DESCRIPTION OF THE TRUST MODEL

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TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

Introduction

TRUST (TRansport eUropean Simulation Tool) is a transport network model developed by TRT at the beginning in MEPLAN software and then transposed in 2017 in PTV VISUM software. TRUST is a transport network model for the assignment of Origin-Destination matrices at the NUTS3 level of detail for passenger and freight demand for the whole Europe and neighbouring countries.

The model is currently used in the DG MOVE Framework Contract regarding the elaboration of long-term policy scenarios and variants for the transport system of all 28 Member States of the European Union with the time horizon of 2050.

Coupled with the ASTRA model, TRUST has been used for many impact assessment studies on behalf of DG MOVE (e.g. The impact of TEN-T completion on growth, jobs and the environment, Support Study for the Impact Assessment Accompanying the Revision of the Eurovignette Directive (1999/62/EC), Study on the Deployment of C-ITS in Europe, Sustainable Transport Infrastructure Charging and Internalisation of Transport Externalities).

This technical note provides a description of the TRUST model and is organised as follows: Chapter 1 presents the general feature of the model, while Chapters 2 to 4 illustrate in detail respectively the road, rail and maritime modes of transport.

A bit of history

In late 1990s and early 2000s, TRT had co-operated to build the SCENES model (earlier called STREAMS) within two different research projects of the European 4th Framework Programme. After those projects, the SCENES model was successfully applied in the European context, namely it was one of the tools used for the mid-term assessment of the White Paper on the European Transport Policy for 2010 (ASSESS project). SCENES transport model data was also the source of the baseline fed of the TREMOVE model for a number of DG ENV studies until the TRANS-TOOLS baseline was set up.

The SCENES transport model included a network model covering also the modal split stage as well as a regional economic module for the endogenous generation of passenger and freight matrices. The experience of SCENES ended for various reasons, not least because the European Commission wanted to develop a reference transport model based on a IPR free platform, i.e. the TRANS-TOOLS model. TRT was part of the consortium that created the first release of the TRANS-TOOLS transport model back in 2008.

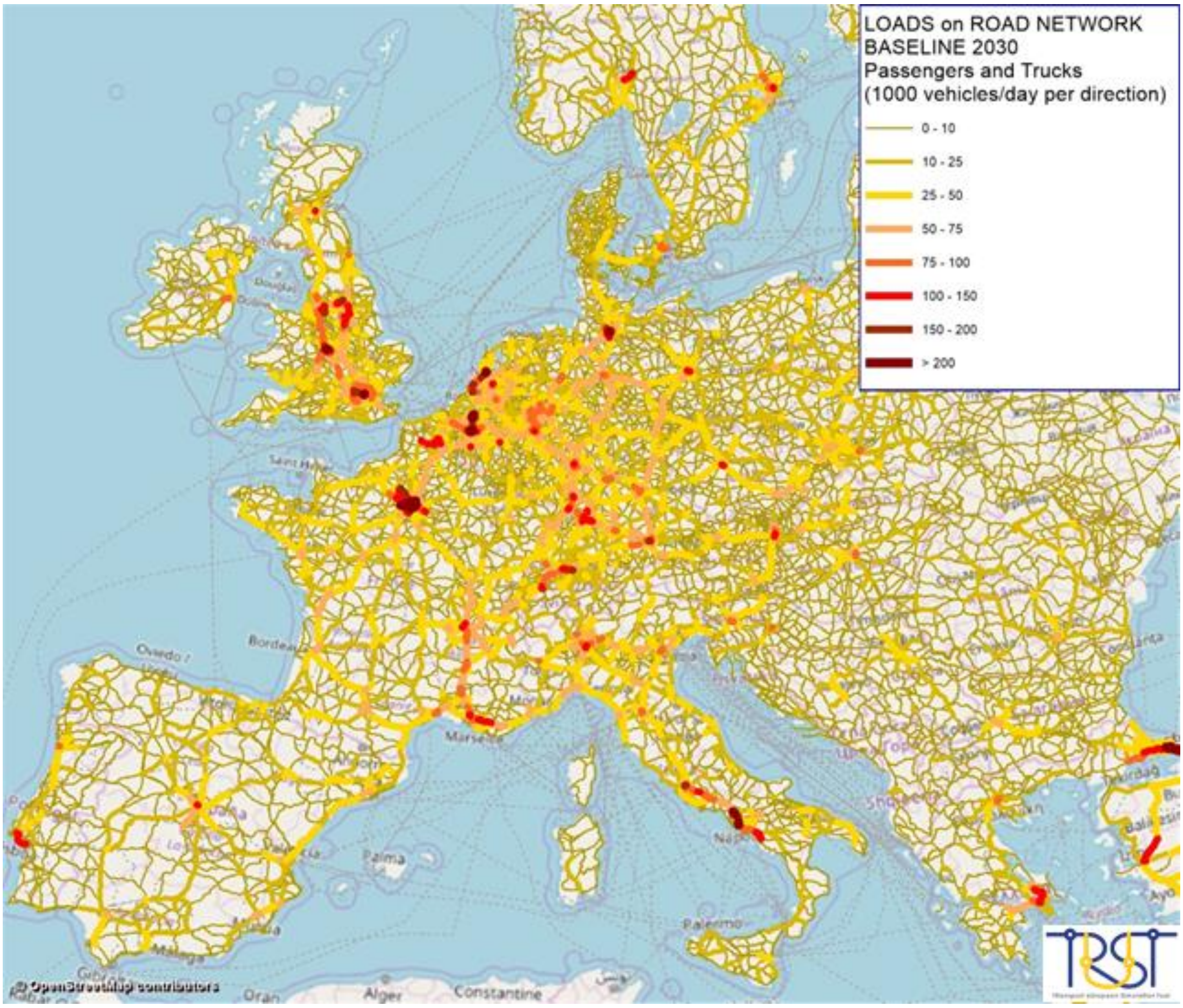
The TRUST model uses the data made available by the ETISplus (http://www.etisplus.eu/default.aspx) project, where TRT was also involved. ETISplus provides a set of data including networks, matrices, traffic counts, etc. to serve for the development of transport modelling at the European level and TRANS-TOOLS is thought as the major user of the ETISplus database. The model has been used also in the context of the TRACC project (http://www.espon.eu/main/Menu_Projects/Menu_AppliedResearch/tracc.html) within the ESPON framework. The rail component was developed in the context of the Living Rail project.

1 General features of the TRUST model

In its current version, TRUST is a transport network model for the assignment of Origin-Destination matrices at the NUTS3 level of detail for passenger and freight demand. Road as well as non-road transport modes are covered in separate modules. Each module has its own network and its matrices: the current version of the TRUST model does not deal with modal split. Therefore, the main output of TRUST is the load on road network links in terms of vehicles per day (see example in figure 1 below) and on non-road links in terms of either trip or tonnes per day.

The model is calibrated to reproduce tonnes-km and passengers-km by country consistent to the statistics reported in the Eurostat Transport in Figures pocketbook net of intra-NUTS3 demand (available from ETISplus), which is not assigned to the network.

Figure 1-1: An example of road transport assignment



1.1 Spatial detail

TRUST covers:

- The 28 EU Member States;
- 8 Candidate and potential candidate countries: Western Balkans (Serbia, FYROM, Albania, Bosnia and Herzegovina, Kosovo, Montenegro), Turkey, Iceland;
- 6 Other EU bordering countries: Norway, Switzerland, Belarus, Ukraine, Moldova, Russia;

The spatial segmentation is at NUST3 zones level for EU28, Accession and Neighbouring countries. A less detailed zoning system is used for other European countries (e.g. European Russia, Ukraine). The NUTS3 classification is the most updated version of ETISplus zoning referring to year 2006. In total 1559 zones are used in the model. Additional external zones are defined in order to consider overseas connections for air and maritime transport.

1.2 Model algorithms

The latest version of TRUST model is built in the PTV-VISUM software environment. The assignment algorithm used is Equilibrium Assignment which distributes demand for each Origin/Destination pair among available alternative routes, according to Wardrop's first principle: "*the journey times on all routes actually used are equal and are not greater than those which would be experienced by a single vehicle on any unused route."* In other words, according to Wardrop's principle, the travel times of all used routes between the same origin-destination (OD) pair are equal and minimal. This principle assumes that each traveller is identical, non-cooperative and rational in selecting the shortest route, and knows the exact travel time he/she will encounter. If all travellers select routes according to this principle the road network will be at equilibrium, such that no one can reduce their travel times by unilaterally choosing another route of the same OD pair. This principle has been extended to consider generalised travel cost instead of travel time, where generalised travel cost can include the monetary cost of in-vehicle travel time, tolls, parking charges and fuel consumption costs.

The impedance function is defined in terms of generalised time from an origin O to a destination D. Travel costs are defined separately by link types using combinations of fixed, time-dependent and distance-dependent parameters.

Travel time is estimated endogenously by the model as result of the assignment. Speed-flow functions are used to model the impact of traffic on free-flow speeds, given links capacity.

The model iterates until a pre-defined convergence criterion for equilibrium is reached.

2 Road transport model

The TRUST road model deals with the assignment of road transport O-D matrices for both passenger (cars) and freight (trucks >3.5t).

2.1 Road transport supply

TRUST road transport network builds upon the TRANS-TOOLS and ETISplus road networks with several integrations (e.g. connections between road network and rail network) and updates.

The road network includes all the relevant links between the NUTS3 regions, i.e. motorways, primary roads as well as roads of regional and sub-regional interest. Also ferry connections (Ro-Ro services) between European regions and between European regions and the North Africa are explicitly modelled with their travel time and fare.

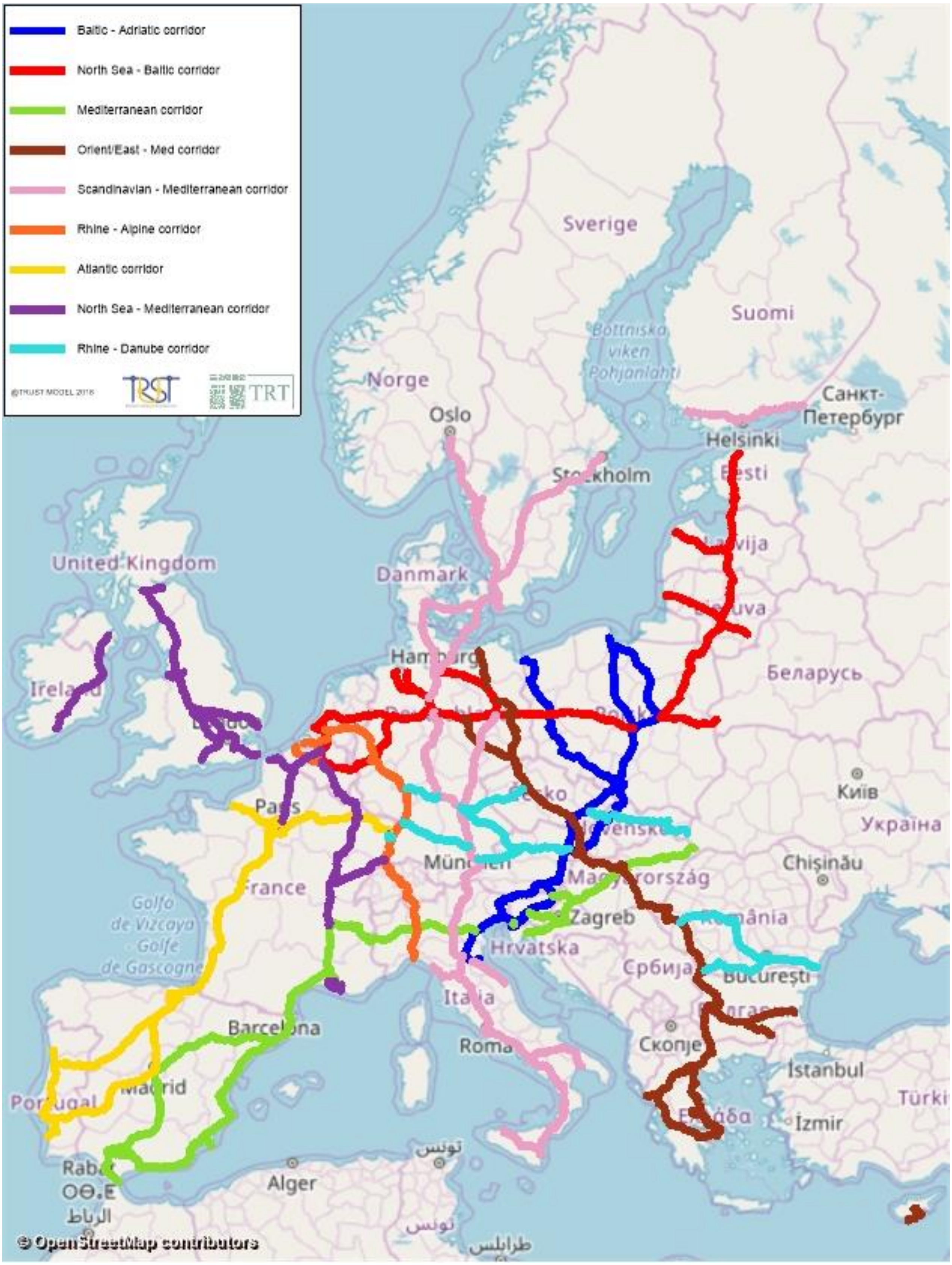
Road network links are separated in different classes, each with specific features in term of capacity, free-flow speed and toll (see below). The link types distinguish different road categories (e.g. motorways). Within the same category link types distinguish roads with other different features, in particular toll level. Specific flags are used to identify links belonging to the Core TEN-T Network, to each TEN-T Corridor and to the comprehensive network. Therefore, results can be provided for these subsets of the network (see Figure 2-1).

A specific attribute identifies to which country each link belongs. This marking allows to implement country-based costs (tolls). The detailed differentiation of link types in EU countries is:

- Motorway (Tolled)
- Motorway (Non tolled)
- Rural with separate directions
- Rural Two Lanes
- Rural Two Lanes No Trucks
- Urban
- Ferries

Figure 2-1: Road Network hierarchy

Figure 2-2: TEN-T Road Corridors



2.2 Road transport demand

Road transport demand is modelled in TRUST by means of origin-destination matrices between NUTS3 zones. Intra-NUTS3 demand is not part of the matrices as it is not assigned to the network, but implicitly considered as pre-load on links. For some non EU countries (e.g. Russia or Ukraine) domestic demand is not part of the matrices.

The passenger matrix includes car trips (coach trips are not modelled) and is segmented into three groups:

- Short distance (< 100 km) commuting
- Short distance (< 100 km) non-commuting
- Long distance (> 100 km)

The freight matrix includes tonnes transported by vehicles above 3.5 tonnes between NUTS3 zones and is segmented into the following demand groups:

- Domestic Short distance (<= 50 km)
- Domestic average distance (50 – 150 km)
- Domestic Long distance (>= 150 km)
- International

This segmentation allows us to apply dedicated parameters (e.g. considering that short distance domestic transport usually is made of lighter trucks than long distance international transport, see below), and to measure the contribution of each segment to link loads.

In addition, each demand group is further divided by considering the origin country, in total, in 242 flows. This allows the differentiation of fuel costs among countries of origin.

Base year matrices are based on those estimated in the ETISplus project. Revisions have been applied to these matrices to update the base year from 2010 to 2017 (i.e. to match Eurostat statistics on road traffic for later years). For forecasting purposes, future matrices are estimated exogenously by applying demand growth rates taken from available sources (e.g. EU Energy and transport trend, ASTRA model, etc.).

2.3 Main parameters

Apart the features of the network links (speed, capacity, etc.), the main parameters used in the TRUST road model are: Speed-flow functions; Transport costs by mode; Values of travel time; Average fuel consumption and emission factors.

2.3.1 Speed-flow functions

Speed-flow functions in TRUST are used to simulate congestion on road links. Since the model assigns daily matrices the speed-flow curves implemented as attributes of the road links are adjusted to take into account that congestion is more hardly recognisable if demand and supply are compared on a 24 hour basis.

Speed-flow functions depends on link type, speed and flow/capacity ratio. Currently implemented capacity restraint function is suitable for all day road type and is shown in figure 2-2. Parameters are different by road type.

Volume-daily functions are as follows:

$$t_{cur} = \begin{cases} t_0 \cdot \left(1 + a \cdot \ sat^b\right), & sat \leq sat_{crit} \\ t_0 \cdot \left(1 + a \cdot \ (sat_{crit})^b\right) + \ a \cdot b \cdot t_0 \cdot (sat_{crit})^{b-1} \cdot (sat - (sat_{crit}) \ , & sat > sat_{crit} \end{cases}$$

Where:

sat – volume /capacity ratio $\left[sat = \frac{q}{q_{max} \cdot c}\right]$

$sat_{crit} - Degree\ of\ saturation\ at\ which\ the\ linear\ section\ of\ the\ volume - delay\ function\ starts$

$t_{cur} - Current\ travel\ time\ on\ a\ network\ object\ in\ loaded\ network$

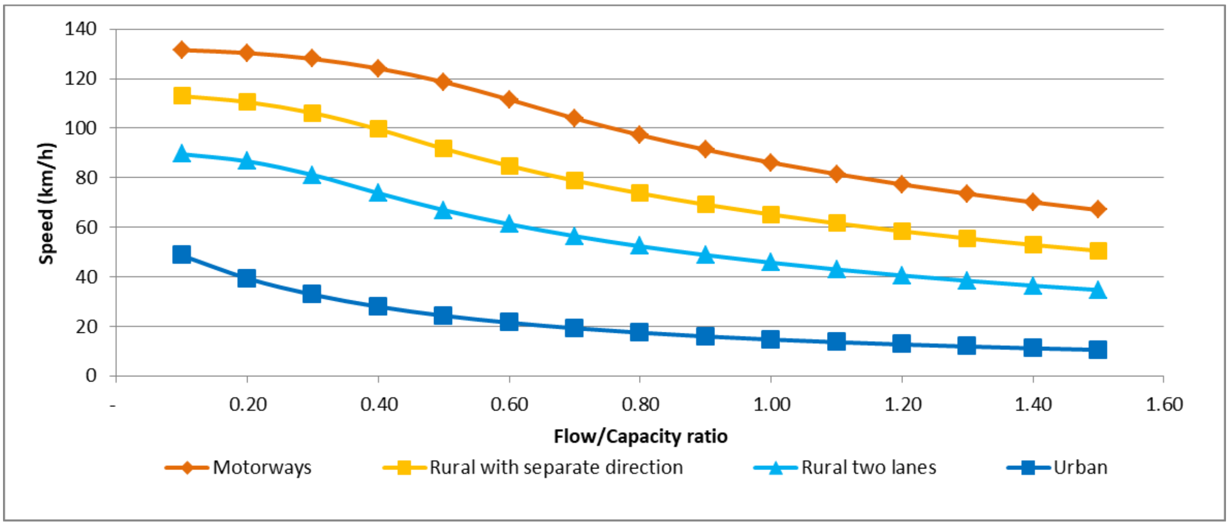
$t_0 - Travel\ time\ on\ a\ network\ object\ with\ free\ flow\ time$

$q - current\ traffic\ volume$

$q_{max} - capacity$

$a, b, c - user - defined\ parameters$

Figure 2-3: Trend of the curves by different link types of the road network



Source: TRT elaboration

2.3.2 Load factors

Matrices are in terms of trips or tonnes in an average day (24 hours). Trips and tonnes are endogenously translated into vehicles loaded onto the road network by means of average occupancy and load factors (see Table 2-1).

Table 2-1: Occupancy / Load factors in the TRUST road model

Demand segment	Occupancy factor / Load factor
Passenger	
Short distance (< 100 km) commuting	1.5 pers/veh
Short distance (< 100 km) non-commuting	1.8 pers/veh
Long distance (> 100 km)	1.9 pers/veh
Freight	
Domestic Short distance (<= 50 km)	4 t/veh (empty trips are considered)
Domestic average distance (50 – 150 km)	10 t/veh (empty trips are considered)
Domestic Long distance (>= 150 km)	10 t/veh (empty trips are considered)
International	14 t/veh (empty trips are considered)

2.3.3 Cost parameters

2.3.3.1 Car cost function

The car cost function reflects the variable operating costs relevant for route choice, i.e. basically fuel and toll costs. Tolls are coded on relevant link types and are always expressed in terms of kilometric cost. When the toll is applied on a different basis (e.g. an annual vignette) assumptions are used (e.g. representative annual kilometres run on tolled roads) to derive an average cost per km.

Operating costs are also coded as kilometric cost and depend on the total distance irrespective of the specific route. Fuel costs are differentiated among countries and are based on the ASTRA model results (Table 2-2).

Table 2-2: Car cost function parameters in the TRUST model (€/vkm)

Country	Short distance demand segment	Long distance demand segment
AT	0.09	0.09
BE	0.08	0.08
DK	0.10	0.11
ES	0.09	0.09
FI	0.09	0.10
FR	0.08	0.08
UK	0.10	0.10
DE	0.08	0.08
EL	0.12	0.12
IE	0.10	0.10
IT	0.08	0.08
NL	0.11	0.11
PT	0.09	0.09
SE	0.10	0.10
BG	0.07	0.07
CH	0.10	0.10
CY	0.10	0.10
CZ	0.08	0.08
EE	0.08	0.08
HU	0.09	0.09
LV	0.08	0.08
LT	0.06	0.06
MT	0.10	0.10
NO	0.10	0.10
PL	0.07	0.08
RO	0.09	0.09
SI	0.08	0.08
SK	0.09	0.09
LU	0.09	0.09
HR	0.09	0.09
Average (used for Extra-EU countries)	0.09	0.09

Source: ASTRA model

2.3.3.2 Truck cost function

Also for trucks cost functions include tolls and variable costs. Again, tolls are transformed into a kilometric cost if the system applied is based on fixed fares. For Switzerland, where the actual toll depends on the EURO standard of the truck and the weight transported, further assumptions are used to derive an average cost per km. Tolls are different across freight demand segment to reflect that lighter vehicles are used on short distances (domestic < 150km) and heavy vehicle are more used on long distances (domestic >150km & international).

Truck variable costs include fuel consumption and labour costs both expressed in €/vkm. Operating costs are differentiated across freight demand segments to reflect that lighter vehicles are mainly used on short distances and heavy vehicle are more used on long distances. Both fuel costs and labour costs are differentiated among countries and are based on the ASTRA model results (**Errore. L'origine riferimento non è stata trovata.**Table 2-3).

Table 2-3: Truck cost function parameters in the TRUST model (€/vkm)

Country	Fuel Costs			Labour Costs	Operating Costs (Fuel + Labour)		
	Domestic Short distance (<=50km)	Domestic average and long distance (>=50km) demand segment	International demand segment		Domestic Short distance (<=50km)	Domestic average and long distance (>=50km) demand segment	International demand segment
AT	0.22	0.47	0.50	0.48	0.70	0.95	0.98
BE	0.21	0.48	0.58	0.46	0.68	0.95	1.04
DK	0.24	0.45	0.50	0.48	0.72	0.93	0.97
ES	0.22	0.47	0.49	0.34	0.56	0.82	0.83
FI	0.30	0.44	0.50	0.46	0.77	0.91	0.97
FR	0.17	0.35	0.41	0.54	0.72	0.89	0.95
UK	0.25	0.66	0.70	0.56	0.81	1.22	1.25
DE	0.15	0.29	0.36	0.46	0.61	0.75	0.82
EL	0.23	0.41	0.50	0.36	0.58	0.76	0.86
IE	0.22	0.35	0.37	0.57	0.79	0.92	0.94
IT	0.17	0.41	0.51	0.47	0.65	0.89	0.99
NL	0.16	0.38	0.42	0.46	0.63	0.85	0.88
PT	0.13	0.28	0.31	0.34	0.48	0.63	0.66
SE	0.24	0.46	0.51	0.46	0.71	0.92	0.98
BG	0.22	0.36	0.45	0.24	0.45	0.60	0.69
CH	0.25	0.55	0.63	0.47	0.72	1.02	1.10
CY	0.17	0.33	0.55	0.35	0.53	0.69	0.91
CZ	0.17	0.34	0.43	0.24	0.41	0.58	0.67
EE	0.24	0.34	0.42	0.23	0.47	0.57	0.65
HU	0.18	0.40	0.48	0.24	0.42	0.64	0.72
LV	0.26	0.35	0.36	0.24	0.50	0.59	0.60
LT	0.28	0.31	0.34	0.23	0.51	0.53	0.57
MT	0.23	0.44	0.55	0.34	0.57	0.78	0.89
NO	0.20	0.44	0.48	0.48	0.68	0.92	0.96
PL	0.21	0.34	0.42	0.23	0.44	0.56	0.65
RO	0.22	0.36	0.47	0.24	0.46	0.60	0.70
SI	0.22	0.36	0.38	0.34	0.57	0.70	0.73
SK	0.25	0.33	0.37	0.25	0.50	0.58	0.62
LU	0.24	0.40	0.42	0.47	0.71	0.88	0.89
HR	0.29	0.34	0.38	0.34	0.63	0.68	0.72
Average (used for Extra-Eu countries)	0.22	0.40	0.46	0.38	0.60	0.78	0.84

Source: ASTRA model

2.3.4 Value of travel time

Value of travel time is used to transform travel time into a monetary equivalent. It is coded in terms of EUROs/hour-trip or EUROs/hour-tonne. Values of time implemented in TRUST (see **Errore. L'origine riferimento non è stata trovata.** and **Errore. L'origine riferimento non è stata trovata.**) are based on the SCENES experience and on more recent literature (e.g. HEATCO).

Table 2-5: Road passenger values of time in the TRUST model (EUROs/hour-trip)

Country	Short distance commuting	Short distance non-commuting	Long distance
AT	7.8	8.3	11.9
BE	7.4	8.0	11.4
DK	8.2	8.9	12.9
ES	8.1	8.3	11.9
FI	7.3	8.0	11.8
FR	10.6	10.6	14.9
UK	8.1	8.6	12.4
DE	7.8	8.3	11.8
EL	6.6	6.7	9.7
IE	8.0	8.7	13.3
IT	9.6	9.6	13.8
NL	7.4	8.1	11.6
PT	6.3	6.6	9.4
SE	7.9	8.6	12.6
BG	2.9	3.0	4.6
CH	10.6	11.1	15.9
CY	7.4	7.6	14.0
CZ	5.4	5.4	7.6
EE	4.7	4.7	7.3
HU	4.7	4.8	6.8
LV	4.3	4.3	6.5
LT	4.2	4.2	6.4
MT	5.9	6.3	11.5
NO	12.2	12.9	18.7
PL	4.7	4.7	6.6
RO	2.8	2.8	4.4
SI	7.8	7.6	10.6
SK	4.2	4.3	6.3
LU	11.5	12.1	17.2
HR	4.6	4.8	6.9
AL	1.8	1.8	2.6
BA	2.0	2.1	3.0
BY	0.8	0.9	1.3
LI	10.6	11.1	15.9
MD	0.2	0.2	0.3
ME	2.5	2.6	3.7
MK	2.3	2.4	3.5
RS	2.6	2.7	3.8
RU	2.8	2.9	4.1
TR	3.4	3.5	5.0
UA	0.4	0.5	0.7
XK	0.8	0.8	1.2

* Estimation based on Eurostat data (GDP per capita in PPS index)
Source: TRT elaboration on ASTRA model values based on HEATCO (D5)

Table 2-6: Road freight values of time in the TRUST model (EUROs/hour-tonne)

Country	Domestic Short distance (<= 50 km)	Domestic average distance (50 – 150 km)	Domestic Long distance (>= 150 km)	International
AT	4.6	7	7	6
BE	4.2	6.4	6.4	5.4
DK	4.5	6.8	6.8	5.8
ES	3.6	5.3	5.3	4.3
FI	4.2	6.3	6.3	5.3
FR	3.9	5.8	5.8	5
UK	3.9	5.8	5.8	4.8
DE	4.3	6.5	6.5	5.5
GR	3	4.4	4.4	4
IE	4.6	6.9	6.9	5.9
IT	3.6	5.5	5.5	4.5
NL	4.7	7.1	7.1	7.1
PT	2.8	4.2	4.2	4
SE	4.5	6.8	6.8	6.5
BG	1.6	2.4	2.4	2.2
CH	5.4	8.2	8.2	8
CY	3.3	5.0	5.0	5
CZ	2.9	4.3	4.3	4
EE	2.4	3.6	3.6	3.2
HU	2.4	3.6	3.6	3.2
LV	2.1	3.1	3.1	3.1
LT	2.2	3.3	3.3	3.3
MT	3.0	4.5	4.5	4.5
NO	6.8	10.2	10.2	10.2
PL	2.3	3.5	3.5	3.5
RO	1.8	2.6	2.6	2.6
SI	3	4.5	4.5	4
SK	2.6	3.9	3.9	3.2
LU	9.9	14.8	14.8	14.8
HR	2.2	3.3	3.3	3
MK	1.3	1.9	1.9	1.9
TR	1.9	2.8	2.8	2.8
LI	5.4	8.2	8.2	8
AL	1.1	1.7	1.7	1.7
BA	1.0	1.6	1.6	1.6
RS	1.3	1.9	1.9	1.9
XK	0.7	1.0	1.0	1
BY	0.8	1.1	1.1	1.1
RU	2.5	3.7	3.7	3.2
UA	0.6	0.9	0.9	0.9
AD	3.5	5.3	5.3	5

Source: TRT elaborations on Value of Time and on Eurostat data on GDP per capita

2.3.5 Fuel consumption and emission factors

Fuel consumption and emissions factors for road modes build on COPERT IV functions but with a relevant modification. Basically, the convex form of the COPERT function has been modified to consider that in real traffic conditions average speeds (the assignment model provides average speeds) are most likely the result of repeated stop-and-go. An average speed of e.g. 70 km/h on motorways means that there is more traffic than when average speed is 110 km/h so one should expect more fuel consumption rather than less fuel consumption as implied by original COPERT functions.

Since COPERT functions are different by vehicle type, an average fleet composition is considered to derive the parameters used in TRUST. When the model is run for forecasting purposes for future years, the emission factors are updated considering projections regarding the evolution of fleet in the selected year.

2.3.5.1 Fuel consumption functions

The fuel consumption functions estimated on driving tests (e.g. COPERT functions) are often unsuitable for estimating emissions from modelling assignment. In those curves emissions decrease with speed until a certain point. The modelled speed measured on links is decreasing when congestion rises and it is also lower on local road links than on motorway links. However, when congestion rises fuel consumption is expected to increase, because of the driving cycle (acceleration and deceleration), rather than decrease. For the same reason, travelling on motorways is usually less fuel consuming than travelling on local roads. In order to estimate fuel consumption and emissions in a more consistent way within the TRUST model, some fuel consumption functions were defined on purpose as follows.

Fuel consumption and emissions increases when vehicles accelerate. The more and for the more time a vehicle accelerate and the stronger is the effect on consumption and emissions. At the same time, according to some literature, acceleration is inversely dependent on speed (the higher the speed the less intense is the acceleration). Taking account of these aspects, three relationships were defined.

First, a relationship between speed and acceleration. At a speed of 130 km/h acceleration was supposed to be zero (constant speed at the maximum allowed speed on motorways). For lower speeds the acceleration is higher until the speed of 40 km/h. From the speed of 40 km/h downwards it was supposed that acceleration is again decreasing as in traffic jam there is no chance to accelerate much.

Second, a relationship between acceleration and consumption/emissions. Each level of acceleration corresponds to a certain increase of consumption/emissions with respect to COPERT functions. The level of increase was quantified taking into account some spot data found in literature.

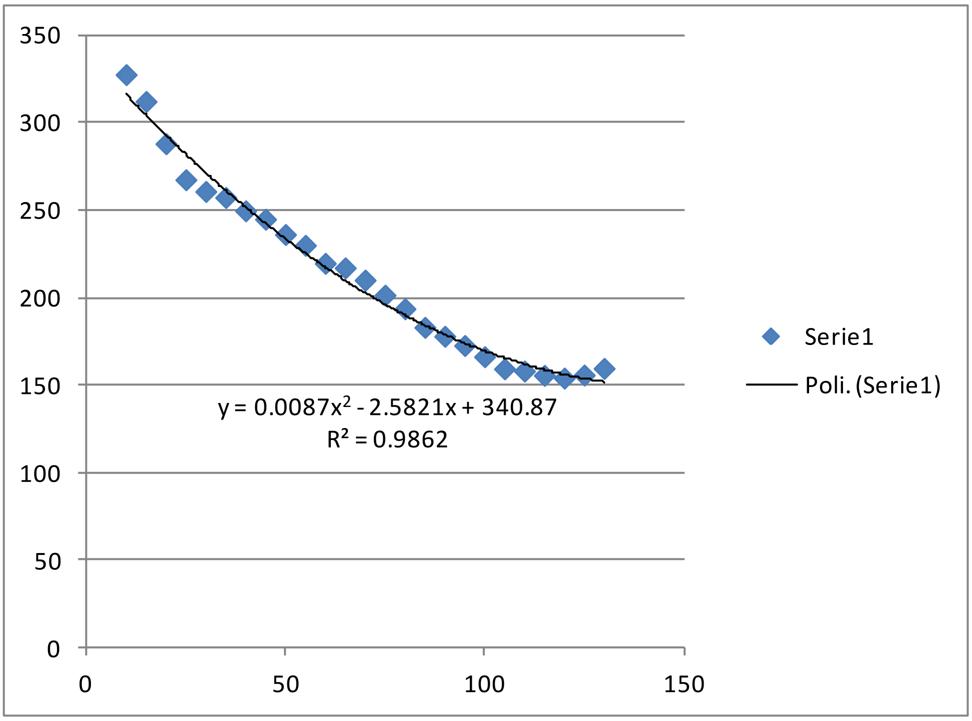
Third, a relationship between speed and the share of travel time in which vehicle is accelerating. It was assumed that for higher speeds this share is lower (when travelling on a motorway with no much traffic there is no much need of decelerating and accelerating) and increases as the speed is reduced until a maximum share of 50% (arbitrary).

Using these three relationships, for each speed a modification factor for the COPERT consumption/emissions values was computed:

$NewEmis_{speed} = [OrigEmis_{speed} * (1 + AccFact_{speed}) * (AccShare_{speed})] + [OrigEm_{speed} * (1 - AccShare_{speed})]$

The resulting values were plotted and interpolated by means of a quadratic function (see Figure 2-4).

Figure 2-4: An example of estimated consumption/emissions function considering acceleration



2.4 Policy scope

The TRUST road model can simulate the policy measures mentioned in Table 3-3:

Table 2-4: Policy measures that can be simulated with the TRUST road model

Measure	Notes
Road charging (e.g. Eurovignette)	Charges can be coded directly if they are based on demand segments described in section 2.2, otherwise average charges based on e.g. fleet composition should be estimated exogenously
Energy taxation	average change of operating cost can be coded according to fleet composition by country
Road infrastructure changes	Changes can consist of new links and improved links. Given the scale of the model, simulation is meaningful for major modifications (e.g. one corridor) rather than for single links.
Speed limits	
Technology – transport information system, management & service	As far as technology is supposed to modify elements like travel speed or link capacity. The entity of the modification should be estimated exogenously
Truck driver regulations	Indirect simulation based on exogenous assumption on expected impact of regulation on driving cost.

2.5 Model output

The TRUST road model provides the following outputs:

- Average daily loads on road links split by demand segment (see section 2.2) and by country of origin[1].
- Road traffic activity (passenger-km, tonnes-km, vehicle-km) per year by country (based on territoriality principle).
- Road traffic activity (passenger-km, tonnes-km, vehicle-km) per year on TEN-T core network and on TEN-T corridors.
- Origin-destination journey time.
- Origin-destination journey (perceived) cost.
- Road accessibility measures by NUTS-III region.
- Origin-Destination Paths.
- Energy consumption by link. This can be aggregated to get results by country (territorial principle), on TEN-T core network and on TEN-T corridors.
- Emissions by link for NOx, PM, VOC, CO and CO2. This can be aggregated to get results by country (territorial principle), on TEN-T core network and on TEN-T corridors.

[1] Origin country is referred to trip, not to vehicle, i.e. international cabotage is not recognised in TRUST.

3 Rail transport model

The TRUST rail model is conceived to assign hypothetical future matrices, provide a rough estimation of how many trains would run on the European network and compare this estimation with a measure of capacity. The structure of the model is therefore designed to describe rail network usage rather than to model rail users decisions.

3.1 Rail transport supply

TRUST adopts a rail transport network based on the TRANS-TOOLS (2005 version 2.5) and ETISplus rail network with several integrations (e.g. connections between road network and rail network, relevant technical information from the ETISplus database.

The rail network includes different link types (see Table 3-1) according to technical elements (number of tracks, electrification, maximum speed allowed, etc.) as drawn from the ETISplus database. Links dedicated to some type of traffic (e.g. High Speed Trains or freight trains) are distinguished as well as links where some types of train are not allowed.

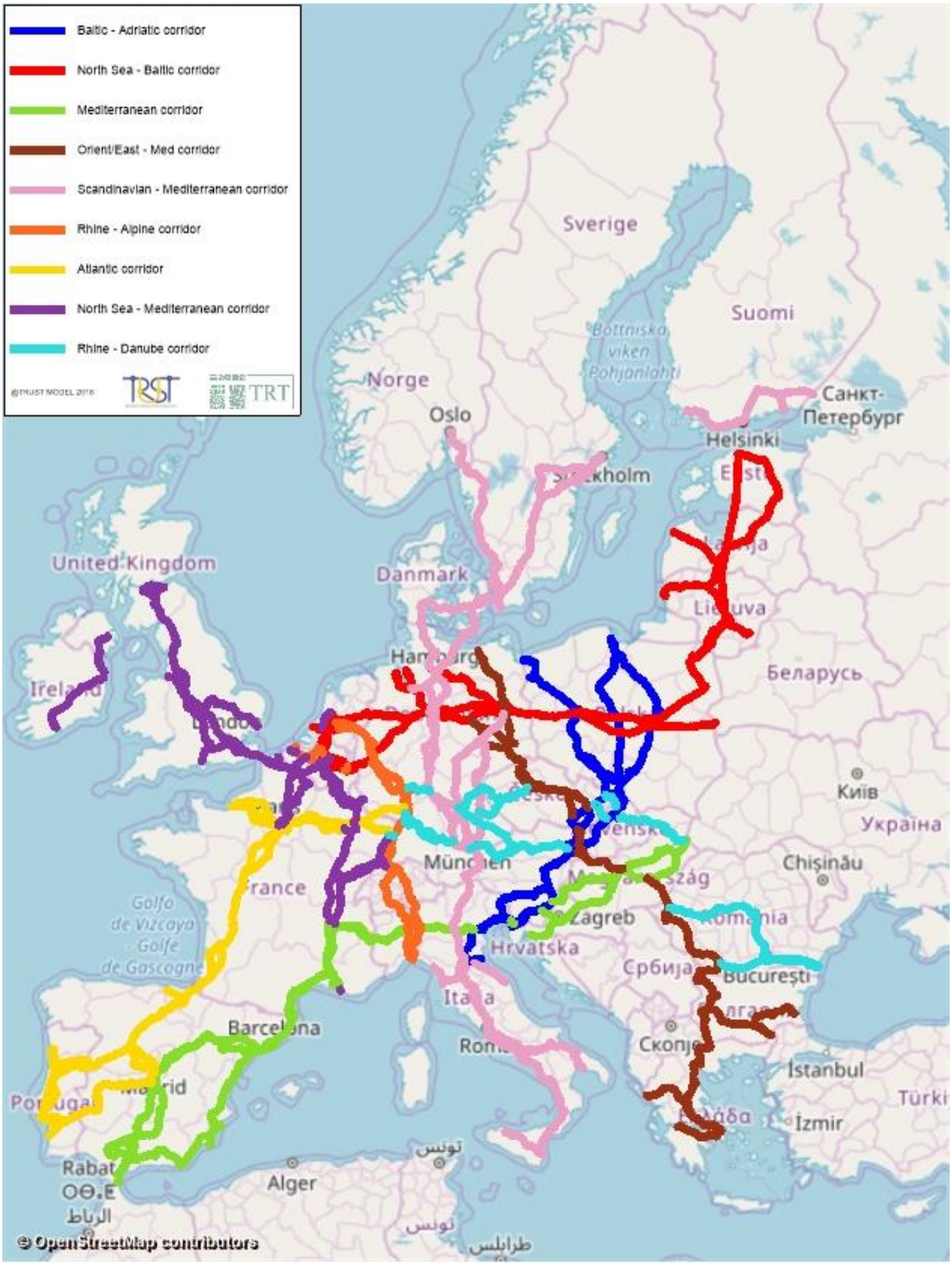
Specific flags are used to identify links belonging to the Core TEN-T Network, to each Corridor and to the comprehensive network. Therefore, results can be provided for these subsets of the network (see Figure 3-1).

The rail network is linked to the road network as intermodal transport is modelled (see below).

Table 3-1: Link types in the TRUST rail network

Link type	Description
Conventional local rail links for the passenger transport	Only regional trains are allowed
Conventional local rail links for both passenger and freight transport	Only regional trains and freight trains are allowed
Conventional long distance rail links for the passenger transport	Both regional and intercity trains are allowed. (Ten-T Corridors and Core Non Corridor Network have dedicated link types)
Conventional long distance rail links for both passenger and freight transport	Both regional and intercity trains and freight trains are allowed. (Ten-T Corridors and Core Non Corridor Network have dedicated link types)
Conventional railway links only for the freight transport	Links where passenger trains are not allowed. (Ten-T Corridors and Core Non Corridor Network have dedicated link types)
High speed rail links on the own tracks for both passenger and freight transport	Links can be used also by freight HS trains. (Ten-T Corridors and Core Non Corridor Network have dedicated link types)
High speed rail links on the own tracks only for the passenger transport	Links where freight trains are not allowed. (Ten-T Corridors and Core Non Corridor Network have dedicated link types)
High speed rail links on existing conventional tracks only for passenger transport	Passenger trains like the German ICE trains (or similar) which share the same infrastructure with other trains are allowed. (Ten-T Corridors and Core Non Corridor Network have dedicated link types)
Borders rail links for both passenger and freight transport	An additional time on borders (e.g. due to different rail electrification and staff changes or changes of locomotives etc.) is coded

Figure 3-1: TEN-T Rail Corridors



Rail supply includes intermodal terminals where loads are transferred between road and rail. There are 917 intermodal terminals across the countries covered by the TRUST model as shown in Figure 3-2. Intermodal transport has a direct access to the rail network only if in the zone a terminal is available. Otherwise has to use the road feeder. A conventional freight transport has always a direct access to the rail network.

Figure 3-2: Intermodal terminals in the TRUST rail network

In case of passenger transport the interchange links between local/intercity services and High Speed services and transfer between car feeder and local/intercity services are modelled as well. Regional and intercity passenger transport has always a direct access to the rail network. Instead the High Speed passenger transport can access to the rail network directly only if the HS train station is in the same zone. Otherwise will use regional and IC network to reach High Speed rail.

3.2 Rail transport demand

Given the purpose of the model, demand is segmented according to types of traffic which correspond to different train types in terms of occupancy of rail capacity. For instance, segments based on trip purposes are not used[2], since the route choice to be modelled is that of trains and not of passengers. However, values of travel time reflect that e.g. business trips are made more frequently by High speed rail than by regional trains.

For passenger demand, three segments based on train type are used:

- Regional Trains
- Intercity Trains
- High Speed Trains (or similar, like the German ICE trains)

Regional Trains stop frequently, so their speed is lower and their capacity occupancy higher than Intercity Trains. High Speed Trains at least partially use dedicated tracks. When they share the same infrastructure with other trains, they need a long free stretch of the network given their speed and length. Therefore, their capacity occupancy is high.

For freight trains, two different types are considered:

- intermodal trains,
- conventional trains (conventional block trains or single wagon load trains),

Since UIC statistics suggest that average load of conventional trains is very different across countries, this type is further split into three groups:

- conventional trains 700 tonnes
- conventional train 1200 tonnes
- conventional train 2900 tonnes.

Conventional freight trains originated in one country belong to only one of these three groups.

Base year matrices are based on those estimated in the ETISplus project (ETISPlus 2010 data). The original matrix from the ETISplus project has been distributed among the segment demands of the TRUST model. Results have been compared with respect to the Eurostat statistics on rail traffic (ton-km and pass-km) for later year i.e. 2011). For forecasting purposes, future matrices are estimated exogenously by applying demand growth rates taken from available sources (e.g. EU Energy and transport trend, ASTRA model).

3.3 Main parameters

Matrices are in terms of trips or tonnes in an average day (24 hours). After the assignment, trips and tonnes can be translated into trains by means of average occupancy and load factors (see Table 3-2).

Beside occupancy and load factors, the other parameters used in the TRUST rail model are the attributes of the links coded in the network.

Table 3-2: Occupancy / Load factors in the TRUST rail model

Demand segment	Occupancy factor / Load factor
Passenger trains	
Regional trains	415 pass/train

[2] Information on trip purposes, e.g. as reported by the ETISplus matrices, can be useful to estimate the number of passengers travelling on different train types (e.g. assuming that most of commuters use regional trains while business trips are more on faster trains) but are not directly used in the TRUST model.

Intercity trains	490 pass/train
High Speed Trains	490 pass/train
Freight trains	
Intermodal trains	700 tonnes/train
conventional trains 700 tonnes	700 tonnes/train
conventional train 1200 tonnes	1,200 tonnes/train
conventional train 2900 tonnes	2,900 tonnes/train

3.4 Policy scope

The TRUST rail model can simulate the policy measures described in Table 3-3:

Table 3-3: Policy measures that can be simulated with the TRUST rail model

Measure	Notes
Infrastructure charging	Charges can be coded directly if they are based on demand segments described in section 3.2, otherwise average charges should be estimated exogenously
Rail infrastructure changes	Changes can consist of new links and improved links. Given the scale of the model, simulation is meaningful for major modifications (e.g. one corridor) rather than for single links.
Technology – transport information system, management & service	As far as technology is supposed to modify elements like travel speed or link capacity. The entity of the modification should be estimated exogenously

3.5 Model output

The TRUST rail model provides the following outputs:

- Average daily loads on rail links split by demand segment (see section 3.2).
- Rail traffic activity (passenger-km, tonnes-km) per year by country (based on territoriality principle).
- Rail accessibility measures by NUTS-III region

4 Maritime transport model

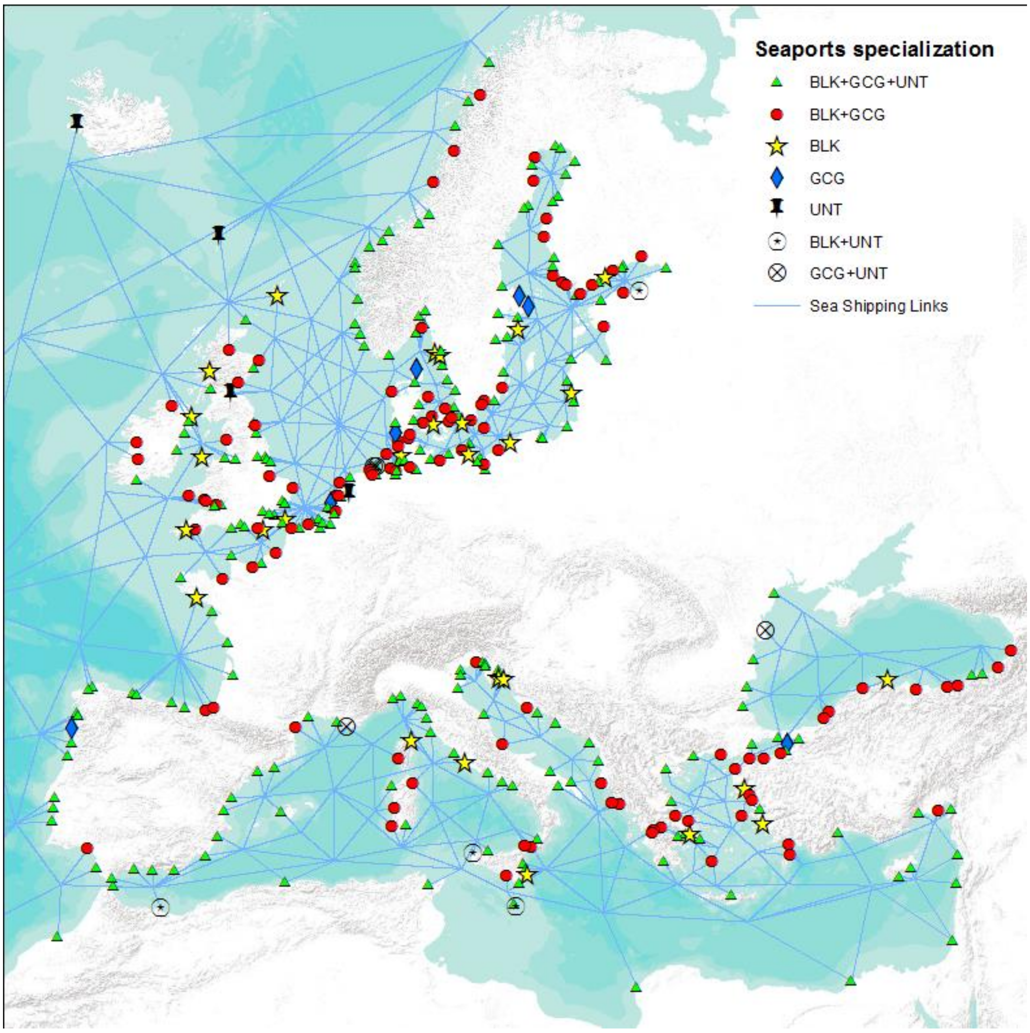
The TRUST maritime model has been developed building on the work done for the ESPON TRACC project. In that project a network model to estimate travel time and cost of maritime transport was implemented in order to compute freight accessibility indicators for NUTS3 zones in Europe. The O/D matrix of freight transport was added later to use the model for the analysis of EU ports.

4.1 Maritime transport supply

The maritime network includes several ports throughout Europe. Notional maritime links provide sea routes to link ports and allows the model to compute travel distances of maritime connections. Using these links each port is at least in principle linked to each other.

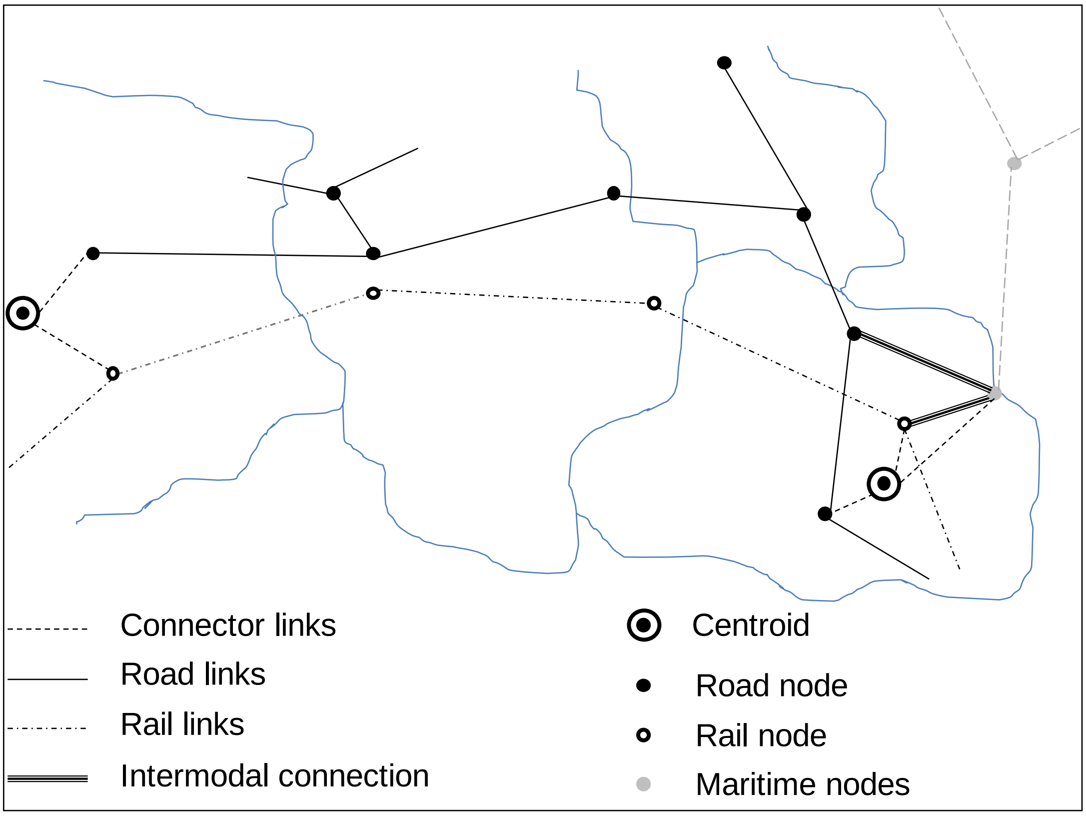
Maritime ports are classified into three categories: bulk (BLK) ports, container (UNT) ports and general cargo (GCG) ports. Most of the ports belong to more than one category but some ports have only one or two specialisation. These ports can host only demand for that or those freight segments (e.g. if one port is classified only as a bulk port, routes for general cargo and container demand cannot go through that port) (see Figure 4-1).

Figure 4-1: Seaports and sea routes in the TRUST maritime network



The main characteristic of the network is that there is no direct access to ship mode in zones without ports. The ship mode has to access through feeder (truck, rail or inland waterway according to existing infrastructures). As a consequence, rail and road networks are also used in the TRUST maritime model as well as inland waterways because trains, barges and trucks are used as feeder modes to connect internal zones with ports and allow the definition of full path between true origin and final destination of freight. So also connections between ports and inland networks are part of the network (see example in Figure 4-2).

Figure 4-2: Intermodal connection at ports in the TRUST maritime network



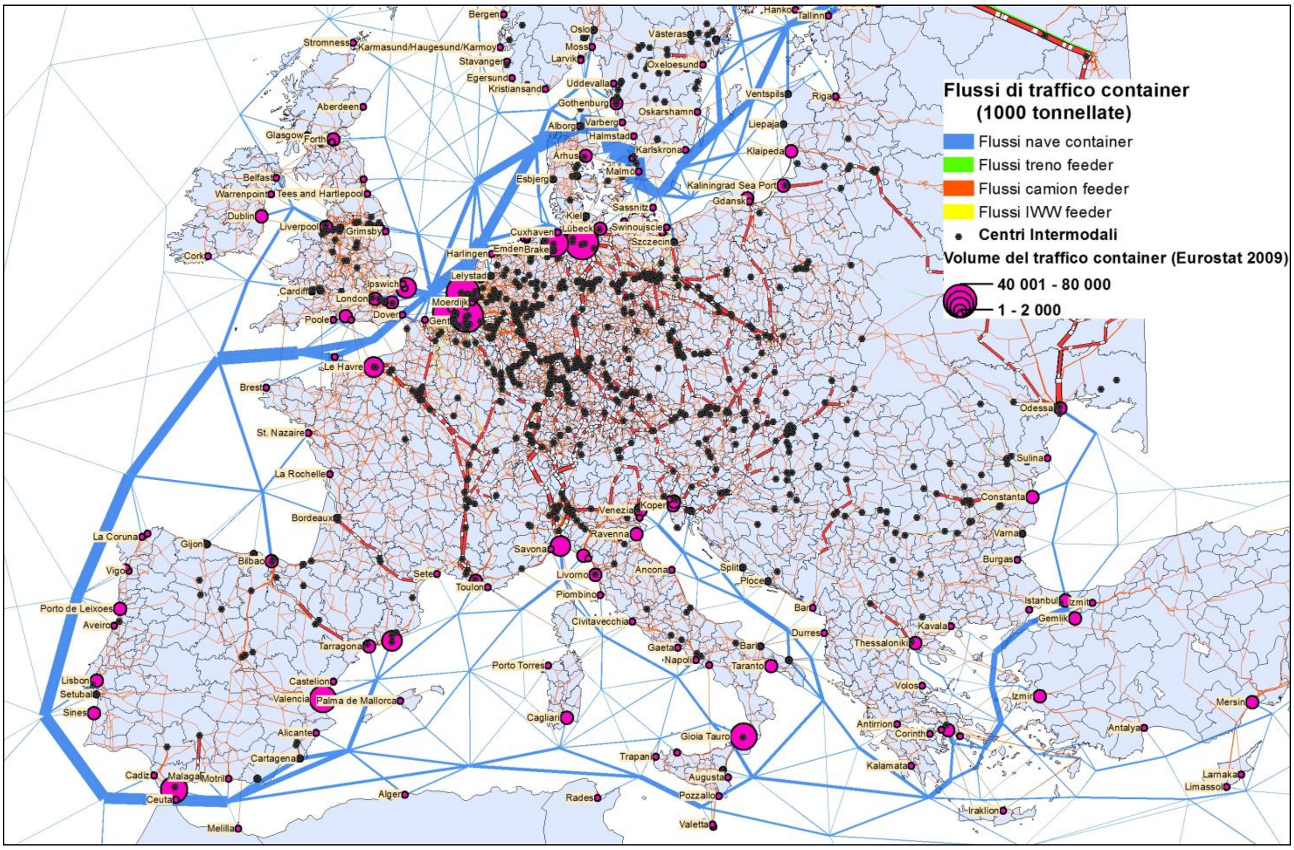
4.2 Maritime transport demand

Maritime demand consists of Origin-Destination matrices segmented according to the three freight categories of bulk, container and general cargo. Matrices are in terms of thousand tonnes per year. Each segment of demand has its autonomous matrix that is assigned independently to the network.

Base year matrices are based on those estimated in the WorldNet OD matrix[3] and then updated using Eurostat and DG MOVE statistics.

[3] WORLDNET – Worldwide Cargo Flows – was a research project funded by the European Commission

Figure 4-3: Example of TRUST maritime network links load (tonnes per year)



4.3 Main parameters

Beside occupancy and load factors, the other parameters used in the TRUST maritime model are the attributes of the links coded in the network.

The parameters functions presented in the following table have been estimated based on the cost and time functions for the TRANS TOOLS freight modal-split model, the ASTRA and TREMOVE models and the COMPETE project. The cost of intermodal transfer is 3 euro/ton.

Table 4-1: Average costs of maritime transport

Cargo type	Fixed / Variable cost	Sea mode	Road feeder	Rail feeder	Inland waterways feeder
average fixed costs					
UNT	Fixed cost €/ton	34.81	-	18.85	13.50
GCG	Fixed cost €/ton	41.61	-	27.82	25.43
BLK	Fixed cost €/ton	26.05	-	9.15	10.33
average variable + energy costs					
UNT	Variable cost €/km	0.007	0.043	0.016	0.025
GCG	Variable cost €/km	0.007	0.048	0.020	0.026
BLK	Variable cost €/km	0.008	0.048	0.022	0.036

The values of time in the maritime TRUST model are the following:

- UNT: 0.8 €/h per ton
- GCG: 0.4 €/h per ton

- BLK: 0.2 €/h per ton

The following tables present the times to access directly to transport zone (differentiated by the network modes) and the types of intermodal transfer implemented in the maritime TRUST model.

Table 4-2: Average times in maritime ports operations

Cargo Type	Average time of loading/unloading + waiting time (in hours)			
	SHIP mode	ROAD feeder	RAIL feeder	IWW feeder
BLK	34.84	1.71	19.10	29.53
GCG	28.78			
UNT	28.59		16.01	

Table 4-3: Intermodal transfer

Type of intermodal transfer	Time (h)	Cargo type	Comments
Rail-intermodal logistic centre (only UNT)	**16.01**	UNT	Average time for LOADING and UNLOADING (+ waiting)
Road-intermodal logistic centre (only UNT)	**1.23**	UNT	Average time for LOADING and UNLOADING (without waiting)
Ship_GCG to ROAD	**22.95**	GCG	load + unload + waiting
Ship_UNT to ROAD*	**22.92**	UNT	load + unload + waiting
Ship_BLK to RAIL	**35.26**	BLK	load + unload + waiting
Ship_GCG to RAIL	**50.07**	GCG	load + unload + waiting
Ship_UNT to RAIL	**37.16**	UNT	load + unload + waiting
Ship_BLK to IWW	**42.48**	BLK	load + unload + waiting
Ship_GCG to IWW	**41.06**	GCG	load + unload + waiting
Ship_UNT to IWW	**41.11**	UNT	load + unload + waiting

* should be noted that no transfer from Ship_BLK to ROAD is assumed

4.4 Policy scope

The TRUST maritime model can simulate the policy measures listed in the following table.

Table 4-4: Policy measures that can be simulated with the TRUST maritime model

Measure	Notes
Infrastructure charging	As far as ports can be charged
Technology – transport information system, management & service	As far as technology is supposed to modify costs or times at ports. Modification should be estimated exogenously
Port regulations	As far as regulation is supposed to modify costs or times at ports. Modification should be estimated exogenously

4.5 Model output

The TRUST maritime model provides the following outputs:

- Seaport throughput (tonnes) per year by port and cargo type (container, bulk, other)
- Share of feeder modes transporting freight to/from seaports
- Maritime accessibility measures by NUTS-III region