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TRANS-TOOLS

TOOLS for Transport forecasting ANd Scenario testing

Instrument: Specific Support Action (SSA)

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Deliverable 6: TRANS-TOOLS Final Report

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TRANS-TOOLS

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TOOLS for TRansport forecasting ANd Scenario testing

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1. INTRODUCTION

1.1. The TRANS-TOOLS Project

TRANS-TOOLS had the objective to produce a European transport network model covering both passenger and freight, as well as intermodal transport, which overcomes the shortcomings of current European transport network models and provides the Commission with an in house updated instrument of simulation. The objective of the project was to build on the experience of existing transport models and implement a number of improvements that are the basis of the development of an integrated policy support tool for transport at EU level. So far the Commission owns the ETIS (European Transport policy Information System) database, but is depending upon external models to assess policies.

TRANS-TOOLS has identified several points for improvement in the field of methodological issues in the available models and proposes specific steps to overcome them. Such shortcomings include the unsatisfactory representation of mix of traffic (short/long distance and freight/passenger), the (partly) missing presence of intermodality and freight logistics in models, differences in implementation of Origin-Destination base year for freight traffic in some models, outdated character of some models, and no sufficient linkage of network based transport models with socio-economic effects and external effects.

A second main issue for the development of TRANS-TOOLS was the availability of several different models for different options and with different IPR[1] settings at European level, and the need to construct an IPR free instrument on the basis of the best available knowledge from the partners that have been involved in building models that involve European policy questions.

The aim has been to develop a European network-based transport model starting from the state of art and the ideas consolidated in the modelling experience of the consortium partners. This meant that some of the features of the available models with an EU scope have been added, considering that while a model cannot be a tool for every purpose, the selection of the model features should be essentially on the basis of the policy needs addressed by the European Commission services. The SCENES model approach which the Commission has launched in the past has provided good suggestions for the treatment of passenger transport and the interaction of local and long distance traffic. The VACLAV transport network has been a suitable basis for the development of an efficient transport assignment model. The NEAC model provided the information for a proper description of freight transport and the SCENES model has constituted a reference for the treatment of intermodal transport, as well as SLAM for logistics.

The model developed is based on the most recent European strategic reference database on transport demand, services, infrastructure networks and impact related information, namely the ETIS Reference database of the ETIS-BASE project. This ensures consistency of the data – models – policy chain at the level of DG-TREN.

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[1] IPR Intellectual Property Right

1.2. TRANS-TOOLS Deliverables

1.2.1. Aims

The aim of this deliverable D6 is to provide a full overview of the TRANS-TOOLS methodology and results. This deliverable has the objective to summarise the more detailed deliverables that have been delivered during the project. These deliverables are:

- D1 Report on Policy Requirements and Selected Relevant Models/Methods
- D2 Description of the datasets needed for model estimation and calibration, supported by databases
- D3 Report on model specification and calibration results
- D4 Description and practice use of the Trans-Tools model
- D5 Report on Scenarios, Model Outcome of Scenarios and Policy Assessment

Furthermore this deliverable D6 has the objective to provide the project conclusions and recommendations for further research.

1.2.2. Methodology

In the figure below the organisation of the project in term of the Work Package (WP) structure is given.

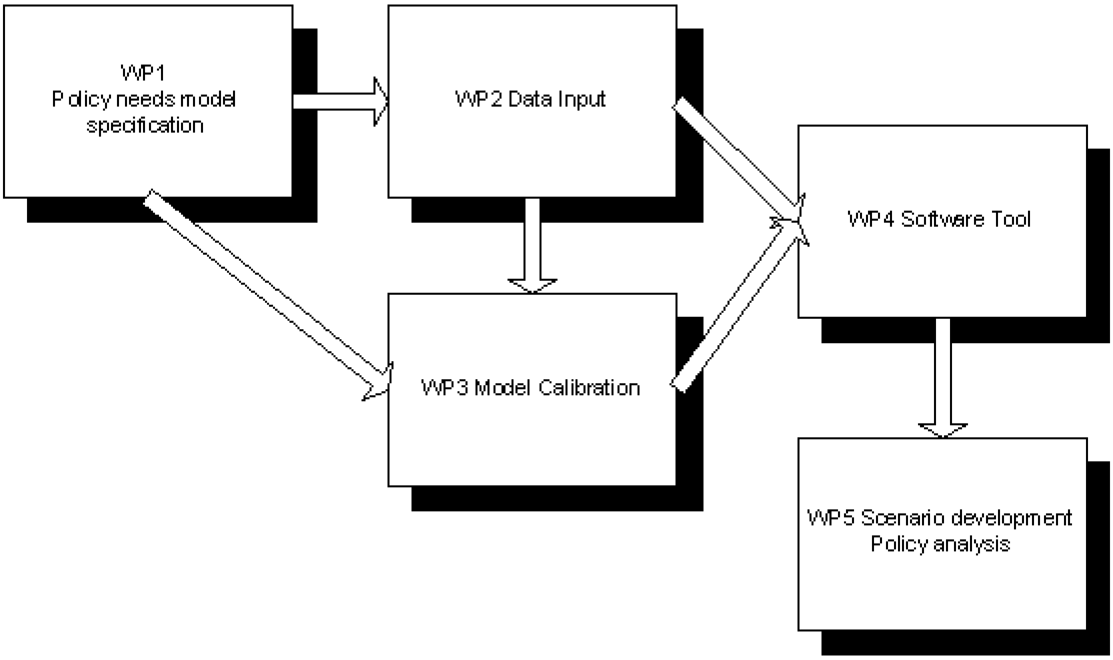


Figure 1: Structure of the Trans-Tools project

The logic behind the structure is that first the definitive selection of modelling elements and the right set of policy variables, i.e. which variables to monitor policies with, was to be chosen in

WP1.The elements of the forecasting procedures are chosen in WP1. This was followed by WP2 where the data needed for the modelling exercises (to be divided in calibration, validation and input) were identified. In WP3 the model specification and calibration are carried out which used the part of the data from WP2 and the model specification of WP1. The model as constructed in WP3 together with part of the data from WP2 was used as input for WP4 where the IPR free software tool is constructed. The tool is used in WP5. In WP5 a common set of scenarios is defined, together, the scenario outcomes of the different models are obtained and validated. For the validation scientific validation and a policy validation are carried out. This resulted in transport forecast for the EU in 2020.

1.2.3. Report structure

This deliverable discusses the work performed in the TRANS-TOOLS project and its results following the structure of the methodology applied as described in the previous section. Chapter 2 describes the Policy and model needs and model specification and chapter 3 describes the data requirements of the TRANS-TOOLS model. The calibration of the freight, passenger, assignment and economic model is described in chapter 4 and in chapter 5 the software implementation of the tool is described. In chapter 6 and 7 the use of the model is described with a chapter on the description of the scenarios and application of the model respectively the results of the model runs. For a more elaborate description of scenario outcomes it is referred to TRANS-TOOLS Deliverable D5. In chapter 9 the validation of the TRANS-TOOLS model takes place, also for a more elaborate validation it is referred to Deliverable D5. Finally chapter 10 is reserved for the project conclusions and recommendations for further potential improvements of the model.

2. POLICY AND MODEL NEEDS

2.1. TRANS-TOOLS model as answer to policy needs

Traffic and transport models are an essential tool for policy makers to identify and assess trends and counter-measures in this field. In addition to the needs of market players, transport models give a quantitative insight in trends in the traffic and transport market, the usage of infrastructure, and the impact on the environment. So far however, traffic and transport models usually focused onto a strongly demarcated perspective of analysis.

The design of the TRANS-TOOLS model is the answer to the need of policy makers for a generic traffic and transport analysis tool that takes all perspectives into account. This includes a network perspective and the interrelationships between passenger and freight models (e.g. modal split, logistics) with economic (e.g. trade) and environment models. Work package 1 identified the policy requirements to obtain an overview on the policy issues that the TRANS-TOOLS model needs to be able to assess (see chapter 2). We conclude that the TRANS-TOOLS model should support transport policy makers in two ways:

1) Monitor the trends in the operation of the transport systems in the EU and identify issues for which policy intervention may be required;
2) Assess the impact of specific transport policy measures on the transport system in the EU, as well as on selected economic and environmental issues.

The TRANS-TOOLS model integrates existing models to one new model that comprehends the complexities of both passenger and goods flows in the European Union. The identified models (see chapter 3 of D1) have been confronted with the requirements (chapter 4 of D1). The designed blue-print of TRANS-TOOLS specifies the interaction of actual modelling techniques and fills the gaps that were not yet covered (chapter 5 of D1). The blueprint has been developed continuously within the project, in the annex of this report the latest version has been included.

2.2. Next to integration also extension and improvement of actual models

The models used as a basis for the TRANS-TOOLS model have most of the elements needed for the development of a EU transport policy support tool, but several of their current shortcomings should be improved. The main characteristics of the TRANS-TOOLS model can be summarised as follows:

- Multi-modal network model, covering EU-25 with links to external zones
- Transport demand responds to changes in infrastructure, transport costs and times
- Changes in transport demand are reflected in changes in traffic on TEN-T and main national networks links (direct transport network effects)
- Congestion is modelled (for road transport only) as a result of the interaction of transport supply and demand
- Indirect transport effects are modelled based on the changes in economic activity and regional development

- The environmental impacts are measured in terms of emissions and fatalities and are related to network assignments
- The model will be calibrated with year 2000 as a base and will provide projections for years 2010 and 2020
- The links between VACLAV and ASTRA and the economic part of the model increases the economic effects on the transport model
- Logistics is explicitly included in the modelling so that a better understanding of factors affecting freight mobility is obtained.
- Most recent data from other projects like ETIS-BASE is used
- Coverage of passenger transport at NUTS-III level in EU25+2
- Usage of recently updated networks
- State-of-art assignment models reflecting the stochastic nature of travel behaviour achieving acceptable accuracy at link level.
- Consistency between assignment procedures and modelling of freight and passenger demands.
- Flexible software adoptable to user needs which is IPR free.

The need for a reliable tool for the estimation of transport volumes in the TEN-T and main transport links can be met by the updated geographic coverage (at NUTS 3 level, and including new EU member states), with the development of new Origin-Destination matrices and a combined passenger/freight assignment algorithm. The various modelling teams participating in TRANS-TOOLS have demonstrated the technical capacity to perform the task in the past and it is in the position to develop and calibrate a new model at this scale. However, and in order to avoid problems concerning the acceptability of the results of the model, specific emphasis should be put on the validation of the results and the comparison with results at national level.

It should be stressed that the policy issues that can be handled are various. In the definition of scenarios in WP5 the scenario elements can be focused on these policy issues and thereby assessing the effectiveness by analysing the outcome of the policies undertaken, these issues are the following (see D5):

- Driving restrictions on heavy good vehicles on designated roads
- First railway package: support the creation of new infrastructure, and in particular rail freight freeways
- Updating the interoperability directives on high-speed and conventional railway networks
- Enter into dialogue with the rail industries in the context of a voluntary agreement to reduce adverse environmental impact
- Support the creation of new infrastructure, and in particular rail freight freeways
- Single European Sky
- Airport charges
- Slot on Community airports
- Motorways of the seas
- Port services liberalisation
- Simplify sea and inland waterway custom formalities and linking up the players in the logistic chain
- Ship and port facility security

- Eliminating bottlenecks in inland waterway transport
- Marco Polo Programme
- Intermodal Loading Units and freight integrators
- Trans European Network projects
- Infrastructure charging
- Uniform commercial road transport fuel taxation
- Harmonising VAT deductions
- Taxation of passenger cars according to environmental criteria
- Taxation of energy products and exemptions for hydrogen and biofuels
- Introduction of a minimum share of biofuels consumption in road transport
- TEN infrastructure in the candidate countries

These policy issues can be modelled relatively easy in TRANS-TOOLS, since there is a “direct” correspondence between the policy measure and the model input. For example “infrastructure charging” can be implemented through a generalised cost change (changes in cost and time). Other policy issues that are identified: a) work indirect and a translation is needed into the model input (for example liberalisation will change the market conditions and will thereby influence cost of transport) and/or b) need a supplementary model analysis (for example introduction of a new innovative transport technology will need a demand model such as TREMOVE). This is beyond the scope of the TRANS-TOOLS project due to time and budget limitations. TRANS-TOOLS will have different possible applications in different policy fields either on national and regional level or also at EU-level. Because of the limitation of the time and budget of the project we concentrate on the White Book policy measures from the above list which satisfy two conditions: first they can be incorporated in the modelling structure of Trans-Tools (the technical condition), secondly, a cooperation between Commission and TRANS-TOOLS team will have to fix the priorities of measures to be incorporated, with in mind the limitations of TRANS-TOOLS in time and resources. TRANS-TOOLS is a research project which has to invent methods and calibrate models, and a policy tool which is user oriented. In this context some arbitrage might be necessary.

3. SPECIFICATION OF THE TRANS-TOOLS MODEL SYSTEM

3.1. Conceptual idea of Trans-Tools Model

The aim of the Trans-Tools project is to construct a new modelling structure for the Commission taking into account the shortcomings in current European models. The Trans-Tools Model is as required by the Commission constructed as an IPR free instrument based on available knowledge.

The Trans-Tools Model is a network-based transport model of Europe started from the ideas consolidated in the modelling experience of the consortium partners. This means that some of the features of the currently available EU models are added, considering that the selection of the features of the model address the essential policy needs by the Commission services. While ASTRA and VACLAV transport models are used as basis for the development of the passenger demand model, freight modelling is based on the NEAC model for trade and mode choice and SLAM for logistics.

All model components are integrated into ArcGIS which allow the user to edit, operate and illustrate results from the same common GIS-based platform. The innovations obtained from the Trans-Tools Model are,

- New set up of a demand/supply model that is IPR free for the Commission.
- Intermodality for passenger/freight as this is part of the national and European transport policy to promote intermodality through different measures.
- Full coverage of Central and Eastern Europe (accession countries and the countries at the borders of the enlarged Union).
- Integration of New Member States at a similar level as the EU15.
- Feedback infrastructure development-economy.
- Logistics/freight chain explicitly included.
- Coupling with local traffic in order to address the effect of road congestion.
- A software approach which results in a modelling tool on network level and GIS based interfacing.

3.2. Model structure

The model structure developed in WP 3 and described in Deliverable 3 is implemented in this work package.

The Trans-Tools Model is similar to a traditional four step model including freight and passenger modelling. The main sub-models are:

- Freight demand model
- Passenger demand model
- Assignment model

In additions to these main elements of the model system, the Trans-Tools Model also includes an economic model based on CGEurope and impact models. The different models are linked applying a number of conversion routines. The principle of the model in overview is illustrated in Figure 2. The model framework allows feedbacks between the sub-models to achieve equilibrium between supply and demand.

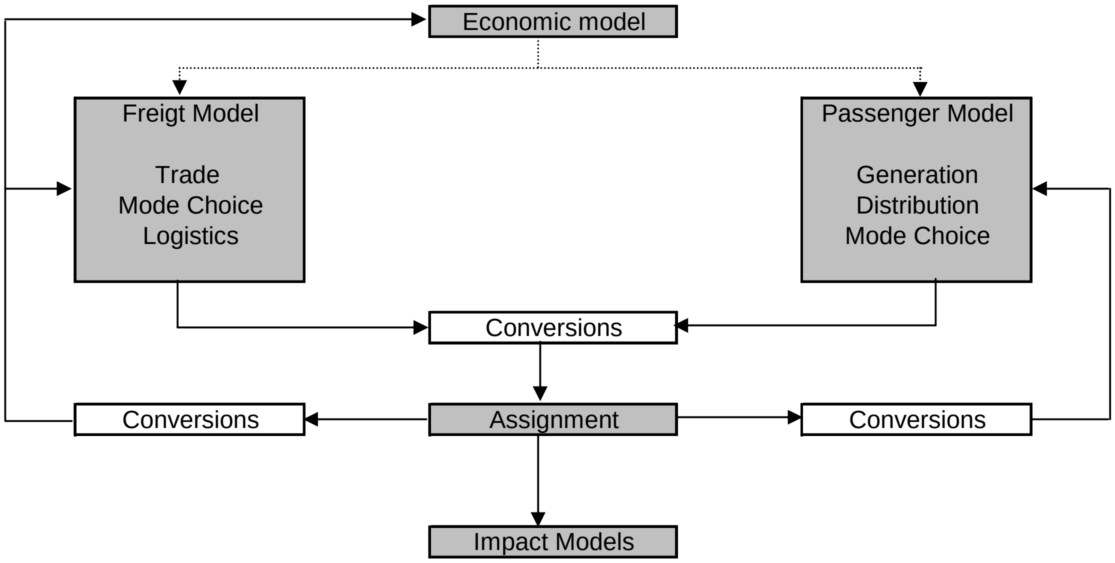


Figure 2: **The principles of the Trans-Tools Model in overview**

3.3. Freight demand models

A generation and attraction pattern of the trade flows in the chosen basis year is a starting point for building a trade model in general. Specifically for the Trans-Tools trade model, the ETIS O/D freight transport matrix will be used as an analog substituting the trade relations matrix. The ETIS matrix describes the generation and attraction of physical flows of goods between the trading countries and geo-clusters given the economical and institutional determinants of the year 2000. For the relations with the trading partner from beyond the established European area the economical mass of the partner is the decisive factor. The output of the Trans-Tools trade model is a forecast O/D matrix for freight including origin region, between transhipments and destination region as well as transport mode at origin, between transhipments, and at destination, commodity group and tonnes.

The Trans-Tools modal split model for freight transport is based on the modal split model in NEAC. In Trans-Tools the modal split model adjusts the stable modal split resulting from the trade model. Output of the Trans-Tools modal split model is a freight matrix, which consists of a forecast O/D matrix including forecast modal split. In the modal split model the market shares of the different modes of transport are estimated for every O/D relation and commodity group. Within the model there are four modes of transport available (road, rail, inland waterway, sea). Choice probabilities of the available modes per commodity group for every O/D relation are determined by using a multinomial logit model.

The working of the Trans-Tools logistic module is based on SLAM, which is a module appended to the SCENES model. This module makes it possible to evaluate the impacts of changes in the logistic and transport systems within Europe on the spatial patterns of freight transport flows, through changes in the number and location of warehouses for the distribution of goods. The logistic module produces output that is to be used in the assignment model as well as in the economic model. For the assignment model the logistic module produces unimodal transport matrices (Origin, destination, mode, tonnes, vehicles). The economic model needs generalized and monetary costs per origin, destination and commodity type. These costs can be computed from the assigning process. The monetary costs (payment to the public budget e.g. toll, fuel taxes) can be separated out if input on these costs is available.

3.4. Passenger demand model

The passenger demand model tackles passenger transport modelling at European level, with main focus on the (transport) models SCENES, VACLAV and ASTRA. The passenger model covers the first three steps of the classic four-step-approach, which are trip generation, trip distribution and modal split. The trip distribution process in ASTRA depends on results of the modal split stage. Hence a feedback mechanism from VACLAV to the trip distribution module is prepared to transfer average generalised times to the trip distribution logit function. Trip generation as the first stage of the classical four-step transport modeling approach is implemented in ASTRA. After the generation of trips emanating from European NUTS3 zones these trips are distributed among destinations. The spatial trip distribution is represented by the second stage of the IWW transport modeling approach. In this process the vector containing generated trips is transferred into an O/D matrix. In the third step the mode for the travel is chosen. Hence impedance data from the Trans-Tools assignment model as well as O/D matrices per trip purpose from the ETIS database are applied. Travel costs, travel time and information about the trip itself like frequencies and number of transfers are used to split the trips between the modes. Subsequently, for each origin-destination pair the modal split model calculates the probability of selecting a modal alternative out of a set of available modes. A non-linear logit function is used in order to calculate the choice probability. The explanatory variables represent the transport service level between two zones e.g. in the dimensions travel costs and travel time. Output of Trans-Tools passenger demand model to assignment model are unimodal passenger O/D transport matrices at NUTS3 level in number of passengers per mode (rail, road, air) and trip purpose as well as unimodal passenger O/D transport matrices at NUTS3 level in number of vehicles for road relations per trip purpose. The level of service-matrix with generalised costs per O/D relation represents the output from Trans-Tools passenger demand model to the economic model.

3.5. Assignment models

The network assignment module produces the direct output from the Trans-Tools Model. However, the models also generate level-of-service data (LOS) as input to passenger, freight, and logistic models in a feed back loop (see Figure 2). Input from the passenger model are unimodal passenger O/D matrices at NUTS 3 level in number of passengers and vehicles by mode and trip purpose. Input from the freight and logistic models are unimodal transport matrices at NUTS 2 level by mode, commodity, tonnes, and vehicles. In the Trans-Tools Model, transport networks are defined at unimodal level.

Following assignment models are developed within the Trans-Tools Model:

- Road network (passenger and freight)
- Rail network (passenger and freight)
- Inland waterway (freight)
- Air network (passenger).

Passengers by rail and air and freight by rail and inland waterways are assigned based on an average day, since congestion is not considered and information on service data differentiated by time and day is not available. LOS in the road assignment is calculated by time period. In Trans-Tools, a stochastic assignment procedure is applied being founded on probit-based models.

Before assignment trip matrices are converted into the NUTS 3 based zonal system of 1,269 zones within Europe used in Trans-Tools Model. Figure 3 illustrates the zonal system.

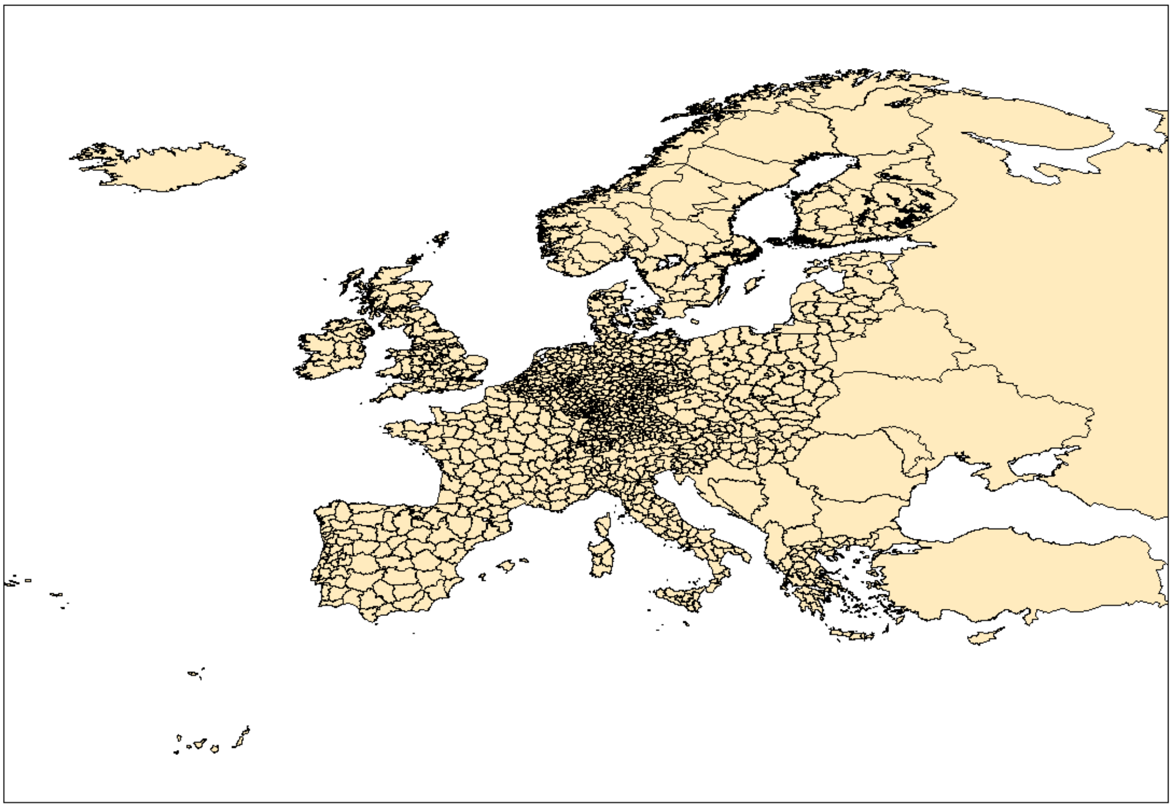


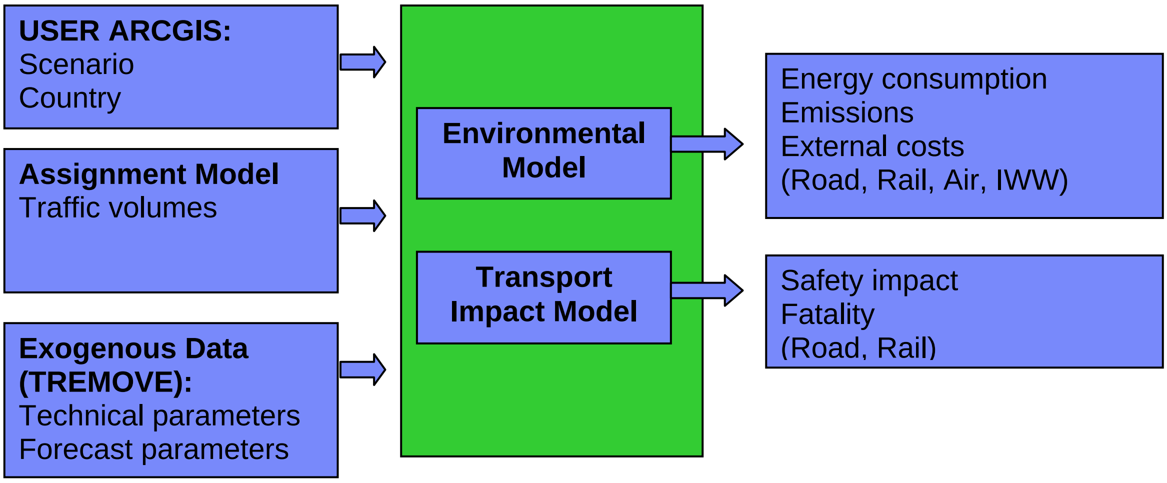
Figure 3: The zonal system of Trans-Tools Model

3.6. Economic model

The future developments by NSTR related sector of the economy of each region of the EU are the outcome of the Trans-Tools economic model CGEurope. Sectoral developments, thus the effects of each policy scenario, are predicted by the model in monetary terms. The computed relative changes of economy by sector with respect to the baseline scenario are passed on to the NEAC model. Policy evaluation measures, in particular real GDP impacts and equivalent variation, by region, year and scenario are further outputs of the Trans-Tools economic model.

3.7. Impact models

The impacts models are used to calculate energy consumption, emissions, external costs and safety based on output from the assignment model as illustrated below.



USER ARCGIS:
Scenario
Country

Assignment Model
Traffic volumes

Exogenous Data (TREMOVE):
Technical parameters
Forecast parameters

Environmental Model

Transport Impact Model

Energy consumption
Emissions
External costs
(Road, Rail, Air, IWW)

Safety impact
Fatality
(Road, Rail)

Figure 4: Impact Model within Trans-Tools Model

4. DATA REQUIREMENTS OF THE TRANS-TOOLS MODEL

4.1. Use of data in the TRANS-TOOLS model

TRANS-TOOLS requires a large amount of data for its development. Data is of different nature and can be segmented into three main categories:

- input data,
- calibration/validation data and
- forecast data.

Input data is needed to build the model and quantifying the relationships between model variables. This type of data is also necessary for implementing the different policies within the model. Calibration data is needed as guide for finding the correct value of parameters and adapting the theoretical relationships and formulae to the study area and context. Validation data is needed to check the capability of the model of reproducing observed data and dynamics. Forecast data is needed to allow the model to simulate future years and include the future project of input data as well as of calibration data.

Data can be classified also from a different point of view:

- physical quantities: tonnes of freight exchanged between a country pair, vehicles flows on a given corridor, passenger travelling by train within a given country, etc.
- monetary values: domestic rail fares, average cost per km of trucks, etc.
- behavioural aspects: willingness to pay for a given service, propensity to use a given mode of transport, etc.

Some data is used in more than one model: e.g. the value of time is a key variable in the modal split (the choice of the transport mode) and in the assignment (the choice of the path through the transport network).

The level of data disaggregation changes in line with the corresponding specific model component. In fact it ranges from the country level (in the case of economic data used to feed and calibrate the regional economic model), to the regional level (which differs for passengers – NUTS3 – and freight – NUTS2) and to the specific link level (it is the case of the link representing the toll road or bridge).

4.2. Available data sources

There is no single source providing all transport models data needed at European scale, thus information has to be collected from several sources at different levels: regional, national, supranational.

For some data item more sources are available, but one reference source is chosen (e.g. population data can be drawn from EUROSTAT and from ETIS-BASE, although the latter is considered as the reference source whenever it is possible). In some other cases more sources are mentioned and each provide a piece of information (e.g. value of travel time can be estimated used different studies).

When a data source is common to more models (e.g. population is used in the regional economic model as well as in the passenger model), a unique source is chosen to ensure that a consistent dataset is used throughout the TRANS-TOOLS project.

A short presentation of ETIS-BASE is provided in the next paragraph, as it represents the major source and covers a good part of the specific needs on the TRANS-TOOLS model components. In the following paragraphs sources for common data are considered with special reference to ETIS-BASE.

4.3. ETIS-BASE

The objectives of ETIS reference database (ETIS, 2004) are:

- To contribute to the building of a consensus view of the reference pan European transport modelling data set.
- To develop an open methodology to generate a version of such a set from existing international and national sources.
- To produce a first compilation of the data set by applying the methodology mentioned above, as on-line database.

The identification of policy domains and specification of performance and supporting indicators was developed incrementally and with the support of external users and Member State representatives brought together in a series of workshops organized by the ETIS-LINK consortium. The database is therefore a reference source to ensure that model applications use a common set of data recognised at the European level. ETIS-BASE will provide all available data to TRANS-TOOLS.

4.3.1. Description of ETIS data

Table 1 lists the data that is included in the ETIS reference database and the sources of this data. In the annex of D2 a full list of ETIS data is provided. The data has been classified in seven categories:

- Socio-economic data
- Freight demand
- Passenger demand
- Transport infrastructure network
- Freight services and costs
- Passenger services and costs
- External effects

In cases where no suitable trans-national source was available, it was necessary to use national sources. This is the case for freight and passenger demand and the external effects data.

For freight demand no regional, domestic and transhipment data is available at trans-national level at the required level of detail. For this reason in all countries national statistical offices and ministries have been approached in order to collect this type of data. For most countries this has been successful.
In the development of the passenger demand data even national OD matrices of UK and Germany have been made available at the most detailed level to be used exclusively for the development of the model used in ETIS resulting in the ETIS passenger OD matrix. For external effects national sources have been used for estimation and validation of the models applied.

Table 1 Data included in the ETIS pilot

Category	**Data included (examples)**	**Data sources (examples)**
Socio-Economic	GDP Labour market participation Population Age distribution … etc.	EUROSTAT (NEW CRONOS, REGIO, COMEXT, GISCO) EUROGEOGRAPHICS (SABE) CORINE land cover World Bank, IMF, WTO, OECD Worldfact Book (CIA database) Project results i.e. SCENES
Freight demand	Transport chain OD matrix Transport / trade volumes Truck movements Cross boarder traffic Combined transport Tons of shipments Commodity types … etc.	EUROSTAT (NEW CRONOS, COMEXT) CAFT (Cross Alpine Freight Traffic), National statistical offices Port authorities United Nations Trade data Freight operators (ICF, UIRR) Project results, i.e. INTERMODA and SPIN
Passenger demand	OD matrix Number of passengers per day, Trip purpose Mode of transport … etc.	EUROSTAT (NEW CRONOS) DATELINE project results IATA Digest on Statistics UN-ECE Road Transport Census Official World Airways Guide Airline Coding Directory HAFAS railway schedule information system EUROCONTROL flight schedule National passenger O/D matrices UIC
TRANSPORT INFRASTRUCTURE Network	GIS data (nodes and links) Km of network Number of railway or motorway lanes	UN-ECE, UIC, EUROSTAT (GISCO) EU project results like TEN-STAC and GETIS ICAO statistics

Category	Data included (examples)	Data sources (examples)
	Airport capacity Quality of infrastructure … etc.	Official Airline Guide EUROGEOGRAPHICS, EUROCONTROL Computer Reservation Systems Government internet websites Tariff database of consolidator (air tariffs) …
Freight services and costs	Transport schedules Price per ton Equipment deployed Vessel/vehicles Operators, … etc.	EUROSTAT (GISCO) Transport operators, shippers, ports and terminals Business directories Project results RECORDIT, SPIN and GBFM
Passenger services and costs	Flight Rail and ferry schedules Ticket prices Airport taxes Access times Routing … etc.	Official Airline Guide (OAG), EUROGEOGRAPHICS (SABE) Websites of ferry and rail companies, Timetable for passenger ferry services, international rail timetables, tariff database of a consolidator for air tariffs UIC, EUROCONTROL, ICAO, HAFAS, …
External effects	Emissions Accidents Injuries … etc.	EUROSTAT National data sources and publications Project results: COMMUTE, RECORDIT, TEN-STAC, INTERNAT, MEET...

4.3.2. ETIS methodologies applied

A database like ETIS comprises a set of constructed variables to describe indicators identified as important for tapping on various transport policy dimensions. These variables are constructed on the basis of the primary data using mathematical formulas and algorithms. Often the primary data is not complete or disaggregated at an adequate level to allow the formulation of constructed variables. In this case we refer to data gaps.

There are different types of data gaps. Some arise by reason of the absence of specific data overall or at a specific geographical level; others result from the lack of comparability among available datasets. In order to fill-in these gaps different methodologies have been developed:

- methodologies to assemble and harmonize data (for instance, road transport cost for freight or passengers);
- methodologies to combine data (for instance, OD data freight);
- modelling methodologies to estimate data (for instance road traffic flows on links, passenger OD, inter-regional domestic freight transport by commodity and mode, emissions).

All three types of methodologies and combinations were used in the development of the ETIS pilot reference database. Modelling was applied for the estimation of data that was in turn needed for the construction of other variables. Table 2 summarizes the main data gaps observed for each ETIS broad data category and the methodology used for estimating the missing information.

External models were used in the case of network data and freight and passenger O/D matrices. In other data areas, data gaps were filled by using alternative data sources. Results of previous or parallel projects were used in yet other cases – one example here was the use of the OD-ESTIM project results for estimating the freight demand data. For passenger transport flow data, more generally, different models were tested based on the four-stage model of generation, attraction, distribution and model-split. The DATELINE database on long-distance mobility was used to validate the passenger demand data.

In conclusion, the development team of the ETIS pilot reference database used a combination of estimation and modelling approaches to fill-in gaps in the data. Priority was given to supplementing missing values through data from alternative sources provided these alternative sources were comparable in design, methodology and output to the primary data sources. When this was not possible, estimation techniques based on statistical analytical tools (such as regression analysis) and conceptual models (object-oriented framework) were used. All methods and data sources were described in detail in order to ensure that they can be repeatedly applied in the future.

Table 2 **Main data gaps and methods of data estimation in the ETIS reference database development**

	Socio Economic area	**Freight Demand area**	**Passenger Demand area**	**Network Data area**	**Freight service and costs area**	**Passenger Service cost area**	**External Effect data**
Data gaps	Inconsistency of regional coding within or across countries. The NUTS regional coding scheme is not equally relevant in all countries for describing regional socio-economic disparities. The years for which data is available are heterogeneous	Transport chain O/D Region-region international Region-country trade data (by mode, by commodity) Region-country transport data (by mode, by commodity) Transshipment data in ports (by origin and destination country/region by commodity by mode) Transshipment data in inland terminals (by origin and destination country/region by commodity by mode) Domestic region-region data (by mode, by commodity)	Passenger O/D matrices Transport modes coverage Trip purpose of passengers	Data gaps in network databases No calculation network Dispersed data availability	A European Cost/price freight transport database does not exist Reliability of intermodal transport on specific links and routes	Direct passengers travel costs road Direct passengers travel costs rail	(Monetary) evaluation of external effects
Method	Harmonisation and combination	O/D ESTIM Project Alternative sources All data available in modelling NEAC type of models	DATELINE dataset methodology VACLAV, VIA models	GETIS Network modelling Input from other areas TEN-STAC Models	A Transport Network Data Model (TNDM) A Generic Cost Model (GCM)	Modelling, generic cost model for rail tariffs	Modelling approach based on input from other ETIS data areas

4.4. Input/data needs trade transport model

The input for the trade model consists of:
A) Transport component: ETIS database OD “base matrix” for freight:

- Origin, first transhipment, second transhipment, and destination region
- Transport mode at origin, between transhipments, and at destination
- Commodity group
- Tonnes.

B) Socio-economic component (profile-matrices), consisting of the following 2 components:

1. Data on economical/political granulation of the world (meaningfully filtered in relation to Europe):

   A profile-sheet for each relevant granule (a country or clusters of countries):
   - which economical/trading area/zone
   - characteristic of that economical/trading area
   - which political/institutional system
   - EU attitude towards that political system (for instance, special treatment China)
   - The level of sensitivity/dependence on the developments in that area for the EU
     - ➢ general economic implication (for instance, towards import of oil from external areas)
     - ➢ sector-specific implication (including transport sector).

2. Economical data set by country (also the country (groups) in the rest of the world as in the ETIS country codes) consisting of at least the following variables:

- GDP at constant prices
- Population
- GDP per head
- Agriculture production
- Industrial production.
- Other production variables:
  - Metal products
  - Chemical production: petroleum products
  - Chemical production: other products
  - Mining and Quarrying production
  - Construction
  - Electricity/water/gas production.
- Other expenditures variables:
  - Private final consumption
  - Food consumption
  - Residential construction.

For calibration these variables are needed for the base year 2000.

For running the models the average growth rates between the base year and the forecast year are needed for these variables.

In addition to the socio-economic data, the actual and expected trade arrangements in the basis year and in the forecast year for each country or country group have to be also specified in respect to any trade and/or specific commodity group. The year when the change of trade arrangements is expected to take place has to be known as well.

4.5. Input/data needs modal-split model

ETIS database freight matrix [trade model forecasted OD matrix with stable modal-split]*:*
- Origin, first transhipment, second transhipment, and destination region
- Transport mode at origin, between transhipments, and at destination
- Commodity group
- Tonnes.

Unimodal level of service – matrices [scenario forecast year]*:*
- Year
- Origin and destination region
- Mode (road, rail, inland waterways, sea)
- Distance per mode
- Time per mode
- Cost per mode
- Existence of service per mode.

4.6. Input/data needs logistic model

The logistic module needs both exogenous and endogenous input data. The following exogenous data is required: input data for specification of the module, possibilities, cost data and parameters. From the other models of TRANS-TOOLS, input is needed from the assignment model and the other modules of the freight model.

Exogenous input
All the exogenous data is stored in an Access database. It contains information about regions, countries, modes, commodities, chain types, segment types, relation types, shipment sizes, speeds and other parameters. Furthermore, it contains information that is related to two or more of these groups. The table NstrRegion contains for example region and commodity type specific costs. In Annex D a figure is included which shows all the tables in the database, the fields of the tables and the relations between the tables.

The exogenous input can be grouped as follows:

- Specification of the module.

The following data items belong to this category: lists of regions *(NUTS 2(½))*, countries, modes, commodities *(Nstr 1-digit)*, chain types, segment types, relation types, shipment sizes and speeds.

Modes
The following modes are included: road, rail, inland waterway and maritime transport.

Commodities
The NSTR 1-digit classification of commodity groups will be used in the freight model:
0. Agricultural Products and Live Animals

1. Foodstuffs and Animal Fodder
2. Solid Mineral Fuels
3. Crude oil
4. Ores and Metal Waste
5. Metal Products
6. Crude and Manufactured Minerals, Building Materials
7. Fertilizers
8. Chemicals
9. Machinery, Transport Equipment, Manufactured Articles And Miscellaneous Articles
10. Petroleum Products[2].

NSTR groups 0,1,5,8,9 need to be modelled for including logistics, since distribution/inventory logistics mainly takes place in these commodity groups. This classification is not very detailed, but contains probably just enough detail for modelling logistics properly. This is because logistic decisions depend on the characteristics of the commodity.

- Possibilities
  Items in this category can be seen as restrictions on the transport chains that can be used (possible modes, possible chain types, possible segments, maximum number of chains per chain type).
- Data needed for computation of costs
  For the computation of the costs of different transport chains, the following exogenous cost data is needed: volume to weight ratio, value density, package density, interest rate, tariffs, border resistance, fixed costs at DC's, storage costs, shipment handling costs and values of time.
- Parameters (importance of activity, centrality and flexibility, ellipse factor, distribution over shipment size and speed classes, parameters of logit model for assignment of tonnes). These parameters are explained in the following section.

Endogenous input
The trade/transport matrices that are output from the trade and modal split module of the freight model are input to the logistic module. These matrices must contain an origin, first transhipment location, second transhipment location, destination, mode at origin, mode between transhipments, mode at destination, commodity group (NSTR 1) and tonnes transported.

From the assignment model the following data is needed:
- Distances between regions for each mode (km)
- Travel times between regions for each mode (hour/vehicle)
- Toll costs (and costs of other pricing strategies) between regions for each mode (€/ton).

Other information about the number of different modes by which a region can be reached and the fact whether or not transport between regions is possible for each mode (region, region, mode, possible?). This information has to come directly from the networks.

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[2] NSTR1 chapters with crude oil (code 3) separate and NSTR chapter 3 excl. crude oil with code 10

4.7. Input/data needs passenger transport model

Input to passenger demand model from ETIS database:
The ETIS O/D matrix passenger (differentiated by trip purposes) delivers the input to IWW passenger demand model from ETIS database.

Input to passenger demand model from socio-economic data:
- Population at NUTS3 level
- GDP at NUTS3 level
- Employment at NUTS3 level
- Car ownership rate at NUTS3 level.

Input to passenger demand model from unimodal Level of service - matrices:
- Total travel time (including access/egress) per mode
- Net travel time (excluding access/egress) per mode
- Time cost (including access/egress) per mode and trip purpose
- Out-of-pocket cost (including access/egress) per mode and trip purpose
- Net out-of-pocket cost (excluding access/egress) per mode and trip purpose
- Distance per mode
- Frequency per public transport mode
- Out-of-vehicle time per public transport mode
- Number of transfers per public transport mode.

Input to passenger demand model from networks:
This link does not appear necessary, as for consistency reasons the travel impedances for the modal split calculation should solely stem from the network assignment model.

4.8. Input/data needs economic model

Table 3 reports the list of data required by the regional economic model. The data are subdivided into input and calibration data. Calibration data are used to determine all parameters of the model equations and accommodate the model to the real world data. Input data are used for model simulation runs. The data to be used in CGEurope can roughly be subdivided into five categories, namely (1) national accounts data, (2) regional data, (3) trade data, (4) transportation costs data, and (5) model parameters.

Table 3: Data requirement for the economic model

Item	Definition	Scope/Segmentation	Available sources
Input data			
Elasticities of substitution between regions	Measuring substitutability of goods between regions of origin	**Commodities:** 12 (NST/R classification + services)	Estimates from literature
Elasticities in production functions	CES: measuring substitutability between inputs; CET: measuring substitutability between outputs	**Sectors:** 5 model sectors	Estimates from literature

Item	Definition	Scope/Segmentation	Available sources
Competition parameter	Measuring the degree of competition for goods of a specific sector	**Sectors:** 5 model sectors	Estimates from literature
Freight transportation costs in Euro/ton	Average cost of travelling on origin/destination pairs with freight modes	**Geo**: NUTS 2 O/D pairs	TRANS TOOLS freight model
Passenger travel costs in Euro/passenger	Cost of travelling on origin/destination pairs	**Geo**: NUTS 2 O/D pairs	TRANS TOOLS passenger model
Passenger flows Pass/year	Number of passenger trips between regions	**Geo**: Whole Europe at NUTS 3 level; **Demand segments**: business trips	TRANS TOOLS passenger model
Calibration data			
GDP in Million Euro	Gross Domestic Product	**Geo**: Whole Europe at NUTS 2 level	EUROSTAT NEWCRONOS
Value added in Million Euro	Value added by industry	**Geo**: Whole Europe at NUTS 2 level; **Sectors**: Goods production and services production	EUROSTAT NEWCRONOS
Interregional trade in tons/year	Trade flows between regions by commodity	**Geo**: Whole Europe at NUTS 2 level; **Commodities**: NST/R	ETIS-BASE
Input-Output table, $ Million	Matrix describing the production/use relationships among economic sectors	**Geo**: Whole world at country level; **Sectors**: 5 model sectors	GTAP
International trade in $ Million /year	Trade flows between countries	**Geo**: Whole world at country level **Commodities**: GTAP sectors	GTAP
International trade in tons/year	Trade flows between countries	**Geo**: Flows from and to EU25 **Commodities**: HS classification, 2-4-6 digit	EUROSTAT COMEXT
Final demand in $ Million	Value of products and services demanded in a country including households demand, investment and public demand	**Geo**: Whole Europe at country level; **Sectors**: 5 model sectors	GTAP
Sectoral output in $ Million	Value of output of each industry in each region	**Geo**: Whole Europe at NUTS 2 level **Sectors**: 5 model sectors	GTAP

National Accounts

For the sectoral disaggregation of CGEurope, information is needed on input-output coefficients as well as on trade flows by commodity. The complete disaggregation of industries in the economy according to the full NACE system of sectors is not reasonable not only for data availability reasons, but also for modelling reasons. The main problem of the modelling part is that the freight model divides industrial production into commodities, whereas the CGEurope divides the production into sectors. The choice of the sectoral disaggregation therefore has to take account of a correspondence between commodities and sectors that should go as far as possible. Therefore, we choose to divide the economy into five sectors: A to E, defined in Table 4.

Table 4: Matching of NSTR commodity groups with GTAP sectors

Industry in the model	NSTR code	GTAP sectors included
A	0	PDR, WHT, GRO, V_F, C_B, PFB, OCR (part), CTL, OAP (part), RMK, WOL, FRS, TEX
A	1	OSD, OCR (part), OAP (part), FSH, CMT, OMT, VOL, MIL, PCR, SGR, OFD, B_T
D	2	COA, P_C (part)
B	3	OIL
D	4	OMN (part), I_S, NFM
C	5	FMP
D	6	OMN (part), NMM (part)
D	7	CRP (part)
D	8	CRP (part)
D	9	LEA, LUM, PPP, P_C (part), NMM (part), MVH, OTN, ELE, OME
D	10	GAS, P_C (part)
E	-	ELY, GDT, WTR, CNS, TRD, OTP, WTP, ATP, CMN, OFI, ISR, OBS, ROS, OSG, DWE

This sectoral disaggregation allows us to establish a correspondence between GTAP and NSTR commodity classifications, first being the base for input-output information, and second for trade flows and cost information. In this way each commodity type is used as an input by all sectors, but is produced by only one. GTAP also provides the total production and final demand figures for all countries in the model.

Regional Data

Apart from national accounting data, CGEurope needs regional GDP and sectoral value-added data for the calibration of the benchmark year 2000. These data are available from Eurostat NewCronos. Unfortunately NACE sectoral structure in NewCronos is not consistent with NSTR commodity structure. That is why we can only split value-added between goods and service sectors and rely on country-level data for further sectoral split. Eurostat NewCronos contains such data only for the EU countries with reference year 2000. For the Balkan countries, Russia, Turkey, Switzerland and Norway additional data from the International Labour Organization and national statistical offices are used. The indicators used are regional gross value added and employment by sector.

Trade

Information on interregional exchange of goods and services plays a key role in the CGEurope model. The ETIS-BASE dataset provides trade data for 11 commodities on region by region basis that will be used in CGEurope to calibrate the model. CGEurope, however, works with 12 commodities by adding a further commodity, i.e. services. No information is available for interregional flows in service trade from the transport models in TRANS-TOOLS. Interregional service flows are therefore generated in the calibration process using interregional goods trade data from ETIS and international service trade estimates from GTAP.

Transport Costs
Interregional trade cost data for all region pairs and transport modes are obtained from the TRANS-TOOLS freight model, i.e. the NEAC model. Changes of transport costs and times obtained from the freight model are inputs into CGEurope that determine the impact on production in each region, trade between regions, prices and utilities.

Model Parameters
Model parameters determine the households' preferences and market forms. They are derived from econometric estimations taken from the literature.

4.9. Input/data needs assignment model

Networks and outputs from passenger, freight and logistic models form the inputs to assignment.

Input from the passenger model is unimodal passenger O/D matrices at NUTS 3 level in number of passengers and vehicles by mode (road, rail, and air) and trip purpose (business, tourism, and private). Output from the freight and logistic models are unimodal transport matrices at NUTS 2 level by mode (road, rail, inland waterways, and sea), commodity (NST/R), tonnes, and vehicles.

In the TRANS-TOOLS model, transport networks are defined unimodally:
1. Road network (passenger and freight)
2. Rail network (passenger and freight)
3. Maritime network (freight)
4. Inland waterway (freight)
5. Air network (passenger).

The road network used in GISCO version II of TEN-STAC has been selected as the most appropriate and detailed by comparing to e.g. SCENES. Comprehensive manual inspections have been added resulting in an improved road network containing 47,500 road segments covering whole Europe and including attributes as: segment length, segment type (road or ferry), no. of lanes, free flow speeds, capacity, and link type (motorway, urban road, rural road, and ferry). Ferry attributes concerning costs, time and frequency have been estimated since actual information has not been available.

The primary rail network of GISCO in version of TEN-STAC (17,600 links) originating from UIC network includes comparable detailed attributes necessary for assignment: link length, passenger travel time, time for freight carriage, max speeds for passenger and freight trains, line type, and no. of tracks. It is, however, necessary to add links to the primary network to achieve proper modelling at NUTS 3 level and the most important secondary links from GISCO (38,400 links) has been imported. The number of attributes is limited to link length and type making it necessary to estimate attributes e.g. travel time on secondary rail links. Since data are not available at line level it is impossible to differentiate between line competing services with respect to fare and travel time, and frequency (waiting times) cannot enter the assignment.

The maritime network of GISCO contains a comprehensive list of ports which is reduced to major ports before implementation. Inland waterways are described by GISCO in version of TEN-STAC including about 800 links in Middle and East Europe. The data source includes length, travel time and costs.

In TRANS-TOOLS, the GISCO air network of TEN-STAC is used acknowledging its limited level of detail. It includes a list of airports in Europe (419 nodes) and links between airports describing distance, travel time and costs (4,800 links). Line service attributes to include competing air services and calculation of waiting times are not provided by the network limiting the assignment procedures.

The NUTS 3 matrices are connected to the networks via zonal connectors containing information about length and access speed. In order to connect zones to the networks, a geographical referred zonal layer is established.

5. CALIBRATION FREIGHT, PASSENGER, ASSIGNMENT AND ECONOMIC MODELS

5.1. Introduction

“Calibrating a model requires choosing its parameters in order to optimise one or more goodness-of-fit measures, which are a function of the observed data.” (Ortuzar and Willumsen, 1994, p.19) “In the validation stage the modeller intends to ensure that the model is appropriate for the decisions likely to be tested with it.” (Ortuzar and Willumsen, 1994, p.169). The performance of the model is judged against data different from that being used to specify it and, ideally, taken at another point in time.

For the calibration and validation process of the individual modules inherent to the TRANS-TOOLS model outputs of previous EU-funded projects are applied, as well as various data sources underlying the models applied for previous EU-funded modelling applications. As elaborated within the previous chapter one of the most relevant projects in this context is the ETIS project, in which reference data sets for the year 2000 have been generated for passenger and freight transport demand, transport networks, passenger and freight transport supply, external effects as well as socio-economic and -demographic data. Since at least a part of the data sets generated within the ETIS project has been checked by national representatives, and, based on comments received, updated, the final matrices and results of ETIS represent a reliable, state-of-the-art reference data source for transport-related information at European level. Thus several of the TRANS-TOOLS modules rely on ETIS data. Further important data sources applied for calibration purposes are data from Eurostat and the United Nations (UN), the New Cronos data set, as well as traffic count data and information gathered from literature reviews (e.g. for the measurement of value of time).

The present chapter is organised as follows: Whereas section 5.2 refers to the trade model, section 5.3 deals with the modal-split freight model and paragraph 5.4 with the logistic freight model. Section 5.5 addresses the passenger model, section 5.6 the economic model and 5.7 the assignment model.

5.2. Calibration and validation Trade model

5.2.1. Calibration

In general, the set of model parameters $\alpha1, \alpha2, \alpha3, \alpha4, \alpha5$ has to be both OD pair-specific (international, interregional, intraregional), commodity-specific and even time-specific. On the one hand, such individual dependence relates to the fact that the gravity form was chosen to describe the bilateral trade pattern between the production zone *i* and the attraction zone *j*. In real life the bilateral trade between two partners occurs not in a vacuum but within the resultant environment of socio-economic forces/institutional settings and their implications of the remaining external world. This resultant environment for each OD pair is different and changes through the time.

On the other hand, it can be assumed that a variety of trading options exist for each country/zone for a given moment and that each looks for most suitable ones to maximize its comparative advantages.

In order to calibrate the parameter values for each individual case, a tremendous work would be needed. Since an macro-economic approach is used here as basis, some simplifications are assumed for facilitation of the calibration process:

- model parameters per OD per commodity group remain constant over the time;
- model parameters are considered to be cluster specific (i.e. slight differences within the cluster are ignored).

As explained in the paragraph 3.2, for practical calibration of these parameters, the trading countries were clustered into the economical cooperation clusters. For instance, the EU 25 plus Switzerland, Norway and Iceland, in turn was subdivided into smaller country groups on the basis of alike-criteria (similar economical development level, growth rates, geographical vicinity, economies of scale, living style etc).

The following list of sub-clusters is considered per commodity group:

Cluster	members
1	Norway, Iceland, Sweden, Denmark, Finland
2	Germany
3	BENELUX countries
4	Poland
5	Baltic countries
6	UK, Ireland
7	France
8	Austria, Switzerland
9	Czech Republic, Slovak Republic, Hungary
10	Spain, Portugal
11	Italy
12	Slovenia, Malta
13	Greece, Cyprus,
14	Romania, Bulgaria, Turkey
15	Balkan countries
16	Ukraine, Russia, Belarus, other CIS countries
17	Middle East
18	North African countries
20	China, India
21	Japan, USA, Canada, Australia
22	Rest of America
23	Rest of Asia
24	Rest of the World

Ideally for the calibration of the model parameters, one should have a time-series empirical data. However, in our case the calibration of the model parameters against the registered physical tonnages (ETIS mother matrix) and the socio-economic data for one year (2000) are used only. Therefore, the cluster-specific parameter set assumption reduces the number of variants and helps to estimate the parameter values. For example, for the calibration of the parameters λ_3, λ_4 for the export of the commodity g from the country *i* to the country *j* and country *k* from the same cluster (having two or more countries), the application of the gravity formula (see paragraph 2.2.2) leads to the following simplified relation between the model variables:

$$T_{ijg} / T_{ikg} = (A_{jg} / A_{kg})^\wedge \lambda_3 * (D_{ik} / D_{ij})^\wedge \lambda_4$$

where variables *T*, *A* and *D* represent respectively the empirical data on physical flow in tons, the added value of the attraction sector and the transport costs.

A similar mathematical manipulation for the import of the same commodity from the different countries of the same cluster leads to estimation of the λ_2, λ_4 parameter pair.

In order to further narrow the testing range of combinations, the parameter values contained in the NEAC model as well as other in-house models for Eastern Europe were consulted. The value ranges of the parameters for production and respective attraction sectors throughout the clusters are, as follows:

Commodity group	Production sector λ_2		Attraction sector λ_3	
0	Agriculture	0.478-0.990	Consumption	0.523-1.099
1	Agriculture	0.342-0.990	Consumption	0.640-0.891
2	Mining& quarrying	0.217-1.000	Industry	0
3	Substitute-GDP	1; 0	GDP	1
4	industry	0.545-0.862	Industry	0.515-0.735
5	Basic metal industry	0.664-1.019	Industry	0.373-0.735
6	Construction	0.404-0.950	Residential construction	0.439-0.910
7	Chemicals, petroleum	0.355-0.934	Agriculture	0.346-0.973
8	Chemicals, petroleum	0.528-0.901	Industry	0.490-1.058
9	Metal products industry	0.660-0.980	Private final consumption	0.660-1.013
10	Petroleum products	0.851-1.010	GDP; GDP/capita	0.410-1.267

The values for the transport costs variable used in the parameter calibration process were derived from the distance/cost per ton-matrix of ETIS/NEAC sources. The criteria for filtration of the cheapest and at the same time most popular way of transportation of a specific commodity group between specific OD-pair was the comparison of the ratios:

C(x,y)= (Unit cost for mode x)/(unit cost for mode y)

versus

T(x,y)=(Tons transported with mode x)/(Tons transported with mode y)

The latter condition was introduced, in order to exclude ambiguous situation, when the cheapest route in monetary terms (according available distance/costs matrix) for some reasons is not very much used or even not used at all (for instance, in the case of time-sensitive goods).

5.2.2. Validation

A rather wide spread of the parameters values is caused not only due to the variety of country clusters and the specializations of the countries itself, but also due to large differences in values per ton ratios within the same commodity group. Also, the link between the production sector and attraction sector per commodity group is not one-to-one link in a real life. The substitution of GDP variable is to some extent a solution for that, but not always the optimal one (our focus on EU25+3, while the remaining countries economies are considered only to the extent they are dealing with this focus area).

Also the assumption that the momentive parameter values for the year 2000 will be taken as constant to estimate also the future transport flows remains for some countries more feasible than for others. Namely, the preservation for a longer run of the trade relations with the fast growing countries with low production costs (for instance, China), might lead to discrepancies with the real pattern in Europe.

5.3. Calibration and validation Modal-split Freight model

5.3.1. Calibration

The modal-split model formulated in section 2.3.2 in deliverable D3 is calibrated with the ETIS database OD mother matrix for freight, which includes the modal-split for the base year. The explanatory variables are the levels of service for the base year.

For the transport modes rest (8) and unknown (9) no levels of service are available so these modes are not included in the choice set and the transport flows with these modes are removed from the data used for the calibration of the model. Furthermore, the commodity group crude oil (3) is removed from the data used for the calibration of the model since political and technical developments have a large influence on the trade and transport of this commodity group. Also the OD relations with only road transport available are removed, since there is only one mode to choose in that case. The final category removed from the data before calibration of the model is intercontinental transport, because sea transport is the only available mode for those transport flows.

The logit parameters are calibrated for a number of market segments. The segmentation is based on the commodity group (NST/R), with crude oil excluded. On the next page a schedule of the segmentation is given.

Segment	Commodity Group (NST/R 1-digit)
0	0. Agricultural products
1	1. Foodstuffs
2	2. Solid mineral fuels
4	4. Ores, metal waste
5	5. Metal products
6	6. Building minerals & material
7	7. Fertilisers
8	8. Chemicals
9	9. Machinery & other manufacturing
10	10. Petroleum products

For every market segment the parameters are estimated for various model configurations using the maximum likelihood method. The difference between the various configurations are the distinct restrictions on the parameters. The restriction of the parameter of a certain level of service to equal zero corresponds to that level of service having no influence on the modal-split for the given market segment. In the calibration process the configuration that models the base year modal-split best is selected given that the parameters have intuitionally correct signs and magnitudes and are statistically significant. A list of the best configuration for every segment is presented below. The list contains the following explanatory variables: an alternative specific constant (A_MODE), mode specific dummy variables for transport within Eastern Europe (AMODEE), mode specific dummy variables for transport between Eastern Europe and Western Europe (AMODEWE), dummy variables for border resistances (B_ROAD, B_RAIL). the generalized cost of transport (BCOST), mode specific generalized cost variables for transport within Eastern Europe (BCMODEE), mode specific generalized cost variables for transport between Eastern Europe and Western Europe (BCMODEWE), and a port dummy variable for sea transport in relation with major ports and a distance exceeding 500 kilometres (BC_SEA500).

segment	a_mode	amodee	amodewe	b_road	b_rail	bcost	bcmodee	bcmodewe	bc_sea500
nstr0	rail, inlww, sea	rail, inlww, sea	rail, inlww, sea	-	rail	all	road, rail	rail	sea
nstr1	rail, inlww, sea	rail, sea	rail	road	rail	all	road, rail	rail	-
nstr2	rail, inlww, sea	rail, inlww, sea	rail, sea	-	rail	all	road, rail	rail	sea
nstr4	rail, inlww, sea	rail, inlww	rail	-	rail	all	road, rail	rail	-
nstr5	rail, inlww, sea	rail, inlww, sea	rail, sea	-	rail	all	road, rail	road, rail	sea
nstr6	rail, inlww, sea	rail, inlww, sea	rail	-	rail	all	road, rail	road, rail, inlww	sea
nstr7	rail, inlww, sea	rail	rail, inlww, sea	-	rail	all	-	rail	sea

nstr8	rail, inlww, sea	rail, sea	rail, inlww, sea	-	rail	all	road, rail	rail	sea
nstr9	rail, inlww, sea	rail, sea	rail, inlww, sea	road	rail	all	road, rail	rail	sea
nstr10	rail, inlww, sea	rail, sea	rail, sea	-	rail	all	rail	rail	-

More detailed information on the model used can be found in Deliverables D3 and D4.

5.3.2. Validation

The validation of the choice for the multinomial logit model has been done for the NEAC modal-split model. A study of the available literature lead to choice for a multinomial logit model as the best suitable model for the modal-split model. Furthermore specification tests have been carried out to check if all the assumptions underlying the model are valid. These tests for the distributional assumptions, homoskedasticity, independence of irrelevant alternatives and the linear model specification did not indicate violations of the model assumptions. The NEAC modal-split model uses a freight database and explanatory variables that are similar to the ETIS database freight matrix and the levels of service used as explanatory variables for the TRANS-TOOLS modal-split model. Therefore, the conclusions of the validation of the use of a multinomial logit model for the NEAC modal-split model will also hold for TRANS-TOOLS. In annex A further details are presented on the choice for a multinomial logit model as the best model for the modal-split model.

The specific model specifications which are calibrated for all market segments are validated by a number of checks. The signs and magnitudes of the estimated parameters must be correct; the parameters have to be statistically significant; the estimated modal-split should replicate the base year modal-split properly; and sensitivity analysis on the levels of service must show plausible shifts in the modal-split.

5.4. Calibration and validation Logistic Freight model

5.4.1. Calibration

This section describes the calibration of the logistic module as formulated in section 2.4.3. A nested logit model is used to model the decision between chain types, chains and modes. There are two reasons why a nested logit model is used: this is a type of discrete choice model that is often used in literature and this type of model is also used in SLAM: the model on which the logistic module is based. The parameters of this model are calibrated by using the available data and expert judgement. Besides the parameters of the nested logit model, also the values of some other parameters like importance of activity, centrality and flexibility and the ellipse factor will be determined in the calibration.

5.4.1.1. *Mode Choice*

In the freight model of TRANS-TOOLS the mode choice is determined in two phases. The mode choice in the logistic module is complementary to the mode of the modal-split module. Therefore, the results of the modal split module are explicitly taken into account in the calibration of the logit parameters of the mode choice model of the logistic module. Logistic activities could influence the mode choice. Since not much data is available about these kind of effects, the results of the modal split model are used in the calibration of the mode choice parameters of the nested logit model.

5.4.1.2. *Chain Choice*

For each chain type a number of chains is built. The choice between these chains is modelled in the nested logit model. The chains differ in the location of the distribution centres and the selection of these locations is based on the location scores, because the location scores determine which regions are the most likely regions to be used as a distribution centre. The location scores consist of three components: economic activity, centrality and flexibility. In this calibration step the importance of each of these components will be determined as well as the ellipse factor and the values of the parameters for the chain choice parameters of the nested logit model. All the available data about the usage of distribution centres will be used and if necessary this will be complemented with expert judgement.

5.4.1.3. *Chain Type*

There are four chain types: direct transport, transport through an European distribution centre, transport through a national distribution centre and transport through both an European and a national distribution centre. Because data availability about different chain types is very scarce, the calibration of the parameters for the choice between chain types will mainly be based on expert judgement.

5.4.2. Validation

The validation of the logistic module will consists of some tests of extreme cases and of a sensitivity analysis of the most important parameters of the model. This can be seen as a check on the behaviour of the model.

Furthermore, the validity of the results will be tested by comparing the results of the logistic module with the known distribution strategies of some large companies that are operating on an international level.

5.5. Passenger

5.5.1. Calibration

5.5.1.1. Trip Generation:

The most important socio-economic data, population and GDP on NUTS3 level, will be provided and hence synchronized with CGEurope. The other endogenous drivers of the trip generation module, employment and car fleets are calibrated to Eurostat data sources. Employment has been calibrated to fit Eurostat New Cronos data, car fleets are calibrated to fit Eurostat Transport in Figures 2003 and UN Statistical Yearbook data from 2002. Trip generation rates were originally adopted from SCENES and disaggregated into the necessary dimensions. To disaggregate trip rates on NUTS3 level another calibration is necessary. For this calibration the ETIS database O/D matrix will be transformed back into a vector containing generated trips per NUTS3 zone. Trip rates will be adjusted in this calibration by these vectors and the population segments disaggregated in the same dimensions.

5.5.1.2. Trip Distribution:

The distribution model will be using the ETIS database for the base year as calibration data source. Hence the spread parameter λ and the specific disutility *SD* of the linear logit function described in section 4.7 are calibrated.

5.5.1.3. Modal split:

The parameters of the modal split module of the VACLAV model have been calibrated by European travel surveys. Particularly within the STEMM project travel and household surveys from Germany and Switzerland as well as European databases have been applied in order to estimate model parameters. Due to feedback loops from the assignment to modal split calculation, the determination of modal shares is influenced by travel count data as well.

5.5.2. Validation

Based on available literature and studies the passenger trip generation approach multiplying passenger trip generation rates and specifically clustered population segments has been chosen as best suitable model. According to available European mobility studies trip making behavior is strongly related to age, employment status, car availability of the trip making person and the purpose of the trip. Hence, population segments and trip generation rates were generated by this classification. Passenger trips forming the basis of the ETIS database passenger matrix have been considered to disaggregate SCENES trip generation rates on NUTS3 level. The ASTRA approach of endogenously computing socio-economic impacts like population age structure, employment and car ownership forming the relevant population segments has been applied in several projects like ASTRA, TIPMAC and IASON.

Like in the trip generation stage for the disaggregation of passenger trip rates, the ETIS database passenger matrix for the base year 2000 will be used to validate the passenger trip distribution. The chosen logit function as approach for the distribution has been applied in ASTRA and gets like gravitational models generalized times as specific input.

The modal split function of the passenger transport model has been subject to careful checks during the course of application of the model for various purposes, like the modeling of intermodality within STEMM, the modeling of impacts of road charges within SCENES, the generation of traffic forecasts within TEN-STAC and various other field of applications. In the course of model development model results for certain O/D relations have been compared – as far as data availability allowed – to real data. Furthermore, due to the requirement of adjusting of modeled network flows to traffic count data, the working mechanism of the modal split calculation process has been subject to careful checks.

5.6. Economic model

5.6.1. Calibration

Given a much larger amount of data used in this project compared to earlier runs of CGEurope, the whole calibration is contained in the trade flows adjustment procedure.

The new data source that enables extension of the model with the industry-commodity framework is the ETIS-BASE. It contains trade flows for 11 NSTR commodities on NUTS2 origin-destination scheme. However, these flows are given in tons, while the economic model requires all parameters to be in value terms. To solve this problem, a multidimensional adjustment procedure has been designed, which is based on a micro-consistent GTAP database, as well as on value-to-weight ratio information in COMEXT database.

The object of the adjustment is the ETIS-BASE flow information, appended using the COMEXT flow information. These flows are adjusted using a set of unknown multipliers subject to a set of constraints. The constraints come in three groups:

1. Commodity flows into each destination country should sum up to use figures from GTAP (for each commodity, for each destination country).
2. Flows of all commodities from each origin country sum up to output figures from GTAP (for each industry, for each origin country).
3. Values of international trade should be matched (for each commodity, each country pair).

More specifically, we introduce the following notation:

i	Commodity
I,J	Industry (A, B, C, D)
s,r	Region
N,L	Country
P	Output
V	Value added
D	Intermediate demand
F	Final demand
Y	GDP

Given this notation, the constraints are:

$$\sum_{r\in N} P_{Ir} = P_{IN}, \text{ where } P_{Ir} = \sum_{i\in I}\sum_{s} X_{irs} \,;$$

$$\sum_{I} P_{Ir} C_{IN} = V_r, \text{ where } C_{IN} = \frac{V_{IN}}{P_{IN}} \,;$$

$$\sum_{i\in I} T_{iNL} = T_{INL}, \text{ where } T_{iNL} = \sum_{r\in N}\sum_{s\in L} X_{irs} \,;$$

$$\sum_{i\in I}\sum_{s} X_{isr} = \sum_{J} a_{IJ}^{N} P_{Jr} + b_{I}^{N} Y_r, \text{ where } a_{IJ}^{N} = \frac{D_{IJN}}{P_{JN}} \text{ and } b_{I}^{N} = \frac{F_{IN}}{Y_N} \,.$$

The micro-consistent database assures that $P_{IN} + \sum_{L}(T_{ILN} - T_{INL}) = F_{IN} + \sum_{J} D_{IJN}$.

5.6.2. Validation

The only relevant validation of the economic model in TRANS-TOOLS is checking if the output indicators have plausible values. However, this check requires the knowledge of the transport cost change information, which will be available only in the later stage of the project.

5.7. Assignment

5.7.1. *Calibration*

5.7.1.1. Estimation of AADT at link level

Short distance traffic needs considerations for modelling of road congestion, and a simple approach based on estimation of AADT is described in Section 2.7.2.2. Using network information and counted traffic on 25% of the road segments the following model has been derived:

$$\mathrm{AADT}_{lhz} = \alpha_{hL} L_l + \alpha_{hD_M} D_{lM} + \alpha_{hD_E} D_{lE} + \alpha_{hD_U} D_{lU} + \alpha_{hP_z} P_z + \alpha_{hP_l} P_l + \alpha_{hT} T_z + \beta_h$$

Where α, β = parameters estimated
AADT_{lhz} = estimated AADT on link l in segment h and zone z
L_l = number of lanes on link l
D_{lM} = 1 if motorway else 0 (dummy)
D_{lE} = 1 if not Europen road else 0 (dummy)
D_{lU} = 1 if urban road segment else 0 (dummy)
P_z = Population desinty per square km in NUTS 2 or 3
P_l = Population desinty per square km in buffer surrounding road segment by 1 km
T_z = Average counted AADT on European roads in NUTS 2 or 3.

The traffic on minor roads is more likely to be influenced by population density of the surroundings than major roads carrying longer distance traffic. Therefore, P_l is only applied to non motorways and European roads defined by the attributes in the network. Count data vary among countries making it necessary to aggregate to NUTS 2 in some countries. Due to consistency between regions only counted traffic on European roads is used to estimate an average of activity in the zone.

Consequently, the limited number of count data leads to aggregation of countries into 15 segments based on data analyses and indicated in table 6 For each segment parameter values has been estimated shown in table 6. It has not been possible to estimate all values with correct sign due e.g. to correlations or few observation, therefore, they have been removed from the expression above.

Table 5 Segmentation of European counties in estimating AADT

Segment	Country
1	Denmark, Norway
2	Germany
3	Sweden, Finland, Island
4	Netherlands, Belgium, Luxembourg
5	Austria, Switzerland
6	France
7	Spain, Portugal
8	Italia
9	UK, Ireland
10	Polen
11	Czech Republic, Slovakia, Croatia
12	Hungary, Slovenia
13	Greece, Turkey, Albania, Bosnia and Herzegovina, Bulgaria, Moldova, Macedonia, Rumania, Serbia and Montenegro
14	Belarus, Russia, Ukraine
15	Latvia, Lithuania, Estonia

Table 6 Parameter values in estimating AADT

Seg.	Obs.	α_{hL}	$\alpha_{\mathrm{hD_M}}$	$\alpha_{\mathrm{hD_E}}$	$\alpha_{\mathrm{hD_U}}$	$\alpha_{\mathrm{hP_Z}}$	$\alpha_{\mathrm{hP_l}}$	α_{T}	β_{h}	R^2	NUTS
1	1639	4377	6422	-4517	9389	4,091	1,989	0,220	-3582	0,69	3
2	1551	3347	-	207	2759	0,446	0,720	0,901	-9379	0,83	3
3	593	1958	2401	-1807	8758	1,563	2,427	0,690	-3597	0,55	3
4	643	2591	1935	-6960	-	1,165	5,028	0,945	-10073	0,70	3
5	682	-	8893	-23027	6151	0,023	0,104	0,696	1878	0,54	3
6	1553	-	8573	-3578	14223	18,499	1,224	0,752	-3477	0,50	3
7	879	613	1353	-4582	3634	1,736	11,624	0,881	-861	0,55	3
8	700	-	1867	-7933	3329	0,835	6,258	0,979	-1356	0,78	3
9	478	-	5308	-16919	3974	5,602	-	0,849	910	0,68	3
10	1126	521	5505	-4258	586	0,749	0,951	0,426	4510	0,58	3
11	444	2012	2262	411	7476	-0,666	2,073	0,736	-3348	0,51	3
12	167	1156	3893	-7785	4594	38,506	-	0,514	-2558	0,57	2
13	599	384	4441	74	1911	20,022	-	1,620	-7897	0,62	2
14	231	-	2075	-2126	-	38,365	-	0,705	-1668	0,56	2
15	126	-328	3320	-595	3459	-18,560	0,076	0,881	1658	0,65	3

5.7.1.2. Time distribution of road traffic

The passenger model includes three trip purposes: business (commuting and work related trips), tourism, and other private trips which should be distributed according to the type of day by different shares of AADT. For instance, business trips are mainly done on weekdays. Freight traffic varies different from passenger traffic across the type of days, since most long distance trucks traffic is carried out on weekdays and weekends outside the summer holidays.

Table 4.3 illustrates AADT-shares by type of day and purpose restrained, since they weighed by the relative share of days must add up to 1. The AADT-shares based on professional judgements will be validated in the process of calibrating the road assignment model.

Table 7 **Example of AADT-shares dived by type of day and purpose**

Type of day	Number of days	Long distance trips				Short distance
		Business	Tourism	Private	Trucks	
Weekdays outside summer	200	1,50	0,80	1,00	1,40	1,12
Weekday within summer	35	0,80	1,20	1,00	0,15	1,00
Busy holidays	20	0,00	2,00	1,00	0,15	0,90
Weekends	110	0,34	1,12	1,00	0,70	0,80
Total	365	1,00	1,00	1,00	1,00	1,00

The long distance trip matrices are split as formulated in Section 2.7.2.2 into medium distance trip matrices (≤ 150 km) and real long distance trip matrices (> 150 km). Trips above 150 km is simply assumed to be distributed evenly over time and direction.

The medium trip distance matrices are distributed over time and direction depending on trip purpose. On weekdays outside summer holidays tourism, private, and trucks trips are primarily done in day time. Therefore, trips is assumed to be evenly distributed among the three time periods according to hours outside night period: am peak (2 hours, 7-9 am), pm peak (2 hours, 3-5 pm), and off-peak (16 hours). Business trips including commuting are differentiated by direction and time periods on weekdays outside summer holidays. Using zonal population as generation and jobs as attraction the equation in Section 2.7.2.2 is applied to rearrange the symmetrical OD trip matrix from the passenger model after division by day type. Then, the new GA-based tour matrix is given by (tours = trips divided by two):

$$T_{ij}^{GA} = \frac{T_{ij}^{OD}}{1 + F_{ij}}$$

The trip matrices for the three time periods is calculated from shares of outbound and homebound trips. Table 8 shows ToD factors from the regional traffic model for Copenhagen which are applied in the project (Jovicic & Hansen, 2003).

Trips on other days than weekdays outside summer holidays are simply distributed evenly over the day time period (20 hours).

Table 8 **ToD factors for splitting business tours into time periods on weekdays**

Time period	Outbound	Homebound
7-9 am peak	65%	1%
3-5 am peak	2%	44%
Off-peak	33%	55%
Total	100%	100%

Short distance traffic calculated as the difference between AADT and matrix assigned traffic needs also to be split by direction and time period (am peak, pm peak, and off-peak) for weekdays outside summer holidays. The split by time periods is assumed to be: 35% in am peak, 40% in pm peak, and 25% in off-peak. Since no information on the directional split is available, it is estimated from the assignment of medium distance matrices. Without taking capacity into consideration, the medium distance business trip matrices for weekdays outside holidays in base year is assigned to the network. The directional shares by time period are calculated per link and applied to short distance traffic to be preloaded.

5.7.1.3. Value of time (VoT)

In TRANS-TOOLS, VoT will not be estimated specifically for the project but assessed based on other studies and models. Average values of time are applied in the assignment models covering the geographical area of interest, since data source are limited for Eastern European countries and complexity is reduced. The missing information about home residence in demand matrices also prevents regional differentiation of VoT.

At first, it seems best to apply the same VoT used in the passenger and freight models. However, due to the framework of the models and feedbacks from LOS from assignment to estimation of the demands models it seems unrealistic within the time constraints of the project. The second choice would be to apply VoT used in international models like SCENES or VACLAV or national models. National VoT studies are other sources of information. Theoretically, however, these studies usually provide data for economic evaluations rather than input to traffic models parameters. VoTs for use in assignment will be determined in the following procedure assessing VoT data of each step on its ability to meet the requirement by time components and travel purposes:

- Investigation of parameters used in existing international models for passenger and freight
- Literature study of parameters used in selected national and regional European passenger and freight models
- Literature review of European VoT studies.

Table 5.5 shows VoT applied in some Danish models. It illustrates differences between the framework of mode choice models and assignment models which needs consideration when importing parameters from external models. KRM and OTM are regional models where parameters used in the assignment models have been estimated in separate procedures. The Great Belt, Øresund, and Fehmarnbelt are screen lines model used for assessment of the fixed links projects. Lolland and Djursland are regional Danish passenger models.

AKTA as part of the 5th EU framework programme includes survey of commuters in the Copenhagen area used for estimating VoT. Based on recent survey results from AKTA, CTT has estimated and updated VoT which has been applied in car assignment models.

Table 9 VoT by time component and purpose in Danish passenger models (Euro per hour at 2000 price level)

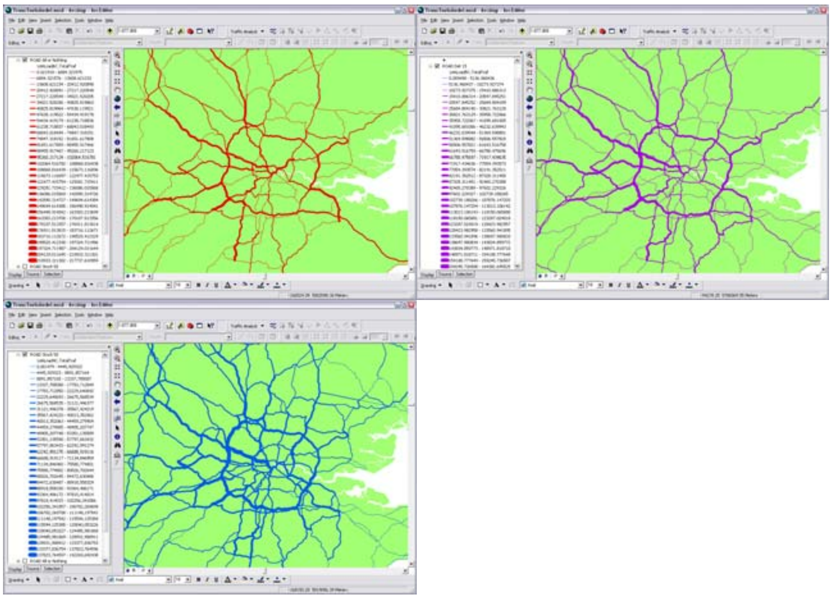
Time component	Source	Commute		Education		Business		Other	
		Mode choice	Assignment	Mode choice	Assignment	Mode choice	Assignment	Mode choice	Assignment
Passenger car, free flow time	KRM[1]	5,8	4,6	7,1	4,6	23,3	6,9	5,7	3,0
	OTM[2]	3,0	4,6	1,4	4,6	7,4	6,9	3,6	3,0
	AKTA[3]	4,2	3,0						
	Fehmarnbelt[4]					107,0		29,1	
	Great Belt[4]					29,3		6,0	
	Øresund[4]							7,9	8,5
Passenger car, congested time	KRM	7,4	6,0	7,9	6,0	41,7	11,5	11,0	6,3
	OTM	10,1	6,0	4,1	6,0	20,6	11,5	4,1	6,3
	AKTA	6,9	4,6						
Ferry time	Øresund							5,3	10,7
	Fehmarnbelt					44,1		8,2	
	Great Belt					53,5		4,6	
Ferry, headway	Øresund							3,1	0,5
	Great Belt					7,2		2,0	0,9
Train, invehicle time	KRM	6,1	4,2	3,3	1,4	21,6	33,2	5,2	1,4
	OTM	4,1		1,6		13,5		2,7	
	Fehmarnbelt					89,2		13,8	
	Lolland[5]	4,6		3,6				4,4	
	Djursland[5]	6,8		4,9				6,0	
	Great Belt					37,8		10,9	5,5
	Øresund							13,4	
Transfer time	KRM	9,9	6,0	7,4	4,4	28,2	42,5	10,4	4,4
	OTM	10,1		4,4		29,9		4,4	
	Lolland	8,3		6,6				7,9	
	Djursland	12,1		8,8				10,9	
Access and egress time	KRM	7,6		2,8		23,1		8,2	
	OTM	8,0	7,1	5,7	3,1	38,7	42,5	6,0	3,1
	Lolland	5,8		4,7				5,7	
	Djursland	8,5		6,1				7,6	

[1] Passenger and simple freight model covering Sealand and Funen
[2] Regional traffic model for the Greater Copenhagen Area
[3] Survey of commuters in the Copenhagen Area
[4] Screen line passenger and freight model
[5] Regional passenger models of Lolland and Djursland

5.7.2. *Validation*

Based on ETIS car trip matrices preliminary assignments have been conducted testing different setups. The figures below illustrate in a case for London results from an all-or-nothing (AON) assignment, a deterministic user equilibrium assignment (UE) and a stochastic user equilibrium assignment (SUE). The advantages of the model formulated in Section

5.7.2.1 are apparent distributing the trips over the network more consistent to actual travel behaviour.



When calibrated the road assignment models discussed above and software implemented in WP 4, results will be validated against count data which may lead to some adjustments of networks or model parameters.

The same procedure should be followed for the other modes. Due to lack of data, however, the assignment results will only roughly be validated on actual figures and professional judgements.

6. SOFTWARE IMPLEMENTATION TOOL

6.1. Technical information

The entire Trans-Tools Model is embedded in ArcGIS from ESRI. The Trans-Tools Model is executed in ArcGIS' GeoProccessing (GP) environment by using the Model Builder application.

It is assumed in the following that the user is familiar with ArcGIS, Geoprocessing and Model Builder. The following ArcGIS User Guides are recommended for in depth knowledge on these subjects:

- What_Is_ArcGIS.pdf
- Getting_Started_with_ArcGIS.pdf
- Using_ArcCatalog.pdf
- Geoprocessing_in_ArcGIS.pdf
- Writing_Geoprocessing_Scripts.pdf
- Geoprocessing_Quick_Ref_Gde.pdf
- Using_ArcMap.pdf
- Editing_in_ArcMap.pdf

6.2. Installation

ArcGIS Desktop 9.1 or later must be installed, before installing the Trans-Tools package. The Trans-Tools package consists of:

- Traffic Analyst from Rapidis
- TransTools GP Tools from Rapidis
- PassengerModel from IWW
- Logistic Module from TNO
- TradeModel from NEA
- Freight Modal Split from NEA
- Economoc Model from CAU
- MatLab Runtime
- Several converters etc. from CTT
- A geoprocessing Toolbox
- Data

The TRANS-TOOLS package is installed by executing the batch file transtoolsinstall.cmd. This will place the TransTools modelling system in C:\TransTools. All data will be placed in C:\TransTools\Data and programs will be placed in C:\TransTools\Programs.

Once the installation is complete, start ArcCatalog and turn on the ArcToolbox pane. Right-click ArcToolbox and choose Add Toolbox. Navigate to the \data\toolboxes\ folder under the folder where TransTools was installed and pick the TransTools.tbx file. Click “OK”. This permanently adds the TransTools models to ArcToolbox.

Uninstallation of the TransTools package falls in 2 steps. Step 1 is to uninstall all the installed MSI-packages. Thais is done by using the provided uninstallation batch file (transtoolsUNinstall.cmd). Step 2 is to manually delete the TransTools folder with the remaining software and all data. It is possible to uninstall only the software and not the data, since all program files are installed under the same folder, which is separate from the folder with all the data.

6.3. Creating a new scenario

The recommended procedure for creating a new scenario is to copy an existing scenario.

This is done by copying each of the folders with the name of the original scenario and renaming them to have the name of the new scenario. The folders to be copied exist here:

- TransToolsDatafolder\Logistics
- TransToolsDatafolder\Matrices
- TransToolsDatafolder\Network
- TransToolsDatafolder\Scenario
- TransToolsDatafolder\Zones

It is very important, that a subfolder with the scenario name is copied to all the above folders and that they have exactly the same name. The subfolder in the TransToolsDatafolder\Logs folder should not be copied.

After this, change the data that shall be different from the original scenario (e.g. scenario year, network, GDP growth rates etc.).

In addition a new model should be created in Model Builder, so that this scenario can be executed in ArcGIS. Using ArcCatalog or ArcMap, create a new model in the Scenario Models toolset (and name it after the new scenario). Make sure to immediately activate the “Store relative path names” setting on the “general” tab in the settings dialog for the model. From the “Models” toolset, drag the “TransTools Full Model” model into the new scenario model and set it’s two parameters to respectively the path to the “data”-folder in the location where the TransTools system was installed and the precise name of the new scenario folders that was just created. Mark the two input variables in the model as “Model Parameters”. Save and close the new model. (As an alternatively to creating a new model, an existing model can be copied).

After these procedures are complete, the necessary changes should be made to the new scenario so that it represents what is required. This is done simply by editing the relevant databases with Microsoft Access or ArcMap. For tabular data, either application can be used, but ArcMap must be used for editing networks. See section 4.4 of Deliverable 4 (D4) for details.

See Annex A for an overview of datasets used in the Trans-Tools modelling system and for information on which specific datasets are meant to be edited when creating new scenarios. For more information on the purpose and role of specific datasets in the Trans-Tools modelling system, see Annex B to H in Deliverable 4 (D4) on the individual models.

6.4. Network editing

Networks are edited with ArcMap.

In addition to using the normal features of ArcMap for editing networks, it is necessary to make certain that topology information is present in the networks in a format that the assignment models can use. This can take one of two forms:

- Ordinary database fields named FromNodeID and ToNodeID on each network link and database fields named CentroidID and NodeID on each connector with consistent and up to date values.
- A built Network Dataset created with the Network Analyst extension to ArcGIS. The Network dataset should include Links, Connectors and Centroids and should have an ID attribute.

6.5. Calculation procedures

As mentioned previously the Trans-Tools modelling system is based on ArcGIS. This means that the ArcGIS software is used to execute calculations with the Trans-Tools modelling system.

Previous chapters have described the individual models that make up the Trans-Tools modelling system as well as the applications which implement these models. In this section it is described how to use ArcGIS to execute the entire Trans-Tools Model.

ArcCatalog as well as ArcMap can be used to execute the Trans-Tools Model. Since some of the models in TransTools are extremely demanding, it is recommended to use ArcCatalog, since this Application carries a smaller memory overhead than ArcMap. Consequently this user guide only deals with using ArcCatalog.

In ArcCatalog, turn on the ArcToolbox pane and expand the TransTools toolbox. In the TransTools toolbox, expand the Scenario Models toolset. Here you see a number of models, each of which will execute the Trans-Tools modelling system for a specific scenario. The names of the models indicate the scenario. (Alternatively to using ArcToolbox, the TransTools toolbox can be located in the Catalog pane by navigating to the TransTools.tbx toolbox in the \data\toolboxes\ folder under the folder where Trans-Tools Model was installed.)

Open (by double clicking or right clicking and choosing Open) the model representing the intended scenario. Verify that the two parameters are set correctly. Click OK. This starts the execution of the model.

As the model goes through its many stages, a wide range of information on progress and status is displayed in the status-window; possibly also warnings of different kinds (green text). Pay attention to this to verify that the model is executing correctly. If an error occurs, this will display as red text and execution will halt.

In addition to the information in the status window, a number of log files are created in the \Data\Logs\ folder. Much of the status information is redundant between the log files and the Status window, but not all. Consequently, it is a good idea to look at both.

As the calculations are executing, the user has the option to cancel. This is simply done by clicking the Cancel button in the status window. Depending on which specific sub-model is being executed at the time, execution might halt more or less right away (true of assignment calculations) or it might only halt when the currently executing module has completed. It is strongly recommended to wait for this. Also important is the fact that the state of all the databases for a scenario for which a model execution was interrupted, is determined by how far along the process was. This specific state might not be internally consistent and it is the responsibility of the user to make sure the data is OK before executing the model again.

When calculations are finally complete, the status window will show “Completed” in the upper left corner and the cancel button will change to a Close button. BEFORE the status window is closed, it is highly recommended to copy its contents (Ctrl-A, Ctrl-C) to the clipboard and paste them in to a new RTF-file or Text-file and save this file in predictable location (like \TransTools\Data\Logs\[Scenarioname]\) so that the details of when this scenario was executed and how can be examined later on.

6.6. Result presentations

Each of the sub-models in the Trans-Tools modelling system produces a number of outputs. See Annex A of D4 for an overview of all the datasets used in the Trans-Tools modelling system and for information on which specific datasets are outputs after a complete execution of a scenario. All the results can be viewed in Microsoft Access or ArcMap.

7. SCENARIOS AND APPLICATION

The TRANS-TOOLS model is applied to simulate the impact of a reference scenario and three policy scenarios. The reference scenario works as 'business as usual' scenario and the policy scenarios is devoted to 1) infrastructures and intermodality, 2) pricing of the road mode and 3) improving competition. It should once again be stated that the scenarios have as aim to test the model in standard type of scenarios.

7.1. Reference scenario

The TRANSTOOLS reference scenario is a 'Business as usual' scenario: i.e. it will assume that the evolution of the transport system is an extension of the current trends. Therefore, the definition of the reference scenario will include:

- projections concerning the population (which is a relevant element for the generation of passengers trips);
- projections concerning the GDP (which is a relevant element for the generation of freight trips);
- autonomous changes in transport costs (i.e. due to more expensive oil price);
- transport network changes due to completed TEN projects. Additional network changes not due to the Trans-European transport network could also be part of the reference scenario according to available data (e.g. from national infrastructure plans).

Projections of population growth rates per country until 2030 are reported in the table 10 below; these figures are based on Eurostat data from the year 2005 and were already used in the ASSESS project (Ying et al., 2005). According to such forecast, EU25 total population is stable over the next 25 years, with a small growth until 2015 and then a decrement, so that at the horizon of the year 2030 the growth rate is null or even negative for EU New Member States. The same table shows DG TREN projections of GDP growth rates per country until 2030 (DG TREN, 2005). Projections have been revised downwards in the recent past, taking into account the latest observed trends. The average growth rate is about 1.8% p.a. until 2030 in EU15 while new EU Member States show a faster development (more that 3% p.a. on average). Assumptions adopted for the growth rates for European countries outside the Union are reported in Table 11, these are derived from the PRIMES report.

Autonomous changes of transport costs will mainly affect fuel components of road costs. The forecasts of international agencies like Energy Information Administration, International Energy Agency, European Environmental Agency, can be used to define a reference growth rate for oil price and, consequently for fuel price. In the recent STEPs research project[3], a 'Generally accepted energy supply forecast' scenario was defined using the projections of Energy Outlook of the International Energy Agency. Such a scenario assumed an average growth rate of 2% p.a. of the oil price (STEPs, 2005). Still in the STEPs project, through a modelling exercise, this assumption concerning oil price growth was translated into a fuel resource price growth rate of 1% p.a. (STEPs, 2006). Assuming that fuel taxes are varied to keep unchanged their relative weight on total fuel price, this growth rate of 1% p.a. can be adopted for the fuel component of road costs.

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[3] STEPs Scenarios for the transport system and energy supply and their potential effects - Framework Programme 6 – DG RTD; see www.steps-eu.com.

Finally, the choice of TEN infrastructures to be included in the reference scenario is somewhat arbitrary as, in principle, all TENs are expected to be completed up to the year 2020. The criteria chosen is to include:

- projects for which some money has been already spent and whose completion expected before 2015;
- projects sections already started and whose completion is expected before of 2010.

The list of TEN projects is in Table 12 and details are reported in Table 14.

Table 10: Population and GDP projections per country: average growth rates (EU 25)

Country	Population yearly growth rate (%)		GDP yearly growth rate (%)	
	2005-2015	2005-2015	2005-2030	2005-2030
EU15	0.2%	2.0%	1.8%	0.0%
Austria	0.2%	2.0%	1.7%	0.0%
Belgium+Luxemburg	0.2%	2.0%	1.9%	0.1%
Denmark	0.2%	1.8%	1.7%	0.1%
Spain	0.1%	2.5%	2.1%	-0.1%
Finland	0.1%	2.2%	2.0%	0.0%
France	0.3%	2.2%	2.1%	0.2%
United Kingdom	0.2%	2.0%	1.9%	0.1%
Germany	0.2%	1.7%	1.5%	0.1%
Greece	0.2%	2.7%	2.6%	0.0%
Ireland	0.8%	4.2%	3.1%	0.6%
Italy	-0.1%	1.2%	1.2%	-0.2%
Netherlands	0.5%	2.0%	2.1%	0.3%
Portugal	0.2%	2.6%	2.4%	0.0%
Sweden	0.2%	2.0%	1.8%	0.1%
NMS	-0.2%	3.4%	3.3%	-0.5%
Cyprus	0.8%	2.7%	2.5%	0.5%
Czech_Republic	-0.4%	2.3%	2.5%	-0.6%
Estonia	-0.8%	4.9%	4.1%	-1.1%
Hungary	-0.7%	3.2%	2.6%	-0.9%
Latvia	-0.9%	6.3%	4.5%	-1.1%
Lithuania	-0.3%	5.0%	4.7%	-0.6%
Malta	0.6%	2.0%	2.4%	0.4%
Poland	-0.1%	3.6%	3.7%	-0.3%
Slovenia	-0.5%	1.8%	1.9%	-0.8%
Slovakia	-0.1%	3.7%	3.6%	-0.3%
Total EU25	0.1%	2.0%	1.9%	0.0%

Source: DG TREN (2005)

Table 11: GDP yearly growth rates for countries outside EU-25 (2000-2020)

Country	GDP	Agriculture	Industry
Albania	7.2%	3.3%	9.9%
Bosnia	4.5%	2.6%	3.4%
Bulgaria	3.7%	2.0%	3.6%
Belarus	3.2%	-3.2%	4.0%
Switzerland	2.1%	0.5%	2.3%
Macedonia	4.7%	0.1%	3.8%
Croatia	3.4%	1.7%	1.0%
Iceland	1.9%	0.3%	2.8%
Liechtenstein	3.7%	0.0%	3.6%
Moldavia	4.1%	-2.1%	2.9%
Norway	2.3%	0.2%	2.1%
Romania	4.6%	2.4%	4.3%
Russia	3.0%	-2.6%	5.6%
Turkey	4.7%	3.3%	4.7%
Ukraine	3.7%	-1.5%	6.4%
Yugoslavia	3.4%	0.7%	2.8%
Australia + New Zealand	3.5%	2.0%	2.2%
Algeria	2.6%	3.2%	1.3%
Egypt	2.6%	3.2%	1.3%
Georgia, Armenia and Azerbaijan	4.8%	1.7%	4.4%
Israel	4.0%	3.0%	6.7%
Japan	1.5%	-1.1%	2.5%
Lebanon	4.0%	3.0%	6.7%
Libia	2.6%	3.2%	1.3%
Morocco	2.6%	3.2%	1.3%
Middle Asia	4.0%	3.0%	6.7%
Middle + south America	2.9%	2.5%	2.7%
Rest of Africa	2.0%	2.1%	0.9%
Rest of Asia	4.0%	3.0%	6.7%
Rest of Europe	3.7%	0.0%	3.6%
Rest of Northern America	2.3%	0.8%	2.3%
Rest of the World	2.2%	1.7%	1.6%
Syria	4.0%	3.0%	6.7%
Tunisia	2.6%	3.2%	1.3%
USA	2.4%	1.8%	2.0%

Source: PRIMES

Table 12: TEN projects for the reference scenario

Project code	Project name	Completion year	Total cost	Investments up to 2004	Included in Reference Scenario
P01	Railways line Berlin-Verona/Milano-Bologna-Napoli-Messina	2015	166,422	64,056	Partial
P02	High-speed train PBKAL (Paris–Brussels–Cologne–Amsterdam–London)	2014	103,332	92,342	Yes
P03	High-speed railway axis of south-west Europe	2020	213,432	39,758	Partial
P04	High-speed railway axis east	2007	20,509	6,966	Yes
P05	Betuwe Line	2006	14,055	12,390	Yes
P06	Railway axis Lyon-Trieste-Divaca/Koper/Divaca-Ljubljana-Budapest-Ukrainian border	2018	89,023	5,581	No
P07	Motorway axis Igoumenitsa/Patra-Athina-Sofia-Budapest	2010	62,701	31,016	Yes
P08	Multimodal axis Portugal/Spain-rest of Europe	2015	44,696	25,519	Partial
P09	Railway axis Cork-Dublin-Belfast-Stranraer	2001	Completed		Yes
P10	Malpensa Airport (Milan)	2001	Completed		Yes
P11	Öresund fixed link	2001	Completed		Yes
P12	Nordic triangle railway-road axis	2015	46,116	13,452	Partial
P13	UK-Ireland/Benelux road axis	2013	27,056	15,373	Yes
P14	West Coast Main Line	2008	173,856	154,880	Yes
P16	Freight railway axis Sines-Madrid-Paris	2020	31,760	0	No
P17	Railway axis Paris-Strasbourg-Stuttgart-Vienna-Bratislava	2015	36,554	9,475	No
P18	Rhine/Meuse-Main-Danube inland waterway axis	2019	7,914	848	No
P19	High-speed rail interoperability on the Iberian peninsula	2020	106,136	9,353	No
P20	Fehmarn Belt railway axis	2015	17,091	4	No
P22	Railway axis Athina-Sofia-Budapest-Vienna-Prague-Nürnberg/Dresden	2017	62,605	0	No
P23	Railway axis Gdansk-Warsaw-Brno/Bratislava-Vienna	2015	24,303	3,406	No
P24	Railway axis Lyon/Genoa-Basel-Duisburg-Rotterdam/Antwerp	2018	69,727	4,473	No
P25	Motorway axis Gdansk-Brno/Bratislava-Vienna	2013	33,219	77	No
P26	Railway-road axis Ireland/United Kingdom/continental Europe	2020	17,942	6,275	Partial
P27	Rail Baltica axis Warsaw-Kaunas-Riga-Tallinn-Helsinki	2018	5,600	0	No
P28	Eurocaprail on the Brussels-Luxembourg-Strasbourg railway axis	2013	7,962	0	No
P29	Railway axis if the Ionian/Adriatic intermodal corridor	2014	8,561	0	No
P30	Inland waterway Seine-Scheldt	2016	5,312	69	No

Source: elaboration from ASSESS, Final Report Annex V (Martens et al., 2005)

7.2. Policy scenario 1: infrastructures and intermodality

Policy scenario 1 includes the completion of all TEN projects as well as the implementation of additional measures to improve freight intermodality and logistics. In particular, scenario 1 assumes the realisation of the *motorways of sea* and the development of the *freight integrators*.

In terms of modelling implementation, while the TEN projects will be represented through new or improved links in the networks, measures to improve intermodality are implemented in terms of their indirect effects. For the quantification of such effects, the exercise carried out for the ASSESS project is taken as reference. Table 13 presents the quantitative assumptions for each measure, while Table 14 provides the detail of TEN projects' sections.

The implementation of the Trans European transport network projects (measure 44) in scenario 1 requires the modification of the transport network.
Measures 28 (Motorways of the seas) and 43 (Intermodal Loading Units and freight integrators) have an impact on the freight modal split model of TRANSTOOLS.

Table 13: Quantification of the measures included in Policy Scenario 1: infrastructures and intermodality

Measure	Implementation
44: Trans European Network projects	- Implementation of new links - Improvements of existing links
28: Motorways of the seas	- Shipping service frequency on suitable routes: +50% - Sea shipping waiting time at ports on suitable routes: -10%
43: Intermodal Loading Units and freight integrators	- Cost at freight terminals –2% - Waiting time at freight terminals: -3% - Rail freight travel time: -2%

Source: elaboration from ASSESS, Final Report Annex V (Martens et al., 2005)

Table 14: Implementation of TEN network in reference scenario and Policy Scenario 1

TEN projects	Subprojects	Deadline after 2004 revision[1]	Implementation in reference scenario	Implementation in scenario 1
1. High-speed train/combined transport north–south	1. Berlin Bahnhof-Berlin/Ludwigsfelde	1. 2008	Yes	Yes
	2. Berlin/Ludwigsfelde-Halle/Leipzig	2. 2002	No	Yes
	3. Halle/Leipzig-Erfurt	3. 2015	No	Yes
	4. Erfurt-Nurenburg	4. 2015	No	Yes
	5. Nurenburg-Munich	5. 2006	Yes	Yes
	6. Munich-Kufstein	6. 2015	No	Yes
	7. Kufstein-Innsbruck	7. 2009-2018	No	Yes
	8. Innsbruck-Fortezza (Brenner Base tunnel)	8. 2015	No	Yes
	9. Fortezza-Verona	9. 2002	Yes	Yes
	10. Verona-Bologna	10. 2007	Yes	Yes
	11. Milan-Bologna	11. 2006-2008	Yes	Yes
	12. Bologna-Florence	12. 2007	Yes	Yes
	13. Florence-Rome (re-electrification)	13. 2007	Yes	Yes
	14. Rome-Naples	14. 2007	Yes	Yes
	15. Rail/road bridge over the strait of Messina	15. 2015	No	Yes
2. High-speed train PBKAL (Paris–Brussels–Cologne–Amsterdam–London)	1. Belgian/German border Cologne	1. 2007	Yes	Yes
	2. Cologne-Frankfurt	2. 2004	Yes	Yes
	3. London-Channel tunnel rail link	3. 2007	Yes	Yes
	4. Belgium	4. 2006	Yes	Yes
	5. Netherlands	5. 2007	Yes	Yes
	6. Paris-Lille-Calais-Channel tunnel	6. 1994	Yes	Yes
3. High-speed railway axis of south-west Europe	1. Spain, Atlantic branch	1. 2010-2011	Yes	Yes
	2. Spain,Mediterranean branch	2. 2008	Yes	Yes
	3. French Atlantic branch	3. 2010	Yes	Yes

TEN projects	**Subprojects**	**Deadline after 2004 revision**[1]	**Implementation in reference scenario**	**Implementation in scenario 1**
	4. French Mediterranean branch 5. International section, Perpignan-Figueras 6. Montpellier-Nîmes 7. Madrid-Barcelona 8. Lisboa/Porto-Madrid 9. Dax-Bordeaux 10. Bordeaux-Tours	4. 2015 5. 2008-2009 6. 2010-2015 7. 2005 8. 2011 9. 2020 10. 2015	No Yes No Yes Yes No No	Yes Yes Yes Yes Yes Yes Yes
4. High-speed train east	1. Paris-Baudrecourt 2. Metz-Luxembourg 3. Saarbrucken-Mannheim	1. 2007 2. 2007 3. 2007	Yes Yes Yes	Yes Yes Yes
5. Conventional rail/combined transport: Betuwe line	1. Port Railway line 2. A15 line	1. 2007 2. 2007	Yes Yes	Yes Yes
6. High-speed train/combined transport, France–Italy	1. Lyon-Montmélian-Modane (St Jean de Maurienne) 2. St Jean de Maurienne-Bruzolo 3. Bruzolo-Turin 4. Turin-Venezia 5. Venezia-south Ronchi-Trieste [...]-Divaca (2015) 6. Koper-Divaca-Ljubljana (2015) 7. Ljubljana-Budapest (2015)	1. 2015 2. 2017 3. 2011 4. 2010 5. 2015 6. 2015 7. 2015	No No No No No No No	Yes Yes Yes Yes Yes Yes Yes
7. Motorway axis Igoumenitsa/Patra-Athina-Sofia-Budapest	1. Via Egnatia 2. Pathe 3. Sofia-Kulata-Greek/Bulgarian border motorway, with Promahon-Kulata as cross-border section 4. Nadlac-Sibiu motorway (branch towards Bucuresti and Constanta)	1. 2006-2008 2. 2008 3. 2010 4. 2007	Yes Yes Yes Yes	Yes Yes Yes Yes
8. Multimodal link Portugal–Spain–Central Europe	1. Railway La Coruña-Lisboa-Sines 2. Railway Lisboa-Valladolid 3. Railway Lisboa-Faro 4. Lisboa-Valladolid motorway 5. La Coruña-Lisboa motorway 6. Sevilla-Lisboa motorway 7. New Lisboa airport	1. 2010 2. 2010 3. 2004 (f) 4. 2010 5. 2003 (f) 6. 2001 (f) 7. 2015	No No Yes No Yes Yes No	Yes Yes Yes Yes Yes Yes Yes
9. Conventional rail link Cork–Dublin–Belfast–Larne,Stranraer	1. UK sections 2. Republic of Ireland sections	1. 2001 (f) 2. 2001 (f)	Yes Yes	Yes Yes
10. Malpensa airport,Milan		2001 (f)	Yes	Yes
11. Øresund fixed rail/road link between Denmark and Sweden (completed)	1. Øresund fixed link 2. Danish access routes 3. Swedish access routes	1. 2000 (f) 2. 1999 (f) 3. 2001 (f)	Yes Yes	Yes Yes
12. Nordic triangle rail/road	1. Road and railway projects in Sweden 2. Helsinki-Turku motorway 3. Railway Kerava-Lahti 4. Helsinki-Vaalimaa motorway 5. Railway Helsinki-Vainikkala (Russian border)	1. 2010 2. 2010 3. 2006 4. 2015 5. 2014	No No Yes No No	Yes Yes Yes Yes Yes
13. Ireland/United Kingdom/Benelux road link		2010	Yes	Yes
14. West coast main line (rail)	West coast main line	2007-2008	Yes	Yes
16. Freight railway axis Sines/Algeciras-Madrid-Paris	1. New high-capacity rail axis across the Pyrenees 2. Railway Sines-Badajoz 3. Railway Algeciras-Bobadilla	1. no date mentioned 2. 2010 3. 2010	No No No	Yes Yes Yes
17. Railway axis Paris-Strasbourg-Stuttgart-Wien-Bratislava	1. Baudrecourt-Strasbourg-Stuttgart with the Kehl bridge as cross-border section 2. Stuttgart-Ulm 3. München-Salzburg 4. Salzburg-Wien 5. Wien-Bratislava	1. 2015 2. 2012 3. 2015 4. 2012 5. 2010-2012	No No No No No	Yes Yes Yes Yes Yes
18. Rhine/Meuse-Main-Danube inland waterway axis	1. Rhine-Meuse, with the lock of Lanaye as cross border section 2. Vilshofen Straubing	1. 2019 2. 2013 3. 2015	No No No	Yes Yes Yes

TEN projects	**Subprojects**	**Deadline after 2004 revision[1]**	**Implementation in reference scenario**	**Implementation in scenario 1**
	3. Wien-Bratislava, cross-border section 4. Palkovicovo-Mohacs 5. Bottlenecks in Romania and Bulgaria	4. 2014 5. 2011	No No	Yes Yes
19. High-speed rail interoperability on the Iberian peninsula	1. Madrid-Andalucía 2. North-east 3. Madrid-Levante and Mediterranean 4. North/North-west corridor, including Vigo-Porto 5. Extremadura	1. 2010-2020 2. 2010-2020 3. 2010-2020 4. 2010-2020 5. 2010-2020	No No No No No	Yes Yes Yes Yes Yes
20. Fehmarn Belt: fixed link between Germany and Denmark	1. Fehmarn Belt fixed rail/road link 2. Railway for access in Denmark from Öresund 3. Railway for access in Germany from Hamburg 4. Railway Hannover-Hamburg/Bremen	1. 2014-2015 2. 2015 3. 2015 4. 2015	No No No No	Yes Yes Yes Yes
21. Motorways of the sea	1. Motorway of the Baltic Sea 2. Motorway of the sea of Western Europe 3. Motorway of the sea of south-east Europe 4. Motorway of the sea of south-west Europe	1. 2010 2. 2010 3. 2010 4. 2010	No No No No	Yes Yes Yes Yes
22. Railway axis Athina-Sofia-Budapest-Wien-Praha-Nürnberg/Dresden	1. Railway line Greek/Bulgarian border-Kulata-Sofia-Vidin/Calafat 2. Railway line Curtici-Brasov 3. Railway line Budapest-Wien 4. Railway line Breclav-Praha-Nürnberg 5. Railway axis Prague-Linz	1. 2015 2. 2010-2013 3. 2010-2019 4. 2010-2016 5. 2016	No No No No No	Yes Yes Yes Yes Yes
23. Railway axis Gdansk-Warszawa-Brno/Bratislava-Wien	1. Railway line Gdansk-Warszawa-Katowice 2. Railway line Katowice-Brno-Breclav 3. Railway line Katowice-Zilina-Nove Mesto n.V	1. 2015 2. 2010 3. 2010-2015	No No No	Yes Yes Yes
24. Railway axis Lyon/Genova-Basel-Duisburg-Rotterdam/Antwerpen	1. Lyon-Mulhouse-Mülheim 2. Genova-Milano/Novara-Swiss border 3. Basel-Karlsruhe 4. Frankfurt-Mannheim 5. Duisburg-Emmerich 6. "Iron Rhine" Rheidt-Antwerpen	1. 2018 2. 2013 3. 2015 4. 2015 5. 2009-2015 6. 2010-2015	No No No No No No	Yes Yes Yes Yes Yes Yes
25. Motorway axis Gdansk-Brno/Bratislava-Wien	1. Gdansk-Katowice motorway 2. Katowice-Brno/Zilina motorway 3. Brno-Wien motorway	1. 2010 2. 2010 3. 2009-2013	No No No	Yes Yes Yes
26. Railway/road axis Ireland/UK/continental Europe	1. Road/railway corridor linking Dublin with the North and South 2. Road/railway corridor Hull-Liverpool 3. Railway line Felixstowe-Nuneaton 4. Railway line Crewe-Holyhead	1. 2010 2. 2015-2020 3. 2011-2014 4. 2008-2012	No No No Yes	Yes Yes Yes Yes
27. "Rail Baltica" railway axis Warszawa-Kaunas-Riga–Tallinn	1. Warszawa – Kaunas 2. Kaunas - Riga 3. Riga - Tallinn	1. 2010-2017 2. 2014-2017 3. 2016-2017	No No No	Yes Yes Yes
28. Eurocaprail on the Bruxelles-Luxembourg-Strasbourg railway axis	1. Bruxelles-Luxembourg-Strasbourg	1. 1:2012	No	Yes
29. Railway axis on the Ionian/Adriatic intermodal corridor	1. Kozani-Kalambaka-Igoumenitsa 2. Ioannina-Antirrio-Rio-Kalamata	1. 2012 2. 2014	No No	Yes Yes
30. Inland waterways Seine-Scheldt	1. Navigability improvements Deulemont-Gent 2. Compiègne-Cambrai	1&2: (2012-2014-2016)	No	Yes

Source: elaboration from ASSESS, Final Report Annex V (Martens et al., 2005)

Table 15: Quantification of measures included in Policy Scenario 2: pricing of road transport

Measure	**Implementation**		
57: Infrastructure charging (in all EU25 countries, only for	**Country**	**Truck Charge (Eurocent/veh-km)**	**Car Charge (Eurocent/veh-km)**

Measure	Implementation		
trucks and cars only on the motorway network, Social Marginal Costs after subtracting excises)	AT	14.87	5.35
	BE	4.30	7.97
	CY	17.07	6.06
	CZ	14.90	5.27
	DE	3.33	3.99
	DK	7.57	5.56
	EE	17.03	6.18
	EL	17.53	7.62
	ES	8.70	4.77
	FI	14.43	9.32
	FR	5.80	4.31
	HU	14.13	5.11
	IE	27.53	8.29
	IT	18.47	11.26
	LT	17.00	6.23
	LU	18.17	8.62
	LV	17.63	6.33
	MT	16.93	6.12
	NL	7.83	2.51
	PL	17.47	5.99
	PT	14.93	1.74
	SE	1.03	0.82
	SI	15.27	5.44
	SK	13.23	5.08
	UK	0.50	4.45

Source: elaboration from ASSESS, Final Report Annex V (Martens et al., 2005)

7.3. Policy scenario 2: pricing of road transport

Scenario 2 is based on the (partial) internalisation of external costs for road transport. In more detail, the scenario includes homogenous infrastructure charging for road freight (measure 57 of the White Paper), based on an estimation of social marginal costs. New charges are not added to current charges, but replace them - taking into account the share of social marginal costs already internalised through the fuel excises - and are applied only on motorways for passenger and freight (see Table 15).

Charges are applied on a link-by-link basis in the road transport assignment module, which also calculates the revenues on a region level. These revenues will be then returned to the household per country.

7.4. Policy scenario 3: improving competition

The third scenario is based on the implementation of European Transport Policy measures aimed at improving competition through liberalisation of transport markets, including:

- Adoption of common rules in the rail sector to improve interoperability (measure 9) and enhancing the quality of services (measure of the White Paper).

- Liberalisation of the rail sector with reference to the full separation between infrastructure and services (measure 6) the opening of the rail freight market (measure 7) and of the international passengers services (measure 12);

- Liberalisation of airport slots (measure 21) so that budget airlines are allowed to provide their services also between major airports.

Such measures are implemented in terms of their indirect effects. Also in this case, the exercise ASSESS project is taken as reference (Table 16) for the quantification of such effects.

Table 16: Quantification of measures included in Policy Scenario 3: improving competition

Measure	Implementation
9: Updating the interoperability directives on high-speed and conventional railway networks	- Rail freight travel time: -2%
14: Third railway package: improving quality of the rail freight services	- Rail freight travel time: -10%
6: First railway package: separated functions of management of infrastructure and service operation and opened access to international services	- Rail freight travel cost: -2% - Rail freight travel time: -2%
7: Second railway package: opening up the national and international freight market	- Rail freight travel cost: -3% - Rail freight travel time: -5%
12: Third railway package: gradual opening-up of international passengers services	- Rail passenger cost: -2%
21: Slot on Community airports	- Extending the low-cost air network to the main airports

Source: elaboration from ASSESS, Final Report Annex V (Martens et al., 2005)

7.5. Policy scenario: combined scenario

In addition to the 3 policy scenarios also a combination of all measures included in the 3 scenarios has been elaborated with the Trans Tools model.

8. CALCULATION RESULTS OF TRANS-TOOLS

8.1. Introduction

In this chapter for each of the defined scenarios the outcome of the TRANS-TOOLS model is described. The outcome of the scenarios will be explained along the sub-models of TRANS-TOOLS:

1. Freight transport (tonnes per commodity, country, mode and logistics activity)
2. Passenger transport (amount of passengers per country, mode, etc.)
3. Economic outcome of feedback processes (GDP change and generated traffic for freight and business passenger)
4. Network characteristics (number of freight and passenger vehicles in yearly value, AADT, and peak moments)
5. External effects related to network intensities (in terms of emissions and accidents).

In the following 5 paragraphs these will be described.

8.2. Scenario Outcome for the freight model

In this section the scenario outcome for the freight model will be described, it consists of the trade model, the modal split model and the logistics model.

8.2.1. Trade model

Being an integral sub-model of the TRANS-TOOLS *Freight Model*, the *Trade Model* calculates a (future) freight demand per commodity per OD relation, regardless the mode of transport.

Two types of inputs are used in Trade Model to run the defined policy scenarios:

(i) exogenous macro socio-economic growth projections applied as common ground for each of the policy scenario (table '**GrowthRates**')

(ii) policy scenario specific feedback implications on GDP derived from the Economic Model (table '**GDPfromEconomicModel**')

Exogenous growth trends

As used in the Trade Model at this point of time, the growth projections describe the macro-economic development over the period 2000-2030. These values are outsourced from the PRIMES model scenario. PRIMES is being extensively used since 1995 by the European Commission in forecasting of energy supply and demand in the European Union.

With regard to scope, the projections refer to national GDP, population and all those economic sectors which produce and/or consume physical goods. The following exogenous input variables are of relevance:

- GDP
- GDP per capita
- Agriculture
- Industry
- Basic metals
- Metal products
- Chemicals
- Other chemicals

- Mining
- Construction
- Energy
- Private consumption
- Food consumption
- Residence construction

For each of these input variables the average annual growth rates (%) are available for every consecutive 5-year interval until the time horizon 2030. The intervals are restricted to the threshold years 2000, 2005, 2010, 2015, 2020, 2025 and 2030. For finding an average growth rate $\overline{R}$ for any desired time span on the basis of the 5-year period specific values, the following formula is applicable:

$$(100+\overline{R})^{(HorizonYear-BasisYear)} = (100+R_1)^{(ThresholdYear(1)-BasisYear)} \prod_{i=2}^{N-1}(100+R_i)^5\,(100+R_N)^{(HorizonYear-ThresholdYear(N-1))}$$

Specifically the TRANS-TOOLS scenario time framework specifies the year 2000 as basis and the year 2020 as horizon. For that the following average growth trends over the period 2000-2020 for EU27 Member States are derived and applied within the Trade Model:

Table 15: Average macro-economic growth trends in 2000-2020 per sector in EU27 (%).

Country	GDP	GDP/ capita	Agriculture	Industry	Basic Metals	Metal Products	Chemicals	Chemicals Other	Mining	Construction	Energy	Private Consumption	Food Consumption	Residence Construction
AT	1,94	1,67	1,57	2,32	1,46	3,65	3,00	3,21	1,59	1,47	2,12	1,80	1,61	1,47
BE	2,02	1,76	0,43	1,50	0,23	1,68	2,24	1,55	0,70	1,28	0,15	1,72	1,57	1,28
BG	3,70	4,80	2,00	3,60	3,60	3,60	3,60	3,60	-0,50	3,70	3,70	3,70	3,70	3,70
CY	3,55	2,45	2,25	2,85	0,00	0,00	1,96	0,25	3,73	4,43	3,62	3,77	3,07	3,48
CZ	3,37	3,56	0,32	3,89	1,35	1,61	3,18	2,73	3,50	2,25	0,57	3,65	4,05	4,02
DE	1,46	1,43	0,89	1,56	1,12	2,16	2,06	1,85	0,60	-0,45	0,73	1,23	1,21	0,58
DK	1,59	1,41	0,56	1,01	1,01	3,41	1,32	1,64	0,35	1,37	0,39	1,61	1,36	1,37
EE	4,90	5,40	-0,25	6,31	0,10	1,34	6,77	7,10	5,20	6,80	4,42	5,09	3,77	4,42
ES	2,70	2,02	0,66	2,49	1,06	2,46	3,69	4,18	2,55	3,42	1,95	2,78	2,31	2,88
FI	2,11	1,89	0,49	2,09	1,81	1,29	0,80	0,76	1,04	1,41	1,64	2,00	1,94	1,41
FR	2,01	1,76	-0,47	1,97	0,90	2,22	2,25	2,03	1,15	1,11	1,64	1,88	1,53	1,11
GR	3,42	3,18	0,70	2,28	4,41	1,58	3,09	2,94	2,95	4,01	1,35	2,95	2,89	2,84
HU	3,46	3,73	3,86	3,14	1,48	2,94	2,07	0,71	3,59	5,56	-1,03	4,19	1,98	5,13
IE	4,29	3,12	0,70	4,49	0,00	2,21	5,54	1,80	3,15	4,90	1,71	3,40	5,58	3,68
IT	1,61	1,56	0,68	1,34	0,91	0,78	2,31	1,78	0,71	1,19	1,41	1,65	2,52	1,19
LT	5,68	6,18	1,07	6,86	2,04	2,04	5,95	4,42	7,70	7,32	5,67	5,84	4,23	7,32
LU	4,44	3,55	-1,06	3,96	0,98	3,96	7,10	6,32	2,38	4,66	3,03	3,96	4,60	4,66

LV	6,20	6,81	2,01	7,27	2,04	2,04	12,52	13,02	6,61	7,40	2,48	6,33	8,81	7,71
MT	3,55	2,45	2,25	2,85	0,00	0,00	1,96	0,25	3,73	4,43	3,62	3,77	3,07	3,48
NL	1,63	1,23	-0,06	0,92	0,74	0,97	1,50	1,45	0,31	0,84	0,66	1,49	1,17	0,84
PL	4,15	4,36	3,29	5,01	0,97	2,04	5,80	6,64	5,16	2,40	0,17	4,15	5,36	5,18
PT	2,01	1,75	1,82	1,28	-1,87	2,10	1,55	1,64	1,50	0,27	1,13	2,19	1,25	1,08
RO	4,60	5,00	2,40	4,30	4,30	4,30	4,30	4,30	-0,40	4,60	4,60	4,60	4,60	4,60
SE	2,36	1,97	1,49	3,12	1,22	1,74	4,18	1,28	2,57	2,43	0,51	2,01	2,31	2,43
SI	2,99	2,92	-0,59	3,42	2,31	3,78	3,92	3,10	3,86	2,73	0,25	2,73	3,48	2,73
SK	4,46	4,59	3,05	5,22	2,81	4,00	2,33	5,12	6,39	4,64	0,25	3,92	3,26	4,64
UK	2,55	2,19	0,21	0,89	-0,80	0,50	1,54	-0,56	0,56	2,82	-0,44	2,57	1,14	2,82

As mentioned above, these exogenous growth rates are kept unchanged in all five policy scenarios (*Reference Scenario, Scenario 1, Scenario 2, Scenario 3, Combined Scenario*).

Policy scenario specific repercussions on GDP growth

On the other hand, the policy scenario outcome from the Economic Model, which gives the feedback implications on expected GDP growth, is used as input for adjustment of the exogenous GDP growth rates values to be applied in Trade Model. These repercussions are always policy scenario dependant, although they usually do not exceed a few percent in absolute change over the time horizon.

As a result of this adjustment, the final growth rates input values for GDP and economic sectors slightly differ per policy scenario and therefore respectfully lead to a slightly varying freight demand in each scenario.

8.2.1.1. Base year scenario

The freight demand in the basis year originates from the ETIS freight trip matrix 2000. It comprehensively describes primarily the trade relations of each old EU member state, including with 10 New Member States and Candidate Countries. However the trade of the New Member States, which in the year 2000 were not yet the members, reflected to a some extent only - mainly showing their relations with the old EU members. This aspect has to be taken into account when analyzing the scenario outputs.

The freight volumes and their composition per country and per commodity group (10 NST/R groups plus refined oil products as separate group) in 2000 is shown in the following figure

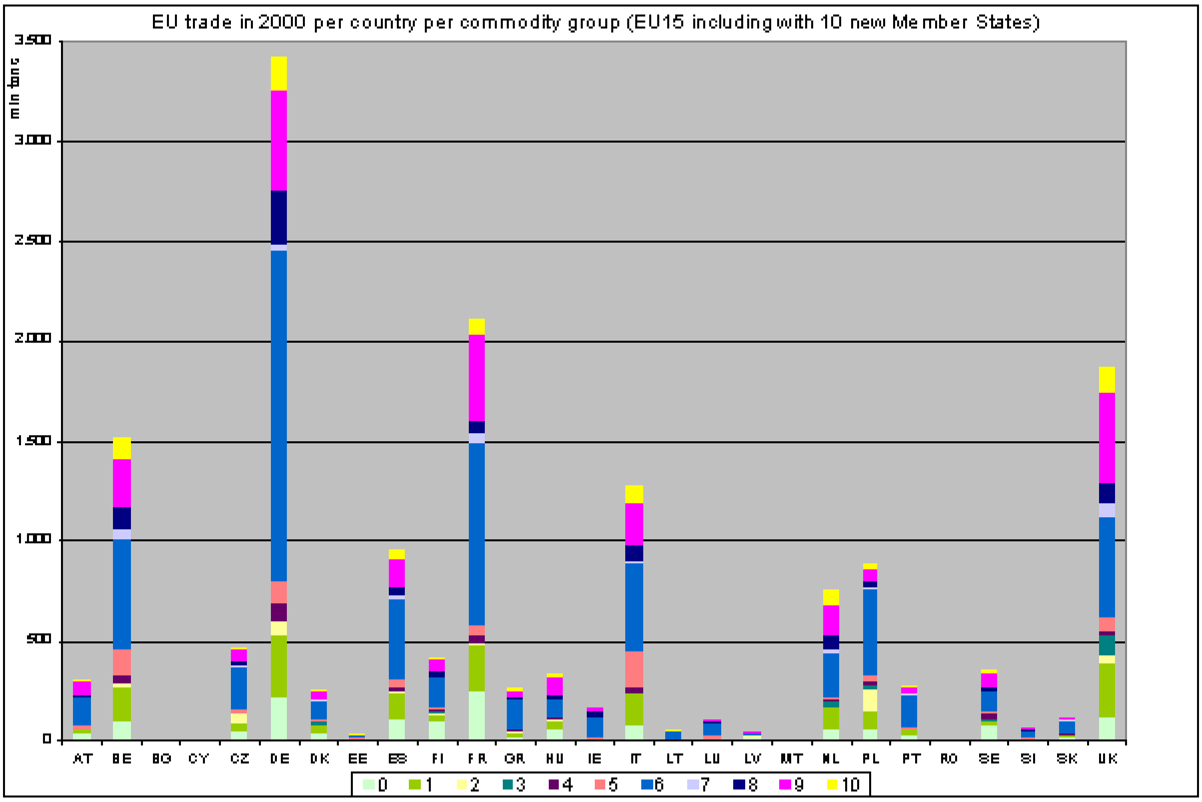


Figure 5: EU trade per country and commodity in 2000 (NSTR10)

Within the Trade Model methodology each commodity group is linked to its own sector of production and sector of attraction. The applied growth rates for these sectors therefore allow modelling the freight demand for the future years.

8.2.1.2. Reference Scenario

The scenario inputs are the exogenous macro-economic growth rates, as adjusted with the scenario-specific outcome from the Economic model computed under the Reference Scenario. The outputs – the resultant aggregated goods volumes, including the absolute growth, expected to be produced and traded by each EU27 country under this scenario are demonstrated in the overview table below.

8.2.1.3. Scenario 1

The scenario inputs are the exogenous macro-economic growth rates, as adjusted with the scenario-specific outcome from the Economic model computed under the Scenario 1.
The outputs - the resultant aggregated goods volumes, including the absolute growth, expected to be produced and traded by each EU27 country under this scenario are shown in the overview table below.

8.2.1.4. Scenario 2

The scenario inputs are the exogenous macro-economic growth rates, as adjusted with the scenario-specific outcome from the Economic model computed under the Scenario 2.
The outputs – the resultant aggregated goods volumes, including the absolute growth, expected to be produced and traded by each EU27 country under this scenario are shown in the overview table below.

8.2.1.5. Scenario 3

The scenario inputs are the exogenous macro-economic growth rates, as adjusted with the scenario-specific outcome from the Economic model computed under the Scenario 3.
The outputs – the resultant aggregated goods volumes, including the absolute growth, expected to be produced and traded by each EU27 country under this scenario are shown in the overview table below.

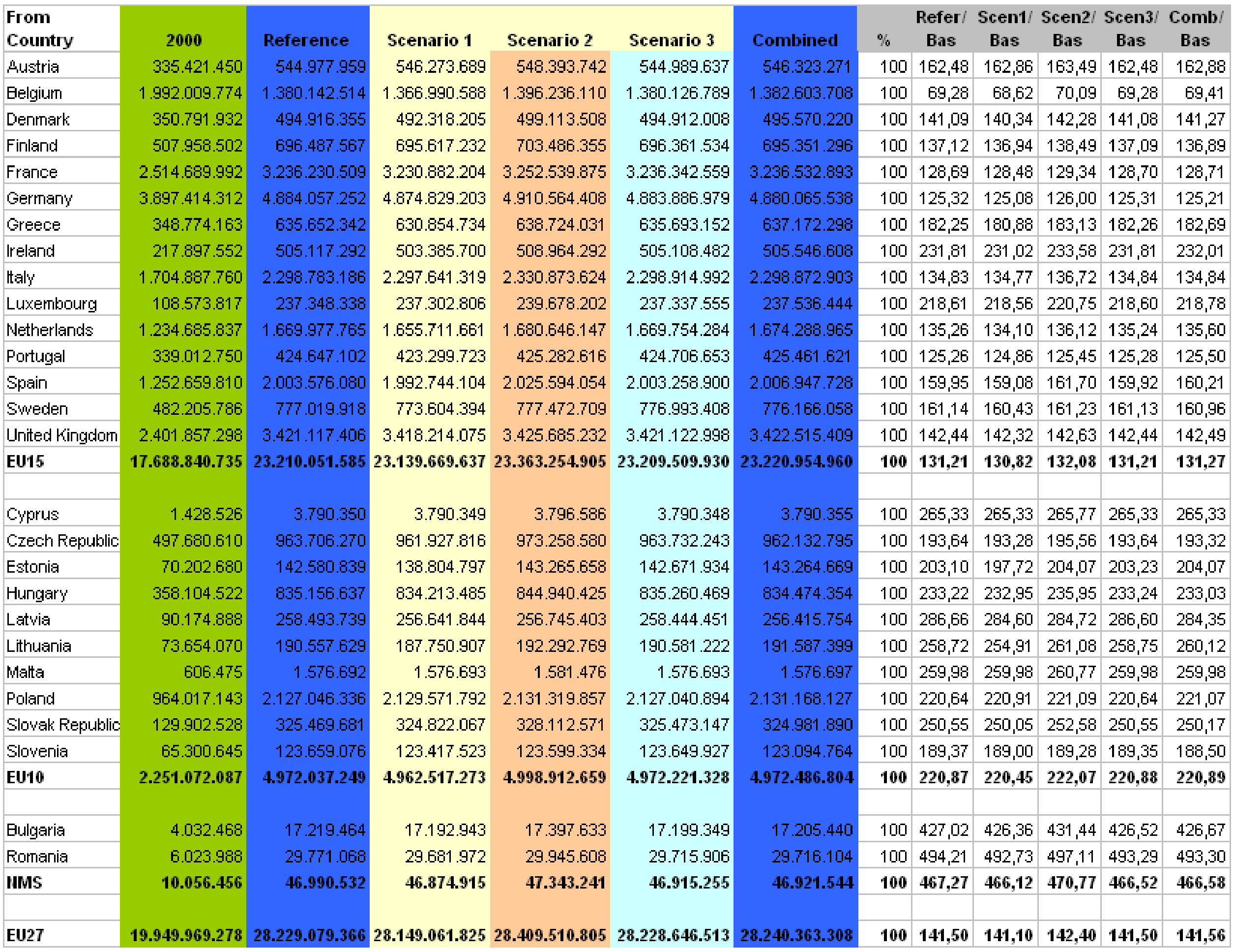
8.2.1.6. Combined Scenario

The scenario inputs are the exogenous macro-economic growth rates, as adjusted with the scenario-specific outcome from the Economic model computed under the Combined Scenario.
The outputs – the resultant aggregated goods volumes, including the absolute growth, expected to be produced and traded by each EU27 country under this scenario are shown in the overview table below.

Comparison of scenario outputs

All those different policy scenarios by tackling specific elements of transport supply on European networks, within the Trade Model produce slight fluctuations of the expected transport demand (trade of material goods). The absolute figures (tons) and the absolute growth per each scenario are shown in the overview table below.

Table 17: Expected freight volumes per production country per policy scenario in 2020 and their growth % in relation to basis year 2000



From Country	2000	Reference	Scenario 1	Scenario 2	Scenario 3	Combined	%	Refer/ Bas	Scen1/ Bas	Scen2/ Bas	Scen3/ Bas	Comb/ Bas
Austria	335.421.450	544.977.959	546.273.689	548.393.742	544.989.637	546.323.271	100	162,48	162,86	163,49	162,48	162,88
Belgium	1.992.009.774	1.380.142.514	1.366.990.588	1.396.236.110	1.380.126.789	1.382.603.708	100	69,28	68,62	70,09	69,28	69,41
Denmark	350.791.932	494.916.355	492.318.205	499.113.508	494.912.008	495.570.220	100	141,09	140,34	142,28	141,08	141,27
Finland	507.958.502	696.487.567	695.617.232	703.486.355	696.361.534	695.351.296	100	137,12	136,94	138,49	137,09	136,89
France	2.514.689.992	3.236.230.509	3.230.882.204	3.252.539.875	3.236.342.559	3.236.532.893	100	128,69	128,48	129,34	128,70	128,71
Germany	3.897.414.312	4.884.057.252	4.874.829.203	4.910.564.408	4.883.886.979	4.880.065.538	100	125,32	125,08	126,00	125,31	125,21
Greece	348.774.163	635.652.342	630.854.734	638.724.031	635.693.152	637.172.298	100	182,25	180,88	183,13	182,26	182,69
Ireland	217.897.552	505.117.292	503.385.700	508.964.292	505.108.482	505.546.608	100	231,81	231,02	233,58	231,81	232,01
Italy	1.704.887.760	2.298.783.186	2.297.641.319	2.330.873.624	2.298.914.992	2.298.872.903	100	134,83	134,77	136,72	134,84	134,84
Luxembourg	108.573.817	237.348.338	237.302.806	239.678.202	237.337.555	237.536.444	100	218,61	218,56	220,75	218,60	218,78
Netherlands	1.234.685.837	1.669.977.765	1.655.711.661	1.680.646.147	1.669.754.284	1.674.288.965	100	135,26	134,10	136,12	135,24	135,60
Portugal	339.012.750	424.647.102	423.299.723	425.282.616	424.706.653	425.461.621	100	125,26	124,86	125,45	125,28	125,50
Spain	1.252.659.810	2.003.576.080	1.992.744.104	2.025.594.054	2.003.258.900	2.006.947.728	100	159,95	159,08	161,70	159,92	160,21
Sweden	482.205.786	777.019.918	773.604.394	777.472.709	776.993.408	776.166.058	100	161,14	160,43	161,23	161,13	160,96
United Kingdom	2.401.857.298	3.421.117.406	3.418.214.075	3.425.685.232	3.421.122.998	3.422.515.409	100	142,44	142,32	142,63	142,44	142,49
EU15	**17.688.840.735**	**23.210.051.585**	**23.139.669.637**	**23.363.254.905**	**23.209.509.930**	**23.220.954.960**	**100**	**131,21**	**130,82**	**132,08**	**131,21**	**131,27**
Cyprus	1.428.526	3.790.350	3.790.349	3.796.586	3.790.348	3.790.355	100	265,33	265,33	265,77	265,33	265,33
Czech Republic	497.680.610	963.706.270	961.927.816	973.258.580	963.732.243	962.132.795	100	193,64	193,28	195,56	193,64	193,32
Estonia	70.202.680	142.580.839	138.804.797	143.265.658	142.671.934	143.264.669	100	203,10	197,72	204,07	203,23	204,07
Hungary	358.104.522	835.156.637	834.213.485	844.940.425	835.260.469	834.474.354	100	233,22	232,95	235,95	233,24	233,03
Latvia	90.174.888	258.493.739	256.641.844	256.745.403	258.444.451	256.415.754	100	286,66	284,60	284,72	286,60	284,35
Lithuania	73.654.070	190.557.629	187.750.907	192.292.769	190.581.222	191.587.399	100	258,72	254,91	261,08	258,75	260,12
Malta	606.475	1.576.692	1.576.693	1.581.476	1.576.693	1.576.697	100	259,98	259,98	260,77	259,98	259,98
Poland	964.017.143	2.127.046.336	2.129.571.792	2.131.319.857	2.127.040.894	2.131.168.127	100	220,64	220,91	221,09	220,64	221,07
Slovak Republic	129.902.528	325.469.681	324.822.067	328.112.571	325.473.147	324.981.890	100	250,55	250,05	252,58	250,55	250,17
Slovenia	65.300.645	123.659.076	123.417.523	123.599.334	123.649.927	123.094.764	100	189,37	189,00	189,28	189,35	188,50
EU10	**2.251.072.087**	**4.972.037.249**	**4.962.517.273**	**4.998.912.659**	**4.972.221.328**	**4.972.486.804**	**100**	**220,87**	**220,45**	**222,07**	**220,88**	**220,89**
Bulgaria	4.032.468	17.219.464	17.192.943	17.397.633	17.199.349	17.205.440	100	427,02	426,36	431,44	426,52	426,67
Romania	6.023.988	29.771.068	29.681.972	29.945.608	29.715.906	29.716.104	100	494,21	492,73	497,11	493,29	493,30
NMS	**10.056.456**	**46.990.532**	**46.874.915**	**47.343.241**	**46.915.255**	**46.921.544**	**100**	**467,27**	**466,12**	**470,77**	**466,52**	**466,58**
EU27	**19.949.969.278**	**28.229.079.366**	**28.149.061.825**	**28.409.510.805**	**28.228.646.513**	**28.240.363.308**	**100**	**141,50**	**141,10**	**142,40**	**141,50**	**141,56**

The demand fluctuations per policy scenario, which are the repercussions on GDP growth, as estimated by the Economic model, for the following country groups fall in the range of:

- EU15: 0,33%-2.56%
- EU10: 0,44%-6,35%
- NMS: 4.38%-5,38%

It looks like the levels of production of goods in the new Member States is slightly more sensitive to those policy scenarios compared to the ones in old countries. Noticeably, the Scenario 2 (*Pricing of Road Transport*) seems to have the most optimal environment for the overall growth of trade in EU27.

8.2.2. Modal split

8.2.2.1. Baseyear

The modal split for freight transport for the baseyear is based on the ETIS freight matrix for the year 2000. This data is the base for the TRANS TOOLS freight model. The division of the annual volume of transported freight by transport modes per origin region, destination region and commodity group from the ETIS freight matrix is the modal split for the baseyear. The following table shows the modal split for the baseyear for the EU member states. The country in the table is the country of origin of the transported freight and the modal-split is given as the percentages of the total annual volume transported by the respective transport modes at the origin of the transport chain.

Table 18: Baseyear freight modal-split per country of origin.

Country	Volume (tonnes) Baseyear	Road (%) Baseyear	Rail (%) Baseyear	Inlww (%) Baseyear	Sea (%) Baseyear
Austria	335.432.537	85,0%	13,7%	1,4%	0,0%
Belgium	944.388.121	62,8%	10,3%	12,3%	14,6%
Denmark	351.325.201	60,8%	2,0%	0,6%	36,6%
Finland	510.631.944	82,0%	6,3%	0,0%	11,7%
France	2.545.080.731	83,7%	5,9%	2,4%	8,0%
Germany	3.909.429.285	85,2%	7,6%	3,7%	3,5%
Greece	348.771.922	77,9%	1,0%	0,0%	21,1%
Ireland	217.904.126	83,9%	4,0%	0,0%	12,1%
Italy	1.716.297.662	79,4%	4,9%	0,0%	15,8%
Luxembourg	109.129.221	92,5%	4,5%	3,0%	0,0%
Netherlands	1.245.155.918	52,4%	4,7%	24,6%	18,3%
Portugal	339.028.921	86,3%	2,8%	0,0%	10,9%
Spain	1.268.892.322	80,4%	3,7%	0,0%	15,9%
Sweden	485.595.869	71,9%	5,2%	0,0%	22,9%
United Kingdom	2.403.881.728	81,2%	5,0%	0,1%	13,8%
Cyprus	1.428.526	3,4%	3,1%	0,0%	93,6%
Czech Republic	497.688.630	83,5%	16,1%	0,4%	0,0%
Estonia	70.201.430	20,4%	21,6%	0,0%	58,0%
Hungary	358.111.823	88,4%	10,8%	0,8%	0,0%
Latvia	90.550.878	36,6%	5,7%	0,0%	57,7%
Lithuania	73.654.066	56,0%	15,9%	0,0%	28,1%
Malta	606.475	1,8%	0,1%	0,0%	98,1%
Poland	964.012.020	80,3%	16,8%	0,6%	2,4%
Slovak Republic	129.917.676	71,5%	27,6%	0,8%	0,0%
Slovenia	65.302.835	90,3%	8,3%	0,0%	1,4%
Bulgaria	4.038.065	35,3%	33,7%	2,7%	28,4%
Romania	6.024.151	31,6%	17,8%	1,0%	49,7%
EU	18.992.482.083	78,5%	7,1%	3,4%	11,0%

8.2.2.2. Reference

The baseyear modal split based on the ETIS freight matrix is also the base for the freight modal split model for determining the forecast modal split for the scenarios. Changes in the levels of service of the different transport modes for the stated scenarios cause shifts in the modal split for these scenarios. Also different growth rates of trade for different relations (origin region, destination region and commodity group combinations) with unequal modal splits can lead to changes in the modal split on country level. The changes in the level of service are based on business as usual. The following table shows the modal split for the reference scenario compared to the modal split in the base year. Most changes in the modal split will be caused by the differences in growth rates of trade for distinct relations, since the changes in the level of service are based on business as usual. The country in the table is the country of origin of the transported freight and the modal-split is given as the percentages of the total annual volume transported by the respective transport modes at the origin of the transport chain.

Table 19: Baseyear and reference scenario freight modal-split per country of origin

Country	Volume (tonnes)		Road (%)		Rail (%)		Inlww (%)		Sea (%)	
	Baseyear	Reference	Baseyear	Reference	Baseyear	Reference	Baseyear	Reference	Baseyear	Reference
Austria	335.432.537	544.977.959	85,0%	82,3%	13,7%	16,0%	1,4%	1,7%	0,0%	0,0%
Belgium	944.388.121	1.380.142.514	62,8%	60,0%	10,3%	10,1%	12,3%	12,4%	14,6%	17,6%
Denmark	351.325.201	494.916.355	60,8%	58,5%	2,0%	2,1%	0,6%	0,7%	36,6%	38,6%
Finland	510.631.944	696.487.567	82,0%	80,3%	6,3%	6,3%	0,0%	0,0%	11,7%	13,4%
France	2.545.080.731	3.236.230.509	83,7%	83,4%	5,9%	6,2%	2,4%	2,5%	8,0%	8,0%
Germany	3.909.429.285	4.884.057.252	85,2%	82,7%	7,6%	8,5%	3,7%	4,2%	3,5%	4,7%
Greece	348.771.922	635.652.342	77,9%	53,3%	1,0%	5,0%	0,0%	0,0%	21,1%	41,7%
Ireland	217.904.126	505.117.292	83,9%	86,3%	4,0%	4,3%	0,0%	0,0%	12,1%	9,5%
Italy	1.716.297.662	2.298.783.186	79,4%	77,6%	4,9%	5,5%	0,0%	0,0%	15,8%	16,9%
Luxembourg	109.129.221	237.348.338	92,5%	94,4%	4,5%	3,2%	3,0%	2,4%	0,0%	0,0%
Netherlands	1.245.155.918	1.669.977.765	52,4%	49,8%	4,7%	5,4%	24,6%	24,0%	18,3%	20,7%
Portugal	339.028.921	424.647.102	86,3%	85,5%	2,8%	3,1%	0,0%	0,0%	10,9%	11,4%
Spain	1.268.892.322	2.003.576.080	80,4%	80,8%	3,7%	3,9%	0,0%	0,0%	15,9%	15,3%
Sweden	485.595.869	777.019.918	71,9%	70,8%	5,2%	5,1%	0,0%	0,0%	22,9%	24,1%
United Kingdom	2.403.881.728	3.421.117.406	81,2%	82,3%	5,0%	5,2%	0,1%	0,1%	13,8%	12,3%
Cyprus	1.428.526	3.790.350	3,4%	3,1%	3,1%	2,7%	0,0%	0,0%	93,6%	94,3%
Czech Republic	497.688.630	963.706.270	83,5%	80,2%	16,1%	19,3%	0,4%	0,5%	0,0%	0,0%
Estonia	70.201.430	142.580.839	20,4%	19,4%	21,6%	25,9%	0,0%	0,0%	58,0%	54,7%
Hungary	358.111.823	835.156.637	88,4%	88,5%	10,8%	10,4%	0,8%	1,1%	0,0%	0,0%
Latvia	90.550.878	258.493.739	36,6%	35,8%	5,7%	6,4%	0,0%	0,0%	57,7%	57,7%
Lithuania	73.654.066	190.557.629	56,0%	51,0%	15,9%	15,5%	0,0%	0,0%	28,1%	33,5%
Malta	606.475	1.576.692	1,8%	2,7%	0,1%	0,1%	0,0%	0,0%	98,1%	97,2%
Poland	964.012.020	2.127.046.336	80,3%	74,8%	16,8%	21,2%	0,6%	0,8%	2,4%	3,2%
Slovak Republic	129.917.676	325.469.681	71,5%	67,6%	27,6%	31,6%	0,8%	0,8%	0,0%	0,0%
Slovenia	65.302.835	123.659.076	90,3%	85,3%	8,3%	11,4%	0,0%	0,0%	1,4%	3,4%
Bulgaria	4.038.065	17.219.464	35,3%	47,7%	33,7%	31,5%	2,7%	1,2%	28,4%	19,6%
Romania	6.024.151	29.771.068	31,6%	51,3%	17,8%	10,9%	1,0%	0,7%	49,7%	37,1%
EU27	18.992.482.083	28.229.079.366	78,5%	76,2%	7,1%	8,5%	3,4%	3,2%	11,0%	12,1%

8.2.2.3. Scenario1

This scenario consists of measures improving infrastructure and intermodality. For freight transport this means improved infrastructure throughout Europe for the different modes and reducing the waiting times and costs at transhipment points. The following table shows the modal split for scenario1 compared to the modal split for the reference scenario. The results show the improved infrastructure favours road transport most, since road transport gains some market share at the expense of sea and rail transport. The intermodality measures also can cause the increase of road transport at origin, since they decrease the cost of transhipment onto another mode of transport somewhere along the transport chain. The country in the table is the country of origin of the transported freight and the modal-split is given as the percentages of the total annual volume transported by the respective transport modes at the origin of the transport chain.

Table 20: Reference and scenario1 freight modal-split per country of origin

Country	Volume (tonnes)		Road (%)		Rail (%)		Inlww (%)		Sea (%)	
	Reference	Scenario1	Reference	Scenario1	Reference	Scenario1	Reference	Scenario1	Reference	Scenario1
Austria	544,977,959	546,273,689	82.3%	82.2%	16.0%	16.1%	1.7%	1.8%	0.0%	0.0%
Belgium	1,380,142,514	1,366,990,588	60.0%	60.6%	10.1%	10.0%	12.4%	12.3%	17.6%	17.2%
Denmark	494,916,355	492,318,205	58.5%	59.2%	2.1%	2.1%	0.7%	0.7%	38.6%	38.0%
Finland	696,487,567	695,617,232	80.3%	80.6%	6.3%	6.1%	0.0%	0.0%	13.4%	13.3%
France	3,236,230,509	3,230,882,204	83.4%	83.6%	6.2%	6.0%	2.5%	2.4%	8.0%	7.9%
Germany	4,884,057,252	4,874,829,203	82.7%	82.8%	8.5%	8.5%	4.2%	4.1%	4.7%	4.6%
Greece	635,652,342	630,854,734	53.3%	78.8%	5.0%	0.9%	0.0%	0.0%	41.7%	20.2%
Ireland	505,117,292	503,385,700	86.3%	86.4%	4.3%	4.3%	0.0%	0.0%	9.5%	9.3%
Italy	2,298,783,186	2,297,641,319	77.6%	78.1%	5.5%	5.2%	0.0%	0.0%	16.9%	16.7%
Luxembourg	237,348,338	237,302,806	94.4%	94.3%	3.2%	3.3%	2.4%	2.4%	0.0%	0.0%
Netherlands	1,669,977,765	1,655,711,661	49.8%	50.2%	5.4%	5.3%	24.0%	24.0%	20.7%	20.4%
Portugal	424,647,102	423,299,723	85.5%	85.8%	3.1%	2.9%	0.0%	0.0%	11.4%	11.3%
Spain	2,003,576,080	1,992,744,104	80.8%	81.3%	3.9%	3.7%	0.0%	0.0%	15.3%	15.0%
Sweden	777,019,918	773,604,394	70.8%	71.3%	5.1%	4.8%	0.0%	0.0%	24.1%	23.9%
United Kingdom	3,421,117,406	3,418,214,075	82.3%	82.4%	5.2%	5.2%	0.1%	0.1%	12.3%	12.3%
Cyprus	3,790,350	3,790,349	3.1%	3.1%	2.7%	2.7%	0.0%	0.0%	94.3%	94.3%
Czech Republic	963,706,270	961,927,816	80.2%	80.3%	19.3%	19.2%	0.5%	0.5%	0.0%	0.0%
Estonia	142,580,839	138,804,797	19.4%	19.8%	25.9%	26.8%	0.0%	0.0%	54.7%	53.4%
Hungary	835,156,637	834,213,485	88.5%	88.6%	10.4%	10.5%	1.1%	0.9%	0.0%	0.0%
Latvia	258,493,739	256,641,844	35.8%	36.2%	6.4%	6.4%	0.0%	0.0%	57.7%	57.3%
Lithuania	190,557,629	187,750,907	51.0%	51.6%	15.5%	16.0%	0.0%	0.0%	33.5%	32.4%
Malta	1,576,692	1,576,693	2.7%	2.7%	0.1%	0.1%	0.0%	0.0%	97.2%	97.2%
Poland	2,127,046,336	2,129,571,792	74.8%	75.3%	21.2%	20.8%	0.8%	0.6%	3.2%	3.2%
Slovak Republic	325,469,681	324,822,067	67.6%	67.6%	31.6%	31.6%	0.8%	0.8%	0.0%	0.0%
Slovenia	123,659,076	123,417,523	85.3%	85.6%	11.4%	11.3%	0.0%	0.0%	3.4%	3.1%
Bulgaria	17,219,464	17,192,943	47.7%	48.3%	31.5%	32.2%	1.2%	1.2%	19.6%	18.3%
Romania	29,771,068	29,681,972	51.3%	52.2%	10.9%	11.9%	0.7%	0.7%	37.1%	35.2%
EU	28,229,079,366	28,149,061,825	76.2%	77.0%	8.5%	8.4%	3.2%	3.2%	12.1%	11.4%

8.2.2.4. Scenario2

This scenario implements pricing of road transport on motorways in all EU member states. The following table shows the modal split for scenario2 compared to the modal split for the reference scenario. The results show that the effect of road pricing is a decreased market share for road transport in favour of rail transport and in some countries inland waterways or sea transport. The country in the table is the country of origin of the transported freight and the modal-split is given as the percentages of the total annual volume transported by the respective transport modes at the origin of the transport chain.

Table 21: Reference and scenario2 freight modal-split per country of origin

Country	Volume (tonnes)		Road (%)		Rail (%)		Inlww (%)		Sea (%)	
	Reference	Scenario2	Reference	Scenario2	Reference	Scenario2	Reference	Scenario2	Reference	Scenario2
Austria	544,977,959	548,393,742	82.3%	81.1%	16.0%	17.1%	1.7%	1.8%	0.0%	0.0%
Belgium	1,380,142,514	1,396,236,110	60.0%	59.4%	10.1%	10.4%	12.4%	12.6%	17.6%	17.6%
Denmark	494,916,355	499,113,508	58.5%	58.4%	2.1%	2.2%	0.7%	0.7%	38.6%	38.7%
Finland	696,487,567	703,486,355	80.3%	80.0%	6.3%	6.8%	0.0%	0.0%	13.4%	13.2%
France	3,236,230,509	3,252,539,875	83.4%	82.9%	6.2%	6.6%	2.5%	2.5%	8.0%	8.0%
Germany	4,884,057,252	4,910,564,408	82.7%	82.3%	8.5%	8.8%	4.2%	4.3%	4.7%	4.6%
Greece	635,652,342	638,724,031	53.3%	51.0%	5.0%	5.7%	0.0%	0.0%	41.7%	43.3%
Ireland	505,117,292	508,964,292	86.3%	86.0%	4.3%	4.5%	0.0%	0.0%	9.5%	9.6%
Italy	2,298,783,186	2,330,873,624	77.6%	76.4%	5.5%	6.4%	0.0%	0.0%	16.9%	17.2%
Luxembourg	237,348,338	239,678,202	94.4%	94.1%	3.2%	3.4%	2.4%	2.5%	0.0%	0.0%
Netherlands	1,669,977,765	1,680,646,147	49.8%	49.3%	5.4%	5.6%	24.0%	24.2%	20.7%	20.9%
Portugal	424,647,102	425,282,616	85.5%	85.2%	3.1%	3.4%	0.0%	0.0%	11.4%	11.5%
Spain	2,003,576,080	2,025,594,054	80.8%	80.2%	3.9%	4.4%	0.0%	0.0%	15.3%	15.5%
Sweden	777,019,918	777,472,709	70.8%	70.7%	5.1%	5.1%	0.0%	0.0%	24.1%	24.2%
United Kingdom	3,421,117,406	3,425,685,232	82.3%	82.3%	5.2%	5.3%	0.1%	0.1%	12.3%	12.3%
Cyprus	3,790,350	3,796,586	3.1%	3.1%	2.7%	2.7%	0.0%	0.0%	94.3%	94.3%
Czech Republic	963,706,270	973,258,580	80.2%	79.0%	19.3%	20.4%	0.5%	0.6%	0.0%	0.0%
Estonia	142,580,839	143,265,658	19.4%	19.2%	25.9%	26.1%	0.0%	0.0%	54.7%	54.7%
Hungary	835,156,637	844,940,425	88.5%	86.8%	10.4%	12.0%	1.1%	1.1%	0.0%	0.0%
Latvia	258,493,739	256,745,403	35.8%	36.0%	6.4%	6.7%	0.0%	0.0%	57.7%	57.3%
Lithuania	190,557,629	192,292,769	51.0%	50.2%	15.5%	16.0%	0.0%	0.0%	33.5%	33.7%
Malta	1,576,692	1,581,476	2.7%	2.7%	0.1%	0.1%	0.0%	0.0%	97.2%	97.2%
Poland	2,127,046,336	2,131,319,857	74.8%	71.8%	21.2%	24.1%	0.8%	0.8%	3.2%	3.3%
Slovak Republic	325,469,681	328,112,571	67.6%	63.7%	31.6%	35.4%	0.8%	0.8%	0.0%	0.0%
Slovenia	123,659,076	123,599,334	85.3%	84.2%	11.4%	12.5%	0.0%	0.0%	3.4%	3.3%
Bulgaria	17,219,464	17,397,633	47.7%	38.6%	31.5%	35.6%	1.2%	1.3%	19.6%	24.5%
Romania	29,771,068	29,945,608	51.3%	37.2%	10.9%	17.5%	0.7%	1.2%	37.1%	44.1%
EU	28,229,079,366	28,409,510,805	76.2%	75.3%	8.5%	9.2%	3.2%	3.3%	12.1%	12.2%

8.2.2.5. Scenario3

This scenario consists of measures improving competition. For freight transport this means improved international rail transport with decreased transport times and costs. The following table shows the modal split for scenario3 compared to the modal split for the reference scenario. The results show that these measures lead to a small increase of market share for rail transport at the expense of road transport, mainly in the recently acceded member states. The country in the table is the country of origin of the transported freight and the modal-split is given as the percentages of the total annual volume transported by the respective transport modes at the origin of the transport chain.

Table 22: Reference and scenario3 freight modal-split per country of origin

Country	Volume (tonnes)		Road (%)		Rail (%)		Inlww (%)		Sea (%)	
	Reference	Scenario3	Reference	Scenario3	Reference	Scenario3	Reference	Scenario3	Reference	Scenario3
Austria	544,977,959	544,989,637	82.3%	82.2%	16.0%	16.1%	1.7%	1.7%	0.0%	0.0%
Belgium	1,380,142,514	1,380,126,789	60.0%	59.9%	10.1%	10.1%	12.4%	12.4%	17.6%	17.6%
Denmark	494,916,355	494,912,008	58.5%	58.5%	2.1%	2.1%	0.7%	0.7%	38.6%	38.6%
Finland	696,487,567	696,361,534	80.3%	80.3%	6.3%	6.4%	0.0%	0.0%	13.4%	13.4%
France	3,236,230,509	3,236,342,559	83.4%	83.4%	6.2%	6.2%	2.5%	2.5%	8.0%	8.0%
Germany	4,884,057,252	4,883,886,979	82.7%	82.7%	8.5%	8.5%	4.2%	4.2%	4.7%	4.7%
Greece	635,652,342	635,693,152	53.3%	53.2%	5.0%	5.3%	0.0%	0.0%	41.7%	41.5%
Ireland	505,117,292	505,108,482	86.3%	86.2%	4.3%	4.3%	0.0%	0.0%	9.5%	9.5%
Italy	2,298,783,186	2,298,914,992	77.6%	77.6%	5.5%	5.5%	0.0%	0.0%	16.9%	16.9%
Luxembourg	237,348,338	237,337,555	94.4%	94.4%	3.2%	3.2%	2.4%	2.4%	0.0%	0.0%
Netherlands	1,669,977,765	1,669,754,284	49.8%	49.8%	5.4%	5.4%	24.0%	24.0%	20.7%	20.7%
Portugal	424,647,102	424,706,653	85.5%	85.5%	3.1%	3.0%	0.0%	0.0%	11.4%	11.4%
Spain	2,003,576,080	2,003,258,900	80.8%	80.8%	3.9%	3.9%	0.0%	0.0%	15.3%	15.3%
Sweden	777,019,918	776,993,408	70.8%	70.8%	5.1%	5.1%	0.0%	0.0%	24.1%	24.1%
United Kingdom	3,421,117,406	3,421,122,998	82.3%	82.3%	5.2%	5.3%	0.1%	0.1%	12.3%	12.3%
Cyprus	3,790,350	3,790,348	3.1%	3.1%	2.7%	2.7%	0.0%	0.0%	94.3%	94.3%
Czech Republic	963,706,270	963,732,243	80.2%	80.0%	19.3%	19.4%	0.5%	0.5%	0.0%	0.0%
Estonia	142,580,839	142,671,934	19.4%	19.3%	25.9%	26.0%	0.0%	0.0%	54.7%	54.7%
Hungary	835,156,637	835,260,469	88.5%	88.4%	10.4%	10.6%	1.1%	1.1%	0.0%	0.0%
Latvia	258,493,739	258,444,451	35.8%	35.8%	6.4%	6.4%	0.0%	0.0%	57.7%	57.7%
Lithuania	190,557,629	190,581,222	51.0%	50.9%	15.5%	15.5%	0.0%	0.0%	33.5%	33.5%
Malta	1,576,692	1,576,693	2.7%	2.7%	0.1%	0.1%	0.0%	0.0%	97.2%	97.2%
Poland	2,127,046,336	2,127,040,894	74.8%	74.6%	21.2%	21.4%	0.8%	0.8%	3.2%	3.2%
Slovak Republic	325,469,681	325,473,147	67.6%	67.3%	31.6%	31.9%	0.8%	0.8%	0.0%	0.0%
Slovenia	123,659,076	123,649,927	85.3%	85.2%	11.4%	11.5%	0.0%	0.0%	3.4%	3.3%
Bulgaria	17,219,464	17,199,349	47.7%	47.3%	31.5%	32.0%	1.2%	1.2%	19.6%	19.4%
Romania	29,771,068	29,715,906	51.3%	50.9%	10.9%	11.4%	0.7%	0.7%	37.1%	36.9%
EU	28,229,079,366	28,228,646,513	76.2%	76.1%	8.5%	8.6%	3.2%	3.2%	12.1%	12.1%

8.2.2.6. Combined scenario

This combined scenario consists of the implementation of all measures from the three scenarios mentioned before. The following table shows the modal split for scenario1+2+3 compared to the modal split for the reference scenario. The results of this combined scenario are mainly alike those of scenario2. The conclusion is that the implementation of pricing of road transport for freight transport has the most dominant effect on the freight modal split. The country in the table is the country of origin of the transported freight and the modal-split is given as the percentages of the total annual volume transported by the respective transport modes at the origin of the transport chain.

Table 23: Reference and scenario1+2+3 freight modal-split per country of origin

Country	Volume (tonnes)		Road (%)		Rail (%)		Inlww (%)		Sea (%)	
	Reference	Scenario1+2+3	Reference	Scenario1+2+3	Reference	Scenario1+2+3	Reference	Scenario1+2+3	Reference	Scenario1+2+3
Austria	544,977,959	546,323,271	82.3%	81.2%	16.0%	17.0%	1.7%	1.8%	0.0%	0.0%
Belgium	1,380,142,514	1,382,603,708	60.0%	59.4%	10.1%	10.4%	12.4%	12.6%	17.6%	17.6%
Denmark	494,916,355	495,570,220	58.5%	58.3%	2.1%	2.2%	0.7%	0.7%	38.6%	38.8%
Finland	696,487,567	695,351,296	80.3%	79.9%	6.3%	6.8%	0.0%	0.0%	13.4%	13.3%
France	3,236,230,509	3,236,532,893	83.4%	82.9%	6.2%	6.6%	2.5%	2.5%	8.0%	8.0%
Germany	4,884,057,252	4,880,065,538	82.7%	82.3%	8.5%	8.8%	4.2%	4.3%	4.7%	4.6%
Greece	635,652,342	637,172,298	53.3%	50.7%	5.0%	6.0%	0.0%	0.0%	41.7%	43.2%
Ireland	505,117,292	505,546,608	86.3%	85.9%	4.3%	4.5%	0.0%	0.0%	9.5%	9.6%
Italy	2,298,783,186	2,298,872,903	77.6%	76.4%	5.5%	6.4%	0.0%	0.0%	16.9%	17.2%
Luxembourg	237,348,338	237,536,444	94.4%	94.1%	3.2%	3.5%	2.4%	2.5%	0.0%	0.0%
Netherlands	1,669,977,765	1,674,288,965	49.8%	49.4%	5.4%	5.5%	24.0%	24.3%	20.7%	20.8%
Portugal	424,647,102	425,461,621	85.5%	85.1%	3.1%	3.4%	0.0%	0.0%	11.4%	11.6%
Spain	2,003,576,080	2,006,947,728	80.8%	80.1%	3.9%	4.4%	0.0%	0.0%	15.3%	15.5%
Sweden	777,019,918	776,166,058	70.8%	70.7%	5.1%	5.1%	0.0%	0.0%	24.1%	24.2%
United Kingdom	3,421,117,406	3,422,515,409	82.3%	82.3%	5.2%	5.3%	0.1%	0.1%	12.3%	12.4%
Cyprus	3,790,350	3,790,355	3.1%	3.1%	2.7%	2.7%	0.0%	0.0%	94.3%	94.3%
Czech Republic	963,706,270	962,132,795	80.2%	79.1%	19.3%	20.3%	0.5%	0.6%	0.0%	0.0%
Estonia	142,580,839	143,264,669	19.4%	19.3%	25.9%	26.1%	0.0%	0.0%	54.7%	54.6%
Hungary	835,156,637	834,474,354	88.5%	86.9%	10.4%	12.0%	1.1%	1.1%	0.0%	0.0%
Latvia	258,493,739	256,415,754	35.8%	36.0%	6.4%	6.7%	0.0%	0.0%	57.7%	57.2%
Lithuania	190,557,629	191,587,399	51.0%	50.2%	15.5%	16.1%	0.0%	0.0%	33.5%	33.7%
Malta	1,576,692	1,576,697	2.7%	2.7%	0.1%	0.1%	0.0%	0.0%	97.2%	97.2%
Poland	2,127,046,336	2,131,168,127	74.8%	71.9%	21.2%	24.1%	0.8%	0.8%	3.2%	3.3%
Slovak Republic	325,469,681	324,981,890	67.6%	63.5%	31.6%	35.7%	0.8%	0.8%	0.0%	0.0%
Slovenia	123,659,076	123,094,764	85.3%	84.6%	11.4%	12.2%	0.0%	0.0%	3.4%	3.2%
Bulgaria	17,219,464	17,205,440	47.7%	39.0%	31.5%	35.7%	1.2%	1.3%	19.6%	24.1%
Romania	29,771,068	29,716,104	51.3%	46.6%	10.9%	13.6%	0.7%	0.8%	37.1%	39.0%
EU	28,229,079,366	28,240,363,308	76.2%	75.3%	8.5%	9.2%	3.2%	3.3%	12.1%	12.2%

8.2.3. Logistics (TNO)

This section reports the results of the logistic module for the different scenarios. A comparison is made between the tonnes lifted by country before the logistic module is run and after the module is run. The difference between the two is an indicator for the extra tonnes lifted due to logistic activities. Below an example is given of the way in which this indicator is computed. In table 22 the indicator is reported for all the scenarios.

Example:

The modal split model produces transport chains like the one shown in figure 4..

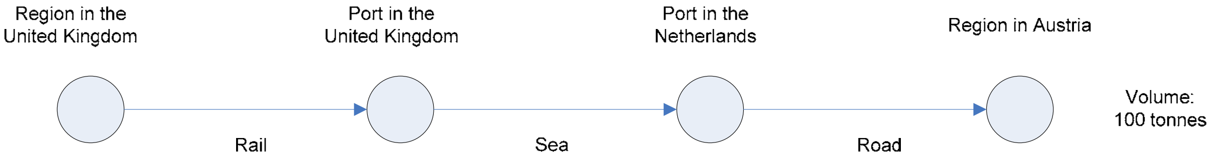


Figure 6: Example of a transport chain produced by the modal split model

The volume on this chain is 100 tonnes. This implies that the UK would have lifted 200 tonnes (100 tonnes in the region of origin and 100 tonnes at the port in the UK) and the Netherlands 100 tonnes.

After the logistic module is run, logistic activities at distribution centres are added to the chain. The new chain could look like the one shown in figure 5.

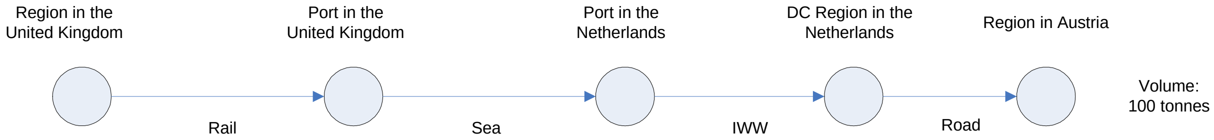


Figure 7: Example of a transport chain produced by the logistic module

In this example, the Netherlands lifted 100 tonnes extra because of logistic activities. This is equal to an increase of 100 %. This is the indicator that is used for analyzing the results of the logistic module.

Table 24: Increase in tonnes lifted due to logistic activities in the old member states

FromCountry	Base year	Reference 2020	Scenario1	Scenario2	Scenario3	Combined scenario
Austria	8.4%	11.5%	11.7%	11.6%	11.5%	11.8%
Belgium	17.5%	20.5%	20.5%	20.7%	20.6%	20.7%
Denmark	7.5%	9.6%	9.5%	9.5%	9.6%	9.5%
Finland	4.3%	4.1%	4.2%	3.9%	4.1%	4.0%
France	7.7%	8.2%	8.2%	8.2%	8.2%	8.2%
Germany	8.9%	11.9%	11.8%	11.8%	11.9%	11.8%
Greece	7.7%	7.8%	7.8%	7.7%	7.8%	7.8%
Ireland	2.6%	2.7%	2.8%	2.8%	2.7%	2.8%
Italy	10.0%	11.4%	11.5%	11.3%	11.5%	11.4%
Luxembourg	1.9%	1.8%	1.8%	1.8%	1.8%	1.9%
Netherlands	10.9%	13.2%	13.1%	13.3%	13.2%	13.3%
Portugal	3.6%	4.0%	4.0%	3.7%	4.0%	4.0%
Spain	7.2%	7.4%	7.5%	7.4%	7.4%	7.4%
Sweden	3.4%	4.0%	4.0%	4.2%	4.0%	4.2%
United Kingdom	7.3%	7.0%	7.0%	7.0%	7.0%	7.0%
EU15	**8.4%**	**9.6%**	**9.6%**	**9.6%**	**9.6%**	**9.6%**

Table 25: Increase in tonnes lifted due to logistic activities in the new member states

FromCountry	Base year	Reference 2020	Scenario1	Scenario2	Scenario3	Combined scenario
Cyprus	-37.2%	-29.5%	-29.5%	-29.5%	-29.5%	-29.5%
Czech Republic	4.3%	5.6%	5.4%	5.7%	5.6%	5.4%
Estonia	2.5%	3.5%	3.4%	3.4%	3.4%	3.3%
Hungary	5.5%	6.9%	6.7%	7.0%	6.9%	6.8%
Latvia	2.7%	6.7%	6.7%	5.7%	6.7%	5.8%
Lithuania	1.2%	1.4%	1.6%	1.9%	1.4%	1.8%
Malta	-74.2%	-66.4%	-66.4%	-66.4%	-66.4%	-66.4%
Poland	3.7%	4.9%	5.1%	4.9%	4.9%	5.1%
Slovak Republic	2.8%	3.2%	3.1%	3.2%	3.2%	3.0%

Slovenia	1.2%	2.3%	2.1%	1.9%	2.3%	1.8%
EU10	**3.7%**	**5.0%**	**5.0%**	**5.0%**	**5.0%**	**5.0%**

Bulgaria	-15.5%	-16.5%	-16.7%	-15.8%	-16.6%	-16.6%
Romania	1.8%	2.4%	2.1%	2.3%	2.2%	2.2%
NMS	**-5.9%**	**-5.5%**	**-5.7%**	**-5.2%**	**-5.6%**	**-5.6%**

8.2.3.1. Average results member states

From table 24 it can be conclude that, in the base year, logistic activities add on average 8.4% to the total tonnes lifted in the old member states. In the other scenario’s this is 9.6%.

In the new member states (EU 10) logistic activities add 3.7% to the total tonnes lifted in the base year and 5.0% in the scenarios.

For Bulgaria the results are negative. This would imply that logistics deviate traffic flows away from Bulgaria. In principal this is not possible, because the volumes are measured at the origin of the transport chain. Logistic activities can only add new stops at distribution centres to the chain. The negative numbers for Bulgaria, Cyprus and Malta are explained by the fact that the logistic module eliminates some chains for which no feasible chain can be found due to restrictions in the transport network. Cyprus, Malta and Bulgaria are the three countries with the lowest transport volumes. A small decrease in volumes, therefore leads to a large percentage decrease. The negative effects in Bulgaria are stronger than the positive effects in Romania and therefore the overall average results in the two newest member states are negative.

8.2.3.2. Differences between countries

In figure 6 the absolute values of the volumes added by logistic activities are presented for the base year. Figure 7 shows this volume as a percentage of the volumes without logistics (equal to the results shown in table 24 and 25). The other scenarios give more or less similar pictures. Therefore, these are not included in the report. In the next section a comparison is made between scenarios.

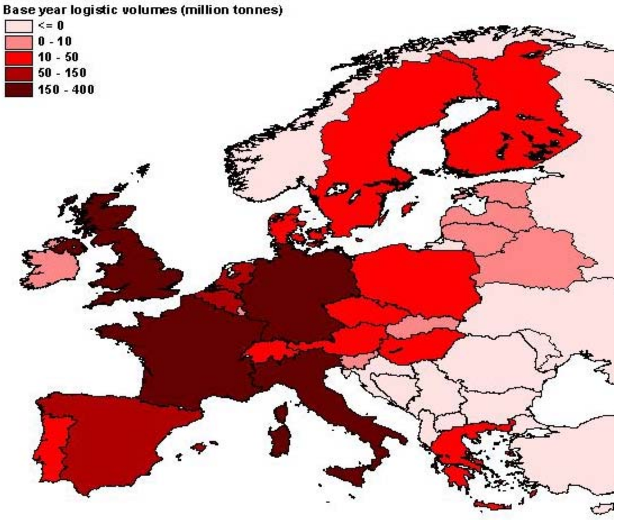


Figure 8: Logistic volumes in the base year

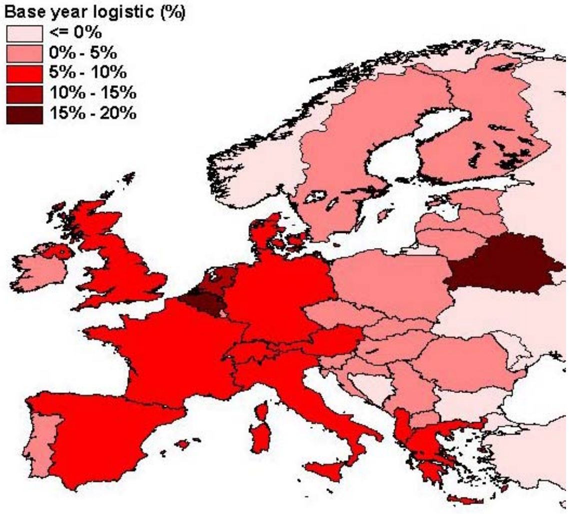


Figure 9 Logistic volumes in the base year as a percentage o volumes after modal split

From these figures it can be concluded that the majority of the logistic activities take place in Germany, France, Italy and the United Kingdom when absolute volumes are considered. Belgium, the Netherlands and Spain belong to the second group. When relative numbers are considered (figure 7) Belarus, Belgium and the Netherlands are the key countries with respect logistic activities. Since Belgium and the Netherlands show up in both figures it can be concluded that these two countries play an important role in logistics. These countries are followed by Germany, France, the United Kingdom, Italy and Spain.

8.2.3.3. Comparison of scenario output

Table 23 shows that the differences between the scenarios are very small. Only the base year differs significantly from the other scenarios for 2020. For the Reference scenario and for scenario 2 no specific measures are taken that have an impact on logistics. In scenario 1 (infrastructure and intermodality) and 3 (improving competition) the cost at distribution centres are decreased with 20% and 10% respectively. Therefore, it was to be expected that in these two scenarios the logistic activities would increase somehow. However, this appears not to be the case as the costs changes where to small to have a significant effect. Logistic structures are difficult to change and certainly not with a lowering of inventory costs.

8.3. Scenario Outcome for the passenger model

The passenger module produces forecasts for scenarios within the following 3 steps;

1. Trip generation approach
2. Trip distribution approach
3. Modal split calculation

The main determinants of trip generation are:

- Population per country (total population children, people in working age, retired)
- Employment / Unemployment per country
- Car-ownership / car fleet per country
- GDP per country

- Trip rates per country

The trip distribution and modal split are based on logit models. The figure below shows the procedure for calculating scenarios for passenger transport.

The trip distribution and modal split are based on logit models. The figure below shows the procedure for calculating scenarios for passenger transport.

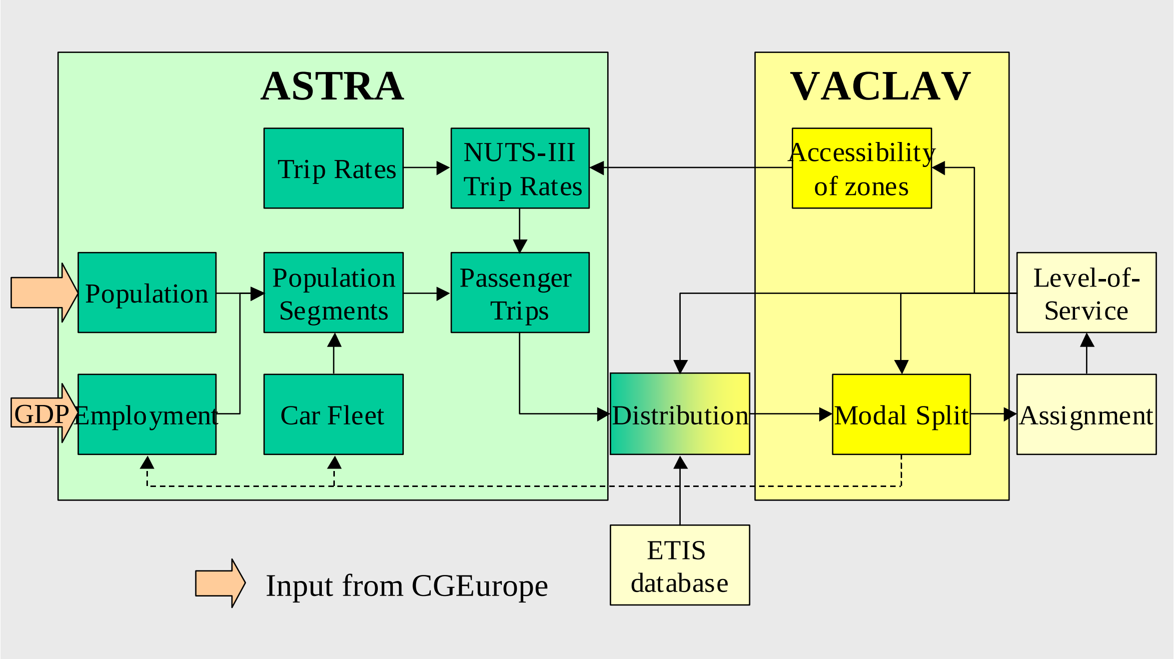


Figure 10: Overview over passenger transport model

8.3.1. *Generation/ distribution*

8.3.1.1. Reference 2020 versus base year 2000

The passenger model predicts a moderate increase in the passenger transport volume (measured in number of trips) by 10.7% (EU25) within the period of time between 2000 and 2020. The moderate growth in number of trips can be explained by the socio-demographic and -economic assumptions underlying the forecast scenarios. On the one hand, the number of inhabitants is expected to decrease in some countries (which results in the generation of less trips), whereas on the other hand household income and motorization (particularly in the new member states) are expected to rise considerably. In combination, the assumptions result to the moderate changes in the generation of number of trips as summarized by Table 26, Table 27 and Table 28.

The large difference in number of trips between the EU15 and the EU10 member states is mainly driven by the zoning system underlying the modeling approach. The traffic zones are largely represented by the NUTS3 regions. Since the passenger transport model considers inter-zonal trips only, the share of traffic demand captured by the model increases with a decreasing size of the traffic cells. Since several countries of the EU15 group have particularly small NUTS3 regions (e.g. Germany, Netherlands, Belgium) and most of the EU10 countries relatively large ones, the share of passenger trips considered in case of the EU15 countries is higher than in case of the EU10 countries.

Table 26 Passenger transport volume, base year 2000 vs. Reference 2020, EU25

EU25	Passenger transport volume [billion trips p.a.]
Base year 2000	14.9
Reference 2020	16.5

Table 27 Passenger transport volume, base year 2000 vs. Reference 2020, EU15

EU15	Passenger transport volume [billion trips p.a.]
Base year 2000	13.6
Reference 2020	14.9

Table 28 Passenger transport volume, base year 2000 vs. Reference 2020, EU10

EU10	Passenger transport volume [billion trips p.a.]
Base year 2000	1.3
Reference 2020	1.5

The passenger transport performance (measured in p-km) is forecasted to grow more intensely than the passenger transport volume. The expected growth in mobility amounts to 17.7% for the EU25 countries. The growth for the country group of the EU10 countries (52.4%) is considerably above growth rate for the EU15 countries (13.6%), which can be explained by the higher economic dynamic and the associated growth in motorization in the new member states. Compared to other studies, the forecasted growth in passenger mobility is at a lower level – an item which may need to be analysed further. The results for the development of the passenger transport performance are contained in Table 29, Table 30 and Table 31.

Table 29 Passenger transport performance, base year 2000 vs. Reference 2020, EU25

EU25	Passenger transport performance [billion p-km p.a.]
Base year 2000	2,714.9
Reference 2020	3,195.3

Table 30 Passenger transport performance, base year 2000 vs. Reference 2020, EU15

EU15	Passenger transport performance [billion p-km p.a.]
Base year 2000	2,430.1
Reference 2020	2,761.2

Table 31 Passenger transport performance, base year 2000 vs. Reference 2020, EU10

EU10	Passenger transport performance [billion p-km p.a.]
Base year 2000	284.8
Reference 2020	434.0

8.3.1.2. Reference 2020 versus policy scenarios for 2020

The impacts of the policy scenarios are examined by comparing the results with the Reference scenario. Policy scenario 1 results in a moderate increase in passenger transport performance, which is due to the fact that with the implementation of major infrastructure projects (such as motorways and high-speed rail links) trip distances tend to lengthen: Many of the infrastructure projects assumed of being realised in the policy scenario 1 have an impact on route choice within a wide geographical scope. They attract demand, even if they do not provide the shortest path. This pattern explains the increase in passenger transport performance in the policy scenario 1. The motorway charges applied in policy scenario 2 have an influence on route choice of road transport. For some demand segments the usage of uncharged roads becomes more attractive than the usage of the charged motorway system. Using the secondary road network instead of the motorway network often results in a decrease in trip distances, which explains the overall decrease in passenger mobility in the policy scenario 2. In policy scenario 3 the user costs for one mode (rail) are reduced, which results to a moderate increase in overall mobility. The combined scenario shows a large decrease in mobility for the EU15. A decrease was to be expected because of the effects of policy scenario 2, but the reasons for this strong reaction are still under research. The percentage changes of the policy scenarios from the reference scenario are shown in the 3 tables below.

Table 32 Passenger transport performance, relative change policy scenarios 2020 vs. Reference 2020, EU25

EU25	**Relative change against Reference scenario 2020 [%]**
Scenario 1, 2020	0.38
Scenario 2, 2020	-1.39
Scenario 3, 2020	0.27
Scenario 1+2+3, 2020	-2.30

Table 33 Passenger transport performance, relative change policy scenarios 2020 vs. Reference 2020, EU15

EU15	**Relative change against Reference scenario 2020 [%]**
Scenario 1, 2020	-0.10
Scenario 2, 2020	-1.83
Scenario 3, 2020	0.29
Scenario 1+2+3, 2020	-2.96

Table 34 Passenger transport performance, relative change policy scenarios 2020 vs. Reference 2020, EU10

EU10	**Relative change against Reference scenario 2020 [%]**
Scenario 1, 2020	3.41
Scenario 2, 2020	1.37
Scenario 3, 2020	0.11
Scenario 1+2+3, 2020	1.88

8.3.1.3. Results at the country level

Table 35 Passenger transport performance per country [million trips p.a]

	Base year	Reference 2020	Scenario 1, 2020	Scenario 2, 2020	Scenario 3, 2020	Scenario 1+2+3, 2020
Austria	346.8	379.7	382.5	371.1	380.2	375.8
Belgium	597.8	658.4	658.9	657.9	658.6	658.7
Denmark	219.9	230.4	232.6	230.3	230.7	230.7
Finland	169.1	175.2	175.7	174.8	177.0	177.2
France	1,726.6	1,901.3	1,911.3	1,849.1	1,905.8	1,869.4
Germany	3,558.6	3,781.4	3,791.0	3,776.4	3,783.2	3,791.1
Greece	188.8	219.3	219.6	216.8	219.8	218.2
Ireland	110.0	141.3	141.4	140.9	141.4	141.0
Italy	1,240.1	1,306.7	1,331.1	1,284.4	1,309.2	1,300.0
Luxembourg	23.1	25.4	25.6	25.4	25.4	25.5
Netherlands	860.3	956.2	956.7	955.4	956.6	956.3
Portugal	223.4	259.6	261.7	257.6	260.0	260.3
Spain	754.1	908.3	916.3	888.9	911.6	904.5
Sweden	316.6	342.3	343.6	341.6	342.9	342.7
United Kingdom	3,295.0	3,642.6	3,642.8	3,628.8	3,643.2	3,639.8
EU 15	13,630.2	14,928.2	14,990.8	14,809.2	14,945.6	14,891.2
Cyprus	2.6	3.2	3.2	3.2	3.2	3.2
Czech Republic	294.0	340.2	342.6	339.0	340.4	340.8
Estonia	28.5	28.5	29.3	28.4	28.6	30.3
Hungary	173.0	315.7	316.7	313.0	316.7	315.5
Latvia	1.9	1.8	2.0	1.8	1.8	2.0
Lithuania	46.0	46.0	47.2	46.0	46.1	48.3
Malta	1.4	1.6	1.6	1.6	1.6	1.6
Poland	508.9	545.2	552.3	542.1	546.3	547.4
Slovak Republic	157.9	163.1	163.8	162.0	163.3	163.1
Slovenia	93.1	99.8	100.3	98.8	99.9	99.8
EU 10	1,307.5	1,545.2	1,559.2	1,536.0	1,548.1	1,552.2

Table 36 Passenger transport performance per country [billion p-km p.a.]

	Base year	Reference 2020	Scenario 1, 2020	Scenario 2, 2020	Scenario 3, 2020	Scenario 1+2+3, 2020
Austria	73.0	81.7	81.5	79.4	81.9	77.8
Belgium	54.7	61.1	61.1	60.1	61.2	60.2
Denmark	39.2	41.9	44.6	41.6	42.0	41.7
Finland	51.6	54.3	54.6	53.7	55.7	55.3
France	451.1	503.2	497.0	485.1	505.2	474.3
Germany	559.5	644.3	639.7	641.5	644.8	630.7
Greece	54.0	74.4	74.4	73.2	74.8	73.7
Ireland	22.4	28.8	29.3	28.6	28.8	29.0
Italy	294.3	312.1	316.7	302.2	313.2	293.2
Luxembourg	4.1	4.6	4.6	4.6	4.6	4.6
Netherlands	94.2	108.0	108.1	107.0	108.1	107.0
Portugal	48.8	57.2	57.7	56.5	57.5	57.3
Spain	252.6	305.3	304.5	298.5	306.6	295.3
Sweden	81.4	89.9	90.6	89.6	90.2	89.2
United Kingdom	348.8	394.6	394.3	389.5	394.6	390.3

EU 15	2,429.6	2,761.3	2,758.7	2,710.9	2,769.3	2,679.6

Cyprus	7.4	8.9	8.9	8,9	9.0	9.0
Czech Republic	55.1	89.9	91.9	91.3	89.6	90.6
Estonia	6.9	6.9	7.2	6.7	7.0	7.2
Hungary	43.9	120.0	120.5	124.6	119.5	120.4
Latvia	1.3	1.5	1.6	1.5	1.5	1.6
Lithuania	8.6	8.8	9.3	8.9	8.9	9.6
Malta	2.1	2.3	2.3	2.3	2.3	2.3
Poland	114.6	147.1	158.2	147.6	148.2	153.9
Slovak Republic	26.6	28.9	29.3	28.7	28.9	28.5
Slovenia	18.5	19.6	19.5	19.4	19.7	19.1
EU 10	284.8	434.0	448.9	440.0	434.5	442.2

8.3.2. Modal split

Reference scenario 2020 versus base year 2000

When comparing the passenger transport performance between the base year 2000 and the Reference scenario 2020 by modes, following patterns can be observed: The passenger transport performance of all modes is forecasted to increase, but clearly the air mode is expected to rise most dynamically. Despite of a doubling of the air passenger transport performance in the EU10 countries, the overall growth in air transport for inter-european trips predicted seems to be at a relatively low level. This pattern may need to be further considered in future model updates. The model predicts a positive development of the rail mode, too, which can be explained by the implementation of several important high-speed rail projects in the Reference scenario, such as the high-speed lines Frankfurt – Köln, Paris – Baudrecourt or Madrid – Barcelona. The passenger transport performance by mode is summarized by Table 37, Table 38 and Table 39.

Table 37 Passenger transport performance by modes, relative change Reference 2020 vs. base year 2000, EU25

EU25; Passenger transport performance [billion p-km p.a.]	**Air**	**Rail**	**Road**
Base year 2000	222.4	210.8	2,281.8
Reference 2020	301.6	254.7	2,639.0

Table 38 Passenger transport performance by modes, relative change Reference 2020 vs. base year 2000, EU25

EU15; Passenger transport performance [billion p-km p.a.]	**Air**	**Rail**	**Road**
Base year 2000	201.4	185.1	2,043.6
Reference 2020	251.9	205.6	2,303.8

Table 39 Passenger transport performance by modes, relative change Reference 2020 vs. base year 2000, EU10

EU10; Passenger transport performance [billion p-km p.a.]	**Air**	**Rail**	**Road**
Base year 2000	21.0	25.6	238.2
Reference 2020	49.7	49.2	335.2

The development of the market shares is contained in Table 40. The changes are moderate, with slight shifts from road to the public modes rail and road. The loss of market share of road is due to the underlying infrastructure scenario, which is clearly in favour of the rail mode.

Table 40 Market shares by mode (passenger transport performance), Reference 2020 vs. base year 2000, EU25

Passenger transport performance; EU25	**Air [%]**	**Rail [%]**	**Road [%]**
Base year 2000	8.19	7.76	84.05
Reference 2020	9.44	7.97	82.59

8.3.2.1. Reference 2020 versus other policy scenarios for 2020

When comparing the outcomes for the policy scenarios with the Reference scenario, following pattern can be recognized: The infrastructure-related policy scenario 1 results in shifts from air to the land-bound modes road and rail. This model result is due to the fact that the infrastructure assumptions of the policy scenario 1 are largely related to the land-bound modes rail and air. However, the dimension of modal shifts seems to be comparatively low. In policy scenario 2 the reactions are much clearer: because of the assumption that motorway charges are applied to passenger transport, demand is shifted to rail and, at a lower dimension, to air transport. The policy measure of policy scenario 2 is a ‘generic’ measure, with impacts on user costs on a sub-network in all EU countries, which explains the considerable modal split effects. Policy scenario 3 implies a reduction of user costs for rail, which causes a slight shift from road to rail is forecasted. The rise in air passenger demand is rather striking, but can be explained by the fact that by a change in rail access/ egress costs to/ from airports also the air mode becomes more attractive. In the combined scenario policy scenario 2 shows a dominant role which is intensified by policy scenario 3. The model’s passenger transport performance values are summarized by Table 37, Table 38 and Table 39.

Table 41 Passenger transport performance by modes, EU25

EU25; Passenger transport performance [billion p-km p.a.]	**Air**	**Rail**	**Road**
Reference 2020	301.6	254.7	2,639.0
Scenario 1, 2020	299.5	258.6	2,649.4
Scenario 2, 2020	345.1	454.2	2,351.6
Scenario 3, 2020	306.7	259.9	2,637.1
Scenario 1+2+3, 2020	348.6	461.9	2,311.3

Table 42 Passenger transport performance by modes, EU15

EU15; Passenger transport performance [billion p-km p.a.]	**Air**	**Rail**	**Road**
Reference 2020	251.9	205.6	2,303.8
Scenario 1, 2020	249.7	205.2	2,303.7
Scenario 2, 2020	293.4	379.9	2,037.6
Scenario 3, 2020	256.5	210.1	2,302.7
Scenario 1+2+3, 2020	296.2	381.6	2,001.8

Table 43 Passenger transport performance by modes, EU10

EU10; Passenger transport performance [billion p-km p.a.]	**Air**	**Rail**	**Road**
Reference 2020	49.7	49.2	335.2
Scenario 1, 2020	49.8	53.4	345.7

Scenario 2, 2020	51.7	74.3	314.0
Scenario 3, 2020	50.2	49.9	334.5
Scenario 1+2+3, 2020	52.4	80.2	309.6

Regarding the development of market shares, the results of the policy scenarios can be summarized as follows: the investment in land-bound modes rail and road in policy scenario 1 results in a shift from air to rail and road, however, at an unexpected low level. Charging motorways in policy scenario 2 is forecasted to cause noticeable shifts from road to air and particularly to rail. A decrease in user costs for the rail mode in policy scenario 3 is expected to cause a slight shift from road to rail and, since also the impedance to airports declines, to air. The combined scenario is dominated from the effects of policy scenario 2 and to a lesser degree from scenario 3. The modal shares are contained in Table 44.

Table 44 Market shares by mode (passenger transport performance), Scenarios 2020, EU25

Passenger transport volume; EU25	**Air [%]**	**Rail [%]**	**Road [%]**
Reference 2020	9.44	7.97	82.59
Scenario 1, 2020	9.34	8.06	82.60
Scenario 2, 2020	10.95	14.42	74.63
Scenario 3, 2020	9.57	8.11	82.31
Scenario 1+2+3, 2020	11.17	14.79	74.04

8.4. Scenario Outcome for economic model

CGEurope is a Spatial Computable General Equilibrium model in which final demand is represented by utility maximizing households and production presented by profit maximizing firms. The income-expenditure loop is closed and flexible prices clear all markets simultaneously. The production is diversified, with different varieties produced at different locations. Firms and households choose supply sources according to relative prices, which include interregional transfer costs. International trade imposes extra costs on trade due to international and cultural impediments. This model explicitly incorporates the transport costs as a cost component for the firms and business travellers.

The output of the model concerns the measurement of impact of transport policies on real regional GDP and the equivalent variation of income for the representative household of each TRANS-TOOLS model region. The parameters of the CGEurope model are calibrated on the data for the year of the reference scenario. By varying the transport costs for freight and passengers, it evaluates the impact of the transport cost changes with respect to the reference scenario. The evaluation is done by using the transport cost changes that are passed on to CGEurope by the freight and the passenger model. The output of CGEurope is passed on to the trade model and passenger model, which creates the economic feedback effect in the TRANS-TOOLS model.

The model is designed for comparative analysis of policy scenarios; therefore we don’t present any model outcomes for the base year and reference scenario, as the model just reproduces the respective GDPs of these 2 states of the world. The outcomes of the scenarios that we present here are changes with respect to the reference scenario.

It must be noted before the output of the CGEurope model is presented, that at the present time, the links between the economic model and the other models of TRANS-TOOLS (mainly the logistic module) are still not working entirely correct at all stages. As a consequence, before CGEurope model could be supplied with necessary input information, these inputs had to be thoroughly examined in order to filter out implausible data. As a matter of fact, the restrictions on the input from the logistic module (generalized freight costs) had to be imposed, which had a purpose to limit the change of the cost per ton indicator (that is cost in euros of transporting one ton of a given NSTR commodity between the region of origin and region of destination) between the reference situation and policy scenario by a factor of three in either direction. In other words, the cost per ton indicator for any NSTR and any O/D pair was not allowed to increase more than 200% or drop more than 67%. The reason for this step was the fact that in many cases this indicator indeed changed even more than by a factor of three, without an obvious cause for such a dramatic effect. Also, in the cases where cost per ton was zero in reference situation and nonzero in policy scenario situation, we assumed that the nonzero value applied to both situations. When the source of these inconsistent freight cost changes is identified and corrected, it may be that the output of CGEurope will also change. Also, with current inputs to CGEurope, it is only possible to test either pure infrastructure scenarios, or pure pricing scenarios. The mixed scenarios will lead to unreliable estimates, as there is no mechanism envisioned in TRANS-TOOLS to separate the revenue-generating part of the transport costs from the pure resource costs.

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8.4.1. Scenario1

The scenario 1 is a European infrastructure scenario, which has been described in chapter 3.2, it includes mainly the implementation of the TEN priority projects and changes of intermodal loading units and freight integrators. The impact of these measures is shown in the figure below, the spatial pattern of the impacts of the TEN is similar to the ones we have already seen in TEN policy scenarios in former studies, the highest impacts can be found in the regions where projects are actually implemented, as one can see in Ireland and the UK where road and rail projects are being implemented (project 9, 13 and 14), or in Spain and Portugal (projects 8 and 19). The impacts range from –2.2% in a region the Slovak Republic (SK04) to 5.8% in Ireland (IE01). The overall effect is an increase of 0.59 % of GDP for the EU-27.

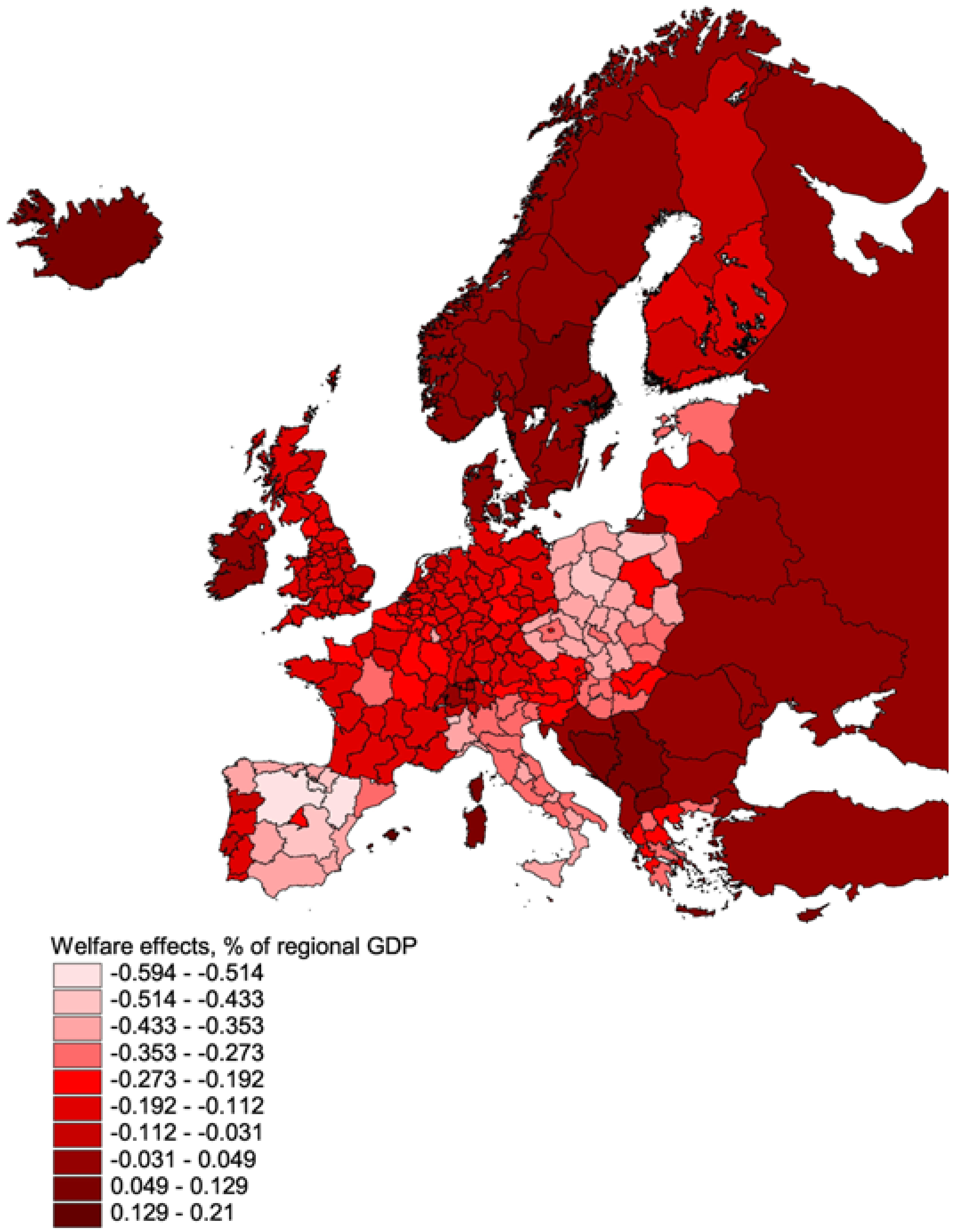

Figure 11: Impact of Trans-Tools scenario 1 on regional welfare

8.4.2. Scenario2

In scenario 2 a road-pricing scheme is implemented that collects fees from passengers in cars and trucks that carry freight. Both are charged according to vehicle-kms. However, the results presented below correspond to the scenario version in which the freight costs were not affected at all. The information on the revenues from pricing comes from the assignment model. The total revenue is redistributed across regions based on regional GDP. The revenue from road pricing is assumed to accrue to the households. This revenue redistribution scheme creates a wedge between the GDP effect and the real income effect. The effect of increased road charges on GDP is then expected to be negative, if these charges increase the price level in the region. The reason for this is the desire of households and firms to purchase cheaper goods stemming from other locations. The effect on the real income is however expected to be around zero, because the households are being compensated for the increased prices by the transfers of revenue. The average impact of the scenario in the EU27 (see the figure below) is negative (-0.18 % of GDP) with the variation of levels of impact mainly coming from the different magnitudes of the charges in each country. The countries not experiencing much of increase of road charges in the scenario (Sweden, Ireland, Denmark, Portugal), as well as the neighbouring countries, are showing slightly positive effects on GDP due to the increased exports into the EU. This pattern could however change if the revenue were used in another way, for example to reduce the taxes.

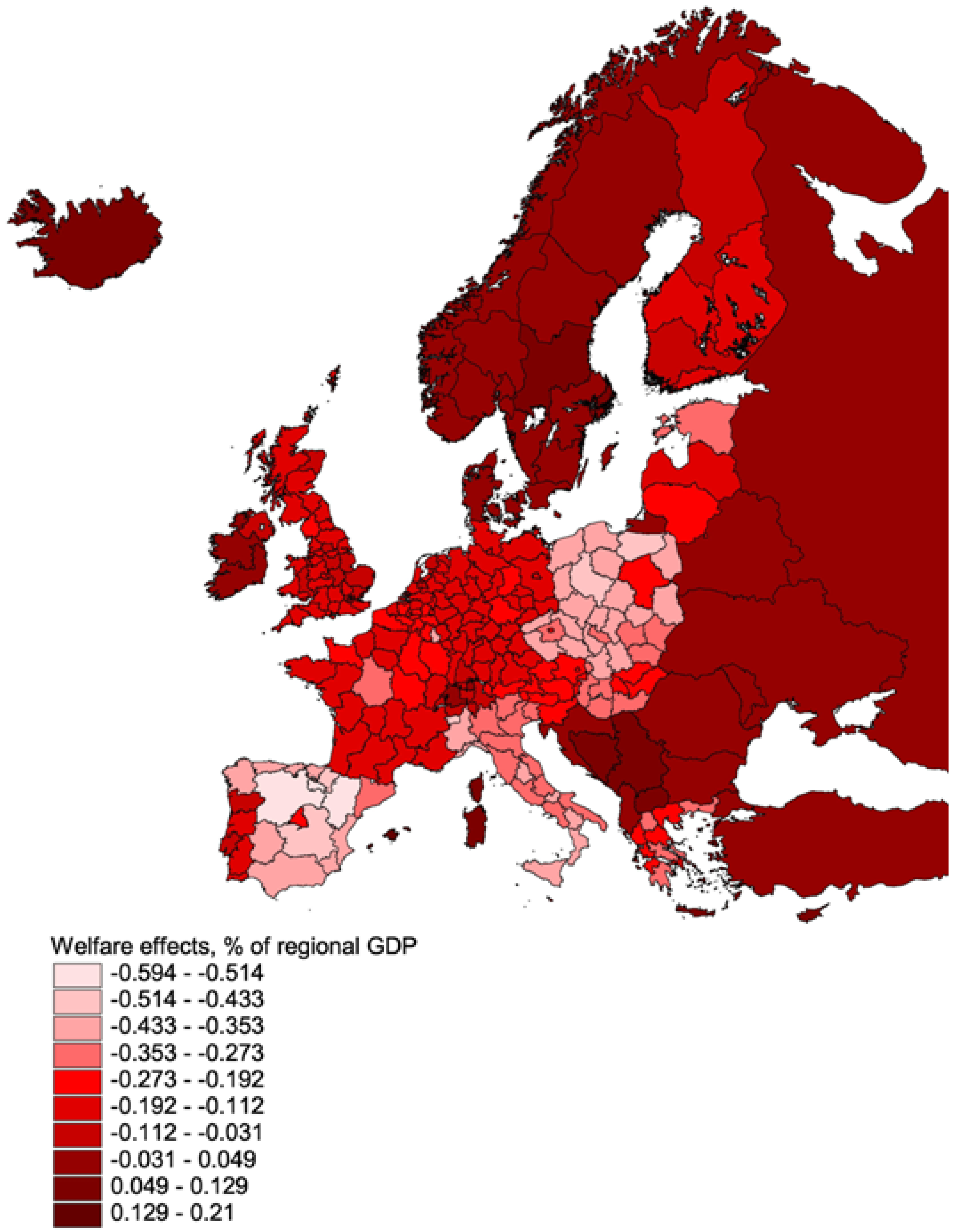

Figure 12: Impact of Trans-Tools scenario 2 on regional welfare

8.4.3. Scenario3

Scenario 3 is the liberalization that affects rail freight travel time and cost as well as costs for the passengers. The effects are positive in general, but with some regions negatively affected by it (especially BE 23 and SK04). The impacts that we show in the figure below do not show a clear spatial pattern, but one can see that the measure has higher impacts than the average in

Ireland, Spain, the Netherlands and Belgium especially. The overall effect for the EU-27 is 0.58 % of GDP.

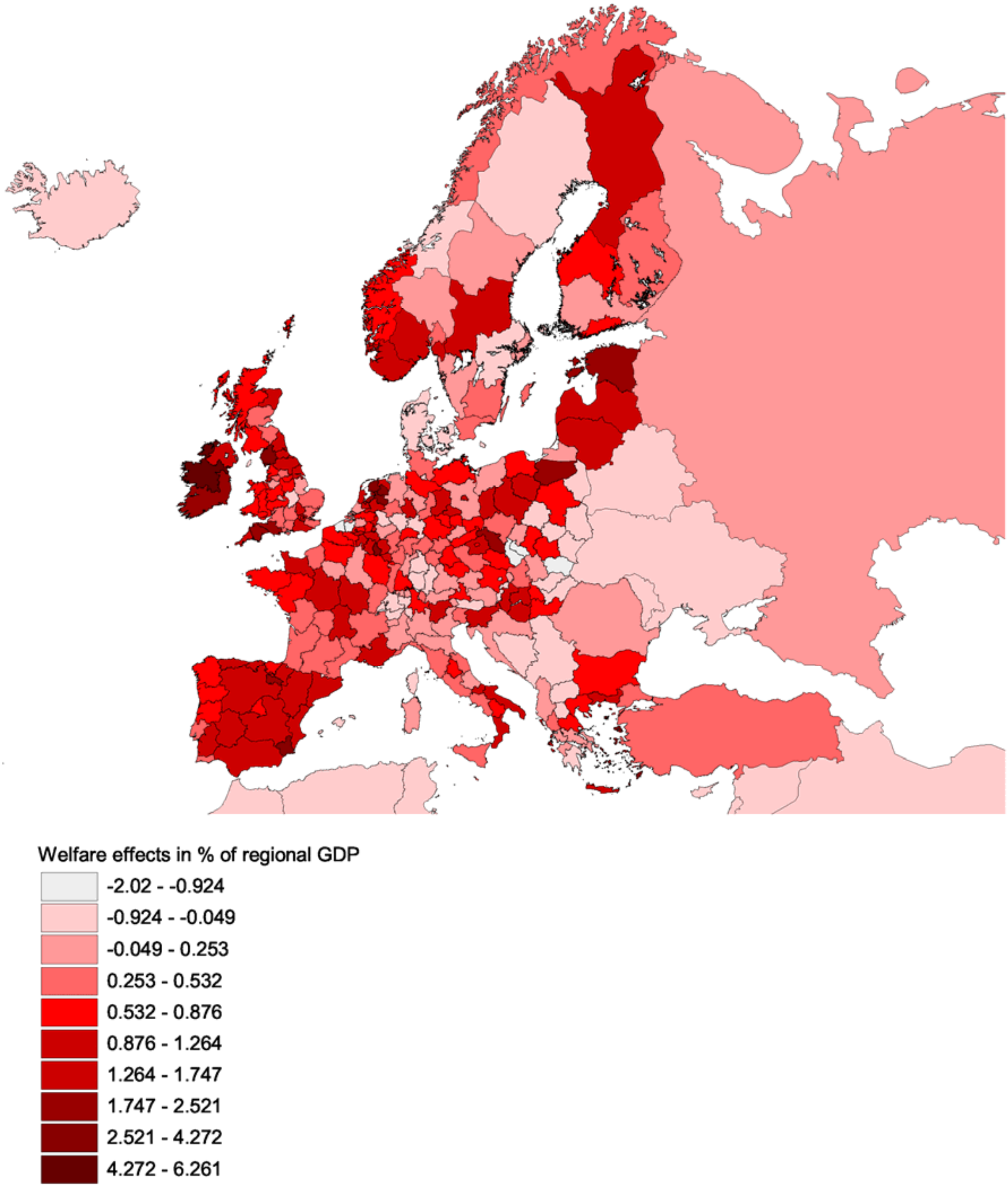

Figure 13: Impact of Trans-Tools scenario 3 on regional welfare

8.4.4. Combined scenario

The combined scenario is an overlay of all the patterns of the 3 different scenarios. Here the problem of evaluating mixed scenarios arises, and so the estimates cannot be regarded as reliable. The impact of the combined scenario and the sum of the first 3 scenarios are not identical, but there is a high correlation (the coefficient of correlation is 0.77) between them, as one can see in the figure below. One can also see that the effects of this scenario are actually lower than the sum of the isolated scenarios.

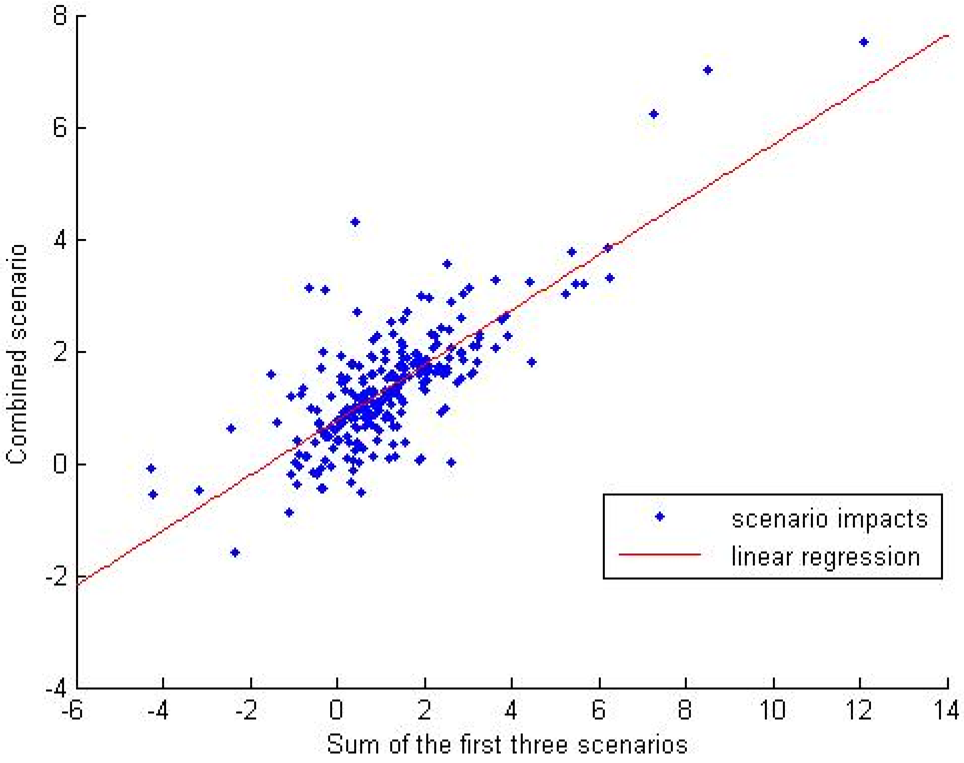

Figure 14: combined scenario vs sum of the first 3 scenarios

The overall effect of the scenario in the EU27 is 0.9% of GDP, which is also lower than the sum of the first 3 scenarios (1.0 %). The highest gainers are the regions of Ireland, Finland, Belgium, Luxemburg and the Netherlands.

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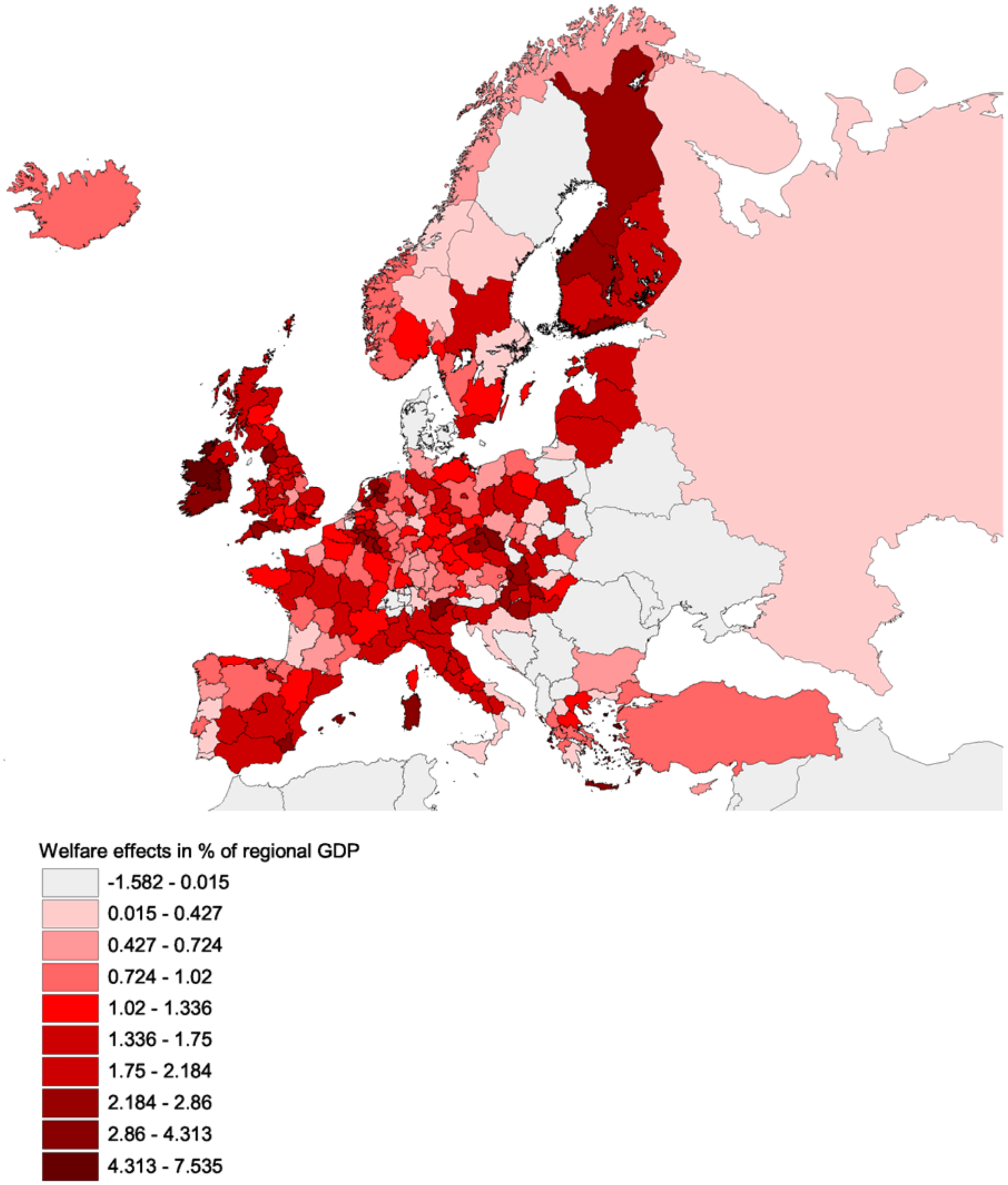

Figure 15: Impact of Trans-Tools the combined scenario on regional welfare

8.5. Scenario Outcome for the assignment model

The results of the assignment procedure are presented in this section, the following networks are included in TRANS-TOOLS describing base year 2000:

- Road 47,373 links, 35,079 nodes, 1,366 connectors
- Rail 19,867 links, 18,851 nodes, 1,269 connectors
- Air 8,507 links (legs), 522 nodes (airports), 7,962 connectors

Because maritime transports are not assigned onto a network, transport costs and times are included in a LOS-matrix which can be manipulated by the user. The networks have been checked upon consistency and coverage. Also EUROSTAT was informed about the results of the network updating and the assignments.

Assignments are done at NUTS 3 level to improve accuracy at link level. Therefore the output from the logistics model is converted from NUTS 2 to NUTS 3 using distance and location of harbour in the disaggregation of NUTS 2 zone flows.

The assignment of cars and trucks uses a probit based Stochastic User Equilibrium (SUE) model. Each trip purpose: private (including commuters), business, tourism, and trucks, has its own utility function based on the VoT (Value of Time);

$$U_a = \beta_{l(\varepsilon)} l_a + \beta_{tF(\varepsilon)} t_{aF} + \beta_{tC(\varepsilon)} t_{aC} + \beta_{tS(\varepsilon)} t_{aS} + \beta_{tW(\varepsilon)} t_{aW} + \frac{c_a l_a}{\omega}$$

$l_a = road\ length\ of\ link\ a$

$t_{aF} = \ free\ time\ on\ link\ a$

$t_{aC} = congsted\ time\ on\ link\ a$

$t_{aS} = \ ferry\ sailing\ time\ on\ link\ a$

$t_{aW} = waiting\ time\ at\ \ ferry$

$c_a = toll\ and\ \ ferry \cos t(Euro\ per\ km\ per\ car)$

$\omega = driving\ \ \cos t\ (Euro\ \ per\ \ km)$

Since road assignment considers congestion, short distance traffic (intra zonal trips at NUTS 3 level) is added to the trip matrices from the passenger and freight models as preloaded link volumes which can be changed by the user. Travel time is then computed based on the well-known BPR-formula,

$$t_a = t_{aF}\left(1+\alpha\left(\frac{T_{a(forward)} + \gamma\, T_{a(backward)}}{N_a}\right)\right)^{\beta}$$

$t_{aF} = \ free\ time\ on\ link\ a$

$\alpha, \beta, \gamma = parameters\ depending\ on\ link\ type$

$T_a = assigned\ volume\ in\ passenger\ car\ equivalents\ on\ link\ a$

$N_a = capacity\ in\ passenger\ car\ equivalents$

The different car equivalents and influences on capacities by trucks and passenger cars are included in the speed-flow calculation, and trucks are assumed to have lower maximum speeds than passenger cars. The capacity at two-lane roads is assumed to depend on flows in both directions (overtaking).

In the assignment, trips are distributed over types of days and time periods. The following four types of days are considered ion the model: usual weekdays outside the summer holidays, usual weekdays within the summer holidays, busy holidays, and weekends and holidays. Trips on other days than weekdays outside summer holidays are simply distributed evenly over the day. Congestion primarily occurs in peak periods on weekdays. Therefore, trips on weekdays outside summer holidays are split into: morning peak (7 am to 9 am), afternoon peak (3 pm to 5 pm) and off-peak.

Capacity is not considered in assignment of rail passengers. Therefore, short distance rail passengers and time distributions are not included in the assignment of rail passengers. The assignment is conducted in the framework of stochastic assignment simulating parameter values and link costs. While assuming cost proportional to travel distance, the utility function includes link travel time and length. For instance, passengers will be assigned to high speed links only by recognition of the higher speeds.

The network used in assignment of rail freight is almost similar to the passenger rail network because it except few cases not has been possible to classify tracks. Like assignment of rail passengers a stochastic procedure based on a utility function including length and time is used.

The model for inland waterways operates with five ship types (CEMT class 2 to 6). An approximated method secures that large ships are assigned only to minor canals in case of non-existing large canals on the route section. Freight is assigned to inland waterways by an all-or-nothing procedure where the utility function includes length and time attributes.

The air model assign both the air journeys in the air network, but it also calculate the choice of feeder and access link, and choices of the airports that are used for the journey. The choice of journeys between airports is then based on number of transfers, fare and travelling time. The overall air model is solved by a stochastic traffic assignment model.

8.5.1. Baseyear

Modelled road volumes for the base year 2000 have been compared with counts at link level and network calibrated to reduce the divergence between estimated and observed flows. The efforts have differed depending on the coverage of available traffic counts. Ferry routes are part of the road network, but assigned vehicles onto ferry routes have only in rare cases been compared with count data. Therefore, estimated volumes at ferry routes are seldom accurate.

A similar calibration procedure has not been possible for rail passenger and freight, since updated count data were missing. Visual inspections have been conducted to verify the assignment method, but larger divergences may occur due to the lack of calibration, for instance, on some high speed rail lines.

The enclosed maps show the assigned volumes onto road and rail networks. The road traffic volumes include passenger car, truck and local traffic for an average annual day (AADT) in year 2000. The passenger flows in the rail network illustrate the number of regional and long distance travellers (excluded local passengers) on an average annual day in 2000. The rail freight map shows e.g., large link volumes (tonnes per average annual day) in Russia.

As mentioned above the assignment of freight matrices onto inland waterway network is quite simple and gives only approximated figures at link level. Therefore, in the evaluation of freight movements by inland waterways aggregated figures should be used based on matrix output (tonnes) and aggregated link volumes (tonnes, tonnes km etc.).

The air passenger network has been updated with low budget lines and to some extend calibrated to count data. However, validations reveal that the air network and assignment fails to represent actual travel behaviour, services, and air fares in some regions, in particular in east Europe. Therefore, separate link and line volumes are often inaccurate and more aggregated figures (trips, passengerkm, bundling of routes etc.) should primarily be used in assessments of air passenger transport.

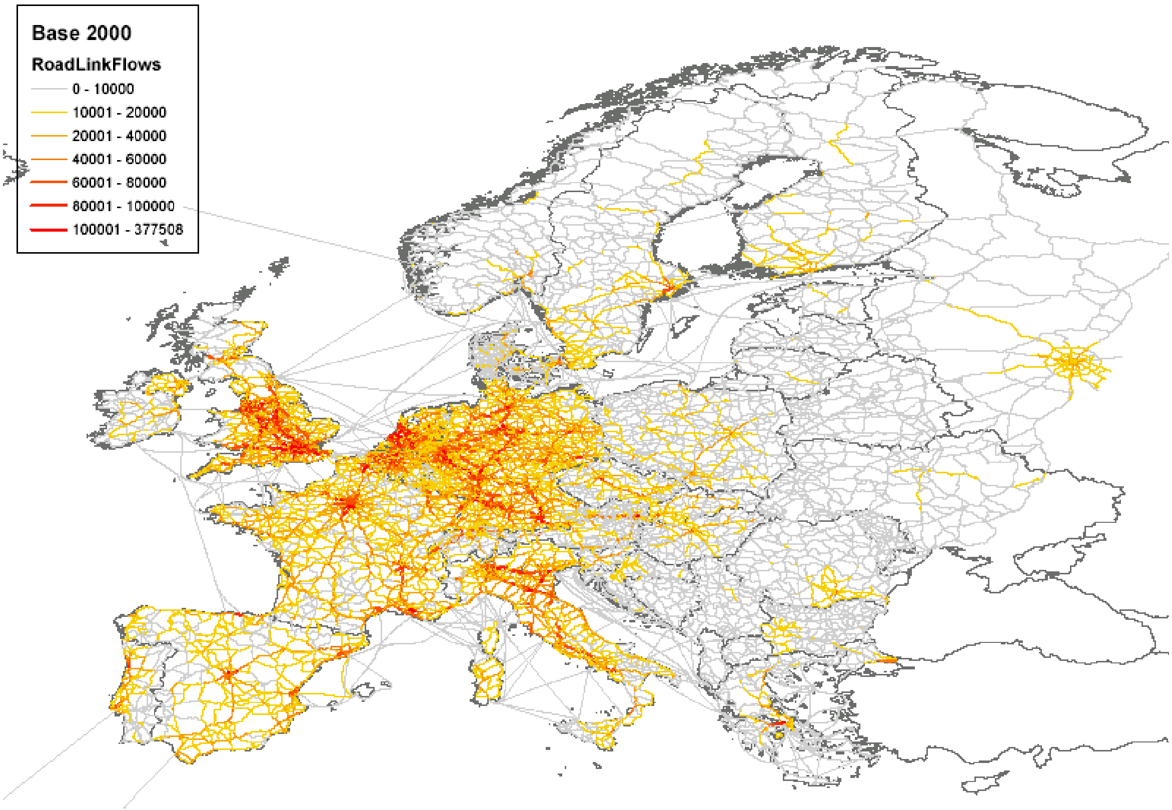

Figure 16: **Road assignment base year, vehicles per day**

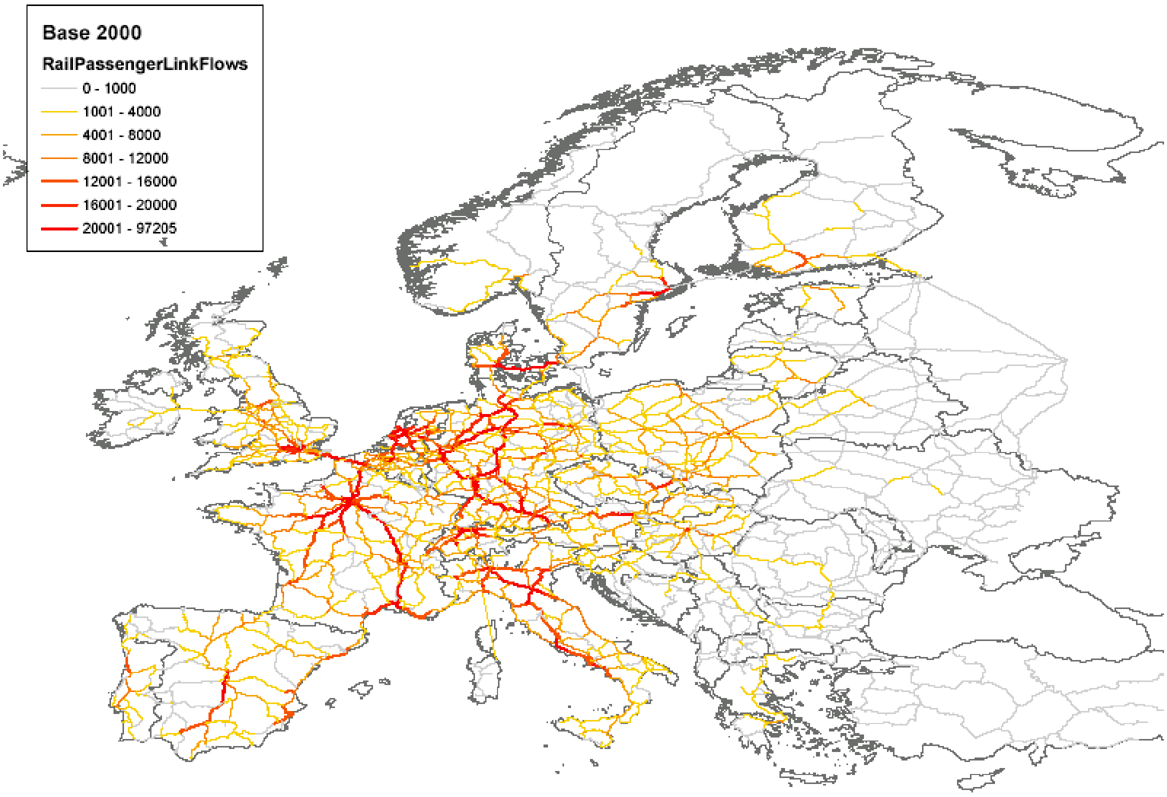

Figure 17: Rail passenger assignment base year, passengers per day

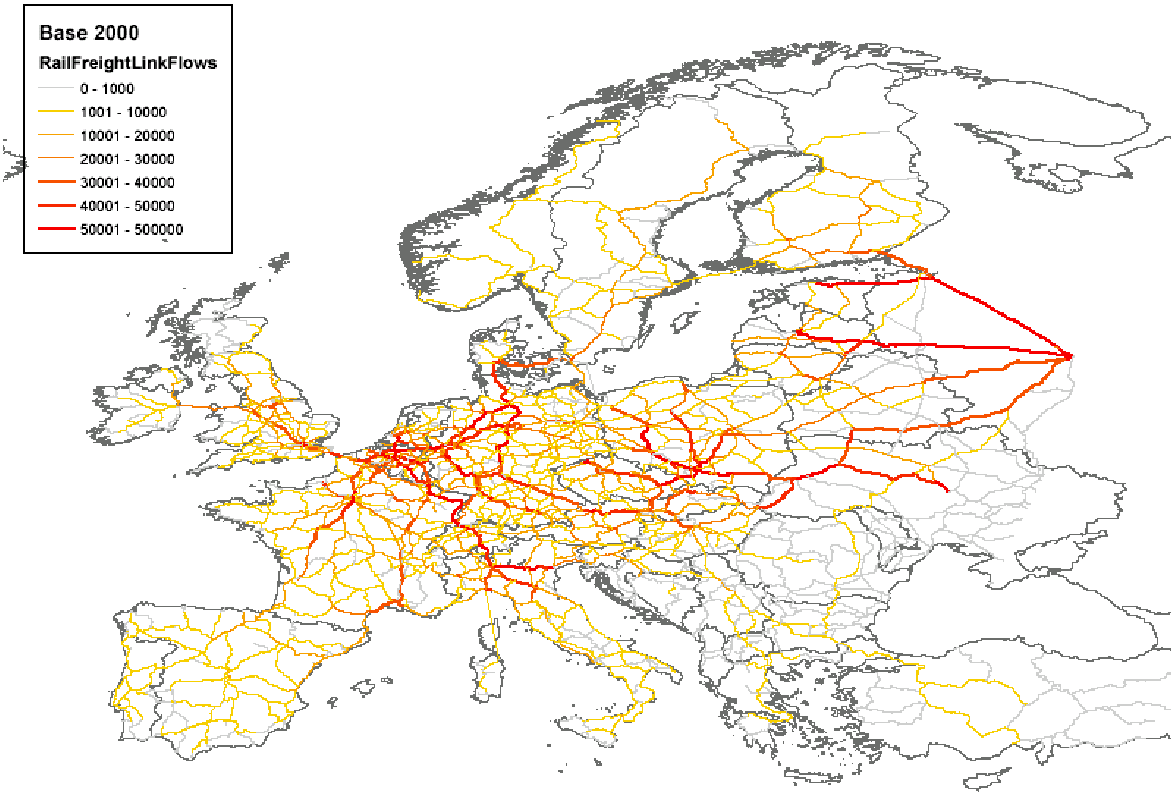

Figure 18: Rail freight assignment base year, tonnes per day

8.5.2. Reference

The model is used to forecast demand from in a Reference scenario year 2020 as described in the previous sections. The demand in form of matrices is assigned onto the respective networks, and the enclosed maps show results from assignment of car trips, rail passenger and freight transport for Reference 2020 and differences to base year 2000.

The model forecasts generally large increases in car traffic all over Europe compared to year 2000. However, the map reveals also regions and roads with decreases in traffic volume. This is primarily caused by movements to other and new roads. But also changes in mode choice, trade patterns and logistics are likely some of main contributors to the local decreases in road traffic.

The assignment of rail passengers shows minor changes compared to year 2000. A few large differences are caused by new expected infrastructure developments. The usage of rail in freight transport is expected to increase in the future according to the model. It seems to be a general trend likely caused by shifts from truck to rail due to expected increases in road congestion and fuel costs.

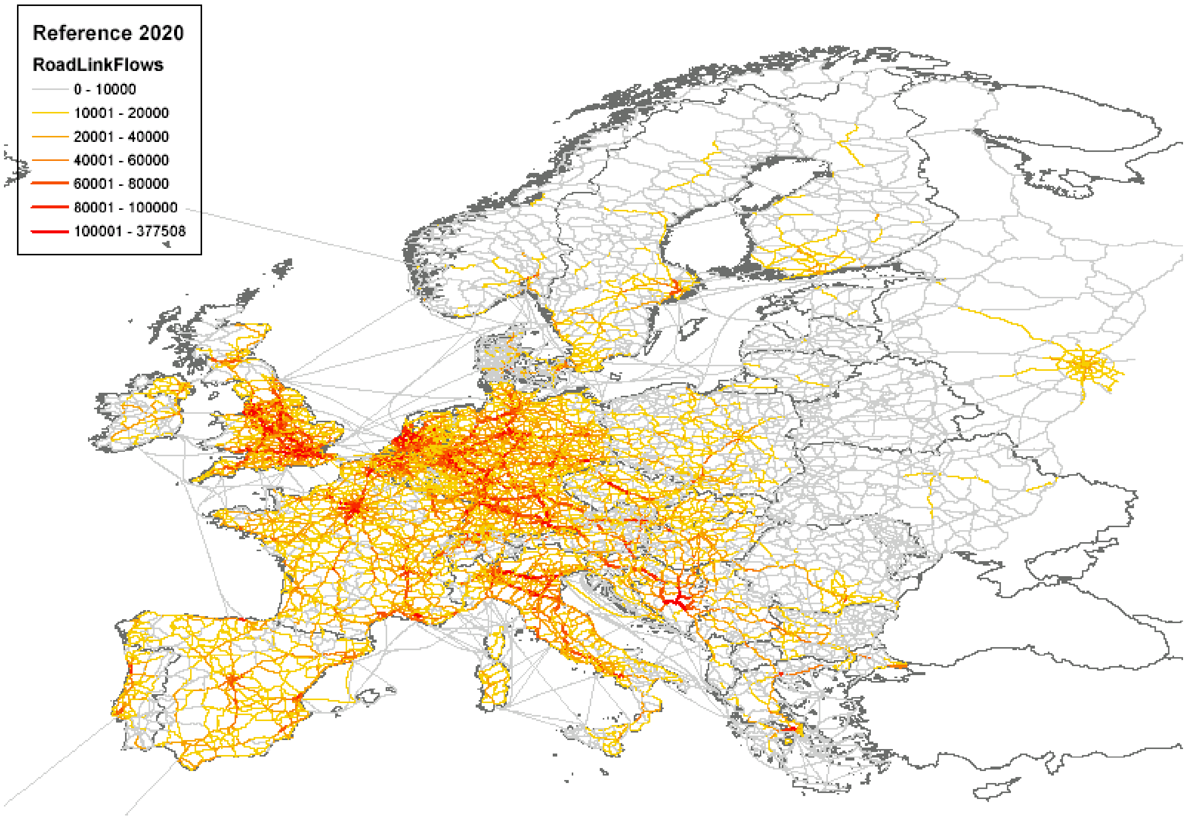

Figure 19: Road assignment 2020 reference scenario, vehicles per day

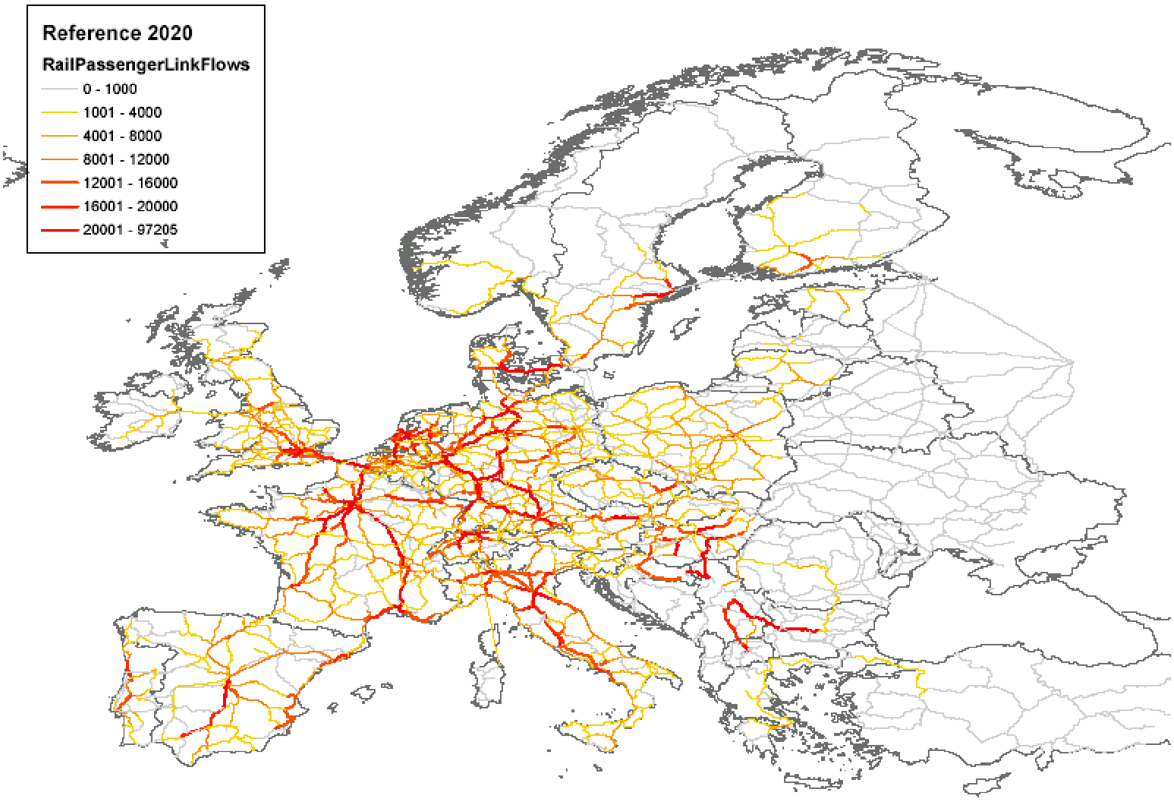

Figure 20: Rail passenger assignment 2020 reference scenario, passengers per day

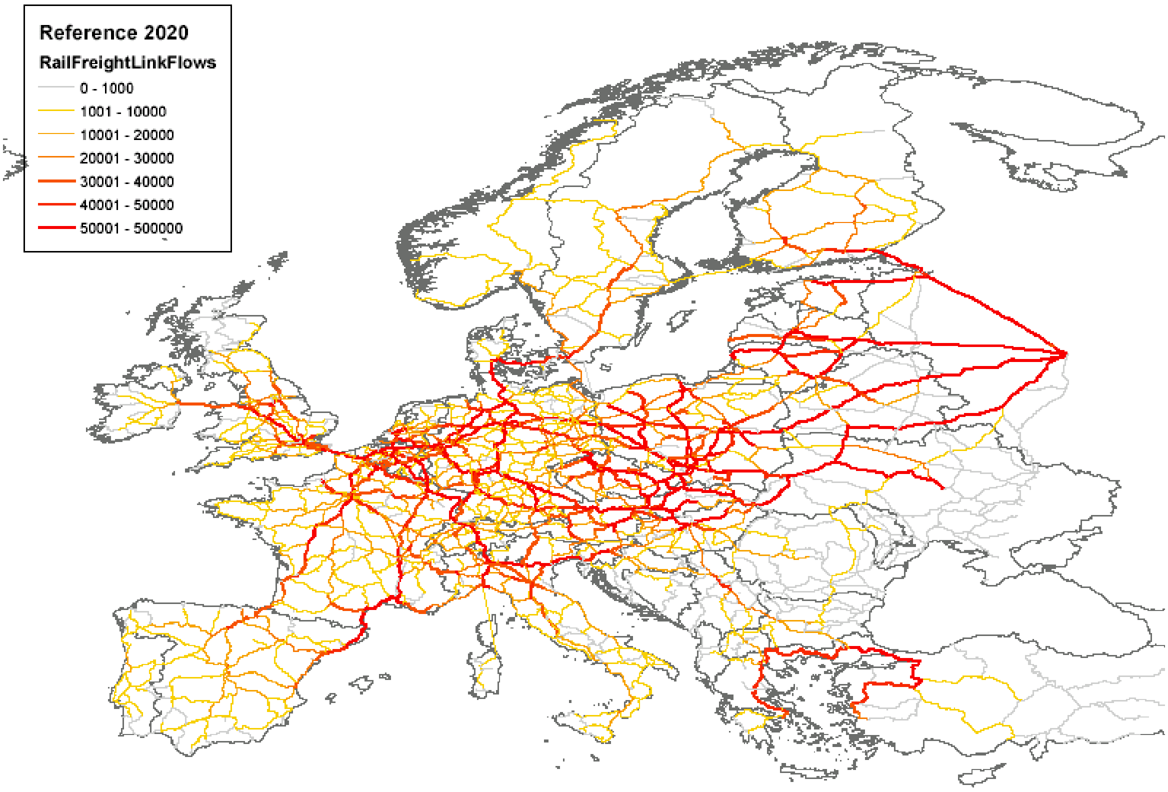

Figure 21: Rail freight assignment 2020 reference scenario, tonnes per day

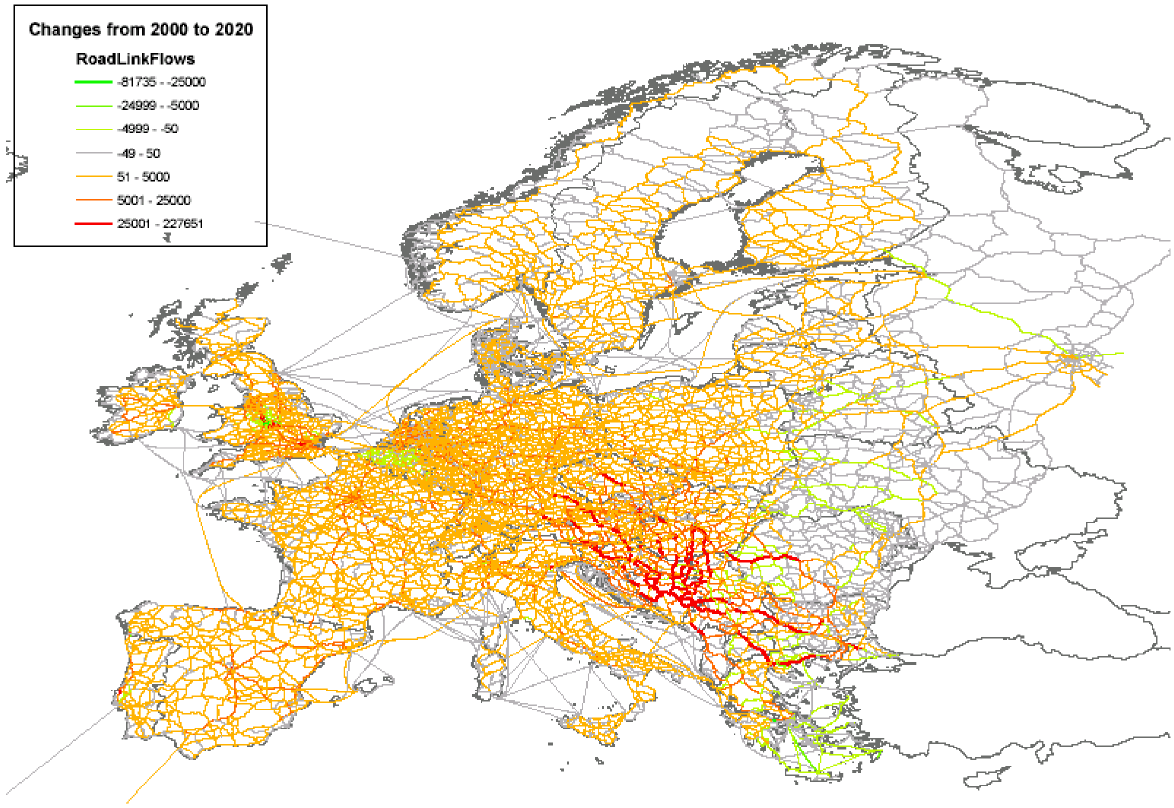

Figure 22: Road assignment 2020 reference compared to base year, vehicles per day

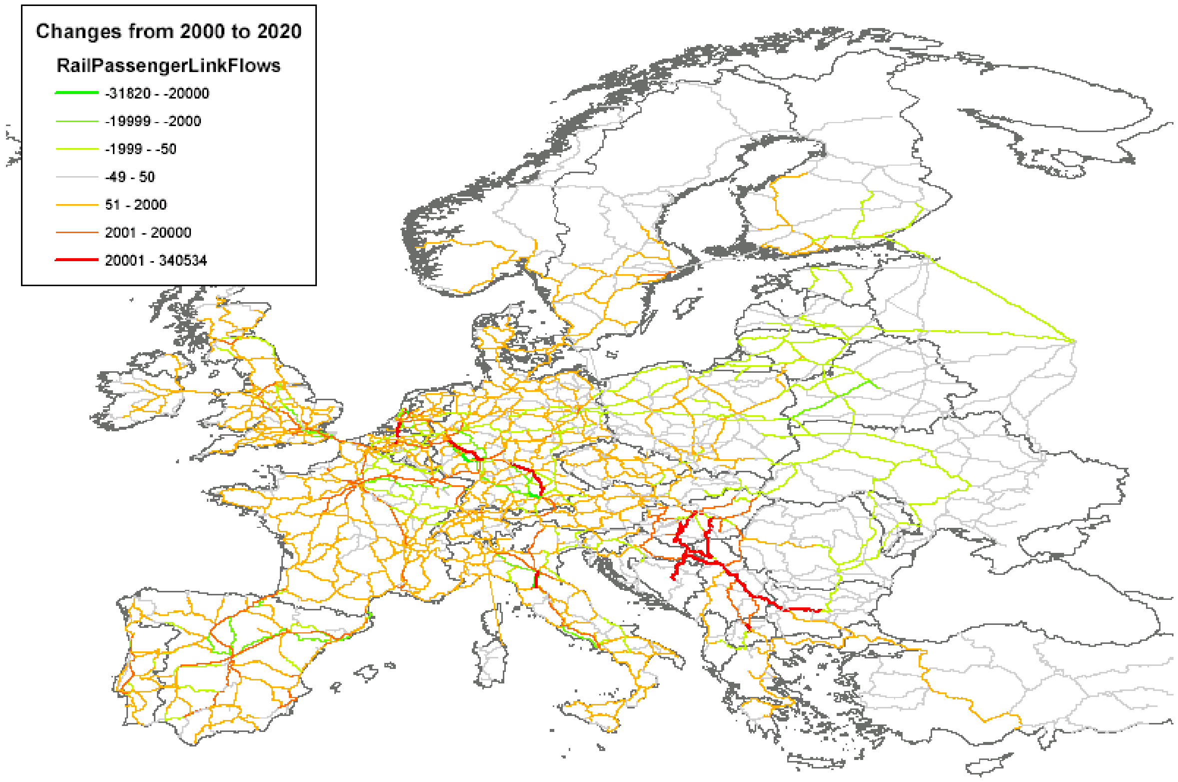

Figure 23: Rail passenger assignment 2020 reference compared to base year, passengers per day

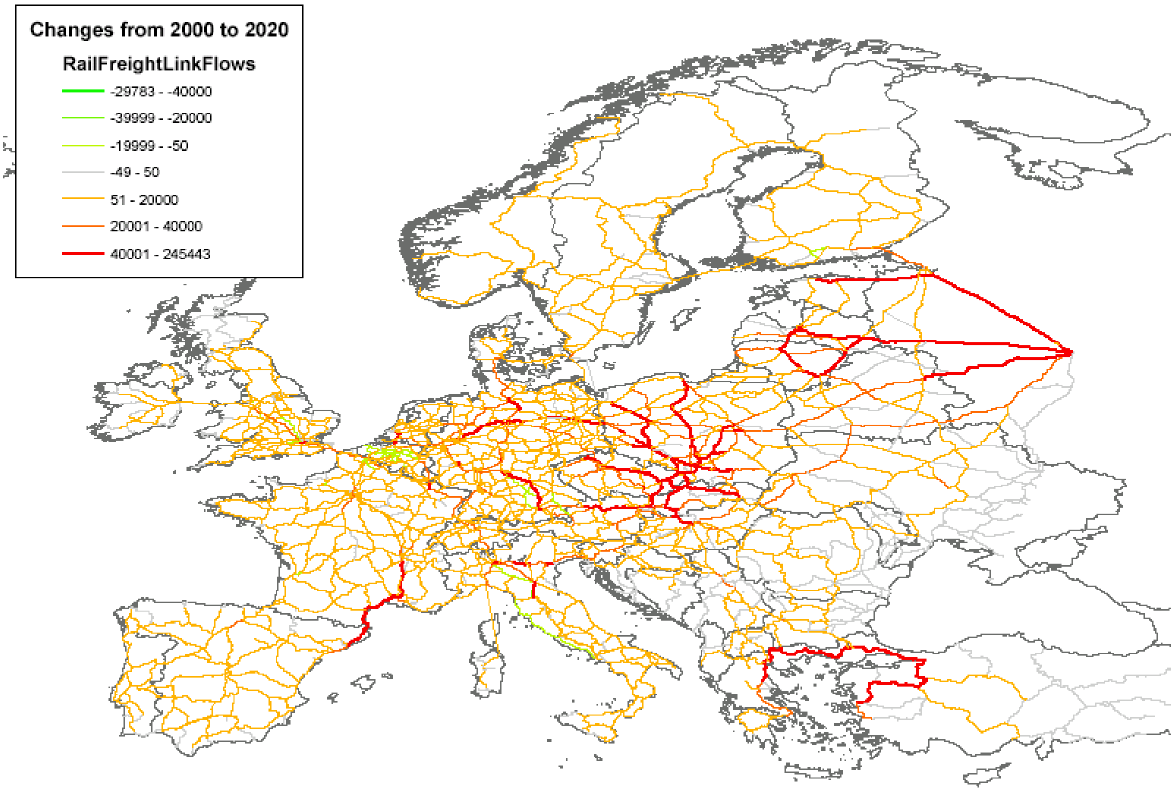

Figure 24: Rail freight assignment 2020 reference compared to base year, tonnes per day

8.5.3. Scenario1

This Scenario includes the implementation of TEN priority projects and changes of intermodal loading units and freight integrations. The enclosed flow plots show assigned vehicles, rail passengers and rail freight onto the networks.

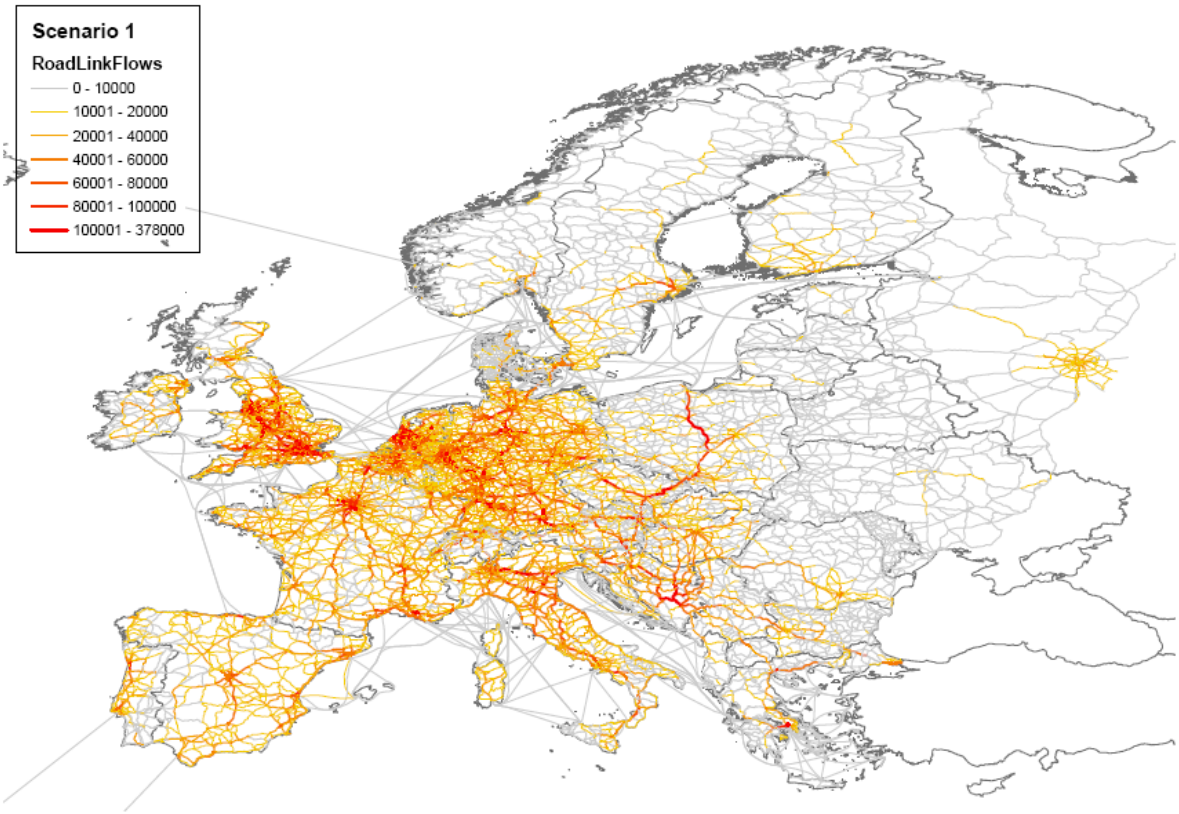

Figure 25: **Road assignment 2020 scenario 1, vehicles per day**

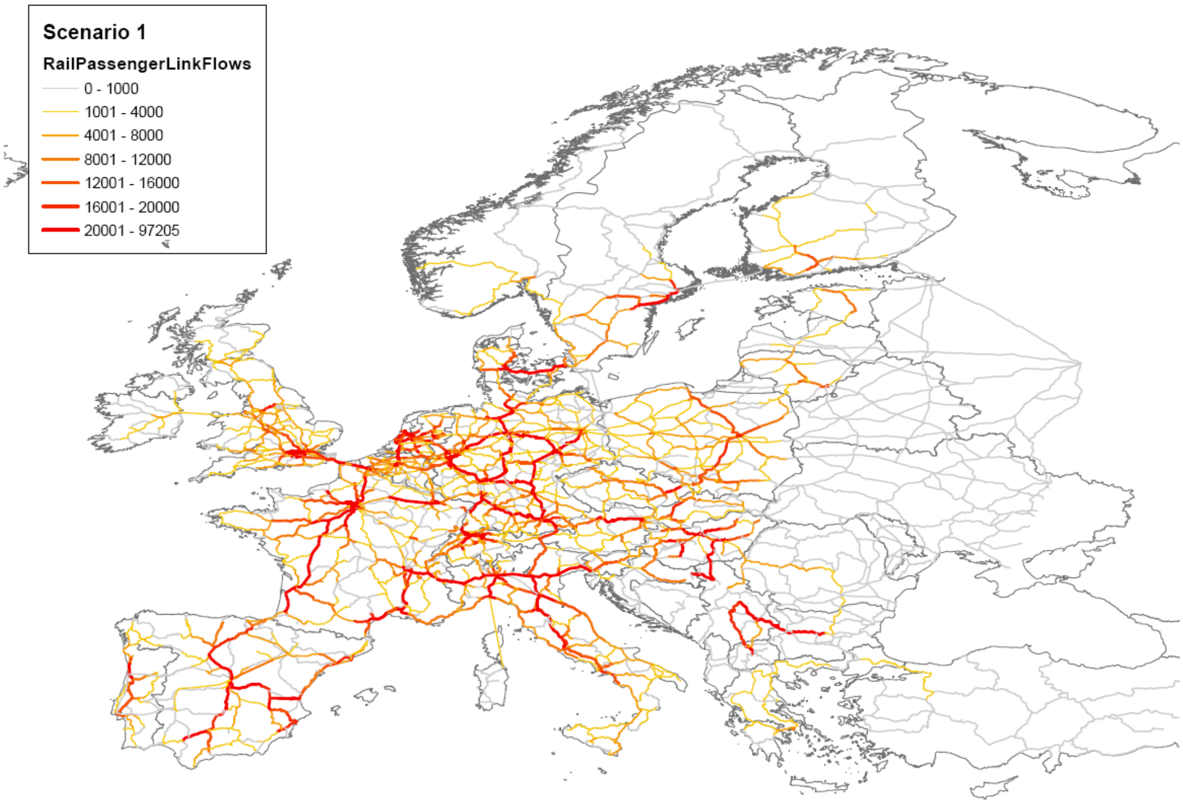

Figure 26: **Rail passenger assignment 2020 scenario 1, passengers per day**

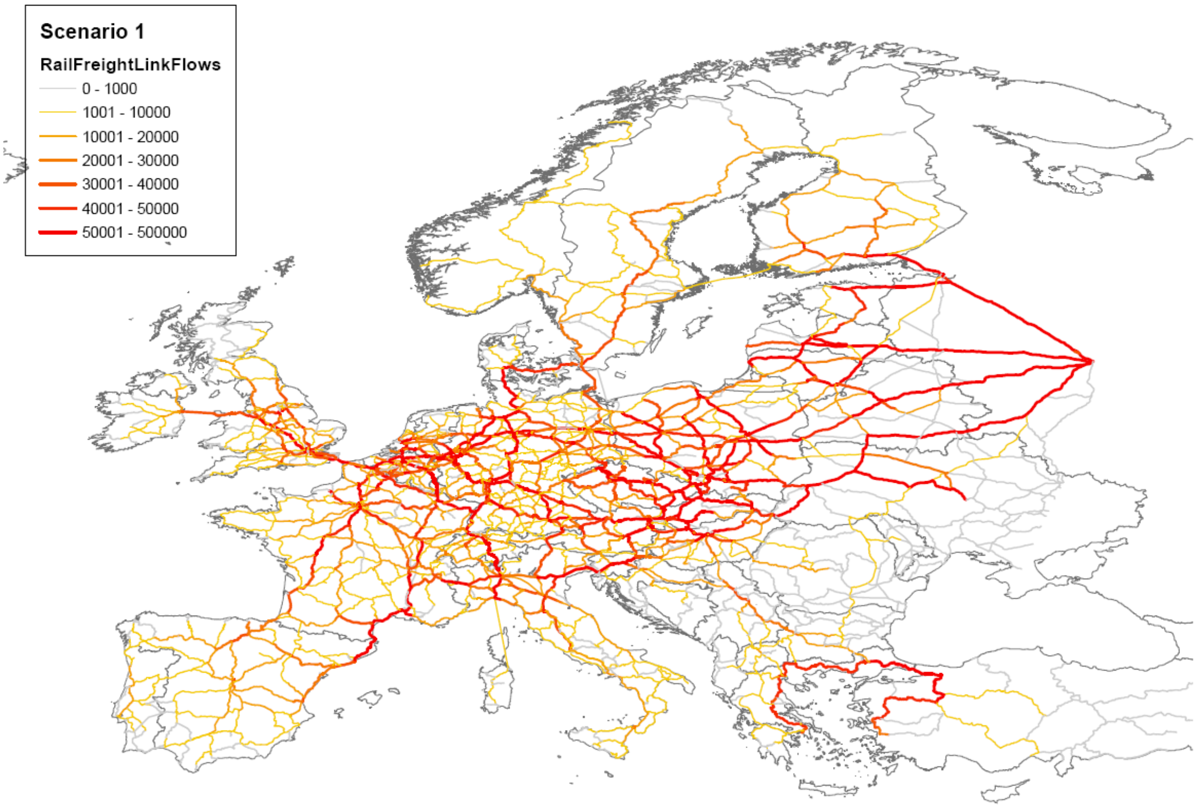

Figure 27: **Rail freight assignment 2020 scenario 1, tonnes per day**

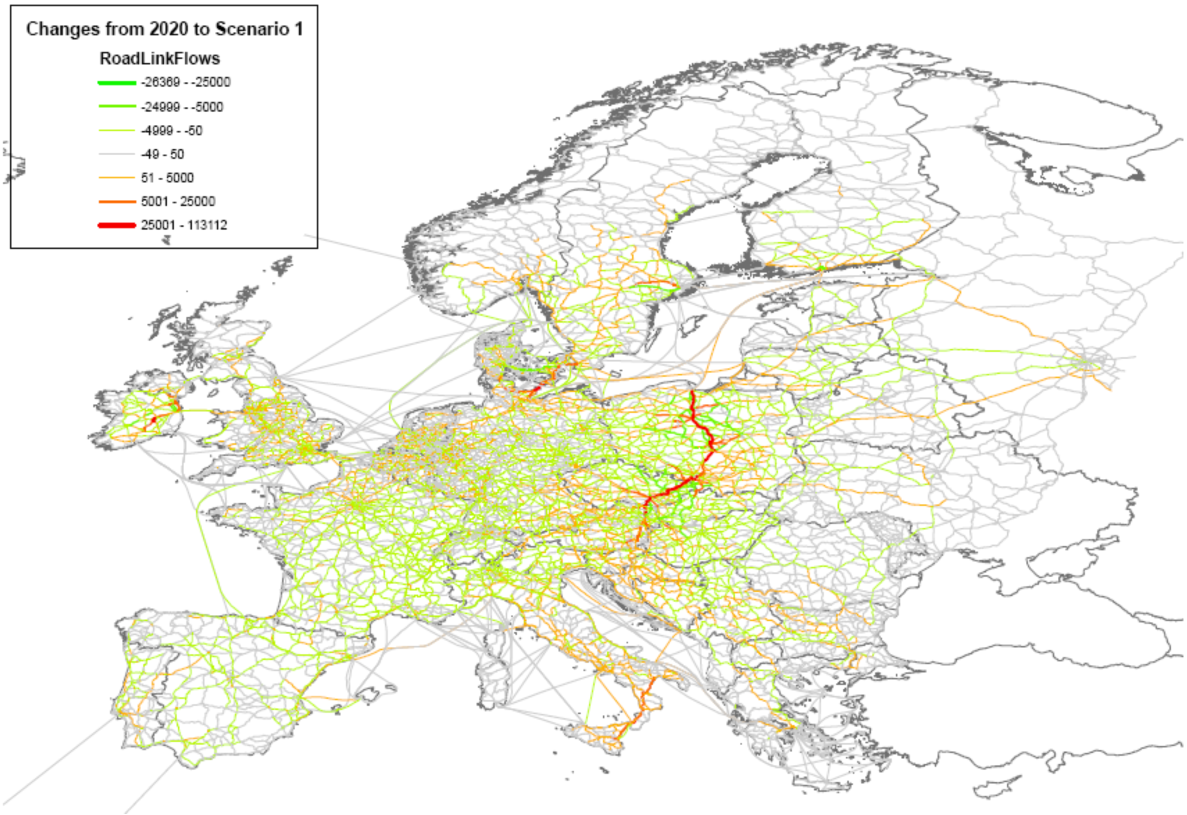

Figure 28: **Road assignment scenario 1 compared to reference 2020, vehicles per day**

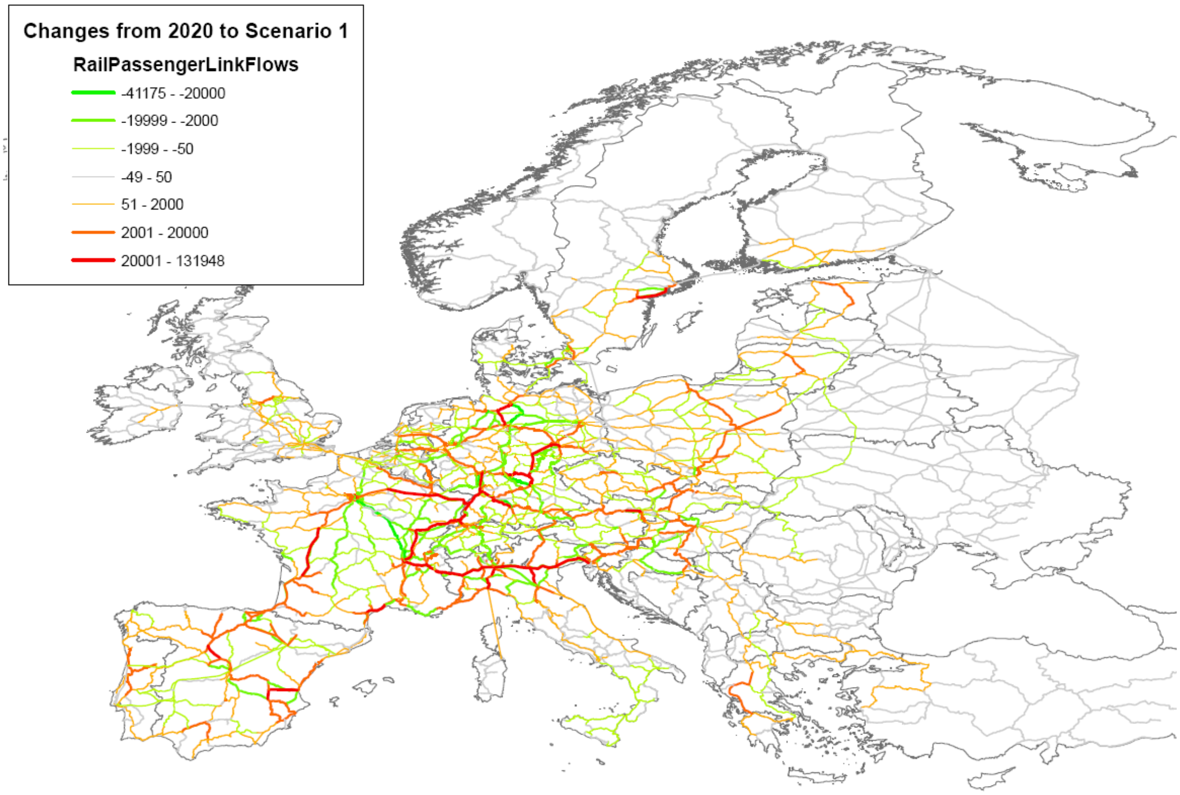

Figure 29: Rail passenger assignment scenario 1 compared to reference 2020, passengers per day

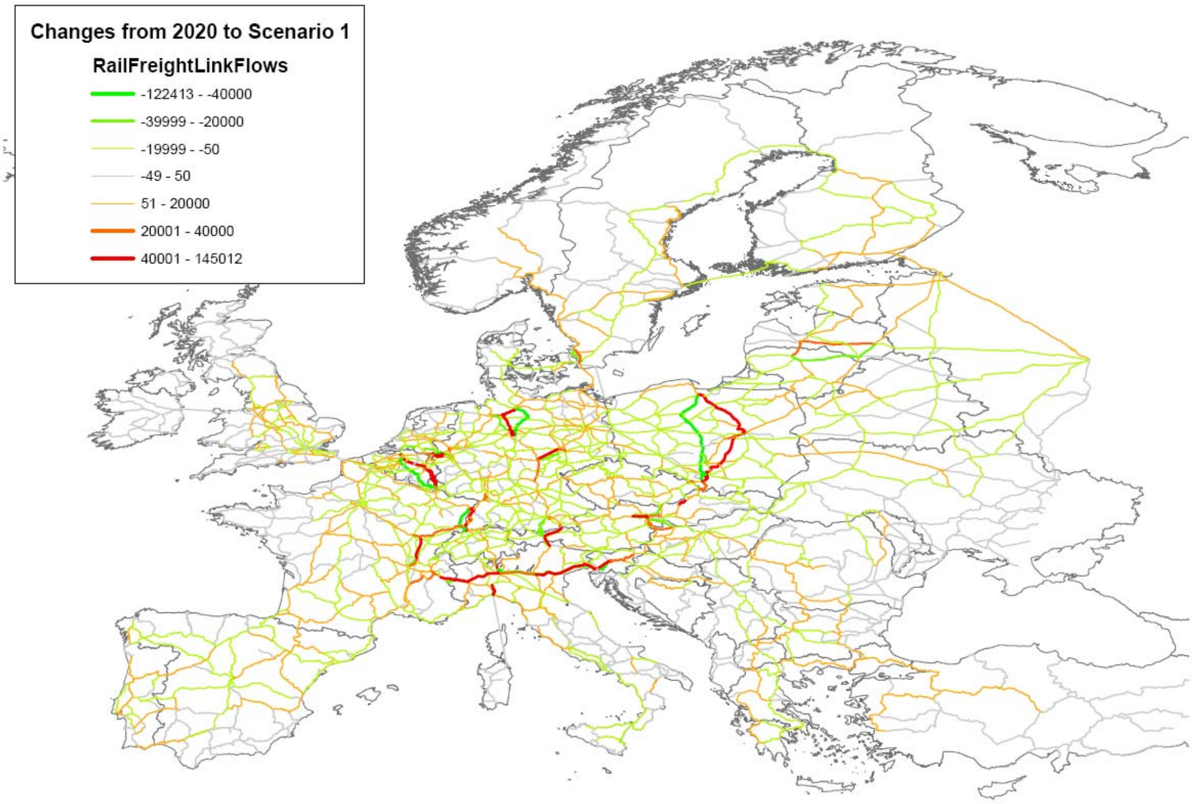

Figure 30: Rail freight assignment scenario 1 compared to reference 2020, tonnes per day

8.5.4. Scenario2

In Scenario 2 road pricing of passenger cars and trucks is implemented on motorways in all EU member states. The flow plots of vehicles, rail passengers and freight transport are supplemented with flow plots of the differences compared to Reference 2020. While red indicates increases relative to Reference 2020, green indicates decreases in traffic volume.

It is noticed as expected that road traffic general is lower in EU member states in Scenario 2 compared to Reference 2020. Pricing of motorway affects traffic on other roads, since traffic outside the motorway network generally decreases. However, there are also cases, for instance in the Northern European countries, were road traffic moves to uncharged roads. It is also noticed that more traffic is attracted to ferry routes when roads are charged. Traffic volumes in Switzerland and East European countries not affected by the pricing scheme seem in general to increase compared to Reference 2020.

As a consequence of road pricing, the usage of rail increases as shown in the enclosed flow plots. The model forecasts increases in rail passengers and freight movements by rail overall in Europe.

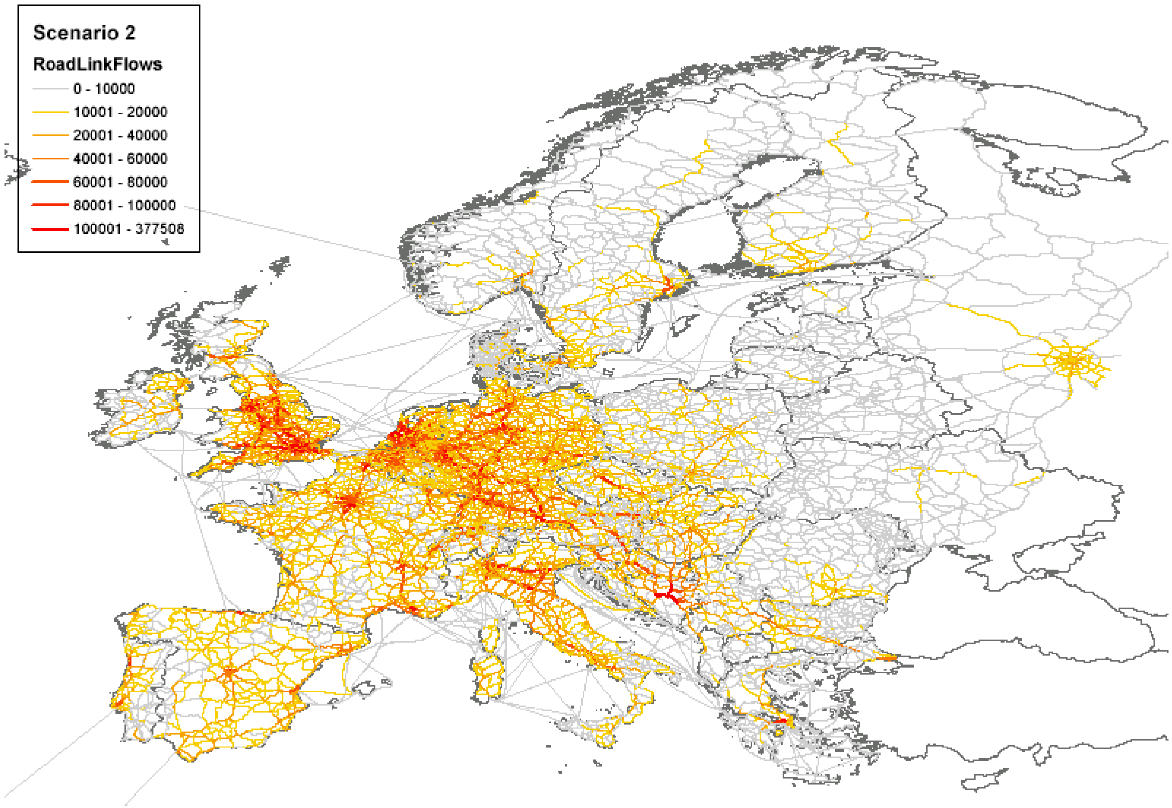

Figure 31: Road assignment 2020 scenario 2, vehicles per day

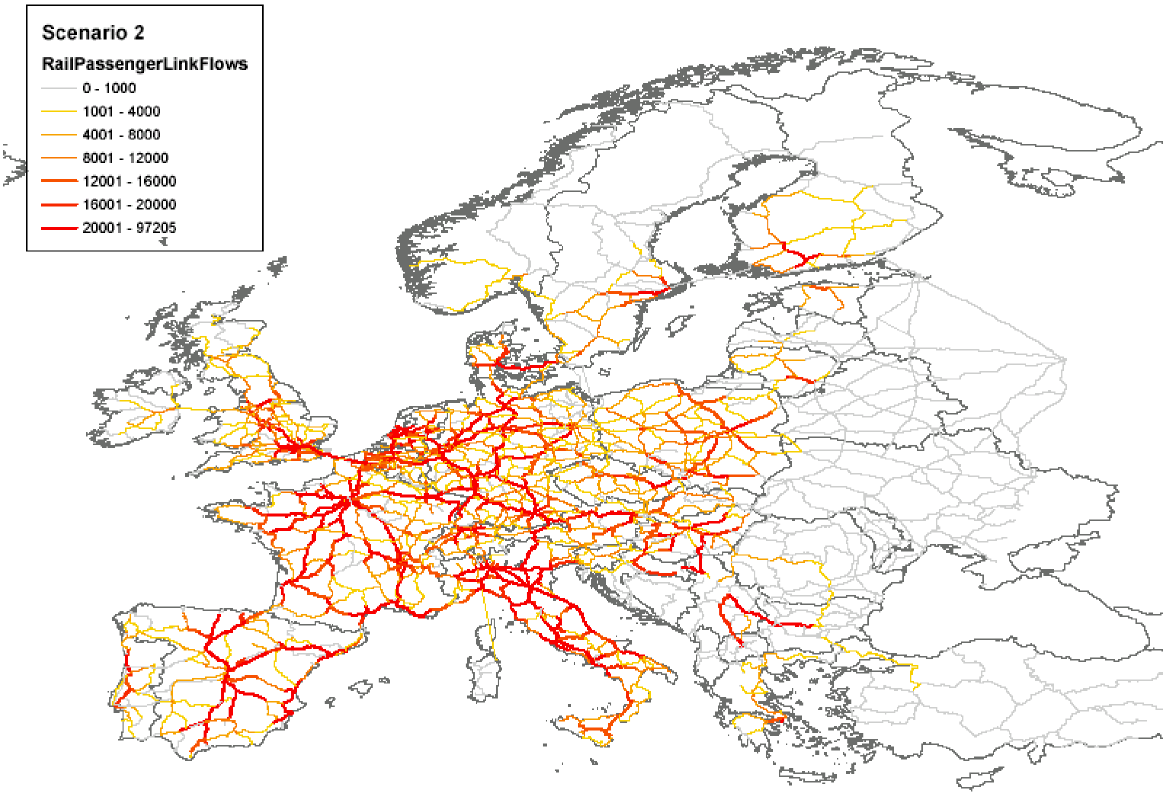

Figure 32: **Rail passenger assignment 2020 scenario 2, passengers per day**

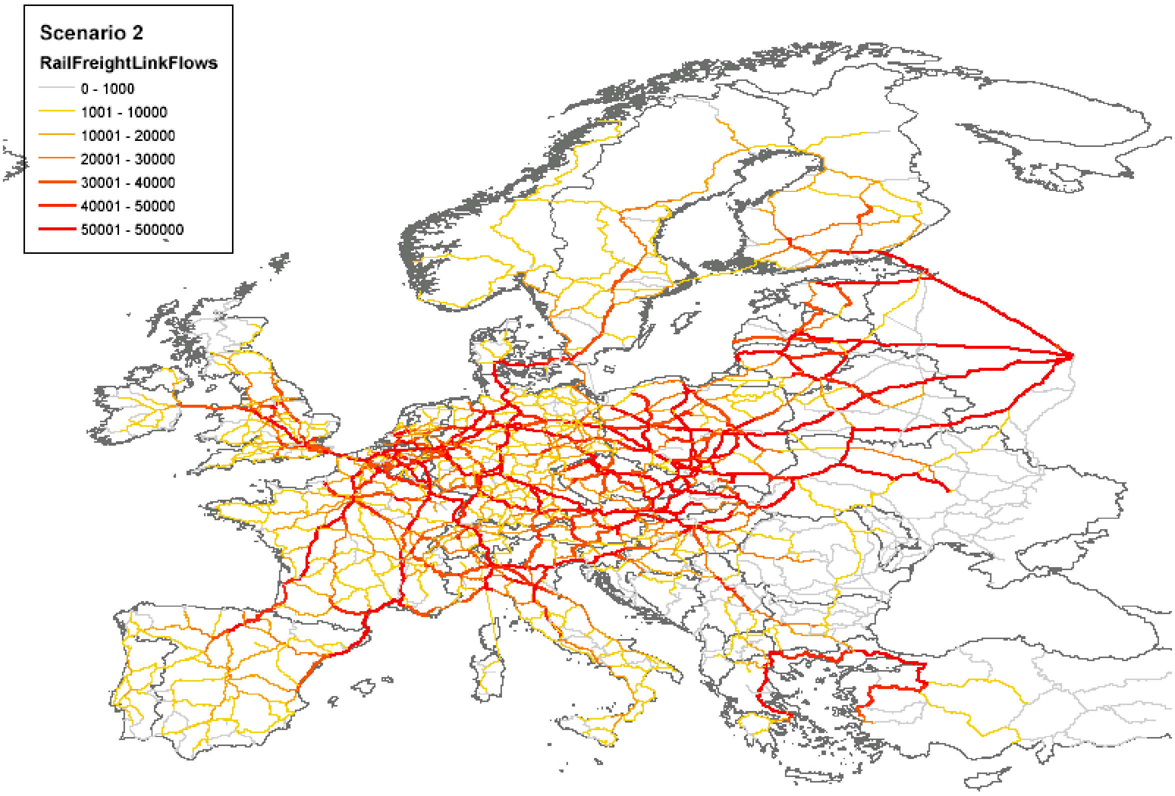

Figure 33: **Rail freight assignment 2020 scenario 2, tonnes per day**

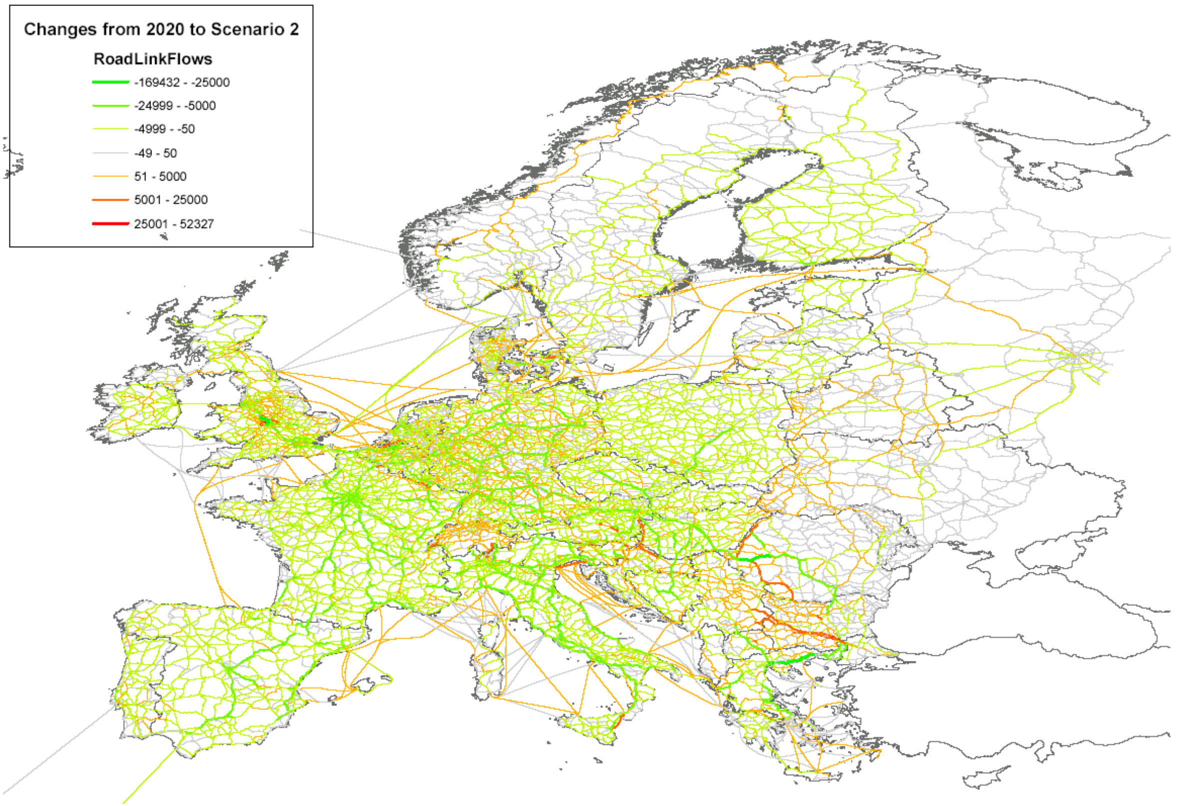

Figure 34: Road assignment scenario 2 compared to reference 2020, vehicles per day

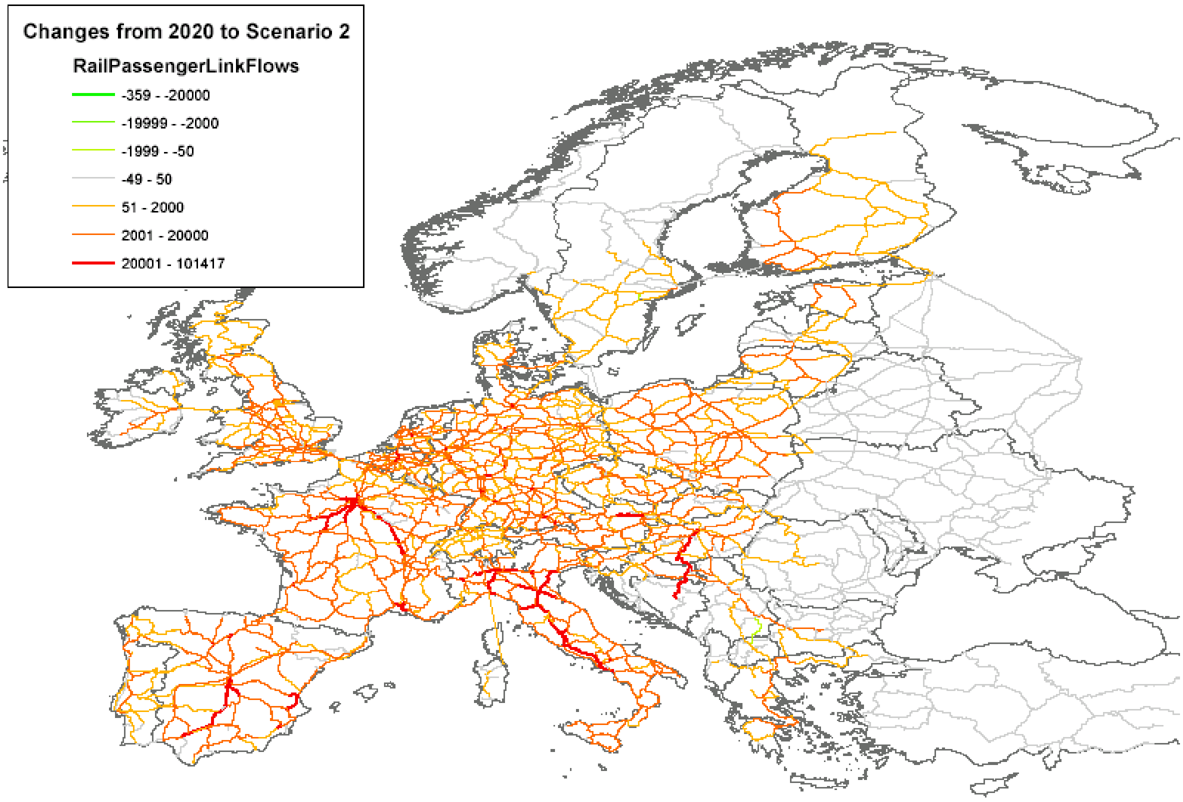

Figure 35: Rail passenger assignment scenario 2 compared to reference 2020, passengers per day

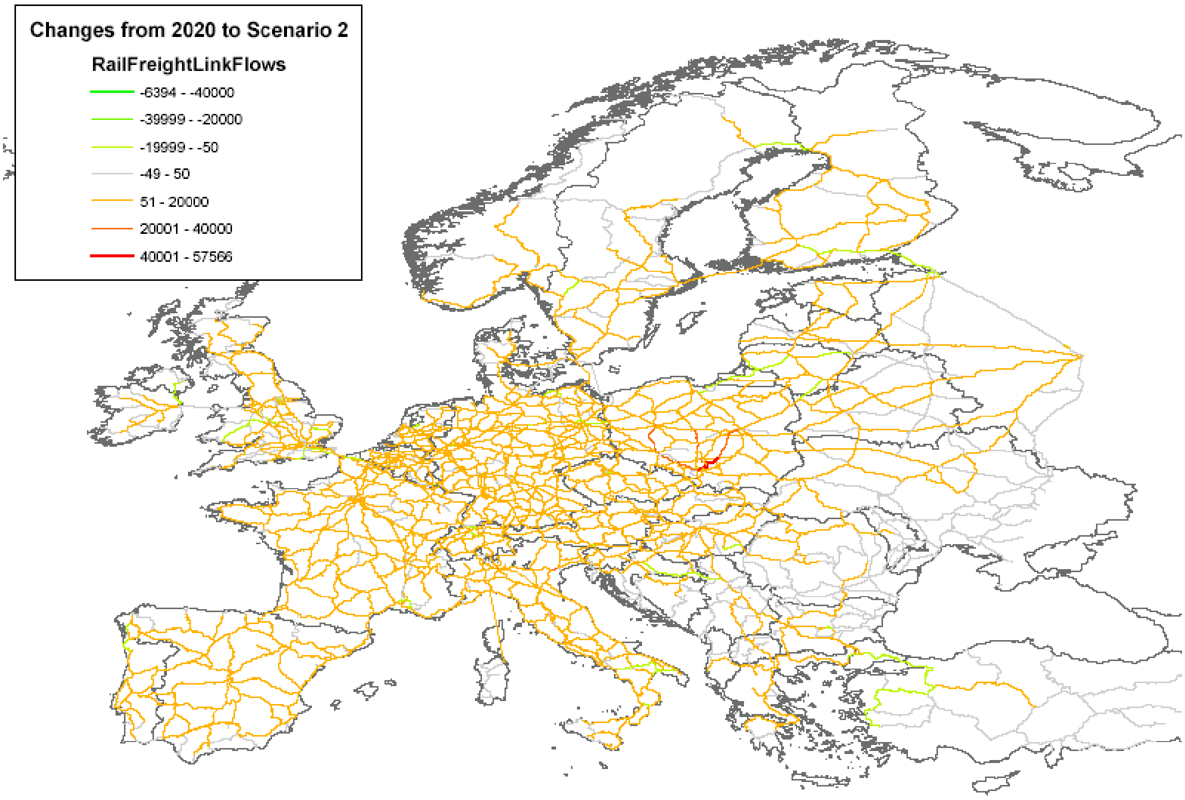

Figure 36: Rail freight assignment scenario 2 compared to reference 2020, tonnes per day

8.5.5. Scenario3

In Scenario 3 rail transport is promoted by substantial improvements and cost reductions. The flow plots shown movements to rail transport, and therefore generally increases compared to Reference 2020. Looking at the changes in road traffic, however, there are only marginal effects in form of lower volumes. Clearly the direct pricing scheme in Scenario 2 has larger impacts on road traffic flows.

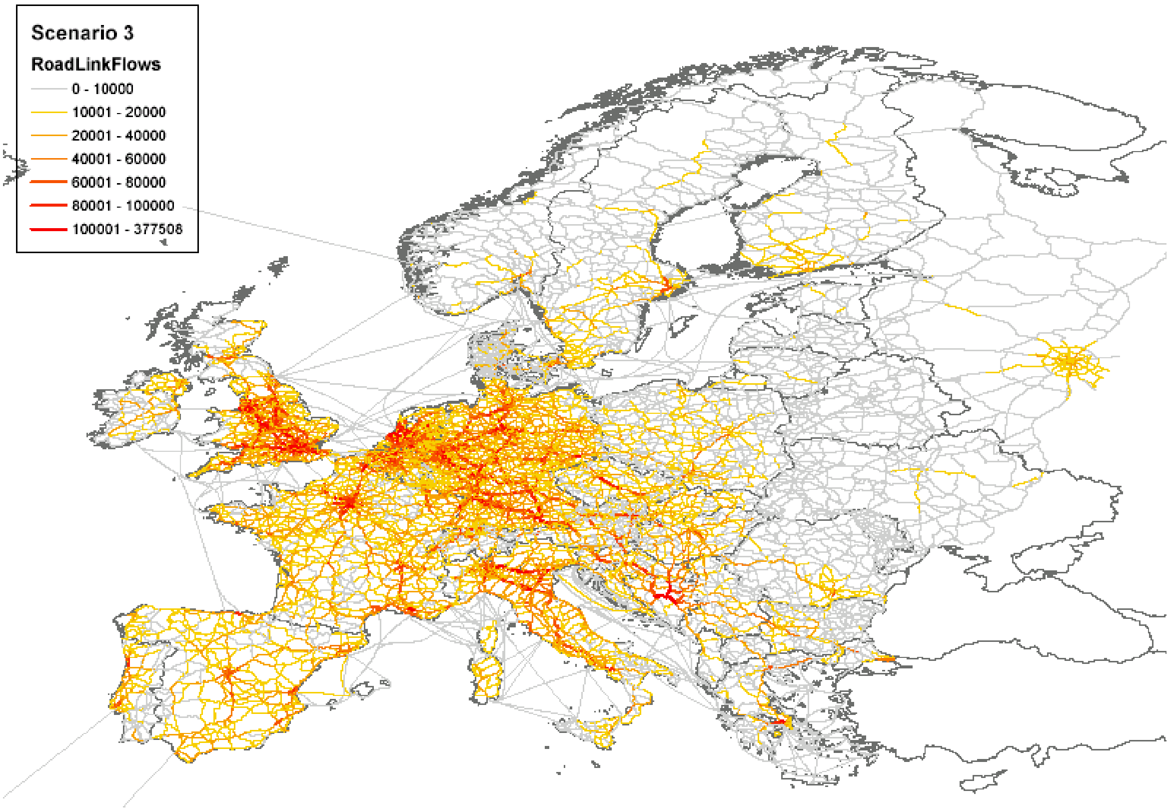

Figure 37: **Road assignment 2020 scenario 3, vehicles per day**

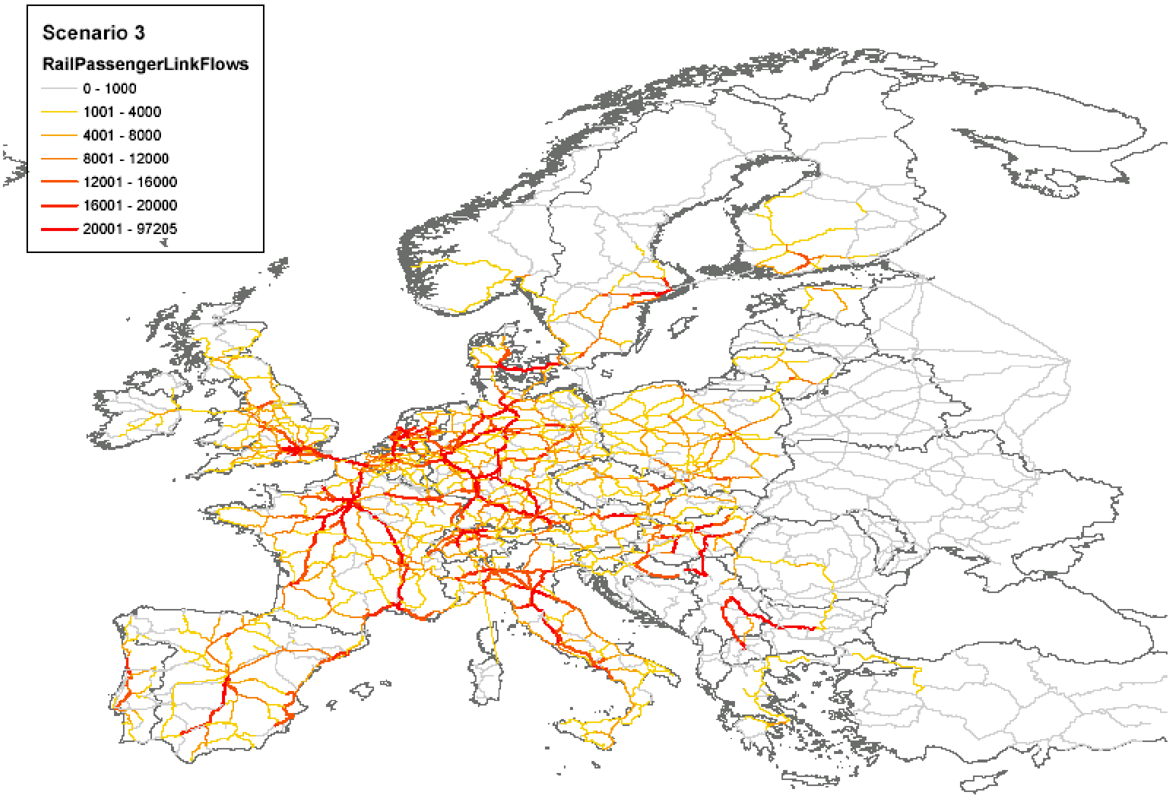

Figure 38: **Rail passenger assignment 2020 scenario 3, passengers per day**

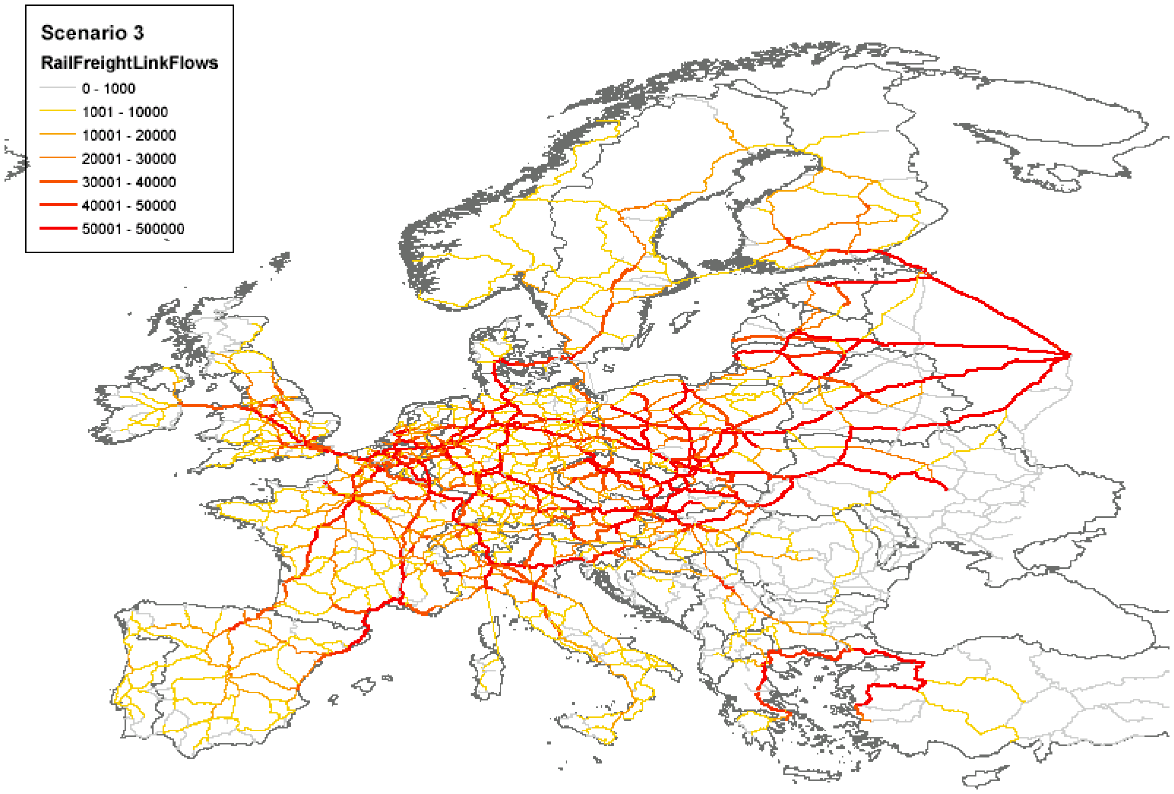

Figure 39: **Rail freight assignment 2020 scenario 3, tonnes per day**

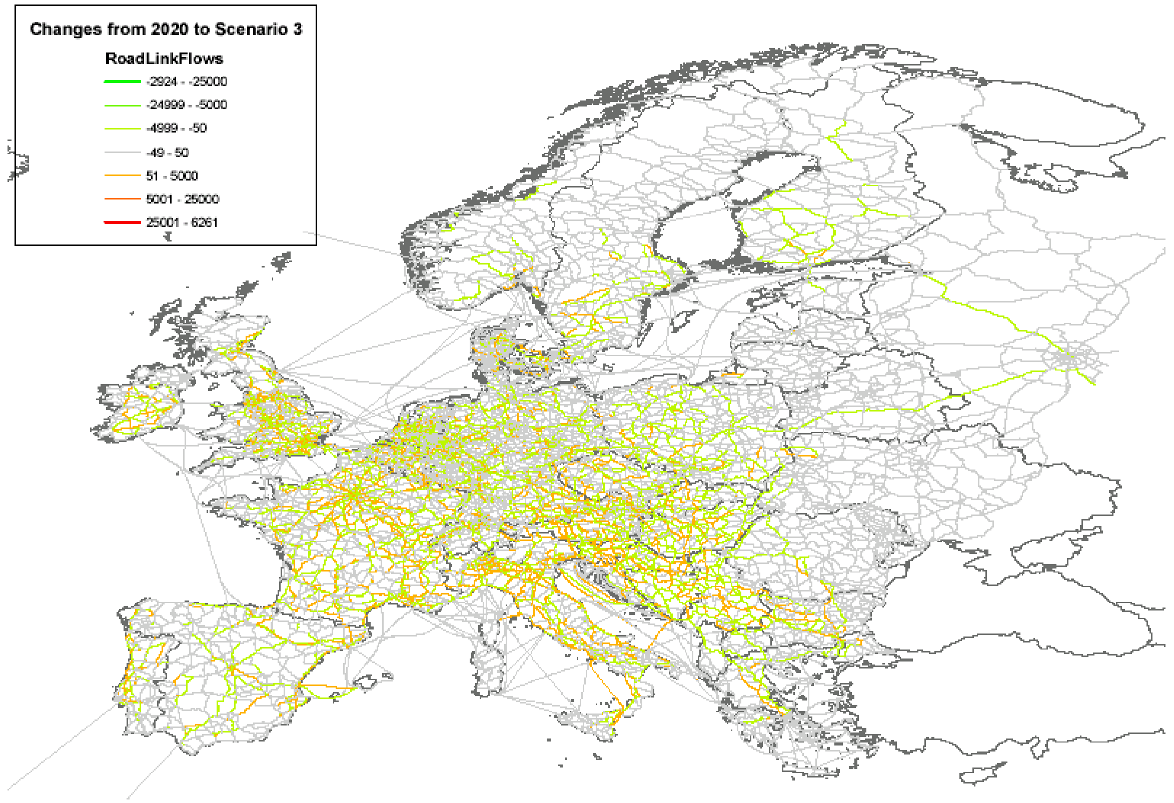

Figure 40: **Road assignment scenario 3 compared to reference 2020, vehicles per day**

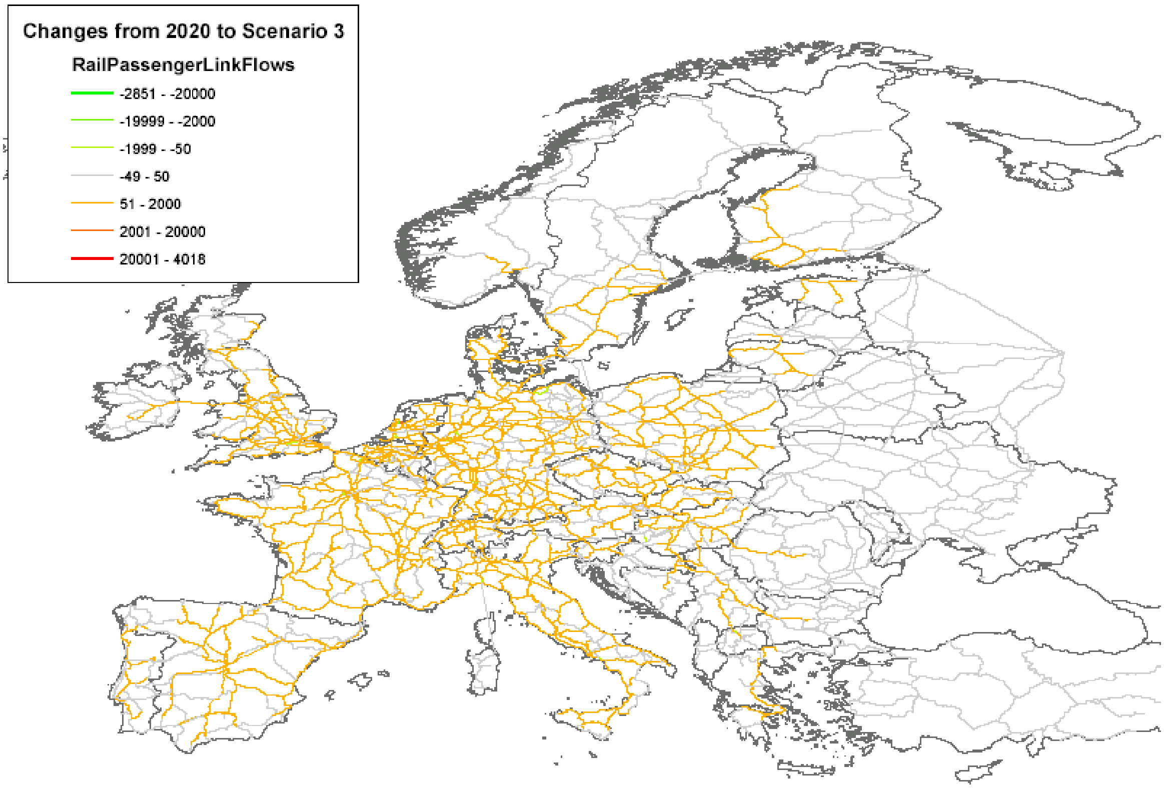

Figure 41: **Rail passenger assignment scenario 3 compared to reference 2020, passengers per day**

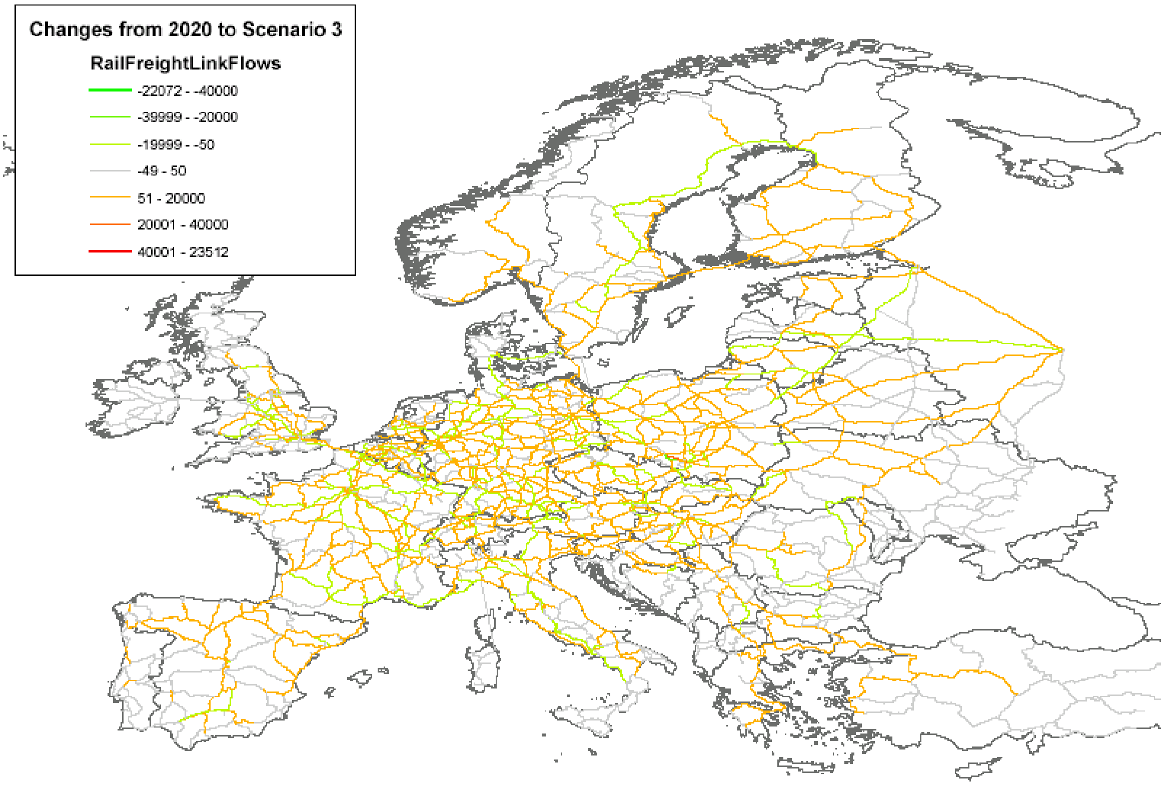

Figure 42: **Rail freight assignment scenario 3 compared to reference 2020, tonnes per day**

8.5.6. Combined scenario

In this Scenario, all above mentioned scenarios are combined. The overall picture illustrated in the flow plots are less road traffic and more rail traffic compared to Reference 2020. In particular, the number of rail passengers is expected to increase significantly in all EU member states. The forecast shows that road traffic on some minor roads, ferry routes, and roads in East Europe increases compared to Reference 2020. It is mainly caused by the road pricing scheme of motorway in EU member states where drivers prefer uncharged roads and ferry routes, and new infrastructure.

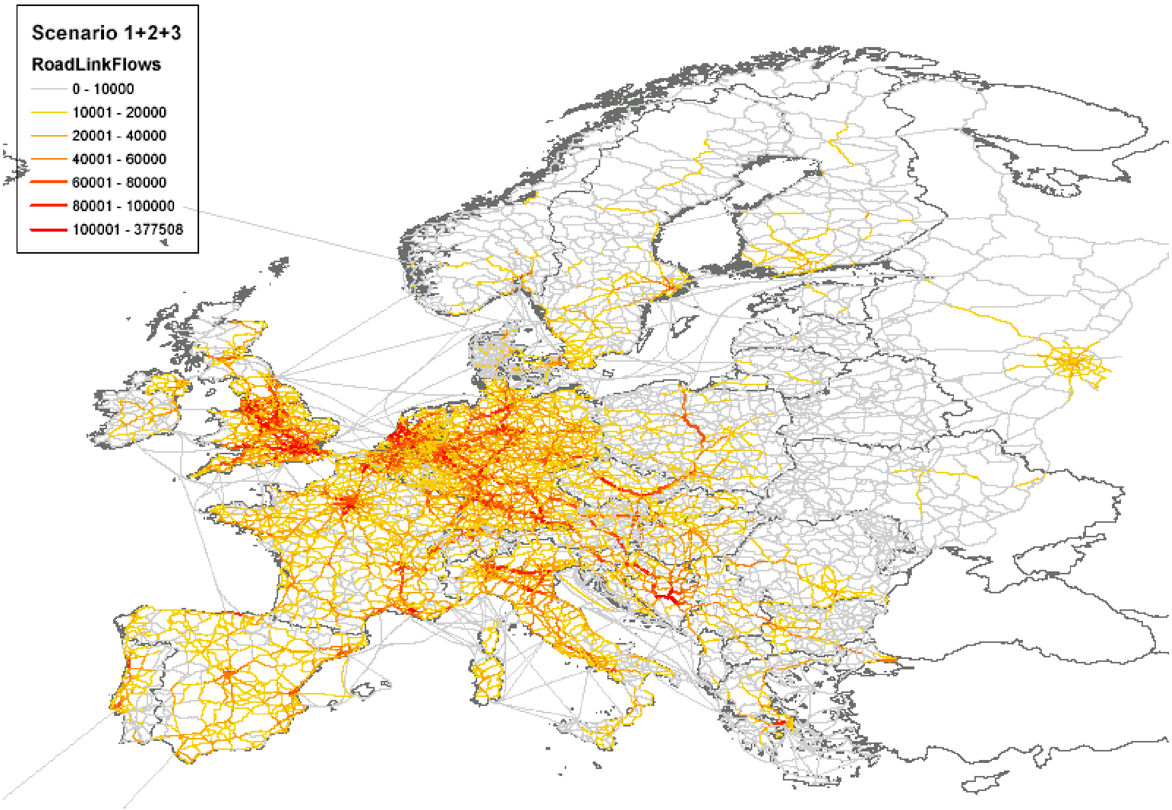

Figure 43: Road assignment 2020 combined scenario, vehicles per day

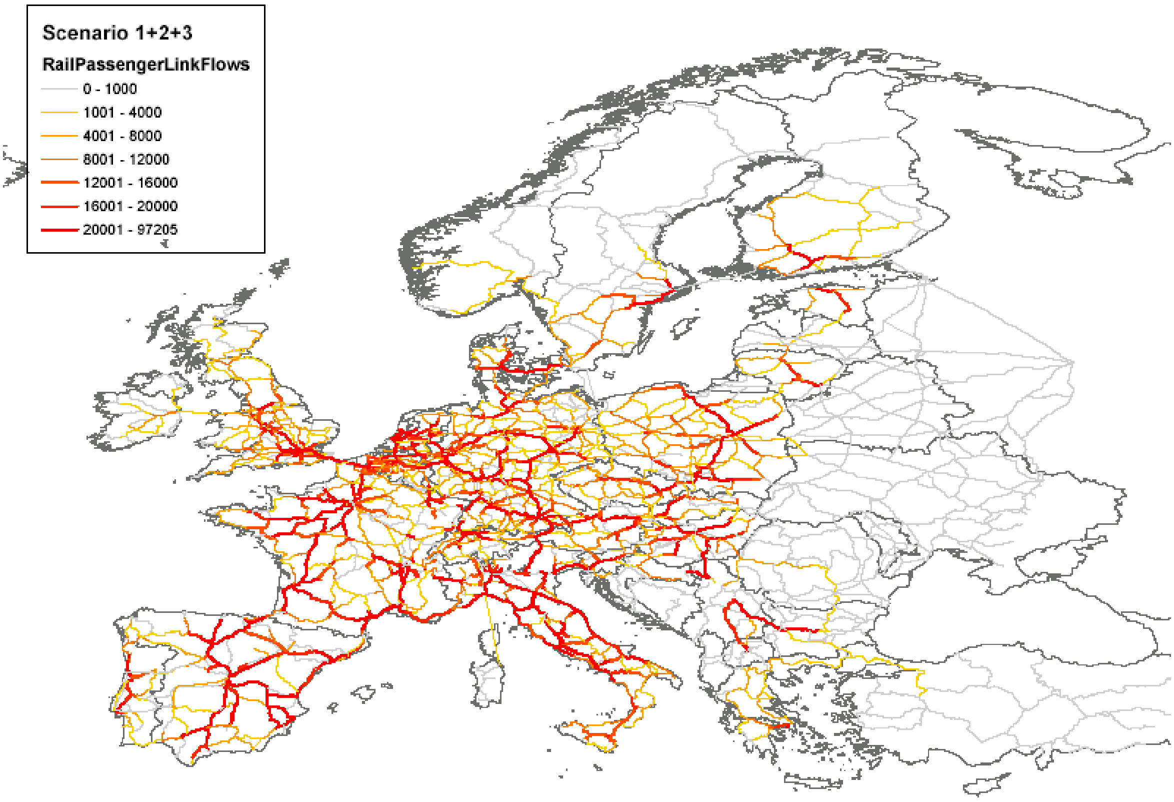

Figure 44: Rail passenger assignment 2020 combined scenario, passengers per day

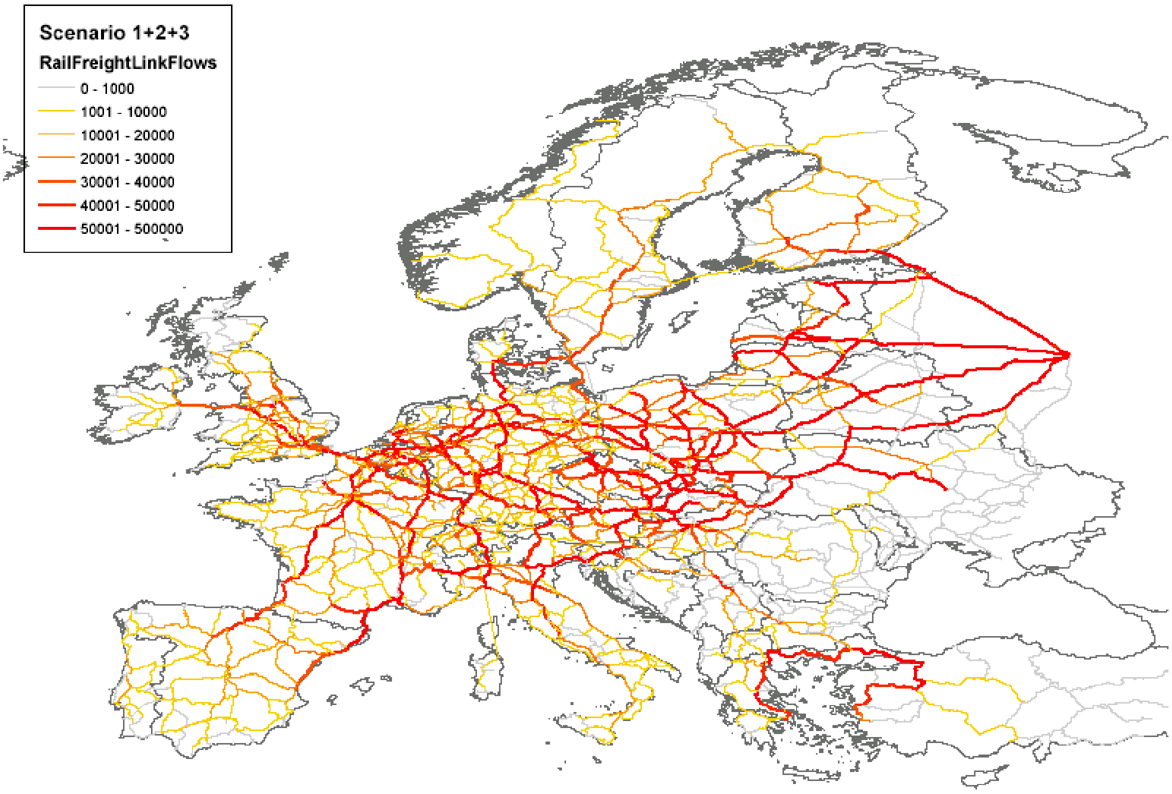

Figure 45: Rail freight assignment 2020 combined scenario, tonnes per day

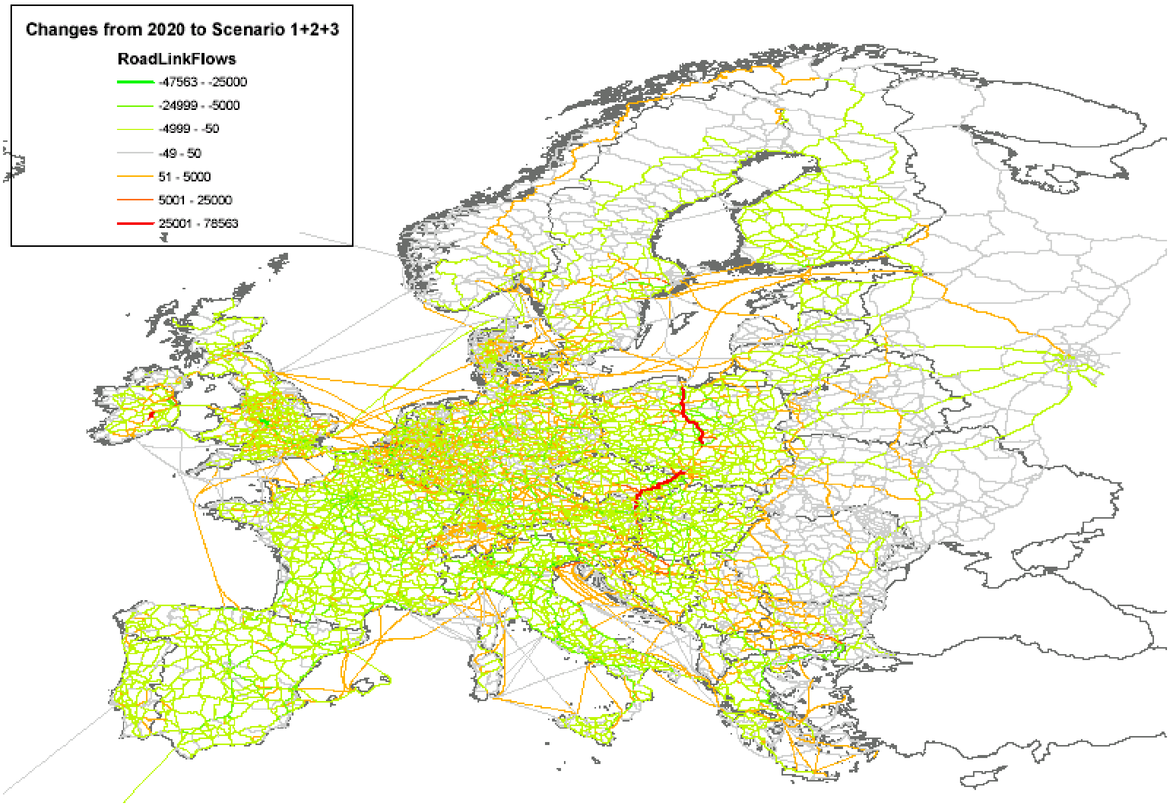

Figure 46: Road assignment combined scenario compared to reference 2020, vehicles per day

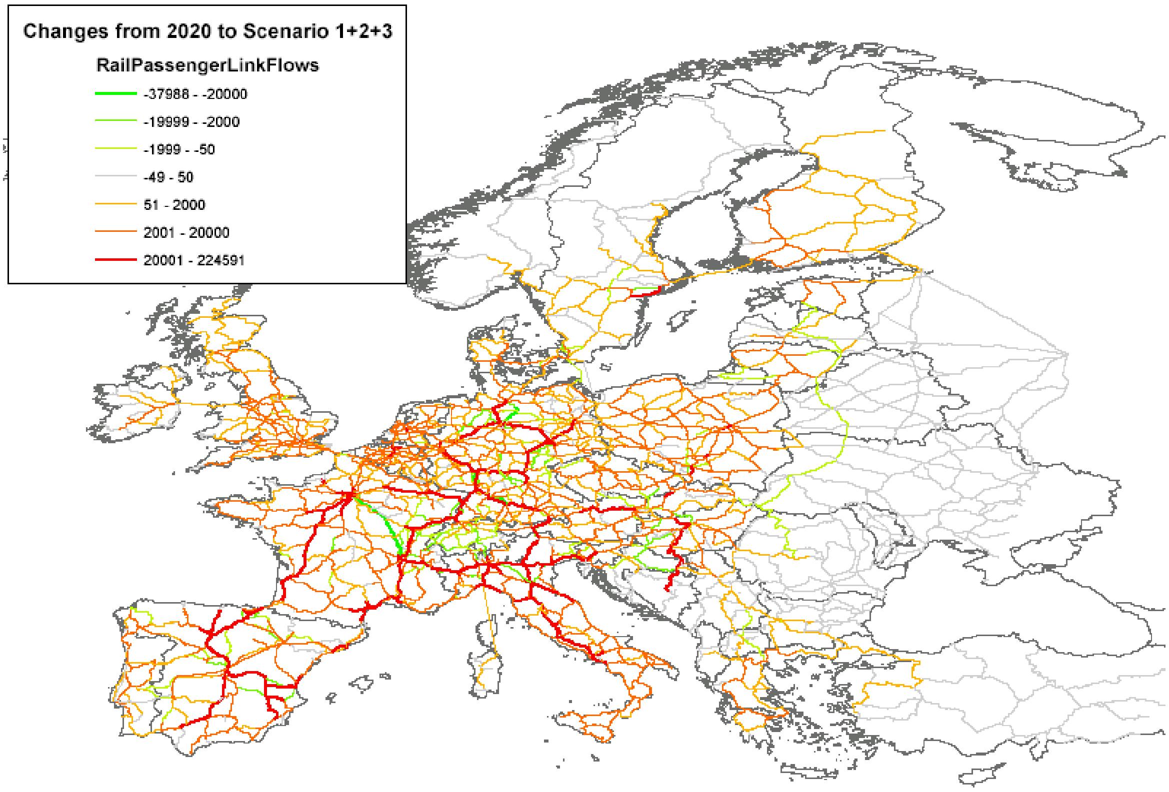

Figure 47: Rail passenger assignment combined scenario compared to reference 2020, passengers per day

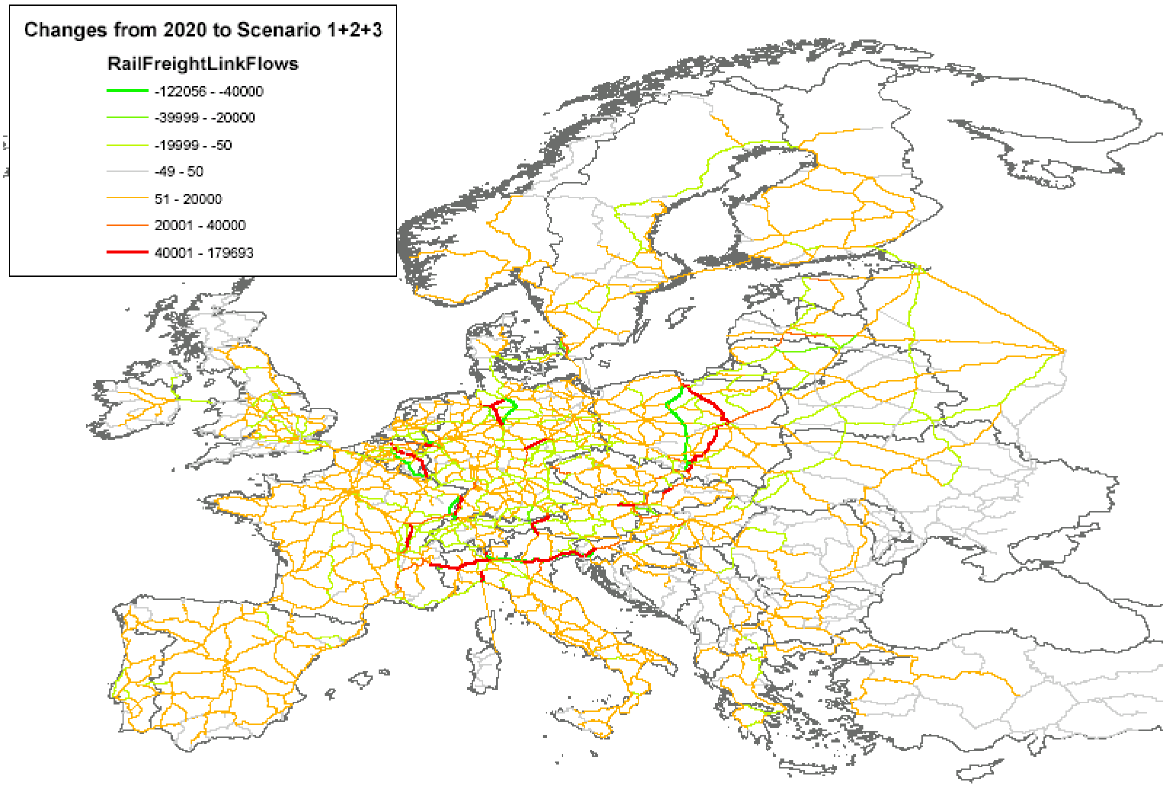

Figure 48: **Rail freight assignment combined scenario compared to reference 2020, tonnes per day**

8.6. Scenario Outcome for the external effects model

In this section the scenario outcome for the external effects model will be given, this will be described for the baseyear and the 5 scenarios elaborated. Two main items of the externalities will be described: CO2 emission and fatalities in road transport.

8.6.1. Baseyear

Accidents

The following table shows the number of fatalities in road transport in the TRANS-TOOL reference scenario and in the DG TREN Transport in figures statistics at the base year (2000).

Table 45: **Fatalities in the TRANS-TOOLS reference scenario and in the DG TREN statistics (road transport, year 2000)**

	Trans-tools reference scenario			DG TREN	Var %
	CAR	HGV	Total		
	A	B	A+B	D	(A-D)/D
Austria	825	200	1025	976	4.8%
Belgium	1253	230	1483	1470	0.9%
Bulgaria	986	43	1029	1012	1.7%
Croatia	619	42	661	655	0.8%
Czech Republic	1418	102	1519	1486	2.2%

Denmark	528	25	553	498	9.9%
Estonia	207	5	212	204	3.9%
Finland	370	36	406	396	2.5%
France	7100	1352	8452	8079	4.4%
Germany	7048	834	7882	7503	4.8%
Greece	1963	151	2114	2037	3.6%
Hungary	1028	161	1189	1200	-0.9%
Ireland	400	22	422	418	0.8%
Italy	6187	428	6615	6649	-0.5%
Latvia	569	12	582	588	-1.1%
Lithuania	641	17	658	641	2.6%
Luxembourg	65	10	75	76	-1.2%
Netherlands	1023	117	1140	1082	5.1%
Norway	325	29	354	341	3.8%
Poland	6118	282	6400	6294	1.7%
Portugal	1655	314	1969	1877	4.7%
Romania	2207	172	2379	2499	-5.0%
Slovak Republic	565	86	651	628	3.5%
Slovenia	293	15	308	313	-1.7%
Spain	4167	1703	5870	5777	1.6%
Sweden	555	29	584	591	-1.2%
Switzerland	515	116	631	592	6.2%
Turkey	6235	11	6247	5510	11.8%
United Kingdom	3766	421	4188	3580	14.5%

The comparison shows in general slight differences, i.e. included in the range of +- 5%. The only exception is for Turkey and the UK, for which the TRANS-TOOLS scenario show higher fatalities, respectively by 11.8% and 14.5%.

With reference to the evaluation of social costs, it should be stressed that the estimation of external costs involves a complex procedure, with a significant number of assumptions and hypothesis. Furthermore, given that an official and transparent procedure for the assessment of external costs is lacking, it is not possible to use standard results as reference values.

Hence, the “validation” of the external costs is always subjected to a certain degree of uncertainty, to the extent that given the lack of official evaluations, the only reasonable step is to compare the TRANS-TOOLS estimates with similar evaluations from other studies.

An example is provided in the table below, comparing the UNITE accounts results, the estimates from INFRAS and the TRANS-TOOLS reference scenario outcomes.

The UNITE pilot accounts[4], have been developed in order to provide accurate information about the social costs (internal and external), benefits and revenues of all transport modes including the underlying economic, financial, environmental and social factors.

The base year of this exercise has been 1998, with un update to 2005. An ongoing project, GRACE, has recently published a report addressing methods for updating the national accounts originally developed in UNITE[5].

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[4] UNITE, “UNIfication of accounts and marginal costs for Transport Efficiency”, Pilot Accounts

The INFRAS study updated to 2000[6] a previous study delivered in 2000 in which costs were estimated at 1995.

Table 46: External costs of accidents in € per 1000 vkm in 2000 (cars)

	Trans-tools	INFRASIWW				UNITE
		Motorway	Interurban	Urban	Average	(Data at 1998)
Austria	115	27	42	54	41	120
Belgium	99	22	69	126	72	108
Denmark	56	12	41	92	48	50
Finland	38	10	33	10	17	32
France	60	15	53	64	44	46
Germany	62	14	56	126	65	51
Ireland	104	22	22	62	35	92
Netherlands	51	12	64	157	77	73
Sweden	36	8	31	20	20	43
Switzerland	83	10	60	61	44	105
United Kingdom	61	15	53	55	41	74

In general, it can be said that the order of magnitude in is the same, taking into account the different hypothesis, e.g.

- the INFRAS/IWW values refer to average data (of motorways, interurban and urban types of road) in medium traffic flows conditions
- the UNITE data are at 1998, and consider the risk value as a component of the external costs
- the TRANS-TOOLS data, similar to the UNITE data also consider the risk value as a component of the external costs, applying cost values from HEATCO.

Emissions

Road transport represents the most important sector that causes high environmental costs, the following table shows the level of road CO2 emissions respectively for TREMOVE[7] and TRANS-TOOL reference scenario at the year 2000.

Table 47: Road CO2 emissions (tonne) by country

Country	**CO2**		
	TREMOVE	**TRANS-TOOLS**	**Var %**
Austria	14.793.036	14.633.872	-1%
Belgium	25.765.220	25.738.082	0%
Czech Republic	11.754.401	9.078.435	-23%
Denmark	12.400.238	9.388.090	-24%
Finland	14.558.638	10.950.524	-25%
France	126.562.185	124.121.229	-2%
Germany	189.293.091	193.261.491	2%
Greece	13.569.396	9.464.078	-30%
Hungary	7.889.003	7.864.884	0%
Ireland	6.144.686	4.081.769	-34%
Italy	131.212.970	86.263.144	-34%
Luxembourg	1.265.749	1.242.950	-2%

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[5] GRACE project (2006) " Generalization of Research on Account and Cost Estimation", in particular the Del 5 "Monitoring pricing policies using accounts"

[6] INFRAS/IWW "External costs of transport", 2004

[7] http://www.tremove.org/

Netherlands	31.277.655	29.092.365	-7%
Norway	10.651.666	8.903.844	14%
Poland	26.901.852	21.433.847	-20%
Portugal	16.807.047	11.730.799	-30%
Slovenia	1.992.610	1.836.541	-8%
Spain	95.572.723	58.101.800	-39%
Sweden	21.544.456	19.140.600	-11%
Switzerland	16.919.003	10.184.041	-29%
United Kingdom	115.129.781	92.736.153	-19%

Differences between two scenarios are rather heterogeneous. The median value of the variation is about -19%, maximum value is reached for Spain (-39%) and positive values have been achieved for Germany and Norway, even if the latter has been calculated by excluding urban network figures.

It is important to highlight that differences in the level of CO2 emissions are highly correlated to the total number of mileages driven as well to the distribution of vehicles-km between the different types of network (urban, non urban and motorway): larger the variation of the traffic volume between scenarios is bigger the variation of the amount of CO2 emitted is. Table shows quite well the sensibility of emissions to the different vehicle-km figures. Some cases, like Czech Republic, find answer for a different repartition of the traffic volume between networks.

Concerning the validation of the external costs, the comparability of the external costs strictly depends on the traffic and emissions figures: multiplying a cost factor for tonne of CO2 emitted external costs are obtained. In this contest, UNITE case studies represent the best study to compare TRANS-TOOL figures since they provide comparable European average shadow values. The table below provides estimates of total external costs due to CO2 emissions for the road sector.

Table 48: External costs of CO2 emissions for road transport

	TRANS-TOOLS	**UNITE**
	MEuro 2000	MEuro 1998
Belgium	540,9	625,09
Finland	230,1	253
Greece	198,9	320
Hungary	165,3	190,8
Italy	1812,5	2323,7
Luxembourg	26,1	36,11
Portugal	246,4	482,7
Sweden	402,2	383

8.6.2. Reference

Accident

In 2020, the implementation of the reference scenario determines an average reduction by 65.7% of the number of fatalities (road transport) compared to the situation at 2000 (TRANS-TOOLS base year).

Table 49: Fatalities in road transport after the TRANS-TOOLS Reference scenario

Country	2000	2020	Var %
Albania	59	89	33.4%
Austria	1025	572	-79.1%
Belarus	193	113	-70.3%
Belgium	1483	517	-186.8%
Bulgaria	1029	987	-4.3%
Croatia	661	694	4.8%
Czech Republic	1519	2070	26.6%
Denmark	553	263	-110.5%
Estonia	212	75	-184.3%
Finland	406	180	-126.2%
France	8444	2881	-193.1%
Germany	7881	3644	-116.3%
Greece	2112	982	-115.1%
Hungary	1190	1379	13.8%
Ireland	422	239	-76.6%
Italy	6612	2988	-121.3%
Latvia	582	152	-281.9%
Lithuania	658	421	-56.2%
Luxembourg	75	41	-84.0%
Macedonia	71	71	0.7%
Moldavia	50	31	-62.7%
Netherlands	1140	565	-101.7%
Norway	354	163	-117.2%
Poland	6400	4713	-35.8%
Portugal	1970	529	-272.2%
Romania	2379	1554	-53.1%
Russia	1646	988	-66.7%
Slovak Republic	651	901	27.8%
Slovenia	308	275	-11.9%
Spain	5873	5225	-12.4%
Sweden	584	268	-117.9%
Switzerland	631	257	-145.1%
Turkey	6247	2753	-126.9%
Ukraine	668	397	-68.4%
United Kingdom	4187	2455	-70.5%
Yugoslavia	356	992	64.2%
Total	68719	41460	-65.7%

The reduction appear to be particularly significant in Belgium, Estonia, France, Portugal and Latvia.

Emissions

At 2020, the implementation of the Reference Scenario involves different performances. Some new accession countries and in general the eastern countries present an increment of CO2 emission levels (Bosnia shows a huge value that it is expected to be an outlier), on the contrary for the central and northern countries a fairly good reduction of the CO2 emissions by road transport compared to the Base Year Reference Scenario has been observed except for. Austria, Ireland and Spain.

Table 50: Road CO2 emissions (tonne) by country after the TRANS-TOOLS Reference Scenario implementation

Country	2000	2020	Var %
Albania	324.255	687.746	112%
Austria	14.633.872	19.657.559	34%
Belarus	1.132.704	1.046.090	-8%
Belgium	25.738.082	22.378.131	-13%
Bulgaria	4.778.371	5.312.661	11%
Croatia	4.916.628	8.095.619	65%
Czech Republic	9.078.435	10.557.539	16%
Denmark	9.388.090	8.077.985	-14%
Estonia	961.584	751.177	-22%
Finland	10.950.524	9.358.581	-15%
France	124.121.229	122.767.970	-1%
Germany	193.261.491	188.945.262	-2%
Greece	9.464.078	9.141.780	-3%
Hungary	7.864.884	13.858.995	76%
Ireland	4.081.769	4.318.190	6%
Italy	86.263.144	84.572.194	-2%
Latvia	1.481.838	1.244.844	-16%
Lithuania	2.300.860	2.045.745	-11%
Luxembourg	1.242.950	1.207.141	-3%
Macedonia	406.296	769.048	89%
Moldavia	349.501	311.671	-11%
Netherlands	29.092.365	28.184.607	-3%
Norway	8.903.844	7.942.343	-11%
Poland	21.433.847	26.365.271	23%
Portugal	11.730.799	11.364.902	-3%
Romania	7.926.369	6.635.914	-16%
Russia	10.610.890	8.240.619	-22%
Slovak Republic	7.153.658	7.965.264	11%
Slovenia	1.836.541	3.308.809	80%
Spain	58.101.800	60.861.488	5%
Sweden	19.140.600	16.553.047	-14%
Switzerland	10.184.041	10.255.043	1%
Turkey	1.974.397	2.045.679	4%
Ukraine	3.864.437	3.292.581	-15%
United Kingdom	92.736.153	90.280.533	-3%
Yugoslavia	2.072.761	5.846.142	182%

8.6.3. Scenario1

Accident

In 2020, the implementation of the Scenario 1 (infrastructure and intermodality) determines an average reduction by 67 % of the number of fatalities (road transport) compared to the situation at 2000 (TRANS-TOOLS base year).

Table 51: Fatalities in road transport after the TRANS-TOOLS Scenario 1 implementation

Country	2000	2020	Var %
Albania	59	89	33.4%
Austria	1025	576	-77.8%
Belarus	193	113	-70.9%
Belgium	1483	517	-186.7%
Bosnia	88	1038	91.5%
Bulgaria	1029	985	-4.5%
Croatia	661	705	6.3%

Czech Republic	1519	2007	24.3%
Denmark	553	266	-107.7%
Estonia	212	74	-186.0%
Finland	406	175	-131.8%
France	8444	2865	-194.7%
Germany	7881	3637	-116.7%
Greece	2112	983	-114.9%
Hungary	1190	1360	12.5%
Ireland	422	240	-75.9%
Italy	6612	3019	-119.0%
Latvia	582	152	-283.0%
Lithuania	658	416	-58.3%
Luxembourg	75	41	-84.4%
Macedonia	71	71	0.3%
Moldavia	50	30	-65.2%
Netherlands	1140	565	-101.7%
Norway	354	164	-116.3%
Poland	6400	4491	-42.5%
Portugal	1970	528	-272.9%
Romania	2379	1541	-54.3%
Russia	1646	992	-66.0%
Slovak Republic	651	831	21.7%
Slovenia	308	278	-10.8%
Spain	5873	5208	-12.8%
Sweden	584	268	-117.6%
Switzerland	631	256	-146.1%
Turkey	6247	2756	-126.7%
Ukraine	668	393	-70.0%
United Kingdom	4187	2455	-70.6%
Yugoslavia	356	980	63.7%
Total	68719	41066	-67.3%

The reduction appears to be evenly spread across the countries, with the exception of the Eastern countries, e.g. Slovak Republic, the Czech Republic, Hungary, etc which show increasing trends in road fatalities.

Emissions

Running the Scenario 1, in 2020 an overall decrease of the CO2 emission levels compared to 2000 Reference Scenario has been achieved. On average, reduction of CO2 emissions by road transport is about 22%: the highest values are obtained for Albania, whereas the minimum decrement is equal to 11% for Belgium and Spain.

Table 52: Road CO2 emissions (tonne) by country after the TRANS-TOOLS Scenario 1 implementation

Country	2000	2020	Var %
Albania	324.255	212.531	-34%
Austria	14.633.872	12.490.122	-15%
Belarus	1.132.704	841.107	-26%
Belgium	25.738.082	22.813.854	-11%
Bulgaria	4.778.371	3.404.945	-29%
Croatia	4.916.628	3.502.580	-29%

Czech Republic	9.078.435	7.250.932	-20%
Denmark	9.388.090	7.743.219	-18%
Estonia	961.584	656.752	-32%
Finland	10.950.524	8.490.733	-22%
France	124.121.229	108.839.177	-12%
Germany	193.261.491	167.262.460	-13%
Greece	9.464.078	8.182.874	-14%
Hungary	7.864.884	6.431.045	-18%
Ireland	4.081.769	3.163.541	-22%
Italy	86.263.144	75.959.578	-12%
Latvia	1.481.838	1.045.912	-29%
Lithuania	2.300.860	1.661.738	-28%
Luxembourg	1.242.950	1.038.451	-16%
Macedonia	406.296	293.305	-28%
Moldavia	349.501	250.654	-28%
Netherlands	29.092.365	25.523.326	-12%
Norway	8.903.844	6.818.998	-23%
Poland	21.433.847	15.803.282	-26%
Portugal	11.730.799	10.287.512	-12%
Romania	7.926.369	5.768.827	-27%
Russia	10.610.890	7.857.672	-26%
Slovak Republic	7.153.658	5.234.101	-27%
Slovenia	1.836.541	1.509.490	-18%
Spain	58.101.800	51.482.376	-11%
Sweden	19.140.600	14.795.781	-23%
Switzerland	10.184.041	8.800.206	-14%
Turkey	1.974.397	1.742.748	-12%
Ukraine	3.864.437	2.900.035	-25%
United Kingdom	92.736.153	80.439.371	-13%
Yugoslavia	2.072.761	1.355.602	-35%

8.6.4. Scenario2

In 2020, the implementation of the Scenario 2 (Pricing in road transport) determines an average reduction by 73.5 % of the number of fatalities (road transport) compared to the situation at 2000 (TRANS-TOOLS base year).

Table 53: Fatalities in road transport after the TRANS-TOOLS Scenario 2 implementation

Country	2000	2020	Var %
Albania	59	83	28.4%
Austria	1025	527	-94.3%
Belarus	193	114	-69.7%
Belgium	1483	495	-199.8%
Bulgaria	1029	1124	8.4%
Croatia	661	691	4.4%
Czech Republic	1519	1976	23.1%
Denmark	553	260	-112.7%
Estonia	212	69	-209.2%
Finland	406	169	-140.6%
France	8444	2666	-216.7%
Germany	7881	3552	-121.9%
Greece	2112	862	-145.1%
Hungary	1190	1230	3.3%
Ireland	422	231	-82.3%
Italy	6612	2661	-148.4%
Latvia	582	149	-290.7%

Lithuania	658	400	-64.5%
Luxembourg	75	37	-101.9%
Macedonia	71	57	-23.3%
Moldavia	50	29	-72.8%
Netherlands	1140	558	-104.2%
Norway	354	164	-115.9%
Poland	6400	4323	-48.0%
Portugal	1970	518	-280.3%
Romania	2379	1578	-50.8%
Russia	1646	978	-68.3%
Slovak Republic	651	851	23.5%
Slovenia	308	268	-14.8%
Spain	5873	4975	-18.0%
Sweden	584	265	-120.6%
Switzerland	631	268	-135.5%
Turkey	6247	2620	-138.4%
Ukraine	668	420	-59.0%
United Kingdom	4187	2448	-71.0%
Yugoslavia	356	1007	64.7%
Total	68719	39606	-73.5%

In general, the eastern countries, e.g. Albania, Hungary, the Czech Republic and the Slovak Republic show an increase in road fatalities.

Emissions

At 2020, the implementation of the Scenario 2 implies diverse situations: about 21 countries show a more or less reduction of CO2 emissions by road transport, the remaining countries present positive values; except some cases, it has been observed a substantial increment.

Table 54: Road CO2 emissions (tonne) by country after the TRANS-TOOLS Scenario 2 implementation

Country	2000	2020	Var %
Albania	324.255	658.478	103%
Austria	14.633.872	17.970.402	23%
Belarus	1.132.704	918.201	-19%
Belgium	25.738.082	21.390.154	-17%
Bulgaria	4.778.371	5.936.629	24%
Croatia	4.916.628	8.168.775	66%
Czech Republic	9.078.435	9.722.299	7%
Denmark	9.388.090	7.789.935	-17%
Estonia	961.584	687.764	-28%
Finland	10.950.524	8.789.411	-20%
France	124.121.229	112.637.500	-9%
Germany	193.261.491	183.316.557	-5%
Greece	9.464.078	7.405.923	-22%
Hungary	7.864.884	12.498.158	59%
Ireland	4.081.769	4.187.835	3%
Italy	86.263.144	74.330.358	-14%
Latvia	1.481.838	1.161.193	-22%
Lithuania	2.300.860	1.948.354	-15%
Luxembourg	1.242.950	1.022.434	-18%
Macedonia	406.296	572.331	41%
Moldavia	349.501	252.638	-28%
Netherlands	29.092.365	27.585.200	-5%
Norway	8.903.844	7.960.492	-11%
Poland	21.433.847	22.823.059	6%

Portugal	11.730.799	11.108.817	-5%
Romania	7.926.369	6.896.353	-13%
Russia	10.610.890	7.999.633	-25%
Slovak Republic	7.153.658	7.373.204	3%
Slovenia	1.836.541	2.997.659	63%
Spain	58.101.800	58.195.424	0%
Sweden	19.140.600	16.312.072	-15%
Switzerland	10.184.041	10.733.336	5%
Turkey	1.974.397	1.992.688	1%
Ukraine	3.864.437	3.616.575	-6%
United Kingdom	92.736.153	89.609.496	-3%
Yugoslavia	2.072.761	6.051.922	192%

8.6.5. Scenario3

Accident

In 2020, the implementation of the Scenario 3 (improving competition through market liberalization) determines an average reduction by 66% of the number of fatalities (road transport) compared to the situation at 2000 (TRANS-TOOLS base year).

Table 55: Fatalities in road transport after the TRANS-TOOLS Scenario 3 implementation

Country	2000	2020	Var %
Albania	59	88	32.9%
Austria	1025	571	-79.3%
Belarus	193	113	-71.3%
Belgium	1483	517	-186.8%
Bulgaria	1029	985	-4.5%
Croatia	661	692	4.6%
Czech Republic	1519	2067	26.5%
Denmark	553	263	-110.6%
Estonia	212	75	-184.7%
Finland	406	179	-126.7%
France	8444	2882	-193.0%
Germany	7881	3641	-116.5%
Greece	2112	980	-115.6%
Hungary	1190	1378	13.7%
Ireland	422	239	-76.7%
Italy	6612	2991	-121.1%
Latvia	582	152	-281.8%
Lithuania	658	421	-56.3%
Luxembourg	75	41	-84.0%
Macedonia	71	70	-0.6%
Moldavia	50	31	-62.8%
Netherlands	1140	565	-101.8%
Norway	354	163	-117.6%
Poland	6400	4703	-36.1%
Portugal	1970	529	-272.6%
Romania	2379	1552	-53.3%
Russia	1646	987	-66.8%
Slovak Republic	651	900	27.7%
Slovenia	308	274	-12.3%
Spain	5873	5219	-12.5%
Sweden	584	268	-118.1%

Switzerland	631	257	-145.2%
Turkey	6247	2749	-127.2%
Ukraine	668	396	-68.7%
United Kingdom	4187	2455	-70.6%
Yugoslavia	356	986	63.9%
Total	68719	41407	-66.0%

Emissions

The implementation of the Scenario 3 involves different performances. In general, the eastern countries present increasing CO2 emission levels, on the contrary for the central and northern Europe a fairly good reduction of the CO2 emissions by road transport compared to the Base Year Reference Scenario has been observed.

Table 56: Road CO2 emissions (tonne) by country after the TRANS-TOOLS Scenario 3 implementation

Country	2000	2020	Var %
Albania	324.255	682.965	111%
Austria	14.633.872	19.585.801	34%
Belarus	1.132.704	1.032.887	-9%
Belgium	25.738.082	22.357.287	-13%
Bulgaria	4.778.371	5.304.521	11%
Croatia	4.916.628	8.071.596	64%
Czech Republic	9.078.435	10.522.562	16%
Denmark	9.388.090	8.072.692	-14%
Estonia	961.584	748.921	-22%
Finland	10.950.524	9.328.009	-15%
France	124.121.229	122.548.908	-1%
Germany	193.261.491	188.692.938	-2%
Greece	9.464.078	9.101.319	-4%
Hungary	7.864.884	13.830.174	76%
Ireland	4.081.769	4.315.280	6%
Italy	86.263.144	84.484.655	-2%
Latvia	1.481.838	1.244.457	-16%
Lithuania	2.300.860	2.046.974	-11%
Luxembourg	1.242.950	1.209.151	-3%
Macedonia	406.296	759.233	87%
Moldavia	349.501	311.161	-11%
Netherlands	29.092.365	28.163.447	-3%
Norway	8.903.844	7.929.047	-11%
Poland	21.433.847	26.234.790	22%
Portugal	11.730.799	11.353.076	-3%
Romania	7.926.369	6.624.284	-16%
Russia	10.610.890	8.213.314	-23%
Slovak Republic	7.153.658	7.938.615	11%
Slovenia	1.836.541	3.293.601	79%
Spain	58.101.800	60.801.808	5%
Sweden	19.140.600	16.531.327	-14%
Switzerland	10.184.041	10.239.325	1%
Turkey	1.974.397	2.043.044	3%
Ukraine	3.864.437	3.280.054	-15%
United Kingdom	92.736.153	90.243.460	-3%
Yugoslavia	2.072.761	5.812.704	180%

8.6.6. Combined scenario

Accident

In 2020, the implementation of the combined Scenario (a combination of the scenarios 1, 2 and 3) determines an average reduction by 76% of the number of fatalities (road transport) compared to the situation at 2000 (TRANS-TOOLS base year).

Table 57: Fatalities in road transport after the TRANS-TOOLS Combined Scenario implementation

Country	2000	2020	Var %
Albania	59	84	29.5%
Austria	1025	530	-93.2%
Belarus	193	111	-74.7%
Belgium	1483	494	-200.0%
Bulgaria	1029	1049	1.9%
Croatia	661	704	6.1%
Czech Republic	1519	1930	21.3%
Denmark	553	260	-112.8%
Estonia	212	68	-212.8%
Finland	406	164	-146.9%
France	8444	2645	-219.2%
Germany	7881	3529	-123.4%
Greece	2112	871	-142.5%
Hungary	1190	1217	2.3%
Ireland	422	231	-82.8%
Italy	6612	2629	-151.5%
Latvia	582	149	-291.3%
Lithuania	658	395	-66.3%
Luxembourg	75	37	-102.3%
Macedonia	71	62	-13.7%
Moldavia	50	30	-66.5%
Netherlands	1140	558	-104.5%
Norway	354	164	-116.0%
Poland	6400	4081	-56.8%
Portugal	1970	515	-282.6%
Romania	2379	1565	-52.0%
Russia	1646	979	-68.1%
Slovak Republic	651	794	18.1%
Slovenia	308	268	-14.7%
Spain	5873	4845	-21.2%
Sweden	584	263	-122.2%
Switzerland	631	265	-137.8%
Turkey	6247	2708	-130.6%
Ukraine	668	405	-65.0%
United Kingdom	4187	2437	-71.8%
Yugoslavia	356	976	63.5%
Total	68719	39006	-76.2%

The table shows that in some countries the risk of fatality may increase, due probably to the forecasted increase of road mileage.

Emissions

At 2020, the implementation of the Combined Scenario (1, 2 and 3) implies a general reduction of the CO2 emissions by road transport compared to the Base Year Reference Scenario for the central and northern countries (just Austria and Switzerland show positive values) whereas for eastern countries an increasing level of CO2 has been observed except for Romania and Moldavia. On average it has been noted an overall increase of 43%.

Table 58: Road CO2 emissions (tonne) by country after the TRANS-TOOLS Combined Scenario implementation

Country	2000	2020	Var %
Albania	324.255	663.811	105%
Austria	14.633.872	18.597.857	27%
Belarus	1.132.704	906.292	-20%
Belgium	25.738.082	21.384.930	-17%
Bulgaria	4.778.371	5.553.564	16%
Croatia	4.916.628	8.411.124	71%
Czech Republic	9.078.435	9.916.631	9%
Denmark	9.388.090	7.796.486	-17%
Estonia	961.584	680.982	-29%
Finland	10.950.524	8.797.059	-20%
France	124.121.229	112.166.769	-10%
Germany	193.261.491	181.975.910	-6%
Greece	9.464.078	7.332.048	-23%
Hungary	7.864.884	12.425.857	58%
Ireland	4.081.769	4.081.752	0%
Italy	86.263.144	73.739.179	-15%
Latvia	1.481.838	1.158.589	-22%
Lithuania	2.300.860	1.906.643	-17%
Luxembourg	1.242.950	1.021.245	-18%
Macedonia	406.296	641.481	58%
Moldavia	349.501	289.990	-17%
Netherlands	29.092.365	27.559.070	-5%
Norway	8.903.844	7.958.281	-11%
Poland	21.433.847	21.221.965	-1%
Portugal	11.730.799	11.051.323	-6%
Romania	7.926.369	6.564.682	-17%
Russia	10.610.890	8.048.763	-24%
Slovak Republic	7.153.658	7.007.440	-2%
Slovenia	1.836.541	2.966.061	62%
Spain	58.101.800	56.614.329	-3%
Sweden	19.140.600	16.302.950	-15%
Switzerland	10.184.041	10.651.570	5%
Turkey	1.974.397	2.022.634	2%
Ukraine	3.864.437	3.299.499	-15%
United Kingdom	92.736.153	89.101.336	-4%
Yugoslavia	2.072.761	5.827.641	181%

9. POLICY VALIDATION

The objective of the simulation tests of the specific policy measures was to demonstrate the applicability of TRANS-TOOLS in transport policy impact assessment. Even though the input for the scenarios is based on past studies and can be considered as realistic, it is still not detailed enough for it to be suitable for a complete impact assessment. In addition, since no information on the implementation cost was available, the scenarios are not directly comparable. The scenarios and the analysis are however very useful in determining whether the model is suitable for impact assessments of this type, as well as the additional inputs, assumptions and improvements that would be necessary in order to do so.

The development of TRANS-TOOLS had the clear goal of delivering a transport network model that would be useful for policy makers at European level mainly, extendable to analyses at other geographic levels. A first step in the assessment is therefore the identification of its capabilities as a policy support tool. Even though the scenarios tested can be considered to be limited in number, they are sufficient to allow some main conclusions to be drawn.

9.1. Reference 2000 scenario

The Reference 2000 scenario of TRANS-TOOLS mainly serves for the validation of the model results and their consistency with data and other models used for policy support. The model results have a high correlation with the data it was calibrated on, but there are some differences with that of other models. As explained in chapter 2, an important difference is the fact that the underlying variables modelled by the various models are different. The fact that TRANS-TOOLS doesn't model intra-NUTS3 traffic is also a limiting factor for comparisons or policy analysis.

Nevertheless, taking these differences into account allows some conclusions to be drawn. There is a very good match for non-urban passenger rail in TREMOVE with TRANS-TOOLS passenger rail volumes. The total passenger rail volume in TREMOVE is different than the one in ASSESS or PRIMES, but still within a logical distance (299 to 351/361). All three cover all types of rail, including trams and metro, so the main reason for any difference is the lack of NUTS3 traffic in TRANS-TOOLS. One way around the problem until such traffic is included in TRANS-TOOLS is the application of the growth rates of the TREMOVE scenario results on the part that corresponds to urban rail, based on the TREMOVE totals.

In freight transport TRANS-TOOLS gives a much higher projection for total volumes, and especially rail freight, than the other models but is in line with the Statistical Pocketbook. The issue of not including intra-NUTS3 traffic in TRANS-TOOLS is not really a problem in this case, since the majority of rail freight traffic consists of inter-NUTS3 traffic.

The GDP and population assumptions used in TRANS-TOOLS are the ones also used in ASSESS and PRIMES. Any differences in transport intensity and generated traffic would need to be traced to the demand models used in each model. Taking into account the absence of intra-NUTS3 traffic, trip generation rates shouldn't have significant differences with those in other models.

The current Reference year 2000 scenario of TRANS-TOOLS can be used as a baseline reference, but one has to always take into account the definition of the variables it models, especially as regards the zonal coverage. In order for the model to give a complete picture of the situation in the EU, it is important that this issue is resolved in one of the next TRANS-TOOLS versions.

Table 59: Comparison of modelled year 2000 passenger transport volumes (EU-15, billion passengerkilometres)

Year 2000	*Model version/ scenario code*	*Air*	*Rail*	*Road*	*Total*	*Share road in total*
Reference 2000		201	185	2044	2430	84%
TRANS-TOOLS baseline 2000	2000_r_JRC	202	185	2043	2430	84%
TREMOVE baseline 2000	TREMOVE BC v2.52	284	299	3962	4545	87%
TREMOVE baseline 2000 non-urban	TREMOVE BC v2.52	284	186	2983	3453	86%
PRIMES		423	361	3861	4645	83%
ASSESS		422	351	4094	4867	84%

Table 60: Comparison of modelled year 2000 freight transport volumes (EU-15, billion tonne-kilometres)

Year 2000	*Model version/ scenario code*	*Short-Sea*	*Rail*	*Road*	*IWW*	*Total surface*	*All modes*	*Share road in surface*	*Share road in total*
Reference 2000		1016	349	1675	228	2252	3269	74.4%	51.2%
TRANS-TOOLS baseline 2000	2000_r_JRC	1069	352	1635	215	2202	3271	74.3%	50.0%
TREMOVE baseline 2000	TREMOVE BC v2.52		250	1468	127	1845		79.6%	
TREMOVE baseline 2000 non-urban	TREMOVE BC v2.52		250	1438	127	1815		79.2%	
PRIMES			249	1317	266	1832		71.9%	
ASSESS		1269	250	1319	121	1690	2959	78.0%	44.6%

9.2. Reference 2020 scenario

As regards the general trends in the transport sector, the reference scenario confirms the projections from other models (PRIMES, TREMOVE, SCENES, ASTRA and POLES) and is in line with the forecast of the White Paper on the Common Transport Policy. More specifically, the TRANS-TOOLS reference scenario expects an overall growth of 50% in freight transport activity and 18% in passenger transport activity for the period 2000-2020. As regards modal shift, a marginal increase of the share of rail at the cost of road is expected in freight, while both air and rail are expected to show modest gains in share compared to road.

The GDP growth rates used as input in TRANS-TOOLS are the same as the ones used in the forecasts for transport activity by the European Commission. The fact that the resulting projections of transport activity are also similar suggests that the underlying trip generation rates and transport intensities are of comparable levels. It also implies that the link between economy and transport is modelled in a consistent way. This permits comparability with past official projections and will allow continuity in the analysis of impacts using TRANS-TOOLS in the future.

Table 61: Comparison of modelled year 2020 passenger transport volumes (EU-15, billion pass*kms)

Year 2020	***Model version/ scenario code***	***Air***	***Rail***	***Road***	***Total***	***Share road in total***
TRANS-TOOLS baseline 2020	2020_r_JRC	252	206	2304	2761	83%
TREMOVE baseline 2020	TREMOVE BC v2.52	586	368	5231	6185	85%
TREMOVE baseline 2020 non-urban	TREMOVE BC v2.52	586	227	3892	4705	83%
PRIMES		811	478	5083	6372	80%
ASSESS		861	429	5388	6678	81%

Table 62: Comparison of modelled growth rates 2000-2020 for passenger transport volumes (EU-15)

Growth 2000-2020	***Model version/ scenario code***	***Air***	***Rail***	***Road***	***Total***	***Share road in total***
TRANS-TOOLS baseline 2020	2020_r_JRC	25%	11%	13%	14%	-1%
TREMOVE baseline 2020	TREMOVE BC v2.52	106%	23%	32%	36%	-3%
TREMOVE baseline 2020 non-urban	TREMOVE BC v2.52	106%	22%	30%	36%	-4%
PRIMES		92%	32%	32%	37%	-3%
ASSESS		104%	22%	32%	37%	-3%

Table 63: Comparison of modelled year 2020 freight transport volumes (EU-15, billion tonne-kilometres)

Year 2020	***Model version/ scenario code***	***Short-Sea***	***Rail***	***Road***	***IWW***	***Total surface***	***All modes***	***Share road in surface***	***Share road in total***
TRANS-TOOLS baseline 2020	2020_r_JRC	1757	587	2246	305	3137	4894	71.6%	45.9%
TREMOVE baseline 2020	TREMOVE BC v2.52		273	2163	157	2593		83.4%	
TREMOVE baseline 2020 non-urban	TREMOVE BC v2.52		273	2135	157	2565		83.2%	
PRIMES			300	1919	309	2528		75.9%	
ASSESS		2010	280	1907	164	2351	4361	81.1%	43.7%

Table 64: Comparison of modelled growth rates 2000-2020 for freight transport volumes (EU-15)

Growth 2000-2020	*Model version/ scenario code*	*Short-Sea*	*Rail*	*Road*	*IWW*	*Total surface*	*All modes*	*Share road in surface*	*Share road in total*
TRANS-TOOLS baseline 2020	2020_r_JRC	64%	67%	37%	41%	42%	50%	-3%	-5%
TREMOVE baseline 2020	TREMOVE BC v2.52		9%	47%	24%	41%		4%	
TREMOVE baseline 2020 non-urban	TREMOVE BC v2.52		9%	48%	24%	41%		4%	
PRIMES			20%	46%	16%	38%		4%	
ASSESS		58%	12%	45%	36%	39%	47%	3%	-1%

As the following table shows, the increase in total tons lifted between 2000 and 2020 is 48.5%, slightly lower than the increase in tonne-kilometres in the same period (50%). This means that the average distances of transport, and subsequently the transport intensity of the economy, are expected to increase. This increase comes mainly from road and rail, which increase their average distance by 19% and 18% respectively. On the other hand, short-sea and inland waterways demonstrate a marginal decrease in their average distance. For short sea, taking into account that its share of the total increases, this probably means that its competitive position against rail and road improves and can attract shorter trips that in year 2000 would have preferred other modes. But in the case of inland waterways it is probably the opposite, since it grows slower than the rest and also loses part of the longer distance trips to the other modes. The change in tons lifted confirms the modal shift indicated by the changes in tonne-kilometres. There is a small decrease in the share of road transport that benefits mainly rail and short-sea shipping.

As a result of the shift away from road transport, the growth of rail freight volumes between 2000 and 2020 is expected to be 67%, significantly higher than the average growth of 42% foreseen for all surface modes. The shift to rail freight foreseen by TRANS-TOOLS is higher than that foreseen by the other models but can be justified by the multi-modal assignment applied in TRANS-TOOLS as opposed to the rather low elasticities of substitution used by the other models. Even though in absolute terms the loss for road transport is not significant, since rail freight has a much lower initial level the resulting percentage growth is high.

Table 65: Growth in tons lifted, EU-27, 2000-2020

Mode	Change 2000-2020
Short-sea	62.6%
Rail	79.2%
Road	44.1%
IWW	40.1%
Total	**48.5%**

The growth in passenger trips is much lower, and consistent with the lower increase expected in passenger-kilometres. As in freight transport, the average trip distance is expected to increase, as a result of the increase in road trip distances. The growth in air transport is surprisingly expected to be lower than what projections from the airlines and aircraft manufacturers suggest. A main reason for this is the fact that TRANS-TOOLS only cover intra-EU trips at this stage, and the markets where stronger growth is expected (e.g. EU- Asia, EU-South America) are not included. Even so though, the expected growth for this market segment seems too low, especially if one considers that the model predicts that average air trip distances will fall, implying that more short flights are expected.

Table 66: Growth in passenger trips, EU-27, 2000-2020

Mode	**Change 2000-2020**
Air	28.6%
Rail	13.5%
Road	9.7%
Total	**10.3%**

As discussed in the previous chapter, the GDP growth rates for the reference scenario in 2020 have been defined exogenously as an assumption. The results of the economic module therefore only reproduce the regional distribution of GDP and are not related in this scenario with the transport activity modelled. They can be though used as a reference in order to compare the regional distribution of GDP that was caused by the measures in the scenarios.

The analysis of congestion points in the reference scenario can however be useful. TRANS-TOOLS allows the calculation of a number of variables (speed, share of capacity used) that can be used as a proxy for congestion in road networks at various time periods. The following figure gives an example of expected congested road network points in the UK. For the policy maker such points can be an indication of future infrastructure investment needs, although a case-by-case analysis should be made to ensure that the future networks in the model are accurate enough. On the other hand, the information on congestion points is also useful for the comparison with the alternative scenarios, using congestion as an additional indicator to assess the effectiveness of policy measures. It is however important to remember that only the road network connecting NUTS3 provinces is covered and that the local traffic using it was not updated for year 2020 (the preloaded local traffic corresponds to that of year 2000).

As regards externalities, the current version of TRANS-TOOLS in practice projects emissions, accidents and external costs to be directly proportional to the growth of vehicle-kilometres in each mode. The fuel consumption, emission and externality factors used in the externalities module come from the TREMOVE model simulation of year 2000 and are used for the reference scenario as well. This introduces a major error in the model projections, since these factors will probably change significantly in the future. A way to solve this inconsistency is to use updated externality factors, for example from a TREMOVE simulation for year 2020, and multiply them with the traffic volumes generated by TRANS-TOOLS.

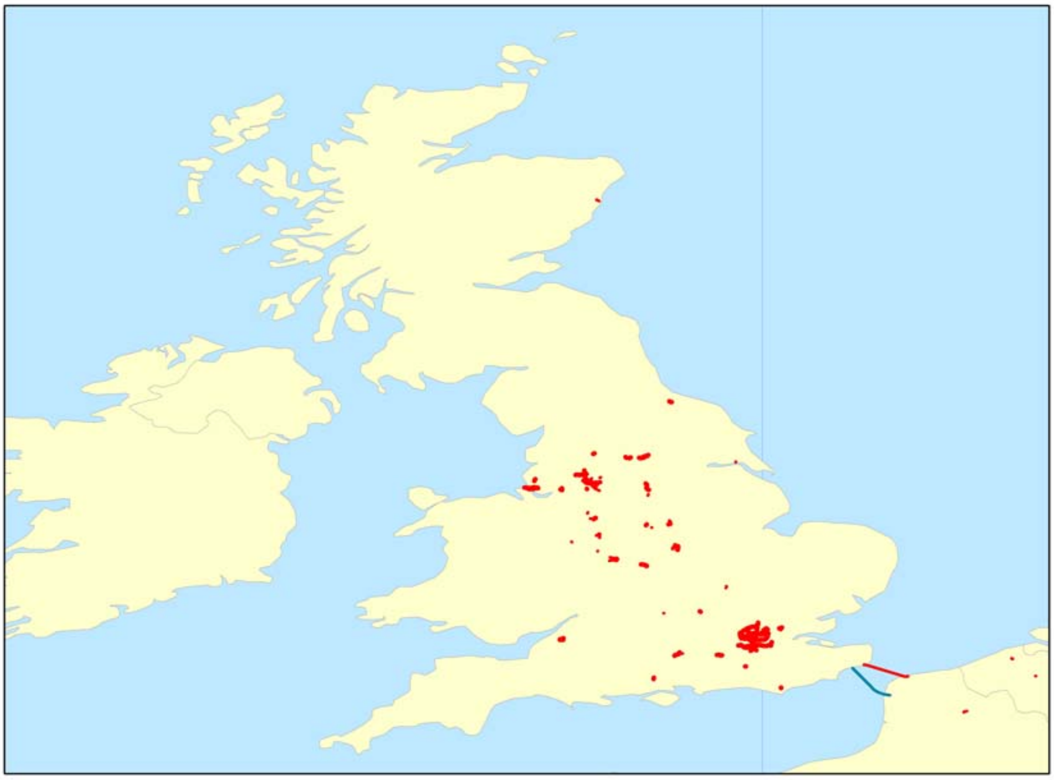

Figure 49 Example of expected congestion points in year 2020, UK road network

9.3. Accidents and emissions

In this section we pay attention to the validation of the externalities module that is included in the TRANS-TOOLS model. For the scenario results we refer to the annex report. Forecasting accidents risk rates is a challenging task. The accident risk originating for example from a road transport journey depends in fact on a multitude of factors, e.g. traffic composition, the type of vehicles used, the road characteristics (including weather conditions) and above all the behaviour of the drivers.

The TRANS-TOOLS accident module is based on the following components: the unitary cost per casualty ci (€ per fatality, slight and severe injury), the accident risk rate ri and the mileage m (in vehicle kilometre).

- Unitary accident costs expressed at 2000 factor prices per fatality, slight and severe casualties have been collected from the HEATCO project , using the Harmonised Index of Consumer Prices for adjusting for inflation the original accident costs expressed at factor costs 2002.

- Unitary accidents risk rates by vehicle type and network type distinguish between accident risk rates concerning the vehicle user(s) (r) and the accident risk rates with reference to the rest of society (r’). The former risk rate concerns the so called “value of safety per se”, i.e.

the WTP for reducing risk by the user(s) of the vehicle exposed to the risk to be injured of killed in an accident. The latter concerns the costs for the rest of society, i.e. the WTP of vehicle users and costs for the rest of society related to the increase or decrease in the accident risk for all other users of the same mode (mainly other vehicles and pedestrians), caused by an additional user. Fatality risk rates on motorways have been based on IRTAD data at 2003 per billion of vehicle kilometre), corrected for underreporting using the HEATCO corrections rates.

- The future mileage, i.e. the number of vehicle kilometre on specific routes, has been an input variable provided by the TRANS-TOOLS transport models.

The comparison at 2020 of the road predicted fatalities between TRANS-TOOLS and the ASSESS most likely implementation scenario shows for a representative sample of European countries a similar trend, with an average difference by -9.5%.

Table 67 Road fatalities TRANS-TOOLS vs ASSESS

Country	TRANS-TOOL S	ASSESS	Var %
Belgium	494	501	1.3%
Germany	3529	3037	-13.9%
Finland	164	174	5.8%
France	2645	2570	-2.8%
Germany	3529	3037	-13.9%
Italy	2629	2880	9.5%
Netherlands	558	477	-14.5%
Spain	4845	4207	-13.2%
Sweden	263	247	-6.0%
United Kingdom	2437	1962	-19.5%
	21093	19092	-9.5%

The environmental module aims at estimating energy consumption and related emissions due to transport activities. It appraises the damages due to environmental effects of air pollution and greenhouse gas emissions, providing the monetary valuation of the negative environmental impacts (external costs) as well. Indeed, such type of assessment follows a fairly straightforward methodology based on a list of specific components: energy consumption factors, emission factors, cost factors and traffic volume on the route.

- energy consumption factors (expressed as lt/vkm or kWh/vkm) have been collected from the TREMOVE database. In order to make the environmental analysis more consistent data have been disaggregated taking into account the following key drivers: country, network type, vehicle type and type of fuel;

- emission factors (expressed as ton/vkm) and the assumptions used to disaggregate unitary energy coefficients have been based on the TREMOVE figures.

- cost factors related to road and rail transport have been derived from the HEATCO project; the original value expressed in 2002 Euro per tonne of pollutant emitted have been converted in 2000 cost factor prices through the Harmonised Index of Consumer Prices (HICP);

- traffic volume (expressed in vehicle kilometre) have been derived from the TRANS-TOOLS model chain.

Comparing TRANS-TOOLS scenarios and PRIMES at 2020, the CO2 emissions show that at EU level PRIMES values are higher on average by 29% than those of TRANSTOOLS (EU15 and EU25). For the New Member States the difference is about 24%. The higher projections of PRIMES scenario derive from the inclusion of all the transport modes, unlikely from the TRANS-TOOLS scenario, in which only road, rail and IWW emissions have been taken into account.

Table 68 tonnes of CO2 Emissions

	TRANSTOOLS Reference Scenario	PRIMES Baseline Scenario
EU15	715.634.607	1.013.000.000
NMS*	78.035.329	102.500.000
EU25*	793.669.935	1.115.500.000

** in TRANSTOOLS data Malta and Cyprus are missing*

9.4. TEN-T infrastructure investment scenario

Scenario 1 simulates investment in infrastructure, in particular TransEuropean Networks and Motorways of the Seas, as well as more specialised measures addressing issues of logistics. This family of measures in practice increase the capacity of the networks and/or improves their efficiency. Transport costs normally decrease and the demand in the affected networks is expected to increase. Since overall costs decrease too, more trips will probably be generated. Shifts within the same mode are also to be expected, since improved links will probably attract traffic from links without improvements. Being a network model, TRANS-TOOLS is particularly suitable for the analysis of such measures. The change in the network characteristics are directly introduced into the model and new generalised transport costs, resulting from e.g. differences in driving distances or speeds, are calculated for the whole system modelled by TRANS-TOOLS. Based on these new costs, trip generation and distribution as well as modal or route choice are re-calculated.

Scenario 1, dealing mainly with infrastructure improvement measure, estimates the impacts of decreasing costs and travel times on the TEN-T and the Highways of the See. The model results suggest that such measures will have clearly positive impacts in terms of economic development as the results for GDP, freight transport generated (tonnes lifted) and mobility (passenger trips) demonstrate. As a consequence, transport activity is also expected to grow, without however any important changes in terms of congestion in the networks (due to the combination of the improvements themselves and the already existing spare capacity of the networks). Although this is positive from the mobility point of view, the growing external impacts would mean that from the environmental point of view the situation will become marginally more negative. It should be noted though that the latter should not be considered as a conclusive case; in its current form, the model does not take into account the changes in technological trends that such measures can provoke, assuming that the fleet mix in all modes will remain the same. This is probably not the case in practise and further analysis would be necessary in order to capture the environmental impacts more accurately. This is already being done in newer TRANS-TOOLS projects linking the model to TREMOVE, a specialised model that can capture technological changes. A second important point to take into account is that the positive impacts on economic activity come as a result of the improved accessibility of the system and do not include the impact of the cost of the projects the measures would require. This cost would have both positive and negative economic impacts (the return on the capital investment for infrastructure vs. the decrease of government spending in other areas) that the model doesn't fully cover yet. A more detailed study on the impacts of TEN-T using TRANS-TOOLS is ongoing at the time of writing. This study will provide more details on impacts and will also improve the detail of the input used for the simulation of the measures.

9.5. Road pricing scenario

Scenario 2 addresses another major policy option, pricing of road transport. In this case, users of road transport are charged according to the external cost of their transport activity, through the increase of tolls or taxes. Transport costs are expected to rise and the impact on demand depends on the relative changes in costs among modes and network links, as well as on whether there is on impact on the overall economic activity or trip generation. TRANS-TOOLS is also suitable for this type of analysis, since the modified transport costs can be introduced as either modified link costs at network level or as modified generalised costs at mode level. As in scenario 1, these new costs affect all stages from economic activity to route choice.

In scenario 2, the internalisation of external costs for road transport, at least with the levels of charges used in the simulation, is not expected to have a negative impact in economic activity. Neither tonnes lifted or trips generated seem to be influenced significantly. There is however a stronger impact in terms of transport activity (expressed in terms of tonne-kilometres or passenger-kilometres), with a noticeable decrease in the share of road transport and a shift to other modes. Consequently, the externalities of transport as a whole decrease in comparison with the reference case. These are favourable conclusions from the policy point of view, since internalisation seems to meet several policy objectives. It would be however premature to draw definitive conclusions on its impact without analysing the impact of the implementation cost of the measures (that were not available to be used as input) or the impact from decreased welfare in terms of mobility (a methodology for which is being developed in a more detailed impact assessment for internalisation of external costs currently ongoing).

9.6. Interoperability and liberalisation scenario

Scenario 3 deals with interoperability and liberalisation issues in rail freight and air transport. In this case, rail freight costs and travel times are expected to decrease, while the air transport network is expected to improve. The generalised costs of rail freight are thus directly affected, while in air transport the modified capacity and characteristics of the network will indirectly change the generalised costs. In both cases, the relative costs compared to other transport modes are also expected to change, stimulating modal shift but also leading to changes in the overall transport and economic activity.

Scenario 3 mainly affects rail transport and the results show only marginal differences at large scale. One would need to use a smaller scale of analysis, examining specific cases in the railway network and estimate the impacts on modal shift. There are indeed noticeable impacts at network level, but perhaps not of the order of magnitude policy makers would hope for. The reason is probably that even with the improvements in travel times and the decrease in costs assumed in the input of the scenario, the difference in generalised costs between rail and (mainly) road are still large enough to dissuade users from shifting to rail. As in the other scenarios, a more detailed analysis of the impact of the measures on user costs would be necessary in order for the input and the model results to be closer to reality. In addition, the implementation costs of the measures should be taken into account in this case too.

9.7. Combined scenario

The combination scenario simulates all of the above changes simultaneously. The results are in most cases not cumulative though, since relative differences in generalised costs from measures in one scenario can be counteracted, neutralised or even enhanced by changes from measures in another.

9.8. Reaction of model to policy measures

The results of the TRANS-TOOLS scenarios were quite satisfactory in terms of the reaction of the model to the changes introduced into the modelled transport system. Since the results of the scenarios cannot be compared to any reliable reference unless the same measures are simulated with another reliable model using the same input and the same external assumptions, the only way to test the reaction of the model was to compare the results with what economic, transport and traffic theory expect.

The direction of the impacts forecasted are in general in line with what was expected from theory. When transport costs increase, economic activity is influenced and this is expressed in terms of lower trips generated. If charges in one mode increase, traffic shifts to other alternatives, when available. And if the costs for a link are increased, traffic shifts to adjacent links or other modes. There are of course several exceptions in the scenario results, most of which can be explained by other changes at some part of the modelled system. A moderate number of inconsistencies mainly at local level still remain, usually the result of inaccurate data concerning specific links or spatial relationships. This should be considered as acceptable for a model of this size and in principle does not affect the quality of the overall results. It is a point that is being improved in the new research projects based on TRANS-TOOLS.

Perhaps more puzzling was the extent of the changes forecasted by the model as the result of a policy measure. The responsiveness of traffic volumes to changes in transport costs appears as lower than what was theoretically expected, something that suggests that transport demand as modelled by TRANS-TOOLS is less elastic than what is generally assumed. There are several reasons and implications for such a reaction, although it is difficult to reach a definitive conclusion.

One reason may be the fact that TRANS-TOOLS deals with long distance transport which may be less elastic than the predominantly short distance transport most theoretical evidence comes from. Another reason may be the fact that while most studies from literature refer to a specific mode in a limited area, TRANS-TOOLS covers most modes and a very wide area. As a result, cost increases in a specific link in one mode may be cushioned through the selection of a slightly different route. Or, in the other extreme hypothesis, when the overall cost increase is not enough to dissuade the transport user from making a trip and no other alternative modes or routes are available or attractive, the trip may still be made even at a higher cost. And a fourth possibility, perhaps more policy relevant, is that transport at this scale is in fact less elastic than expected. This would mean that the economy would be able to absorb increases in transport costs without a significant impact on transport or economic activity, something that the recent increases in fuel prices seem to confirm. The responsiveness of the model appears to be symmetric, i.e. the positive impact from a decrease in costs is of the same magnitude with the negative impact from an increase in costs. This is a point where more research is needed in general, since there is little theoretical evidence to clarify whether this is correct.

The model was calibrated based on year 2000 data, and there is good reason to believe that resulting (apparent) elasticities in TRANS-TOOLS are accurate enough. Nevertheless, a new calibration based on newer data for year 2005 which is being carried out in a new study funded by the Commission will help clarify this point.

9.9. Selection of model input

As is the case with any model in any field, the quality of the input to the model is fundamental for the quality of its output. Assuming that TRANS-TOOLS represents the transport system and responds to changes in a sufficiently accurate way, the other important factor that determines the reliability of an impact assessment based on TRANS-TOOLS is the quality and level of detail of the input used to simulate the measure to be tested. There is the risk of underestimating the required effort to convert the often qualitative description of a policy measure into the quantitative input required by the model. In the implementation of the scenarios modelled in TRANS-TOOLS, the values to be used as input were based on other studies or expert input, but this does not necessarily mean that the policy measure has been simulated accurately. For example, in the case of scenario 1, the improvements from TEN-T have been identified empirically and an average improvement was defined. In the case of scenario 2, an average charge per country was selected. In scenario 3, average improvements in rail freight were used.

An accurate impact assessment of the policy measures described in the three scenarios would entail a detailed estimation of the changes in costs or network characteristics these measures would lead to. Depending on the requirements in terms of accuracy, a suitable level of detail can be selected. This task can be quite resource-intensive and should be taken into account in the planning of an impact assessment.

9.10. Format of model output

The TRANS-TOOLS model is admittedly complex and the analysis of its results can be complicated. This is not surprising given the complex nature of transport activity and the interaction of many driving factors. An additional reason for complexity is the need to provide sufficient detail for policy analysis, as well as the several levels of interdependent variables that the model uses for computation and presentation of results.

There are several types of model output that can serve different policy analysis needs. The main output of the model consists of traffic flows on each link of all networks. This information also includes costs, speeds, capacities and lengths, which in turn allow the estimation of additional indicators related to congestion, external impacts or accessibility. Especially for road transport, results are detailed for different periods of the year, week or day. This level of output provides a large volume of information that is needed for further levels of analysis and can be useful for link-level studies. Such level of analysis can be useful for specific large infrastructure projects of EU, national or regional interest. Summarising the data at province (NUTS 3), region (NUTS2) or country level, aggregate results for transport activity and subsequent indicators can be provided for the respective geographic level.

Based on the above, a second level of analysis comprises of Origin-Destination (O-D) matrices between provinces, regions or countries across the whole TRANS-TOOLS modelled system. These matrices include traffic and cost information and can be useful for the analysis of trade or economic impacts. They also form the basis of summaries for transport activity generated in or attracted by each zone.

Each module of TRANS-TOOLS provides its own output at link or zone level. The information is provided in the form of databases with detailed data and as Geographic Information System (GIS) files that can be readily converted into maps or used for further analysis. More than 70 policy relevant variables are produced as output at link level and their number increases exponentially when these are used for further calculations (e.g. indicators for congestion, welfare, accessibility, etc.). A similar number of output variables are produced at zonal level, with similar possibilities for further processing.

The experience from the first scenarios simulated with TRANS-TOOLS suggests that although the output and the interface of the model are useful for and relatively easily usable by experienced users of TRANS-TOOLS, the interpretation of the results and the production of tables and maps that summarise the impacts in a form usable by policy analysts are still quite complicated. This point is already being improved by a new generation of projects based on TRANS-TOOLS.

9.11. Conclusions

The simulations performed in the TRANS-TOOLS project confirm the applicability, in principle, of the model for the type of analysis required in an impact assessment of such transport policy measures. In addition to the estimation of the potential impacts on transport activity, its detailed economic, trade and trip generation modules allow an analysis of the causes for changes at various levels of the transport decision chain (economic activity, trip generation, selection of mode, selection of route). By comparing changes at each of these levels, the analysis of the results can identify areas where the simulated measure may have positive or negative results from the policy point of view. Given the complexity of the role of transport in the economic, social and environmental context, it is often unclear whether an increase or decrease in transport activity is a welcome result on its own. The results of the model provide policy makers with additional relevant information that allows the assessment of impacts on e.g. economic activity, externalities or accessibility. Trade-offs between positive changes in one dimension and negative in another can be identified with relative ease.

By extension of the conclusions drawn from the TRANS-TOOLS scenarios, the applicability of the TRANS-TOOLS model can cover all measures that may have an impact on the characteristics of transport networks or transport costs, either at link or mode level. Even if the input does not affect the characteristics or costs of specific links, the capability of the model to still capture the reaction of the networks at link level is valuable. The same can be said for changes that do not affect transport characteristics directly but do affect parts of the modelling system in TRANS-TOOLS. These can include input variables that would affect overall transport activity, like GDP or demography, which can be modified in order to analyse different development scenarios. The same can be done with intermediate variables such as emission factors, which can be modified in order to estimate the changes in the environmental impacts from technological change in vehicles using the same traffic volumes.

A major weakness of the model in terms of policy analysis capabilities however is the fact that traffic within a province (NUTS3 zone) is not modelled, although local traffic using the networks is in fact taken into account. There are several practical and technical reasons justifying this, but it is still an issue one should take into account when deciding the applicability of the model in cases where local impacts may be important. This point can hopefully be improved in the future, as long as a feasible technical solution can be found.

10. CONCLUSIONS AND RECOMMENDATIONS

10.1. Conclusions

The TRANS-TOOLS model is the largest and most comprehensive European Transport model so far and it covers the whole of Europe, all modes, freight and passenger transport. It is probably the largest transport model in the World concerning population and GDP covered and by far the largest with respect to number of countries covered (55). The model is IPR free and general available but it requires ArcGIS and Traffic Analyst to run. Despite all efforts within the TRANS-TOOLS project still additional work is needed in order to align the model and/or to provide additional clarifications in line with results from other studies and data. This is to be seen as a continuous update of the TRANS-TOOLS model. Notably in D5 the validation is carried out, in this section we repeat the main conclusions concerning the future development of TRANS-TOOLS.

The objective was to develop a European freight and passenger model for the assessment of large-scale policy questions raised by the challenging environment of an enlarged Europe. The development of new European strategic models is guided by the existing developments of the European models and recent applications, as the TEN-STAC project.

The TRANS-TOOLS model is one of the largest existing transport models in terms of number of countries covered, population covered, geographical scale, as well as the complete coverage of both freight and passenger transport, and both cars, trucks, trains, canal ships, sea ships and air transport.

The TRANS TOOLS model integrates existing models to one new model that comprehends the complexities of both goods and passenger transport flows in the European Union. In deliverable 3 (Model development and calibration) this new European strategic model is documented, based on the experience with existing models and tools, by taking into account the findings of deliverable 1 (Policy and model needs and identify model specifications) and deliverable 2 (Implementation of data input). The objective is to develop European freight and passenger models for the assessment of large-scale policy questions raised by the challenging environment of an enlarged Europe. The development of new European strategic models is guided by the existing developments of the European models and recent applications, as the TEN-STAC project. The new modelling tool considers ETIS as the basis for transport performance which has to be modelled. In order to manage the task of integrating existing models to one new TRANS-TOOLS model a sound interaction of the different existing models is necessary (see blueprint in the Annex). The main modules of the TRANS-TOOLS are as follows:

- The **TRANS-TOOLS freight demand model** is represented by following sub-modules:
  A generation and attraction pattern of the trade flows in the chosen basis year is a starting point for building a trade model in general. Specifically for the TRANSTOOLS trade model, the ETIS O/D freight transport matrix will be used as an analog substituting the trade relations matrix. The ETIS matrix describes the generation and attraction of physical flows of goods between the trading countries and geo-clusters given the economical and institutional determinants of the year 2000. For the relations with the trading partner from beyond the established European area the economical mass of the partner is the decisive factor. The output of the TRANS-TOOLS trade model is a forecast O/D matrix for freight

including origin region, between transhipments and destination region as well as transport mode at origin, between transhipments, and at destination, commodity group and tonnes.

The TRANS-TOOLS modal split model for freight transport is based on the modal split model in NEAC. In TRANS-TOOLS the modal split model adjusts the stable modal split resulting from the trade model. Output of the TRANS-TOOLS modal split model is the ETIS freight matrix, which consists of a forecast O/D matrix including forecast modal split. In the modal split model the market shares of the different modes of transport are estimated for every O/D relation and commodity group. Within the model there are four modes of transport available (Road, rail, inland waterway, sea). Choice probabilities of the available modes per commodity group for every O/D relation are determined by using a multinomial logit model.

The working of the TRANS-TOOLS logistic module is based on SLAM, which is a module appended to the SCENES model. This module makes it possible to evaluate the impacts of changes in the logistic and transport systems within Europe on the spatial patterns of freight transport flows, through changes in the number and location of warehouses for the distribution of goods. The logistic module produces output that is to be used in the assignment model as well as in the economic model. For the assignment model the logistic module produces unimodal transport matrices (Origin, destination, mode, tonnes, vehicles). The economic model needs generalized and monetary costs per origin, destination and commodity type. These costs can be computed from the assigning process. The monetary costs (payment to the public budget e.g. toll, fuel taxes) can be separated out if input on these costs is available.

- The **TRANS-TOOLS passenger demand module** tackles passenger transport modelling at European level, with main focus on the (transport) models SCENES, VACLAV and ASTRA. The passenger module covers the first three steps of the classic four-step-approach, which are trip generation, trip distribution and modal split. The trip distribution process in ASTRA depends on results of the modal split stage. Hence a feedback mechanism from VACLAV to the trip distribution module is prepared to transfer average generalised times to the trip distribution logit function. Trip generation as the first stage of the classical four-step transport modeling approach is implemented in ASTRA. After the generation of trips emanating from European NUTS3 zones these trips are distributed among destinations. The spatial trip distribution is represented by the second stage of the IWW transport modeling approach. In this process the vector containing generated trips is transferred into an O/D matrix. In the third step the mode for the travel is chosen. Hence impedance data from the TRANS-TOOLS assignment model as well as O/D matrices per trip purpose from the ETIS database are applied. Travel costs, travel time and information about the trip itself like frequencies and number of transfers are used to split the trips between the modes. Subsequently, for each origin-destination pair the modal split model calculates the probability of selecting a modal alternative out of a set of available modes. A non-linear logit function is used in order to calculate the choice probability. The explanatory variables represent the transport service level between two zones e.g. in the dimensions travel costs and travel time. Output of TRANS-TOOLS passenger demand model to assignment model are unimodal passenger O/D transport matrices at NUTS3 level in number of passengers per mode (rail, road, air) and trip purpose as well as unimodal passenger O/D transport matrices at NUTS3 level in number of vehicles for road relations per trip purpose. The level of service-matrix with generalised costs per O/D relation represents the output from TRANS-TOOLS passenger demand model to the economic model.

- As transport policy influence the accessibility of a region it thereby influences the development of the economy in each region of the EU. This effect is included in the **TRANS-TOOLS economic module** CGEurope. Sectoral developments, thus the effects of each policy scenario, are predicted by the model in monetary terms. The computed relative changes of economy by sector with respect to the baseline scenario are passed on to the NEAC model. Policy evaluation measures, in particular real GDP impacts and equivalent variation, by region, year and scenario are further outputs of the TRANS-TOOLS economic module.
- Constituting the final modelling step, the **network assignment module** produces the direct output from the TRANS-TOOLS model. However, the models also generate level-of-service data (LOS) as input to passenger, freight, and logistic models in a feed back loop. Input from the passenger model are unimodal passenger O/D matrices at NUTS 3 level in number of passengers and vehicles by mode and trip purpose. Input from the freight and logistic models are unimodal transport matrices at NUTS 2 level by mode, commodity, tonnes, and vehicles. In the TRANS-TOOLS model, transport networks are defined at unimodal level. There are following network models developed: Road network (passenger and freight), rail network (passenger and freight), maritime network (freight), inland waterway (freight) and air network (passenger). Passengers by rail and air and freight by rail and inland waterways are assigned based on an average day, since congestion is not considered and information on service data differentiated by time and day is not available. LOS in the road assignment is calculated by time period. In TRANS-TOOLS, a stochastic assignment procedure is applied being founded on probit-based models. The probability of using a certain link or route is calculated by a multinomial normal distribution resulting in the probit model.

10.2. Recommendations and Possible improvements to the TRANS-TOOLS model

10.2.1. Implementation

Presentation to the Commission

The TRANS-TOOLS model needs a clear presentation to the Commission, the Commission should be aware of the capabilities of the model and the way in which it can be integrated in the policy analysis.

Acceptance by the Commission and Member States

It is crucial that the model produces reliable results in terms of base-year and forecasting year, it is therefore of importance that the baseyear and scenario's are frequently updated. Through TRANS-FORUM a relatively loose contact with stakeholders is established. A user group with representatives of the Commission and Member States could be established.

Installation at Commission

The installation of the model at the Commission requires that capacity should be made available for installing hardware and software. The model when operating in full detail will need about 3 days in total to run. A dedicated PC for TRANS-TOOLS will be necessary.

Organization (including role JRC-IPTS)

JRC-IPTS could be an intermediary in providing training for users, policy makers, modelers, etc.. Though the website it is tried to establish a modelling community, JRC-IPTS could take up a central position in the organization of the implementation of the model.

Website

The website should play a central role for dissemination of TRANS-TOOLS results. In addition it should also be the method of communication for modelers and so contributing to the establishment of a modeling community. A section of the website should be devoted to user experiences with the model, eventual forthcoming improvements and modifications to the TRANS-TOOLS model can be centrally gathered on this section of the website.

Helpdesk

The helpdesk is something that can be established when there is already a network of users. A helpdesk enhances the use of the TRANS-TOOLS model. In the long run a decision should be taken whether a helpdesk will be installed and whom should provide capacity. A suggestion is that it could be located within JRC-IPTS.

10.2.2. Maintenance

Data

The data requirements of TRANS-TOOLS are very much linked to ETIS (European Transport policy Information System). For the updating of the data therefore reference can be made to deliverable D14 of ETIS-LINK and the different ETIS-BASE deliverables in which this is descried in full. Also different service levels, the role of EUROSTAT and organizational schemes for the organization around ETIS are described in this report.
It should be noted that in the upcoming 6th framework WORLDNET project an update will be made of the freight flow data and network data. The passenger flow data of ETIS have been used in TRANS-TOOLS for calibration purposes. The TRANS-TOOLS model generates a new passenger OD base-year on its own. New data still has to be collected when a new model calibration will be made. It is recommended to do this every 5 years in line with the ETIS update timing.

Software

The interdependency between TRAFFIC ANALYST and ARC-GIS is a point of attention. The TRANS-TOOLS model is based on implementation in TRAFFIC ANALYST, it was learnt during the project that this software helped in making the relations between the different models explicit. From now on within TRANS-TOOLS new modeling concepts can be easily implemented, as long as the format of the datafiles is followed.

Modelstructure and parameters

The updating of the model requires new estimation of the model parameters. The reports of TRANS-TOOLS should provide enough detail on the construction of the models and allows the calibration on the basis of new data. Also if new concepts with new model setup an different parameters

Networks

During the project a communication with GISCO (EUROSTAT) has been started up to discuss the updating procedures of the networks. In the current situation GISCO is not entirely suitable for modelling purposes. For this reason each project or consultant makes his own changes to the network in order to make it suitable. These model networks are updated in each project. At the same time GISCO makes updates in a parallel process. A way has to be found to make these processes to work in line with each other. GISCO is working on this process but was interested to use the TRANS-TOOLS rail network. The updating and improvement of the networks is an ongoing issue which requires special attention.

Organization (incl. community of users)
The organization of the maintenance of the model is preferably centrally organized. Again here, like in the implementation of the model, JRC-IPTS could take up this role. Another possibility could be that this is established in FP7.

10.2.3. Improvements

Software
The choice for using Access for data storage had been discussed. A problem with Access is that it takes quite a long time to read and write all the data in the software applications and that the databases grow large sizes. These problems can be solved by using the EDO library and by automatically compacting the databases. In this initial phase of development the choice for Access was made because it reduces the risk of miscommunication and misunderstandings about the content of the data files. Furthermore Access provides a user friendly environment for the end user of the tool. It might be an idea to use another type of database in the future in order to decrease the computation time.

The possibility to optimise software codes and data flows in order to reduce running times will have to be studied, also taking into account that the main contribution to the remarkably high model running time is given by the assignment model.

User friendliness
In the current version of TRANS-TOOLS it is attempted to have a tool which is as user friendly as possible. However there still remain some aspects which can be improved. For instance the facilities for making changes to the scenarios and other input is not in all cases worked out to the full. In the annex an example is described for making changes to the GDP scenario. This is one of the aspects that could be improved in a future update step.

Model improvements
- Extent the network (the network is already being extended for freight with respect to the relations with countries outside Europe).
- Consolidate results and compare with other existing tools at national level. In order to make the model more solid and accepted by others.
- Estimate matrices for intra-zonal traffic (since this is not included in the ETIS matrices), and use this as a basis to implement a more sophisticated approach to model intra-zonal flows.
- Provide a link to other models such as energy models, environmental models, etc..
- Improve the front-end of the model, this makes it also easier to distribute the model.
- Also Neighbouring countries to the EU should be included.
- Improvement of the passenger air model with respect to explicitly modelling of feeder modes (car and rail) as well as intercontinental passenger transport

- The modelling of sea transport could be improved with respect to port choice.
- Containerisation could be included in the model.
- Vehicle types should be taken more explicit into account.
- A way should be found to use the multi-sectoral model for the CGEurope model.
- A better connection to the national models and outcome of national models.
- Include GA (generation and attraction) information to improve the assignment, demand and economic models.

Check the logistics module/economic module interaction

- The interaction between the logistics module and the economic module was not properly working at the time of the scenario runs. This caused some strange results in terms of economic impact. This aspect will need to be carefully checked to detect the source of the malfunctioning and improve the results of the model.

Check matrices and consistency to Eurostat data

- The figures for aggregate traffic performance (passenger and freight) the TRANS-TOOLS model provides are often different from published Eurostat data (e.g. Energy and Transport in Figures). There are significant justifications for the differences as TRANS-TOOLS does not simulate local and urban demand and also the definition used to compute traffic performance may be not homogenous (traffic on the national territory vs. country generated demand). Nevertheless, more analysis is required to clarify the role of each source of difference and possibly detect any flaws in the demand matrices used in TRANS-TOOLS to be corrected.

Establish intra-zonal flows of the matrices of transport demand

- Furthermore, the TRANS-TOOLS modelling approach lacks from a sophisticated method to model intra-zonal traffic. This is due to the contractual requirement, that TRANS_TOOLS should build upon the ETIS matrices which do not include Zonal internal traffic. As discussed in WP3, TRANS-TOOLS uses pre-load to consider the share of intra-zonal traffic in the base year that uses the main road network. However, this ignores the flows on the local network, as well as changes of the pre-loaded traffic in scenarios. But it secure that congestion is modelled correctly on the road network in the base-year estimation. Since, depending on the country-specific size of the NUTS-3 regions, intra-zonal passenger transport can make up considerably more than 50% of the total passenger mobility, an advanced consideration of intra-zonal traffic is highly recommended in order to obtain a realistic picture of the distribution of transport demand on the networks. A more advanced approach to model intra-zonal road passenger traffic at European level has been obtained for instance by the VACLAV model (Schoch 2004), which however, could not be implemented in the current version of the TRANS-TOOLS assignment approach. By the VACLAV road assignment approach ‘virtual’ feeding nodes are created automatically within a NUTS-3 zone, under consideration of geographical data on the number of inhabitants of settlements. This allows both the distribution of inbound and outbound trips to several feeding nodes per NUTS-3 region instead of to just one feeding node (which is already done by multiple zonal connectors in the present TRANS-TOOLS model). Furthermore, it allows the assignment of intra-zonal trips, which are modelled as well, under consideration of traffic count information and geographical data on the distribution of inhabitants[8]. Any approach to model intra-zonal traffic flows should allow the generation of forecasts for intra-zonal traffic too.

Check the future trend of transport demand by mode

- The growth rates of transport demand per mode in the TRANS-TOOLS baseline are different from those emerging from other models and analysis (e.g. the mid-term assessment of the White Paper). The differences arise from a different methodology but also different assumptions concerning the evolution of determinants of demand can have a role. The reasons for the differences will have to be checked more carefully, with special reference to some modes like air passenger and rail freight. If needed, revisions of the current TRANS-TOOLS baseline will have to be undertaken.

Check model elasticities

- From the scenarios simulations emerged that model elasticities are often quite low. While link based charges for road modes give rise to visible reactions, the model seems also insensitive to change of other cost or time components (e.g. speed on rail links). This will have to be checked in order to provide more robust justifications for modelling results.

Updating exogenous preloads on road links

- The TRANS-TOOLS model takes into account local demand on the modelled road network by means of exogenous preloads. Such preloads have been estimated for the base year 2000. A correct simulation of the transport demand in the future years would require that preloads are updated to consider the evolution of local demand as well. Currently, preloads are fixed and a methodology for their update to future simulation years has not been established. This issue should be addressed in order to improve the definition of the exogenous input for scenarios.

Make model parameters changeable to users

- In the current version of the TRANS-TOOLS model, a number of input parameters (unitary costs components, fixed times, etc.) are either not explicit or cannot be readily modified by users or both. For instance, fuel is not a separate component of road modes cost so that policy measures aiming at modifying e.g. fuel taxes cannot be readily implemented. Also, most of the tables where input changes can be implemented do not allow users to apply national-based values or allow to just introduce relative change with respect to a base value, which is often unknown however (e.g. motorisation rates). The set of available inputs changeable by users and their level detail will have to be increased in order to extend the potential of TRANS-TOOLS as a policy simulation tools.

Widen the available output detail

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[8] This may overestimate the congestion on the major network, since local roads are not represented in TRANS-TOOLS (i.e. all zonal-internal traffic will be forced onto the major network). As an example in Copenhagen Region, 80% of the congestion and volumes are in the real life on the non-national roads and only 20% on the national roads (similar to the TRANS-TOOLS network). By assigning everything on the national roads one would overestimate the volumes here by a factor 5. Therefore, it is not a question about whether the software technically can do so, but whether it is reasonable to assign all the zonal-internal traffic onto a road network database that only contains the major roads.

- TRANS-TOOLS outputs several tables of results. The size of many tables is huge (the full set of output is currently about 3.5 GB in size), therefore for saving space often only aggregated results are available. Some more detail would however required for some variables. For instance, speed on roads is currently available for PCUs only, while it would be useful to have it separated for cars and trucks[9]. Also origin-destination travel costs are not always available for all modes. Finally, aggregated summary tables of traffic performance (e.g. total vehicles-km by country) have been created for this report outside the model. The needed queries could be embedded in the model in order to have this kind of output by default.

Check the assignment results

- The pictured assignment results reveal in certain areas unrealistic patterns, such as “disappearance” of flows on some sections of European main corridors. This pattern holds true particularly for the assignment results of the forecast year 2020. Hence in the further development process of the TRANS-TOOLS model, – and, particularly, if the TRANS-TOOLS model is applied to infrastructure project assessment – a careful check of plausibility of assignment results, further calibration and a diligent check of the technical features of the assignment routine (e.g. location of feeding nodes, routing of transport flows according to the optimal path etc.) seems indispensable. The main reason though seams to be the large zones within east Europe. Also flows in inland waterways seem to have a wrong representation.

Variable elasticity’s

- In TRANS-TOOLS the models have been calibrated on the base year data. The elasticities estimated therefore represent the current relation between transport and for instance economic activities. When applying the model for a future year it is therefore assumed that this estimated correlation will still be valid in the future. It could be tested whether this assumption is correct. If this would not be the case then the model could be improved by introducing variable elasticities that take into account the changing correlation between transport and the explaining variables. Especially with regards to passenger demand modelling, time elasticities seams quite small. The freight models are also quite in-elastic concerning time and cost, but this is more in line with the literature.

Trend break analysis

- Trend breaks are very likely to occur in the coming period up to 2020/2030 considering the difficulties the energy suppliers (seem to) have to keep pace with the demand. This could for instance be a change in technology allowing the use of different energy sources, or a very rapid increase of energy prices and a corresponding impact on economy. Making forecasts taking into account possible trend breaks requires an extension of the model suite of TRANS-TOOLS. In future work TRANS-TOOLS could be extended with this possibility

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[9] Now the model reaches equilibrium with congested speeds that are equal for trucks and cars, but above congestion level there could be speed differences.

10.2.4. Extensions

Some extensions as proposed above of the TRANS-TOOLS model are already foreseen in two 6th framework projects I-TREN, WORLDNET and REFIT.

iTREN project (Task 3 in FP6 call)
The TRANS-TOOLS model is developed to be the core detailed transport analysis tool for the EU. Its policy forecasting capabilities can be significantly enhanced by linking it with state-of-the-art tools in the field of energy, environment and economic analysis. iTREN-2030 will built this linkage from TRANS-TOOLS to the following state-of-the-art tools: POLES for energy technology and energy prices, TREMOVE for environmental assessment and vehicle fleet development and ASTRA for provision of the economic repercussions exerted by the sectoral policies.
A key task of iTREN-2030 will be to generate a consistent baseline development until 2030 that is reflected by each of the four tools. This baseline integrates and harmonizes technological developments on the energy and transport side, energy prices and economic trends with demand for energy and transport and their environmental impacts. The baseline will be compared with experiences of past projects and it will be shown how the combination of tools fits to the user needs for forecasting and policy analysis of a large spectrum of energy and transport policies.

WORLDNET project (Task 4 in FP6 call)
Although the scope of ETIS and subsequently TRANS-TOOLS is EU25, there is some lack of recent information on the new members (EU27) and on the new neighbors, as well as detailed country or group of countries information recording trade with the Rest of the world. Intermodal transport outside the EU is an innovative issue, as well the information on air (freight) transport. As such the forecasting capabilities and scenario developments of TRANS-TOOLS can be significantly improved or used in parallel and cooperation with the iTREN project.
A key task of WORLDNET will be to implement a communication tool with the other world regions or countries in order to make them to benefit of the knowledge of world transport with the EU. The work foresees in a concertation with international organisations or countries, in the framework of existing platforms like TRANSFORUM or on an ad hoc basis.

Besides the extensions that will be made in iTREN and WORLDNET there are some other possible extensions. The extensions made to the rest of the world in WORLDNET for instance cover only the freight related models. A similar extension should be made for the passenger model and other models. The core for the entire WORLDNET model should become the EU27 with special focus on the neighbouring countries. For the neighbouring countries for instance a (limited) further rationalization could be made for the partner flows in order to fine tune the cross-EU-border flows also for passenger transport.

REFIT
The TRANS-TOOLS model is also part of the REFIT project (April 2006-October 2008), whose objective is to develop, test and validate a “modelling tools-based” methodology that produces data on a set of identified indicators and that enables ex-ante evaluation of the European Common Transport Policy considering the economic, environmental and social dimensions of sustainability. REFIT will build upon the combination of TRANS-TOOLS (including the spatial economic CGEurope model) and TREMOVE models. New additional evaluation modules will be developed in this project to produce data for those policy targets

and indicators that were till now hard to address quantitatively, notably impacts on regional development, (un)employment; fair competition between modes, noise and air-pollution exposure, personal health, transport safety, equity issues and income distribution.

11. REFERENCES

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Annex 1: Example Changing the GDP scenario in TRANS-TOOLS

Current situation

There are several models that require GDP scenario input:

- Economic model
- Trade model
- Passenger model

In the current TRANSTOOLS set up the economic model and the passenger model use the same input file which is for the EU 25 and is at the NUTS 3 level and no sector information. The trade model uses a different input file which is EU25 + countries in the rest of the world and at the NUTS2 level and 11 sectors.

File	**EU 25**	**Other countries**	**Regional detail**	**sectors**	**Horizon**
Trade	X	X	NUTS 2	11	2030 with 5 year intervals
Econ/pass	X		NUTS 3		2020

In case a user wants to run a new scenario it is quite complex to implement this in the tables in a consistent way.

One additional restriction has to do with the ASTRA model. It can not be predicted how the model responds to a new scenario because of its dynamic nature. Normally a new scenario can be applied but it has not been tested on large deviations. This implies that implementation of a complete new scenario can only be done by expert users to avoid. What is possible in the TRANS-TOOLS passenger model is to make relative (and small) changes to the current scenario. IWW has indicated that it should be possible to make changes of + or – 1 percentage point. So for example if the current value would be 2,5% then the range 1,5% - 3,5% should be possible.

Possible improvements

Options for changing the scenarios

1. In the operational TRANS-TOOLS software it should only be possible to make (small) relative changes.
2. Completely new scenarios can only be implemented by the expert users.

Combined file for generating consistent sub files

So here it should be observed that one file has more sector detail and the other more regional detail. This would imply that in order to combine the files one would require a file with NUTS 3 and 11 sectors.

File	EU 25	Other countries	Regional detail	Sectors	Horizon
Trade	X	X	NUTS 2	11	2030 with 5 year intervals
Econ/pass	X		NUTS 3	Total GDP	2020
Combined	*X*	*X*	*NUTS 3*	*11*	2030 with 5 year intervals

Once such a table is available then the other 2 can be derived from it. A separate executable should then be made that generates the 2 sub-files:

- To generate the trade model input file the NUTS 3 regions have to be aggregated to NUTS2
- To generate the Econ/pass model input file the sectors have to be added up to the total GDP and the information for non-EU countries should be omitted.

When making a new scenario this has to be implemented in this combined file.

When making relative changes to the scenario this should also be done in the combined file but guidance is needed to ensure that the total of the changes to the sectors result in a change in total GDP that lies within the allowed ranges. Furthermore the user might not want to make separate changes for all NUTS 3 regions separately but for instance for a country as a whole or not for all the intermediate time horizons separately. If this option is chosen by the user this change to the country value then is applied to all its NUTS 3 regions at once. It should also be possible to make changes to the NUTS 3 regions individually.

Annex 2: TRANS-TOOLS Blue Print