*Commission modelling inventory and knowledge management system (MIDAS)*
*Report generation date* 05/11/2020

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# Factsheet

## SWD/2019/0096 final

Impact assessment accompanying the document Commission Delegated Regulation supplementing Directive 2010/40/EU of the European Parliament and of the Council with regard to: the deployment and operational use of cooperative intelligent transport systems

## Supporting model(s)

ASTRA, TRUST

# Impact assessment SWD/2019/0096 final

*Fact sheet on model contributions*

Source: Commission modelling inventory and knowledge management system (MIDAS)

Date of Report Generation: 05/11/2020

# Overview

**Title**

Impact assessment accompanying the document Commission Delegated Regulation supplementing Directive 2010/40/EU of the European Parliament and of the Council with regard to: the deployment and operational use of cooperative intelligent transport systems

**Document ID**

SWD/2019/0096 final

**Year of publication**

2019

**Led by**

MOVE

**Model(s) used**

ASTRA, TRUST

# ASTRA

**Full title**

ASsessment of TRAnsport Strategies

**Run for this impact assessment by**

Trasporti e Territorio Srl

**Contributed to**

Baseline and assessment of policy options

**Details of the contribution**

The baseline and a set of policy options and deployment scenarios were assessed with the European scale modelling tools ASTRA and TRUST for the analysis and comparison of the impacts in terms of economic, environmental and social indicators.

*Further details can be found in:*

https://dx.doi.org/10.2832/067308

# TRUST

**Full title**

TRansport eUropean Simulation Tool

**Run for this impact assessment by**

Trasporti e Territorio Srl

**Contributed to**

Baseline and assessment of policy options

**Details of the contribution**

The baseline and a set of policy options and deployment scenarios were assessed with the European scale modelling tools ASTRA and TRUST for the analysis and comparison of the impacts in terms of economic, environmental and social indicators.

*Further details can be found in:*

https://dx.doi.org/10.2832/067308

# ASTRA
# ASsessment of TRAnsport Strategies

*Fact sheet*

Source: Commission modelling inventory and knowledge management system (MIDAS)

Date of Report Generation: 05/11/2020

# Overview

**Acronym** ASTRA
**Full title** ASsessment of TRAnsport Strategies

**Main purpose**
ASTRA (ASsessment of TRAnsport Strategies) is an integrated assessment model designed for strategic policy assessment of transport policies and investments up to the year 2050. Policy assessment capabilities in ASTRA cover a wide range of measures with flexible timing and levels of implementation. Potential policies include vehicle technologies, infrastructure development, pricing, taxation, speed limits, trade policies etc. A strong feature of the model is the ability to simulate integrated policy packages and to provide indicators for the indirect effects of transport policies and investments on the economy and the environment. Over time the application of the model has been extended from transport also towards economic impact assessment of climate policy and of renewable energy policy. For such analyses the ASTRA model has often been coupled to bottom-up techno-economic models.

**Summary**
ASTRA is a strategic model based on the Systems Dynamics Modelling approach simulating the transport system development in combination with the economy and the environment until the year 2050. The ASTRA model is grounded on empirical data of its calibration period (which today is from 2000 until 2015). The model is made of different modules that interact among each other with direct and feed-back effects.

Strategic assessment capabilities in ASTRA cover a wide range of transport measures and investments with flexible timing and levels of implementation. Also when coupled with bottom-up models economic impact assessment of climate policy has been provided. Since many years the ASTRA model has been successfully used for the following applications:

- Transport policy assessment: pricing, taxation (on fuel or vehicle), emissions and efficiency standards, infrastructure investments
- Technology and scenario analysis: alternative vehicle technology (e.g. electric and fuel cell vehicles), integrated energy and transport policy (e.g. vehicle efficiency improvement)
- Renewable policy assessment: subsidies, feed-in tariffs, investment strategies
- Climate policy assessment and energy price trends

Geographically, ASTRA covers all EU 27 Member States plus United Kingdom, Norway and Switzerland. The model is built in Vensim software and is developed and maintained by TRT, M-Five and ISI Fraunhofer.

**Keywords**

Transport , Energy , Environment , economy

**Model category (thematic)**

Transport

**Model home page**

http://www.astra-model.eu/

# Ownership & license

**Ownership**

Multiple copyright [Original code owned by 3rd party]

**Ownership details**

ASTRA is a private model, developed and maintained by TRT, M-FIVE and Fraunhofer-ISI[1]. The 2013 version of ASTRA, so-called ASTRA-EC, is available to external users through a user interface [2]. The 2020 version of ASTRA, so called ASTRA 2.0, is currently used at the Energy and Transport Unit of Economics of climate change at EC JRC Seville. [1] Source: http://www.astra-model.eu/index.htm [2] Source: http://www.assist-project.eu/assist-project-en/content/deliverables.php

**Licence type**

Non-Free Software licence. The license has one or more of the following restrictions: it prohibits creation of derivative works; it prohibits commercial use; it obliges to share the licensed or derivative works on the same conditions.

# Details

**ASTRA structure and approach**

ASTRA consists of different modules, each related to one specific aspect such as the economy, transport demand or the vehicle fleet. The main modules cover the following aspects:

- Population and social structure (age cohorts and income groups)
- Economy (e.g. GDP, input-output tables, employment, consumption and investment both at aggregate and at sectoral level)
- Foreign trade (inside EU and to partners from outside EU)
- Transport (including demand estimation, modal split, transport cost and infrastructure networks)
- Vehicle fleet (passenger and freight road vehicles by segment and drivetrain)
- Environment (including pollutant emissions, $CO_2$ emissions, energy consumption).

The economy module simulates the fundamental economic variables. Some of these variables (e.g. GDP) are transferred to the transport generation module, which uses the input to generate a distributed transport demand. In the transport module, demand is split by mode of transport. The traffic performance by mode is associated with the composition of the fleet (computed in the vehicle fleet module) and the emissions factors (defined in the environmental module), in order to estimate total emissions.

Several feedback effects take place in the ASTRA model. For instance, the economy module provides the level of income to the fleet module, in order to estimate vehicle purchase. The economy module then receives information on the total number of purchased vehicles from the fleet module to account for this item of transport consumption and investment. Furthermore, changes in the economic system immediately feed into changes of the transport behaviour and alter origins, destinations and volumes of European transport flows.

The indicators that ASTRA can produce cover a wide range of impacts; in particular transport system operation, economic, environmental and social indicators. The environment module uses input from the transport module (in terms of vehicle-kilometres-travelled per mode and geographical context) and from the vehicle fleet module (in terms of the technical composition of vehicle fleets), in order to compute fuel consumption, greenhouse gas emissions and air pollutant emissions from transport. ASTRA also estimates the upstream emissions (well-to-tank) due to fuel production and vehicles production. Therefore, well-to-wheel emissions can be provided as well.

ASTRA is calibrated to reproduce major indicators such as transport performance, fuel consumption, CO2 emissions and GDP according to the main European reference sources such as Eurostat and the EU Reference Scenario (European Commission, 2016) for future trends.

By simulating different policy bundles and framework conditions, ASTRA enables the comparison of different scenarios concerning, e.g., the diffusion of technologies, emission reductions, energy demand by energy carrier, required investments, etc.

**Input and parametrization**

The model includes four main components: economy, transport, technology and environment.

The *economy component* consists of five elements: supply side, demand side (including an investment module), an input-output model based on 25 economic sectors, employment module and government module. In addition, two trade models are implemented (i.e. intra-EU trade and EU to rest-of-the-world trade) [3].

The *transport component* is represented by means of two classical 4-stage transport models, one for passenger and one for freight transport, including endogenous feedback on all stages. Even if a full origin-destination matrix is not modelled, demand is segmented according to trip purpose and in different distance bands to better consider the competition between alternative modes. The transport network is not explicitly represented but information on network capacity is considered in a simplified way for the different transport modes drawing on a network based transport model such as TRUST.

The *technology component* covers the differentiation of road vehicle fleets into drivetrain technologies, age classes and different emission standard categories[1],[2]. The technologies considered are listed below and cover gasoline, diesel, compressed natural gas (CNG), liquefied natural gas (LNG), liquefied petroleum gas (LPG), battery electric vehicles (BEV), plug-in hybrid electric vehicles (PHEV), fuel cell electric vehicles (FCEV) and trolleys for urban buses and long-distance trucks.

- Car: gasoline, diesel, CNG, LPG, BEV, PHEV, FCEV
- LDV: gasoline, diesel, CNG, LPG, BEV, PHEV, FCEV
- HDV: diesel, CNG, LNG, BEV, PHEV, FCEV, trolley
- Urban Buses: diesel, CNG, BEV, PHEV, FCEV
- Coaches: diesel, LNG, FCEV

Investments and learning curves are included in the simulation of the fleet development process. Road freight transport demand is segmented by different vehicle types: light commercial vehicles (below 3.5 tonnes), medium heavy goods vehicles (from 3.5 to 12 tonnes) and large heavy goods vehicles (from 12 to 26 tonnes, from 26 to 32 tonnes and above 36 tonnes) - according to different spatial domains (i.e. local, short, national, international). Assumptions on the composition of vehicle fleet used in each spatial domain are made to reflect the use of each vehicle type. The demand for new heavy goods vehicles as well as the replaced vehicles is associated with emission standards depending on the year of registration, covering conventional diesel technologies as well as other technologies mentioned above. Efficiency improvements are also included for non-road modes.

The *environment component* calculates the air pollutant emissions and energy consumption from transport based on traffic flows, the information on the composition of the vehicle fleets and on emission / energy consumption factors. ASTRA quantifies the impacts on energy consumption by fuel, CO2 emissions and air pollutants (NOx, PM, CO and VOC), as well as transport accidents and the related externality value.

**References**

[1] See Deliverable D4.3 of REFLEX project (Analysis of the European energy system under the aspects of flexibility and technological progress), Call: H2020-LCE-21-2015, Grant Agreement Number: 691685

[2] See Annex A of Ricardo et al. (2017) Support Study for the Impact Assessment Accompanying the Revision of Directive 1999/62/EC.

[3] See Schade et al. (2018) The impact of TEN-T completion on growth, jobs and the environment - METHODOLOGY AND RESULTS. Final Report. On behalf of the European Commission.

**Main output**

ASTRA assessment capabilities cover a wide range of policies with flexible timing and variable levels of the policy implementation. Potential policies include standards setting, infrastructure pricing, fuel taxation, speed limits, carbon taxes, investment in energy and transport infrastructure, trade policies etc. A strong feature of ASTRA is the ability to simulate and test integrated policy packages and to provide indicators for the indirect effects of transport on the economic system (e.g. sectoral value-added, sectoral employment, GDP, trade flows, income by income groups). ASTRA has also been applied to analyse future challenges, in particular the impact of high oil prices on the EU economy and the impact of ambitious European climate policy until 2050.

ASTRA model has been successfully used for the following applications:

- Transport policy assessment: pricing, taxation, TEN infrastructure, CO2-standards, Cost-benefit-analysis of transport projects;
- Technology and scenario analysis: technology and employment policy, hydrogen technology strategy, integrated energy and transport scenarios, energy and transport policy, impacts of connected and automated driving;
- Renewable policy assessment: subsidies, feed-in tariffs, investment strategies;

- Climate policy assessment: transport policy, EU-ETS, energy scenarios, decarbonisation strategies, investment strategies, cost implications.

The indicators that ASTRA can produce cover a wide range of impacts; in particular transport system operation, economy, environmental and social indicators.

More in detail, transport system operation indicators are estimated at aggregated level (namely at Country level); nevertheless, the additional value of using system dynamics for transport modelling enriches the analysis with respect to a traditional transport model, thanks to the linkage with the modules related to economic and technological aspects. The economic module of the ASTRA model addresses the linkages between transport and economy, mainly in terms of the effects of transport policy measures on regional GDP, consumption or sectoral employment; the fleet module reflects impacts on the technology side; the environmental module deals with health impacts of air-pollution. Furthermore, these additional impacts can interact with each other. As an example, let's take the impact of road charging. If a charge is introduced or increased for cars in the transport module, this measure has a depressing effect on car purchasing. In turn, less cars mean that some less population has a private vehicle available and, since car availability promotes personal mobility, less trips will be generated. In another step forward, the impact of road charging on the vehicle fleet propagates itself until the economic model, where less consumption and investment are modelled and therefore lower GDP, less employment and less production. The reduction of economic activity is fed back into the demand estimation, because freight transport demand depends on production and because employed people travel more than unemployed people. However, since endogenous productivity impacts are considered in the ASTRA economy model, the economic impulses of a policy may generate different impacts than in general equilibrium models primarily considering price effects.

In general, the variety of indicators estimated with the ASTRA model and the fact that these indicators are provided as time series offer the opportunity to apply a large variety of different assessment schemes to support the development of European energy, transport and climate policies. As an example, the following indicators can be provided by the ASTRA model:

- Passenger trips by mode
- Freight tonnes transported by mode
- Passenger-km travelled by mode
- Tonne-km travelled by mode
- Air pollutant emissions
- Energy consumption of transport sector
- GHG emissions of transport sector

- Transport Accidents
- Externalities of transport sector
- Transport expenditure
- Road vehicle fleet composition by technology
- GDP
- Employment total and sectoral
- Consumption total and sectoral
- Investment total and sectoral
- Sectoral gross value-added
- Sectoral trade flows.

**Spatial - temporal extent**

*The output has the following spatial-temporal resolution and extent:*

| Parameter | Description |
|---|---|
| Spatial Extent / Country Coverage | EU27 + UK, NO and CH |
| (Spatial) resolution | NUTS0 (with NUTS1 or NUTS2 level for some transport variables) |
| Temporal extent | 2015 - 2050 |
| Temporal resolution | 1-year-steps |

# Quality & transparency

## Quality

| Question | Answer | Details |
|---|---|---|
| Models are by definition affected by uncertainties (in input data, input parameters, scenario definitions, etc.). Have the model uncertainties been quantified? Are uncertainties accounted for in your simulations? | yes | ASTRA is a model based on the System Dynamics approach which is a methodology perfectly suited for dealing with uncertainty as it offers the possibility to combine quantitative and qualitative inputs in the modelling. Furthermore, the running time of ASTRA model simulations up to the year 2050 takes only a few minutes and this makes it possible to analyse effectively different scenarios and respective variants. |
| Sensitivity analysis helps identifying the uncertain inputs mostly responsible for the uncertainty in the model responses. Has the model undergone sensitivity analysis? | yes | Sensitivity analysis tests are usually performed during the ASTRA model calibration phase.<br>In many studies sensitivity tests have been done as well during the analysis of policy options in order to assess the soundness of model results. |
| Has the model undergone external peer review by a panel of experts, or have results been published in peer-reviewed journals? | yes | Model results have been published in different peer reviewed journals as well as in PhD thesis. Since many years the model is also regularly used by the Energy and Transport Unit of Economics of climate change at EC JRC Seville. Nevertheless, a peer review of the model itself by a panel of experts has not being performed. |
| Has model validation been done? Have model predictions been confronted with observed data (ex-post)? | no | |

*References related to external peer-review and publication in scientific journals:*

- No references provided in MIDAS

## Transparency

| Question | Answer | Details |
|---|---|---|
| Is the model underlying database (i.e. the database the model runs are based on) publicly available? | yes | The ASTRA database is a combination of publicly available data from official sources (such as Eurostat) and specific data that have been elaborated by the modellers team on purpose drawing from scientific literature, statistics, sector studies, etc. |
| Can model outputs be made publicly available? | yes | According to the needs of the clients of the studies, model outputs have been made public. Over the years ASTRA model results have been presented in many publicly available reports. |
| Is the model transparently documented (including underlying data, assumptions and equations, architecture, results) and are these documents available to the general public? | yes | The detailed description of ASTRA-EC version of the model is available at [1] http://www.astra-model.eu/index.htm, [2] Fermi F., Fiorello D., Krail M., Schade W. (2014): Description of the ASTRA-EC model and of the user interface. Deliverable D4.2 of ASSIST (Assessing the social and economic impacts of past and future sustainable transport policy in Europe). Project co-funded by European Commission 7th RTD Programme. Fraunhofer-ISI, |

| | | |
|---|---|---|
| | | Karlsruhe, Germany, and [3] Schade W. (2005): „Strategic Sustainability Analysis: Concept and application for the assessment of European Transport Policy". NOMOS-Verlag, ISBN 3-8329-1248-7, Baden-Baden. |
| Is the model source code publicly accessible or open for inspection? | no | |

*References related to documentation:*

- No references provided in MIDAS

# The model's policy relevance and intended role in the policy cycle

**The model is designed to contribute to the following policy areas**

- Climate action
- Economy, finance and the euro
- Energy
- Environment
- Transport
- Research and innovation

**The model is designed to contribute to the following phases of the policy cycle**

- Formulation
- Evaluation

**The model's potential**

Policy assessment capabilities in ASTRA cover a wide range of policies with flexible timing and levels of the policy implementation. Potential policies include standard setting, infrastructure pricing, fuel taxation, speed limits, carbon taxes, trade policies etc. A strong feature of ASTRA is the ability to simulate and test integrated policy packages and to provide indicators for the indirect effects of transport on the economic system. More info can be found at: http://www.astra-model.eu/index.htm

*Impact types that can be assessed with the models include:*

**Transport**

- Transport modes
    - Transport volumes
    - Modal split
    - Transport expenditure

*Can be assessed through: Modelling of specific scenarios, also in combination with TRUST*

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**Economy**

- Economy sectors
    - GDP

    - Employment
    - Trade

*Can be assessed through: Modelling of specific scenarios; Combined modelling with bottom-up models*

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**Environment and Climate Policy**

- Emissions
    - GHG emissions
    - Air Pollutant emissions
    - Accidents

*Can be assessed through: Modelling of specific scenarios*

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**Energy**

- Energy consumption from the transport sector
    - Energy consumption by mode of transport

*Can be assessed through:* Modelling of specific scenarios

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**Innovation and Technology Policy**

- Economy
    - GDP,
    - Investment,
    - Productivity

*Can be assessed through: Modelling of specific scenarios; Combined modelling with bottom-up models*

# Previous use of the model in ex-ante impact assessments of the European Commission

Use of the model in ex-ante impact assessments since July 2017.

| In the Year | ASTRA contributed to the Impact assessment called | Led by | By providing input to the | The model was run by | Details of the contribution |
|---|---|---|---|---|---|
| 2019 | Impact assessment accompanying the document Commission Delegated Regulation supplementing Directive 2010/40/EU of the European Parliament and of the Council with regard to: the deployment and operational use of cooperative intelligent transport systems<br><br>SWD/2019/0096 final | MOVE | Baseline and assessment of policy options | *Trasporti e Territorio Srl* | The baseline and a set of policy options and deployment scenarios were assessed with the European scale modelling tools ASTRA and TRUST for the analysis and comparison of the impacts in terms of economic, environmental and social indicators.<br><br>Documented in:<br>- DOI 10.2832/067308 |

# Bibliographic references

- *No references provided in MIDAS*

# TRUST
# TRansport eUropean Simulation Tool

*Fact sheet*

Source: Commission modelling inventory and knowledge management system (MIDAS)

Date of Report Generation: 05/11/2020

# Overview

**Acronym** TRUST
**Full title** TRansport eUropean Simulation Tool

**Main purpose**
TRUST is a European scale transport network model simulating road, rail and maritime transport activity.

**Summary**
TRUST is a European scale transport network model developed and maintained by TRT and simulating road, rail, inland waterways and maritime transport activity.

TRUST covers the whole Europe and its neighbouring countries and it allows for the assignment of passenger and freight origin-destination matrices at NUTS3 level of detail (about 1600 zones) on the multimodal transport network. Based on Eurostat data, national statistics and ETISPLUS database (CORDIS RCN : 92896), TRUST is calibrated to reproduce tonnes-km and passengers-km by country consistent to the statistics reported in the DG MOVE Transport in Figures pocketbook.

TRUST can be used in the context of impact assessments and for supporting policy formulation and evaluation. It is particularly suitable for modelling road charging schemes for cars and heavy goods vehicles as well as policies in the field of infrastructure (e.g. completion of the core and comprehensive Trans-European Transport (TEN-T) network). 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.

Further information on TRUST is available on http://www.trt.it/en/tools/trust/

**Keywords**
transport network

**Model category (thematic)**
Transport

**Model home page**
http://www.trt.it/en/tools/trust/

# Ownership & license

**Ownership**
Sole copyright [3rd party]

**Ownership details**
TRT

**Licence type**
Non-Free Software licence. The license has one or more of the following restrictions: it prohibits creation of derivative works; it prohibits commercial use; it obliges to share the licensed or derivative works on the same conditions.

# Details

**TRUST structure and approach**
TRUST is a transport network model for the assignment of Origin-Destination matrices at the NUTS3 level of detail for passenger and freight demand on the multimodal transport network of Europe. Road rail, inland waterways and maritime transport modes are covered in separate modules, each with its own matrices, that are then assigned simultaneously on the multimodal transport network. The current version of the TRUST model does not deal with modal split and its main output is the load on road network links in terms of vehicles per day and on non-road links in terms of either passengers or tonnes per day.

TRUST is built in 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 first principle. 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.

TRUST 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). The road network includes all 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 North Africa are explicitly modelled with their travel time and fare.

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 network 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 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) and to measure the contribution of the typical vehicles of each segment to link loads. In addition, each demand group is further divided by considering the origin country (the are 242 flows in total) as this allows for the differentiation of fuel costs for the vehicles. Base year (2017) matrices are derived from those estimated in the ETISplus project with further revisions to match Eurostat statistics on road traffic. 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.).

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.

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.

TRUST rail transport module

TRUST rail module does not consider capacity restrictions and follows an AON (All or Nothing) assignment of origin/destination matrices on the minimum path available on the network. This means that the transport volume on the rail links are computed irrespective of the availability of rail services and of transport chains.

The rail network includes different link types 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 service or freight trains) are distinguished as well as links where some types of train are not allowed. The rail network is linked to the road network as intermodal transport is modelled. Rail supply includes intermodal terminals where loads are transferred between road and rail. There are 917 intermodal terminals across the EU countries. 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.

Rail demand is segmented according to types of traffic which correspond to different train types in terms of occupancy of rail capacity. 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)

Two different types of freight trains are considered:

- intermodal trains,
- conventional trains (conventional block trains or single wagon load trains), which is further split into three groups:
    - conventional trains 700 tonnes
    - conventional train 1200 tonnes
    - conventional train 2900 tonnes.

TRUST maritime transport module

The maritime network includes several ports throughout Europe. Fictitious maritime links provide sea routes to link ports and allows the model to compute travel distances of maritime connections.

Maritime ports are classified into three categories: bulk ports, container ports and general cargo ports. Most of the ports belong to more than one category but some ports have only one or two specialisations; ports can host only demand for those freight segments (e.g. if one port is classified as a bulk port only, maritime routes for general cargo and container demand cannot go through that port). For zones without ports there is no direct access to ship mode, which in turn can be accessed through feeder modes (truck, rail or inland waterway according to existing infrastructures). As a consequence, rail, road and inland waterway networks are also used in the TRUST maritime model because trains, trucks and barges are used as feeder modes to connect inland zones with ports and allow a full path between the origin and the final destination of freight shipment.

Maritime demand consists of origin/destination matrices segmented according to the three categories of bulk, container and general cargo. Matrices are in terms of tonnes per year and each segment of demand has its matrix that is assigned independently to the network.

TRUST inland waterway transport module

TRUST inland waterways (IWW) network includes all the relevant canals among all the NUTS3 regions covered by the spatial area of the model. The network includes 70 main inland ports across Europe selected on the basis of the quantities of goods handled or on their strategic role along the international routes. Each IWW network link has specific features in term of free-flow speed. 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. Demand Origin-Destination matrices are segmented according to two main freight categories: container and non-container. Matrices are based on ETISplus project and further refined on Eurostat statistics.

Further information on TRUST is available on http://www.trt.it/en/tools/trust/

**Input and parametrization**

TRUST road transport module input

- OD Matrices at NUTS3 level in terms of vehicles
- Speed-flow functions
- Transport costs by mode
- Travel time value
- Average fuel consumption
- Average emission factors

TRUST rail transport module input

- OD Matrices at NUTS3 level in terms of trips or tonnes in an average day (24 hours)
- Transport costs
- Occupancy / Load factors

- Rail link attributes

TRUST maritime transport module input

- OD Matrices at NUTS3 level in terms of tonnes (bulk, container and general cargo)
- Transport costs
- Occupancy / Load factors
- Maritime link attributes

TRUST inland waterways transport module input

- OD Matrices at NUTS3 level in terms of tonnes (container, non-container)
- Transport costs
- Occupancy / Load factors
- Iww link attributes

**Main output**

TRUST road module outputs

- Average daily loads on road links split by demand segment and by country of origin
- 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.

TRUST rail module outputs

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

TRUST maritime module 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

TRUST inland waterways module outputs

- Average daily loads on iww links split by demand segment
- Iww traffic activity (tonnes-km) per year by country (based on territoriality principle).

**Spatial - temporal extent**

*The output has the following spatial-temporal resolution and extent:*

| Parameter | Description |
|---|---|
| **Spatial Extent / Country Coverage** | 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. |
| **(Spatial) resolution** | 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). 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. |
| **Temporal extent** | 2020 - 2050 |
| **Temporal resolution** | 2020, 2025, 2030, 2040, 2050 |

# Quality & transparency

**Quality**

| Question | Answer | Details |
|---|---|---|
| Models are by definition affected by uncertainties (in input data, input parameters, scenario definitions, etc.). Have the model uncertainties been quantified? Are uncertainties accounted for in your simulations? | yes | TRUST assigns O/D matrices at NUTS3 level. Intra-zonal traffic is not assigned on the network, although it is taken into account as pre-load on road links. The lack of intra-zonal demand modelling might be particularly relevant for passenger demand as the most part of it is short to medium distance.<br>TRUST rail assignment does not consider capacity restrictions. This means that transport volumes on the rail links are computed irrespective of the availability of rail services and of transport chains.<br>Given the strategic European scale of the model, detailed analysis at local level or at project level are outside its scope. |
| Sensitivity analysis helps identifying the uncertain inputs mostly responsible for the uncertainty in the model responses. Has the model undergone sensitivity analysis? | yes | Sensitivity analysis on key model's parameters are regularly performed during the calibration of the model and its applications. |
| Has the model undergone external peer review by a panel of experts, or have results been published in peer-reviewed journals? | no | Not provided |
| Has model validation been done? Have model predictions been confronted with observed data (ex-post)? | no | Not provided |

*References related to external peer-review and publication in scientific journals:*

- No references provided in MIDAS

**Transparency**

| Question | Answer | Details |
|---|---|---|
| Is the model underlying database (i.e. the database the model runs are based on) publicly available? | no | TRUST model databases are the results of TRT work of harmonization and integration of different sources. They are property of TRT. |
| Can model outputs be made publicly available? | yes | Results of model applications are provided to the Client. The Client has the right to make outputs publicly available or not. |
| Is the model transparently documented (including underlying data, assumptions and equations, architecture, results) and are these documents available to the general public? | yes | A detailed description of the model is available at: http://www.trt.it/en/tools/trust/ |
| Is the model source code publicly accessible or open for inspection? | no | The model source code is property of TRT. |

*References related to documentation:*

- No references provided in MIDAS

# The model's policy relevance and intended role in the policy cycle

**The model is designed to contribute to the following policy areas**

- Transport

**The model is designed to contribute to the following phases of the policy cycle**

- Formulation
- Evaluation

**The model's potential**

TRUST is particularly suitable for modelling road charging schemes for cars and heavy goods vehicles, and policies in the field of infrastructure (e.g. completion of the core and comprehensive Trans-European Transport (TEN-T) network).

More specifically the policy measures that can be simulated with TRUST are:

Road sector

- Road charging (e.g. Eurovignette): Charges can be coded directly if they are based on demand segments of the model, 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.

Rail sector

- Infrastructure charging: Charges can be coded directly if they are based on demand segments of the model 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 operational costs. The entity of the modification should be estimated exogenously

Maritime sector

- 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

Inland waterways sector

- IWW infrastructure changes: Changes can consist of new links and improved links. Given the scale of the model, simulation is meaningful for major modifications.

- Port regulations : As far as regulation is supposed to modify costs or times at IWW ports. Modification should be estimated exogenously

- Technology – transport information system, management & service: As far as technology is supposed to modify elements like travel speed or reduce operation costs. The entity of the modification should be estimated exogenously.

*Impact types that can be assessed with the models include:*

Transport

- Transport impact, Environmental impact, Economic impact
    - Transport volumes
    - Modal split
    - Network impacts
    - Emissions
    - Noise
    - Transport costs

*Can be assessed through: Modelling of specific scenarios in combination with ASTRA*

# Previous use of the model in ex-ante impact assessments of the European Commission

Use of the model in ex-ante impact assessments since July 2017.

| In the Year | TRUST contributed to the Impact assessment called | Led by | By providing input to the | The model was run by | Details of the contribution |
|---|---|---|---|---|---|
| 2019 | Impact assessment accompanying the document Commission Delegated Regulation supplementing Directive 2010/40/EU of the European Parliament and of the Council with regard to: the deployment and operational use of cooperative intelligent transport systems<br><br>SWD/2019/0096 final | MOVE | Baseline and assessment of policy options | *Trasporti e Territorio Srl* | The baseline and a set of policy options and deployment scenarios were assessed with the European scale modelling tools ASTRA and TRUST for the analysis and comparison of the impacts in terms of economic, environmental and social indicators.<br><br>Documented in:<br>- DOI 10.2832/067308 |
| 2018 | Impact assessment accompanying the document Proposal for a Regulation of the European Parliament and of the Council: establishing a European Maritime Single Window environment and repealing directive 2010/65/EU<br><br>SWD/2018/181 final | MOVE | Baseline and assessment of policy options | *Trasporti e Territorio Srl* | PRIMES-TREMOVE together with TRUST have been also used to assess the impacts of policy options on modal shift and CO2 emissions. |

# Bibliographic references

- *No references provided in MIDAS*