for the sub-section under consideration being identified, both for the situation "with" the sub-section and the reference situation "without" it, the dimension of impacts caused by all transport flows concerned by the sub-section, can be measured.

The approach is visualised by Figure 3.4.

Figure 3.4 *Organisation of generation of performance data for impact variables based on the whole transport system (individual priority project scenario)*



Approach for eliminating double counting

The approach for generation of performance data for impact variables based on transport flows in the whole transport system as described above implies the possibility of double counting: If a certain O/D pair tackles more than one sub-section of a priority project, the problem of double counting arises, with the O/D, their routing through the network and the subsequent environmental assessment being analysed for each sub-section individually. In order to overcome this pattern the sub-section-specific assessment is combined with the assessment at project level:

The corrected performance index for sub-section i on priority project j, $(X_i)'$ is calculated as follows:

$$(X_i)' = \frac{X_i}{\sum_i X_i} \cdot X_j \quad ,$$

with:

X_i performance value of impact variable X for sub-section i, belonging to priority project j

X_j performance value of impact variable X for priority project j

3.2 Measurement of effects in monetary terms

3.2.1 Background and introduction

The aim of this section is to provide an overview of the monetary values used for time, accidents and emissions effects.

Relation to the phase I of TEN-STAC

Monetarisation of time and emissions has already been done as part of the extended phase I. The values in this section are primarily an up-date and amendment of the values used in the extended phase I of TEN-STAC.

Values for non-urban areas only

The values are for non-urban areas only. First, most of the priority projects are outside the cities. Second, the sub-sections nearby the cities relate to by-pass roads more than being within the city per se.

Price level is 2003

All values are indexed to 2003, using the nominal growth rate in GDP (PPP) per capita for EU15. The applied historic growth rates are listed below in Table 3.1.

Table 3.1 *Growth rate for EU15 based on the GDP (PPP) nominal growth rate per capita*

Year	Value
1998-2003	31%
2000-2003	17%

Source: EUROSTAT
The growth rates for 2001 to 2003 is based on the average growth rate for 1998-2000

Country specific values
Where country specific values are needed to reflect differences in income levels, a correction factor is defined as the country's GDP (PPP) relative to the average EU GDP (PPP). GDP (PPP) is GDP measured in PPP exchange rates.

Market prices versus factor prices
The choice to use market or factor prices depends on the purpose of the analysis, and in this analysis all values are converted to market prices. The respective use of factor versus market prices in this sub-section follows the measurements used by UNITE (2001). It must be noted that before aggregating the values from time, accidents and emissions, the unit of measurement must be the same. This is also true for other cost components such as investments. Details on conversion from market prices to factor prices are found in UNITE (2001) Annex 3, p. 18.

Units of measurements
The units of measurements for the values are made coherent with units of measurements for impacts of the different sub-sections (see Table 3.2).

Table 3.2 *Monetary units of measurements applied in TEN-STAC*

Project impact area	Operationalisation	Monetary units of measurements
Accidents	• Number of fatalities per year • Number of injuries per year	• Costs per fatality • Costs per injury
Travel time	• Number of vehicle hours for light and heavy goods vehicles per year • Number of ton hour or other modes of transport (freight) per year	• Costs per vehicle hour • Costs per ton hour
Air pollution	• Amount of missions measured in ton per year	• Costs per ton of emission

The values for a statistical life are used in the estimations of air pollution and accidents. With respect to the value for a statistical life, UNITE recommends that the official national value for a statistical life is used if it is available. If not, country specific values can be derived from the European value adjusting for the country's relative GDP (PPP) per capita. Official values for a statistical life do not exist for all countries.

In the case where it exists, however, the methodology used is not comparable across countries. Therefore, differences between values for the different countries are more reflecting differences in the methodological approach than differences in the WTP for a statistical life per se as the WTP estimate is very sensitive to the used approach.

On this basis, it is decided to base the values for accidents on the UNITE value for EU15 and derive country specific values based on the country's relative GDP (PPP) per capita. By using this approach, it is ensured that the differences between the countries measure income reflected differences in the WTP value and not methodological differences. This is very important as the ranking of sub-sections is partly based on the values for a statistical life.

In relation to this, it should be stressed that country specific monetary values reflect the relative GDP (PPP) per capita. The implication of this is that sub-sections in countries with relative high GPD (PPP) per capita are given more weight than sub-sections in countries with relative low GDP (PPP) per capita.

3.2.2 Monetary value of time

The units of measurements for the monetary value of time are

- value per person hour for passenger transport
- freight
  - values per vehicle hour for road transport
  - values per ton hour for other modes of transport

In Table 3.3 and Table 3.4 e 3.4, the country specific values for time are listed. All the values are based on UNITE (2001)[1] and updated to 2003 values.

[1] *ITS et al. (2001). Valuation conventions for UNITE*. Version 1.0. 11 April 2001. http://www.its.leeds.ac.uk/projects/unite/

Table 3.3 *Country specific values of time for passenger transport applied in the sub-section (€, 2003)*

EUR15+ ACC	Road transport. Car, motor cycle, and coach (value per person hour)			Inter-urban rail (value per person hour)			Air traffic (value per person hour)		
	Business	Commuting /private	Leisure/holiday	Business	Commuting /private	Leisure/holiday	Business	Commuting /private	Leisure/holiday
Austria	36,96	8,61	5,74	36,96	9,18	6,74	50,16	14,35	14,35
Belgium	36,52	8,51	5,67	36,52	9,07	6,66	49,57	14,18	14,18
Germany	34,37	8,00	5,34	34,37	8,54	6,27	46,64	13,34	13,34
Denmark	38,65	9,00	6,00	38,65	9,60	7,05	52,45	15,00	15,00
Spain	28,54	6,65	4,43	28,54	7,09	5,21	38,73	11,08	11,08
Greece	22,84	5,32	3,55	22,84	5,68	4,17	31,00	8,87	8,87
France	34,50	8,04	5,36	34,50	8,57	6,29	46,82	13,39	13,39
Finland	34,91	8,13	5,42	34,91	8,67	6,37	47,37	13,55	13,55
Italy	34,43	8,02	5,35	34,43	8,56	6,28	46,73	13,37	13,37
Ireland	42,32	9,86	6,57	42,32	10,51	7,72	57,43	16,43	16,43
Luxembourg	63,51	14,79	9,86	63,51	15,78	11,59	86,20	24,65	24,65
The Netherlands	37,60	8,76	5,84	37,60	9,34	6,86	51,03	14,60	14,60
Portugal	23,01	5,36	3,57	23,01	5,72	4,20	31,23	8,93	8,93
Sweden	34,33	8,00	5,33	34,33	8,53	6,26	46,60	13,33	13,33
United Kingdom	35,04	8,16	5,44	35,04	8,71	6,39	47,56	13,60	13,60
Bulgaria	8,73	2,03	1,36	8,73	2,17	1,59	11,84	3,39	3,39
Czech Republic	20,65	4,81	3,21	20,65	5,13	3,77	28,03	8,02	8,02
Hungary	19,78	4,61	3,07	19,78	4,91	3,61	26,84	7,68	7,68
Poland	13,51	3,15	2,10	13,51	3,36	2,47	18,34	5,24	5,24
Romania	8,63	2,01	1,34	8,63	2,14	1,57	11,71	3,35	3,35
Slovak Republic	16,38	3,81	2,54	16,38	4,07	2,99	22,22	6,36	6,36
Slovenia	25,47	5,93	3,96	25,47	6,33	4,65	34,57	9,89	9,89
Estonia	14,72	3,43	2,29	14,72	3,66	2,69	19,98	5,72	5,72
Latvia	12,75	2,97	1,98	12,75	3,17	2,33	17,30	4,95	4,95
Lithuania	13,68	3,19	2,12	13,68	3,40	2,50	18,57	5,31	5,31
Norway	48,11	11,21	7,47	48,11	11,95	8,78	65,30	18,68	18,68
Switzerland	39,32	9,16	6,11	39,32	9,77	7,17	53,36	15,26	15,26

Source for the time values is UNITE (2001)

Values are measured in market prices

Table 3.4 *Country specific values of time for freight applied in the sub-section (€, 2003)*

EUR15+ ACC	Road transport (values per vehicle hour)		Rail transport (values per ton hour)			Water transport. Inland navigation or maritime shipping (values per ton hour)		Air transport (values per ton hour)
	LGV (< 12 ton)	HGV (< 12 ton)	Full trainload	Wagon load	Average per tonne	Full ship load	Average per tonne	Average per tonne
Austria	70,40	75,68	1.276,07	52,80	1,34	352,02	0,32	7,04
Belgium	69,57	74,79	1.260,95	52,18	1,32	347,85	0,31	6,96
Germany	65,46	70,37	1.186,50	49,10	1,24	327,31	0,29	6,55
Denmark	73,61	79,13	1.334,23	55,21	1,40	368,06	0,33	7,36
Spain	54,36	58,44	985,26	40,77	1,03	271,80	0,24	5,44
Greece	43,51	46,78	788,67	32,63	0,83	217,57	0,20	4,35
France	65,72	70,65	1.191,15	49,29	1,25	328,59	0,30	6,57
Finland	66,49	71,48	1.205,11	49,87	1,26	332,44	0,30	6,65
Italy	65,59	70,51	1.188,83	49,19	1,25	327,95	0,30	6,56
Ireland	80,61	86,65	1.461,02	60,46	1,53	403,04	0,36	8,06
Luxembourg	120,98	130,05	2.192,70	90,73	2,30	604,88	0,54	12,10
The Netherlands	71,62	76,99	1.298,17	53,72	1,36	358,12	0,32	7,16
Portugal	43,83	47,12	794,49	32,88	0,83	219,17	0,20	4,38
Sweden	65,40	70,30	1.185,34	49,05	1,24	326,99	0,29	6,54
United Kingdom	66,75	71,75	1.209,76	50,06	1,27	333,73	0,30	6,67
Bulgaria	16,62	17,87	301,28	12,47	0,32	83,11	0,07	1,66
Czech Republic	39,34	42,29	713,06	29,51	0,75	196,71	0,18	3,93
Hungary	37,67	40,50	682,82	28,25	0,72	188,36	0,17	3,77
Poland	25,74	27,67	466,46	19,30	0,49	128,68	0,12	2,57
Romania	16,43	17,66	297,79	12,32	0,31	82,15	0,07	1,64
Slovak Republic	31,19	33,53	565,33	23,39	0,59	155,95	0,14	3,12
Slovenia	48,52	52,16	879,41	36,39	0,92	242,59	0,22	4,85
Estonia	28,05	30,15	508,33	21,03	0,53	140,23	0,13	2,80
Latvia	24,28	26,10	440,05	18,21	0,46	121,39	0,11	2,43
Lithuania	26,06	28,01	472,27	19,54	0,50	130,28	0,12	2,61
Norway	91,65	98,52	1.661,10	68,74	1,74	458,23	0,41	9,16
Switzerland	74,90	80,51	1.357,50	56,17	1,42	374,48	0,34	7,49

Source for the time values is UNITE (2001)

Values are measured in market prices

3.2.3 Monetary value of accidents

The units of measurements for the monetary value of accidents are:

- Costs per fatality
- Costs per injury

Based on state-of-the-art studies in Europe, UNITE proposed a value of € 1.5 million (1998 market prices), which corresponds to € 1.962 M in 2003 values (see Table 3.5).

Table 3.5 *Value per fatality in market prices*

	Value 1998 M€	Value 2003 M€
Statistical life	1.500	1.962
Health care costs	0.150	0.196
Value per fatality	1.650	2.158

Source: UNITE (2001)
Value of a statistical life measured in market prices

In order to include health care costs and net production loss, UNITE recommends that 10% is to be added to the value of a statistical life (UNITE 2001). Following the methodology recommended by UNITE (2001) the value per fatality is € 2.158 M in 2003 values.

The values for casualties can be derived from the value per fatality by assigning a severe injury 13% and a minor injury 1% of the value per fatality (UNITE 2001). The values per fatality, severe injury and minor injury are listed below (Table 3.6).

Table 3.6 *Country specific values per fatality, severe injury and minor injury applied in the sub-section (€, 2003 values)*

Country	Value per fatality	Value per severe injury	Value per minor injury
Austria	2,367	0,308	0,024
Belgium	2,339	0,304	0,023
Germany	2,201	0,286	0,022
Denmark	2,475	0,322	0,025
Spain	1,828	0,238	0,018
Greece	1,463	0,190	0,015
France	2,210	0,287	0,022
Finland	2,236	0,291	0,022
Italy	2,206	0,287	0,022
Ireland	2,711	0,352	0,027
Luxembourg	4,068	0,529	0,041
The Netherlands	2,408	0,313	0,024
Portugal	1,474	0,192	0,015
Sweden	2,199	0,286	0,022
United Kingdom	2,244	0,292	0,022
Bulgaria	0,559	0,073	0,006
Czech Republic	1,323	0,172	0,013
Hungary	1,267	0,165	0,013
Poland	0,865	0,113	0,009
Romania	0,552	0,072	0,006
Slovak Republic	1,049	0,136	0,010
Slovenia	1,632	0,212	0,016
Estonia	0,943	0,123	0,009
Latvia	0,816	0,106	0,008
Lithuania	0,876	0,114	0,009
Norway	3,082	0,401	0,031
Switzerland	2,519	0,327	0,025

Source: UNITE (2001)
Value of statistical life is measured in market prices

Potential monetary value of costs of material damage

The values per fatality used in the analysis do include costs of material damage, which is an important part of the total costs to the society. As accurate data on costs of material damage are lacking for most countries in Europe, the impact of including costs of material damage are not included the main analyses.

Valid and reliable data for costs of material damage are available for Denmark (COWI 2002). Therefore, these data can be used to illustrate the potential impact of including costs of material damage in future analyses. Based on these data, costs of material damage could potentially be derived for other countries. Preliminary results for illustration purposes are shown below (Table 3.7).

Table 3.7 *Total material cost per injury (M€ 2003 prices)*

EUR15+ ACC	Total material costs per injury (Mill € 2003 values)
Austria	0,146
Belgium	0,144
Germany	0,136
Denmark	0,152
Spain	0,113
Greece	0,090
France	0,136
Finland	0,138
Italy	0,136
Ireland	0,167
Luxembourg	0,251
The Netherlands	0,148
Portugal	0,091
Sweden	0,135
United Kingdom	0,138
Bulgaria	0,034
Czech Republic	0,081
Hungary	0,078
Poland	0,053
Romania	0,034
Slovak Republic	0,065
Slovenia	0,101
Estonia	0,058
Latvia	0,050
Lithuania	0,054
Norway	0,190
Switzerland	0,155

Source: COWI (2002)[2]
Costs of material damage are measured in factor prices

Monetary value of air pollution

The unit of measurement for the monetary value of air pollution is € per ton. For CO_2 an average value for Europe is applied. For NO_x and particulates, country specific values are used.

Air pollution relates both to emissions at the ground level from ground transport and in the air from air transport. For both types of emissions, the monetary values for emissions at ground level are used. This is an uncertain assumption, as emissions in the air, e.g. NO_x, can have a stronger negative impact than emissions at the ground level. However, due to lack of detailed data on this issue, we have used monetary values for ground emissions for both types of emissions.

[2] *COWI (2002). Traffic unit prices Denmark - 2001 values*. Report prepared for the Danish Ministry of Transportation

Costs ton of CO_2

The costs per ton of CO_2 emission used in the analyses are € 23.50. This value is recommended by UNITE and based on Capros and Mantzos (2000)[3]. Furthermore, this value is in line with the value used in the extended phase I of the TEN-STAC project. In the sensitivity analyses, different values for CO_2 are applied.

Costs per ton of NO_x and Particulates

Country specific values for NO_x and Particulates are based on the BeTa study (2002). These values are also in line with the values used in the extended TEN STAC phase I.

Country specific values are available for EU15 countries in the Beta study (2002). These values are based on country specific incidence rates, whereas the monetary value per incidence is the same for all countries, meaning that there is no country specific difference in willingness to pay for reduced emission levels. However, for acceding countries with considerably lower income levels than in EU-15, country specific values are derived from the average EU15 value using a correction PPP factor based on differences in GDP/capita. The following values are used in the analyses:

[3] *Capros, P. and Mantzos, L. (2000). Kyoto and technology at the European Union:* costs of emission reduction under flexibility mechanisms and technology progress.

Table 3.8 *Country specific values for NO_x and Particulates (€, 2003 values)*

Country	NOx [€ per ton in 2003]	Particulates [€ per ton in 2003]
EU15	5.493	18.311
Austria	8.894	18.311
Belgium	6.147	28.775
Germany	5.363	20.927
Denmark	4.316	7.063
Spain	6.147	10.333
Greece	7.848	10.202
France	10.725	19.619
Finland	1.962	1.831
Italy	9.286	15.695
Ireland	3.662	5.363
Luxembourg	5.493	18.311
The Netherlands	5.232	23.543
Portugal	5.363	7.586
Sweden	3.401	2.224
United Kingdom	3.401	12.687
Bulgaria	1.423	4.743
Czech Republic	3.367	11.225
Hungary	3.225	10.749
Poland	2.203	7.343
Romania	1.406	4.688
Slovak Republic	2.670	8.899
Slovenia	4.153	13.843
Estonia	2.401	8.002
Latvia	2.078	6.927
Lithuania	2.230	7.434
Norway	3.401	2.224
Switzerland	8.894	18.311

Source: BeTa (2002)[4]; Norway = Sweden, Switzerland = Austria
Values measured in market prices

Importance of other emissions

Other emissions are CO, SO_2 and HC. These emissions constitute a non-negligible part of the social costs.

Accurate European data on other emissions are lacking. However, valid and reliable data on these emissions are available for Denmark (COWI 2002). The results show that if CO, HC and SO_2 are not considered, in Denmark 19% of the social costs are missing for cars with catalyst and 2% to 6 % for diesel cars. Hence, on average approximately 10% of the total costs of emissions are not considered.

[4] *Holland, M. and Watkis, P. (2002). BeTa. Benefits Table databases*: Estimates of the marginal external costs of air pollution in Europe. Version E1.02a
http://europa.eu.int/comm/environment/enveco/air/betaec02aforprinting.pdf

Table 3.9 *Percentage value of NO_x and Particulates out of total costs per km in Denmark*

Vehicle	Percentage value
Car with catalyst	81%
Diesel	94-98%

Total costs are costs of NO_x, SO_2, CO, HC and CO_2
Source: COWI (2002)

3.3 Specific transport modelling issues

3.3.1 Detailed approach sea-related flows UK and Northern Ireland

Context
As UK and Northern Ireland have a very special position in Europe, being linked to the continent by the Channel Tunnel and sea ports, a special procedure has been developed to get a better representation of the traffic flows on the country road and rail infrastructure.

Current situation
UK and Northern Ireland are represented at NUTS2 level in the zoning system considered in the TEN-STAC project, similar with the other European countries. Thus, the following regions are considered as territorial units for UK and Northern Ireland:

Country / region code	Country / region
600	**United Kingdom & Northern Ireland**
601	North
602	Yorkshire-Humbershire
603	East Midlands
604	East Anglia
605	South East incl Greater London
606	South-West
607	West Midlands
608	North-West
609	Wales
610	Scotland
611	Northern Ireland

As 10 of the 11 territorial units considered are located at sea, having direct access to ports, a high share of the sea-land related flows becomes intra-regional flows that are not assigned to the network. Therefore, a specific procedure is considered to assess the UK and Northern Ireland corridors.

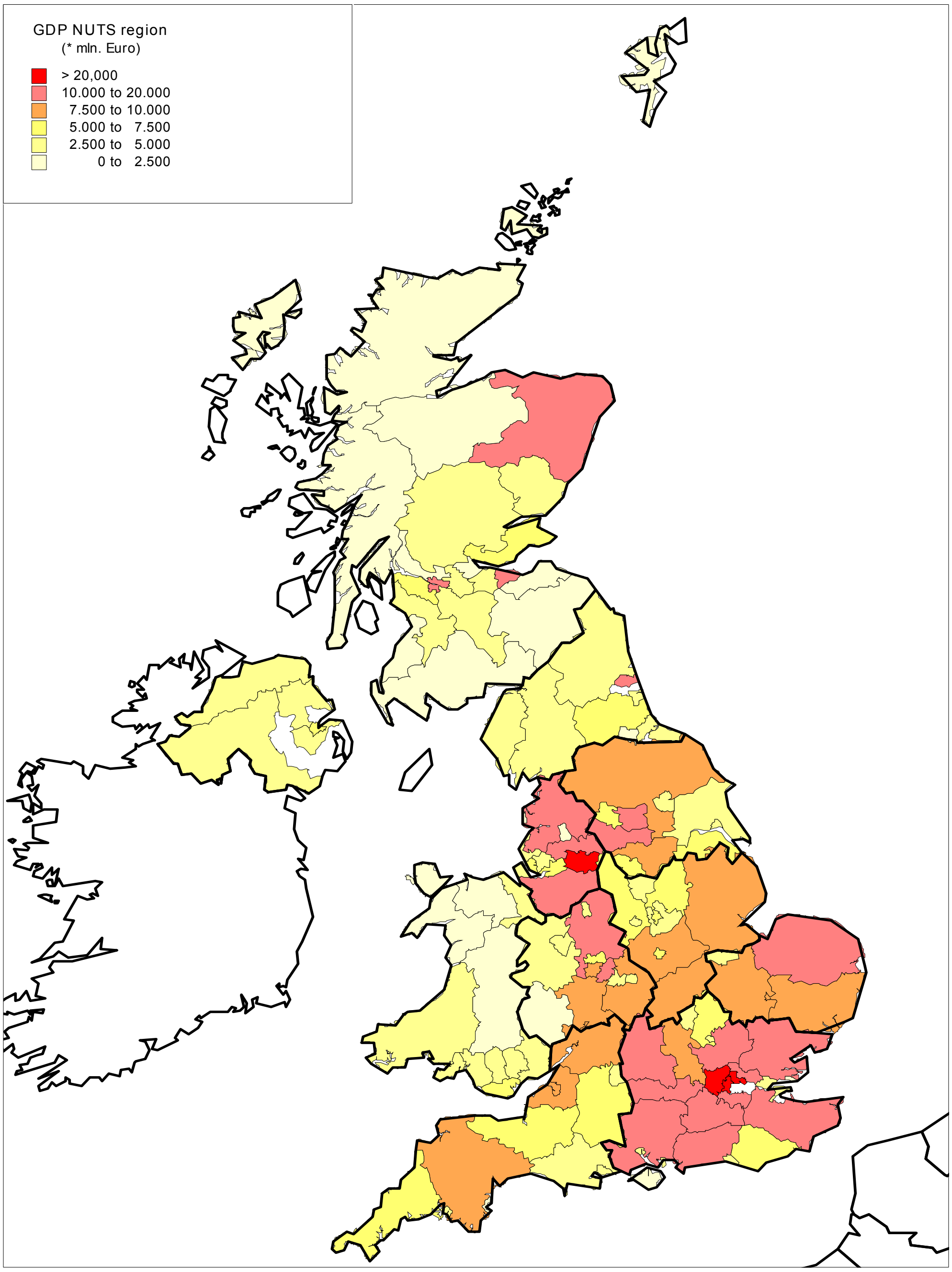
Procedure

A new data file has been made available a short time ago, containing information on sea-land related flows described as per origin partner; UK port, UK destination region, UK land mode for imports and per UK origin region, UK land mode, UK port, destination partner, considering 165 UK ports and 66 regions in the UK – NUTS3 level. Only European partners are considered. Flows from other continents are not included in the data file. Thus, the following approach is has been considered:

1) Consider NUTS3 zoning system for UK and Northern Ireland regions (66 zones) plus the most important port of the 165 listed in the data file.
2) Estimate the base year 2000 transport demand files at the level described before and include in a similar procedure the intercontinental flows in the total demand data.
3) Make separate freight transport demand model runs for UK and Northern Ireland for 2020 UK corridor scenarios.
4) Produce assignments for road and rail.

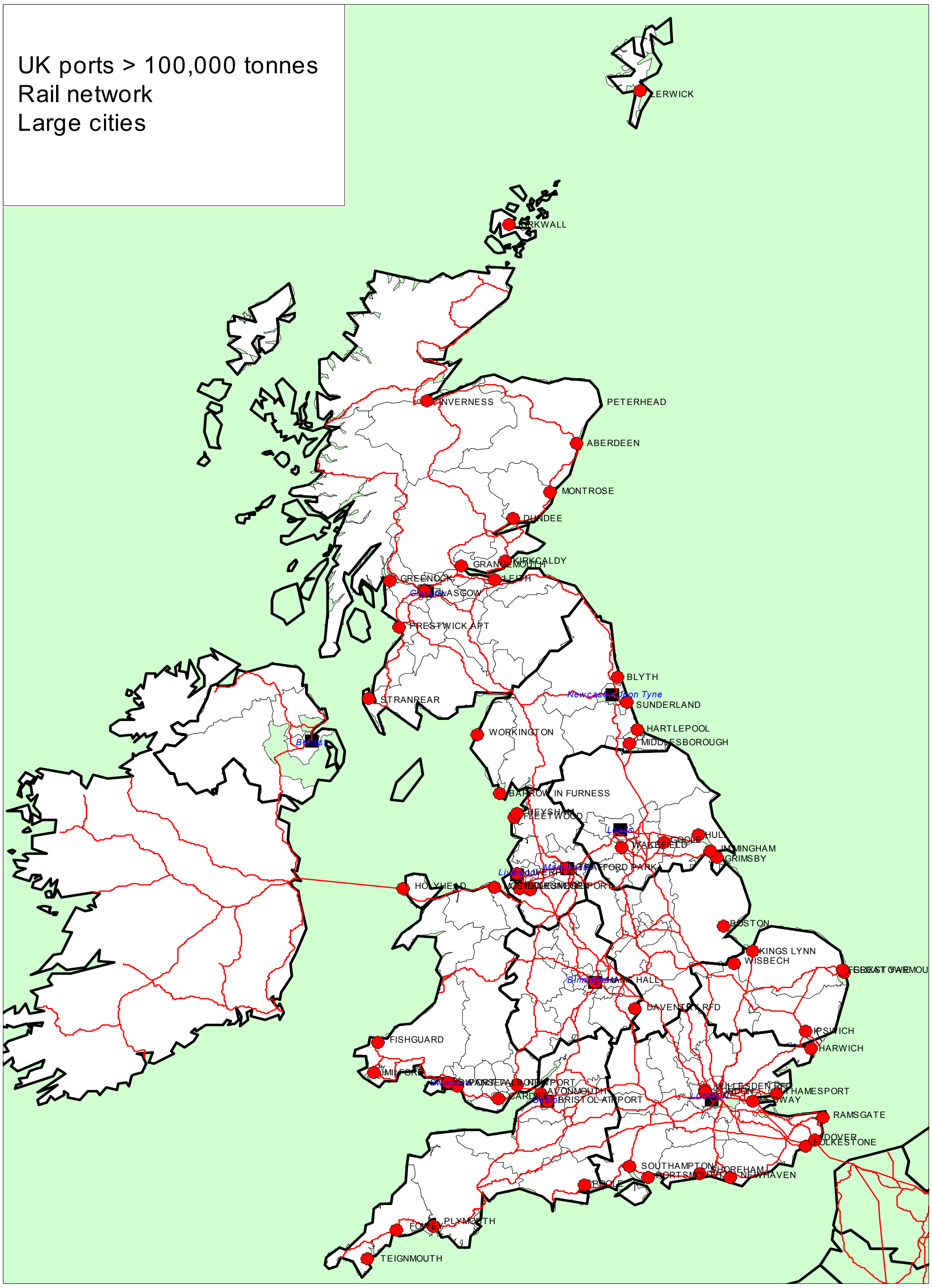
The domestic and international Channel Tunnel flows have been distributed to the NUTS 3 regions in UK based on the GDP distribution for year 1996, shown in Figure 3.5.

Figure 3.5 *Domestic and international Channel Tunnel flows in the UK, based on the GDP distribution for year 1996, NUTS 3*



Next, the UK ports have been connected to the rail and road network and considered as origin and destinations for the import and export flows of goods. In Figure 3.6 the connection between the ports with a total annual traffic above 100,000 tonnes and the connection with the rail network is shown.

Figure 3.6 *Connection Rail network with UK ports with annual traffic over 100,000 tonnes*



Finally, a total number of 478 zones are considered, divided as follows:

1) 276 zones representing the NUTS2 regions / countries in EU27, other countries in Europe and outside Europe,
2) 133 zones representing the NUTS3 regions of UK,
3) 169 ports of the UK.

Consequently, the corresponding freight OD matrix has been constructed for both reference 2 and priority project P26 "Railway line/road Ireland / United Kingdom / continental Europe".

3.3.2 Approach rail freight priority projects

Upgrading of the rail network as a stand-alone measure is not always efficient in producing a modal shift, because the rail transport performance for freight is often service quality / organisation dependent. Nevertheless, the quality of infrastructure is a basic necessary condition for the development of new services and increasing performance of the existing ones.

The assessment of impacts of freight rail priority projects is based on the following considerations:

- Network improvements – upgraded lines or new lines – will allow the circulation of the freight trains with a higher speed than on the old line or the old route. In order to avoid unreliable route changes on the rail network, the maximum speed of freight trains on all new / up-graded lines is considered 80 kph.
- Development of the new services already introduced in Phase 1 of the project, as follows:
    - continental shuttle: on the continental routes where the rail infrastructure has been improved and where there is enough potential/ massification on the market of unitised goods;
    - port shuttle: on the port hinterland routes where new / improved infrastructure is realised and there is enough potential/ massification on the market of unitised goods;
    - wagon load: on the port hinterland and continental relations where new / improved rail infrastructure is realised and there is enough potential/massification on the market of bulk goods.
- The measures consist of a reduction of the generalised cost of rail transport on the relations/ segments of the market that show a potential for the specific services enumerated above. It is assumed that the reduction of generalised costs of continental and port shuttle services is stronger on the international relations than on the domestic ones, because organisational/ interoperability barriers will be eliminated in the future.

The following segments of the markets, considered in the approach and the reduction of the generalised cost per type of service and segment of the market, are shown in Table 3.10. The segments of the market are described by the total volume and distance.

Table 3.10 *Overview accompanying measures in freight rail transport*

Type of service	Market typology	Volume (tonnes)	Distance (kms)	Reduction of the generalised cost rail
Continental shuttle	International	> 500,000	> 600	40%
	Domestic			20%
	International	> 500,000	300 – 600	30%
	Domestic			15%
	International	> 500,000	< 300	20%
	Domestic			10%
	International	200,000 - 500,000	< 600	30%
	Domestic			15%
	International	200,000 - 500,000	300 – 600	20%
	Domestic			10%
	International	200,000 - 500,000	< 300	10%
	Domestic			5%
	International	50,000 - 200,000	> 600	20%
	Domestic			10%
	International	50,000 - 200,000	150 – 600	15%
	Domestic			7.5%
Port shuttle	All	> 500,000	> 200	40%
		200,000 - 500,000	> 200	30%
		50,000 – 200,000	> 200	20%
Wagon load	All	> 500,000	> 300	20%
		200,000 - 500,000	> 300	10%

3.3.3 Approach sea motorways

NEA assessed the competitive position of short sea shipping compared to road transport on the 4 Motorways of the Sea sub-sections described by priority project P21. For this assessment the Macroscan, developed in the 5FP project SPIN (Scanning the Potential of INtermodal transport), was used.

The approach was as follows:

- definition of sub-sections
- definition of transport supply on the corridors
- assessment of door-to-door costs and door-to-door travel times of all relevant transport alternatives on region-to-region relations within these corridors
- evaluating the competitive position of short sea alternatives

We have made the following assumptions on for the sub-sections:

1. Baltic Area:
   Short sea services between Rostock and Tallinn and between Rostock and Klaipeda, serving the Hinterland of Benelux, German areas and Latvia, Lithuania and Estonia. A (virtual) rail service is assumed between Hamburg and Klaipeda, serving the same hinterlands.

2. Atlantic Area:
   Short sea services between Antwerp and Bilbao, serving the hinterland of Benelux, German areas and Spain and Portugal. Rail services between Cologne and Irun and between Antwerp and Irun, serving the same hinterlands.

3. Mediterranean Area 1:
   Short sea services between Valencia and Genua, serving the hinterland of Spain/Portugal and of Central Europe. No rail services taken into account.

4. Mediterranean Area 2:
   Short sea services between Patras and Trieste, serving the hinterland of Greece and Central Europe. No rail services taken into account.

The competitiveness has been assessed for rolling road (ro-ro) transport (using tariffs of the existing ferry by unaccompanied trucks) and for containerised transport (continental pallet wide containers on conventional container vessel).

The potential for modal shift from road to short sea is identified as being the road transport volume of the manufactured products (NSTR 9) on the relations where the generalised cost of short sea transport is under the generalised cost of direct road.

3.3.4 Improvement of modelling transport at regional/ local level

The estimation of local passenger car traffic volumes within selected regions is divided into several steps:

- Determination of regions for which local car traffic volume is to be estimated.
- Estimation of base year car traffic volume for each spatial unit.
- Estimation of forecast year (2020) car volume for each spatial unit.
- Estimation of car traffic flows between the defined areas (current and 2020).

Selection of Regions

The analysis of short distance transport in the priority projects bases on twenty selected regions in which we determine transport flows between NUTS 5 regions, in a distance less than 50 km. These transport flows will be input for the general transport analysis done by IWW. Finally, it will be possible to investigate the effects on local traffic in the framework of the scenarios applied.

Database

(1) Administrative boundaries

The bases to implement socio-economic data into geographical units are administrative boundaries in small scales. We are using the "Seamless Administrative Boundaries of Europe (SABE)"-database, published by EuroGeographics[5]. This database mostly gives us the opportunity to extract the necessary small-scale administrative units. The NUTS–levels we need for data implementation are NUTS 2, NUTS 3 and NUTS 5. If the country is small, we use NUTS 1 instead of NUTS 2. SABE normally uses the national classification of administrative boundaries. In most cases these classifications are in accordance with the NUTS-levels, but sometimes it is necessary to reclassify NUTS-levels on the basis of smaller national classifications of SABE. The following table (Table 3.11) gives an overview on the NUTS-Levels we directly use from SABE or which of them must be reclassified on the basis of SABE. These reclassified NUTS-levels are signed with ">" and the name of the national level of administration they are based on.

Table 3.11 *Necessary administrative levels based on SABE*

Country	NUTS - 5	#	NUTS - 3	#	NUTS – 2 NUTS – 1	#
Austria	Gemeinde	2358	> Gemeinde	34	Bundesland	9
Belgium	Commune	590	Arrondissement	43	Province	11
Czech Republic	Obec	6258	Okres	77	Kraj	14
Germany	Gemeinde	14102	Land-Stadtkreis	442	Regierungs-bezirk	40
Denmark	Kommune	277	Amt		> Amt	1
Spain	Termino municipal	8190	Provincia		Comunidad autónoms	17
Finland	Kunta	448	Maakunta	20	> Lääni, Suuralue	8
France	Commune	36587	Départment	96	Région	22
Great Britain/ Northern Ireland	Ward	10513 582	> District	118 5	> District	36 1
Greece	Municipality/ Commune	1034	Nomos	52	> Nomos	13
Ireland	Ward	3440	> Ward	8	> County	2

[5] http://www.eurogeographics.org/eng/04_sabe.asp

Country	NUTS - 5	#	NUTS - 3	#	NUTS – 2 NUTS – 1	#
Italy	Comune	8108	Provincia	97	Regione	22
Luxembourg	Commune	118	> Canton		> Canton	1
Netherlands	Gemeente	504	> Gemeente		Provincie	12
Poland	Gmina	2489	Poviat		Województwo	16
Portugal	Freguesia	4253	> Conselho	28	> Conselho	5
Sweden	Kommun	289	Län	21	> Län	8
Slovakia	ÚTJ	3543	Okres		Kraj	8

The analysis of short distance transport is carried out on NUTS-5 level. In most cases, this is a reasonable spatial partition for this kind of investigation. In case of Great Britain and Ireland, the NUTS-5 level (wards) seems to be rather small, but the national levels of administration in both countries have no feasible levels that comply with our purpose between NUTS 0 and NUTS 5.

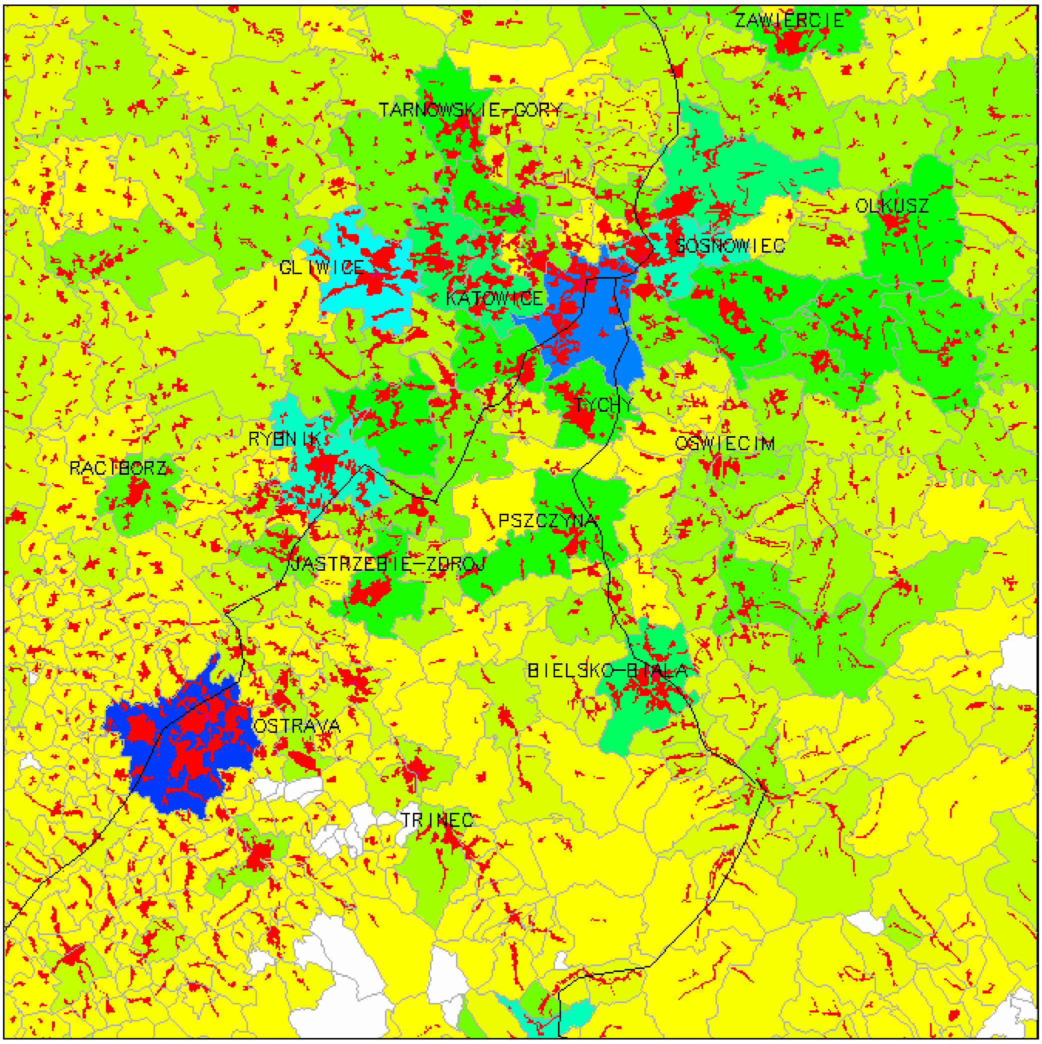
(2) Land-use data

The availability of data in European countries is quite inhomogeneous, especially for small regions. For most countries EUROSTAT has socio-economic data on NUTS 3 level. Only national statistical offices of some countries have population data on NUTS 5 level that can be easily implemented in our GIS in a fast and adequate way. In the other cases we have to reclassify the population on the basis of land-use data. The CORINE[6] land-cover database gives us the opportunity to assign population to settlement areas by using two categories that geographically identify continuous or discontinuous urban fabric. Thus we can approximately assign population to small geographic units in all cases where we do not have population data on NUTS 5 level.

The following picture (Figure 3.7) shows one example in the region of Katowice.

[6] published by the European Environment Agency: http://www.eea.eu.int

Figure 3.7 *Application of land-use data for generation of population in small regions*



The grey boundaries are the NUTS 5 regions of the Poland, Czech Republic and Slovakia. The red pixels are settlement areas given by CORINE. The colour of the regions itself corresponds with the amount of population calculated out of larger regional units. Population we have on NUTS 3 level is assigned to NUTS 5 by the share of settlement areas of the smaller NUTS 5 to the larger NUTS 3 region. Thus, the larger the settlement area in the NUTS 5 region, the larger the share of population of the higher regional level will be. In this way, an estimated figure of the population in small regional units can be made for areas where exact figures are lacking.

(3) Transport Corridors

The regions we have chosen for short-distance analysis are based on the STAC-Corridors implemented by IWW, because the results of this analysis are direct inputs for the transport model of IWW.

For the analysis of short distance transport, it is important to know the exact geographical location of the transport sub-sections. Depending on changes in the geographical determination of access points, the analysis of short distance traffic alternates sensitively. In this stage we can only make some preliminary assumptions on the access points.

Criteria for the selection of regions

Following two main criteria for regions to be pre-selected for short distance transport analysis, the following criteria have been applied:

(1) The sub-sections should be relevant for short distance traffic

This will be the case, if the access points of the network (access roads or rail-stations respectively) are less than 50 km apart from each other and relatively high population density exist. The resulting areas chosen are typically agglomerations, or cities less apart than 50 km and located along the access points of the respective transport priority project or not far from it in case of road transport.

The requirement to be relevant for short distance traffic leads to a preference of road sub-sections in the selection. We assume that the effects of high-speed rail sub-sections on short distance road traffic will be rather small. The only conceivable effect might be a small alteration on route choices, if the new high-speed rail sub-sections lead to remarkable reduction of the road traffic in an agglomeration, because of changes in modal split. A direct replacement of short distance traffic by new rail projects is only possible if the train stops within a distance of 50 km.

(2) Availability of Data

Some regions that are affected by the defined priority projects must be excluded because the necessary data are not available. Some of them, especially CEE-Countries, cannot be selected because the administrative boundaries of small districts are still not sufficiently available. In other cases, we do not have demographic data for small regions and we are not able to derive approximate data by using land-use information from the CORINE dataset. These regions must be excluded from the set of eligible region for analysis of short-distance transport.

All regions that fit these criteria are in principle eligible for the analysis. The twenty regions that are actually selected are part of this set. The final decision if a region will be included in the analysis or not, depends on a clustering process. All regions are different but have a typical pattern concerning topographic, administrative or socio-economic structures. For instance, the regions are more or less peripheral or they include cross-border sections, some of them include bridges, some other priority projects include transport routes which run almost parallel, etc. In the selection process we have taken care of reaching some kind of variety in the final set of chosen regions. By following this selection process we ascertain that we do not only select the capital of each country, but also those regions in which only a few medium-sized cities are linked by the transport project. Thus, we have a diversity in the set of selected regions and we are able to investigate short distance road traffic in different clusters or types of transport below 50 km.

In some cases larger agglomerations are not chosen because this agglomeration is a NUTS5-Region itself, e.g. Vienna. Thus the region cannot be reasonably divided into smaller regions. Other larger cities, linked with a new transport project, are not chosen, because the distance between them is larger than 50 km, e.g. Vienna-Bratislava. In case of larger distances the transport flows between the cities are estimated by the model of IWW and should not be analysed additionally in a short-distance model.

Some cross-border regions, especially border regions to the former CEE-Countries are sparsely populated. Therefore these regions are not relevant for short distance traffic on a high-speed network, because the trains do not stop there and the motorway has no access points in distances clearly below 50 km. The same problem arises at bridges like the Fehmarn Belt Bridge. If the bridge do not directly link greater settlement areas, it is only relevant for long-distance traffic. In case of the Bridge over the Strait of Messina, we can estimate the influence of short distance traffic because Messina and Reggio di Calabria are partly less than 50 kilometres apart and both regions together have about 430,000 inhabitants. The same reasons can be applied analogously for the selection of the link between Copenhagen and Malmoe.

Some cities or agglomerations are also not selected because they are the only settlement area in a wide circumference, e.g. Thessaloniki. In these cases it might be not worthwhile to estimate transport to sparsely populated areas surrounds this kind of cities.

Selected Regions

The following pages (Figure 3.8 - Figure 3.27) show the selected regions for short distance transport analysis. The NUTS5-regions are shown in grey boundaries. The raster pixels which are underlying the administrative boundaries and networks, are the land-cover data given by CORINE. Here, only the red coloured settlement areas are important. The black line represents the part of the priority project that will be analysed.

Figure 3.8 *P01.1a rail - Nürnberg*

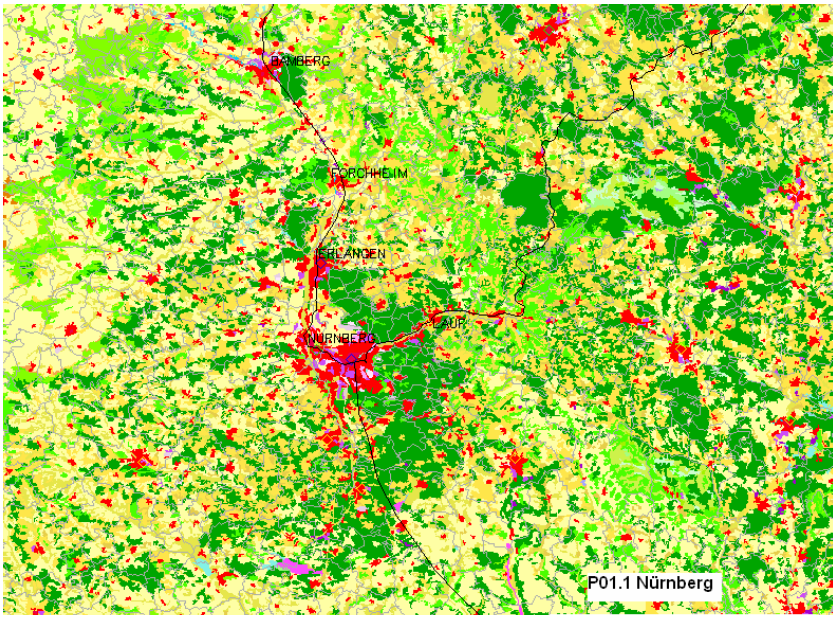


Figure 3.9 *P01.1b rail – Halle/Leipzig*

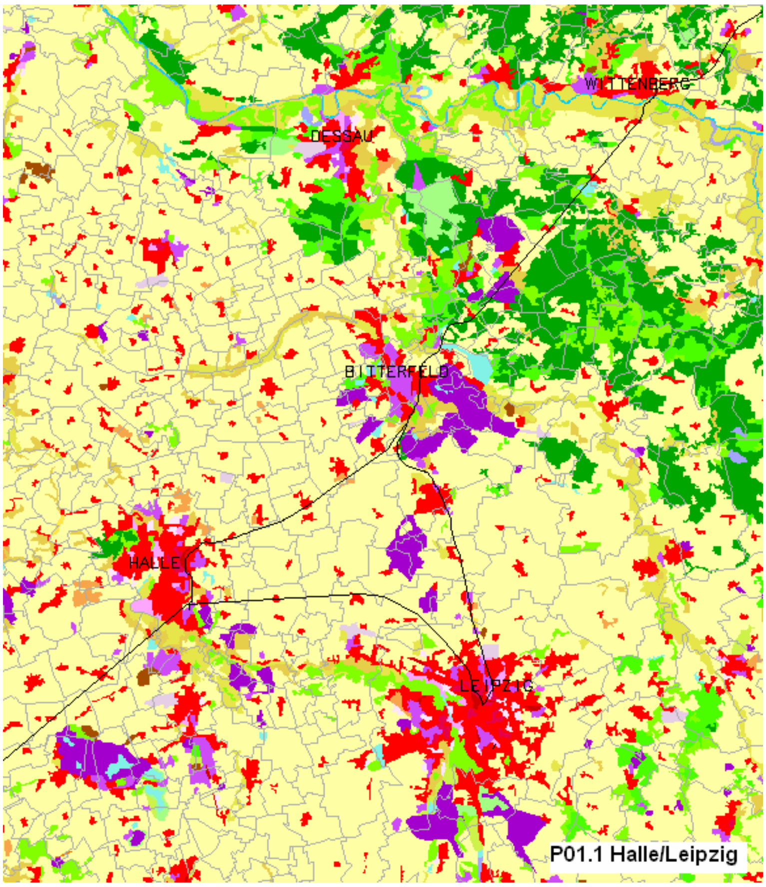


Figure 3.10 *P01.3 rail/road - . Bridge over the Strait of Messina*

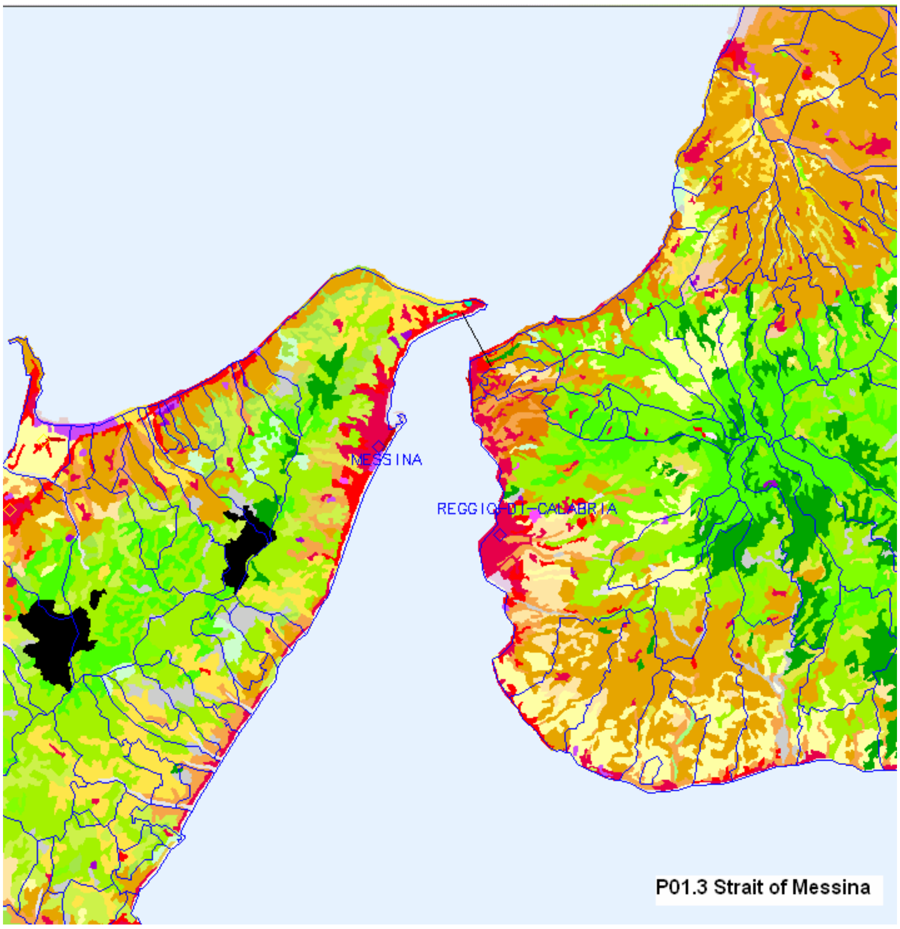


Figure 3.11 *P02.1 rail - Liège-Aachen-Cologne*

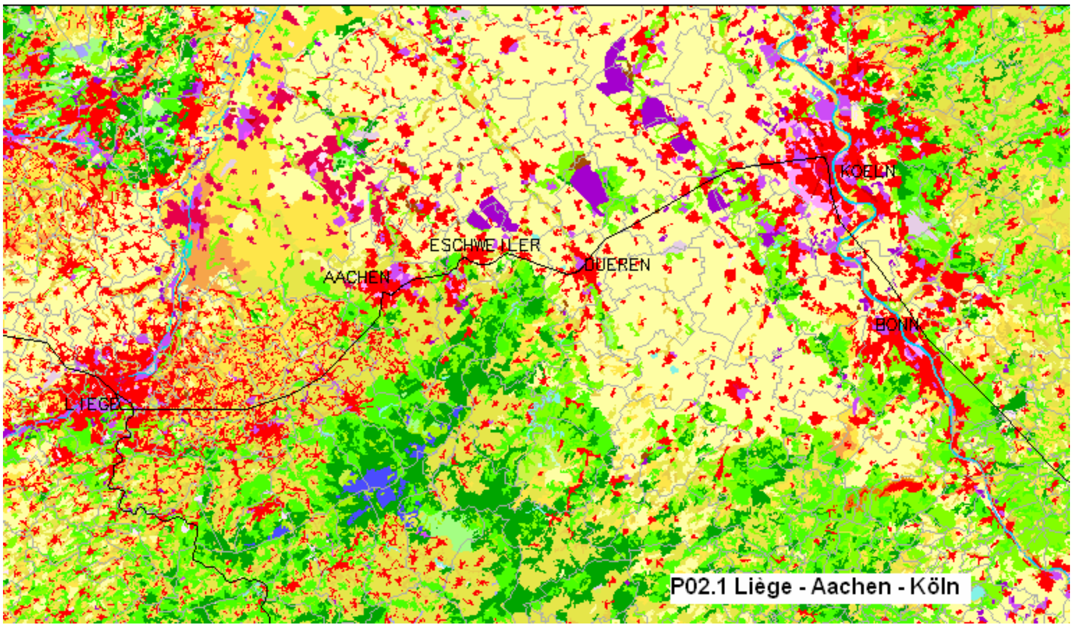


Figure 3.12 *P03.1 road - Lisboa*

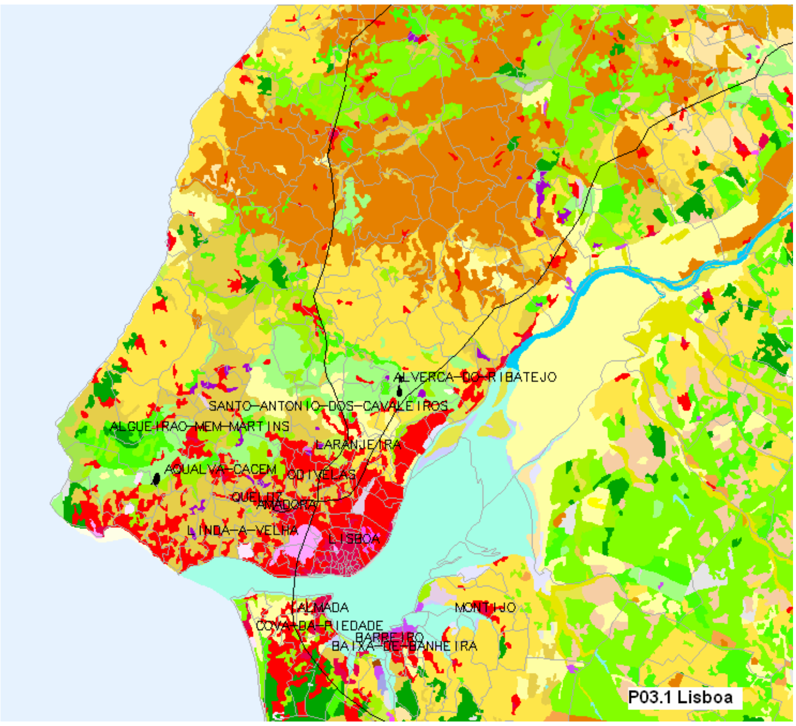


Figure 3.13 *P03.2 rail - Figueras – Perpignan - Montpellier*

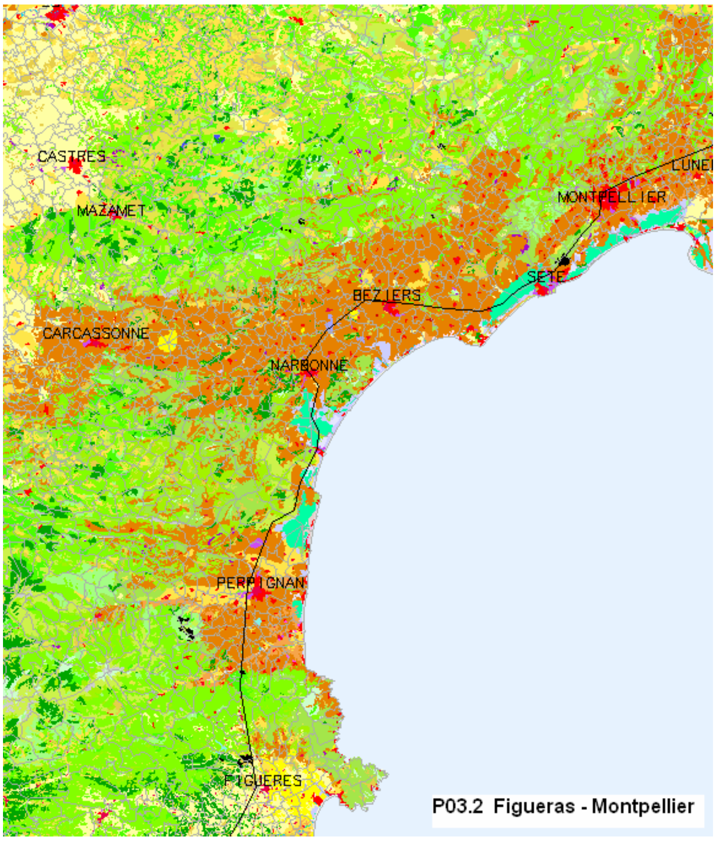


Figure 3.14 *P03.3 rail - San Sebastian – Bayonne*

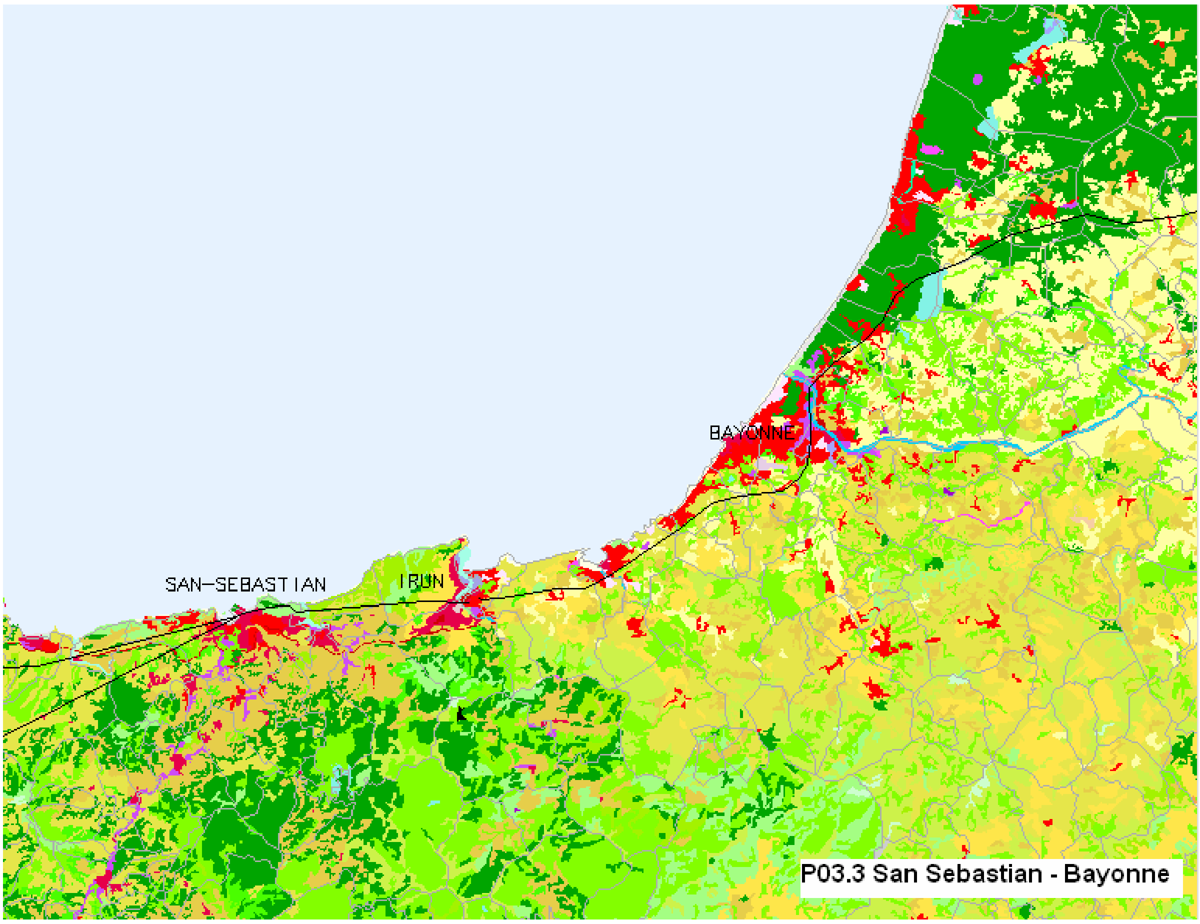


Figure 3.15 *P06.2 rail - Agglomeration: Milano*

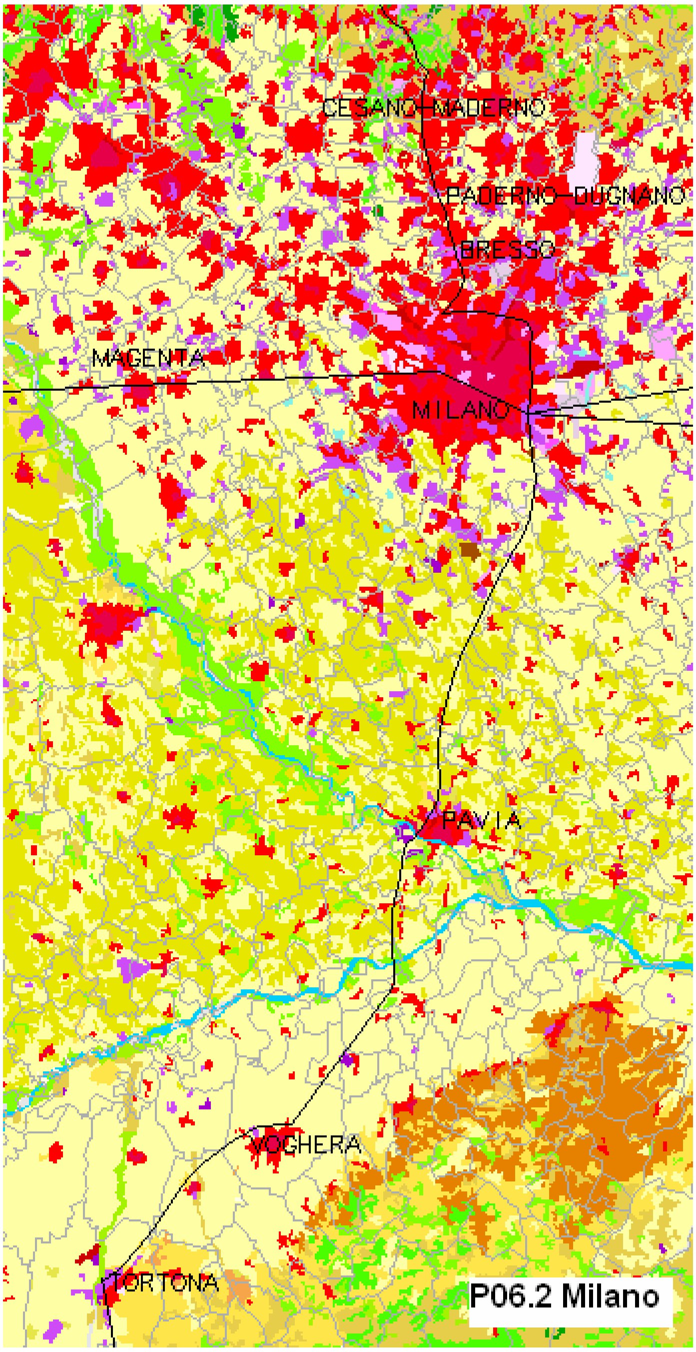


Figure 3.16 *P07.1 Road - Athens*

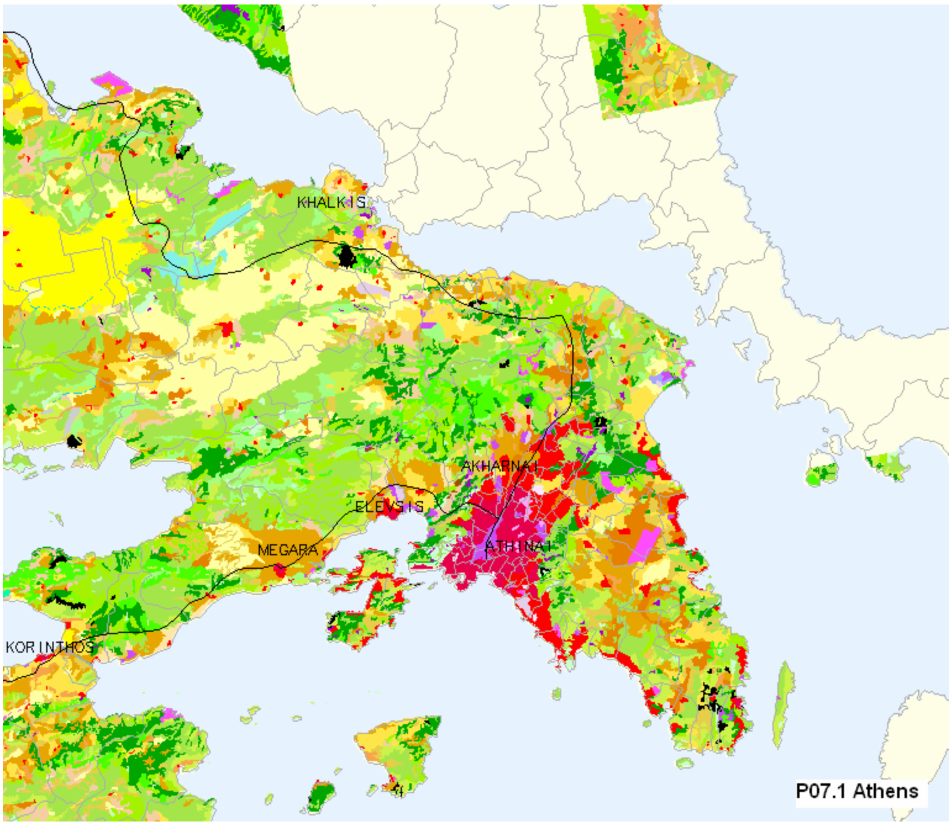


Figure 3.17 *P12.1 road - Copenhagen – Malmoe*

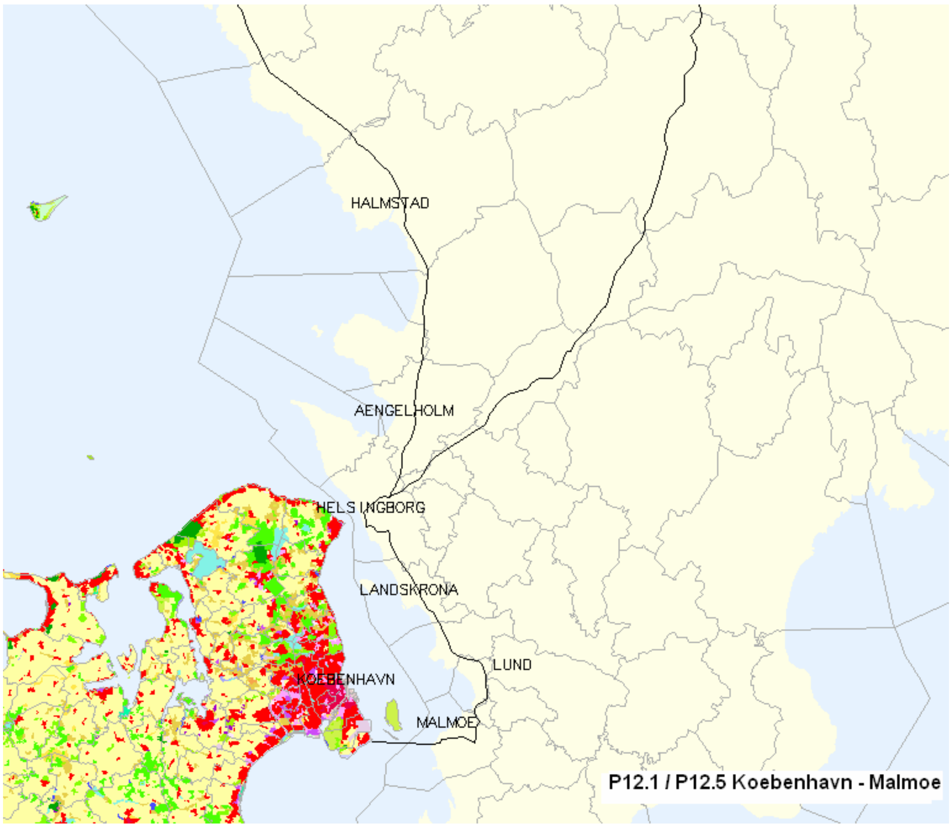


Figure 3.18 *P12.1/P12.5* *road - Stockholm*

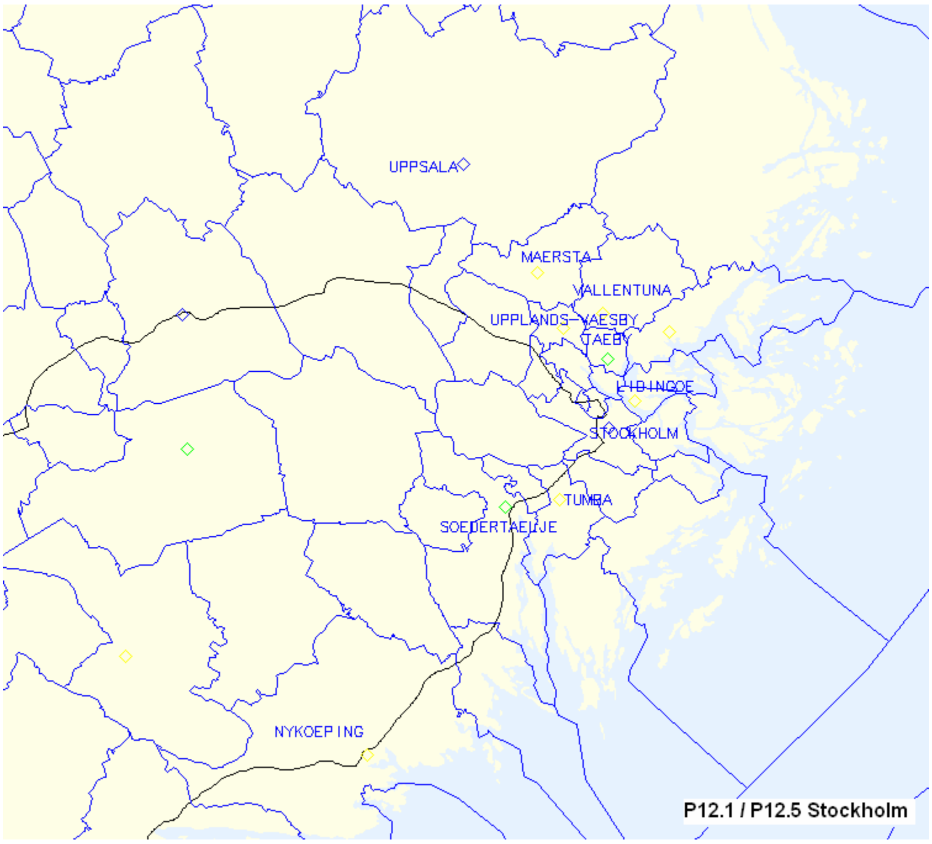


Figure 3.19 *P12.2 road - Helsinki*

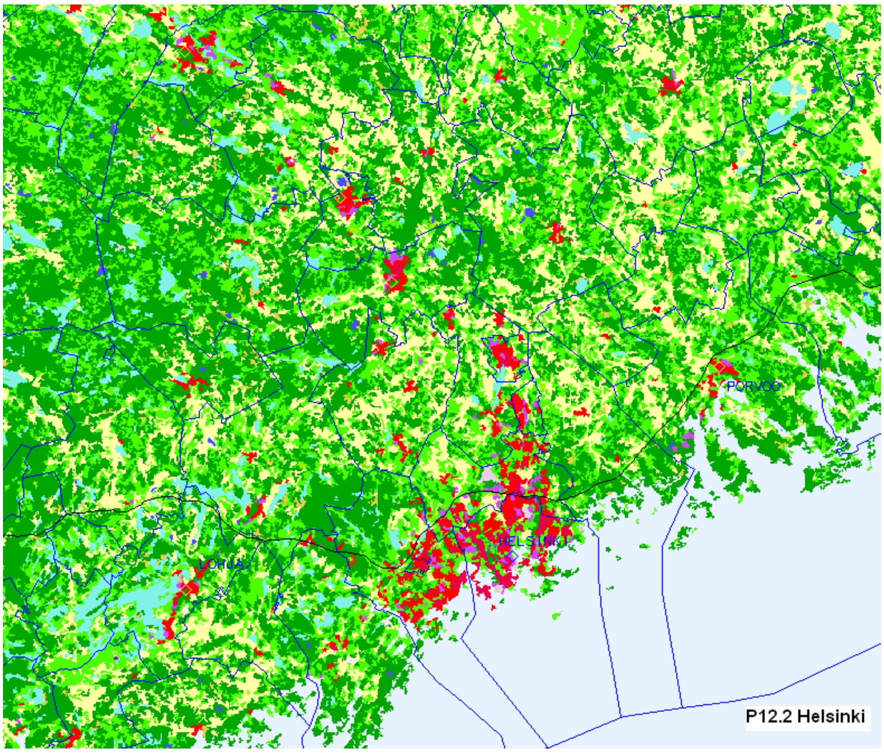


Figure 3.20 *P23.1/P27.1 rail - Warsaw*

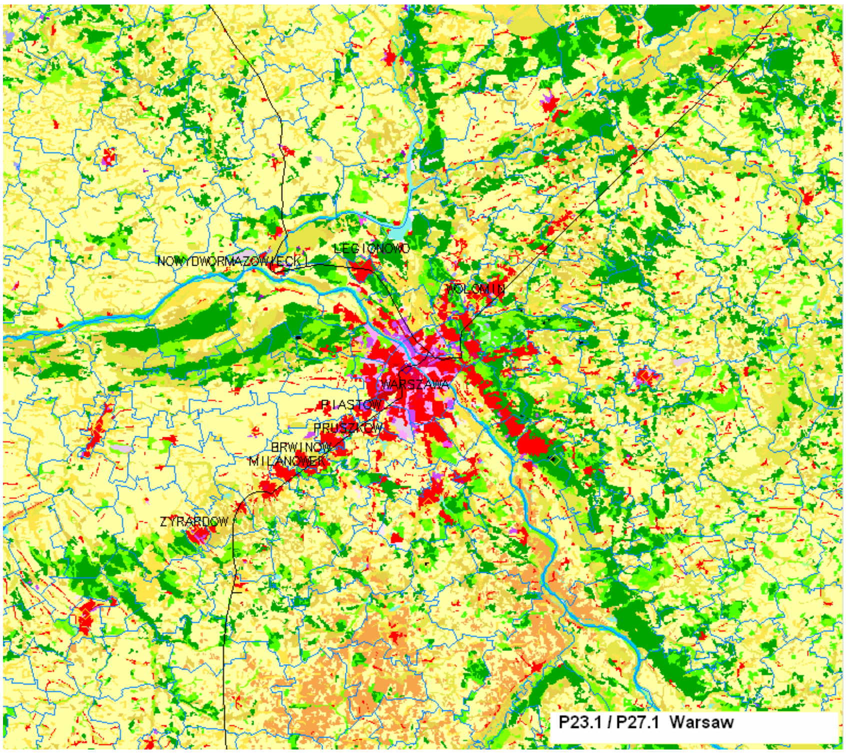


Figure 3.21 *P24.5 rail - Emmerich - Duisburg*

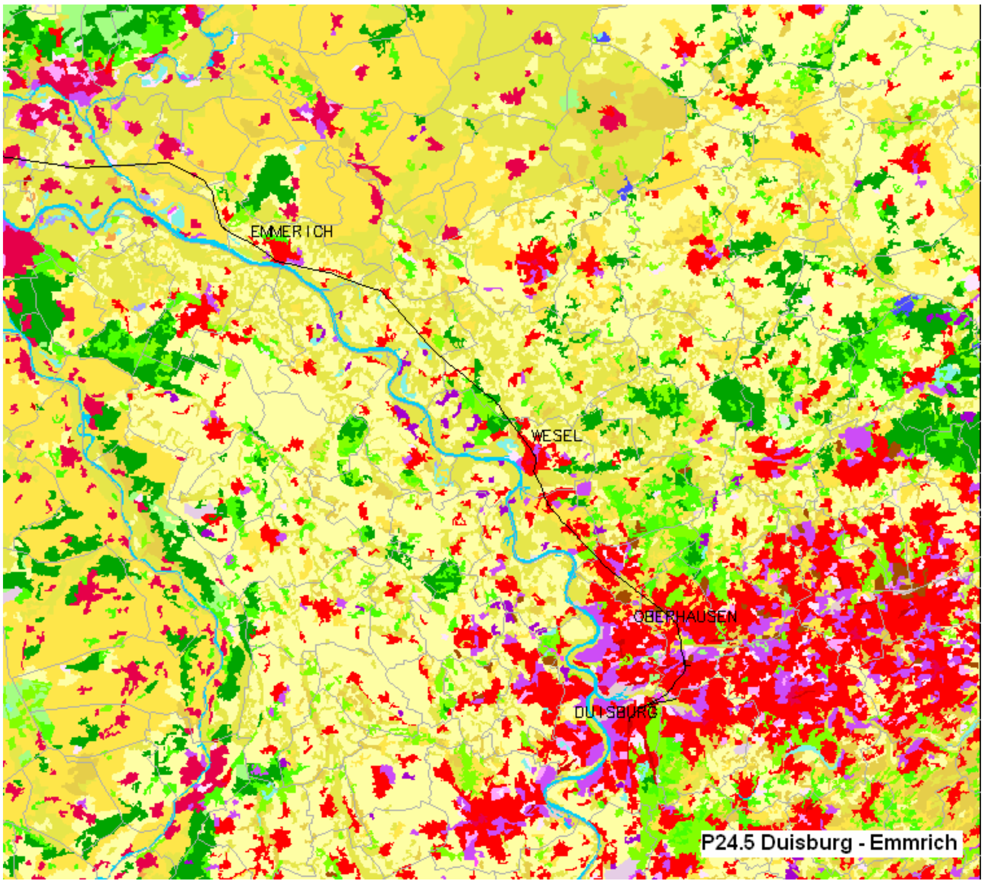


Figure 3.22 *P25.1 road - Gdansk*

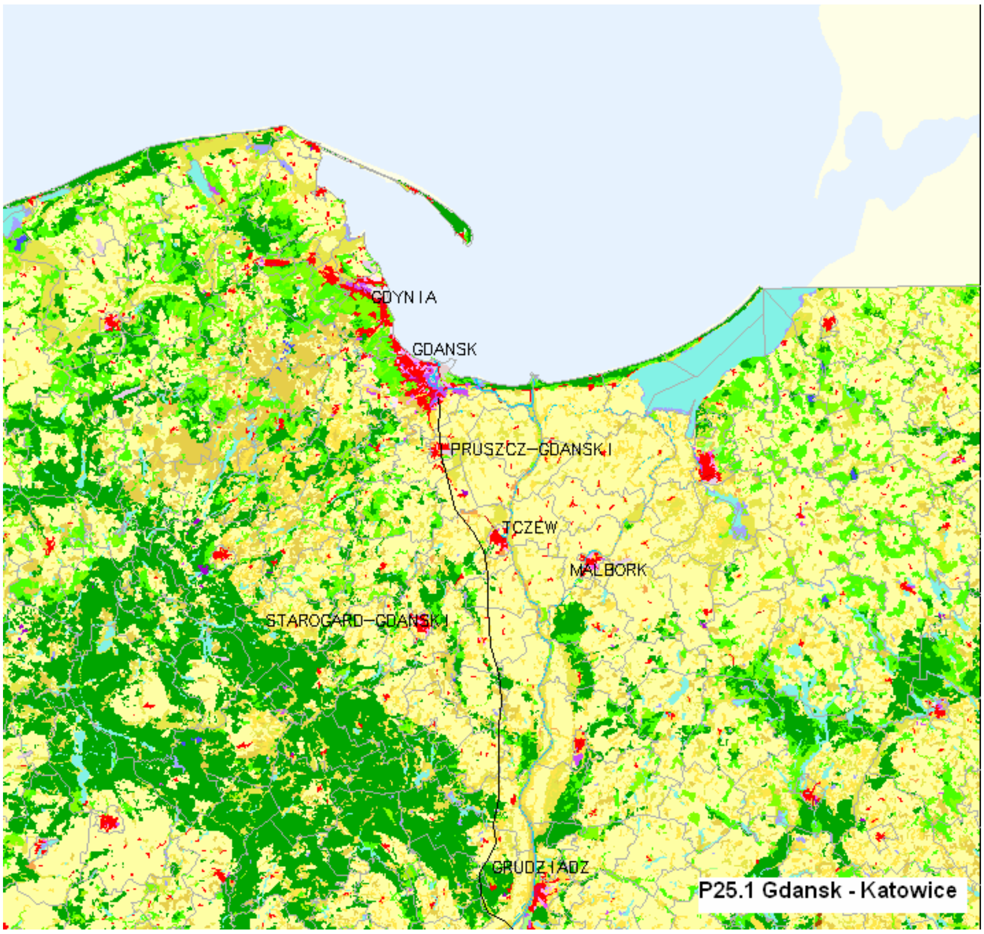


Figure 3.23 *P25.2 road - Katowice*

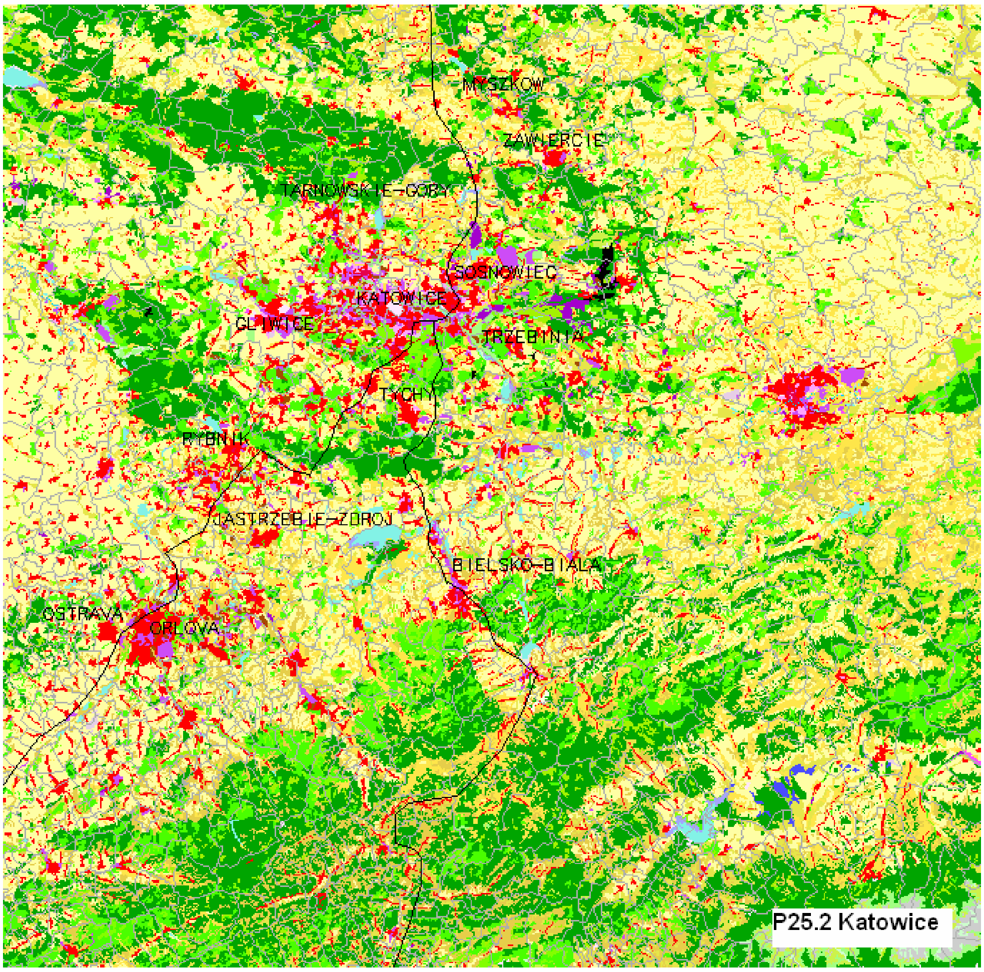


Figure 3.24 P26.1 road - Dublin

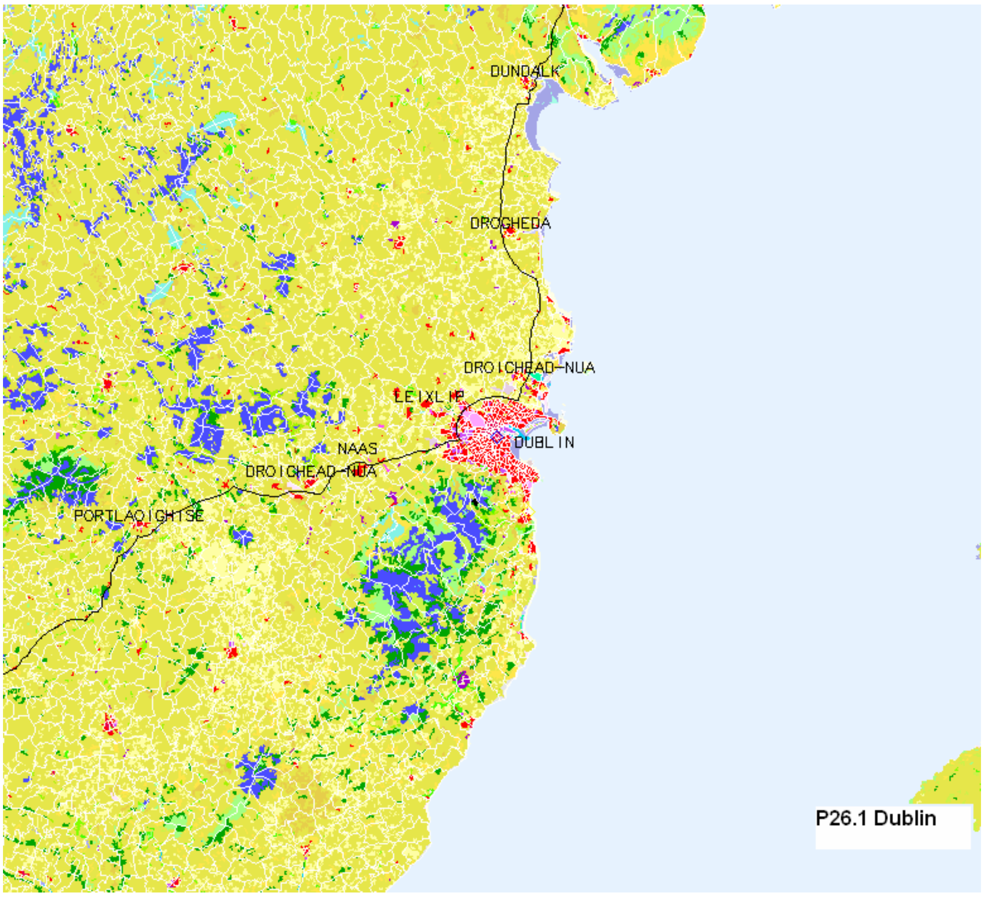


Figure 3.25 *P26.1 road - Belfast*

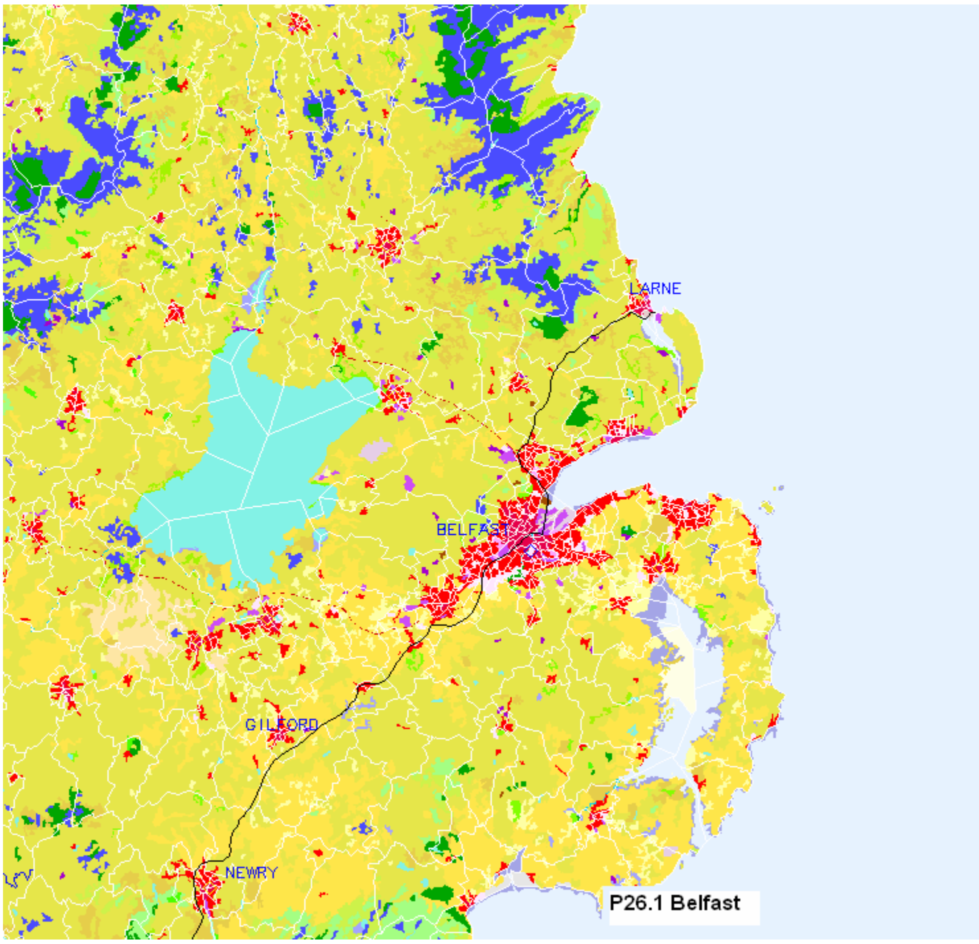


Figure 3.26 *P26.2 road - Liverpool – Manchester – Yorkshire/Wakefield*

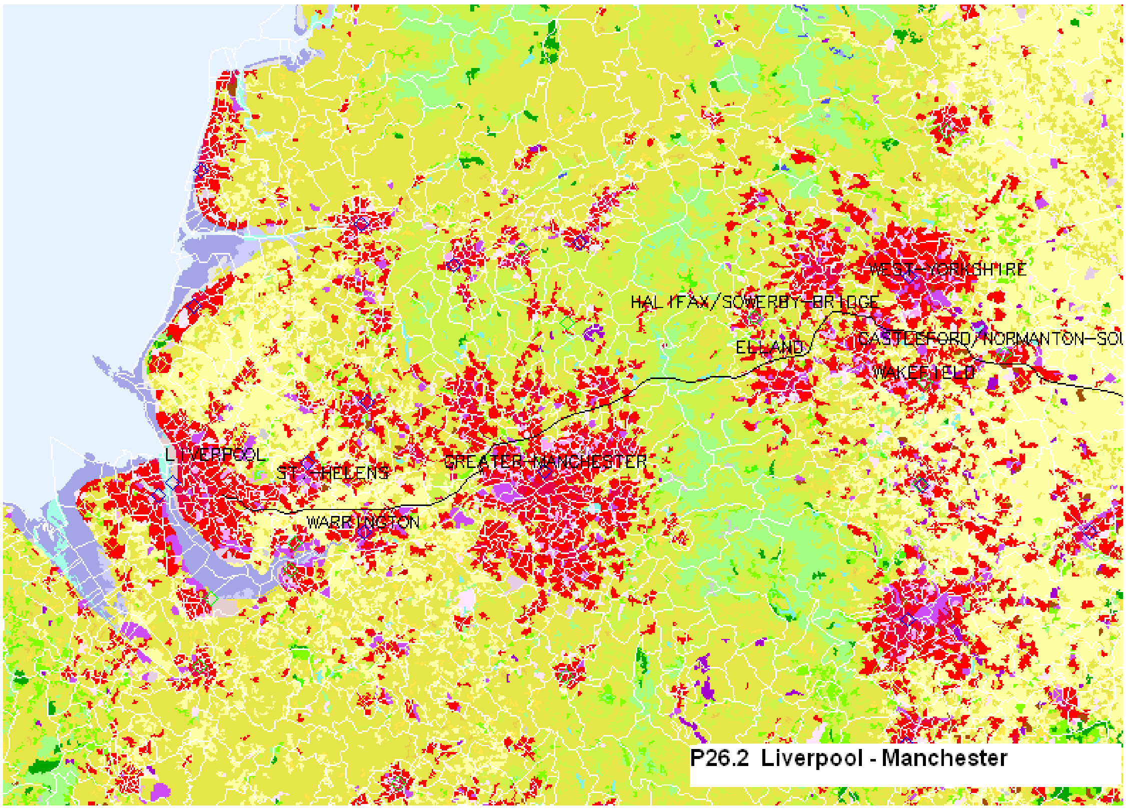
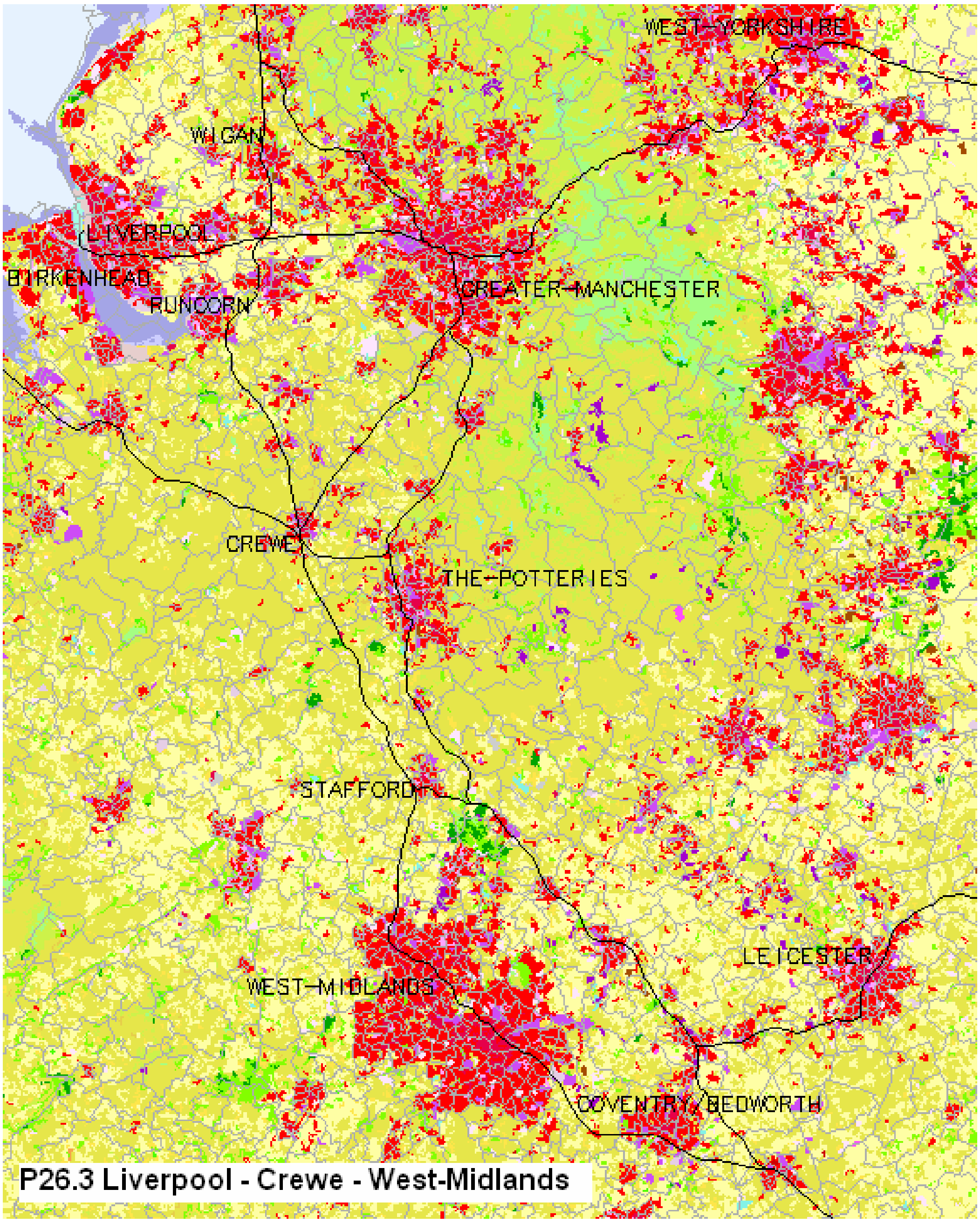


Figure 3.27 *P26.3 rail - Liverpool – Manchester – Crewe – West-Midlands*

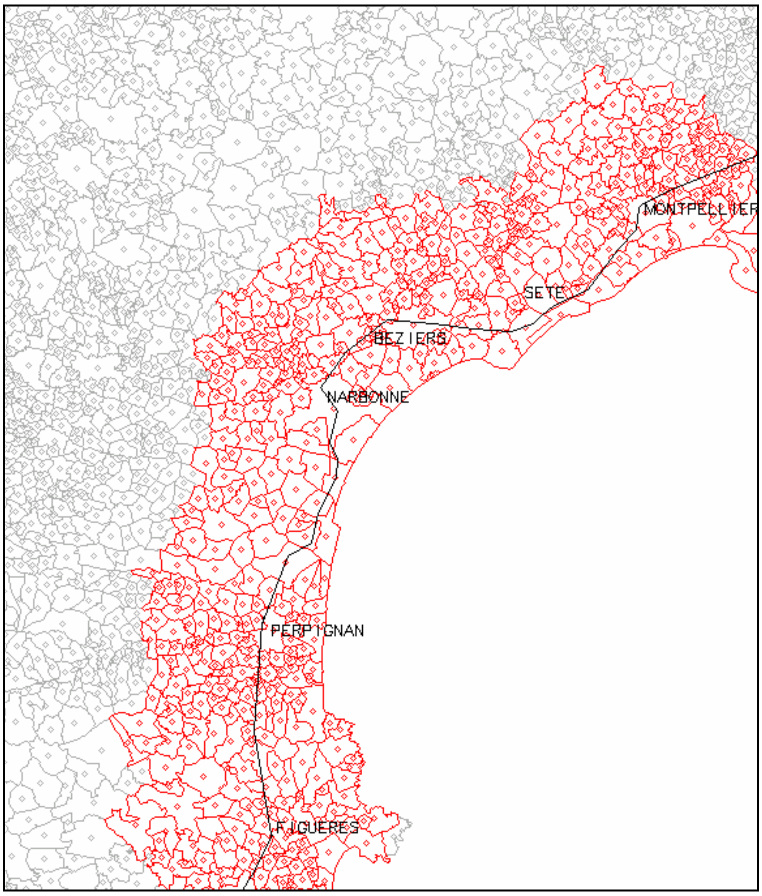


O/D-Distance-matrix between NUTS-5 regions

After selecting the regions, we choose a region around the priority project in a 50 km distance band or a 25 km buffer around a possible access point to the transport network. All centroids of NUTS 5 regions that fall inside this distance band or buffer respectively will be an origin within the transport analysis. Thus we can cover transport flows less than 50 km, in which the transport priority project might be relevant.

The following picture (Figure 3.28) gives an example of the selection of NUTS 5 regions in relation to a given priority projects

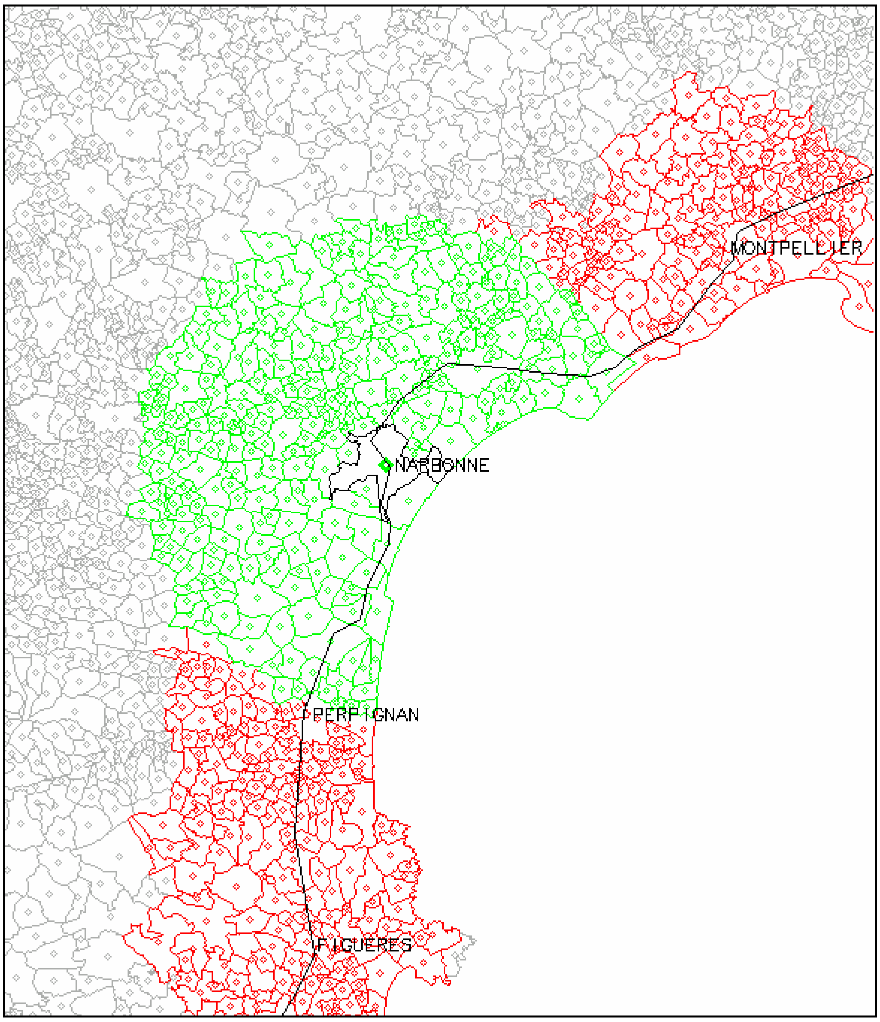
Figure 3.28 *Selection of origins within a distance band around the priority project*



This picture shows part of the project P03.2 Barcelona – Nîmes. The red coloured NUTS-5 boundaries are the 50 km – band around the route of this project.

The selection of origins complies with the geographical route of the transport project. Because we have to estimate the flows from one origin to all other regions around this origin, we include all NUTS-5 regions into the set of possible destinations that lie within a 50 km buffer zone around the centroids of the origin. Thus the set of destination exceeds the set of origins, because it is directly dependent from each origin. The following picture (Figure 3.29) illustrates the selection of destinations in relation to the origin Narbonne.

Figure 3.29 *Selection of destinations within a 50 km buffer around an origin*



The green coloured regions are selected as destination when Narbonne is origin. This area initially circumscribes a radius of 50 km. Multiplying with a detour-factor will extend this direct-line distance. The resulting distance follows an elliptical orbit, which approximates an average detour depending on the direct-line distance. Finally, those regions with detour-distances of 50 km or less will be selected as destination for Narbonne in the OD-distance-matrix. To all other origins within the selected region the respective destinations will be assigned in the same way.

This generates an asymmetric OD-distance-matrix that comprises the following data:

- origin-identifier and destination-identifier,
- distance between origin and destination,
- approximate or real population of origin and destination at year 2001
- economic data of the respective NUTS 2 regions
- transport indicators of the respective NUTS 2 regions

The source of the economic data and the transport indicators on NUTS 2 level is described below. The now available OD-distance-matrix will be the basis of the estimation of traffic flows as described in the following chapters.

Estimation of current car traffic volumes

The objective of this task is to estimate the volume of passenger car traffic for each spatial unit. It is worth noting, that at this strongly desegregated level within Europe there are only few essential data available. Hence, we developed a practicable approach, which can be used for estimating local volumes of individual motor-car traffic.

Generally, the following properties of the methodology to be applied seemed to be important:

- The approach should be suitable to estimate the local volume of traffic for a determined unit.
- The approach should be suitable for application in each country.

In order to reach the objective, we preferred a regression model that takes the dependence of volume of individual motor-car traffic on several kinds of indicators into account.

The main idea is that the total daily number of person trips made by car (driver and/or passenger) can be regarded as a function of population size, car ownership, and economy as well as spatial characteristics of the unit under consideration.

Thus the approach can be referred to as a “zonal trip generation procedure”. It is used to find a relationship between the number of car trips produced by each zone and certain characteristics of the zone.

The general form of the (cross sectional) regression model finally applied is:

$$y_i = \prod_{j=1}^{k} x_{ij}^{b_j} + u_i$$

i	= 1,2,...,63 index of units
y_i	= volume of car traffic per day
x_{ij}	= independent variables (j = 1,2,...,k)
u_i	= error term

The data base - concerning the dependent variable - was built up from a current German traffic survey[7], out of which we were able to estimate the volume of individual motor car traffic per day for each of the 40 NUTS 2 units. The second database was extracted from SCENES. In this way we were able to calculate the volume of traffic by using the number of car trips per person and year. (It was assumed, that the trip rates within the EU were constant from 1995 to 2001 – caused by country-specific increase in motorisation – and have risen in CEEC by 10% in average).

The outcome of this step is the volume of individual motor-car traffic per day for 40 NUTS 2 zones in Germany, 15 EU states, and 8 CEEC countries in 2001.

Furthermore, several kinds of regression models were tested, among them different independent variables as well as different functional forms and levels of variables.

After careful consideration, no intercept is integrated in this model. Hence, a region with zero vehicle stock cannot reveal any positive volume of individual motor-car traffic[8].

The models were formulated by using variables representing aggregate quantities, like total number of trips and cars per zone, together with rates such as population density and GDP per capita.

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7 Kraftfahrzeugverkehr in Deutschland 2001/2002
8 A model with intercept was also applied; the intercept was not significantly different from zero, forcing it to pass through the origin.

Table 3.12 shows the results of model estimation:

Table 3.12 *Model Estimation*

The NLIN Procedure

NOTE: An intercept was not specified for this model.

Source	DF	Sum of Squares	Mean Square	F Value	Approx Pr > F
Regression	4	6.064E16	1.516E16	6006.44	<.0001
Residual	59	1.489E14	2.524E12		
Uncorrected Total	63	6.079E16			
Corrected Total	62	4.893E16			

	Parameter	Estimate	Approx. Std Error
(Density)	b0	-0.0277	0.0159
(Cars)	b1	0.3678	0.0340
(Population)	b2	0.6183	0.0337
(GDP/Capita)	b5	0.1184	0.0216

Approximate Correlation Matrix

	b0	b1	b2	b5
b0	1.0000000	-0.1635529	0.1222604	-0.2808688
b1	-0.1635529	1.0000000	-0.9385823	-0.0146492
b2	0.1222604	-0.9385823	1.0000000	-0.3060879
b5	-0.2808688	-0.0146492	-0.3060879	1.0000000

The regression parameters show the expected signs. For example, the volume of individual motor-car traffic is smaller in high-density areas then when compared to low-density areas and increases with GDP per capita.

In a subsequent step the regression parameters were used to estimate the volume of car traffic with inclusion of NUTS 2 units by each country. If we do so, one can summarise the individual results of determination and compare with the overall result by each country. This is shown in the following table (Table 3.13). In addition, this task was done with all 14,000 German NUTS 5 units (last row). The column "factor" can be interpreted as a country specific adjustment value and is used for estimation purposes.

Table 3.13 *Ratio between overall results and sums of individual results by estimation of the volume of individual motor car traffic*

	Ratio	Factor	Number of units
Austria	112.54%	0.8886	9
Belgium	96.71%	1.0341	11
Denmark	99.01%	1.0100	1
Finland	106.16%	0.9419	6
France	101.28%	0.9874	22
Germany	100.86%	0.9915	40
Greece	102.45%	0.9760	11
Ireland	105.08%	0.9517	2
Italy	104.14%	0.9602	20
Luxembourg	92.89%	1.0765	1
Netherlands	90.29%	1.1075	12
Portugal	85.67%	1.1672	5
Spain	98.57%	1.0145	16
Sweden	110.08%	0.9085	8
UK	97.28%	1.0280	37
Czech	89.88%	1.1126	9
Estonia	115.22%	0.8679	1
Hungary	94.88%	1.0540	7
Lithuania	109.39%	0.9142	1
Latvia	131.04%	0.7631	1
Poland	98.03%	1.0201	16
Slovenia	112.82%	0.8864	1
Slovak Republic	120.94%	0.8269	4

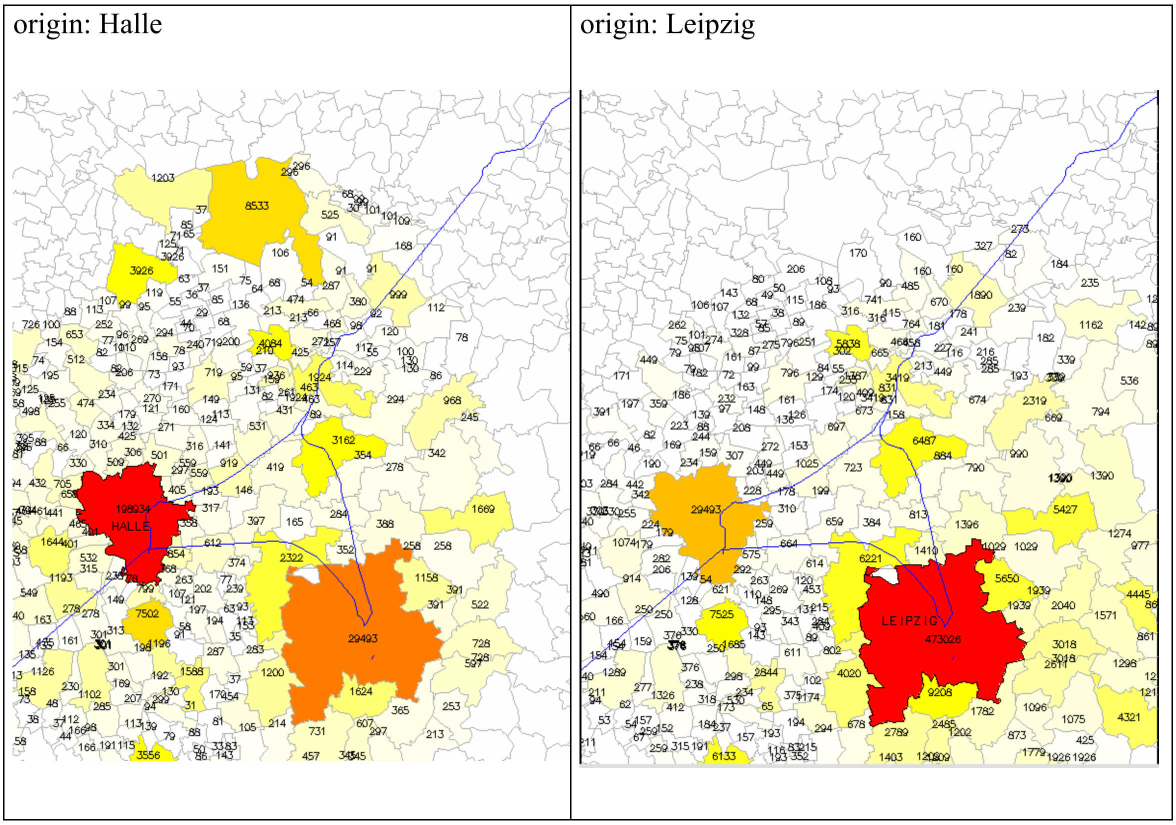
Limitations of the approach

The most relevant limitations of the approach are as follows:

- Zonal trip generation models can only explain the variation in trip making behaviour between regional units.
- A key assumption of this approach is that the model parameters will be constant between base and forecast year.
- The model assumes geographic transferability of trip generation; this is an important attribute of this applied demand model.
- Because no data on GDP and motorisation at NUTS 5 level were available, we had to break higher aggregated data down to the defined units. In order to take the finest possible level of desegregation into consideration, we inserted motorisation data at NUTS 2 level, GDP data at NUTS 0 level and drew the crude assumption that each NUTS 5 unit yields the same GDP per capita and motorisation rate, respectively.

The following picture (Figure 3.30) gives an example of resulting flows for Halle and Leipzig, which are part of the sub-section P01.1 Berlin – Halle/ Leipzig – Nürnberg in the base year 2001.

Figure 3.30 *Short – distance car traffic flows from Halle or Leipzig in the year 2001*



The charts give the number of car trips from the origin to destinations in a distance-area of 50 km. In case of larger cities, the maximum volume (red) is normally the origin itself. This means that most trips are intra-regional trips. In suburban regions or typical commuter residences, this is not the case. As we can see, the number of trips between both cities is the same.
In conclusion we can say that the flows between two regions that lie within the 50 km buffer zone of each other are symmetric.

Estimation of future car volumes
In order to estimate the car volume in 2020, we have to forecast the independent variables. In particular, we need forecasts of population, GDP, and car stock.

- The regional population forecast was done with help of regional scenarios (source: EUROSTAT NEW CRONOS), which provide forecasts of population at NUTS 2 level for all EU member states. For CEEC forecasts at national level (source: TEN-STAC, A Framework For Scenarios) were taken into account
- Furthermore, motorisation was forecasted by applying annual growth rates (NUTS 2 in EU, CEEC in general) taken from TEN-STAC, A Framework For Scenarios.
- Finally, GDP was forecasted with help of average annual growth rates at NUTS 0 level.

Table 3.14 summarises the forecast by showing the average annual growth rate for GDP and motorisation and the population change between 2001 and 2020. In this table NUTS 0 level is considered as an average result of aggregated NUTS 2 (motorisation and population).

Table 3.14 *Average growth rates of GDP, motorisation and population*

	Average annual growth	Average annual growth	Growth rate
	GDP	Motorization	Population
Austria	2.19%	0.25%	5%
Belgium	2.08%	0.36%	4%
Germany	2.21%	0.20%	3%
Denmark	2.11%	0.72%	3%
Spain	3.09%	0.39%	2%
Greece	3.80%	0.74%	7%
France	2.43%	0.13%	7%
Finland	2.19%	0.53%	3%
Italy	2.43%	0.15%	-2%
Ireland	3.65%	0.91%	5%
Luxembourg	3.85%	-0.11%	13%
Netherlands	2.41%	0.39%	8%
Portugal	3.52%	0.27%	4%
Sweden	2.32%	0.38%	7%
United Kingdom	2.62%	0.51%	2%
Bulgaria	3.94%	3.30%	-18%
Czech Republic	3.41%	1.61%	-4%
Hungary	3.49%	2.51%	-11%
Poland	4.26%	2.88%	-2%
Romania	4.88%	4.22%	-7%
Slovak Republic	4.02%	2.78%	-1%
Slovenia	3.05%	1.51%	-5%
Estonia	3.62%	2.59%	-18%
Latvia	4.37%	3.67%	-12%
Lithuania	4.50%	3.19%	-6%

Source: TEN-STAC, A Framework For Scenarios

The final result of our approach is shown in the following table. By using the model parameters and the forecast values of each independent variable, a rate of increase is obtained for each country. The forecast is made with available NUTS 2 (see Table 3.15).

Table 3.15 *Growth rate of individual motor car traffic volume 2001-2020 (trips per day; estimated with NUTS 2)*

Austria	7.14%
Belgium	7.15%
Denmark	9.40%
Finland	7.49%
France	8.96%
Germany	5.48%
Greece	14.44%
Ireland	11.65%
Italy	5.20%
Luxembourg	11.61%
Netherlands	10.09%
Portugal	8.35%
Spain	6.01%
Sweden	9.28%
UK	7.97%
Czech	18.38%
Estonia	14.58%
Hungary	20.07%
Lithuania	30.99%
Latvia	29.69%
Poland	30.99%
Slovenia	16.05%
Slovak Republic	31.22%
Bulgaria	27.82%
Romania	31.95%

While as a result of the first step the total number of person trips made by car originating from each zone has been derived, the second step aims at the distribution of person trips among alternative destinations. The total traffic volume per spatial unit comprises local traffic as well as non-local traffic. This makes it necessary to divide the whole volume into the two distance classes.

Here we take into consideration two national travel surveys, which provide trip length distributions for person trips made by car. Table 3.16 shows a proportion of local traffic (trip distance less than 50 km) of approximately 95%. This share will be integrated in the analysis.

Table 3.16 *Share of local traffic for person trips made by car*

	Distances	
	< 50 km	>= 50 km
Germany 2002*	95.75%	4.25%
Switzerland 2000**	95.69%	4.31%

* Source: Mobility in Germany 2002
** Source Census Switzerland 2000

Furthermore, for each unit – chosen in step 1 – it is important to select destinations within an area of 50 km. This is done with distances by embraced road network and produces an asymmetric matrix.

This task is a pre-condition for distributing the whole local car traffic volume per unit generated in the step before.

The functional form of the gravity distribution model is:

$$P_{ij} = \alpha O_i D_j f(c_{ij})$$

$$\text{s.c.} \sum_{j=1} P_{ij} = O_i$$

wherein

P_{ij}	:	passenger flow between unit i and j
O_i	:	passenger car traffic volume in origin i
c_{ij}	:	distance (costs) between unit i and j
D_j	:	attractiveness of destination j

To ensure that the above restriction is met, the proportionality factor α has to be replaced by a balancing factor A_i (singly constrained model) defined as

$$A_i = \frac{1}{\sum_j D_j f(c_{ij})}$$

and yielding

$$P_{ij} = A_i O_i D_j f(c_{ij})$$

Finally the passenger values must be transformed in car values. This is done with help of occupancy car rates and is listed by country in Table 3.17.

Table 3.17 *Occupancy car rate*

	Occupancy car rate
Austria	1.4
Belgium	1.5
Denmark	2.0
Finland	1.7
France	1.4
Germany	1.3
Greece	2.3
Ireland	2.0
Italy	1.2
Luxembourg	1.1
Netherlands	1.6
Portugal	2.0
Spain	1.5
Sweden	1.5
UK	1.5
Czech	1.9
Estonia	2.0
Hungary	2.7
Lithuania	2.9
Latvia	2.9
Poland	2.7
Slovenia	1.6
Slovak Republic	2.9
Bulgaria	3.0
Romania	3.0

The estimation of these occupancy car rates was done with the aid of country specific ratios “person per car” and adjusted by using the empirical current German occupancy car rate. In Germany this rate has a characteristic of 1.3. The number of cars per 1000 inhabitants is 538, so the rate “inhabitant per car” is finally 1.86. By means of the factor 1.3/1.86 multiplying with the value “persons per car” every occupancy car rate by country was calculated.

In a last step it was necessary to average the flows between unit i and j on the one side and j and i on the other side.

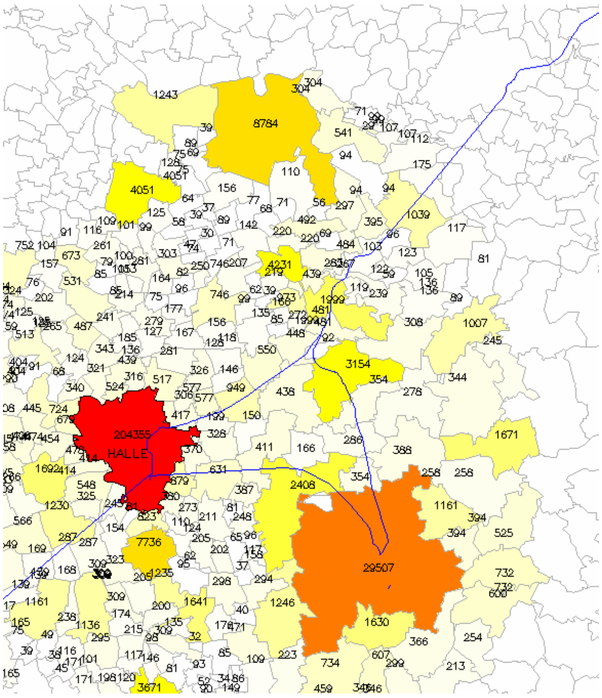
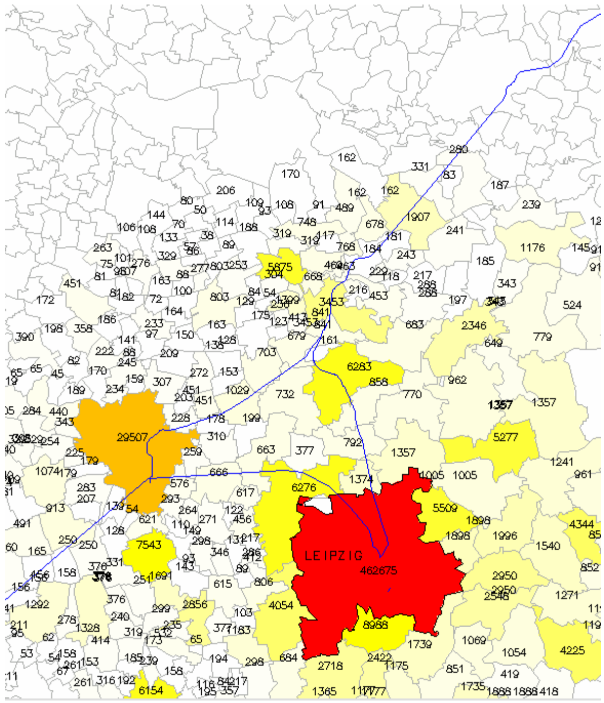
Formally:

$$P_{ij}^{*} = P_{ji}^{*} = \frac{P_{ij} + P_{ji}}{2} \quad i \neq j$$

This proceeding ensures that car flows from unit i to unit j and the oposite direction is completely included.

The following picture (Figure 3.31) shows the corresponding transport volume for the year 2020 of Halle and Leipzig as shown in Figure 3.30 for the base year 2001.

Figure 3.31 *Short – distance car traffic flows from Halle or Leipzig in the year 2020*

origin: Halle	origin: Leipzig
	

This O/D-flow-matrix will be input for the transport model of IWW. Short distance and long distance traffic will be analysed simultaneously in this overall transport model to show possible interactions. Within the assignment procedure, some effects of new transport projects on local passenger transport should become visible.

3.4 Methodology by impact variables

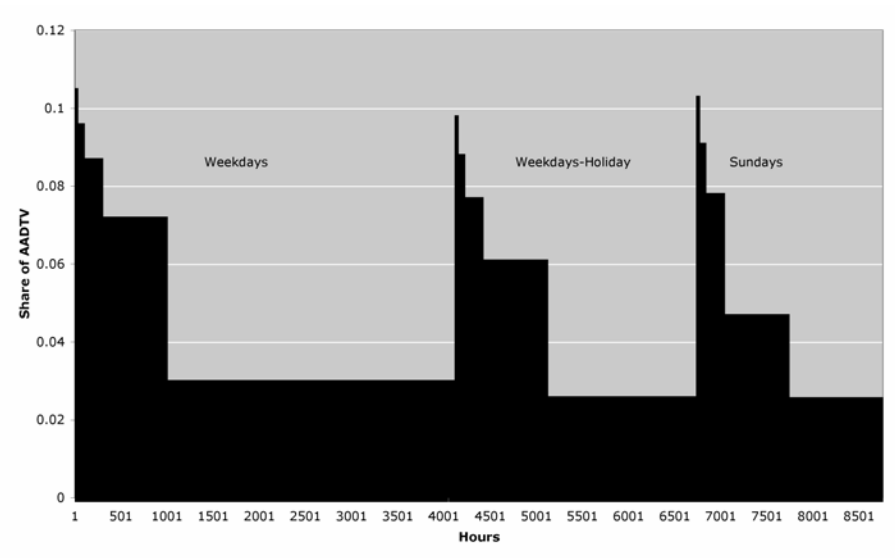
The present chapter is devoted to the methodologies applied for the evaluation of sub-sections. In the following paragraphs the methodology for each impact criterion is dealt with individually. The detailed description of methodologies for the generation of performance values for quantitative impact criteria refer to the first performance matrix. The approach for the generation of data for the second performance matrix is done accordingly

3.4.1 Economic impacts in the transport sector

Indicator 1: Changes in time costs caused by road congestion
With the information on traffic loads on a link of a specific link type, the level-of-service on a road link is estimated by following methodology.

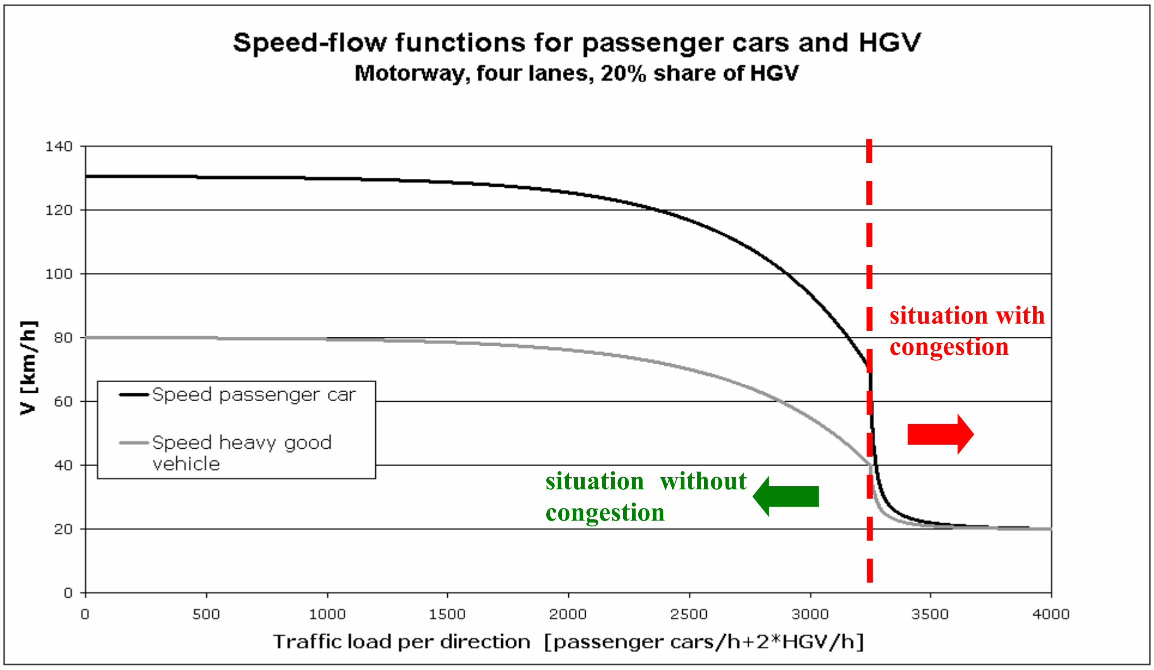
For the quantification of periods of time with a congested situation on the road links, a certain distribution of peak and non-peak periods is assumed. For this purpose typical time slices are defined. The following diagram shows the underlying allocation of number of hours to the share of AADTV (average annual daily traffic volume), differentiated by three types of days: weekdays, weekdays within a holiday period and Sundays. Hence the annual demand of traffic flows on a network link is allocated to specific traffic situations at an hourly basis, as illustrated below in Figure 3.32.

Figure 3.32 *Distribution of number of hours to share of AADTV*



Furthermore, speed-flow curves that allow a comparison of the maximum speed with the actual speed depending on traffic volumes are applied. The speed-flow function is dependant on the road type and the share of heavy goods vehicles (HGV).
Figure 3.33 displays the speed-flow functions for passenger cars and trucks, for a motorway link with four lanes and a HGV share of 20 percent.

Figure 3.33 *Example for a speed-flow curve and definition of a situation with "congestion"*



With the information on the annual traffic volume on a certain link, the assumption of the distribution of the traffic demand over the year and the link type-specific speed-flow curves, the level-of-service is estimated. The estimation of the level-of-service on the road network embraces all road network links of the official EC road network.

The definition of "congestion" within TEN-STAC phase II differs from the definition in phase I and is set as follows: congestion starts at that point in the speed-flow diagram, in which the speed flow curve changes its gradient, i.e. at the point of discontinuity, marked by the dotted line in the diagram above. The situation of a "non-congested" flow is reflected by the situation, in which the speed approaches the point of discontinuity of the speed-flow function.

The costs caused by road congestion in a region j are estimated by following formula:

$$CC_j = \sum_{vt}\sum_{p}\sum_{i}\sum_{s} VOT_p^{UNITE} \cdot CF^C \cdot t_{s,i} \cdot d_s \cdot TF_{s,i}^{vt}$$

where

VOT_p^{UNITE}	basic value of time from UNITE by trip purpose p
CF^C	correction factor for country C the region j and the link i belongs to
$t_{s,I}$	difference in travel time on road link i during time slice s compared to travel time in a situation in which the speed approaches the point of discontinuity of the speed-flow function
d_s	duration of time slice s within a whole year

$TF_{s,i}^{vt}$ traffic volume on link i during time panel s, differentiated by vehicle type vt

Indicator 2: Changes in monetary value of the reduction of passenger travel time

The estimation of reduction of travel times is based on the passenger cost matrices, which represent "potential" travel times, i.e. without the consideration of congestion effects.

As the implementation of a single sub-section is very unlikely, the difference in transport times for the implementation of the whole priority project versus the implementation of the priority project without the sub-section is calculated. For each priority project one reference calculation and one calculation for every sub-section is needed.

The passenger travel time differences resulting from a realisation of sub-section i on priority project j, $TD_{pass}^{i,j}$, are estimated by following formula:

$$TD_{pass}^{i,j} = \sum_p \sum_l \sum_k \left((t_{kl}^{wo})^p - (t_{kl}^{w})^p \right) \cdot TV_{kl}^p$$

where

$(t_{kl}^{wo})^p$ potential travel time for an O/D relation (k, l) for trip purpose p, without realisation of the sub-section

$(t_{kl}^{w})^p$ potential travel time for an O/D relation (k, l) for trip purpose p, with realisation of the sub-section

TV_{kl}^p travel volume on O/D link (k, l), differentiated by travel purpose p

In the next step the aggregated travel time differences are weighted by the country-specific values of time.

Indicator 3: Changes in monetary value of the reduction of freight travel time

The estimation of reduction of travel times is based on the freight cost matrices, which represent "potential" travel times, i.e. without the consideration of congestion effects.

As the implementation of a single sub-section is very unlikely, the difference in transport times for the implementation of the whole priority project versus the implementation of the priority project without the sub-section is calculated. For each priority project one reference calculation and one calculation for every sub-section is needed.

The freight travel time differences resulting from a realisation of sub-section i on priority project j, $TD_{freight}^{i,j}$, are estimated by following formula:

$$TD_{freight}^{i,j} = \sum_k \sum_l \left(t_{kl}^{wo} - t_{kl}^{w} \right) \cdot TV_{kl}$$

where

t_{kl}^{wo}	potential transport time for an O/D relation (k, l), without realisation of the sub-section
t_{kl}^{w}	potential transport time for an O/D relation (k, l), with realisation of the sub-section
TV_{kl}	transport volume on O/D relation (k, l)

In the next step the aggregated travel time differences are weighted by the country-specific values for vehicle*hour (road) and number of tons carried (other modes).

3.4.2 Environmental sustainability (cost-benefit analysis)

Indicators 4, 5 and 6: Variation (in monetary value) of the transport contribution to global warming, NO_X transport emissions and emission of particulates

The sub-section-specific estimation of impacts on emissions of CO_2, NO_X and particulates are based on assignment results, which have been generated for each priority project. Since the results generated at priority project level have to be translated to the sub-section level, the approach on selection of relevant O/Ds on a sub-section is applied.

The changes in emission volumes of emission gases e assigned to sub-section i, CEV_i^e, are calculated as follows:

$$CEV_i^e = \sum_m (EV_m^{ref})_i^e - \sum_m (EV_m^j)_i^e$$

where

$(EV_m^{ref})_i^e$	emission volume of emission gas e, by mode m, caused by all traffic O/D flows, whose path is routed via sub-section i, under the transport infrastructure assumptions of the reference networks
$(EV_m^c)_i^e$	emission volume of emission gas e, by mode m, caused by all traffic O/D flows, whose path is routed via sub-section i on priority project j, under the assumption that all sections on priority project j are realised

In order to avoid double counting the corrected changes in emissions assigned to sub-section i $(CEV_i^e)^{corr}$, are estimated according to following formula:

$$(CEV_i^e)^{corr} = \frac{CEV_i^e}{\sum_{i\,(i \in j)} CEV_i^e} \cdot CEV_j^e \quad \text{, with } \; CEV_j^e = \sum_m (EV_m^{ref})^e - \sum_m (EV_m^j)^e$$

where

$(EV_m^{ref})_i^e$	emission volume of emission gas e, by mode m, caused by all traffic flows, under the transport infrastructure assumptions of the reference networks
$(EV_m^c)_i^e$	emission volume of emission gas e, by mode m, caused by all traffic flows, under the assumption that additionally to the assumptions of the reference scenario all sections on priority project j are realised

Indicator 7:

Impact of transport infrastructure sub-sections on road traffic safety

The aim of this task is to estimate the impact of the sub-sections under consideration on road traffic safety. The reduction of traffic casualties is one important objective of transport infrastructure sub-sections. Normally, new-built transport infrastructure sub-sections are assumed to have a positive effect on road traffic safety, since these sub-sections take improved safety standards into account.

To calculate the safety effects of transport infrastructure sub-sections the total number of road traffic accidents is broken down

- by severity
  - fatal accidents
  - personal injury accidents
- and by road type
  - motorway
  - other roads.

When estimating the impacts of new transport infrastructure, it is useful to consider fatality and/or accident rates that take the sum of vehicle kilometres as an exposure quantity into account. Here, we apply the following rates:

- Fatalities per billion vehicle kilometres
- Injury accidents per million vehicle kilometres.

Unfortunately, in Europe no completely unified statistical system is available in the field of traffic safety. This means, for instance, that all countries indeed provide the total annual number of accidents (by severity), but in many cases no differentiation is made between road types and – most problematical – no estimates of vehicle kilometres are available. These deficiencies refer not only to the CEEC countries but also to some EU member states.

Current accident rates

As mentioned above, for several states no current accident rates are available. In these cases we had to estimate the country-specific values.

The corresponding estimates are based on the following thoughts:

- In some cases (Spain, Italy and Ireland) it was possible to use accident rates from the early nineties.
- In other cases we used vehicle kilometres (source: Federal Statistical Office Germany; Statistical Yearbook 2002) and the numbers of accidents to estimate fatality and (injury) accident rates. Furthermore, we subdivided the accidents and vehicle kilometres by locations, by using length of roads and length of motorways.
- If none of the above mentioned data were available, we estimated the required rates with data on motorisation, length of roads, length of motorways, GDP per capita and population size, taking comparable countries into account.

Table 3.18 shows the results of this procedure for fatality rates, whereas Table 3.19 contains the results for injury accident rates (year 2001 is also presented, if available).

Table 3.18 *Current fatality rates (persons killed per billion vehicle km)*

	Motorways		Other Roads		Total	
	2000	2001	2000	2001	2000	2001
Austria	8,06	9,19	14,68	13,70	13,18	12,68
Belgium	7,63	.	20,80	.	16,33	.
Germany	4,46	3,71	15,71	15,04	12,04	11,25
Denmark	2,89	4,06	12,65	10,60	10,63	9,22
Spain	14,10	13,03	30,55	29,60	28,50	27,22
Greece	13,14	.	23,48	.	23,07	.
France	5,45	4,79	17,53	17,35	15,13	14,81
Finland	4,28	4,46	8,87	9,54	8,48	9,09
Italy	7,30	.	18,03	.	15,39	.
Ireland	3,25	2,10	11,73	11,32	11,30	10,86
Luxembourg	4,32	.	14,83	.	11,52	.
The Netherlands	3,10	.	10,97	.	8,90	.
Portugal	14,51	.	19,65	17,49	19,18	17,23
Sweden	2,54	.	9,48	.	8,50	.
UK	2,00	.	8,56	.	7,29	.
Bulgaria	16,89	.	38,59	.	26,51	.
Czech Republic	11,25	10,49	40,82	34,80	37,81	32,38
Hungary	15,96	9,99	38,46	39,84	36,36	36,99
Poland	24,21	24,57	44,27	38,39	44,01	38,17
Romania	19,60	.	56,64	.	55,53	.
Slovak Republic	12,13	.	49,93	.	46,86	.
Slovenia	13,23	9,39	29,31	26,23	26,62	23,14
Estonia	31,37	.	40,45	.	40,00	.
Latvia	.	.	64,62	.	64,62	.
Lithuania	42,54	.	57,02	.	56,73	.
Switzerland	2,30	3,50	14,45	11,98	10,44	9,10
Norway		2,50		8.45		8,30

Source: IRTAD; red numbers: estimations

Table 3.19 *Current injury accident rates (number per million vehicle km)*

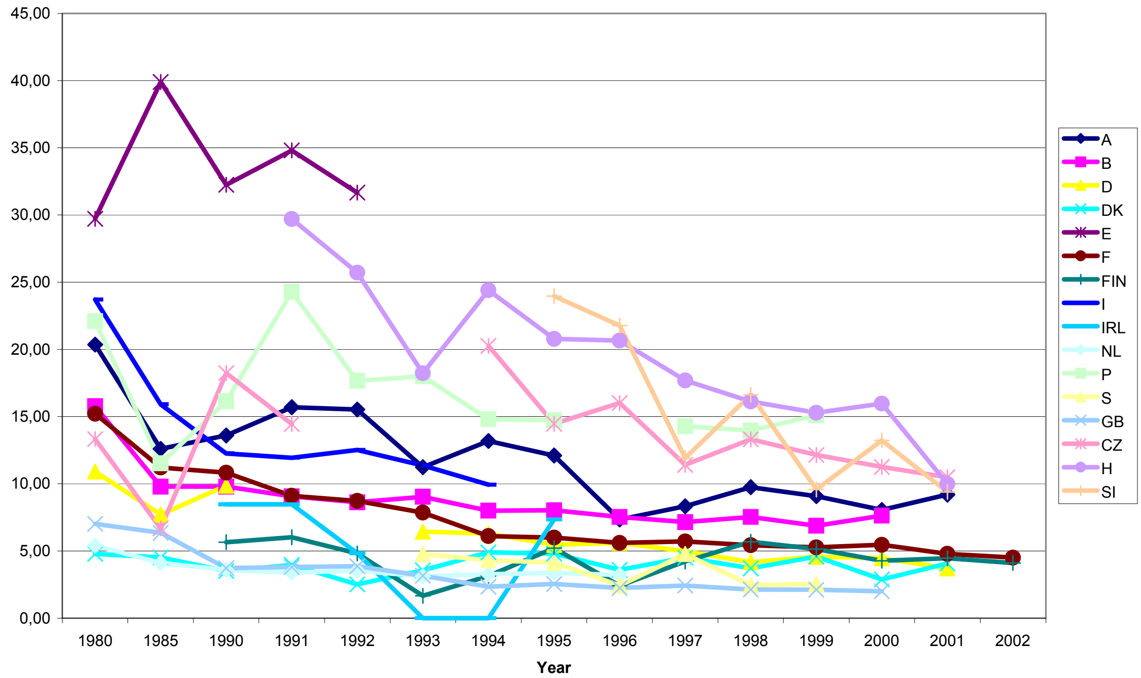
	Motorways		Other Roads		Total	
	2000	2001	2000	2001	2000	2001
Austria	0,15	0,14	0,69	0,70	0,57	0,57
Belgium	0,15	.	0,75	.	0,54	.
Germany	0,13	0,13	0,85	0,84	0,61	0,61
Denmark	0,03	0,03	0,19	0,18	0,16	0,15
Spain	0,12	0,12	0,56	0,56	0,50	0,50
Greece	0,11	.	0,27	.	0,26	.
France	0,07	0,07	0,27	0,24	0,23	0,21
Finland	0,04	0,04	0,15	0,15	0,14	0,14
Italy	0,16	.	0,63	.	0,51	.
Ireland	0,02	0,02	0,22	0,19	0,21	0,18
Luxembourg	0,05	.	0,18	.	0,14	.
The Netherlands	0,09	.	0,39	.	0,31	.
Portugal	0,23	.	0,48	0,46	0,46	0,44
Sweden	0,11	.	0,25	.	0,23	.
UK	0,10	.	0,60	.	0,50	.
Bulgaria	0,17	.	0,53	.	0,51	.
Czech Republic	0,10	0,10	0,71	0,69	0,65	0,63
Hungary	0,09	0,09	0,57	0,60	0,53	0,55
Poland	0,12	0,10	0,40	0,38	0,40	0,37
Romania	0,11	.	0,17	.	0,17	.
Slovak Republic	0,07	.	0,64	.	0,59	.
Slovenia	0,14	0,14	0,84	0,91	0,72	0,77
Estonia	0,18	.	0,30	.	0,30	.
Latvia	.	.	0,49	.	0,49	.
Lithuania	0,41	.	0,52	.	0,51	.
Switzerland	0,12	0,12	0,57	0,55	0,42	0,40
Norway		0,11		0,25		0,25

Source: IRTAD; red numbers: estimations

Forecast of the accident rates for 2020

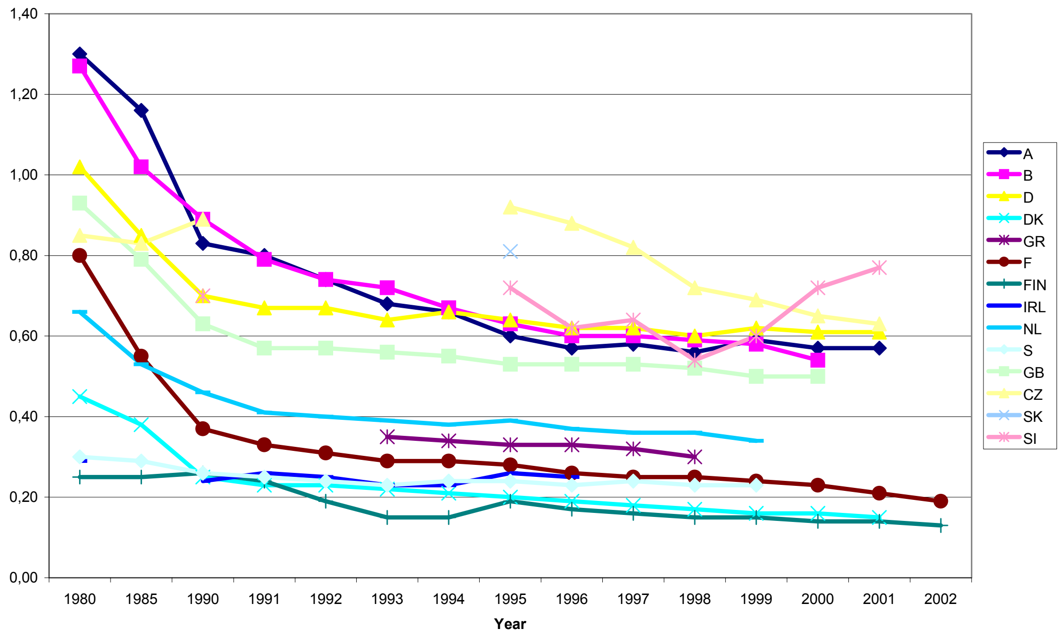
The past and current accident rates build the basis for a necessary forecast. As can be seen from Figure 3.34, there is a negative trend in fatality rates for motorways during the last three decades. A similar development is to be observed when we have a look at injury accident rates (Figure 3.35). The country-specific trends do not differ in their general (negative exponential) nature, only in their level.

Figure 3.34 *Fatalities per billion vehicle kilometres*



Source: IRTAD

Figure 3.35 *Injury accidents per million vehicle kilometres (total)*



Data source: IRTAD

As the charts show a robust development, it is appropriate to apply a trend model. The decision to choose this approach is based on the following considerations:

- Trend procedures are very robust
- Trend procedures need only little information, hence it is useful to estimate national accident rates this way
- One could argue that the use of trend models is "measurement without theory". This is, of course, correct. However, using more sophisticated models would result in enormous difficulties, because in this case specific determinants of traffic safety (e.g. vehicle crashworthiness, speed limit, policy regulations, seatbelt wearing rates by road category and the like) have to be forecasted for each individual country.

Taking into consideration that traffic safety levels may differ between countries, we applied a covariance model (fixed effects model) for each type of rate:

$$y_{it} = \gamma_i r_i + \beta x_t + u_{it} \qquad (i=1,...,N;\ t=1,...,T)$$

where

y_{it}	natural logarithm of accident rate of country i in year t
r_i	dummy variable associated with country i
x_t	natural logarithm of the numerical code of year t
u_{it}	error term
N	number of countries
T	number of time periods (years)

In the model above, the parameter β is constant. This specification corresponds to the simplifying assumption of a constant rate of decrease of accident rates over time for all countries.

The model estimation and testing results for motorway fatality rates are shown as an example in Figure 3.36. Statistical estimation of the model parameters simultaneously considers all available countries. As can be seen, the goodness of fit is excellent (R-Square=0.98). The estimates of the parameters of the country dummies represent the country-specific level of traffic safety.

Figure 3.36 *Motorway fatality rates; Model estimation and testing results*

Dependent Variable: LNFATMW

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	25	4690.034140	187.601366	2141.81	<.0001
Error	162	14.189623	0.087590		
Uncorrected Total	187	4704.223763			

R-Square	Coeff Var	Root MSE	LNFATMW Mean
0.975316	14.80753	0.295957	1.998689

Parameter		Estimate	Standard Error	t Value	Pr > |t|
LNJAHR		-97.1651983	10.56508579	-9.20	<.0001
State	A	740.7194526	80.30263203	9.22	<.0001
State	B	740.4989060	80.29806265	9.22	<.0001
State	CZ	740.9599109	80.30325320	9.23	<.0001
State	D	739.9712064	80.30333958	9.21	<.0001
State	DK	739.8344939	80.30263203	9.21	<.0001
State	E	741.1834381	80.30556264	9.23	<.0001
State	F	740.1726673	80.30619509	9.22	<.0001
State	FIN	740.0405117	80.30641021	9.22	<.0001
State	GB	739.2444451	80.29806265	9.21	<.0001
State	H	741.1269361	80.30300887	9.23	<.0001
State	I	740.5606859	80.29887341	9.22	<.0001
State	IRL	739.5264213	80.30566857	9.21	<.0001
State	NL	739.6527692	80.29833012	9.21	<.0001
State	P	741.1846453	80.29830767	9.23	<.0001
State	S	739.4712628	80.29974975	9.21	<.0001
State	SI	740.9496253	80.30429065	9.23	<.0001

In the next step, the accident rate for each country was forecasted separately (Table 3.20). After intensive discussions we decided to forecast the future development of rates by using model rates up to the year 2010 and assume more constant rates between 2010 and 2020. This assumption is based on an expert judgement, stating that the rates will converge to a certain (lower) level reflecting the realistically achievable safety improvements, as far as the vehicle fleet and the road infrastructure network are concerned.

Table 3.20 *Forecast Rates 2020*

	Fatalities per billion vehicle km			Injury accidents per million vehicle km		
	Motorways	Other Roads	Total	Motorways	Other Roads	Total
Austria	5,43	9,42	8,28	0,13	0,53	0,42
Belgium	4,35	13,05	9,68	0,13	0,57	0,40
Germany	2,57	9,98	7,28	0,11	0,64	0,45
Denmark	2,24	7,60	6,25	0,03	0,14	0,12
Spain	8,63	19,77	17,55	0,11	0,43	0,37
Greece	8,09	15,09	14,38	0,10	0,20	0,19
France	3,14	11,53	9,37	0,06	0,19	0,16
Finland	2,75	6,03	5,58	0,04	0,12	0,10
Italy	4,63	11,59	9,46	0,14	0,47	0,37
Ireland	1,65	7,58	6,96	0,02	0,15	0,14
Luxembourg	2,66	9,53	7,08	0,04	0,14	0,10
The Netherlands	1,87	7,09	5,36	0,07	0,29	0,23
Portugal	8,64	12,13	11,41	0,19	0,36	0,33
Sweden	1,56	5,89	4,95	0,10	0,19	0,16
United Kingdom	1,24	5,40	4,37	0,09	0,45	0,36
Bulgaria	10,40	24,80	16,30	0,15	0,40	0,37
Czech Republic	6,90	24,51	21,86	0,09	0,54	0,48
Hungary	8,16	25,83	23,18	0,09	0,45	0,40
Poland	15,45	26,94	25,68	0,10	0,30	0,29
Romania	12,07	36,40	34,13	0,10	0,13	0,12
Slovak Republic	7,47	32,09	28,80	0,06	0,48	0,43
Slovenia	6,83	18,15	15,91	0,12	0,68	0,52
Estonia	18,11	25,85	24,59	0,26	0,27	0,26
Latvia	28,50	41,52	39,72	0,43	0,45	0,44
Lithuania	26,20	36,65	34,87	0,43	0,47	0,45
Switzerland	2,15	9,21	6,55	0,10	0,39	0,28
Norway	1,57	5,71	4,95	0,10	0,19	0,16

In order to estimate the absolute number of casualties (number of persons injured) associated with injury accidents we have to calculate the average number of (seriously or minor) injured persons for this type of accident.

For each country this average number (average taken over the period 1998-2000) is given in the following table (Table 3.21):

Table 3.21 *Severely or minor injured persons per injury accident (average 1998-2000)*

Austria	1,301
Belgium	1,382
Germany	1,317
Denmark	1,224
Spain	1,461
Greece	1,337
France	1,346
Finland	1,298
Italy	1,435
Ireland	1,508
Luxembourg	1,415
The Netherlands	1,207
Portugal	1,353
Sweden	1,387
United Kingdom	1,363
Bulgaria	1,232
Czech Republic	1,287
Hungary	1,304
Poland	1,237
Romania	1,069
Slovak Republic	1,315
Slovenia	1,313
Estonia	1,155
Latvia	1,196
Lithuania	1,211
Switzerland	1,259

The calculations above are based on data published in the following source: Federal Statistical Office Germany, Statistical Yearbook, several editions.

Multiplying the estimated total number of injury accidents by the above mean value yields the required total number of injured persons (casualties).

One crucial point in this analysis is monetarisation of social accident costs. An average monetary value of 1.5 million € per person killed has been proposed by UNITE for Europe (1998 market prices; Source: Valuation Conventions for UNITE), which corresponds to € 1,962 M in 2003 values.

In order to include health care costs and net production loss, UNITE recommends that 10% is to be added to the risk value (UNITE 2001). Following the methodology recommended by UNITE (2001) the value per fatality is € 2,158 M in 2003 values.

Table 3.22 *Value per fatality in market prices*

	Value 1998 M€	Value 2003 M€
Statistical life	1.500	1.962
Health care costs	0.150	0.196
Value per fatality	1.650	2.158

Source: UNITE

For seriously injured persons, 13% of this value has been taken and 1% for minor injured person.
To derive a country-specific value it is appropriate to consider a GDP index. These calculations are done in Table 3.23.

Table 3.23 *Values per fatality, severe injury, minor injury and costs of material damage (M€ 2003 values)*

		Costs per fatality		Costs per severe injury			Costs per minor injury		
Country	Value per fatality	Costs of material damage	Total costs	Value per severe injury	Costs of material damage	Total costs	Value per minor injury	Costs of material damage	Total costs
Austria	2.367	0.146	2.513	0.308	0.146	0.454	0.024	0.146	0.170
Belgium	2.339	0.144	2.484	0.304	0.144	0.448	0.023	0.144	0.168
Germany	2.201	0.136	2.337	0.286	0.136	0.422	0.022	0.136	0.158
Denmark	2.475	0.152	2.628	0.322	0.152	0.474	0.025	0.152	0.177
Spain	1.828	0.113	1.941	0.238	0.113	0.350	0.018	0.113	0.131
Greece	1.463	0.090	1.553	0.190	0.090	0.280	0.015	0.090	0.105
France	2.210	0.136	2.346	0.287	0.136	0.423	0.022	0.136	0.158
Finland	2.236	0.138	2.374	0.291	0.138	0.428	0.022	0.138	0.160
Italy	2.206	0.136	2.341	0.287	0.136	0.423	0.022	0.136	0.158
Ireland	2.711	0.167	2.878	0.352	0.167	0.519	0.027	0.167	0.194
Luxembourg	4.068	0.251	4.319	0.529	0.251	0.779	0.041	0.251	0.291
The Netherlands	2.408	0.148	2.557	0.313	0.148	0.461	0.024	0.148	0.172
Portugal	1.474	0.091	1.565	0.192	0.091	0.282	0.015	0.091	0.106
Sweden	2.199	0.135	2.335	0.286	0.135	0.421	0.022	0.135	0.157
United Kingdom	2.244	0.138	2.383	0.292	0.138	0.430	0.022	0.138	0.161
Bulgaria	0.559	0.034	0.593	0.073	0.034	0.107	0.006	0.034	0.040
Czech Republic	1.323	0.081	1.404	0.172	0.081	0.253	0.013	0.081	0.095
Hungary	1.267	0.078	1.345	0.165	0.078	0.243	0.013	0.078	0.091
Poland	0.865	0.053	0.919	0.113	0.053	0.166	0.009	0.053	0.062
Romania	0.552	0.034	0.587	0.072	0.034	0.106	0.006	0.034	0.040
Slovak Republic	1.049	0.065	1.113	0.136	0.065	0.201	0.010	0.065	0.075
Slovenia	1.632	0.101	1.732	0.212	0.101	0.313	0.016	0.101	0.117
Estonia	0.943	0.058	1.001	0.123	0.058	0.181	0.009	0.058	0.068
Latvia	0.816	0.050	0.867	0.106	0.050	0.156	0.008	0.050	0.058
Lithuania	0.876	0.054	0.930	0.114	0.054	0.168	0.009	0.054	0.063
Norway	3.082	0.190	3.272	0.401	0.190	0.590	0.031	0.190	0.221
Switzerland	2.519	0.155	2.674	0.327	0.155	0.483	0.025	0.155	0.180

All costs in Mill € 2003 values

One final step remains: If we have determined the number of injured persons, we need an appropriate value quantity for monetarisation purposes. As we do not consider severely and minor injured persons separately, we have to calculate a weighted average of social costs per person injured.

From available sources it was possible to determine the proportion of minor injured persons among all injured persons (excluding persons killed) for several countries:

Austria	0.85 (2001)
Denmark	0.55 (2001)
Germany	0.81 (2001)
Slovenia	0.73 (2001)
Sweden	0.80 (2000) (share in accidents)
Switzerland	0.76 (2001)

Thus, the monetary value of a single severely and minor injured person may, for instance, be weighted by 0.75 and 0.25, respectively. Using these weights, it is easy to obtain the required social costs per person injured (irrespective of injury severity).

<u>Assessment of the sub-section's impact on traffic safety</u>
In order to quantify the impact on traffic safety of each infrastructure sub-section, it is necessary to calculate total vehicle mileage estimates by road type (motorway, other roads) by multiplying total link lengths by average traffic volumes. These traffic volumes have to be derived for both the "with" and "without" case. The results of this step are differences in traffic volumes for each road type and, finally, after multiplication of mileage totals by accident rates differences in absolute numbers of casualties.

The procedure may be illustrated by a simple example:
We consider a new motorway having a length of 10 km. The total length of all other roads existing in the study area is assumed to be 100 km. Let the average traffic volume on these "other roads" be 1000 vehicle per day. Under these assumptions estimated total annual vehicle mileage on the existing road network is 36.5 million vehicle km per year. After completion of the sub-section let the average vehicle volume be 2000 vehicles per day for the motorway and 800 vehicle per day for all other roads. (The sum of vehicle km per year is the same as in the situation without the sub-section, since we do not take induced traffic into consideration.) Furthermore, we assume a fatality rate on motorways of 4.0 (fatalities per million vehicle km) and a fatality rate on other roads of 6.0 (fatalities per million vehicle km).
With these figures we can obtain the following numerical results:

(a) Without the sub-section: *other roads*
36,5 million vehicle km * 6.0 = 219 fatalities per year

(b) With the sub-section: *motorway*
7,3 million vehicle km * 4.0 = 29 fatalities per year

other roads
29.2 million vehicle km * 6,0 = 175 fatalities per year

The difference between the situation “without” and “with” the sub-section in our simple example amounts to 15 fatalities. This means that the motorway sub-section will reduce the annual number of persons killed by 15. Continuation of the example.

Let us expand the little example with the second type of accident: injury accidents.

Assume: 40 injury accident rate per million vehicle km on motorways and
60 injury accident rate per million vehicle km on other roads.

Without implementation of the sub-section we calculate with

36.5 * 60 = 2190 injury accidents on other roads,

with the sub-section

7.3 * 40 = 292 injury accidents on motorways and
29.2 * 60 = 1752 injury accidents on other roads.

The result is an estimated 2190 injury accidents without and 2044 injury accidents with implementation of the sub-section. The difference is 146 injury accidents.

Further we assume that the sub-section is located in Austria.
Here we have a ratio between (only) injured persons and injury accident of 1,301. With this rate it is possible to calculate the injured persons. Multiplying the reduced 146 accidents with 1,301 yields 190 injured persons less, as a consequence of carrying out the new sub-section.

If we presume a ratio of 75% minor and 25% seriously injured persons we get
- 47.5 seriously injured persons and
- 142.5 minor injured persons.

That means, in this example we can estimate the impact of the regarded sub-section on road safety with the values (see table 6 and previous text) for Austria:

fatalities:	15 * 2.513 M€	= 37.70
serious injuries:	47.5 * 0.454 M€	= 21.57
minor injuries:	142.5 * 0.170 M€	= 24.23
total:		83.50

The final result in this example, in terms of reducing road accidents, is 83.50 million Euro per year.

3.4.3 Investment cost

Indicator 8: Total project cost

The "estimated cost" is calculated taking into account the sub-section's "magnitude" (e.g. length for linear infrastructures) and average costs per unit (e.g. km).

The following sources have been taken into account to estimate "standard" average unit costs:

- Planco Consulting et al., *TEN-INVEST Final Report*, January 2002
- BSL Management Consultants, R+R Burger und Partner, *INFRACOST – The cost of railway infrastructure – Final Report*, on behalf of the UIC – Infrastructure Commission, June 2002

The countries have been grouped in cluster of countries having a roughly similar situation in terms of construction costs. For each cluster, average unit costs per type of infrastructure have been estimated.

Table 3.24 *Project "standard" average cost per km*

			ROAD (Meuro)		RAIL (Meuro)				INLAND WATERWAYS (Meuro)			
	COUNTRIES		New 4L	Upgrading	New HS	New T	New B	Upgrade	D and W	Oth upgr m	EN LO	N LO
Group 1 MS	Austria	A	10,25	4,79	24,63	60,86	45,65	12,32	1,08	1,50	0,85	131,79
	Belgium	B	10,25	4,79	24,63	60,86	45,65	12,32	1,08	1,50	0,85	131,79
	France	F	10,25	4,79	24,63	60,86	45,65	12,32	1,08	1,50	0,85	131,79
	Germany	D	10,25	4,79	24,63	60,86	45,65	12,32	1,08	1,50	0,85	131,79
	Luxembourg	LUX	10,25	4,79	24,63	60,86	45,65	12,32	1,08	1,50	0,85	131,79
	Netherlands	NL	10,25	4,79	24,63	60,86	45,65	12,32	1,08	1,50	0,85	131,79
Group 2 MS	Spain	E	3,39	2,49	4,56	11,26	8,44	2,28	1,08	1,50	0,85	131,79
	Portugal	P	3,39	2,49	4,56	11,26	8,44	2,28	1,08	1,50	0,85	131,79
	Italy	I	3,39	2,49	4,56	11,26	8,44	2,28	1,08	1,50	0,85	131,79
	Greece	EL	3,39	2,49	4,56	11,26	8,44	2,28	1,08	1,50	0,85	131,79
Group 3 MS	Denmark	DK	5,83	1,29	8,04	19,85	14,89	4,02	1,08	1,50	0,85	131,79
	Sweden	S	5,83	1,29	8,04	19,85	14,89	4,02	1,08	1,50	0,85	131,79
	Finland	FIN	5,83	1,29	8,04	19,85	14,89	4,02	1,08	1,50	0,85	131,79
	UK	UK	5,83	1,29	8,04	19,85	14,89	4,02	1,08	1,50	0,85	131,79
	Ireland	IRL	5,83	1,29	8,04	19,85	14,89	4,02	1,08	1,50	0,85	131,79
Group 1 AC	Bulgaria	BG	2,07	2,42	1,72	4,25	3,19	0,86	0,16	0,22	0,82	1,79
	Romania	RO	2,07	2,42	1,72	4,25	3,19	0,86	0,16	0,22	0,82	1,79
	Malta	M	2,07	2,42	1,72	4,25	3,19	0,86	0,16	0,22	0,82	1,79
	Cyprus	C	2,07	2,42	1,72	4,25	3,19	0,86	0,16	0,22	0,82	1,79
Group 2 AC	Lithuania	LT	4,41	0,85	2,32	5,72	4,29	1,16	0,16	0,22	0,82	1,79
	Estonia	EE	4,41	0,85	2,32	5,72	4,29	1,16	0,16	0,22	0,82	1,79
	Latvia	LV	4,41	0,85	2,32	5,72	4,29	1,16	0,16	0,22	0,82	1,79
	Poland	PL	4,41	0,85	2,32	5,72	4,29	1,16	0,16	0,22	0,82	1,79
	Czech Republic	CZ	4,41	0,85	2,32	5,72	4,29	1,16	0,16	0,22	0,82	1,79
Group 3 AC	Slovakia	SK	8,57	4,28	1,12	2,77	2,08	0,56	0,16	0,22	0,82	1,79
	Slovenia	SI	8,57	4,28	1,12	2,77	2,08	0,56	0,16	0,22	0,82	1,79
	Hungary	HU	8,57	4,28	1,12	2,77	2,08	0,56	0,16	0,22	0,82	1,79

New 4L = new four lanes' motorway
New HS = new high-speed line
New T = new tunnel
New B = new bridge
D and W = deepening and widening
Oth upgr m = other uograding measures
EN LO = enlargement of locks
N LO = new lock

On the basis of the available information[9] on the sub-sections' nature (type of infrastructure) and extension (length in km), an "estimated cost" has been calculated, and then compared with the sub-section's actual cost as stated in the available sources (Van Miert Report and updates received from the Commission).

The ratio between the actual cost and the "estimated cost" is approximately equal to 1, in case the sub-section is "in line with typical expenditure for that kind of infrastructure in the involved countries. Ratios significantly higher than 1 indicates (relatively) expensive sub-sections, while ratios lower than 1 signify "low price" sub-sections with respect to similar works. Of course, the explanation of a ratio higher than 1 can be various (high percentage of infrastructure lying in areas where the costs increase, such as urban areas, areas with ground requiring particular preparation, drainage, etc.), so that a "bad" ratio does not imply automatically that a negative sub-section's assessment. Besides, the length of the sub-section is not always the best indicator of the sub-section's magnitude and complexity. Thus, the ratio has to be interpreted as an indicator for pointing out sub-sections requiring particular attention in terms of construction costs.

3.4.4 General transport relevance

Indicator 10: Total passenger traffic on the sub-section

The total passenger transport volume is a direct output from the assignment stage of transport modelling and is available at link level.

[9] Information received from the Commission as communicated by the Member States.

For calculating the passenger traffic volume at the level of a sub-section, $\overline{TV}^{p}_{pass}$, following formula is applied:

$$\overline{TV}^{p}_{passt} = \frac{\sum_i l_i \cdot TV_i^{pass}}{\sum_i l_i}$$

where

l_i	length of link i belonging to sub-section p
TV_i^{pass}	total passenger transport volume on link i belonging to sub-section p

Indicator 11: Total freight traffic on the sub-section

The total freight transport volume is a direct output from the assignment stage of transport modelling and is available at link level. The maximum freight traffic volume (indicator 11A) on a sub-section, $TV\max^{p}_{freight}$, can be derived as follows:

$$TV\max^{p}_{freight} = Max_i(TV_i^{freight})$$

Similar as for passenger, the freight traffic volume (indicator 11B) at sub-section level, $\overline{TV}^{p}_{freight}$, is calculated as follows:

$$\overline{TV}^{p}_{freight} = \frac{\sum_i l_i \cdot TV_i^{freight}}{\sum_i l_i}$$

Indicator 11c, the total freight traffic volume on a sub-section ($TV^{p}_{freight}$), can be calculated by the following formula:

$$TV^{p}_{freight} = \sum_i l_i \cdot TV_i^{freight}$$

where

l_i	length of link i belonging to sub-section p
$TV_i^{freight}$	total freight transport volume on link i belonging to sub-section p

Indicator 12: Qualitative appraisal of the sub-section's contribution for an intermodal transport system

Indicators for the sub-section's contribution for an intermodal transport system are:

- Size of the shift in freight transport either in volumes or ton kilometre. Determined by changes measured before (t0) and after (t1) sub-section realisation

E.g. in volumes for each mode (similar formulae for transport performance data):

TV-freight (t1)-TV freight (t0);
TV-passengers (t1)-TV-passengers (t0);

(TV-total volumes)

- Time differences for standardised transports before (t0) and after (t1) sub-section realisation (also for freight and passengers) for the different transport modes

TT- freight (t1)-TT freight (t0)
TT-passenger(t1)-TT passenger (t0)

(TT=transport time for standard O/D's)

Alternatively the indicators may be expressed as percentage reduction instead of differences.

3.4.5 Creation of European value added

Indicator 13: Share of international passenger traffic on total traffic on the sub-section

The share of international passenger traffic on a sub-section p, $\overline{IS}^{p}_{pass}$, is calculated as follows:

$$\overline{IS}^{p}_{pass} = \frac{\overline{TVI}_{i}^{pass}}{\overline{TV}_{i}^{pass}},$$

with $\overline{TVI}^{p}_{pass} = \frac{\sum_i l_i \cdot TVI_i^{pass}}{\sum_i l_i}$ and $\overline{TV}^{p}_{pass} = \frac{\sum_i l_i \cdot TV_i^{pass}}{\sum_i l_i}$

where

l_i	length of link i belonging to sub-section p
$\overline{TV}_{p}^{pass}$	total passenger transport volume on sub-section p

$\overline{TVI}_p^{pass}$	international passenger transport volume on sub-section p
TVI_i^{pass}	international passenger transport volume on link i belonging to sub-section p
TV_i^{pass}	total passenger transport volume on link i belonging to sub-section p

Indicator 14: Volume of international passenger traffic on the sub-section

The volume of international passenger traffic on a sub-section p, $\overline{TVI}_{pass}^{p}$, is calculated as follows:

$$\overline{TVI}_{pass}^{p} = \frac{\sum_i l_i \cdot TVI_i^{pass}}{\sum_i l_i}$$

where

l_i	length of link i belonging to sub-section p
TVI_i^{pass}	international passenger transport volume on link i belonging to sub-section p

With this approach for calculating the average traffic load, the transport volume on a link is weighted by the link's length and therefore with its significance for the priority project in terms of scope of geographical extension.

Indicator 15: Share of international freight traffic on total traffic on the sub-section

The share of international freight traffic on a sub-section p, $\overline{IS}_{freight}^{p}$, is calculated as follows:

$$\overline{IS}_{freight}^{p} = \frac{\overline{TVI}_i^{freight}}{\overline{TV}_i^{freight}},$$

with $\overline{TVI}_{freight}^{p} = \frac{\sum_i l_i \cdot TVI_i^{freight}}{\sum_i l_i}$ and $\overline{TV}_{freight}^{p} = \frac{\sum_i l_i \cdot TV_i^{freight}}{\sum_i l_i}$

where

l_i	length of link i belonging to sub-section p
$\overline{TV}_p^{freight}$	total freight transport volume on sub-section p
$\overline{TVI}_p^{freight}$	international freight transport volume on sub-section p
$TVI_i^{freight}$	international freight transport volume on link i belonging to sub-section p

$TV_i^{freight}$ total freight transport volume on link i belonging to sub-section p

Indicator 16: Volume of international freight traffic on the sub-section

The volume of international freight traffic on a sub-section p, $\overline{TVI}^{p}_{freight}$, is calculated as follows:

$$\overline{TVI}^{p}_{freight} = \frac{\sum_i l_i \cdot TVI_i^{freight}}{\sum_i l_i}$$

where

l_i length of link i belonging to sub-section p

$TVI_i^{freight}$ freight transport volume on link i belonging to sub-section p

With this approach for calculating the average traffic load, the transport volume on a link is weighted by the link's length and therefore with its significance for the priority project in terms of scope of geographical extension.

Indicator 17: Reduction of passengers waiting time at borders for international traffic

The reduction of waiting time at borders has been in the past directly related with the implementation of HST networks and motorways network in Europe: with construction of new infrastructures and implementation of new operating systems at borders waiting time has been considerably reduced between EU countries.

This reduction was indeed an important argument to develop such international sub-sections: there was a risk that the time gained with the implementation of expensive sub-sections could appear modest with regard to the time lost for cross border formalities. This argument has also been frequently used in relation with CEEC countries in order to stimulate facilitation procedures at borders.

To this general context one must also take measures that are taken for "free movement" of passengers within EU in order to comply with the European Treaty independently of infrastructure sub-sections into account; TEN T policy also illustrated objectives of cohesion and construction of a single market for freight, passengers and working forces.

In a more general way it is possible to assume that, at the horizon 2007 and beyond, which the period considered for selection of the sub-sections within TEN STAC, all the countries concerned by the 22 TEN priority projects will be members states including Bulgaria and Romania for which "membership" is expected to take place in 2007.

Consequently and according to the EU agreements and implementation of "acquis communautaires" all these countries must:

- Confirm to Schengen agreement toward free moment of freight and passengers.
- To adapt cross border equipment and procedures according to expected norms of quality, capacity and technicity.

If the application of such agreements does not fully guarantee that all problems of capacity connectivity, interoperability will be solved, the achievement of TEN priority projects will be solved, the achievement of TEN priority project will contribute for the period 2007-2020 to bring the guarantee that waiting time between EU countries will considerably diminish and almost disappear on main corridors of Europe.

An important remaining problem is however the question of waiting time at borders between EU countries and non EU countries: CIS, Mediterranean countries, Balkans and probably sometimes for Turkey, as well as other countries in the world when passengers arrive at main airports.

For these border points waiting time has not reduced and sometimes have even increased due to new security measures; for air transport waiting time has increased for external as well as for internal flights, between EU countries and even within countries.

This factor must also be taken into account for air and maritime passenger traffic, being aware that this waiting time for security has been limited so far for crossing tunnels such as the Channel Tunnel.

Indicator 18: Reduction of freight waiting time at borders for international traffic
It is difficult to give an estimation for cross border time for freight at the horizon 2020.

However, few general remarks can be made about the evolution of cross border time for freight within EU and between EU and non EU countries.

For road, border crossing time within the EU should be null, as it is now within the Schengen zone; when some controls are implemented it is more for control of illegal immigration and not security reasons. Increased security measures in ports or before entering tunnels are not intrinsically related to the crossing of the border.

For rail the problem is more complex, because of interoperability problems which characterise rail operations for crossing border points.Today it is difficult to give an estimation of time spent for crossing the border, because this will depend on the ability to solve these different interoperability problems:

- interoperability of locomotives
- interoperability of drivers
- different systems of control command
- eventually different gauges.

To these specific reasons one can also add the fact that rail marshalling operations are in general organised from a national perspective, which tends to marshal trains before and after the border, creating a multiplication of such operations along the routes, and thus increasing time and cost of transport as well as difficulties for tracking and tracing with additional risk for reliability of services. Therefore, it is not rare to evaluate border crossing time to at least 4 hours for trains when adding all these problems.

However, there is a tendency to organise train operations along the main axis, and in particular along the main international axis with interoperable locomotives and training for drivers; interoperability of control command will be improved for freight as it is already the case for High Speed Trains as shown with results of ERTMS application.

Furthermore new entrants often propose to operate trains along axis, direct trains and shuttle trains, which improve interoperability, limiting crossing time at the borders. In parallel document exchanges and customs control adapt to a rail system without stops at the borders.

From this perspective, major flows along the main European axis should not be penalised in the future by waiting time at the border and from this point of view, rail should be put progressively at an equal level with road.

The only remaining major problem would than be the change of gauge and eventually changes at border between electric and diesel traction: changing locomotive and driver could take up more than two hours if not well organised; but one could presume that the main freight corridors in Europe should be electrified.

Concerning the difference of gauge, the major problem within Europe is the crossing of Spanish borders: Spain is developing a European gauge network for HST, but this network is not designed for freight. In other words, the construction of new HST lines will certainly provide more capacity for freight on existing lines, and therefore increase time performances of rail freight within Spain. But, in this case, transhipment or change of wagon axes will remain necessary at the border; only light freight trains will be able to use the new high speed network. If, at present, such operations take up variable time between 4 and 12 hours, one can think that such an operation in the future will not exceed 2 hours.

Indicator 19: Length of networks becoming interoperable because of the sub-section
This indicator was already included among those the Member States had to give within the project fiches.

A sub-section improves the interoperability in case:

a) it eliminates the differences of rail gauge (e.g. the Spain interoperability sub-sections)
b) it eliminates the differences in terms of voltage and (more in general) allows full interoperability of traction engines among different networks (two rail networks with same voltage do not imply automatically locomotive interoperability, because of non-harmonisation of, for instance, cab signalling, pantographs geometry, etc.)
c) it eliminates differences in terms of tunnel gauges
d) possible other reasons

Of course (b) is more often obtained as an effect of multiple voltage locomotive. In this case, the interoperability has not to be considered as an effect of the infrastructure project.

The assessment is carried out by the following steps:

1) identify the sub-sections that improve the interoperability, specifying whether it is because a, b, c or d
2) estimate the kilometres of interoperable network created. This should be done according to a "normalised" approach, thus to consider the net increase of interoperable network, i.e. the sub-section itself alone, even if this is restrictive.

3.4.6 Improvement of accessibility

For the assessment of centrality of peripheral regions and cohesion the TEN-STAC centrality indicators are applied, which refer to passenger and freight transport:

The *TEN-STAC centrality indicator for passenger transport* has been defined as follows: The centrality C of region i C_i^{pass}, in relation to passenger transport, is estimated by the following formula:

$$C_i^{pass} = \sum_j Pop_j \cdot e^{\beta \cdot \min\{t_{road}(i,j),\, t_{rail}(i,j)\}} \qquad i \neq j$$

with

Pop_j	number of inhabitants in region j (forecast for 2020)
t_{rail}	potential passenger transport time between region i and region j by rail
t_{road}	potential passenger transport time between i and j by road

The model parameter β has been chosen such that following condition is fulfilled:

$$e^{\beta \cdot T} = 0.5$$

The variable T can be interpreted as "half life period", i.e. that period of time, in which the impact of accessible GDP or number of accessible inhabitants decreases by 50%, if the travel or transport time amounts to T. For passenger transport, the T was set to 180 minutes.

The *TEN-STAC centrality indicator for freight transport* has been defined as follows: The centrality C of region i $C_i^{freight}$, for freight transport is estimated by following formula:

$$C_i^{freight} = \sum_j GDP_j \cdot e^{\beta \cdot \min\{t_{road}(i,j), t_{rail}(i,j)\}} \qquad i \neq j$$

with

GDP_j	Gross Domestic Product in region j (forecast for 2020)
t_{rail}	generalised freight transport costs between region i and region j by rail
t_{road}	generalised freight transport costs between i and j by road

Like for the centrality indicator for passenger transport the model parameter β has been chosen such that following condition is fulfilled:

$$e^{\beta \cdot T} = 0.5$$

Indicator 20: Variation of the STAC centrality index for passenger transport

The methodology for this criterion is exactly the same as illustrated in the previous paragraph, – the only difference is that it relates only to relatively low developed regions, i. e. to those NUTS 2 regions, whose GDP per capita value is at least 25 percent below the European average or which belong to the Eligible Regions for Structural Funds ("Objective 1 regions") for the period of time between 2014 and 2020.[10] The set of NUTS 2 regions considered for the cohesion indicator is documented in the Annex.

The relative change in passenger centrality, CC_{ld}^{pass}, is calculated by summing up the centrality values for all relatively low developed regions ($i \in L$) and by calculating the relative change under the assumption that the sub-section is realised in comparison to the situation without realisation:

$$CC_{ld}^{pass} = \frac{\sum_i \left((C_i^{pass})^{w} - (C_i^{pass})^{wo} \right)}{\sum_i (C_i^{pass})^{wo}} \quad \text{with } i \in L$$

[10] See http://europa.eu.int/comm/regional_policy/objective1/map_en.htm

where

$(C_i^{pass})^w$	passenger transport centrality in region i, with realisation of the sub-section
$(C_i^{pass})^{wo}$	passenger transport centrality in region i, without realisation of the sub-section
L	set of relatively low developed NUTS 2 regions

Indicator 21: Impacts Variation of the STAC centrality index for freight transport
As for passenger transport, the TEN-STAC centrality indicator for freight transport is applied to relatively low developed NUTS 2 regions, according to the definition above.

The relative change in freight centrality, $CC_{ld}^{freight}$, is calculated by summing up the centrality values for all peripheral regions ($i \in L$) and by calculating the relative change under the assumption that the sub-section is realised in comparison to the situation without realisation:

$$CC_{ld}^{freight} = \frac{\sum_i \left((\mathrm{C}_\mathrm{i}^\mathrm{freight})^w - (\mathrm{C}_\mathrm{i}^\mathrm{freight})^{wo} \right)}{\sum_i (\mathrm{C}_\mathrm{i}^\mathrm{freight})^{wo}} \quad \text{with } i \in L$$

where

$(C_i^{freight})^w$	freight transport centrality in region i, with realisation of the sub-section
$(C_i^{freight})^{wo}$	freight transport centrality in region i, without realisation of the sub-section
L	set of relatively low developed NUTS 2 regions

Indicator 22: Impacts on centrality of peripheral regions – passenger transport
For this impact criterion the TEN-STAC centrality indicator is applied for all NUTS 2 regions that are considered as peripheral: The threshold for labelling a region “peripheral” is oriented on the approach in TEN-STAC phase I; hence it embraces all regions whose centrality is at least 50 percent under the European average (see Figure 3.37).
The relative change in passenger centrality, CC_{periph}^{pass}, is calculated by summing up the centrality values for all peripheral regions ($i \in P$) and by calculating the relative change under the assumption that the sub-section is realised in comparison to the situation without realisation:

$$CC_{periph}^{pass} = \frac{\sum_i \left((\mathrm{C}_\mathrm{i}^\mathrm{pass})^w - (\mathrm{C}_\mathrm{i}^\mathrm{pass})^{wo} \right)}{\sum_i (\mathrm{C}_\mathrm{i}^\mathrm{pass})^{wo}} \quad \text{with } i \in P$$

where

$(C_i^{pass})^w$	passenger transport centrality in region I, with realisation of the sub-section
$(C_i^{pass})^{wo}$	passenger transport centrality in region I, without realisation of the sub-section
P	set of peripheral regions

Indicator 23: Impacts on centrality of peripheral regions – freight transport
According to the approach for passenger transport, the approach for freight transport refers to all regions whose centrality is at least 50 percent under the European average (see Figure 3.37).

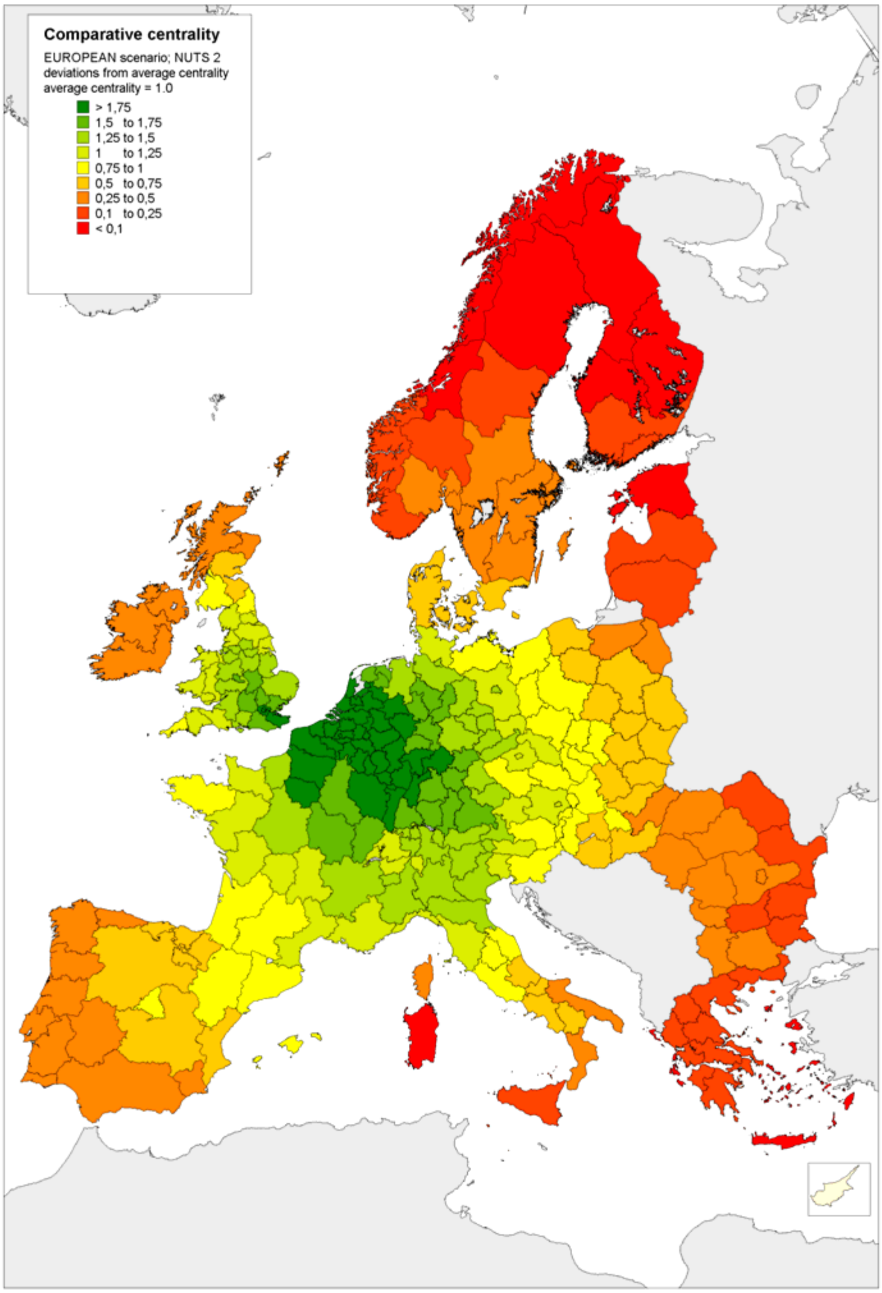
The relative change in freight centrality, $CC_{periph}^{freight}$, is calculated by summing up the centrality values for all peripheral regions ($i \in P$) and by calculating the relative change under the assumption that the sub-section is realised in comparison to the situation without realisation:

$$CC_{periph}^{freight} = \frac{\sum_i \left((\mathrm{C}_\mathrm{i}^{\mathrm{freight}})^w - (\mathrm{C}_\mathrm{i}^{\mathrm{freight}})^{wo} \right)}{\sum_i (\mathrm{C}_\mathrm{i}^{\mathrm{freight}})^{wo}} \quad \text{with } i \in P$$

where

$(C_i^{freight})^w$	freight transport centrality in region i, with realisation of the sub-section
$(C_i^{freight})^{wo}$	freight transport centrality in region i, without realisation of the sub-section
P	set of peripheral regions

Figure 3.37 *Deviations from average centrality (TEN-STAC Deliverable D3)*



3.4.7 Environmental sustainability (non-monetised impacts)

Indicator 24: Volume of road freight traffic shifted to rail, IWW or sea transport

Volume of traffic flows shifted for each mode is automatically estimated in the model split model run for each sub-section. The volume of road traffic shifted to sea transport is estimated in the framework of priority project P21 ‘Motorways of the sea’.

The estimation of the modal shift model is done at the level of the priority projects when the realisation of all sub-sections is foreseen. A special procedure has been developed by type of priority project, to identify the volume of road traffic shifted by each sub-section of the priority project, as described hereunder.

In case of a rail priority project when road and inland waterways LOS remains unchanged the following modal shifts are identified:

- road to rail;
- inland waterways to rail.

In case of a rail priority project when road and/or inland waterways LOS also changes the following modal shifts are identified:

- total modal shift road;
- total modal shift rail.

In case of a road priority project when road and inland waterways LOS remains unchanged the following modal shifts are identified:

- rail to road;
- inland waterways to road.

In case of the inland waterways priority project P18 the following modal shifts are identified:

- rail to inland waterways;
- road to inland waterways.

In case of the motorways of the sea priority project P21 the modal shift road to sea is identified.

Indicator 25: Volume of road and air passenger traffic shifted to rail

The estimation of a sub-section’s impact on the volume of road and air passenger traffic shifted to rail, is based on the exercise, in which the O/D relations routed via a certain sub-section are re-traced.

The volume of road and air passenger traffic shifted to rail caused by a realisation of sub-section i on priority project j, $TVS_{i,j}$, is estimated by following formula:

$$TVS_{i,j} = (TV^{i}_{road})^{ref} + (TV^{i}_{air})^{ref} - (TV^{i}_{road})^{j} - (TV^{i}_{air})^{j}$$

where

$(TV^{i}_{road})^{ref}$	road passenger transport volume caused by O/D flows routed via sub-section i in the network of the reference scenario (pass*km)
$(TV^{i}_{air})^{ref}$	air passenger transport volume caused by O/D flows relevant for sub-section i in the network of the reference scenario (pass*km)
$(TV^{i}_{road})^{j}$	road passenger transport volume caused by O/D flows routed via sub-section i in the network under the assumption that priority project j is realised (pass*km)
$(TV^{i}_{air})^{j}$	air passenger transport volume caused by O/D flows relevant for sub-section i in the network under the assumption that priority project j is realised (pass*km)

Indicator 26: Level of Concern: Traffic transfer

The traffic transfer indicator is defined as the likely resulting transfer of vehicle km transferred from existing road infrastructure to new road infrastructure further away from or closer to an SPA.

The traffic transfer indicator is based on a function of i) traffic flows in the reference 2 scenario and the project scenario and ii) proximity to SPAs.

Methodology:

The traffic transfer indicator will be calculated based on the traffic flows at link level for the reference 2 scenario and the project scenario compared with the location of SPAs.
Based on an over layering of the mapping material produced in Phase I representing a simplified (highly aggregated) map of natural zones (raster 10x10 km) - elaborated by NESTEAR and the latest mapping material of existing infrastructure and relevant Phase II priority projects - it is possible to identify what links are lying within or in the proximity of an SPA, select these links and sum up the difference in traffic flows (passenger/year, tones/year); i.e. project scenario minus reference 2 scenario. For this operation the average traffic flow is estimated as: sum on all links (Flow per link x link length) / (total length) for each sub-section.

Output
The output is an indicator containing the percentage changes in passengers and freight (in tonnes) transported through infrastructures located within or in the proximity of SPA's as in the reference scenario compared to the project scenario.
Thus, the score of the likely environmental impact of proposed sub-sections is a relative score compared to the reference scenario.

Indicator 27: Level of Concern: Distance
The distance indicator is defined as the distance (% length) of the planned infrastructure located within a SPAs.

Data on the likely impact on SPAs at Project Level
The assessment of the likely environmental impact of proposed sub-sections on SPAs is based on a function of i) proximity and ii) distance. i.e.:

- ad i) the share of the proposed sub-section that will be located inside or in the proximity of the SPA, compared with the total area of the SPA, where proximity is defined in terms of three distance bands surrounding the SPA: 0-500 m, 500-1000 m and 1000-2000 m distance band around the SPA); and
- ad ii) the percentage length of the proposed sub-section infrastructure located within the SPA and/or within the defined distance bands of the SPA, compared to the total length of the infrastructure sub-section.

Methodology:
By analysing the result of over-layering the two data sets, it was possible to identify where a proposed sub-section infrastructure is located within the SPA, or in one or more of the three sensitivity zones surrounding the SPAs (i.e. 0-500 m, 500 - 1000 m, and 1000 - 2000 m).

Since the likely environmental impact does not proportionally decrease with increased distance, but exponentially, weighting of impact within the three distance bands is set to: 2 within the 0-500 m distance band, 1 within the 500-1000 m band and 0.5 within the 1000 - 2000 m band. The weight allocated to a location within the SPA is set to 10.

Table 3.25 *Risk matrix for impact on SPAs*

Project infrastructure distance from the SPA	Weight factor (w)
Inside SPA	10
500 metres and less	2
500 – 1000 metres	1
1000 – 2000 metres	0.5

The scoring within the four categories is multiplied with length of the infrastructure for each category and aggregated as one indicator.

Output

Thus, the score of the likely environmental impact of a specific proposed sub-section will be a relative score of the likely environmental impact of the individual sub-sections on the SPA's.

Indicator 28: Level of Concern: Emissions

The *emissions indicator* is defined as changes in emissions (ton/year/link) to which inhabitants living in the proximity to planned infrastructure are exposed if the planned infrastructure is implemented. Here, proximity is defined as three distance bands on each side of the sub-section: 0-500 m, 500-1000 m and 1000-2000 m, totalling a 1000m, a 2000m, and a 4000m broad zone around the sub-section infrastructure. The emission indicator only includes emissions from road traffic sub-sections, as it does not make sense to consider rail air emissions from (electrified) rail traffic, as emissions are at locations different from the infrastructure location where the trains run.

Due to the high number of sub-sections, the likely environmental impact of the proposed sub-sections will not as such be assessed, as this would require specific information at local level; such as likely impacts on inhabitants, where the distribution on various population groups and the number and location of buildings affected by the sub-section; and such as likely impacts on SPAs the criteria for designating the areas under Directives 79/409/EEC and 92/43/EC, as well as the areas covered by the Alpine Convention. This information has been deemed far too detailed vis-à-vis the resources allocated for task 3.3.

Data on the likely impact on inhabitants at Project Level

The assessment of environmental impact of the proposed sub-sections on inhabitants will be based on an interpolation of data on i) number of inhabitants, ii) proximity and iii) emissions.

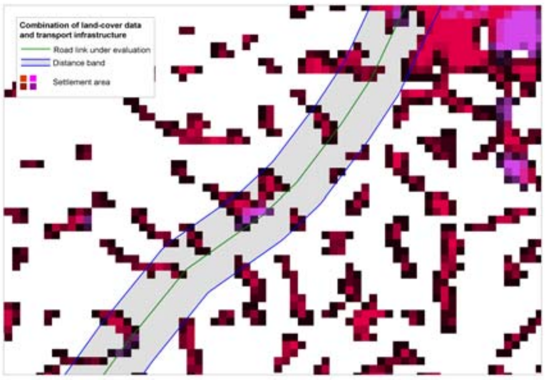
The assessment is included in order to capture the likely environmental impact that the proposed sub-sections may have on people living close to the sub-sections. Population data is presented in defined distance bands relative to the location of the proposed sub-section, and related to change in emissions caused by the implementation of the planned sub-sections.

Methodology:

For the assessment of the impact on population, information from the CORINE[11] landcover database interpolated with data on the number of inhabitants at NUTS 3 level. With the population spatially distributed to grids (250m x 250m grids) the information on spatial vicinity of road links to inhabitants may be measured. For this indicator, the number of inhabitants is calculated within three distance bands: 0-500 metre from the infrastructure, 500-1000 metre from the infrastructure and 1000-2000 metre from the infrastructure.

Figure 3.38 illustrates this approach by showing a 2000-metres distance band along a road link crossing settlement areas.

Figure 3.38 *Crossing of road infrastructure with settlement areas*



By taking characteristics of spreading of air emissions in air and relating this information to the information on spatial vicinity of road links to inhabitants into account, a risk matrix for exposure of inhabitants to road traffic emissions is developed.

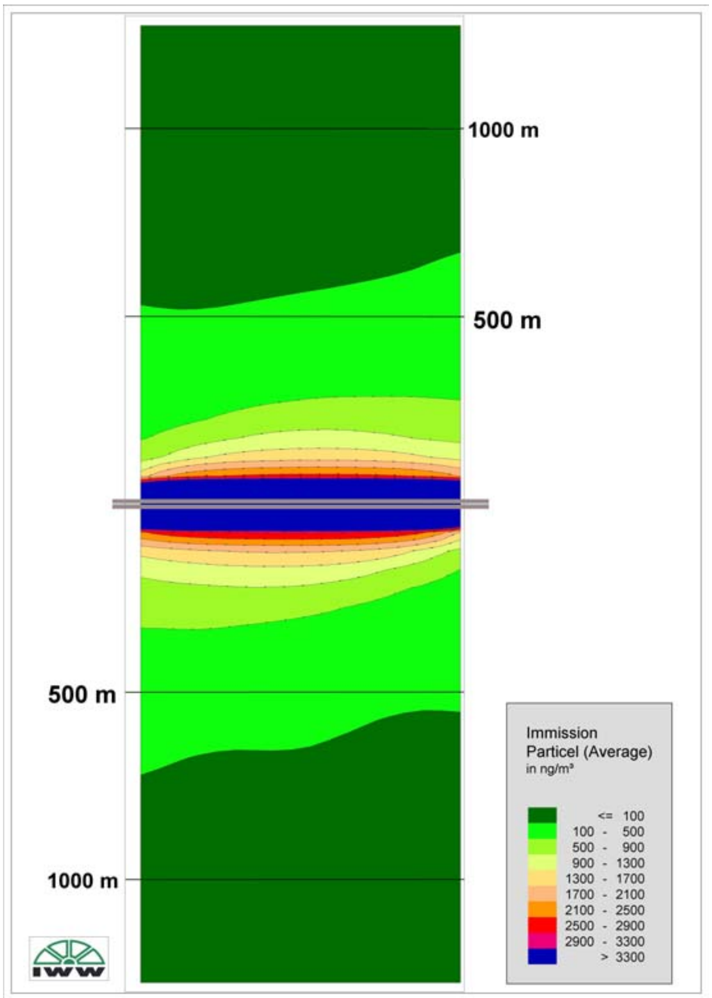
A true picture of impact from air pollution within the three distance bands requires a recalculation from emissions to imissions. However, such calculations require detailed knowledge of climatic and topographical conditions with regard to all links of a sub-section, which is difficult to obtain within this project. Such a calculation is deemed more relevant in a subsequent EIA of the sub-sections in question.

Instead, taking into account the characteristics of spreading of air emissions in air, a risk matrix for exposure of inhabitants to air pollution within the three distance bands is developed. The application of distance bands makes it necessary to weigh the importance of each distance band in the united indicator.

The concentration of traffic imissions does not decrease proportionally with the distance from the location of generation of emissions, but rather exponentially, as illustrated by Figure 3.39

[11] CORINE: Co-ordination on Information of the Environment

Figure 3.39 *Dispersion pattern of particulates as a function of distance from the road link*



Taking into account the dispersion pattern of pollutants, the weighting within the three distance bands in the risk matrix is set to: 20 within a 0-500 m distance band, 2 within the 500-1000 m band and 1 within the 1000-2000 m band (see Table 3.26)

Table 3.26 *Risk matrix for exposure of inhabitants to road traffic emissions*

Distance from the road link	**Weight factor (w)**
0 - 500 metres	20
500 – 1000 metres	2
1000 – 2000 metres	1

The indicator will report the percentage changes in emissions to which people are exposed, if the proposed new sub-section infrastructure is implemented, compared to the existing situation.

The calculation of change in emission levels consists in a re-calculation of the emission data calculated in Phase 1 on the two impact indicators: Particulates and NO_x. Whereas in Phase I, the emission data was calculated at network level, in Phase 2, the data will be calculated at sub-section level and reported at NUTS 2 zone level.

The change in level of concern caused by sub-section i, CLC_i, is calculated as follows:

$$CLC_i = \sum_l \sum_k w_k \cdot I_{k,l} \cdot (EL_l^w)^i - \sum_l \sum_k w_k \cdot I_{k,l} \cdot (EL_l^{ref})^i$$

where

$(EV_l^{ref})^i$	emission volume of road particulates on link l, caused by all traffic O/D flows, whose path is routed via sub-section i, under the transport infrastructure assumptions of the reference networks
$(EV_l^w)^i$	emission volume of road particulates on link l, caused by all traffic O/D flows, whose path is routed via sub-section i, under the assumption that all sections on priority project j are realised
w_k	Level-of-concern weight associated with distance class k
$I_{k,l}$	number of inhabitants along road link l in distance class k

In order to avoid double counting, the corrected change in level of concern assigned to sub-section i $(CLC_i)^{corr}$, is estimated according to following formula:

$$(CLC_i)^{corr} = \frac{CLC_i}{\sum_{i(i \in j)} CLC_i} \cdot CLC_j \quad \text{,with} \quad CLC_j = \sum_l \sum_k w_k \cdot I_{k,l} \cdot (EL_l^w)^j - \sum_l \sum_k w_k \cdot I_{k,l} \cdot (EL_l^{ref})$$

where

$(EV_l^w)^j$	emission volume of road particulates on link l, caused by all traffic flows, under the assumption that all sections on priority project j are realised
(EL_l^{ref})	emission volume of road particulates on link l, caused by all traffic flows, under the transport infrastructure assumptions of the reference networks

Output

The output of the population indicator is quantified at sub-section level and reported at NUTS 2 zone level in terms of percentage changes in emissions, if the proposed new sub-section infrastructure is implemented, compared to the existing situation. Assessing changes in exposure of inhabitants to traffic emissions may result in a positive as well as a negative environmental impact. Hence, the score of the likely environmental impact of a specific proposed sub-section will be an *absolute* score of the environmental impact of the individual proposed sub-section.

Indicator 29: Level of Concern: Proximity
The proximity indicator is defined as the share (%) of the SPA affected by the proposed infrastructure located within or in the proximity of the SPA. The sensitivity zones are defined in three distance bands surrounding the SPA: a 0-500m zone, a 500-1000m zone and a 1000-2000m zone. For this indicator, the area of the proposed sub-section infrastructure is calculated adding a 2000m zone on each side of the sub-section infrastructure totalling a 4 km broad band on each side.

3.4.8 Maturity and coherence of the project

Indicator 30: Development of the project
This indicator is a qualitative appraisal of the status of the sub-section in terms of planning and funding. On the basis of the information communicated by the Member States to the Commission during the phase of revision of the TEN-T guidelines, the following evaluation scheme has been applied to each sub-section:

Score	*Planning status*
0	No design studies, no decision on funding
+1	Design studies on going, no decision on funding
+2	Design studies achieved, no decision on funding
+3	Design studies achieved and approved by relevant authorities, no decision on funding
+4	Project ready to start, 100% funding decided
+5	Project ongoing (100% funding available)

“Design studies” include all related documents (e.g. Environmental Impact Assessment).
“Project ready to start” means that all administrative tasks, including launch and closure of the call for tender, have been achieved.

Intermediate situations have been assessed on a case by case basis (e.g. for sub-sections involving more section with different status). Besides, for several the information was not available.

Indicator 31: Institutional soundness
For this qualitative appraisal different aspects will be considered, being aware that the regulatory context, the content, and the process of elaboration of national plans differ very much from one country to another (See D4 Synthesis).

In this qualitative appraisal of sub-sections compliance with national plans, it is important to stress that the procedure itself adopted by the Commission, to identify and select priority priorities that have contributed considerably to improve this compliance with national plans.

In a first phase the former Van Miert group has been constituted with representatives of transport ministries of the countries who have been asked to report about their priorities and to propose sub-sections of European interest that have been analysed within major European corridors for selection in a second phase. This Commission has pursued national contacts and refined a list of TEN-T priorities that has been widely disseminated in the autumn.

Therefore there has been feedbacks between the European Commission and administrations in charge of national planning process, so that consistent positions could be formulated both at national level for interpretation of national priorities and at international level.

The efficiency of these feedbacks has been particularly noticeable in the following points:

- precision of date for launching of the sub-sections and this is particularly true when the Commission defined "quick start sub-sections" which have to start before 2007
- understanding of the international transport needs at national level for foreign trade and transit: as shown in D4, the international transport appraisal is a fairly weak point of most national plans and national planners are after ready to align on European analysis related to European transport.

In many countries the national plan process is fairly flexible and in constant adaptation if not in constant interpretation: this helps the building of compliance between national and European approaches as long as concertation is developed.

For CEEC countries, it has been shown that national plans are most of the time fairly well aligned with European priorities, and that their horizon is rarely beyond 5 or 10 years: therefore the identification of European priorities beyond 2007, should help the adaptation of national plan and therefore solve the question of compliance between national and European approaches[12] more easily.

However, if there is compatibility for the choice of priorities of European interest between national plans and European proposals, a compatibility that seems to have improved in the recent period, details must still be provided for the exact choice of the routes as well as for the coordination to be launched between neighbouring countries for common planning.

Concerning the details of the sub-sections which are important characteristics of the maturity, it has to be stressed that the geocoding constraints of the sub-sections sometimes reveal lack of geographic location information, and continuity options which must be considered, in order to obtain a consistent programming along a corridor.

[12] TINA will complete the contribution for CEEC

The requirements for maturity should imply:

- Availability of information for geographic implementation of the sub-sections along a corridor in a harmonised GIS (although several hypothesis can be proposed in a first phase, the final route being often submitted to public consultation and detailed environmental impact analysis).

In the last period, choices of routes have been proposed for many sub-sections, in particular when documents had to be submitted to the Commission for qualification for these “quick start projects”. This in particular is the case for relation between Portugal and Spain.

- Removal of congestion points in parallel with construction of new infrastructures along a corridor.

Along several corridors major construction investments, such as tunnels under the Alps and Pyrenees, have to be coordinated with removal of bottlenecks along these corridors. If the removal of the bottleneck itself is not necessarily part of the European project, but more part of the national or regional plan, it is nevertheless very important for the improvement of the fluidity along the whole corridor.

In the case of France, for example, the new projects across the Alps and Pyrenees have to be considered in parallel with the removal of the Bordeaux, Nîmes, Lyon and Dijon bottlenecks.

- Planning of infrastructure access to main border crossing European projects.

Several European border crossing projects will be utilised to full capacity only if access projects are planned in parallel: this is the case for the main Alpine and Pyrenean projects, including Swiss projects.

The solution of these problems can only be brought with improvement of coordination between neighbouring countries within their own planning process, in relation to the Commission.

In order to speed up this process, which has also to be considered as an aspect of the “maturity” of a cross border project, the Commission has proposed the nomination of “corridor coordinators”, monitoring of traffic along a corridor and development of a common assessment method between the countries concerned by common projects.

In other words the “maturity” of the European projects has certainly progressed quickly in the recent period, in compliance with national plans, but the realisation of European projects will probably need such an initiative to be taken in order to limit the time necessary between the identification of the “priority” project and the start of the construction.

A final point of maturity is the financial aspect and the convergence of appraisal between the national and European funding analysis: this point is developed in D7.

Therefore, the following qualitative indicators containing the elements described hereunder, is proposed:

1. Assessment of "quick start projects", which has been settled in relation with national representatives.
2. The existence of a detailed description of sub-sections with harmonised geo-references, in order to appraise the spatial consistency of each sub-section in more detail, reflecting the maturity of a project in a corridor (and this would also be the confirmation that first choices of routes have been validated).
3. Assessment of projects or sub-sections that have already been submitted to public consultation within the national planning process (which can be confirmation of the national prioritisation of the projects).
4. Implementation of a coordination structure for the development of the project, such as "Group of European Interest" or "designation of a corridor coordinator" in the near future.
5. Existence of a financial assessment and funding agreement between parties concerned, with explicit contribution of public and private sources at national, regional and European level in particular for rail projects, which are more dependant on public funds.

Indicator 32: Coherence of the project

In order to analyse to which extent priority projects are compatible with main international traffic corridors, a similar 'Buffer analysis' method can be applied (cf. Deliverable 5, chapter 3, page 27).

The use of this operational method can easily illustrate the importance of international traffic expressed in tons of freight and in number of passengers (if existing assignments allow it), as regards to corresponding priority projects. This analysis could also be considered at more detailed level (according to assigned inputs[13]):

- modal level (by using in separate runs corresponding modal assignments (if any): rail, road, air and inland waterways);
- national level (by using corresponding national project inputs).

This new application of the so-called 'buffer zone' method can consider again capture areas highlights considering a bands of 10km of width on every side or around of each one of 22 TEN-T projects, assigned at project level or/and at sub project level (if assigned data allows it). In this context, the global qualitative appraisal of projects with regard to international traffic loads, expressed in 1000 tons, can be easily estimated on the railway network basis and priority

[13] According to existing modal and inter-modal assignments for the moment only railway runs are possible.

railway projects. The appropriate weighting of overlapped areas computed between the 22 priority projects[14] and assigned traffic flows, will constitute appropriate indicator relevance for the global qualitative appraisal of projects as well as for future more precise and detailed quantitative explanation at sub-section level (if assigned traffic data per mode and per modal segment allows it).

[14] Only railway projects can be considered at this stage of the work.

4 ASSESSMENT OF THE REFERENCE SCENARIOS

The main results of the Reference 1 and Reference 2 scenarios at total rail transport demand level and transport performance are shown in Table 4.1.

Table 4.1 *Rail transport demand and transport performance, Reference I and Reference II scenario*

Scenario	Rail transport demand (* mio tonnes)	Rail transport performance EU 27 (* bill Ton-km)
Reference 1		
All flows	1,261	622
International	455	361
Reference 2		
All flows	1,280	632
International	457	364
Difference Reference 2 – Reference 1		
All flows	19	10
International	2	3

The modal shift effect is generated by:

- Changes in the level of service of rail, as a result of the new / up-graded rail infrastructure corresponding to the Reference 2 scenario.
- Accompanying measures for rail which are applied in a similar way as in Phase I, with the difference that they address the domestic and international markets being more international oriented in a different way.
- Changes in the level of service of road as a result of the new / up-graded infrastructure corresponding to reference 2 scenario.

The results of the reference scenarios are shown in Figure 4.1 up to Figure 4.15. These figures include:

- the Reference scenarios 1 and 2 and
- changes in traffic flows as identified between the Reference 2 and Reference 1 scenario.

The effects at the level of the rail network have the highest intensity at the level of priority projects considered in the Reference 2 scenario. However, the effects at the network level are caused by both modal shift to rail and routing effects given by the new, more attractive routes. In the Reference 2 scenario, specific road improvement projects are considered, for example in accession and candidate countries. This results in a shift from rail to road if the increase in the road level of service is not compensated by similar rail projects on specific routes.

Figure 4.1 *Rail passenger flows, total interregional, Reference 1 scenario*

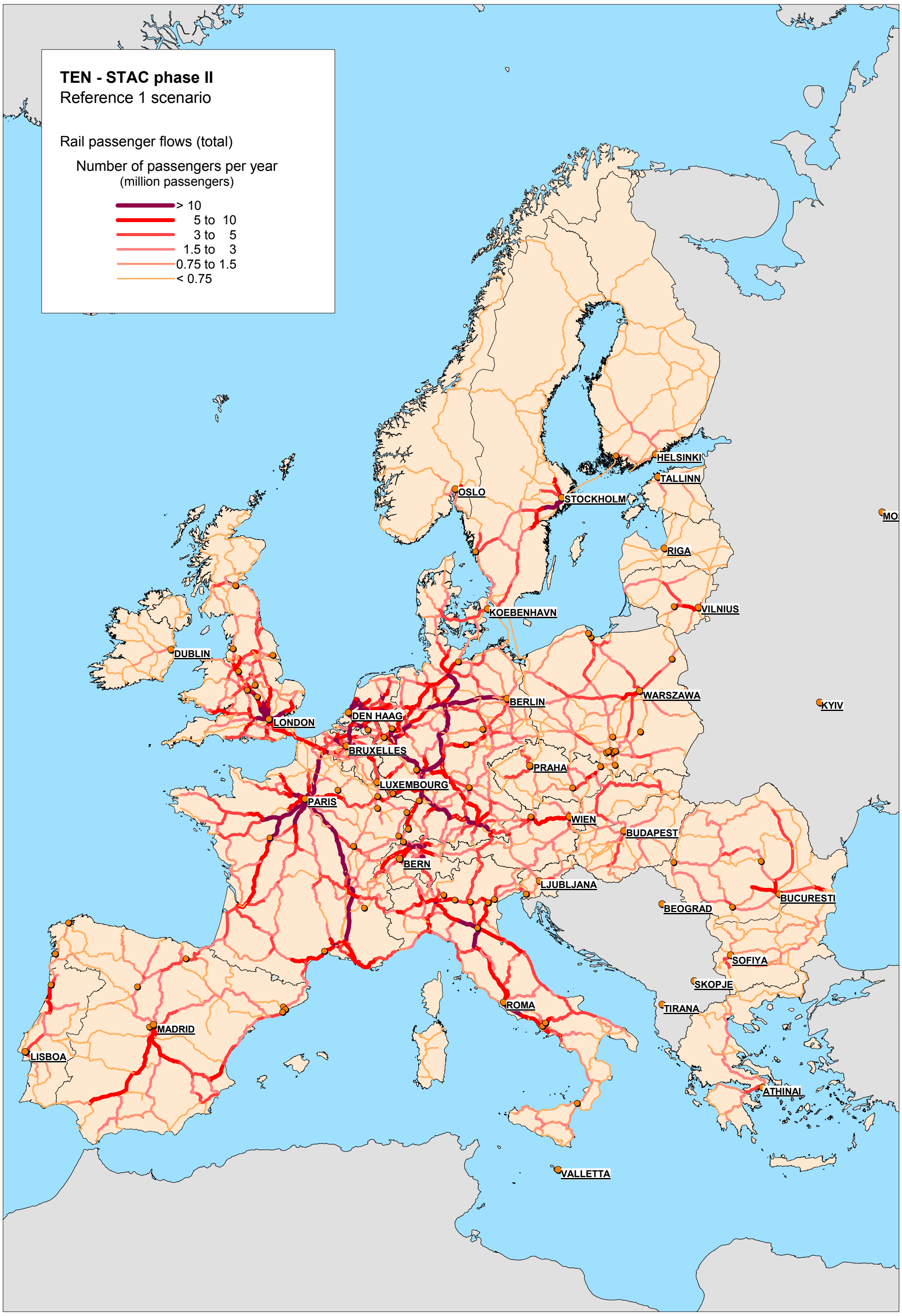


Figure 4.2 *Rail freight flows, total interregional, Reference 1 scenario*

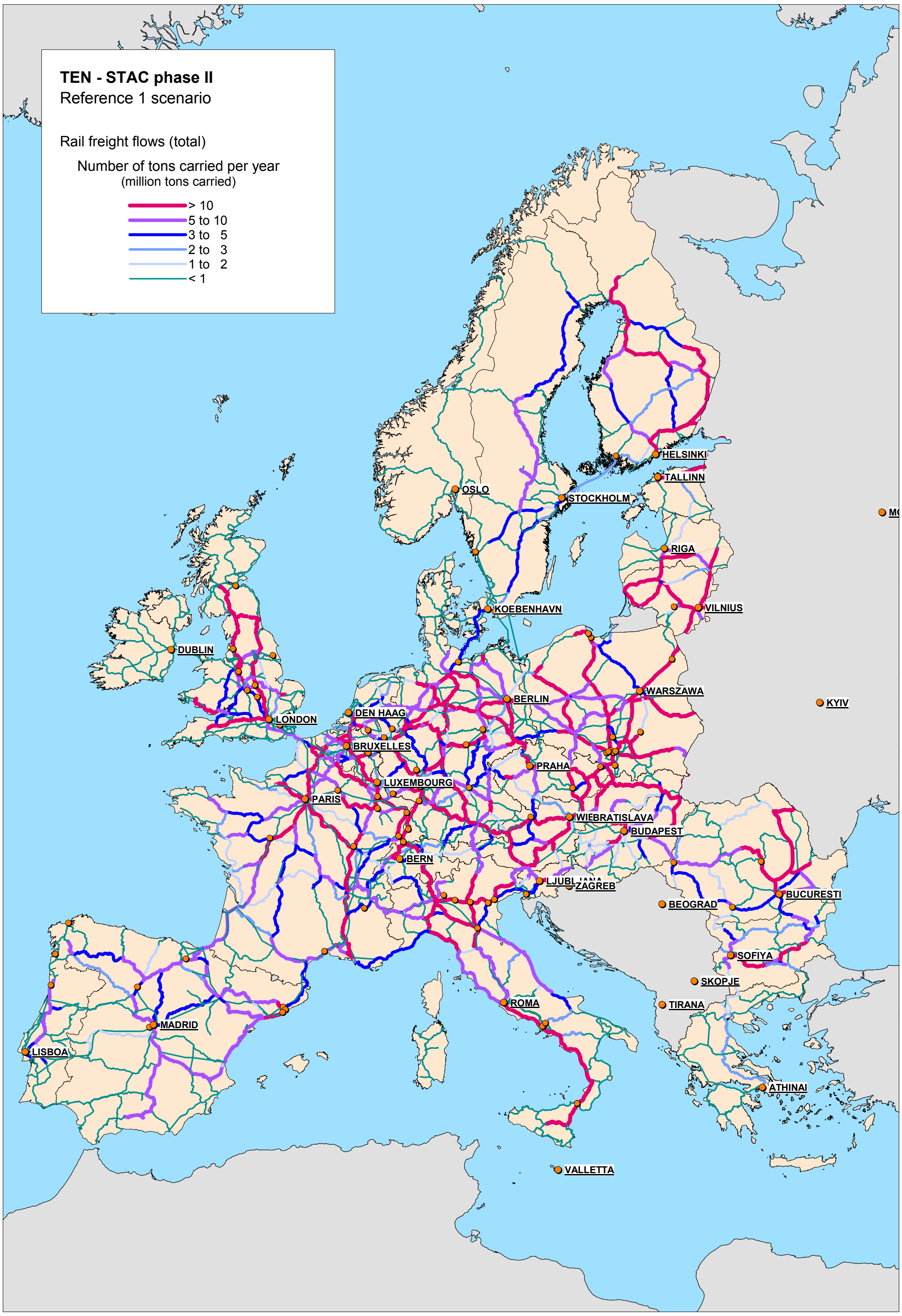


Figure 4.3 *Road passenger flows, total interregional, Reference 1 scenario*

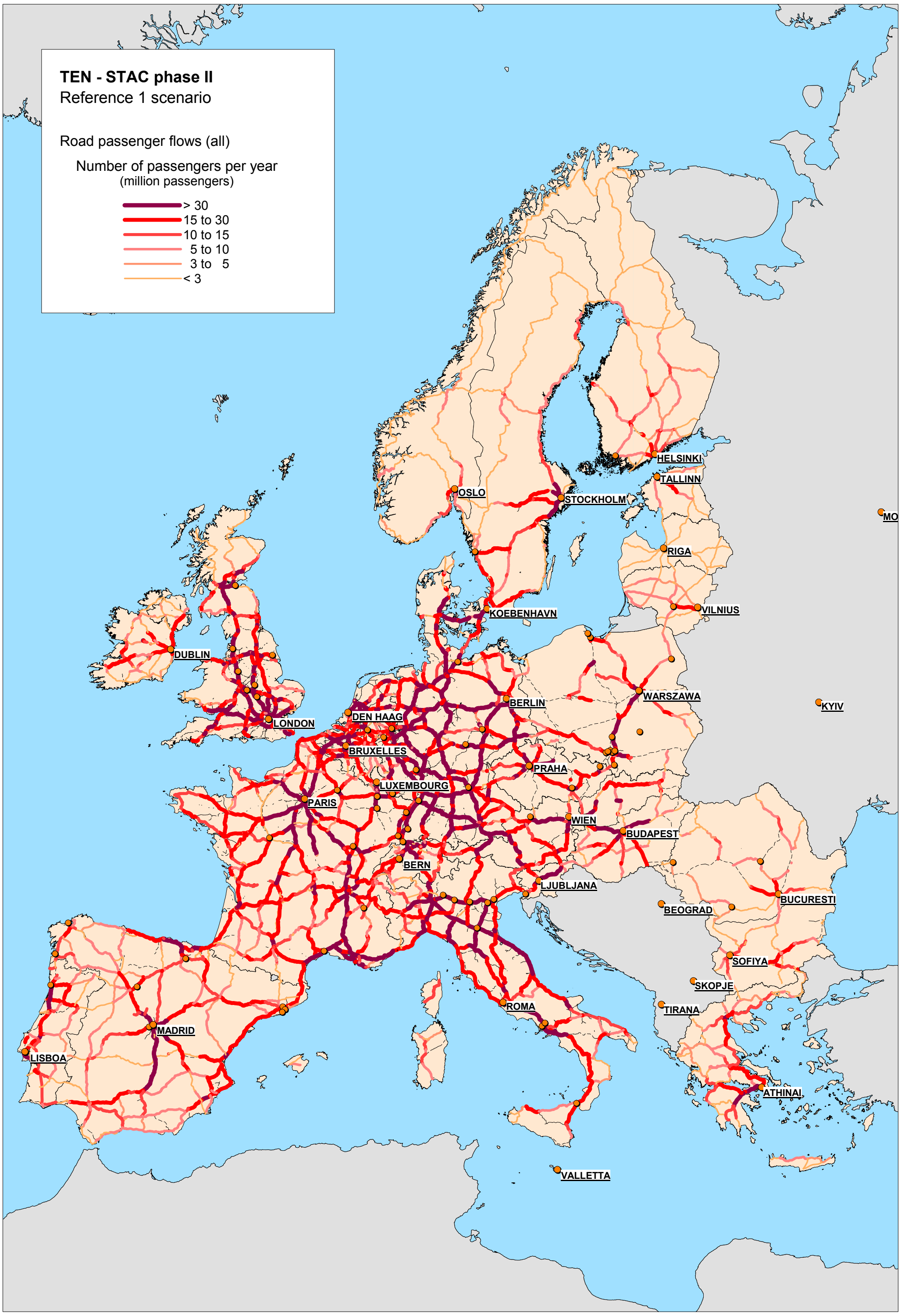


Figure 4.4 *Road freight flows, total interregional, Reference 1 scenario*

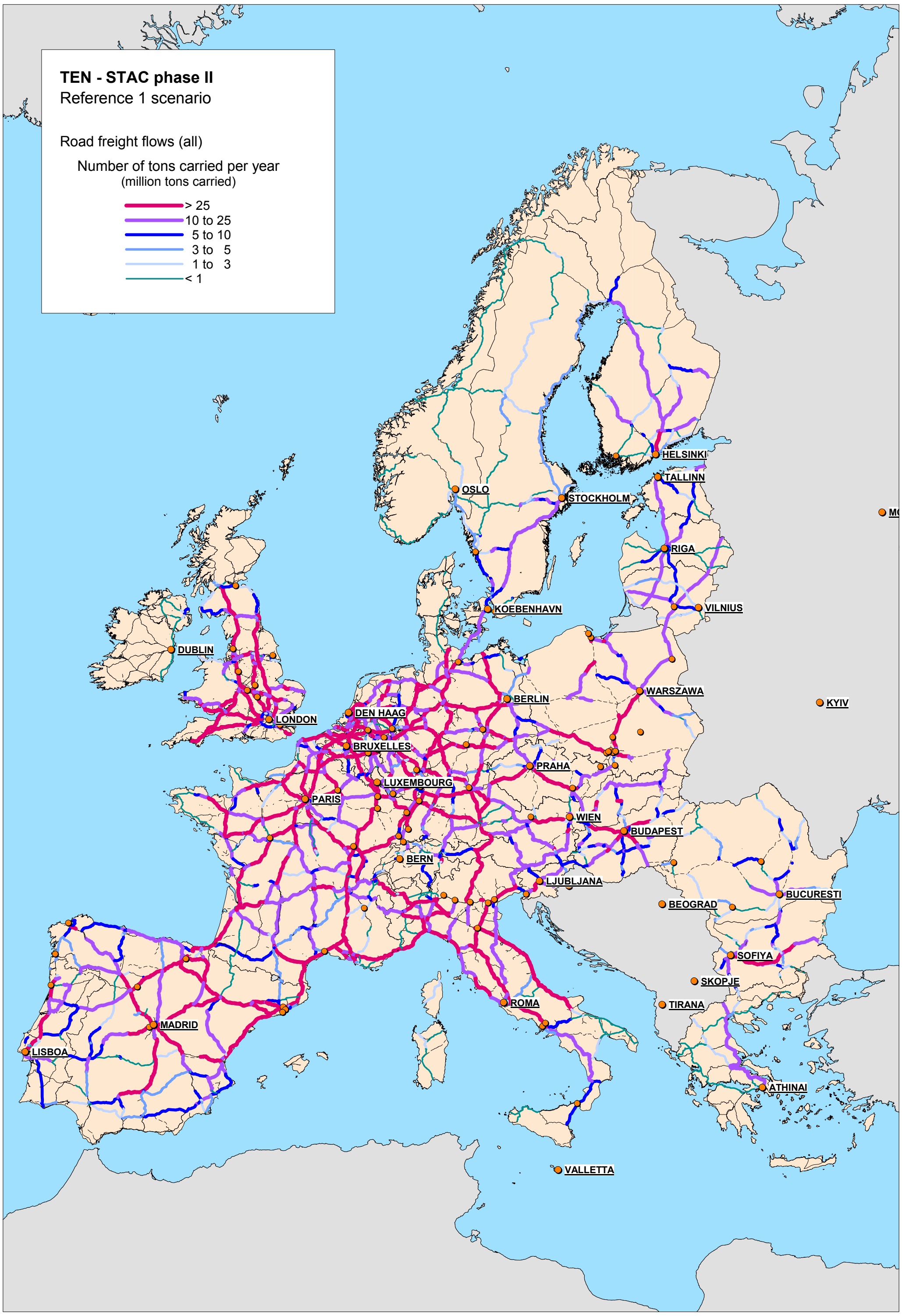
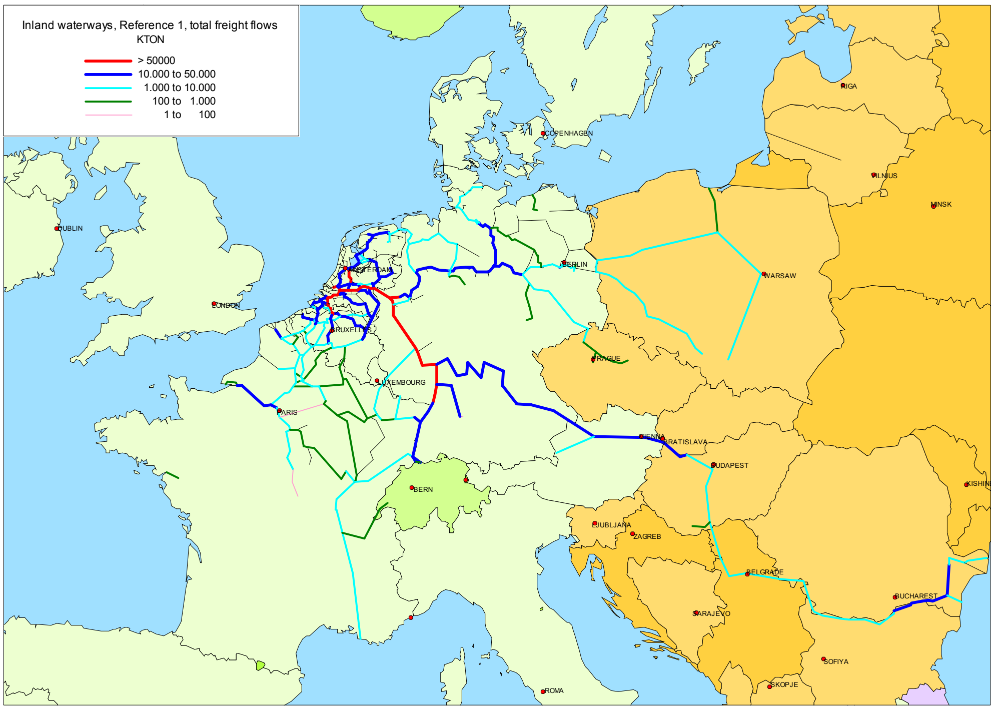


Figure 4.5 *Inland waterways freight flows, total interregional, Reference 1 scenario*



The short-sea traffic flows are the same for reference 1 and reference 2 scenarios, as no changes are foreseen to make the sea transport more attractive in reference 2 compared to reference 1. The short-sea freight flows of the Reference 1 and Reference 2 scenario are shown in the figure hereunder.

Figure 4.6 *Sea freight flows, total interregional, Reference 1 and Reference 2 scenario*

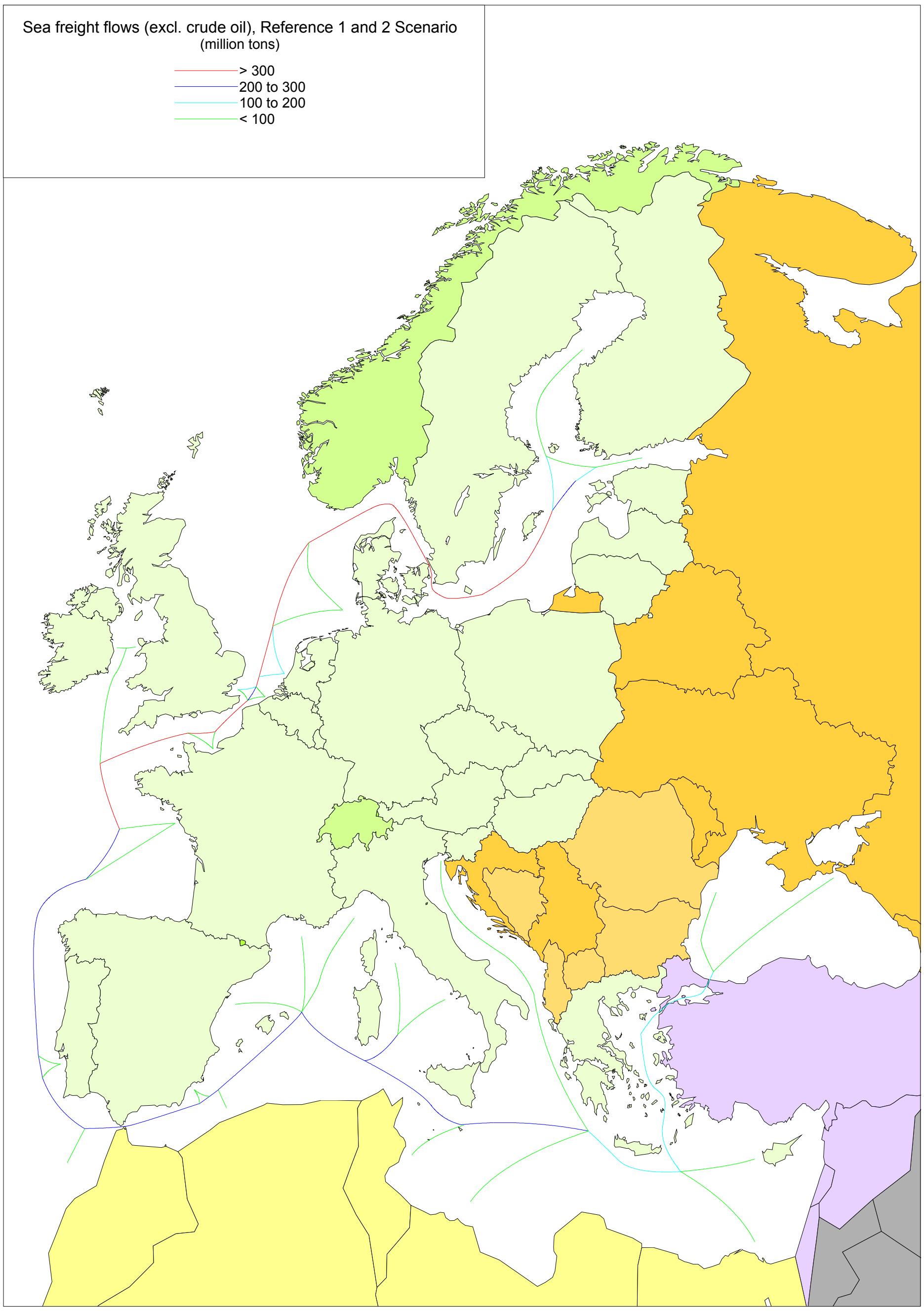


Figure 4.7 *Rail passenger flows, total interregional, Reference 2 scenario*

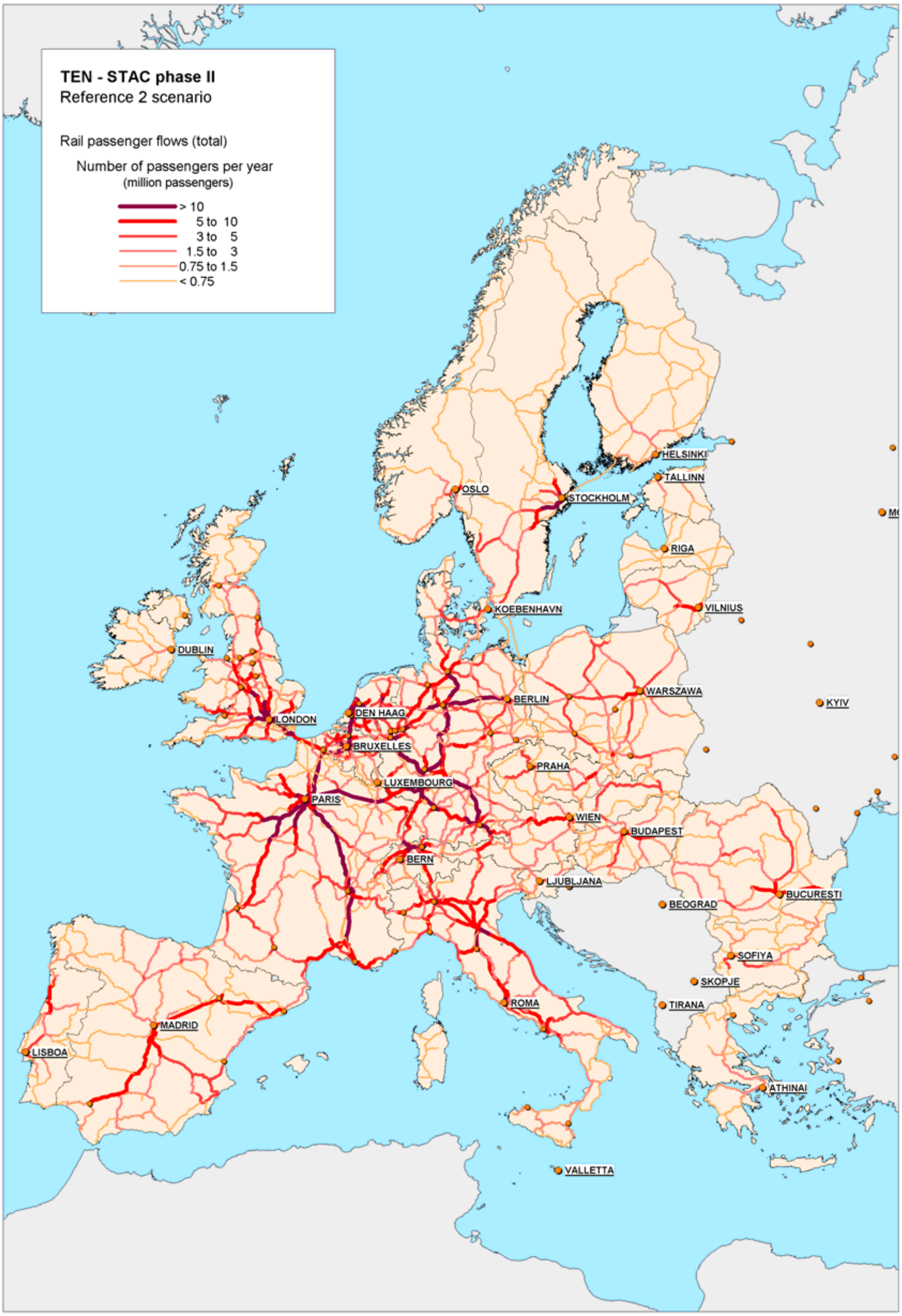


Figure 4.8 *Difference rail passenger flows, total interregional, Reference 2 versus Reference 1 scenario*

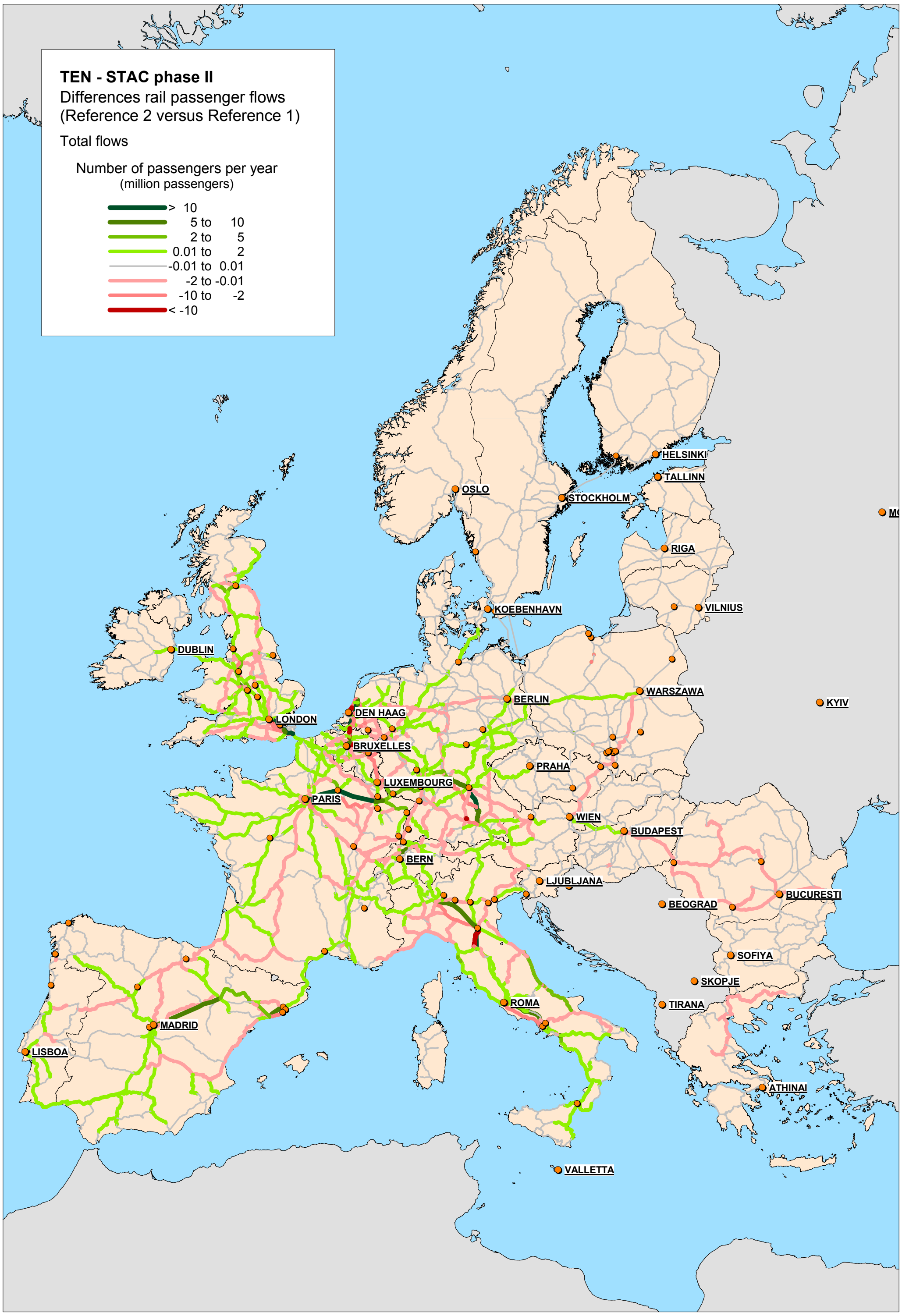


Figure 4.9 *Rail freight flows, total interregional, Reference 2 scenario*

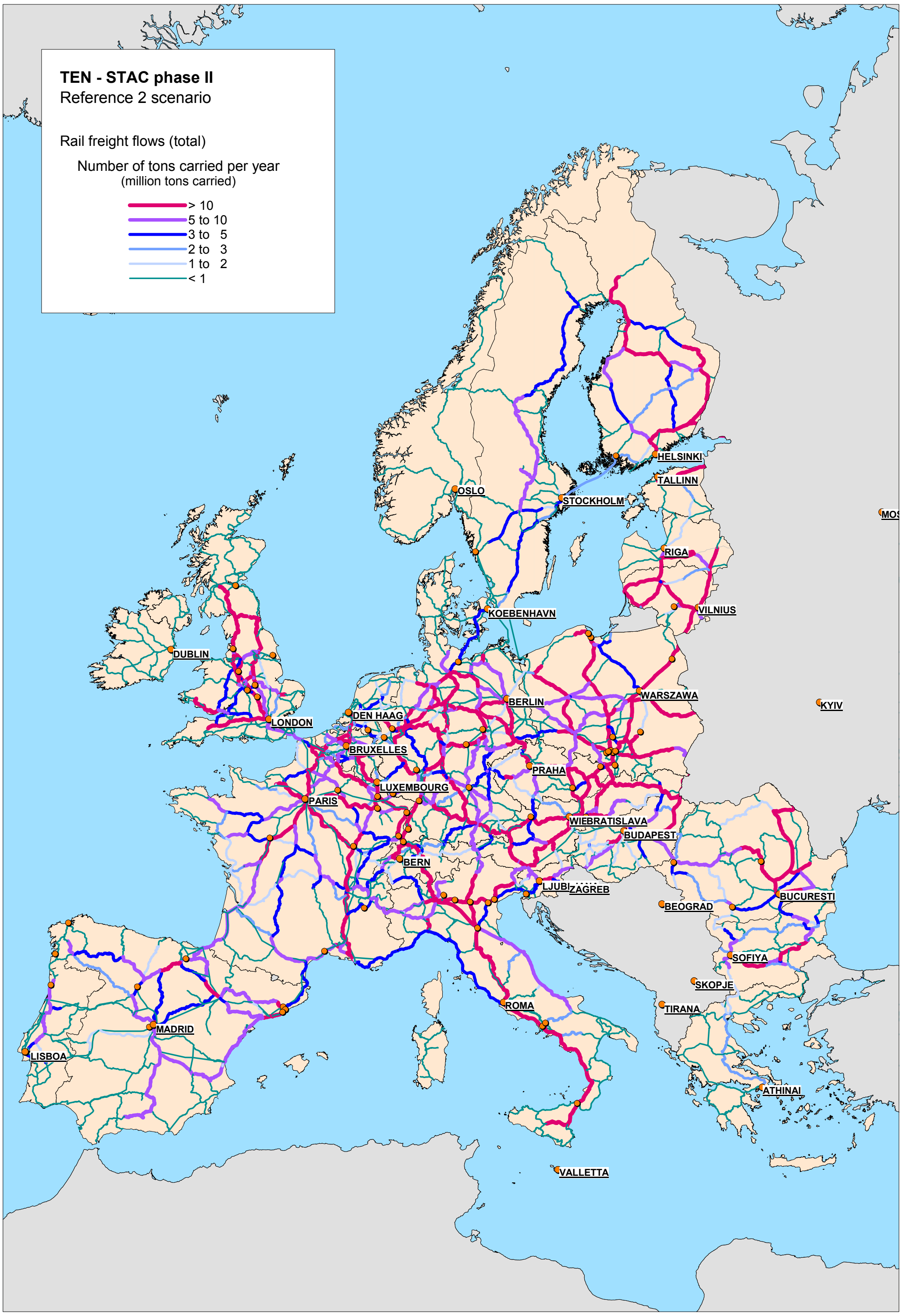


Figure 4.10 *Difference rail freight flows, total interregional, Reference 2 versus Reference 1 scenario*

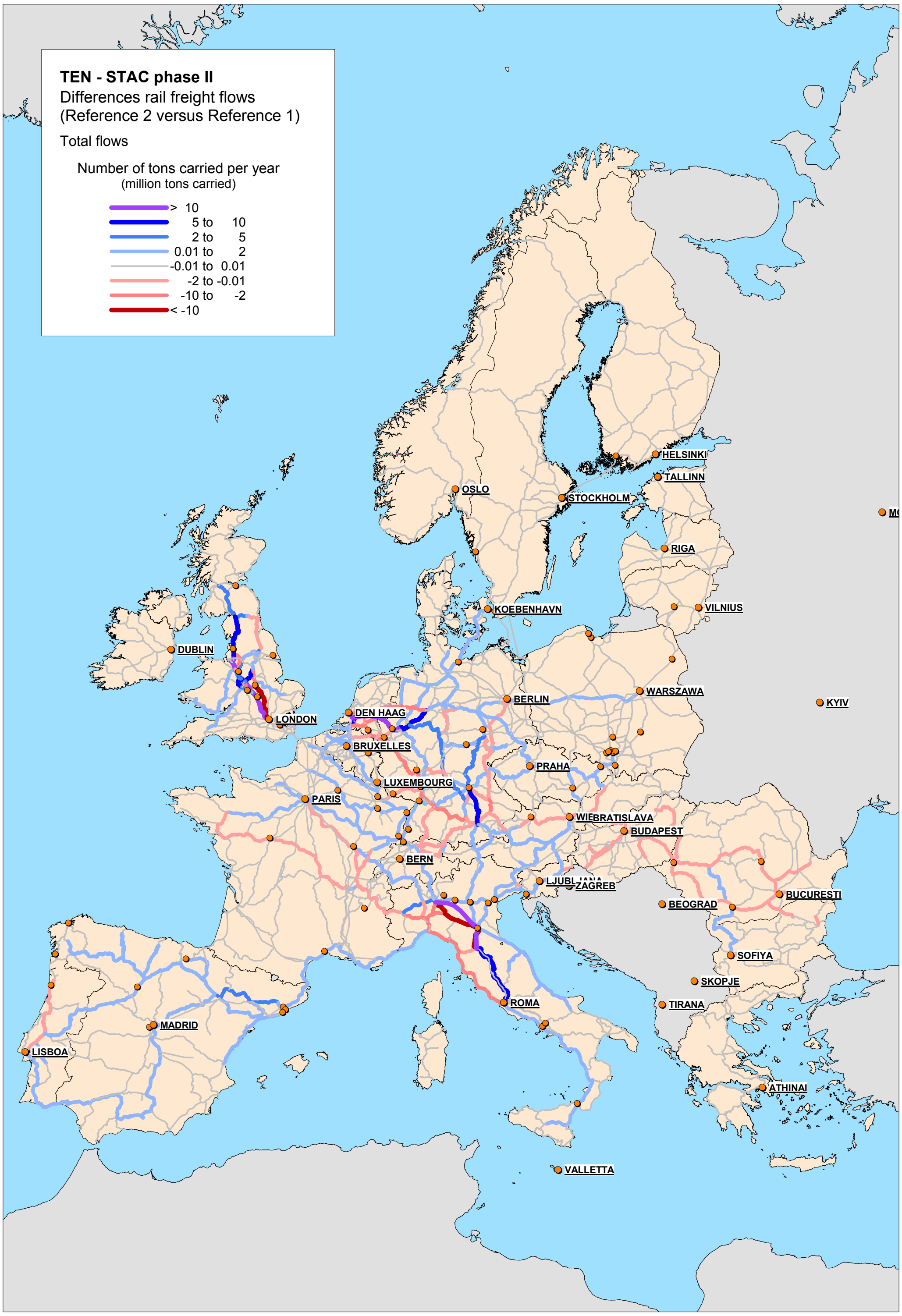


Figure 4.11 *Road passenger flows, total interregional, Reference 2 scenario*

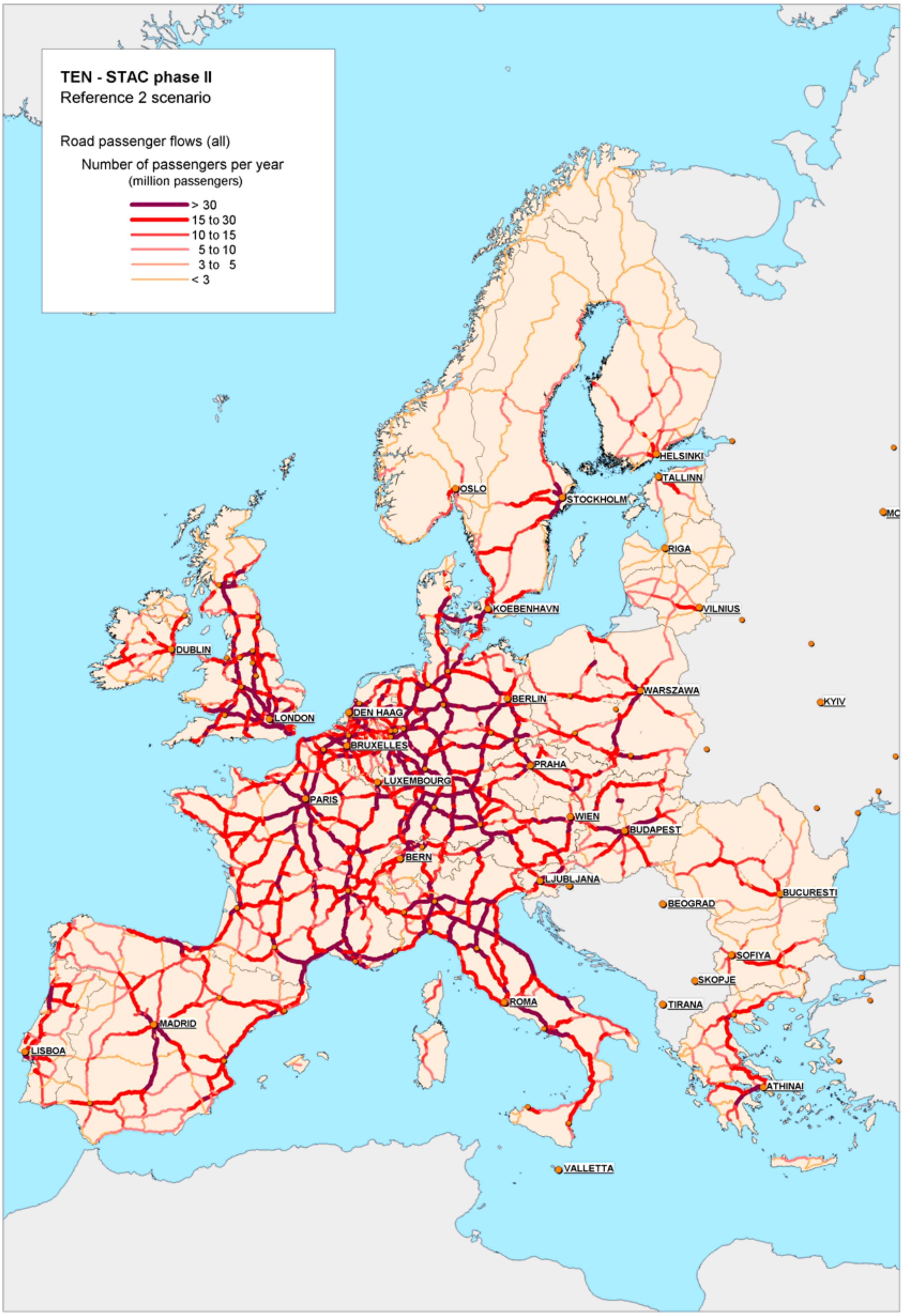


Figure 4.12 *Difference road passenger flows, total interregional, Reference 2 versus Reference 1 scenario*

Figure 4.13 *Road freight flows, total interregional, Reference 2 scenario*

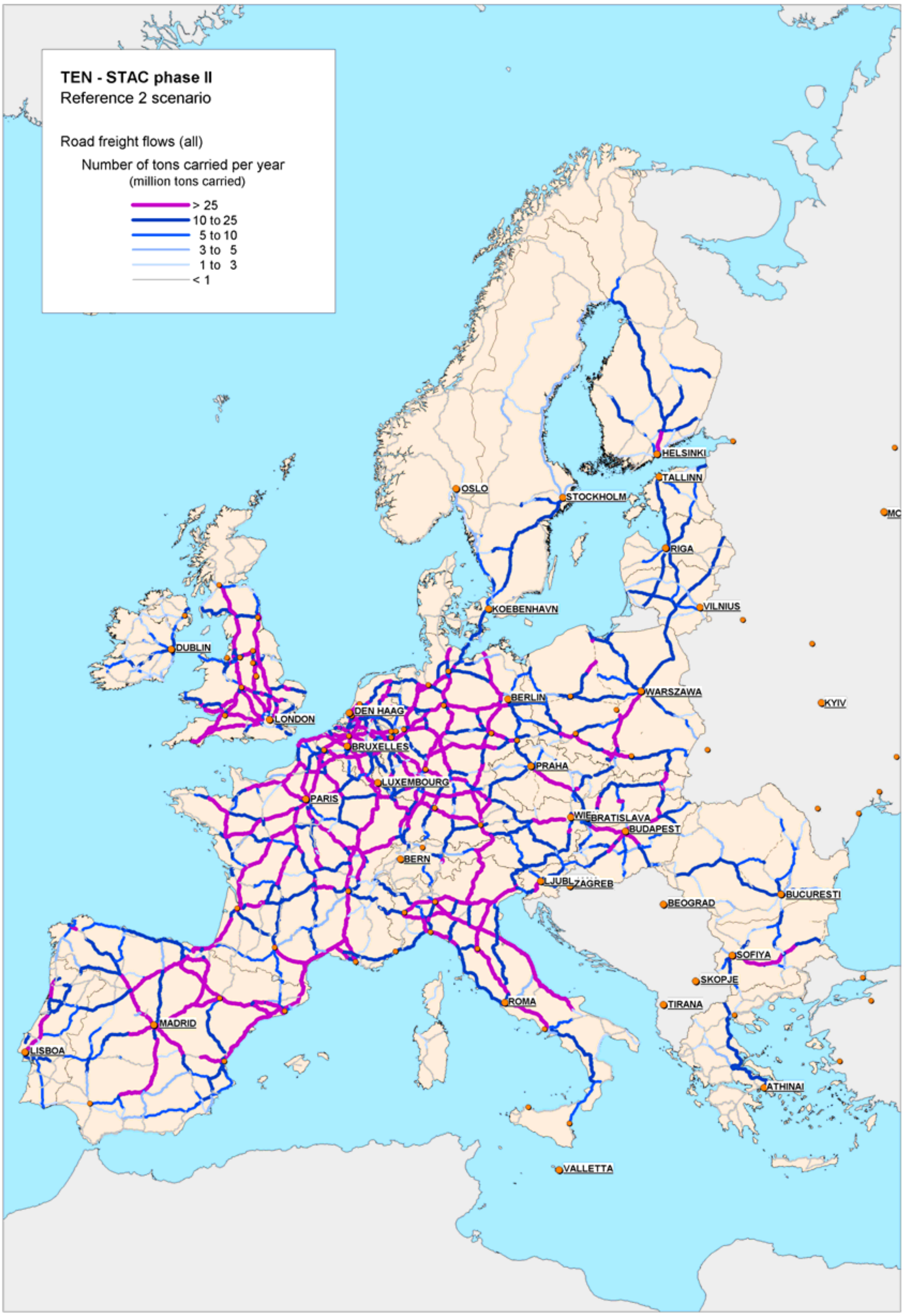
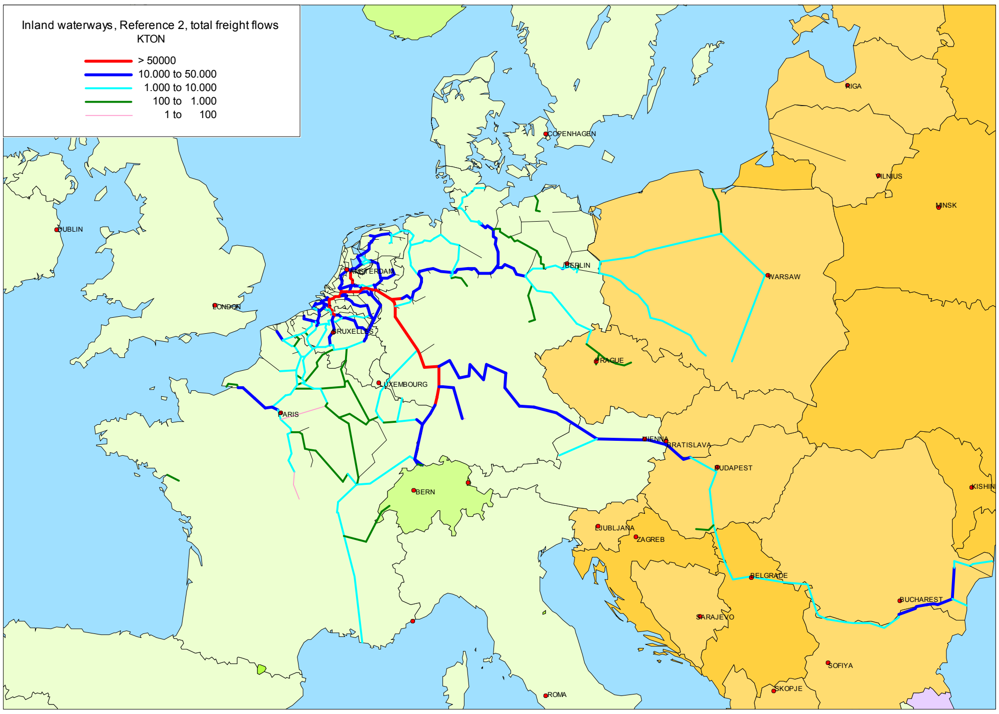


Figure 4.14 *Difference road freight flows, total interregional, Reference 2 versus Reference 1 scenario*

Figure 4.15 *Inland waterways freight flows, total interregional, Reference 2 scenario*



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