DESCRIPTION OF THE TRUST (European transport network model) MODEL

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Introduction

TRUST (TRansport eUropean Simulation Tool) is a transport network model developed by TRT for mode choice and 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 27 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. Other applications of the model include the forecast of long-distance rail passenger and freight traffic on behalf of railway network managers and service undertakings.

This technical note provides a description of the TRUST model and is organised as follows: Chapter 1 presents the general features of the model, while Chapters 2 to 6 illustrate in detail respectively the modal split module, the road, rail, maritime and inland waterway modes of transport.

A bit of history of the model

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). The SCENES transport model data was also the source of the baseline feeding 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 project, that provided a set of data including networks, matrices, traffic counts, etc. to serve for the development of transport modelling at the European level. The initial version of the TRUST model was used also in the context of the TRACC project within the ESPON framework. The rail component was further developed in the context of the Living Rail project. The mode split part was added later. Originally developed under MEPLAN software, since 2017 The TRUST model is based on PTV VISUM software.

1 General features of the TRUST model

In its current version, TRUST is a network-based transport model for mode choice and assignment of passenger and freight Origin-Destination matrices.

TRUST covers:

- The 27 EU Member States;
- 8 Candidate and potential candidate countries: Western Balkans (Serbia, FYROM, Albania, Bosnia and Herzegovina, Kosovo, Montenegro), Turkey, Iceland;
- 7 Other EU bordering countries: United Kingdom, Norway, Switzerland, Belarus, Ukraine, Moldova, Russia.

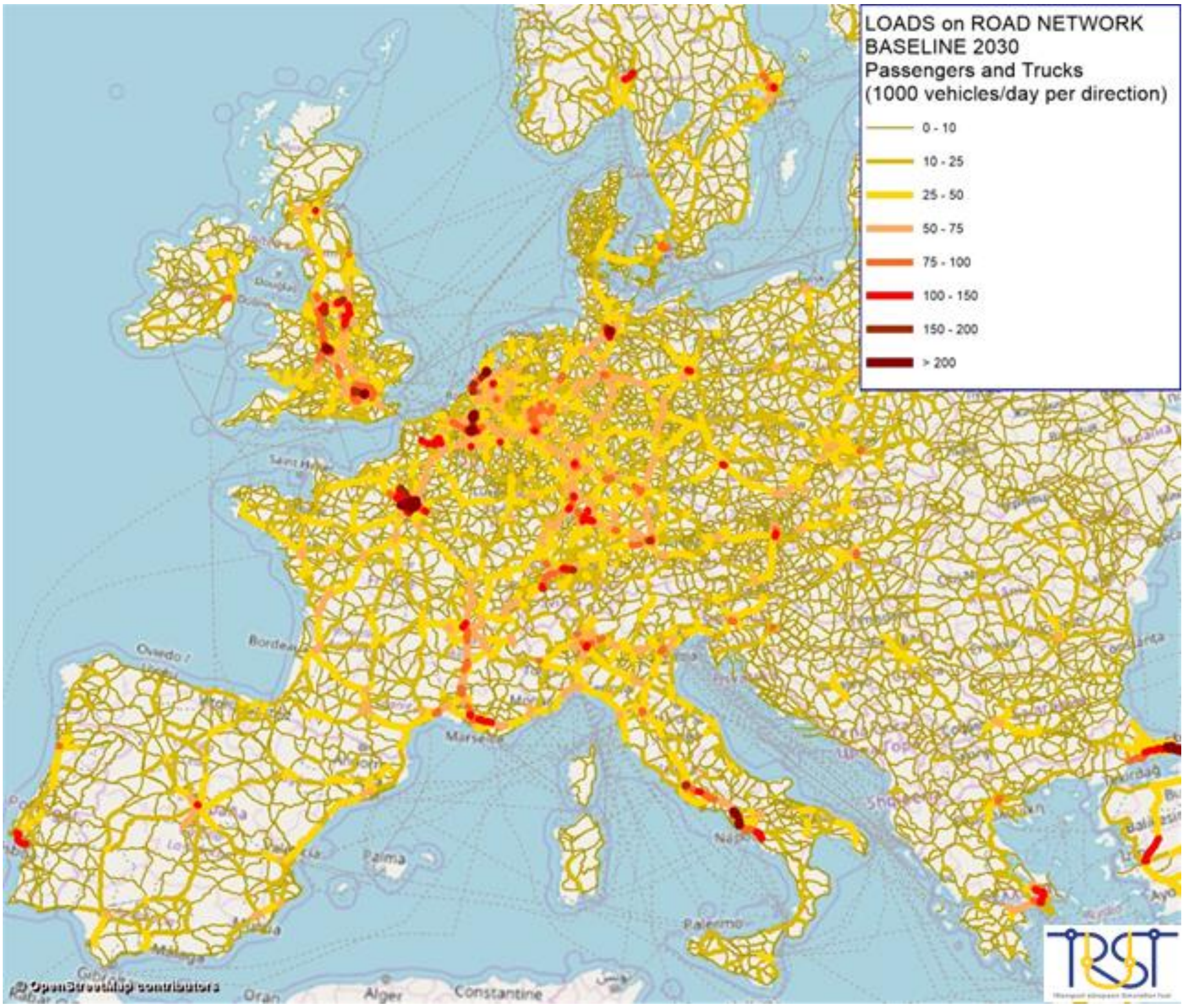
The spatial segmentation is at NUST3 zones level for EU27, Accession and Neighbouring countries. A less detailed zoning system is used for other European countries (e.g., European Russia, Ukraine). In total 1559 zones are used in the model. Additional external zones are defined to consider overseas connections for maritime transport.

The main outputs of TRUST are:

- Loads on road network links in terms of vehicles per day (see example in Figure 1-1 below) and on non-road links in terms of either trips or tonnes per day.
- Overall transport activity along road and non-road links belonging to the TEN-T networks (separately for core and comprehensive TEN-T).
- Modal split by country based on passengers-km or tonnes-km.

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, which is not assigned to the network.

Figure 1-1: An example of road transport assignment



2 Modal split module

The TRUST model performs modal split for both passengers and freight demand. The modal split module is designed to interact with the modal modules described in the following sections. Since different demand segments are defined in each module, the modal split phase is managed for a set of overarching segments, which result from aggregation and disaggregation of those of the modules.

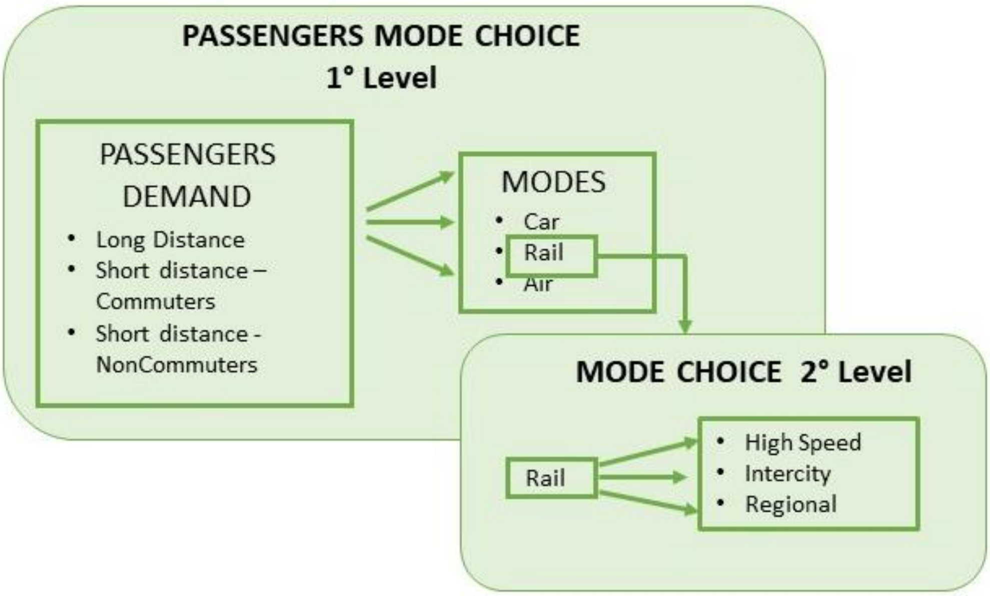
2.1 Passenger demand modal split

The modal split for passenger is carried out separately for short-distance trips (< 100 km) and for long-distance trips (> 100 km).

For both short-distance and long-distance, the mode choice algorithm is a nested logit. At a first level of choice, short-distance passengers can choose between Car and Rail while long-distance passengers can choose among Car, Rail and Air. Air is a very important alternative for long-distance trips. For this reason, although TRUST does not include an air module, the mode Air is included in the choice set. While for Car and Rail, the variables used in modal split algorithm are taken from the related assignment modules, for Air these variables are generated off-model and imported.

Then, there is a second level of choice where long-distance passengers travelling by rail can choose between High Speed and Conventional Intercity trains while short-distance passengers travelling by rail can choose between conventional Intercity trains and regional trains. Figure 2-1 show the scheme of the passengers' modal split.

Figure 2-1: Passengers modal split scheme



Source: TRUST model

At both levels, the choice algorithm has the form:

$$ {}^{m}_{p}f(T_{ij}) = \frac{e^{-\mu[{}^{m}_{p}GT_{ij}]}}{\sum_{m} e^{-\mu[{}^{m}_{p}GT_{ij}]}} \quad \{i \neq j\} \qquad \textbf{(2-1)} $$

Where:

$_{p}^{m}f(T_{ij})$ = share of trips of demand segment p between origin zone i and destination zone j made by transport mode m

$_{p}^{m}GT_{ij}$ = generalised time for travelling between origin zone i and destination zone j by mode m for demand segment p

μ = scale parameter of the logit algorithm

Generalised time $_{p}^{m}GT_{ij}$ is the element determining the share of each transport mode: the lower is generalised time, the higher the share of the mode. Generalised time is computed according to the following equation:

$$_{p}^{m}GT_{ij} = {}_{p}^{m}TT_{ij} + \frac{_{p}^{m}TC_{ij}}{_{p}VOT_{c}} + {}_{p}^{m}ASC_{ij} \quad \{i \in c\} \qquad \textbf{(2-2)}$$

Where:

$_{p}^{m}TT_{ij}$ = Travel time between origin zone i and destination zone j using mode m for demand segment p

$_{p}^{m}TC_{ij}$ = Travel cost between origin zone i and destination zone j using mode m for demand segment p

$_{p}VOT_{c}$ = value of travel time for demand segment p in country c

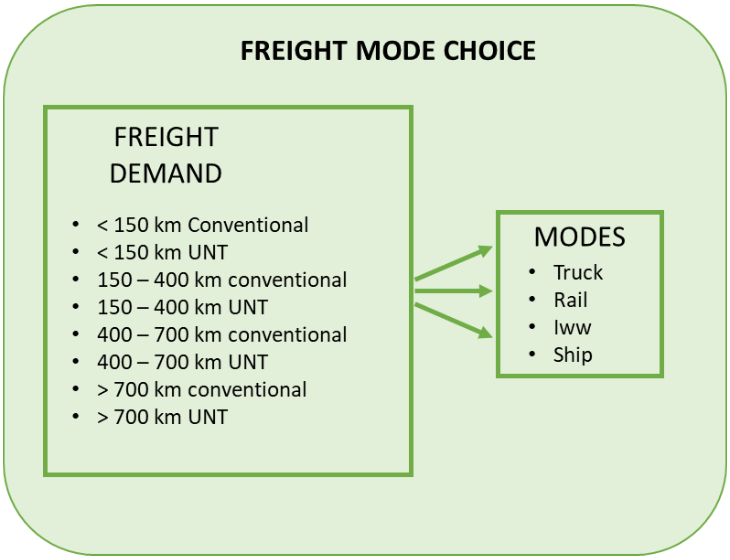
$_{p}^{m}ASC_{ij}$ = Alternative Specific Constant for mode m and demand segment p on the origin-destination pair between i and j. These parameters result from the calibration of the mode choice model.

At the higher level of the nested structure, the generalised time of rail is not computed according to (2-2) but as logsum of the generalised times of the rail services considered at the lower level.

2.2 Freight demand modal split

For freight demand, modal split estimates choice among road, rail, inland navigation and maritime. The algorithm is again a Logit one fed with generalised time computed on times and costs provided by the assignment modules. The calculation is made for different demand segments defined by crossing load type (unitised and conventional) and four distance bands. Figure 2-2 shows the scheme for freight modal split

Figure 2-2: Freight modal split scheme



Source: TRUST model

3 Road transport module

The TRUST road module deals with the assignment of road transport O/D matrices for both passenger (cars) and freight (trucks >3.5t). An equilibrium assignment algorithm is applied.

3.1 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 (including the latest classification of the TEN-T network).

The road network includes all the relevant links between the NUTS3 regions: motorways, primary roads as well as roads of regional and sub-regional interest. 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). Link types are used to distinguish different road categories (e.g. motorways). Specific flags are used to identify links belonging to the Core TEN-T Network, to each TEN-T Corridor and to the comprehensive network according to the TEN-T Regulation 2024. Therefore, results can be provided for these network subsets (see Figures 3-1 and 3-2).

A specific attribute identifies to which country each road link belongs. This attribute allows to implement country-based costs (such as 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

3.2 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; therefore, 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).

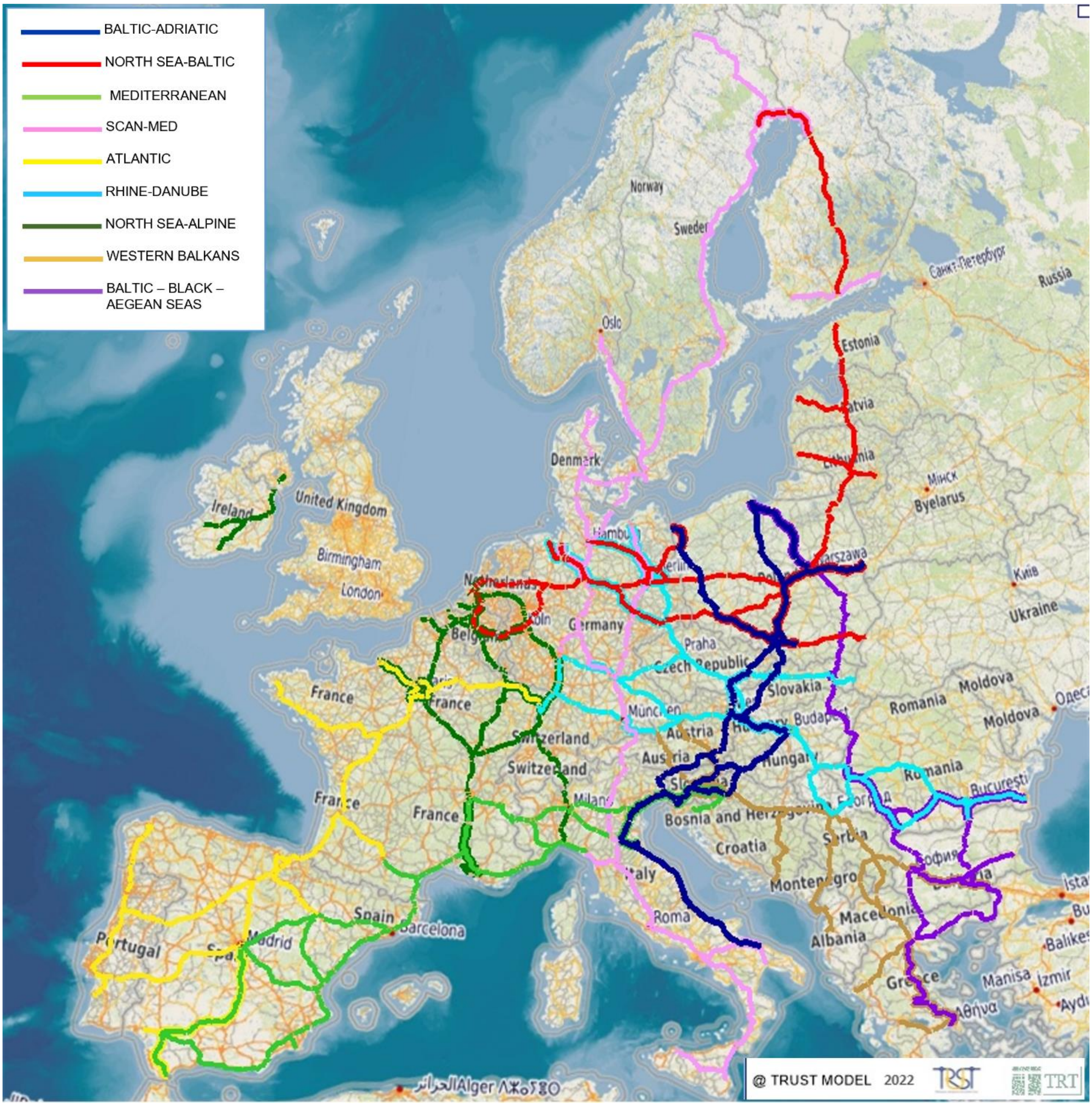
The freight matrix includes tonnes transported by vehicles above 3.5 tonnes between NUTS3 zones and is segmented into the following demand groups:

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

Figure 3-1: Road Network hierarchy

Source: TRUST model

Figure 3-2: Road Network hierarchy: TEN-T Road Corridors



Source: TRUST model

3.3 Main parameters

Further than the features of the network links (speed, capacity, etc.), the main parameters used in the road module are speed-flow functions; transport costs by mode; values of travel time; average fuel consumption and emission factors.

3.3.1 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 are adjusted to consider 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 2-3. 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:

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

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

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

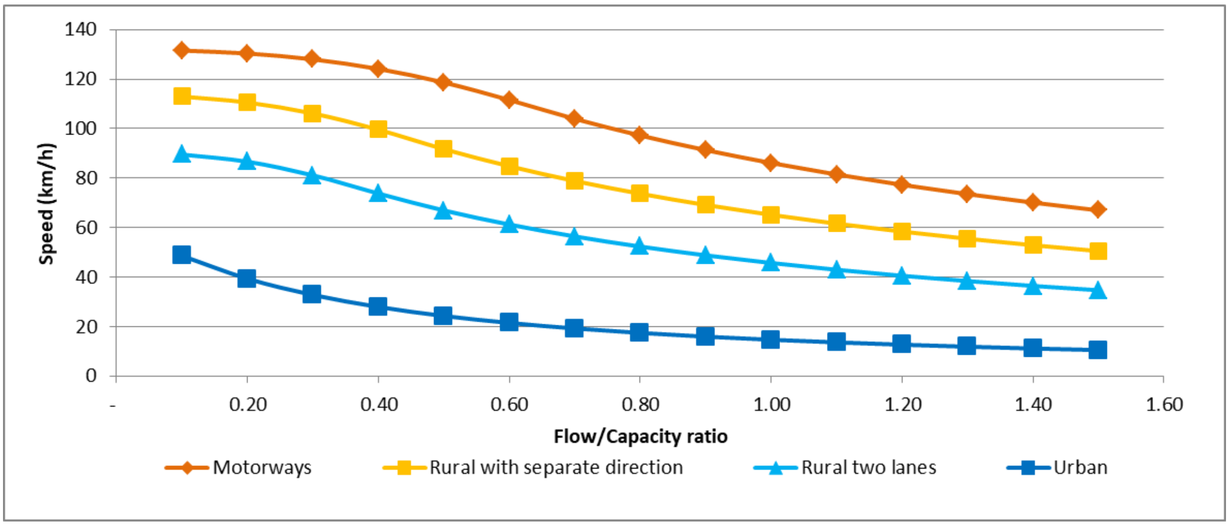
$$t_0 - Travel\ time\ on\ a\ network\ object\ with\ free\ flow\ time$$

$$q - current\ traffic\ volume$$

$$q_{max} - capacity$$

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

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



Source: TRT elaboration

3.3.2 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 3-1).

Table 3-1: Occupancy / Load factors in the road module

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)

Source: TRUST model

3.3.3 Cost parameters

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 in the real world, 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 cost-per-kilometre 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.

Trucks cost functions include tolls and variable costs. Again, tolls are transformed into a cost-per-kilometre if the system applied is based on fixed fares. For those countries where the toll cost depends on the EURO emission 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 segments to reflect that light vehicles are used on short distances (domestic < 150km) and heavy vehicles are used on long distances (domestic >150km & international).

Truck variable costs include fuel consumption and labour costs both expressed in €/vkm. As for tolls, operating costs are differentiated across freight demand segments to distinguish between light vehicles (used on short distances) and heavy vehicles (used on long distances). Both fuel costs and labour costs are differentiated among countries and are based on the ASTRA model results.

3.3.4 Value of travel time

Value of travel time is used to transform travel time into a monetary equivalent. It is coded in terms of €s/hour (per individual) or €s/hour (per tonne). Values of time implemented in TRUST are based on the SCENES experience and on scientific literature.

3.3.5 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.

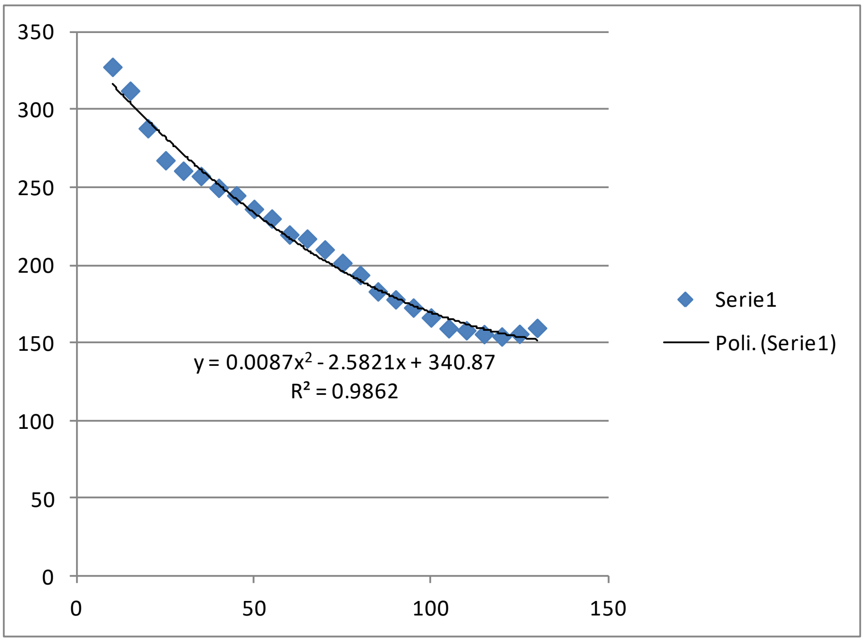
In order to estimate fuel consumption and emissions in a more consistent way within the TRUST model, adapted functions were defined. These adapted functions consider that fuel consumption and emissions increase when vehicles accelerate and that at the same time, according to some literature, acceleration is inversely dependent on speed (the higher the speed the less intense is the acceleration). Three relationships were then defined:

i. Between speed and acceleration: at a speed of 130 km/h acceleration is 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 is supposed that acceleration is again decreasing as in traffic jam there is no chance to accelerate much.

ii. 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 is quantified considering spot data found in literature.

iii. Between speed and the share of travel time in which vehicle is accelerating. It is assumed that for higher speeds this share is lower (when travelling on a motorway with not much traffic there is no need of decelerating and accelerating) and increases as the speed is reduced until a maximum share of 50%.

Figure 3-4: An example of estimated consumption/emissions function considering acceleration



Source: TRT elaboration

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 3-4). 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 in future years, the emission factors are updated considering projections regarding the vehicle fleet evolution in the selected year provided by the ASTRA model.

3.4 Policy scope and output

The TRUST road module can simulate the policy measures mentioned in Table 3-2 and provides the following outputs:

- Average daily loads on road links split by demand segment (see section 3.2) 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 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 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 network and on TEN-T corridors.

Table 3-2: Policy measures that can be simulated with the road module

Measure	Notes
Road charging (e.g. Eurovignette)	Charges can be coded directly if they are based on demand segments described in section 3.2, 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	Speed limits can be different by country and/or by link type and can be defined for specific links only
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.

Source: TRUST model

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

4 Rail transport module

The TRUST rail module is conceived to assign O/D 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 module is therefore designed to describe rail network usage rather than to simulate rail users' decisions.

Since unitised rail freight can require road feeder to reach intermodal terminals, the module computes intermodal paths between origin and destination selecting the zones where interchanging between truck and rail, and vice-versa, and then searching routes for trucks and rail separately on their respective networks. TRUST does not represent services or routes; so, for rail, an equilibrium assignment of the same type used for road assignment is applied to assign tonnes on the rail network.

4.1 Rail transport supply

The rail transport network is 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) and updates (including the latest classification of the TEN-T network).

The rail network includes different link types (see Table 4-1) according to technical elements (number of tracks, electrification, maximum speed allowed, etc.). Links dedicated to some type of traffic (e.g. High Speed Trains or freight traffic) as well as links where some types of train are not allowed are assigned to different link types. The rail network is linked to the road network to simulate intermodal transport.

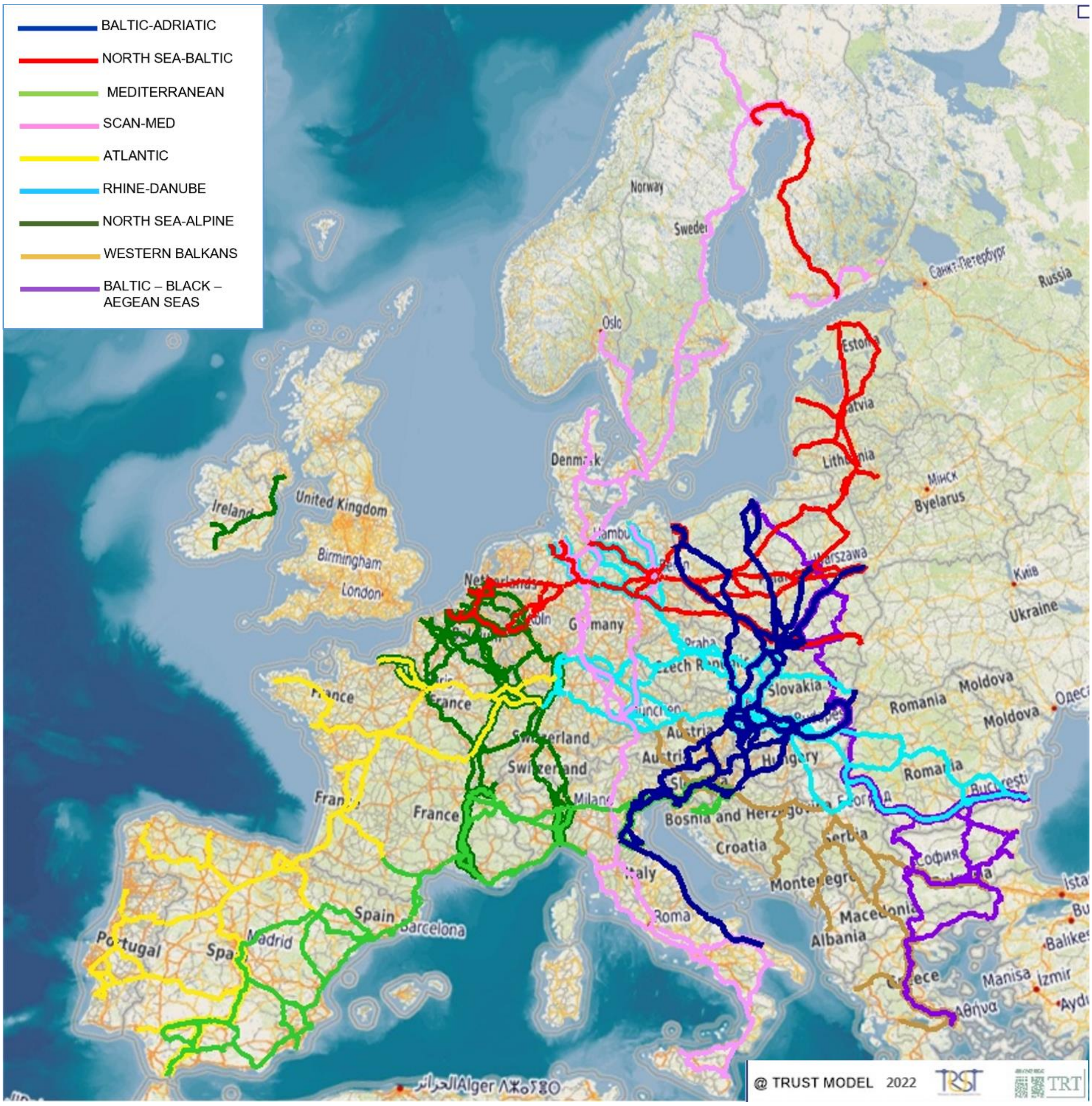
As for the road network, specific flags are used to identify links belonging to the Core/Extended Core TEN-T Network, to each Corridor and to the comprehensive network according to the to the TEN-T Regulation 2024. Therefore, results can be provided for these subsets of the network (see Figure 4-1)

Table 4-1: Link types in the TRUST rail network

Link type	Description
Conventional local rail links for the passenger transport	Only regional passengers' trains are allowed
Conventional local rail links for both passenger and freight transport	Only regional passengers' trains and freight trains are allowed
Conventional long distance rail links for the passenger transport	Both regional and intercity passengers' trains are allowed.
Conventional long distance rail links for both passenger and freight transport	Both regional and intercity trains and freight trains are allowed.
Conventional railway links only for the freight transport	Links where passenger trains are not allowed.
High speed rail links on the own tracks for both passenger and freight transport	Links can be used also by freight HS trains.
High speed rail links on the own tracks only for the passenger transport	Links where freight trains are not allowed.
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.
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

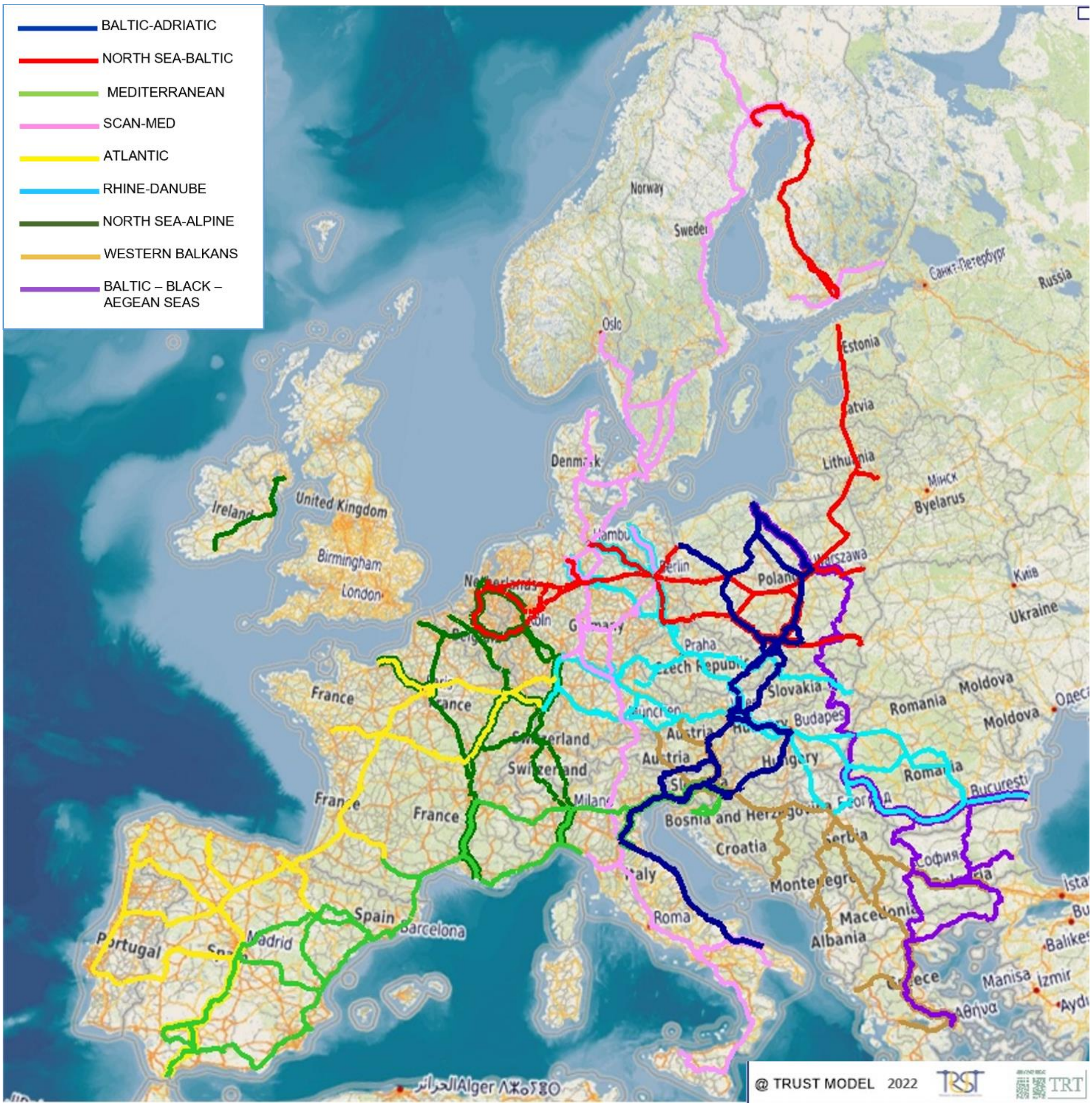
Source: TRUST model

Figure 4-1: TEN-T Rail Freight Corridors



Source: TRUST model

Figure 4-2: TEN-T Rail Passengers Corridors



Source: TRUST model

Rail supply includes freight intermodal terminals where loads are transferred between road and rail. There is almost 1000 intermodal terminals across the countries covered by the TRUST model as shown in Figure 4-3. Rail freight intermodal trips are composed by one or more legs by truck feeder and one or more legs by rail; the modal change can only happen in those zones where an intermodal terminal is available. Rail freight conventional uses exclusively direct access to the rail network.

Figure 4-3: Intermodal terminals in the TRUST rail network

Source: TRUST model

4.2 Rail transport demand

Rail demand is segmented according to types of traffic which correspond to different train types in terms of occupancy of rail capacity. Information on trip purposes is used 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 is not used for the assignment 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 (and trips can be made combining regional and intercity services with High-Speed services, where the latter are available):

- Regional Trains
- Intercity Trains
- High Speed 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: (i) intermodal trains, (ii) 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 freight trains originated in one country belong to only one of the groups): (i) conventional trains 700 tonnes; (ii) conventional train 1200 tonnes; (iii) conventional train 2900 tonnes.

Base year matrices derive from those estimated in the ETISplus project that have been distributed among the segment demands of the TRUST model and matched with Eurostat statistics on rail traffic (ton-km and pass-km). For forecasting purposes, future matrices are estimated exogenously by applying demand growth rates taken from the ASTRA model aligned with the EU Reference Scenario.

4.3 Main parameters

Matrices are in terms of trips or tonnes in an average day. After the assignment, trips and tonnes are translated into trains by means of average occupancy and load factors (see Table 4-2).

Table 4-2: Occupancy / Load factors in the rail module

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

Source: TRUST model

Beside occupancy and load factors, the other parameters used in the TRUST rail module are the attributes of the links and connectors coded in the network that have been estimated based on the cost and time functions of different modelling projects at European scale.

Average cost for rail transport is composed of a variable cost (€/km) and a fix cost (€/ton) different for conventional ad unitised transport.

The Values of Time in the rail module are 1.2 €/h per tonne for intermodal trains and 0.3 €/h per tonne for conventional trains. Additional times to access directly to transport zone (differentiated by the network modes) and intermodal transfer time/cost are considered in the model.

4.4 Policy scope and output

The rail module can simulate the policy measures described in Table 4-3 and provides the following outputs:

- Average daily loads on rail links split by demand segment (see section 4.2).

- Rail traffic activity (passenger-km, tonnes-km) per year by country (based on territoriality principle).
- Rail traffic activity (passenger-km, tonnes-km) per year on TEN-T network and on TEN-T corridors.
- Rail accessibility measures by NUTS-III region
- Origin-Destination Paths.

Table 4-3: Policy measures that can be simulated with the rail module

Measure	Notes
Infrastructure charging	Charges can be coded directly if they are based on demand segments described in section 4.2, 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

Source: TRUST model

5 Maritime transport module

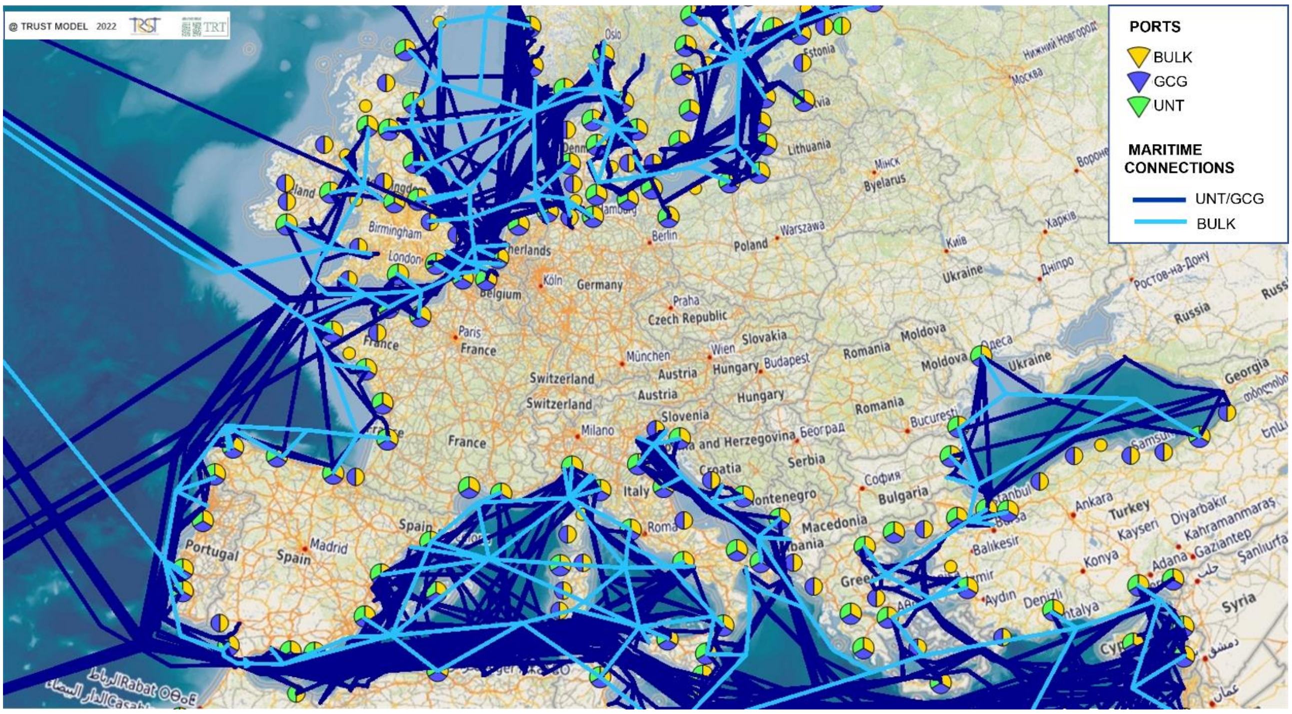
The TRUST maritime module is used to estimate travel time and cost of maritime transport among NUTS3 zones in Europe. Like the rail module, the maritime module considers that paths connecting inland zones include the use of feeder modes. Therefore, the module deals with the calculation of multimodal paths, searching for interchange zones (ports) and then assigning tonnes on maritime, road and rail legs on their respective networks.

5.1 Maritime transport supply

Three main cargo types are considered separately: bulk (BLK), unitised (UNT) and general cargo (GCG). Cargo types follow different routes: while bulk freight moves relatively freely between all ports, unitised and general cargo vessels usually exploit fixed lines that stop in ports geared towards these specific cargo types. Accordingly, two different maritime networks are implemented: one for BLK freight, that allows for free movements between ports, and one for UNT and GCG, that conversely contains only existing commercial links between ports. However, for both types of networks, and therefore for the all the three cargo types, the same equilibrium assignment algorithm is used.

Maritime ports are classified as well into three categories: bulk (BLK) ports, container (UNT) ports and general cargo (GCG) ports and they can host only demand for the specific freight segment (e.g. if one port is classified as a bulk port, routes for general cargo and container demand cannot go through that port). Most of the ports belong to more than one category but some ports have only one or two specialisations (see Figure 5-1).

Figure 5-1: Seaports and sea routes in the TRUST maritime network

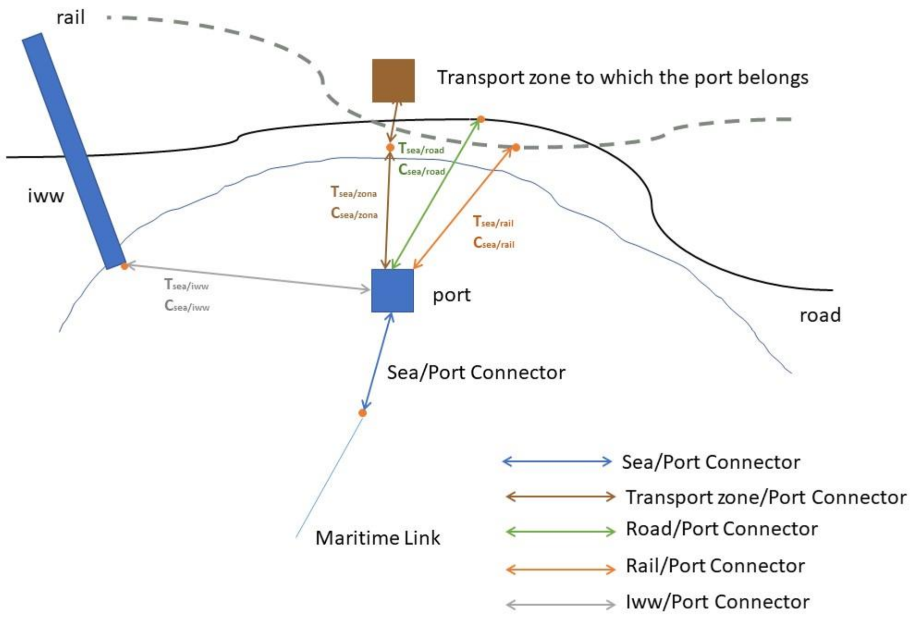


Source: TRUST model

The maritime network can be accessed only through zones with maritime ports and this implies that trips originated from (or bound to) an inland zone can access the maritime network only through feeder modes, either truck, rail or inland waterway according to existing infrastructures. This implies that also those connections between ports and inland networks are part of the maritime network (see example in Figure 5-2).

Ports are modelled as independent zones. In this way each port is a separated zone connected to the different networks (maritime, rail, inland waterway and road) through specific connectors, allowing for a clear management of the waiting times and costs related to the intermodal change. The choice of the path along the maritime network between ports is based on the time and the costs for shipping and loading/unloading.

Figure 5-2: Intermodal connections at ports in the TRUST maritime network



Source: TRUST model

5.2 Maritime transport demand

Maritime demand consists of Origin-Destination matrices segmented according to the three freight categories of bulk, unitised, and general cargo. Matrices are in terms of thousand tonnes per year. Each segment of demand matrix is assigned independently to the network. Base year matrices reflect Eurostat and DG MOVE statistics. For forecasting purposes, future matrices are estimated exogenously by applying demand growth rates taken from the ASTRA model aligned with the EU Reference Scenario.

5.3 Main parameters

The main parameters used in the maritime module are speed, transport costs, values of travel time and time spent in maritime operations and in in intermodal transfers estimated based on the cost and time functions of different modelling projects at European scale.

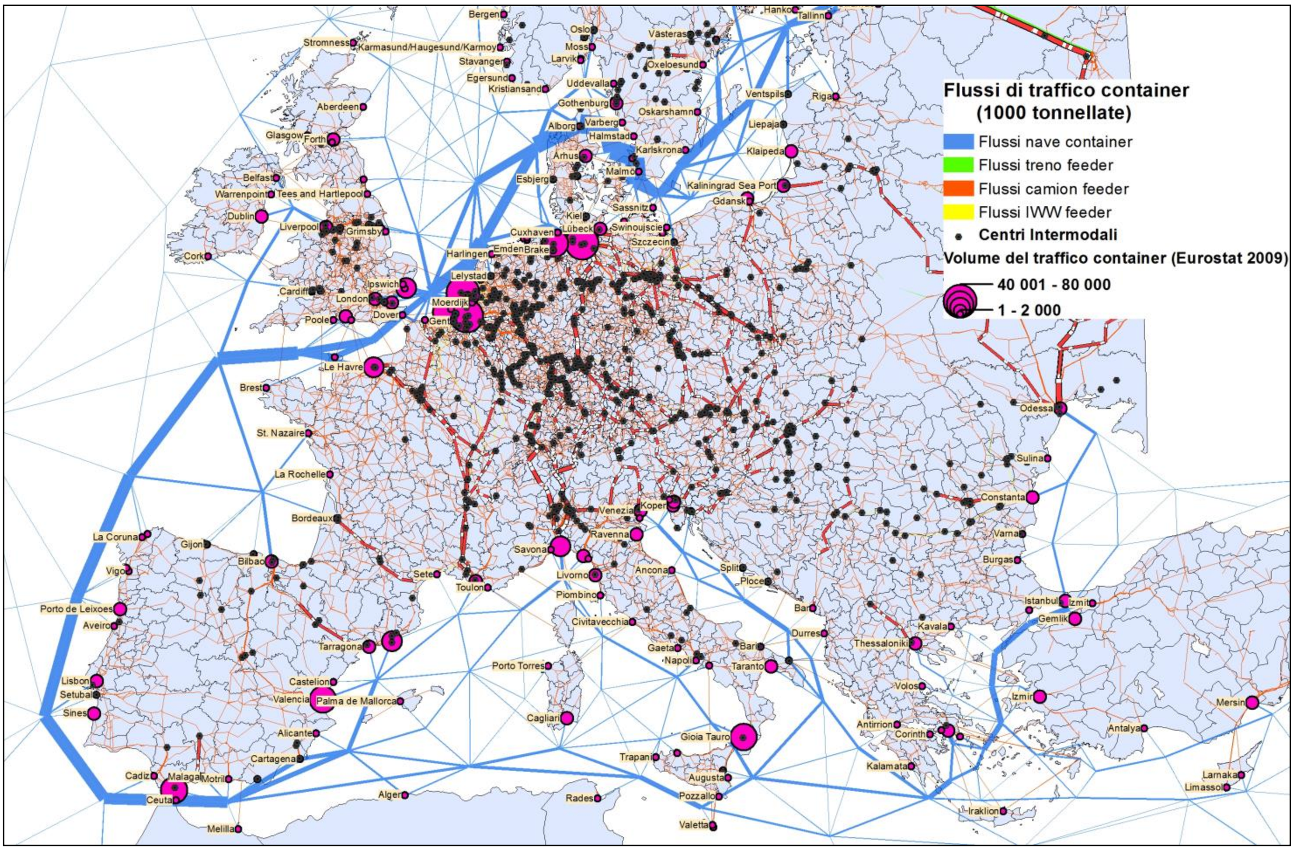
Average cost for maritime transport is composed of a variable cost (€/km) and a fix cost (€/ton) different for cargo type (Bulk, Container, General Cargo) and type of feeder connecting the port to the origin/destination transport zone (Road, Rail or Iww feeder)

The values of time in the maritime module are the following:

- UNT: 0.8 €/h per ton
- GCG: 0.4 €/h per ton
- BLK: 0.2 €/h per ton

Average times and costs in maritime ports operations and intermodal transfer operations (loading/unloading + waiting time) are differentiated by types of intermodal transfer (Road, Rail or Iww) and cargo type (Bulk, Container, General Cargo).

Figure 5-3: Example of TRUST maritime network links load (tonnes per year)



Source: TRUST model

5.4 Main parameters

The main parameters used in the maritime module are speed, transport costs, values of travel time and time spent in maritime operations and in in intermodal transfers estimated based on the cost and time functions of different modelling projects at European scale.

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Average times and costs in maritime ports operations and intermodal transfer operations (loading/unloading + waiting time) are differentiated by types of intermodal transfer (Road, Rail or Iww) and cargo type (Bulk, Container, General Cargo).

5.5 Policy scope and output

The TRUST maritime module can simulate the policy measures listed in the following table and 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

Table 5-1: Policy measures that can be simulated with the maritime module

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

Source: TRUST model

6 Inland waterway transport module

The inland waterway module deals with the assignment of freight inland waterway transport O-D matrices. It is important to note that the capacity of the channels and the capacity of the land-side centres are not considered in the assignment, which is based, as for the other modules, on an equilibrium algorithm.

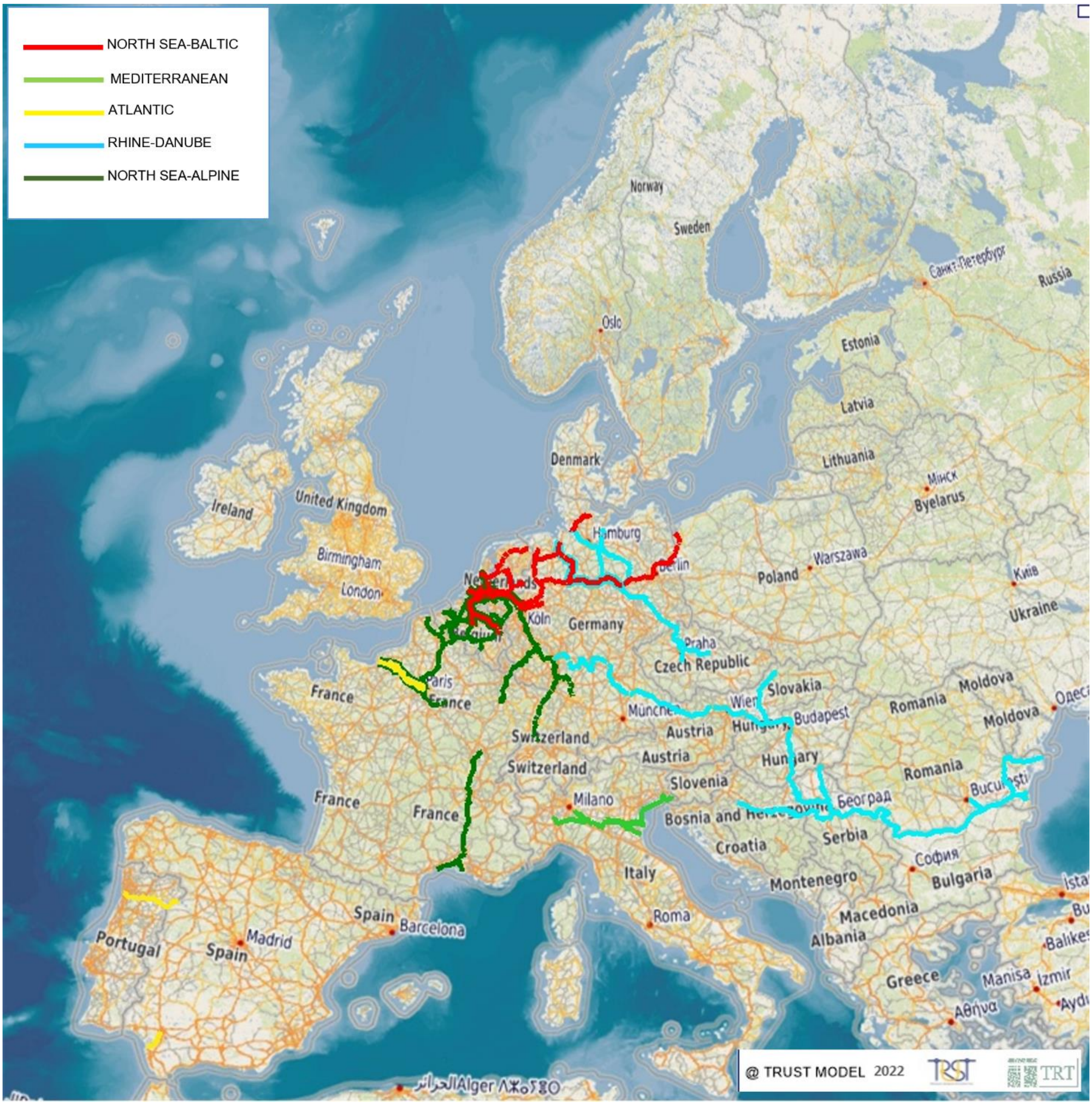
6.1 Inland waterway transport supply

The inland waterway (IWW) network includes all the relevant canals among all the NUTS3 regions covered by the spatial area of the model (see Figure 6-1) and includes 70 inland ports across Europe. These ports have been selected either for their traffic or for their strategic role along the international routes. Each IWW network link has the specific features in term of free-flow speed, class (according to the Classification of European Inland Waterways), draught and capacity. Specific flags are used to identify links belonging to the TEN-T Network and to each TEN-T Corridor. Therefore, results can be provided for these subsets of the network (see Figure 6-2). The choice of the path along the IWW network is based on speed, which is correlated with the type of the canal, and costs and times for shipping and loading/unloading.

Figure 6-1: Inland ports and inland navigable canals in the TRUST inland waterway network

Source: TRUST model

Figure 6-2: TEN-T Inland waterway corridors



Source: TRUST model

Inland waterway container mode has no direct access to IWW network when the origin zone is more than 50 km away from the closest IWW port.). In that case, the IWW container mode has to access through truck feeder (intermodality with rail feeder is not modelled because this interchange is used in very few cases and there is evidence of very few projects regarding this type of intermodality). As a consequence, road networks are also used in the IWW module because trucks are used as feeder mode to connect internal zones (which are distant from the internal navigation port) with an inland navigation port and allow the definition of full path between true origin and final destination of freight. So, also connections between internal ports and road network are part of the network.

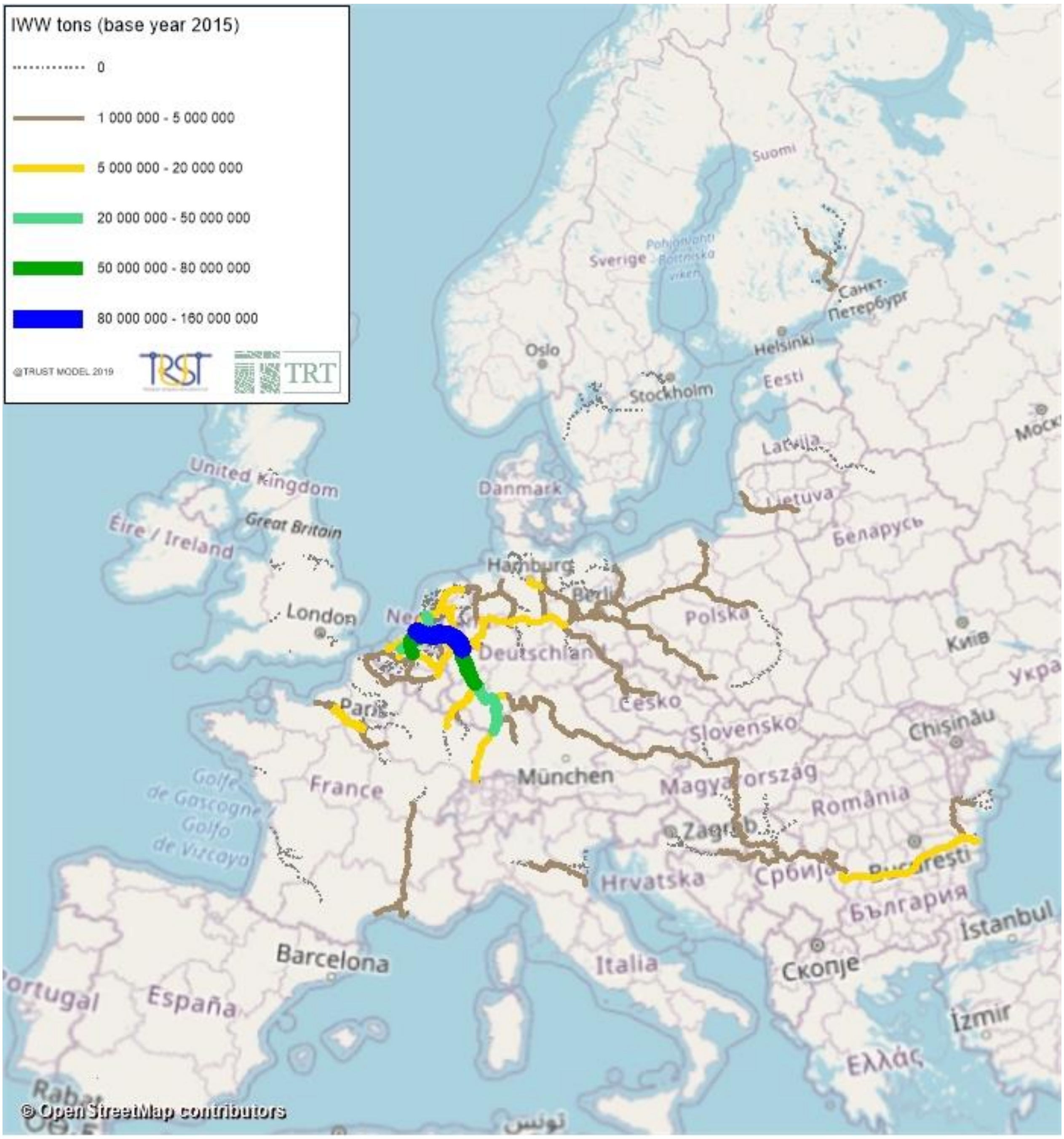
A Non-Container IWW freight transport (bulk and general cargo) has always a direct access to the IWW network as the goods transported of this type in most cases are originated/destined near the port.

6.2 Inland waterway transport demand

The base year inland waterway matrices, originally built on the ETISplus project data, reflect Eurostat and DG MOVE statistics. For forecasting purposes, future matrices are estimated exogenously by applying demand growth rates taken from the ASTRA model aligned with the EU Reference Scenario.

IWW demand consists of Origin-Destination matrices segmented according to the two main freight categories: unitised and non-unitised. Matrices are in terms of tonnes per year. Each segment of demand has its autonomous matrix that is assigned independently to the network.

Figure 6-3: Example of TRUST inland waterway network links load (tonnes per year)



Source: TRUST model

6.3 Main parameters

The main parameters used in the inland waterway module are speed, transport costs, values of travel time and time spent in port operations and in intermodal transfers. The parameters functions have been estimated based on the cost and time functions of different modelling projects at European scale. The values of time for inland waterway are 0.8 €/h per ton for unitised traffic and 0.2 €/h per ton for non-unitised traffic.

Average times and costs in ports operations and intermodal transfer operations (loading/unloading + waiting time) are differentiated by types of intermodal transfer and cargo type (unitised, conventional).

6.4 Policy scope and output

The TRUST IWW module can simulate the policy measures listed in the following table and provides the following outputs:

- Average daily loads on iww links split by demand segment (see section 6.2).
- IWW traffic activity (tonnes-km) per year by country (based on territoriality principle).
- IWW traffic activity (tonnes-km) per year on TEN-T network and on TEN-T corridors.
- Origin-Destination Paths.
- IWW accessibility measures by NUTS-III region.

Table 6-1: Policy measures that can be simulated with the inland waterway module

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 iww ports. Modification should be estimated exogenously
Port regulations	As far as regulation is supposed to modify costs or times at iww ports. Modification should be estimated exogenously
Removal of bottlenecks on the canals	This measure can be simulated by increasing the speed or by the reduction of operative costs along the channels. Modification should be estimated exogenously
Extension of the canal depth / improvement of the locks along the canals	This measure can be simulated by increasing the speed or by the reduction of operative costs along the channels. Modification should be estimated exogenously

Source: TRUST model