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Final Version of the HIGH-TOOL Model: Documentation

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Glossary

Angular.js	A client framework to build web applications in JavaScript
Apache	Web server technology
API	Application Programming Interface: A set of routines, protocols, and tools for building software applications
Bootstrap	Mobile first responsive web framework
Bower	A package management system for client-side programming
C	General-purpose imperative computer programming language
C++	General-purpose programming language. It has imperative, object-oriented and generic programming features.
C#	Multi-paradigm programming language. Developed by Microsoft within its .NET initiative and later approved as a standard by ECMA (ECMA-334) and ISO (ISO/IEC 23270:2006).
CO₂	Carbon Dioxide
CSV	Comma-Separated Values
DEM	HIGH-TOOL Demography module
D3.js	JavaScript library used to manipulate documents based on data. It produces HTML and SVG outputs from raw data.
DG MOVE	European Commission's Directorate-General for Mobility and Transport
DOM	Document Object Model. Cross-platform and language-independent convention for representing and interacting with objects in XML documents
EC	European Commission
ECMA	European Computer Manufacturers Association
ECMAScript	Scripting language standardized by ECMA International in the ECMA-262 specification and ISO/IEC 16262
ECR	HIGH-TOOL Economy & Resources module
EIB	European Investment Bank
Electron	An open source software platform maintained by GitHub. Is a modified version of Node.js which can launch and control WebKit instances
ENV	HIGH-TOOL Environment module
EU	European Union
EU28	28 Member States of the European Union
EUROPOP2010	Eurostat Population Projections 2010-based
Eurostat	Statistical Office of the European Union
FRD	HIGH-TOOL Freight Demand module
GDP	Gross Domestic Product
GHG	Greenhouse Gas
GIS	Geographic information system
Grunt	JavaScript task runner
GTK	Cross-platform widget toolkit for creating graphical user interfaces
HTML	Hyper Text Markup Language. The standard markup language used to create web pages.
HTML5	Fifth version of the HTML Language
HTTP	Hyper Text Transport Protocol. An application protocol for distributed, collaborative, hypermedia information system.

HTTPS	Hyper Text Transport Protocol Secure. A communications protocol for secure communication over a computer network.
IO	Input-Output
IOT	Input-Output Table
IWW	Inland Water Ways
Java	Object oriented programming
JavaScript	A dialect of ECMAScript programming language
JSON	JavaScript Object Notation. Open standard format that uses human-readable text to transmit data objects consisting of attribute–value pairs. It is used primarily to transmit data between a server and web application, as an alternative to XML.
JVM	Java Virtual Machine. An abstract computer used to translate Java programs into actual machine code and execute them.
Linux	The kernel of the GNU/Linux operating system. It is usual to refer GNU/Linux just as Linux.
MS	Microsoft
MVC	Model-View-Controller software architecture pattern
Node.js	A platform built on Chrome's JavaScript runtime for building network applications
NO_x	Nitrogen Oxides
NPM	A JavaScript package manager used in Node.js
NUI	Natural User Interface. A User interface design paradigm.
NUTS	Nomenclature of Territorial Units for Statistics. A number assigned to it defines the level of granularity, such as 0 for the country level.
OECD	Organisation for Economic Co-operation and Development
OGC	Open Geospatial Consortium
ORM	Object-relational mapping. In computer science is a programming technique for converting data between incompatible type systems in object-oriented programming languages, creating a "virtual object database" that can be used from within the programming language.
OS	Operating System
PAD	HIGH-TOOL Passenger Demand module
Pagination bar	Pagination is the process of dividing (content) into discrete pages, either electronic pages or printed pages. A pagination bar is used in User Interface designs as horizontal bar allowing to select different option pages.
Pagination tab	Pagination is the process of dividing (content) into discrete pages, either electronic pages or printed pages. Pagination tabs are used in User Interface designs as a set of horizontal tabs allowing to select different option pages.
pkm	Passenger-kilometre
Porting	In software engineering, porting is the process of adapting software so that an executable programme can be created for a computing environment that is different from the one for which it was originally designed (e.g. different CPU, operating system, or third party library). The term is also used when software/hardware is changed to make them usable in different environments.
PostGIS	An open source software programme that adds support for geographic objects to the PostgreSQL object-relational database.
PostgreSQL	A object-relational database
Python	General-purpose, high-level programming language
Qt	Cross-platform application framework
RES	Renewable Energy Sources

RESTful API	Representational State Transfer (REST) API. A software architecture style consisting of guidelines and best practices for creating scalable web services.
RSS	Rich Site Summary. Family of standard web feed formats to publish frequently updated information: blog entries, news headlines, audio and video.
SAB	Scientific Advisory Board
Sails.js	A server framework to build Node.js applications
SAF	HIGH-TOOL Safety module
Schema	Each database corresponding to a single HIGH-TOOL model run
SDK	Software Development Kit, a set of software development tools
SQL	Structured Query Language
SVG	Scalable Vector Graphics. A markup language used to create two-dimensional graphics with support for interactivity and animation.
Swing	Graphical user interfaces widget toolkit for Java
Three.js	A cross-browser JavaScript library/API used to create and display animated 3D computer graphics on a Web browser
tkm	Tonne-kilometre
TRANSTOOLS	Network-based European Transport Model
TPM	Transport Policy Measure
VAT	Value Added Tax
VES	HIGH-TOOL Vehicle Stock module
VOC	Volatile organic compound
vkm	Vehicle-kilometre
WebKit	An open source browser engine. It powers Google's Chrome web browser
WebSocket	Protocol providing full-duplex communication channels over a single connection
WP	Work Package
XHR	XMLHttpRequest, an API used to send HTTP or HTTPS requests to a web server and load the server response data back into the script

Executive Summary

This Deliverable presents the work developed in the HIGH-TOOL Work Packages WP1 to WP6, that lead to the production of the final version of HIGH-TOOL model.

The HIGH-TOOL model final version is a decentralised modelling system composed of independent, but highly interconnected modules, such as projection models and databases, as well as system's management and administration components that are linked to a web User Interface.

The HIGH-TOOL model allows the user three types of policy analyses:

- Running a Single Transport Policy Measure (TPM): for a number of pre-defined policy measures, HIGH-TOOL identifies variables where policy can potentially impact, and users stress the intensity of these impacts.
- Running a Combined TPM package: the user selects two or more single TPMs and HIGH-TOOL identifies and combines variables where policy can potentially impact, and users stress the intensity of these impacts.
- Running a Customised Policy package: the user selects individual policy levers and combines them.

This document is split into seven chapters:

Chapter 1: Introduction. Presents the scope of HIGH-TOOL, a general overview of its structure and the different versions of the tool.

Chapter 2: Meeting the User Needs. Synthesises the user expectations on HIGH-TOOL that motivated the model characteristics, as stated during its development phase.

Chapter 3: Operating HIGH-TOOL. Presents the main features and rationales behind the HIGH-TOOL model, based on a complete overview of the User Interface capabilities.

Chapter 4: Model Structure and Performance. Synthesises the key organisation of the model from a computation point of view. It presents each of the forecast modules involved in the model, its data management strategy and structure and concludes with a number of indicators that present current model performances.

Chapter 5: System Specifications. Describes the software solution adopted for HIGH-TOOL and the hardware requirements of the model.

Chapter 6: User Handbook for the Online Version. Illustrates how to perform common tasks in the HIGH-TOOL model for its online version.

Chapter 7: User Handbook for the Stand-alone Version. Illustrates how to install and operate the stand-alone version of the HIGH-TOOL model.

1 Introduction

1.1 Approach

Work Package 5 "Development of the HIGH-TOOL model" is about developing the core modelling capabilities of the strategic high-level tool and its basic structure. The tasks of this work package are centred on the development of each individual module (i.e., demography, economy, passenger and freight demand, vehicle stock, as well as environmental and safety impacts), and the later integration of these individual modules in a logical sequence, so that all together they provide a HIGH-TOOL model capable of analysing the potential interest of European transport policies at a strategic level.

The integrated model developed in Work Package 5 is supported by the data stock and data exchange platform developed in Work Package 3, which provides all data related functionalities (reading/writing of inputs, outputs, parameters and intermediate variables).

The development of the model in Work Package 5 goes hand in hand with the development of the User Interface in Work Package 6. The User Interface provides all visualisation and reporting capabilities of the tool, including all functionalities related to the entry of inputs (design of transport policy packages, definition of single transport policy measures, definition of socioeconomic framework conditions through the expert mode), their transformation into quantitative values for model variables, the management of model runs, and all functionalities related to data retrieval, including raw data exports and generation of processed Policy Assessment Reports.

The HIGH-TOOL model is based on the set of mathematical formulations (equations and elasticities) identified in Work Package 4. The overall software architecture was defined in Work Package 2. The development has been accompanied by activities in Work Package 7 and Work Package 8 concerning validation and robustness tests of the model.

From the implementation dimension, the HIGH-TOOL approach follows a three-stage tool development process: a **prototype** version, a **pre-final** version, and **final** version. In this sequence, the final version is the third out of three model versions. The aim of each of the stages is described below, along with main milestone dates:

- **Prototype:** First fully operational aggregated model at EU level developed in Microsoft EXCEL, useful in order to determine user-needs and system's requirements for the actual model to be developed (D5.1, delivered in May 2014).
- **Pre-final:** Second fully operational disaggregated model at NUTS-2 level developed in Java (D5.2, delivered in October 2015).

- **Final:** Final fully operational disaggregated model at NUTS-2 level with improvements and further customisation after in-depth testing and validation of the pre-final version (D5.3, delivered in June 2016).

1.2 Aim of HIGH-TOOL

The HIGH-TOOL model is developed within an interactive and user-friendly approach designed to achieve the following objectives:

- Strategically assess different transport policy measures in terms of economic, environmental and social impacts, in order to select or pre-select advantageous transport policies.
- Prepare policy-oriented communicative reports of results, with tables, graphics, and maps, to be used in reports and high-level discussion groups and negotiations.

1.3 Structure of the Model

The core of the HIGH-TOOL model consists of seven modules, which are summarised in Table 1.

Table 1: HIGH-TOOL modules

Module	Content
Demography (DEM)	Development of the population and its structural changes.
Economy & Resources (ECR)	Quantifies the economic impacts of transport policy, such as transport related employment and GDP growth.
Vehicle Stock (VES)	Considers the development of the vehicle fleet and its structural changes.
Passenger Demand (FRD)	Reflects passenger transport demand whereby it is sensitive to policy measures effecting the generation, distribution and modal split.
Freight Demand (PAD)	Describes freight transport demand whereby it is sensitive to policy measures effecting the generation, distribution and modal split.
Environment (ENV)	Deals with emissions caused by transport activities and its changes.
Safety (SAF)	For road transport, the module deals with fatalities, serious and slight injuries, and total accident costs. For the other modes, fatalities and total accident costs are predicted.

Furthermore, the system consists of the **Data Stock** which ensures the compilation of data for the different modules (including data parameters definition, sources and units) and the definition of the data exchange mechanism, which will be used to download and upload data (see Kiel et al, 2014).

System's management and administration includes utilities for the system's manager to define user's profiles (e.g. in terms of access restrictions, database space available to store outputs...) and control the links, runs and synchronism of the different modules.

The **User Interface** includes three main components:

- **Pre-processing:** A scenario-building component allowing the derivation of input parameters for framework conditions and policy variables which can be used by the different modules.
- **Processing:** A model run component allowing different running options.
- **Post-processing:** A policy assessment component responsible for generating tables and graphs as policy-meaningful outputs.

The overall conceptual scheme of the HIGH-TOOL modelling system is shown in Figure 1.

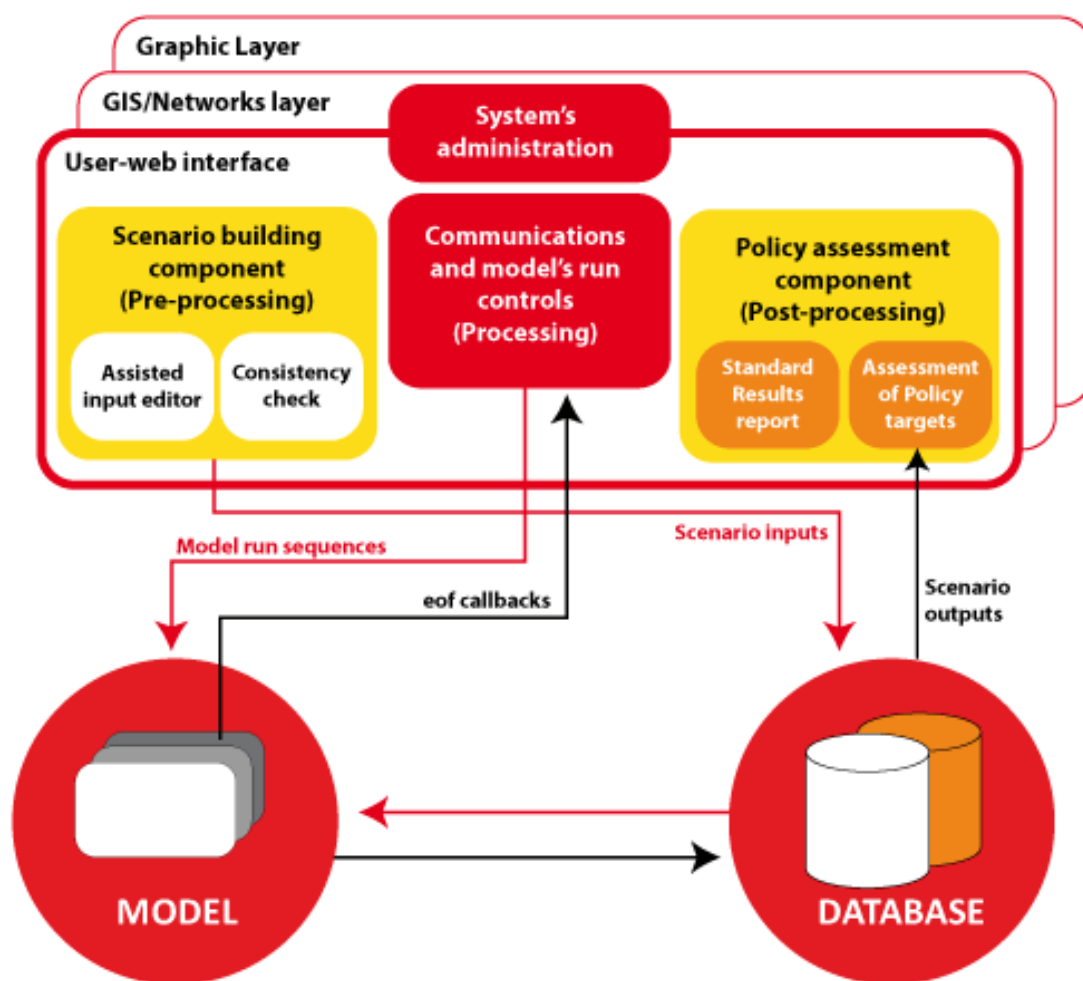


Figure 1: Conceptual scheme of the HIGH-TOOL modelling system

1.4 Model Use and Installation

HIGH-TOOL is provided in two formats:

- A server tool accessible via internet. This server version is to be installed at an EC server computer. However, the consortium provides a working version of the server online version at <http://www.high-tool.eu/model> updated with the latest available version of the model at all times. Contact with the system administrator is needed to obtain a user name and an access password.
- A stand-alone version that runs on a desktop PC.

2 Meeting the User Needs

2.1 User Requirements in Relation to Policy Definition

The main policy aims of the Transport White Paper 2011 were confronted with the specific user needs in a number of activities held by HIGH-TOOL with DG MOVE (see Vanherle et al, 2014), while keeping in mind the scope of the model. In Table 2, the strategic role of each of the policy topics is assessed in the rightmost columns in relation to the opinions expressed by participants of HIGH-TOOL user workshops and user surveys.

Table 2: Key policies considered in HIGH-TOOL, and assessment of their relevance in user workshops

Internal market	crucial	important	optional
Internal market for road	x		
Internal market for rail	x		
Internal market for inland waterway transport	x		
Internal market for maritime	x		
Internal market for air	x		
Transport security for cargo			x
Transport security for passenger			x
Transport security for land transport			x
Transport security for “end-to-end”			x
Multimodal Transport	x		
European TEN-T core network		x	
Cross border missing links		x	
Key bottlenecks (freight and passenger)		x	
Multimodal freight corridor structures		x	
EU transport infrastructure in view of energy efficiency needs and climate change challenges		x	
Planning procedure (timing, communication framework, environmental issues)			x
Capacity and quality of transport systems		x	
Taxation and pricing	crucial	important	optional
Infrastructure charging/Access management schemes	x		
Internalisation of external costs (or selected external costs categories and individual modes)	x		
Public funding of transport		x	
Other/new financing instruments			x
Fuel taxation		x	
Transport taxation (vehicle taxation, company car taxation, transport service taxation)		x	

Research and innovation	crucial	important	optional
Technology for vehicles	x		
Technology for transport infrastructure/system		x	
Technology for transport information systems, management & services	x		
Framework for transport safety	x		
Framework for promotion & incentives			x
Framework for technology and infrastructure			x
Intelligent Transport System (ITS)		x	

Efficiency standards and flanking measures	crucial	important	optional
Standards for transport safety	x		
Standards for passenger rights		x	
Standards for environment		x	
Flanking measures for promotion, information, dialogue			x
Flanking measures for regulation			x

2.2 User Requirements in Relation to Output Indicators

The following list presents the most relevant impact indicators as expressed by participants in HIGH-TOOL user workshops and surveys:

- Transport impact indicators (such as fleet composition or performance of each mode)
- GHG emissions
- Economic growth
- Employment
- Cost savings
- Safety
- Transport sector employment.

By default, assessment results need to be compared to the EU Reference Scenario 2013 (European Commission, 2013) in order to identify the potential impacts of policies being modelled.

2.3 Usability Requirements

Full documentation related to the User Interface can be found in HIGH-TOOL Deliverable D6.2 "Design Criteria for the User Interface & Policy Assessment Reports" (Biosca et al, 2016). The web-interface allows the HIGH-TOOL model to be run in an easy and intuitive way and provides detailed results for different indicators.

Following a ‘user-centric’ approach, the design of the system begun by defining user needs not only in relation to the model but also in relation to its usability. Activities with users have been organised all along the project life to obtain permanent user feedback, which allows considering user needs at the core of all design tasks in HIGH-TOOL.

During the first user workshop in June 2013, participants were asked to express their agreement on a number of statements determining the main pathways of development of HIGH-TOOL. The main conclusions were (Vanherle et al, 2014):

- Opinions diverged whether HIGH-TOOL should focus on certain policy domains in more detail or whether it should be defined as a broad, strategic model covering all domains.
- A certain degree of agreement existed that HIGH-TOOL should focus on a selected number of impact indicators that can be best assessed with the model.
- Participants emphasised the desire for a flexible, transparent model. A medium-detail level of policy inputs should be adopted which is a compromise between user requirements and ability to efficiently model.
- HIGH-TOOL should allow changing assumptions to the baseline and other reference scenarios to prevent it from becoming outdated shortly after its finalisation.
- EC participants would be willing to take responsibility for the consistency of the policy inputs. However, this would not mean that no efforts would have to be made to provide some guidance to the user, e.g. providing sensible ranges for parameters.
- Data and hypotheses in HIGH-TOOL could be introduced in the model both as prefab and as custom input. By ‘prefab’ it is meant that input data and scenarios are (almost) fully pre-prepared during development leaving the users some possibilities to make changes, whereas ‘custom’ meant that the user is mostly in charge for the input which involves more flexibility, but also more complexity.

Other requirements discussed during the user workshops have been included in HIGH-TOOL as much as possible:

- HIGH-TOOL should focus on spatial aspects rather than only providing aggregate results at a national level (at NUTS-2 level). Only indicators for which the regional level does not provide added value, such as GHG emissions, aggregate results at national level would suffice.
- Runtime of the model would depend on the level of detail for policies, but the expectations on computation time were not overly restrictive, in the order from 30 minutes to several hours.
- Relatively balanced opinions were received with regard to the question whether the HIGH-TOOL model should be designed to run locally or online on a remote server. It was mentioned that sharing runs and results with colleagues would be easier with an online version.

3 Operating the HIGH-TOOL: Model Capabilities

3.1 General Approach

Figure 2 shows the logical processes needed to operate the HIGH-TOOL model. These processes are performed through the User Interface, and are complemented by the Data Stock for mechanisms regarding data storage and retrieval.

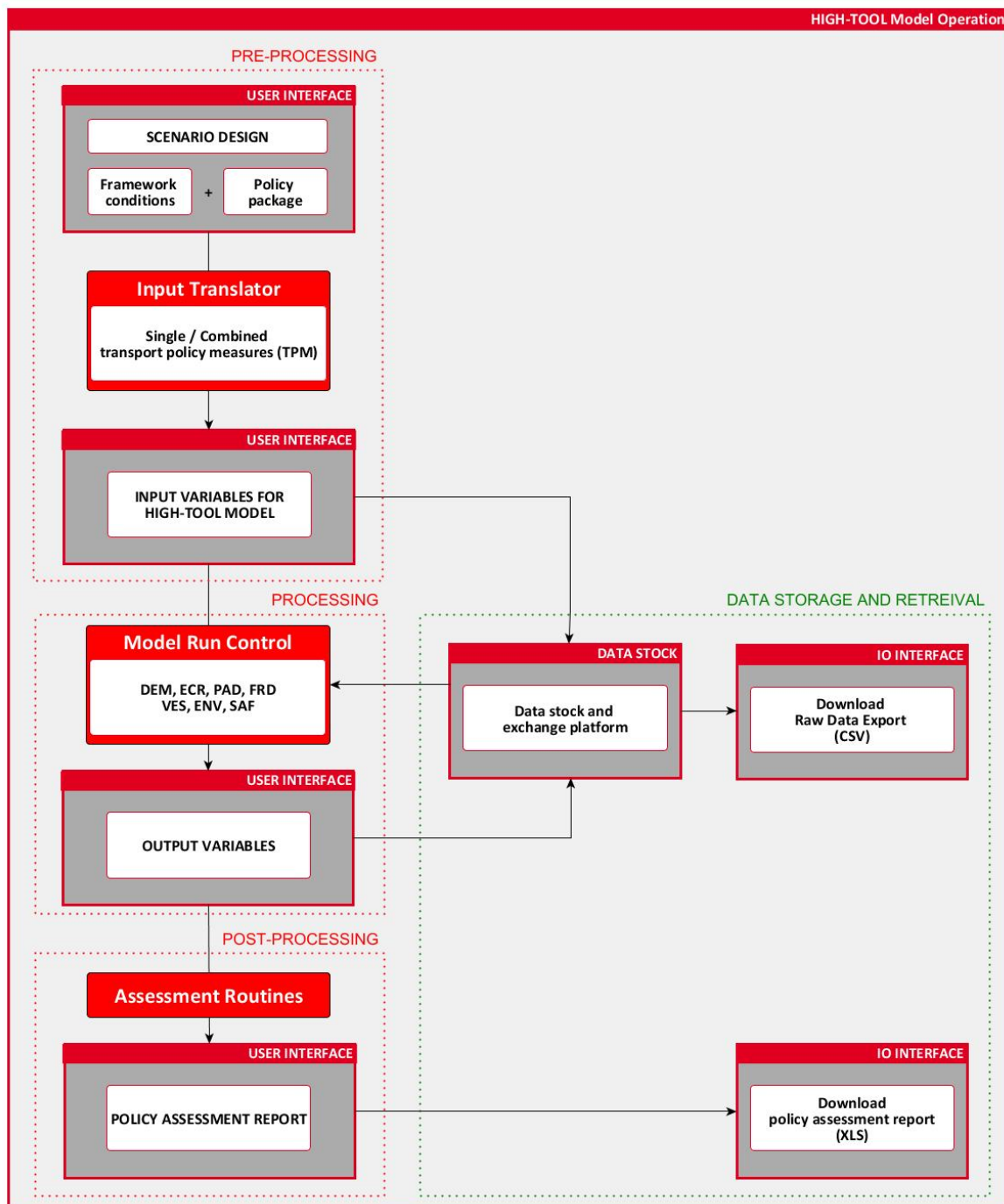


Figure 2: General approach to operation of the HIGH-TOOL model

In brief, the User Interface is integrated by the following components:

- **Pre-processing:** A scenario-building component allowing a derivation of input parameters for policy variables and framework conditions which can be used by different modules.
- **Processing:** A model run component allowing different running options.
- **Post-processing:** A policy assessment component responsible for generating tables and graphs as policy-meaningful outputs.

All User Interface components are reported in detail in the next sections.

3.2 Design Criteria of the User Interface

The final goal of the User Interface is facilitating transport policy experts without a deep modelling background to use the modelling system in a productive way. On one hand the User Interface has to be productive, clear and friendly enough to reduce the user's tasks of low importance as much as possible (e.g. filling large lists with input variables and parameters for model running, exchanging data between software applications). On the other hand, the User Interface has to be intelligent enough to support tasks with more added value such as defining consistent sets of input variables and analysing results in a policy-meaningful way. All considered, the web-interface supports users in the pre-processing (e.g. defining scenarios), processing (e.g. running scenarios) and post-processing tasks (e.g. relevant synthesis of indicators and graphic visualisation options).

The User Interface is therefore conceived as a 'user-centric' application instead of a 'model-centric' application. It is not just the model's interface, but the user's interface for models and databases; thus it is designed as a translator between the user's thoughts and the model's needs for specific input variables. Only in this way users can really feel the interface intuitively.

The design principles adopted for the HIGH-TOOL User Interface are based on the criteria outlined by Tognazzini (2013). They include **Anticipation, Visible Navigation, Efficiency, Consistency, Explorable Interfaces, Learnability, Readability, and Intuitiveness and Self-Explaining.**

The criteria have been addressed by the HIGH-TOOL User Interface as follows:

Anticipation: The HIGH-TOOL User Interface is designed to anticipate user needs. Users are not expected to search for information or evoke necessary tools, but the information and tools needed for each step of the process are provided to the users in a natural way. Thus default values provided by HIGH-TOOL are 'intelligent'.

Visible Navigation: Navigation is reduced to a minimum. The HIGH-TOOL User Interface is designed such that users can access configuration, hypotheses, calculations and result screens by a minimum number of clicks and actions. Navigation is clear and natural, allowing a user to quickly transition from novice to expert.

Efficiency: The HIGH-TOOL User Interface facilitates user's productivity, not computer's productivity. The application is designed such that task flows are comfortable, clear and optimal for the user, rather than organised according to programming needs.

Consistency with user expectations:

- Logical procedures stay coherent along the application.
- Buttons, input fields and navigational controls are always located in the same position of the interface.
- Harmonious 'overall look' of the different screens.

Explorable Interfaces: Users of the HIGH-TOOL User Interface are offered a line of least resistance allowing them to do just what they want, getting the job done in the quickest way possible, while still supporting those who want to explore further. This means stable visual elements to allow fast navigation and making actions reversible.

Learnability: The HIGH-TOOL User Interface allows for a quick learning curve that supports the performance of tasks within the minimum time possible (Natural-User Interface, NUI).

Readability: Texts displayed in the HIGH-TOOL User Interface are incorporated in such a way that they can be read properly without effort, favouring dark text on pale backgrounds, avoiding grey backgrounds and using font sizes that are large enough to be readable on standard monitors.

Intuitive and Self Explaining: The layout of HIGH-TOOL and the logic of processes in the User Interface are conceived in a way that makes it possible for users to run the tool on an intuitive basis. Contextual information provided by the User Interface, information made available through icons and tool-tip displays support the self-explaining property of HIGH-TOOL.

All design criteria together empower users to work efficiently with HIGH-TOOL while enjoying all features.

3.3 Pre-Processing: Definition of Policies

The main component of the User Interface is the scenario-building interface, which helps users to translate policy questions and framework conditions into the specific values of input variables. The HIGH-TOOL model offers different ways of assessing transport policies, ranging from quick and simple policy definitions (but with lower degree of possible user customisation) to more holistic policy scenarios (but requiring more time and effort from the user side to ensure coherence and consistency of hypotheses).

In brief, the following options are available for policy analysis and assessment:

- a Single Transport Policy Measure (TPM)
- a Combined TPM package
- a Customised Policy package.

For any of these three options the user can invoke an expert mode allowing some extra fine-tuning of the inputs.

3.3.1 Single Transport Policy Measure (TPM)

The first module provides a set of pre-defined TPMs to be analysed on a one per one basis.

This is the quickest way to evaluate transport policies. For each pre-defined TPM, HIGH-TOOL identifies which of the model variables are impacted (only a limited number of variables for each TPM), and what are the reasonable impact ranges. Users define the policy intensity for each of these variables (see Figure 3).

Users work directly upon model variables. Users select the evolution of model variables involved in a TPM between 2010 and 2050 (per member state or even NUTS-2 region if needed). Possible variable ranges (maximum and minimum allowed values) are provided as a reference. Such ranges are defined in HIGH-TOOL based on extensive literature review. Details can be found in Deliverable D4.3 "Elasticities and Equations" (van Grol et al, 2016).

HIGH-TOOL
Framework Conditions
Policies
Run
Outputs
Export
HI, HIGH-TOOL Test user

Define a Single Transport Policy Measure (TPM)

« Internal market **Research and innovation** Efficiency standards and flanking measures Pricing »

Dynamic traffic management for road
Save this TPM

Deployment of next generation of road traffic management and information systems (by dynamic traffic management).

Intelligent road vehicles
Save this TPM

Deployment of next generation of road traffic management and information systems (by intelligent vehicles including driver assistance).

Intelligent traffic information system for road
Save this TPM

Deployment of next generation of road traffic management and information systems (by real time traffic information systems).

Variable	Start year	Select value	-20%	0	+20%	Unit	Reset	Time	Map
Change of level of service indicator for passenger road	2015	0	0.01	0		count			
Change of net time for passenger road	2015	97	100	99		percentage (100 = baseline)			
Technology related additional cost for B30 bus	2015	95	100	97,5		eur_veh (100 = baseline)			
Technology related additional cost for battery electric car	2015	95	100	97,5		eur_veh (100 = baseline)			
Technology related additional cost for battery electric van	2015	95	100	97,5		eur_veh (100 = baseline)			

Figure 3: Sample of the interface to define and run a Single Transport Policy Measure (TPM)

The 34 TPMs available for modelling are presented below in Table 3.

Table 3: Single Transport Policy Measures considered in HIGH-TOOL model

Internal Market measure	Explanation
Acceleration of TEN-T implementation	Policy set to simulate an accelerated implementation of TEN-T projects, under the assumptions that the Core TEN Network will be completed by the year 2025 and the Comprehensive TEN Network by the year 2040. This TPM has a different behaviour compared to the others, as it does not contain any explicit lever. When chosen, the model will change the impedance matrices for the passenger road and rail modes.
European Rail Traffic Management System	ERTMS (European Rail Traffic Management System)
Freight corridor management	Develop an integrated approach to freight corridor management, including track access charges.
Harmonized handling of dangerous goods	Streamline the rules for the intermodal transport of dangerous goods to ensure interoperability between the different modes.
Harmonisation of rail safety	Progressively achieve a sector-wide approach to safety certification in the rail transport sector, building on existing approaches for infrastructure managers and railways undertakings and evaluating the possibility to rely on a European standard. Enhance the role of ERA in the field of rail safety, in particular its supervision on national safety measures taken by National Safety Authorities and their progressive harmonisation.

Internal Market measure	Explanation
Harmonized social rules for truck drivers	EU-wide common job quality and working conditions for truck drivers SEC(2008)2632 Policy set to simulate the regulation of job quality and working conditions for truck drivers, assuming an impact on travel costs and travel time for the truck mode.
Maritime traffic management system	Integrate the use of monitoring tools by all relevant authorities, ensure the full interoperability between ICT systems in the waterborne sectors, guarantee the monitoring of vessels and freight (Blue Belt) and set up appropriate port facilities ("Blue Lanes").
Opening the internal IWW market	Establishes an appropriate framework to optimise the Internal Market for Inland Waterway Transport, and to remove barriers that prevent its increased use. Assesses and defines the necessary tasks and mechanisms for their execution, also with a view to the wider European context.
River information system	Policy set to simulate the development of the River Information Services, assuming an impact on IWW transport time thanks to the reduction of administration burdens and the provision of information exchange for freight transport.
Single rail vehicle authorisation and certification	Achieve a single vehicle type authorisation and a single railway undertaking safety certification by reinforcing the role of the European Railway Agency.
Pricing measure	Explanation
CO₂ certificate system for road transport	Policy set to simulate the implementation of a CO ₂ certificate system. A certificate price in constant (2005) EUR per ton CO ₂ can be implemented and the trend for this price over the future time period can be defined. The certificate price is converted in an additional cost by fuel type (depending on their CO ₂ specific emission factor), which is applied to all road modes.
CO₂ feebates for road transport	Policy set to simulate the implementation of a feebates to stimulate the diffusion of low emission, fuel-efficient and alternative fuel vehicles. A system offering rebates for purchasers of clean vehicles and in parallel setting fees for vehicles emitting more CO ₂ than a certain threshold is called feebates.
Circulation tax for cars	Vehicle taxation (circulation & registration taxes). Policy set to simulate the implementation of common rules for annual car circulation taxes based on CO ₂ emissions and the phase out of registration taxes at EU level in order to encourage the use of fuel-efficient cars.
HDV infrastructure charge	Phase in a mandatory infrastructure charge for heavy-duty vehicles. The scheme would introduce a common tariff structure and cost components such as the recovery of wear and tear, noise and local pollution costs to replace the existing user charges.
Internalisation of external costs	Proceed with the internalisation of external costs for all modes of transport applying common principles while taking into account the specificity of each mode.
Urban road charging	Urban Area charging/Cordon pricing.

Efficiency standards and flanking measures	Explanation
Deployment of efficient vehicles	Support the deployment of new vehicles and vessels and retrofitting.
Diffusion of electro cars	Electro mobility road measures to promote increased replacement rate of inefficient and polluting vehicles. The policy is set in order to accelerate the diffusion of vehicles with electric propulsion into the European car vehicle fleet.
Diffusion of H ₂ fuel cell cars	H ₂ Fuel Cell vehicle measures to promote increased replacement rate of inefficient and polluting vehicles. The policy is set in order to stimulate the diffusion of H ₂ fuel cell vehicles into the European car vehicle fleet.
Enhance service quality at airports	Clarify and improve conditions to enter and provide quality services, including ground handling; ensure that all actors in an airport system meet minimum quality standards.
HDV limitation for urban areas	The City Logistics policy includes various measures regarding urban freight distribution (e.g. urban consolidation centres) aimed at reducing the traffic of heavy duty vehicles through cities and metropolitan areas by means of the implementation of technical and planning measures.
Improving local public transport	Policy set to simulate an improvement of frequency and reliability of public transport services (bus or train), in terms of reduction of travel time at local level.
LDV speed limit	Examine approaches to limit the maximum speed of light commercial road vehicles, in order to decrease energy consumption, to enhance road safety and to ensure a level playing field.
Replacement of inefficient LDVs and buses	The policy is set to stimulate purchasing clean and energy-efficient commercial vehicles (LDV and buses) at urban level.
Replacement of inefficient cars	The policy is set in order to stimulate the replacement of inefficient and polluting vehicles into the European car vehicle fleet.

Research and innovation measure	Explanation
Dynamic traffic management for road	Deployment of next generation of multimodal traffic management and information systems.
Intelligent road vehicles	Deployment of next generation of multimodal traffic management and information systems.
Intelligent traffic information system for road	Deployment of next generation of multimodal traffic management and information systems.
Road vehicle safety technology protecting other transport users	Safer vehicle technologies for vulnerable users such as pedestrians, cyclists and motorcyclists.
Safety systems for road vehicle users	The policy is set to simulate the diffusion of a variety of technical safety systems in road vehicles such as driver assistance systems, seat belt reminder, eCall and vehicle-infrastructure interface.

3.3.2 Combined TPM Package

This module allows merging different single TPMs to simulate more complex Policy Packages. As with Single Transport Policy Measures, users work directly upon model variables.

The module shows a list of available TPMs and the user selects the ones to be simulated (Figure 4). Then a list of policy levers from all selected TPMs is presented; the interaction with the policy levers is the same as in the Single TPM module.

Figure 4: Sample of the interface to define and run a Combined TPM package

A key issue is how inputs on different TPMs influencing the same model variables can be considered simultaneously. In some cases it is possible to simply add the impact of two TPMs; but in some other cases there might be impacts in opposite directions, or impacts in the same direction that do not fully add together.

All possible TPM combinations have been analysed so that the interface is able to handle these special cases. The interface always shows a list of the policy levers for all selected TPMs without repeating any lever. In case a lever appears in two or more TPMs, its upper and lower limits are calculated automatically taking into account the possible interactions (Figure 5).

Figure 5: Sample of the interface to define and run a Combined TPM package, showing the active policy levers for a chosen set of TPMs

3.3.3 Customised Policy Package

The Customised Policy package allows selecting any combination of all available individual policy levers.

The policy levers are organised in tabs according to the module they belong to, and their exact number and classification is shown on Table 4.

Table 4: Available policy levers by module on the customised TPM interface

Module	Number of individual levers
Economy and Resources	3
Vehicle Stock	430
Passenger Demand	100
Freight Demand	79
Environment	127
Safety	60

Figure 6 shows the arrangement of the interface for Customised Policy package.

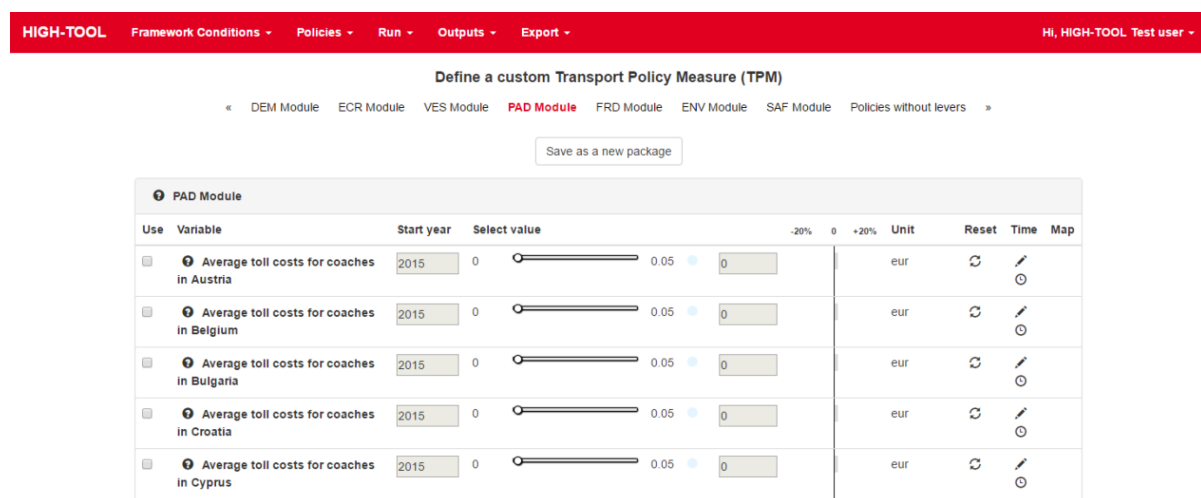


Figure 6: Sample of the interface for building a Customised Policy package

The way of interacting with the policy levers is identical to that of the interface for Single TPM but, in order to use any given policy lever, the user must first tick the checkbox of that lever so that it becomes active.

The list of available policy levers is more extensive than that of the Single TPM interface, as there are some levers that are not used in any predefined TPM but exist nonetheless as possible inputs for HIGH-TOOL (e.g. "Load capacity for rail" or "Purchase VAT for electric cars").

The lower and upper limits for each policy lever are in general wider than the ones appearing on the Single TPM interface, so that the user has a higher degree of freedom for defining more intense policies.

3.3.4 Expert Mode

The three different modules available to input policy options into HIGH-TOOL (chapters 3.3.1, 3.3.2, 3.3.3) can be combined with an extra option called expert mode, with which one can edit input tables of the model at a low level and/or edit the Hyper-Network to control the impedances used in the model. This feature is optional and reserved to users that wish to make some advanced editing to the actual database values before running the model.

By using the expert mode the user can check and adjust the variables that have been previously affected by the changes in policy levers, as well as change other model parameters or inputs such as Framework Conditions.

HIGH-TOOL offers an aggregated way of changing the network impedances of the different transport modes through the policy levers available in the TPM interfaces. However, if the user wishes to explore and make detailed changes to the network, the expert mode has the Hyper-Network interface, which is a graphical simplified representation of the road and rail connections between NUTS-2 regions (see Figure 7).

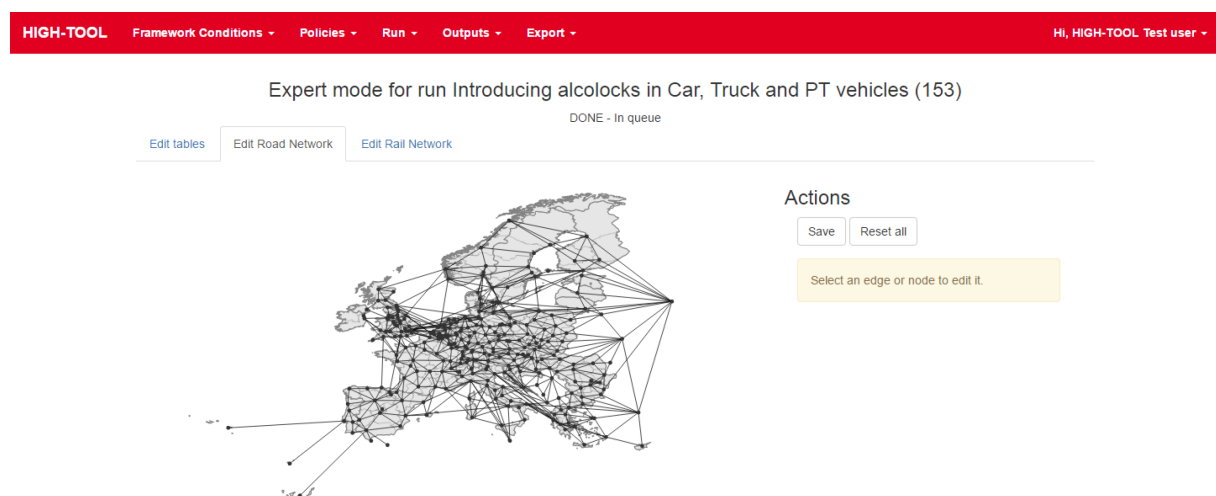


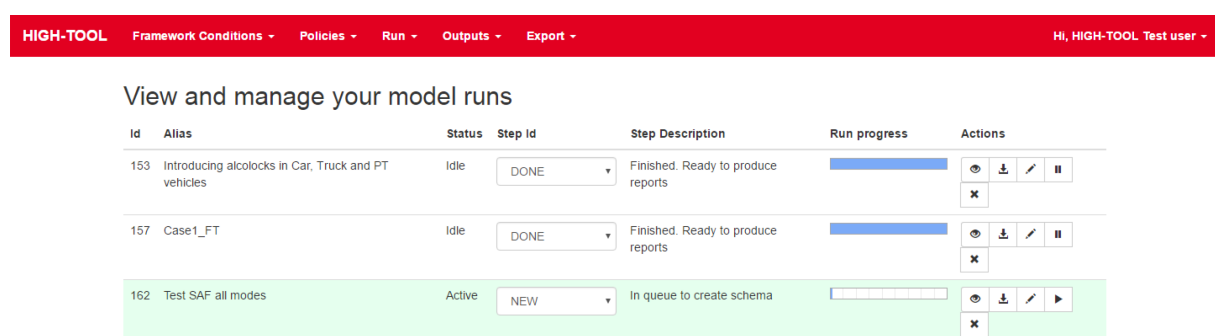
Figure 7: Editing the road Hyper-Network

3.4 Processing: Running Simulations

The User Interface is responsible for calling individual HIGH-TOOL modules in a logical sequence so that a full model run can be developed over time, for the whole simulation period.

When a user launches a run, the User Interface of HIGH-TOOL is responsible for managing this run, calling the different modules in due time, gathering results and presenting them to users. The User Interface allows users to visualise all runs being processed at any time (ongoing runs) and managing the run sequence, e.g. pausing or halting a specific run. HIGH-TOOL is a multitask platform, meaning that it can handle more than one run simultaneously, though available computational resources need to be shared between all active runs. Partial results of an ongoing simulation become available for users before the run has finalised, for instance intermediate results of a module that has finished calculating while the next module is still running can be downloaded using the Export function.

Figure 8 shows the User Interface screen where users can manage ongoing runs. Each line corresponds to a model run. The *Status* field displays whether a run is active, on standby, paused or finalised. The *Step id* field indicates which specific step is being undertaken for an unfinished run; the dropdown selector on this field allows choosing another step if the run is paused, and then carry on the computation from that step onwards. The run progress bar is a graphical representation of the approximate percentage of the run that is already complete. The right-most panel allows users managing active runs. Available options (left to right), are as follows: visualising available results, downloading available data, edit intermediate data with the expert mode interface, pause (or reactivating a paused run), and abort/delete a run.



Id	Alias	Status	Step Id	Step Description	Run progress	Actions
153	Introducing alcolocks in Car, Truck and PT vehicles	Idle	DONE	Finished. Ready to produce reports	<div style="width: 100%;"></div>	<div> <div>👁</div> <div>📄</div> <div>✏</div> <div>⏸</div> </div> <div>✖</div>
157	Case1_FT	Idle	DONE	Finished. Ready to produce reports	<div style="width: 100%;"></div>	<div> <div>👁</div> <div>📄</div> <div>✏</div> <div>⏸</div> </div> <div>✖</div>
162	Test SAF all modes	Active	NEW	In queue to create schema	<div style="width: 10%;"></div>	<div> <div>👁</div> <div>📄</div> <div>✏</div> <div>▶</div> </div> <div>✖</div>

Figure 8: Sample of the User Interface to manage model runs and results

The run sequence of HIGH-TOOL modules is established as illustrated in Figure 9.

There is a sequential interaction of the modules in the HIGH-TOOL model. The sequential approach reduces the number of computation loops.

The chronological sequence a model run is as follows (see Szimba et al. 2015; Mandel et al. 2016):

- The sequence starts with the Demography (DEM) module to produce demographic outputs for all forecast years (2015 to 2050).
- The Economic & Resources (ECR) module is run using the DEM results for a time step (t) and outputs from Vehicle Stock (VES) Passenger Demand (PAD) and Freight Demand (FRD) modules for the previous time step (t-1).
- Vehicle Stock (VES) module is activated using outputs from DEM/ECR (step t), and PAD/FRD (step t-1).
- PAD and FRD are run, using results from DEM/ECR/VES, and ECR/VES, respectively.
- Results from PAD, FRD and VES are delivered for all years to the Environment (ENV) module to compute the environmental impacts, and from PAD and FRD to Safety (SAF) to compute the safety impacts.

The base year is 2010. Thus, the first time step, 2015, is partly driven by 2010 results, and 2020 by 2015 results.

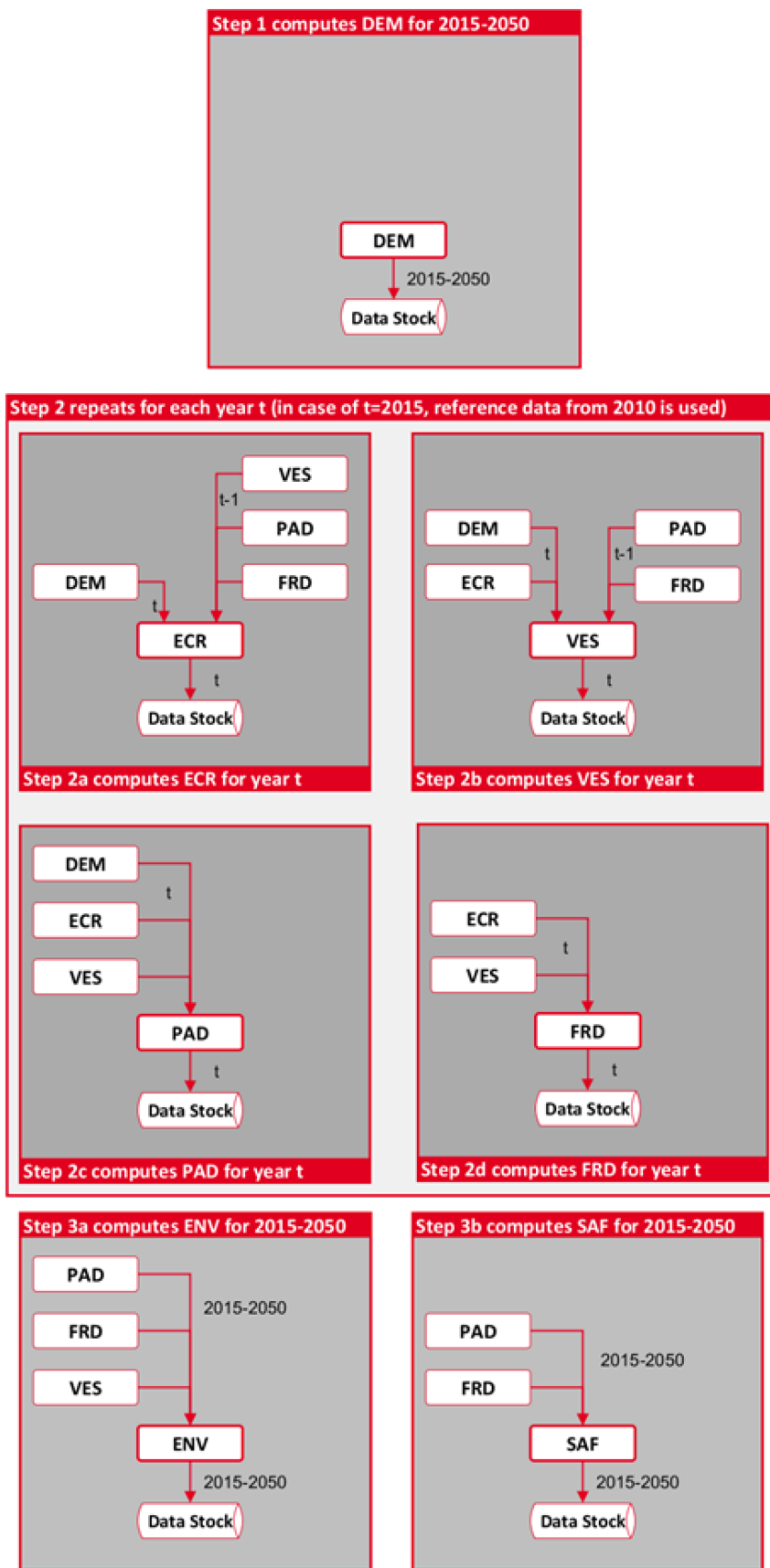


Figure 9: Model run sequence in HIGH-TOOL. The Model run sequence is managed and controlled by the HIGH-TOOL User Interface

3.5 Post-processing: Generation of Policy Assessment Reports

The policy report integrates the outputs of the HIGH-TOOL model into a relatively short number of policy-relevant indicators, and presents these indicators in a meaningful way to the user. Results are provided in a detailed level in the form of tables and figures, for the period 2010–2050 in five-year steps.

Indicators included in policy assessment reports are displayed in the User Interface (Figure 10), and are also published in pre-designed MS EXCEL files (Figure 11), so tables and graphics are automatically produced and the users can easily adjust or modify them whenever needed, or use them in other word processor or presentation documents.

Results of a HIGH-TOOL run

[Download Policy Assessment Report](#)

Simulated Run Demography Economy **Passenger Demand** Freight Demand Vehicle Stock Safety Environment

Modal split based on pkm (in millions)								
Year	Air		Coach		Rail		Road	
	pkm	%	pkm	%	pkm	%	pkm	%
2010	1,180,006.602	8.32	1,033,068.969	7.28	1,018,702.811	7.18	10,955,050.152	77.22
2015	1,288,024.047	8.69	1,085,164.553	7.32	1,137,454.525	7.67	11,310,454.795	76.31
2020	1,457,195.785	9.42	1,107,118.010	7.16	1,258,909.923	8.14	11,646,989.567	75.29
2025	1,664,778.994	10.21	1,140,770.896	6.99	1,390,623.139	8.53	12,113,354.247	74.27
2030	1,898,370.140	11.06	1,176,579.898	6.85	1,517,456.215	8.84	12,571,912.629	73.24
2035	2,068,786.175	11.62	1,211,807.438	6.81	1,579,890.124	8.88	12,937,142.554	72.69
2040	2,247,691.879	12.20	1,245,464.718	6.76	1,627,793.724	8.83	13,309,992.103	72.22
2045	2,396,756.044	12.66	1,278,207.408	6.75	1,634,025.069	8.63	13,622,591.613	71.96
2050	2,547,191.261	13.11	1,302,674.811	6.70	1,656,937.262	8.53	13,926,598.712	71.66

Figure 10: Model results displayed on the User Interface of HIGH-TOOL

A number of pre-defined graphics to illustrate key indicators have been developed in MS EXCEL. In terms of communication, online solutions can be very effective, but in terms of productivity, MS EXCEL is probably the best solution since users are able to get both tables with indicators and graphics pre-designed in a file, and can easily adjust the design, select tables and graphics for their own reports and presentations.

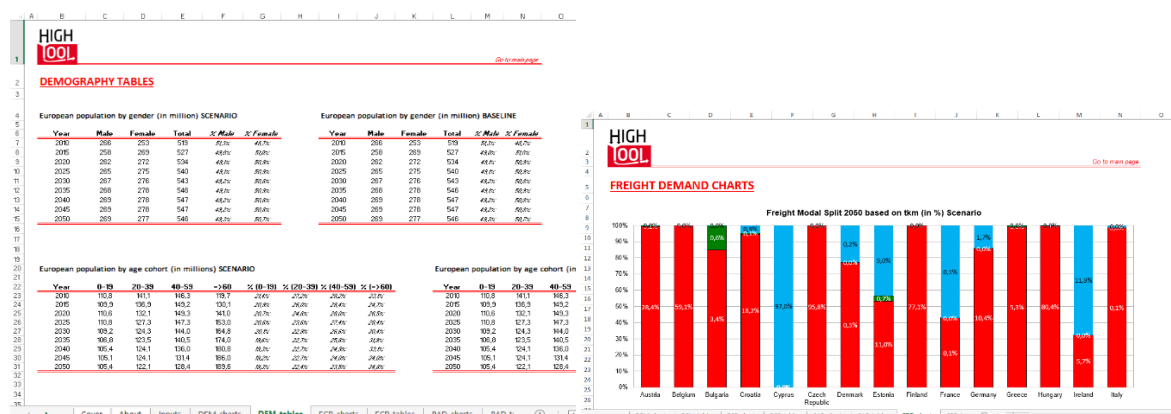


Figure 11: MS EXCEL synthesis of scenario results – Tables and graphics generated by the HIGH-TOOL model

Full results of the HIGH-TOOL model can also be obtained directly in raw formats (CSV) for further user management. The HIGH-TOOL User Interface allows the download of any table produced by a specific HIGH-TOOL module using the Export Table functionality (see Figure 12).

HIGH TOOL Framework Conditions Policies Scenario Run Policy Reports Export Hi High Tool Test user

Export table contents

Select database schema:
High-Tool Baseline (high_tool) --- Status: Idle

Search options

Id Search by variable Id Table Search by table Id Description Search by description

Inputs Outputs Parameters

Variable	Table	Description	Download
i_de_labour_hist	i_de_eurostat	historic labour force (1995 - 2010) by age and gender cohort	ⓐ
i_de_labour_perc	i_de_labour_perc	labour force assumptions	ⓐ
i_de_death	i_de_death	historic number of deaths per country per age and gender cohort	ⓐ
i_de_pop_disag	i_de_pop_disag	historic shares of population 2010 at nuts-2 level per age and gender	ⓐ
i_de_pop_eurostat	i_de_eurostat	historic population (1995 ? 2010) by age and gender cohort	ⓐ
i_de_life_men	i_de_europop_ass	projected life expectancy for men for eu27 countries +ch +no from 2010 ? 2050 (5-year time step)	ⓐ
i_de_life_women	i_de_europop_ass	projected life expectancy for women for eu27 countries +ch +no from 2010 ? 2050 (5-year time step)	ⓐ
i_de_net_migration	i_de_europop_ass	projected net migration (emigration-immigration) for eu27 countries +ch +no from 2010 ? 2050 (5-year time step)	ⓐ
i_de_tot_fert_rate	i_de_europop_ass	projected total fertility rate for eu27 countries +ch +no from 2010 ? 2050 (5-year time step)	ⓐ
i_de_eu_ref	i_de_eu_ref	the calibration coefficients for europop2010 by year (5-year time steps), country (eu27 countries + no + ch), agegroups (0,5, 75) and gender (0,1)	ⓐ
i_de_urban	i_de_urban	urbanisation proxy per nuts-2 region	ⓐ
i_fd_region_share	i_fd_region_share	region shares by o/d and mode for travelled distance	ⓐ
i_fd_imp_dist	i_fd_imp	distance impedances od and mode based	ⓐ
i_fd_route_choice	i_fd_route_choice	tonne share by route chains using two transshipment points	ⓐ

Figure 12: Export raw data control panel

4 Model Structure and Performance

4.1 General Organisation of the Model

Figure 13 illustrates the structure of the HIGH-TOOL model (Mandel et al, 2016). A full overview and a description of inputs and outputs for each module are provided in Deliverable D2.2 (Mandel et al, 2016).

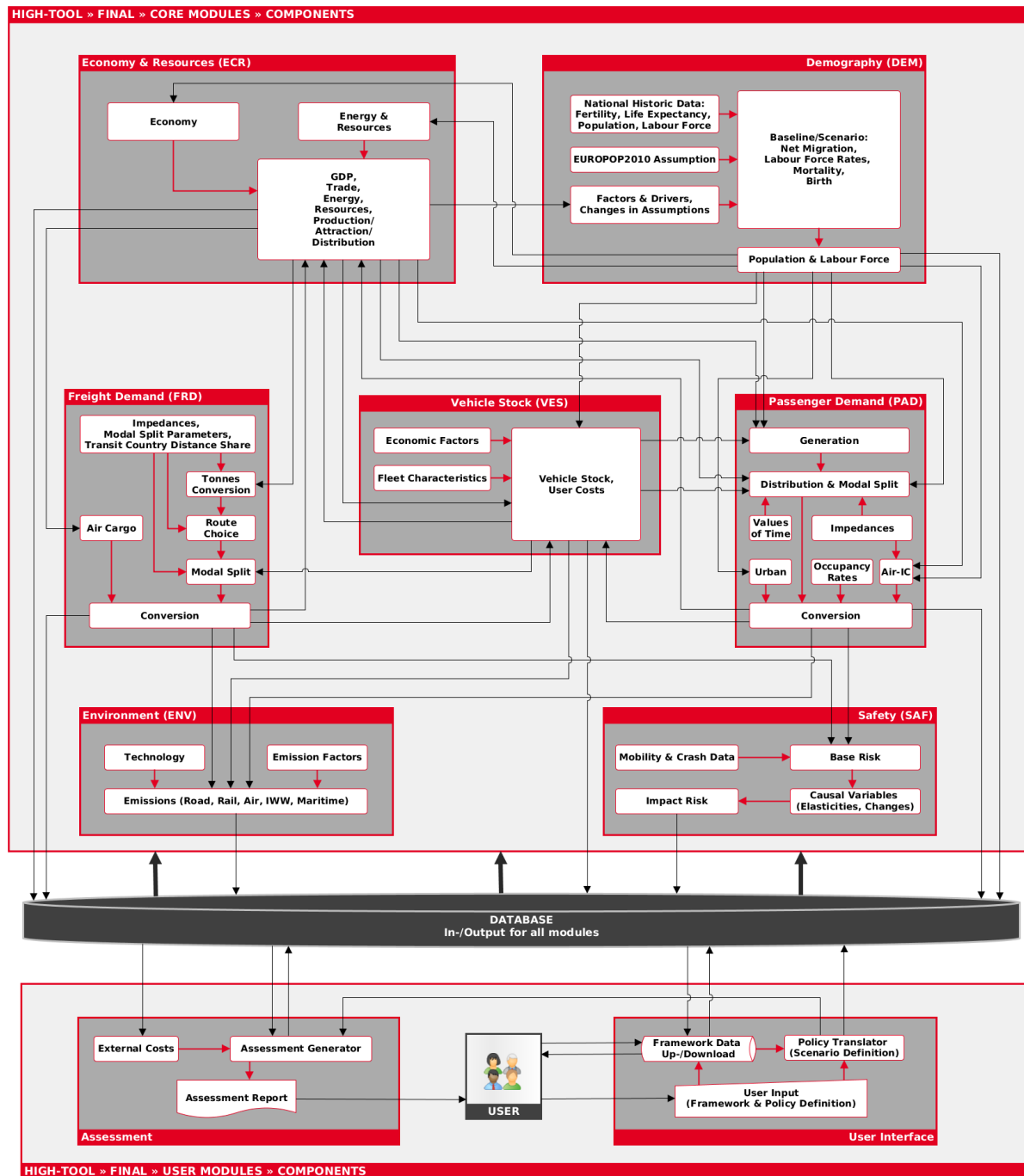


Figure 13: Structure of the final version of the HIGH-TOOL model

4.2 Description of HIGH-TOOL Modules

Full documentation related to models, equations and elasticities can be found in HIGH-TOOL Deliverable D4.3 "Elasticities and Equations" (Van Grol et al, 2016).

4.2.1 Demography Module

The Demographic module reflects the demographic development of the regions considered within HIGH-TOOL. Calculations are performed at the level of countries (NUTS-0 level) and thereafter disaggregated to zones at NUTS-2 level. The development of the population is simulated by the Demography module with a cohort component model that takes the effects of demographic drivers and migration into account. The module is sensitive to changes affecting the exogenous demographics (e.g. fertility rates per specific age group). Exogenously defined demographic scenario data can be uploaded to the Demography module. The output of the Demography module is shown in Table 5. The module does not use any inputs from other HIGH-TOOL modules.

Table 5: Interaction of the Demography module with other HIGH-TOOL modules

I/O	Variable	Description	Dimensions	Module(s)	Equation	Name in database
Out	pop^{tot}	Population [persons]	time period t , zone i , gender g , and age group a	Passenger Demand and Economy & Resources		o_de_pop
Out	LB	Labour force [persons]	time period t , zone i , gender g , and age group a	Passenger Demand and Economy & Resources		o_de_labour

4.2.2 Economy and Resources Module

The Economy & Resources module simulates the impact of transport policies on the economy. Its role is to provide baseline economic projections regarding GDP and value added, to provide projections for inter-regional trade-flows, and to calculate the impacts of changes in freight and passenger costs on the wider economy and on non-transport related and environmental and material use indicators.

To this end, the module first disaggregates national projections of GDP, productivity, and value added from the EU Reference scenario 2013 for 2015–2050 by region (NUTS-2 level) and commodity type (NSTR classification). Therewith, a baseline forecast is composed. In the next step, the impacts of specific transport policy measures (affecting passenger and freight transport costs) on this baseline forecast and on inter-regional trade flows are calculated.

The calculations of the Economy & Resources module are implemented as a set of sequential algebraic equations. The inputs and output of the module are shown in Table 6.

Table 6: Interaction of the Economy & Resources module with other HIGH-TOOL modules

I/O	Variable	Description	Dimensions	Module	Name in database
In	pop^{tot}	Population [persons]	time period t , country ci , gender g , age group a	Demography	o_de_pop
In	LB	Labour force [persons]	time period t , zone i , gender g , age group a	Demography	o_de_labour
In	pkm	Passenger transport mobility [pkm] ¹	time period t , origin i , destination j , purpose p , mode m	Passenger Demand	od_pd_pkm_od and o_pd_airic_pkm_od
In	$vkm^{freight}$	Freight transport mobility [vkm] ¹	time period t , origin i , destination j , commodity c , mode m	Freight Demand	o_fd_vkm_od
Out	GDP	Gross domestic product [million EUR]	time period t , country ci	Passenger Demand & Freight Demand	o_er_GDP
Out	$jobs$	Number of working places [jobs]	time period t , country ci	Passenger Demand	o_er_emp
Out	$income$	Income [EUR]	time period t , country ci	Passenger Demand	o_er_income
Out	T^{econ}	Trade flow [EUR]	time period t , origin i , destination j , mode m , commodity c	Freight Demand	o_er_trade

4.2.3 Vehicle Stock Module

The main task of the Vehicle Stock module is to convert passenger and freight demand into the vehicle fleet size. This fleet size is disaggregated by vehicle type and vehicle age cohort, which is important for emission and energy use calculations. The adopted classification of vehicle types is based on both propulsion and fuel type, as well as on vehicle size. In total, the Vehicle Stock module covers 61 road mode vehicle types and 12 non-road mode vehicle types.

The Vehicle Stock module receives mobility forecasts from the Passenger and Freight Demand modules. In turn, the average generalized costs that are used to derive these forecasts are obtained from the Vehicle Stock module. Furthermore, the calculated vehicle stock is utilized for emission calculations in the Environment model, while the calculated tax revenues are used by the Economy & Resources module. These interactions with other HIGH-TOOL modules are shown in Table 7.

¹ These mobility variables are used to calculate the total monetary costs of passenger and freight transport, which is input to the Economy and Resources module.

Table 7: Interaction of the Vehicle Stock module with other HIGH-TOOL modules

I/O	Variable	Description	Dimensions	Module(s)	Name in Database
In	<i>vkmpas</i>	Passenger transport mobility [vkm]	time period <i>t</i> , origin <i>i</i> , destination <i>j</i> , purpose <i>p</i> , mode <i>m</i>	Passenger Demand	<i>o_pd_vkm_od</i>
In	<i>vkmfreight</i>	Freight transport mobility [vkm]	time period <i>t</i> , origin <i>i</i> , destination <i>j</i> , mode <i>m</i> , commodity <i>c</i>	Vehicle stock, Environment	<i>o_fd_vkm_od</i>
Out	<i>costfix</i>	Fixed vehicle costs [EUR/vkm]	time period <i>t</i> , mode <i>m</i> , country <i>ci</i>	Passenger Demand	<i>o_vs_cstavggen_fix_vkm</i> <i>o_vs_cstavggen_fix_pkm</i>
Out	<i>costvar</i>	Variable vehicle costs [EUR/vkm]	time period <i>t</i> , mode <i>m</i> , country <i>ci</i>	Passenger Demand	<i>o_vs_cstavggen_var_vkm</i> <i>o_vs_cstavggen_var_pkm</i>
Out	<i>stock</i>	Total number of vehicles	time period <i>t</i> , mode <i>m</i> , zone <i>i</i> , vehicle type <i>vt</i> , age cohort <i>ac</i>	Environment	<i>i_vs_veh_stock</i>

4.2.4 Passenger Demand Module

The Passenger Demand module (PAD) largely follows the classical “four-step approach” of transport demand modelling without the network assignment step, given that HIGH-TOOL does not incorporate physical networks. PAD computes trip flows at the level of origin-destination relations at NUTS-2 level, with Europe and neighbouring countries. It distinguishes four trip purposes (business, commuting, private and vacation) and four transport modes (rail, road, air, coach). The Passenger Demand module is not adequate at producing extensive forecasts on intra zonal trips and urban transport respectively in parallel to long haul trips to intercontinental destinations, so it is complemented by two additional sub-models: the urban passenger demand module and the intercontinental air passenger module. The main outputs of PAD are the origin-destination trip matrices by mode and purpose. These trip matrices focus on long distance transport modes and feed an additional sub-model in order to derive other transport indicators like passenger-kilometres and vehicle-kilometres. The inputs and output of the module are shown in Table 8.

Table 8: Interaction of the Passenger Demand module with other HIGH-TOOL modules

I/O	Variable	Description	Dimensions	Module(s)	Name in database
In	<i>pop^{tot}</i>	Population [people]	time period <i>t</i> , country <i>ci</i> , gender <i>g</i> , age group <i>a</i>	Demography	<i>o_de_pop</i>
In	<i>LB</i>	Labour force	time period <i>t</i> , zone <i>i</i> , gender <i>g</i> , age group <i>a</i>	Demography	<i>o_de_labour</i>
In	<i>GDP</i>	Gross domestic product [million EUR]	time period <i>t</i> , country <i>ci</i>	Economy & Resources	<i>o_er_GDP</i>

I/O	Variable	Description	Dimensions	Module(s)	Name in database
In	<i>jobs</i>	Number of working places [jobs]	time period t , country ci	Economy & Resources	o_er_empl
In	<i>income</i>	Income [EUR]	time period t , country ci	Economy & Resources	o_er_income
In	$cost^{fix}$	Fixed vehicle costs [EUR/vkm]	time period t , country ci , mode m	Vehicle Stock	o_vs_cstavggen_fix_vkm, o_vs_cstavggen_fix_pkm
In	$cost^{var}$	Variable vehicle costs [EUR/vkm]	time period t , country ci , mode m	Vehicle Stock	o_vs_cstavggen_var_vkm, o_vs_cstavggen_var_pkm
Out	<i>pkm</i>	Passenger transport mobility [pkm]	time period t , destination j , origin i , purpose p , mode m	Economy & Resources	o_pd_pkm_od and o_pd_airic_pkm_od
Out	<i>pkm</i>	Passenger transport mobility by country [pkm]	time period t , country ci , mode m	Safety	od_pd_pkm_transit_safety, o_pd_pkm_orig_safety, o_pd_urban_pkm_ctry
Out	vkm^{pas}	Passenger transport mobility [vkm]	time period t , destination j , origin i , purpose p , mode m	Vehicle Stock & Environment	o_pd_vkm_od
Out	vkm^{pas}	Passenger transport mobility by country [vkm]	time period t , country ci , mode m	Safety	o_pd_vkm_orig, o_pd_urban_vkm_crtv
Out	T^{pas}	Number of passenger trips [trips]	time period t , destination j , origin i , purpose p , mode m	Safety	o_pd_airic_trips_od

4.2.5 Freight Demand Module

The Freight Demand module (FRD) consists of four components: generation/attraction, distribution, modal split, and a final conversion component that produces final outputs and derives mobility in terms of tonne-kilometres and vehicle-kilometres. The generation-attraction step is already performed by the ECR module (trade projections by origin-destination pair), provided in EUR (2010, constant values), and are transformed by FRD into tonnes using volume-density assumptions. The trade in origin-destination is distributed using a multinomial logit function distributed across the routes represented by multimodal chains (origin-destination flows routed through transshipment points) collected from the ETISplus database. The modal split component applies a multinomial logit function based on commodity types, as well as cost and time parameters to estimate the modal shares in the legs of the multimodal chains. The cost functions and utilities in the modal split component are based on TRANSTOOLS v2 (Rich et al., 2009). Finally, conversion is applied to obtain transport performance in tonne-km and vehicle-km by O/D and transit. Table 9 shows the interaction of FRD with other HIGH-TOOL modules.

Table 9: Interaction of the Freight Demand module with other HIGH-TOOL modules

I/O	Variable	Description	Dimensions	Module(s)	Database name
In	T^{econ}	Trade flow [EUR]	time period t , origin i , mode m , commodity c , destination j	Economy & Resources	o_er_trade
Out	$vkm^{freight}$	Freight transport mobility [vkm]	time period t , origin i , mode m , commodity c , destination j	Vehicle stock, Environment	o_fd_vkm_od
Out	$vkm^{freight}$	Freight transport mobility [vkm]	time period t , country ci , mode m	Safety	o_fd_vkm_transit
Out	tkm	Freight transport performance [tonne-kilometre]	time period t , origin i , mode m , commodity c , destination j	Economy & Resources	o_fd_tkm_od

4.2.6 Safety Module

The aim of the Safety module (SAF) is to estimate the numbers of fatalities (and injuries) derived from transport, as well as associated social costs. The required input includes historical mobility (from the Database), predicted mobility (from the Passenger and Freight Demand modules), and user hypotheses on safety risk and safety risk causal factors. Risk is defined as the number of 'occurrences' (fatalities, injuries) per unit of mobility (in vehicle-kilometre or trips). The module distinguishes road and non-road modes, which are dealt with in different levels of detail. Road safety is treated most intricately since, besides fatalities, it also predicts the number of serious and slight injuries. The road mode is further split into car, truck, powered-two-wheelers, public transport, bike, and pedestrians. Regarding non-road modes, rail, air, short sea shipping, and inland waterways are considered. SAF computes risks in 1-year-steps. This is combined with demand forecasts from PAD and FRD to produce outputs in the same time aggregation as the other HIGH-TOOL modules. For air, short sea shipping, and inland waterways, results on EU-level are produced.

Table 10 shows the interaction of SAF with other HIGH-TOOL modules.

Table 10: Interaction of the Safety module with other HIGH-TOOL modules

I/O	Variable	Description	Dimensions	Module	Name in Database
In	pkm	Passenger transport mobility by country [pkm]	time period t , mode m , country ci	Passenger Demand	od_pd_pkm_transit_safety, o_pd_pkm_orig_safety, o_pd_urban_pkm_etry
In	vkm^{pas}	Passenger transport mobility by country [vkm]	time period t , mode m , country ci	Passenger Demand	o_pd_vkm_orig, o_pd_urban_vkm_etry
In	T^{pas}	Number of passenger trips [trips]	time period t , origin i , destination j , mode m , purpose p	Passenger Demand	o_pd_airic_trips_od
In	$vkm^{freight}$	Freight transport mobility in a country [vkm]	time period t , mode m , country ci	Freight Demand	o_fd_vkm_transit

4.2.7 Environmental Module

The main task of the Environment module (ENV) is to calculate tank to wheel (ttw) fuel consumption and emissions for each vehicle type for each 5 year interval period. The module produces estimates for CO₂ emissions as well as five other pollutants, i.e. CO, VOC, NO_x, SO₂ and PM_{2.5}. Fuel consumption and emissions are calculated per origin country (NUTS-0 level) and thereafter disaggregated to zones at NUTS-2 level. This disaggregation by zones is based on the share of transport demand in each zone within a country. The predicted transport demand is disaggregated by vehicle type and origin country, then fuel consumption and emissions are derived. The Environment module receives input from the Passenger and Freight Demand modules (mobility) and from the Vehicle Stock module (fleet size). Table 11 shows these interactions with other HIGH-TOOL modules.

Table 11: Interaction of the Environment module with other HIGH-TOOL modules

I/O	Variable	Description	Dimensions	Module(s)	Name in Database
In	vkm^{pas}	Passenger transport mobility [vkm]	time period t , origin i , mode m , destination j , purpose p	Passenger Demand	o_pd_vkm_od
In	$vkm^{freight}$	Freight transport mobility [vkm]	time period t , origin i , mode m , destination j , commodity c	Freight Demand	o_fd_vkm_od
In	$stock$	Total number of vehicles [vehicles]	time period t , zone i , mode m , vehicle type vt , age cohort ac	Vehicle Stock	i_vs_veh_stock

4.3 HIGH-TOOL Data Stock

Full documentation related to the HIGH-TOOL data stock and data exchange platform can be found in HIGH-TOOL Deliverable D3.2 "Documentation: Updated input Database for the HIGH-TOOL Model" (Kiel et al, 2016).

The Data Exchange Mechanism prepares an up- and download functionality of the basic datasets used in the HIGH-TOOL model, creating a communication channel with the user for downloading model results as well as feeding in specific user data. The data used (inputs and parameters) and generated (outputs) by the HIGH-TOOL individual modules is also stored in the Data Stock. The Data Stock is a separate module of the HIGH-TOOL model which provides access to the input and output parameters of each module.

The data stock is built with a PostgreSQL + PostGIS database. It hosts the HIGH-TOOL data stock and extra schemata to save user data and to give persistence to the results of model runs. For the version management of the various database files, TortoiseSVN, an open source version management software, is used.

The methodology followed for preparing the Data Stock is the methodology developed in the ETISplus project to build multidimensional models so that they are self-explanatory. This methodology identifies a set of rules for processing multidimensional data.

The database is built from dimensions and parameters:

Dimensions needed were first identified, and for each dimension, e.g. TIME, a table was defined (e.g. _TIME) to store the elements for that dimension (e.g. [2010, 2015, ..., 2050]). This methodology allows adaption of the data stock to changes happening along the development of the HIGH-TOOL model (for example, the geographical coverage of the prototype was initially defined at NUTS-0 level, but changed to NUTS-2 region level for the pre-final and final versions).

Definitions of all the parameters came next. The parameters are sets of numerical factors representing the input and output data of the modules. For example, the economic activity per country and per year is described using GDP. Together all the GDP values per year and country form the GDP PARAMETER. The parameters are complemented by their unit and their source of information. As expected, they are also defined in terms of dimensions. For example, the GDP HIGH-TOOL output parameter was defined by time and country; hence it used the TIME and ZONE dimensions (to be found in the tables _TIME and _ZONE).

To create the database structure required for the HIGH-TOOL Data Stock, definitions of data parameters and dimensions were collected from module developers.

4.4 HIGH-TOOL Model Performance

Table 12 below provides a synthesis of the model performance. Figure 14 displays the relative weight of each module in relation to the total time consumption of a complete simulation in the HIGH-TOOL model.

The Economy and Resources module is the heaviest module, accounting for the 30% of the time of a run. Then Environment, Vehicle Stock, Freight Demand, Safety and Passenger Demand modules take each about 13% of the run time. Demography is a very light module producing results in less than ten seconds.

Figure 15 displays the requirements in terms of minimum RAM memory of each of the modules. Most demanding modules are logically those dealing with largest tables, like the Freight Demand (which models freight transport at the level of different commodities between NUTS-2 regions), the Vehicle Stock (dealing with more than ten vehicle types and almost 30 fuel technologies), and the Economy and Resources module (including a large number of branches of the European and neighbouring economies).

Table 12: HIGH-TOOL model performance and memory requirement

Module name	ID	Iterations needed for a full 2010–2050 run	Estimated time per iteration (min)	Total time for module run (min)	RAM memory requirement (GB)
Demography	DEM	1 (model runs once for the whole 2010–2050 period)	0.03	0.03	2
Economy	ECR	8	6.70	53.60	12
Vehicle Stock	VEH	8	2.62	20.93	12
Passenger Demand	PAD	8	1.53	12.27	8
Freight Demand	FRE	8	2.53	20.27	14
Environment	ENV	1 (model runs once for the whole 2010–2050 period)	14.17	14.17	10
Safety	SAF	1 (model runs once for the whole 2010–2050 period)	16.12	16.12	6
HIGH-TOOL		35	43.70	137.38	14

Total time to complete a full model run 2010–2050, in minutes

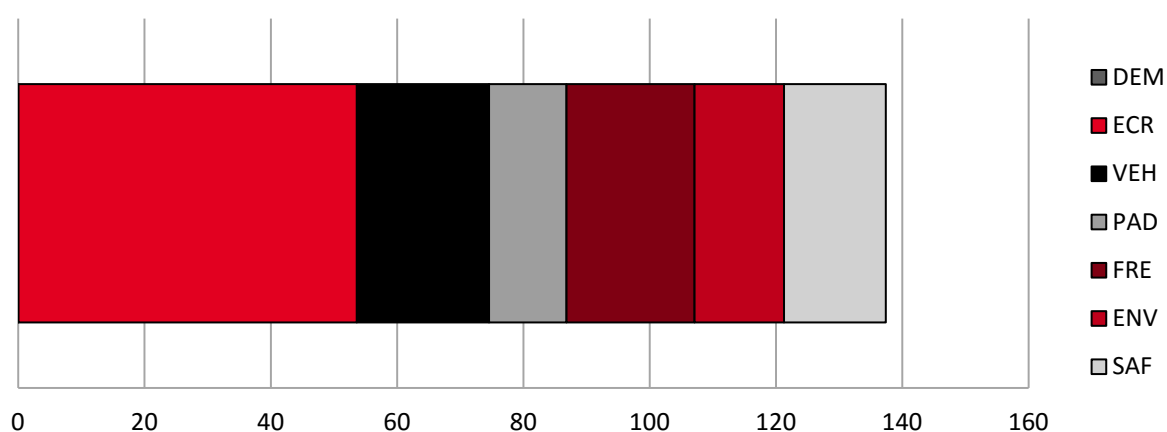


Figure 14: Total time to complete a full model run 2010–2050, in minutes by HIGH-TOOL modules

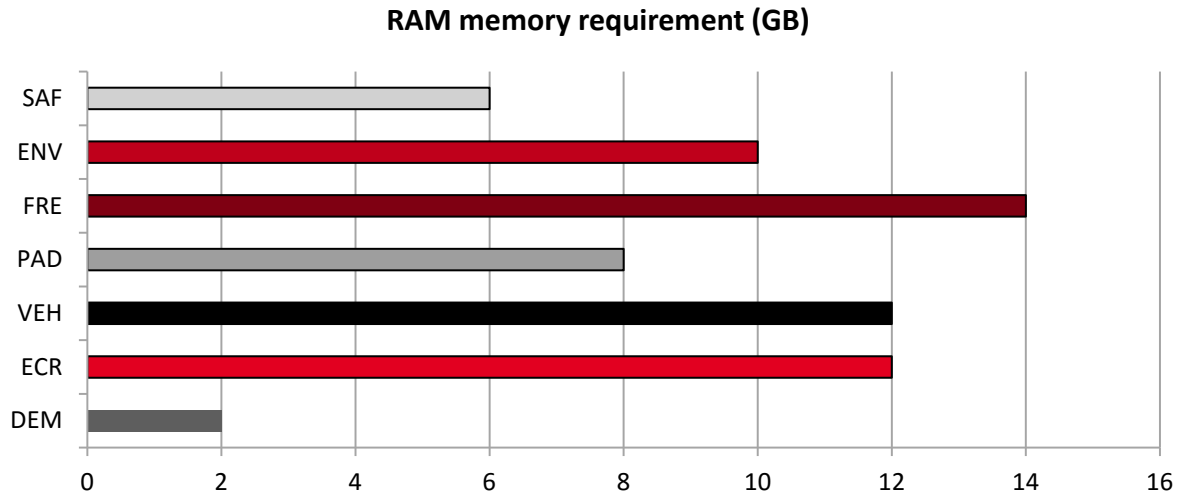


Figure 15: Minimum RAM memory requirements of the HIGH-TOOL modules. 32 GB are recommended for ensuring proper performance of the overall model.

All figures provided above have been determined in test runs performed on a system with the following specifications:

- Ubuntu Server 14.04.3 LTS AMD64 with Linux kernel 3.16.0-46-generic
- Java version '1.8.0_60' 64-bit, -Xms8G -Xmx12G flags
- AMD FX-8370 Eight-Core Processor with 32 GB of memory
- SSD hard disk of 256 GB.

5 System Specifications

5.1 Overview

This chapter focuses on the description of technical specifications of the HIGH-TOOL model.

It describes the adopted software solution for programming model components, and for the User Interface, providing the main motivations behind decisions taken along its design process.

It provides the specification for a proper System Administration and other software solutions to increase the overall security of the model application. As a consequence of software choices, the resulting hardware requirements are also analysed in this section.

In brief, the software solution adopted to program a user-friendly web-based system which is compatible with all devices (PCs, tablets, mobile phones) is JavaScript. The User Interface makes use of specialised open source libraries, such as Angular.js (development framework), D3.js (generates data-driven documents), Three.js (webGL, graphic standards), Bootstrap (User Interface and interaction design), among others.

The HIGH-TOOL model is located in a remote server with Linux OS/Apache, interacting with the client's User Interface by RESTful api. HIGH-TOOL databases are managed by PostgreSQL-PostGIS. The server application is also programmed in JavaScript and mostly uses Node.js and Sails.js.

The server computer requires at least an Intel® Xeon® processor E5-1620 (3.60 GHz Turbo, 10 MB), with 32 GB 1600 MHz DDR3 ECC RDIMM memory and SSD hard drive (solid state disk). If the application is installed locally in a desktop computer, this machine will also require equivalent technical specifications in relation to performance. The system could in theory work with only 16 GB of memory, although the performance would be very bad.

When working remotely, client computers can be standard (as they will not undertake model calculations), but a reliable internet connection and 'evergreen' web browsers (latest versions of Chrome, Firefox or Internet Explorer/Edge) are a strong requirement

These main features are reported in more detail in the following sections of this chapter.

5.2 Analysis of Alternative Software Solutions

Market trends are generally converging towards the use of web technologies for applications such as HIGH-TOOL. Main reasons for this development are listed below:

- Applications are cross-platform, provided that developers restrict themselves to evergreen browsers and open standards.
- Easiness to update and distribute software.

- They can eventually be transformed into stand-alone applications if needed (using solutions like wrappers, web views).

There are also some pitfalls to overcome:

- Performance standards of web interfaces are usually worse than those developed using other technologies like Java, C/C++, C#... and UI/utility libraries (Qt, GTK, Swift).
- Web browsers are sandboxed due to security concerns (running programs from unverified third parties is restricted). Therefore, web applications can only use web APIs to operate with the browser, which in some cases may not be sufficient for all needed functionalities.
- Browsers are single-threaded. Multi-threading is limited to web workers with a simple messaging system to coordinate threads.

To deal with the second pitfall, most applications use tiers to divide responsibility. The most common solution used by web applications is the three tier architecture, with a presentation tier (that renders the User Interface), an application tier (that handles the business logic), and a storage tier (including data persistence mechanisms and a data access layer that encapsulates persistence mechanisms and exposes the data). This solution is also adopted in HIGH-TOOL.

It is common practice to use frameworks to shorten the development cycle. Frameworks are pieces of software that abstract common features from the low level implementation. The following frameworks have been considered when analysing the best software solution for HIGH-TOOL (see Table 13, Table 14 and Table 15). After evaluating their advantages and disadvantages, it has finally been decided to use AngularJS and SailsJS frameworks.

Table 13: Frameworks considered for the development of the HIGH-TOOL: client applications

Client Framework	Open Source	Programming Language	Main Features	Potential Disadvantages
Web2Py	Yes	Python JavaScript	<ul style="list-style-type: none"> - Web framework - Easy to run, requires no installation - Commitment to backward compatibility - Multiple database drivers - Speaks multiple protocols - Prevents most common types of vulnerabilities (Cross Site Scripting, Injection Flaws, Malicious File Execution) - Includes a web-based integrated development environment - Allows mapping via standard OGC services (Geoserver, Mapserver, ...) 	<ul style="list-style-type: none"> - Requires implementation of Python 2.5, 2.6 or 2.7 (not ported to Python 3) - Less popular than other frameworks (less resources and assistance available) - Monolithic framework

Client Framework	Open Source	Programming Language	Main Features	Potential Disadvantages
Django	Yes	Python JavaScript	<ul style="list-style-type: none"> - Web framework - Rich featured - Large community using it, increases completeness of resources - Allows mapping via standard OGC services (Geoserver, Mapserver, ...) 	<ul style="list-style-type: none"> - Monolithic framework
AngularJS	Yes	JavaScript	<ul style="list-style-type: none"> - Web framework - Client side web framework - Eases development of HTML5 Web applications - Promotes good practices like modularity, reuse of components and unit testing - Decouples the client side of the application from the server side - Decouples DOM manipulation from application logic - Dependency injection - Allows mapping via standard OGC services (Geoserver, Mapserver, ...) 	<ul style="list-style-type: none"> - Cannot be pre-rendered in the server to improve performance
OpenLayers	Yes	JavaScript	<ul style="list-style-type: none"> - WebGIS framework - Large community using it, increases completeness of resources - Allows mapping via standard OGC services (Geoserver, Mapserver, ...) 	<ul style="list-style-type: none"> - Need 3rd party sources to render data or install an OpenStreetMaps tile server - Library, not a full framework

Table 14: Frameworks considered for the development of the HIGH-TOOL User Interface: client/server applications

Server/Client Framework	Open Source	Programming Language	Main Features	Potential Disadvantages
Geomedia Webmap & Smart-client	No	.NET	<ul style="list-style-type: none"> - GIS platform - Good documented APIs and SDKs 	<ul style="list-style-type: none"> - Subscription-based and proprietary
ArcGIS	No	Core in C++ and OpenGL. APIs and SDK in multiple languages	<ul style="list-style-type: none"> - GIS platform - Good documented APIs and SDKs 	<ul style="list-style-type: none"> - Subscription-based and proprietary
Joomla	Yes	PHP JavaScript	<ul style="list-style-type: none"> - Web framework - CMS - Easiness in creating and editing web-based User Interfaces - Serves multiple protocols like HTML, JSON, RSS - Follow a MVC paradigm - Modify the database schema - Allows mapping via standard OGC services (Geoserver, Mapserver, ...) 	<ul style="list-style-type: none"> - Most functionality based on contents and user administration - Create modules require knowledge of the platform - Requires ad hoc API for mapping visualisation

Table 15: Frameworks considered for the development of the HIGH-TOOL User Interface: server applications

Server Framework	Open Source	Programming Language	Main Features	Potential Disadvantages
SailsJS	Yes	JavaScript	<ul style="list-style-type: none"> - Web framework - Client side web framework - 100% JavaScript - Waterline ORM, which abstracts Models to JavaScript objects - Auto-generate REST APIs - WebSocket Support - Reusable security policies - Front-end agnostic - Automation of tasks (using Grunt) - Allows mapping via standard OGC services (Geoserver, Mapserver, ...) 	<ul style="list-style-type: none"> - Less popular than Python frameworks

5.3 Architecture of the HIGH-TOOL Model

The User Interface of the HIGH-TOOL model has been programmed as a stand-alone online application based on AngularJS and SailsJS, both free and open source software components programmed in JavaScript (ECMAScript v6). The architecture of the HIGH-TOOL User Interface is defined by:

- A web client application developed in AngularJS to run in web browsers, complemented with other libraries used to handle screen responsiveness and GIS visualisation.
- A Node.js server application developed in SailsJS. It exposes a REST API, handles authentication and can modify the models either directly or via HIGH-TOOL modules.
- PostgreSQL + PostGIS database. It hosts the HIGH-TOOL database and extra schemata to save user data and to give persistence to the results of model runs.
- A Java Virtual Machine (JVM) capable of running Java v8 code. The SailsJS server application calls it to execute HIGH-TOOL modules, which then modify the database. Via call backs, the SailsJS server application controls execution order and replication of the results.

Figure 16 illustrates the architecture of the HIGH-TOOL model User Interface and its interaction with the HIGH-TOOL components and the data stock.

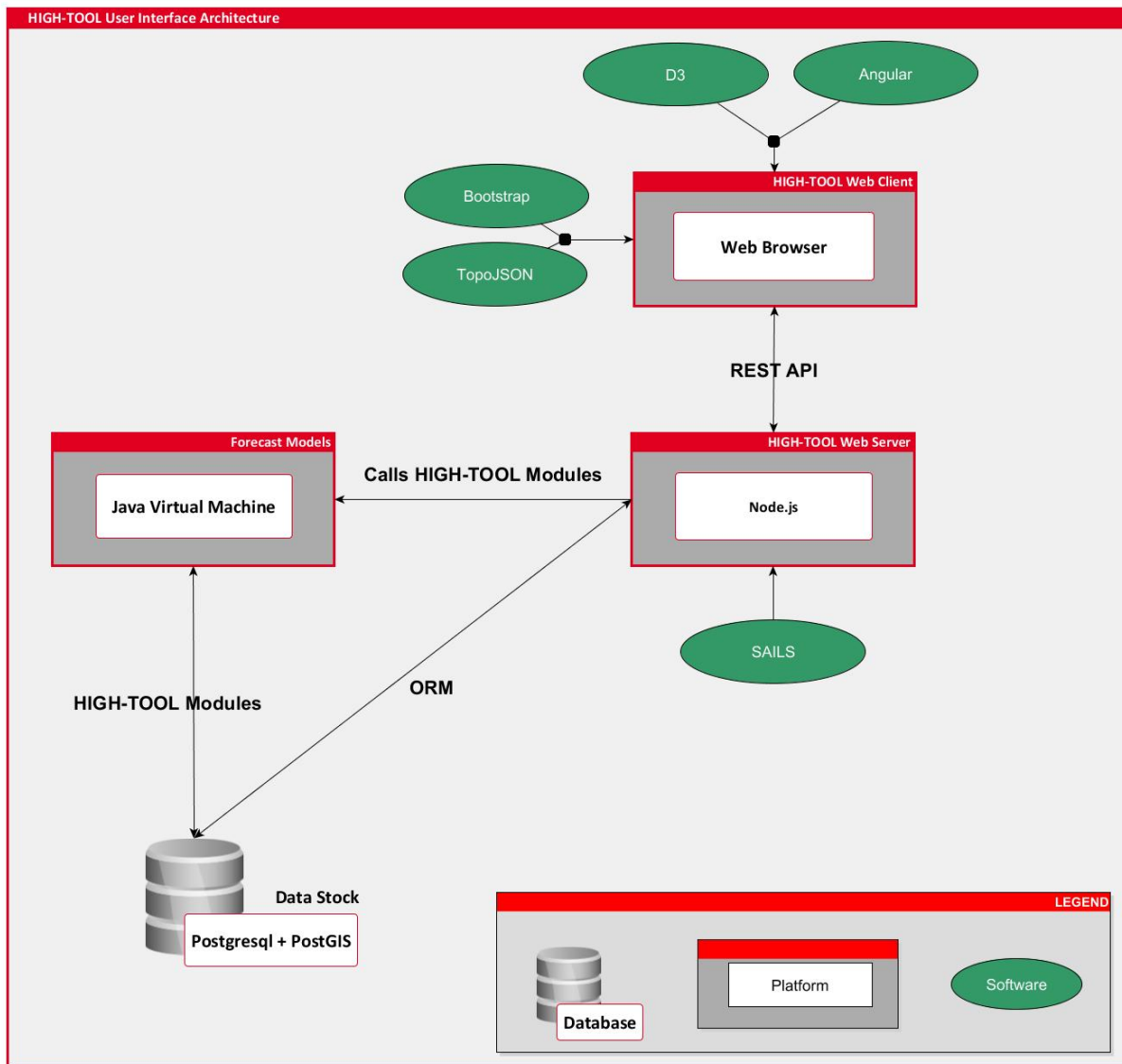


Figure 16: Software Architecture of the HIGH-TOOL User Interface and its interaction with the data stock and HIGH-TOOL components

5.4 Client Software Solution

AngularJS has been selected for the client application because it eases the development of HTML5 web applications and promotes good practices like modularity, reuse of components and unit testing.

The main characteristics of AngularJS are:

- Based on plain 100% JavaScript objects, making code easier to test, maintain and reuse.
- Eliminates DOM manipulation with data-binding protocols, updating the screen view each time the model changes, and updating the model each time the view changes.

- Client-side form validation protocols allow declaring validation rules without having to write code.
- Built-in services are provided on top of XHR using third party libraries, allowing simplification of code by handling asynchronous return of data.
- Uses directives to create reusable components and hiding complex DOM structure, CSS, and behaviour. This allows focusing separately on what the application does or how the application looks.
- Works well embedded in other technologies, whereas many frameworks require full commitment.
- Is designed to be fully testable, encouraging behaviour-view separation. Comes pre-bundled with mocks and takes full advantage of dependency injection. It also comes with end-to-end scenario runner, which eliminates test flakiness.

The AngularJS framework in the User Interface is complemented with the following specialised libraries:

- Bootstrap, a mobile first responsive framework. Fastens the design of rich User Interfaces that scale from small mobile devices to full desktop screens (allows building of responsive web templates).
- D3js, a library used to manipulate documents based on data. It produces high quality HTML and SVG outputs from raw data (allows the creation of charts based on model data).
- Three.js, a lightweight cross-browser JavaScript library/API used to create and display animated 3D computer graphics on a web browser (allows implementing 3D functionalities, applied in the HIGH-TOOL model's GIS application).

5.5 Server Software Solution

A Node.js server application developed in SailsJS has been adopted. It exposes a REST API, handles authentication and can modify the models either directly or via HIGH-TOOL modules.

Using SailsJS for the server application allows the development of event driven, non-blocking IO applications. SailsJS is a Node.js web framework built on Google's Chrome V JavaScript engine. The recommended Node.js version is 0.12.2.

Some characteristics of SailsJS are provided next:

- Based on plain 100% JavaScript objects, making code easier to test, maintain and reuse.
- Provides a simple data access layer that works with most databases.

- Built on the familiar relational model, aimed at making data modelling more practical.
- Comes with blueprints that help jumpstart an application server without writing any code thanks to auto-generated REST APIs.
- Easy WebSocket support translating incoming socket messages compatible with every route.
- Reusable security policies with role-based access control by default.
- Designed to be compatible with any front-end strategy (e.g. Angular, Backbone, iOS/ObjC, Android/Java, Windows Phone).
- Completely customisable asset workflow as it ships with Grunt. Supports already developed Grunt modules.
- Solid foundation thanks to being built on Node.js. Uses Express for handling HTTP requests, and wraps socket.io for managing WebSocket.

Both client and server components use Grunt, NPM and Bower to manage dependencies, environments (development, production, testing) and deployment. PostgreSQL and a JVM capable to run Java v1.8 are required to allow model and database interaction.

5.6 Data Stock Software Solution

The data stock is built with a PostgreSQL + PostGIS database. It hosts the HIGH-TOOL data stock and extra schemata to save user data and to give persistence to the results of model runs.

5.7 Multiplatform User Interface

The User Interface of the HIGH-TOOL model is compatible with all devices (desktops, tablets, mobile phones) (see Figure 17). The User Interface provides responsive web templates, which consider the following design features:

- Text reorganises dynamically with varying screen widths. This allows text to be displayed completely without the need for horizontal scrolling, regardless of the device used.
- Menu entries reorganise themselves dynamically. When insufficient space is available for them to show horizontally, they fold in a vertical menu that can be visible or folded.
- Control buttons and scroll bars change their appearance based on the device being used, so that all functions remain usable even in small cell phone screens, e.g. sliders in the input editors change to +/- buttons when insufficient space to be displayed is available.

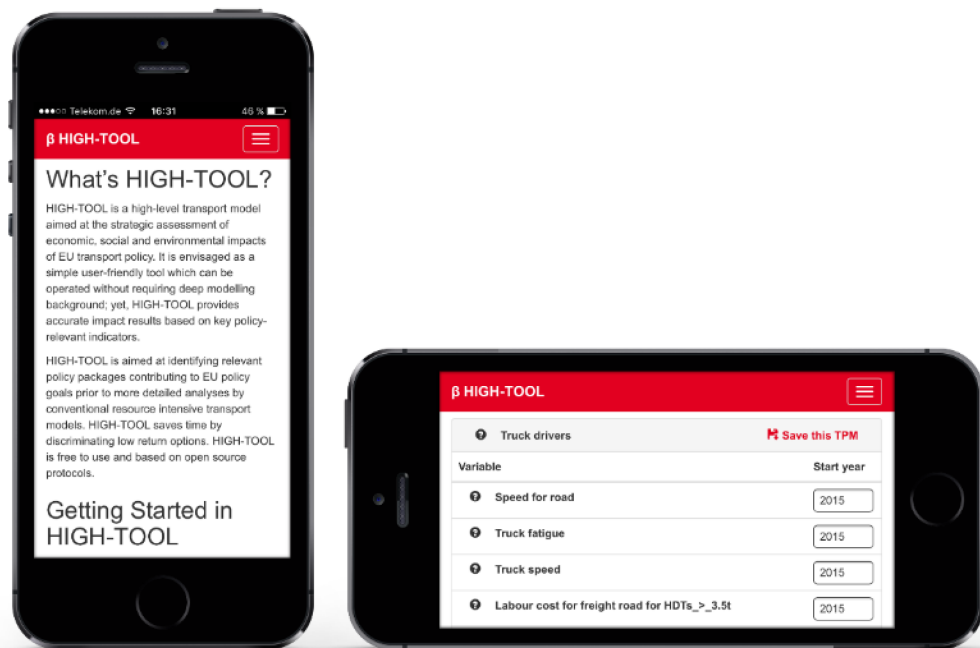


Figure 17: The User Interface of the HIGH-TOOL model visualised on a mobile phone

5.8 Stand-alone Version

In addition to the client-server model, the HIGH-TOOL User Interface is bundled in a single installable file that will run on Windows 7 64-bit or newer. The stand-alone uses GitHub Electron. Electron is a software platform based in a modified version of Node.js that allows running instances of WebKit, the engine behind the Chromium web browser (the open source components of the Google Chrome web browser) and controlling them using an API that adds to the usual browser-server conventions.

The stand-alone version uses the same architecture that the client-server version and adds utilities to automate the edition of configuration files.

5.9 Communications between the User Interface and HIGH-TOOL Modules

The SailsJS server application calls to execution the several HIGH-TOOL modules. Individual modules read inputs from and modify the data stock with outputs. Via call backs, the SailsJS server application controls execution order and replication of the results.

5.10 Security Solutions

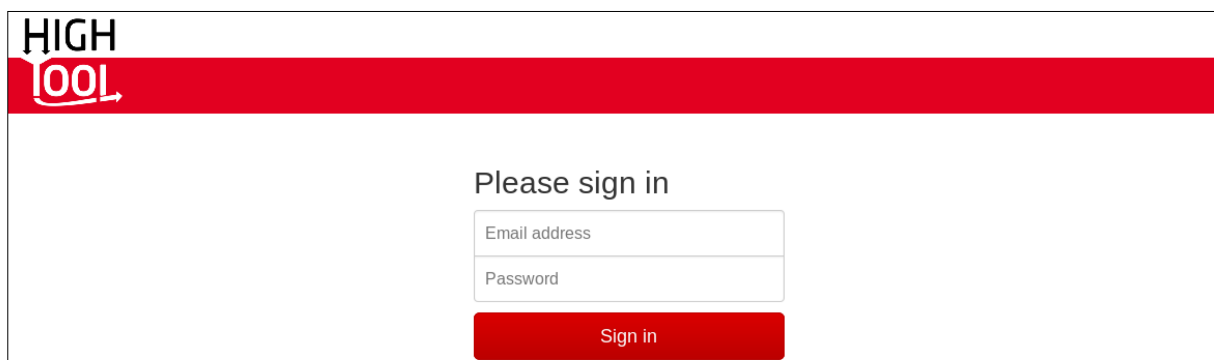
Given that the HIGH-TOOL model will run on an Internet-connected server, it is important to envisage suitable security solutions to protect the application by preventing and mitigating undesired security threats. The communication between client and server is done via a RESTful API secured with JSON-Web-Tokens. This strategy replaces session cookies allowing device agnostic communication with the server, Cross Site Request Forgery protection and improved user privacy.

In order for it to be a secure authentication and identification mechanism, JSON-Web-Tokens require HTTPS to prevent man-in-the-middle attacks, e.g. any machine between the client and the server can get the token from the HTTP header and use it to send requests to the server until the token expires.

5.11 System Administration and Management

Different user profiles and authorised roles need to be defined, access controls and passwords, as well as content administration (e.g. modelling results obtained may be confidential or public, or have a restricted access). The HIGH-TOOL User Interface is by default user and password protected. Only authorised users can access HIGH-TOOL.

The first time a user opens the interface, the web page will request an e-mail address and a password (see Figure 18).



The screenshot shows the login interface of the HIGH-TOOL system. At the top, there is a red header bar with the 'HIGH TOOL' logo. Below the header, the main content area is white. In the center, the text 'Please sign in' is displayed. Underneath this text are two input fields: 'Email address' and 'Password'. Below the input fields is a red button labeled 'Sign in'.

Figure 18: Login screen

User related options of HIGH-TOOL are displayed in the top right corner of the User Interface together with other assistance and help tools. A logout option is also provided to the user in this menu.

Two different user profiles are defined in the HIGH-TOOL User Interface:

- **Standard Users.** They can create new packages (specification of Single TPM, Combined TPM and Customised Policy package, all with or without expert mode editions) which can be edited, deleted and run. They may declare their packages as public so that any other Standard User can read them. A public package can be opened by other users, but cannot be deleted or modified unless it is saved as a new package (copy).
- **Administrators.** They can edit and delete any packages without taking into account their ownership. They manage the accounts of Standard Users: they can create new users and delete/ban exiting ones.

Contact with the system administrator is needed to obtain a user name and an access password.

5.12 Hardware Requirements

The HIGH-TOOL model is optimised to run smoothly on a Linux or Windows Server. As a reference, it consists of Microsoft Windows Server 2012 R2 64-bit equivalent to 8 x 1 GHz Pentium vCPUs with 32 GB RAM.

Hardware requirements in HIGH-TOOL are given by the operation of the different HIGH-TOOL model components rather than by the User Interface, which is envisaged as a simple resource efficient multiplatform component. Computational modules of the HIGH-TOOL model require that the HIGH-TOOL servers meet at least the following specifications:

- Intel® Xeon® processor E5-1620 (3.60 GHz Turbo, 10 MB)
- 32 GB 1600 MHz DDR3 ECC RDIMM memory
- SSD (solid state disk) hard drive.

Both memory sets and hard drive technology are critical to ensure proper HIGH-TOOL performance. Given the large amount of data to be processed by HIGH-TOOL modules, ensuring a minimum quantity of RAM memory will allow the system to undertake calculations without the need to physically write in hard drives, while using SSD hard drives will allow performing of read/write operations at the beginning and the end of each module calculation within reasonable timings.

All the software components in the User Interface are open source and portable to the most popular operating systems. This avoids dependence on a specific technology, meaning:

- The client application will work on most environments, including Microsoft Windows, Mac OS, or Linux.
 - The server software is currently based on Linux but works in other environments like Mac OS or Microsoft Windows.
 - HIGH-TOOL software is also able to run on stand-alone computers.
- Guidelines for installation are provided on chapter 7.

Since HIGH-TOOL is a research project, the software developed does not have security audits and software certification yet. Therefore, it is recommended to install it on a separate computer and/or server environment.

6 User Guidance

This chapter is organised as a user guide, presenting how in practice, users define assumptions and how a model run's outputs are presented. The main tools available in the User Interface are presented and their organisation is shown. Out of the user perspective, the steps necessary to define policies are listed. This chapter applies to both the online and stand-alone versions of the HIGH-TOOL model.

6.1 Getting Started

There are three different ways for the user to define transport analyses in HIGH-TOOL:

Firstly, define and run a ***Single Transport Policy Measure (TPM)*** in the Baseline Framework Conditions (EU Reference Scenario 2013). A set of pre-defined TPMs can be run individually upon the reference socioeconomic baseline conditions. For each TPM, model input variables representing the TPM and their reasonable impact range are provided. This is the simplest way to analyse the impact of transport policies.

Secondly, define and run a ***Combined TPM package*** (combining many policies) in the Baseline Framework Conditions (EU Reference Scenario 2013). This second process is envisaged for the elaboration of more complex policy packages integrating several TPMs at once.

Thirdly, define and run a ***Customised Policy package***. This option allows selecting any combination of all available individual policy levers present in the HIGH-TOOL modules, in order to define more complex policy measures.

When new Transport Policy Measures are created, all variable fields are assigned default reference values, so that users only need to change parameters that will specifically be different from the reference package.

The three options allow an extra optional step called the **expert mode**, where the user may change any individual value from the data stock by downloading raw CSV tables or changing the impedances using the **Hyper-Network** interface.

At the end of a simulation, the HIGH-TOOL model returns a Policy Assessment Report containing all results in a standardised format. A Policy Assessment Report is composed out of two different components:

- A set of Synthesis Indicators summarising the simulation. The set includes the policy set specifications made by the user, framework conditions selected, and results.

This way, results are always linked to the specifications and conditions under which the simulation was executed.

- A complete report in MS EXCEL format containing all results disaggregated by territories and modes. It is generated by the HIGH-TOOL model automatically and can be downloaded from the online application.

In addition, all detailed outputs contained in the data stock are accessible through an interface allowing an easy export of the full tables so that they can be manipulated using any spreadsheet software.

6.1.1 How to Edit and Run a Single Transport Policy Measure (TPM)

Single TPMs allow users to simply and quickly launch runs of specific policy actions without complex input processes. At the end of the simulation, the HIGH-TOOL model returns a Policy Assessment Report containing all results in a standardised format.

In practice, users are required to undertake the following steps to define and assess TPMs:

- Selection of a TPM to be analysed. From **Policies >> Define a Single Transport Policy Measure (TPM)**. Identify a TPM throughout the interface menus.
- Modify values for TPM variables using the interface. Details on this step are reported in the following chapters 6.3 (variable magnitude), 6.4 (temporal dimension) and 6.5 (spatial distribution).
- Click on **Save this TPM** command. Add a title and an abstract describing the policy.
- Selection of a saved TPM to be run. From **Run >> Run a policy package**. Identify the saved TPM from the list and click on **select**. If you wish to make extra editions with the expert mode before running, please tick on the checkbox at the left bottom of the dialog (see chapter 6.7).

6.1.2 How to Edit and Run a Combined TPM Package

HIGH-TOOL allows the user building a more complex simulation of transport policies by combining different predefined TPMs. This option presents the list of available TPMs and by ticking on the checkbox of each TPM they will be added to the simulation. For each TPM added, the interface will display the policy levers related to it.

In practice, users are required to undertake the following steps to define and assess a Combined TPM package:

- Selection of TPMs to be combined. From **Policies >> Define a Combined TPM package**.
- From the list, select the desired TPMs by ticking on the checkboxes.

- Select the **Lever editor** tab and modify values for TPM variables using the interface.
- Click on **Save** command. Add a title and an abstract describing the policy.
- Selection of a saved combined TPM to be run. From **Run >> Run a policy package**. Identify the saved TPM from the list and click on **select**. If you wish to make extra editions with the expert mode before running, please tick on the checkbox at the left bottom of the dialog (see chapter 6.7).

6.1.3 How to Edit and Run a Customised Policy package

The interface includes a third option for defining a policy scenario that gives more freedom to the user. The Customised Policy package option allows selecting any combination of all available individual policy levers. The policy levers are organised in tabs according to the module they belong to.

In practice, users are required to undertake the following steps to define and assess a Customised Policy package:

- Selection of policy levers. From **Policies >> Define a Customised Policy package**.
- Select the desired policy levers from the list by ticking on the checkbox and modify values for the variables using the interface. Mind that the different tabs by module contain different levers.
- Click on **Save as a new package** command. Add a title and an abstract describing the policy.
- Selection of a saved Customised Policy package to be run. From **Run >> Run a policy package**. Identify the saved package from the list and click on **select**. If you wish to make extra editions with the expert mode before running, please tick on the checkbox at the left bottom of the dialog (see chapter 6.7).

6.2 The User Interface Menus

The User Interface consists of the following seven menus:

- **Framework Conditions:** Shows some of the assumptions considered in the EU Reference Scenario 2013, which is the base scenario for running HIGH-TOOL. These conditions can only be changed using the expert mode (see chapter 6.7).
- **Policies:** Contains all options related to the specification and management of policies. (see chapter 6.3).

- **Run:** Allows running any previously saved policy package and managing the ongoing runs as well as entering the expert mode (see chapter 6.6).
- **Outputs:** Contains all options related to Policy Assessment Reports. Users are directed automatically to this area when a run finalises, are shown the synthesis indicators and are allowed to download the full Policy Assessment Report. However, users can also revisit and load Policy Assessment Reports from previous runs, export them or delete them. (see chapter 6.8).
- **Export:** Allows exporting raw data from tables contained in the HIGH-TOOL database (see chapter 6.9).
- **User Profile:** Allows logging in, logging out, managing users (only for administrator profiles), displaying help materials (getting started, user manual, FAQ, downloading reference reports). This menu is separated from other menus and displayed on the right side of the screen.

For any given policy package (Single TPM, Combined TPM, Customised Policy package) several possible actions can be called from the Policy menu list:

- **Load a policy package:** The user selects a previously created policy package and uploads it to the HIGH-TOOL interface.
- **Delete a policy package:** The user deletes a previously created policy package.
- **Save:** The user saves the changes made to a policy package previously loaded to the HIGH-TOOL interface.
- **Save as a new policy measure:** The user makes a copy of the active policy package under a new name.

6.3 Defining Policies at Aggregated EU Level

Based on the results of the User Workshops, the HIGH-TOOL model incorporates Transport Policy Measures (TPMs). The HIGH-TOOL model allows assessing different policy intensities. Maximum and minimum recommended values for all variables are provided, as well as reference baseline values.

TPMs can be defined in three ways:

- Single TPM, where the user can choose a predefined transport policy measure
- Combined TPM package, where the user can combine two or more single TPMs
- Customised Policy package, where the user may choose any number of policy levers from all available ones in order to prepare a fully customised policy package.

6.3.1 Defining Single Transport Policy Measures at Aggregated EU Level

The following information and options are provided (see Figure 19):









- A pagination bar groups individual Transport Policy Measures (TPMs) by different policy dimensions. The following dimensions are currently considered: Internal Market, Research and Innovation, Efficiency Standards and Flanking Measures, and Pricing.
- For each policy dimension, the individual TPMs are shown in a continuous list of boxes, with the variables associated to each TPM inside the same box (levers on a TPM appear collapsed by default and can be expanded using the arrow at the left of the box, see Table 3).
- Individual parameter and variable values can be specified using the options in the variable editor of each TPM.

Variable	Start year	Select value	Unit	Reset	Time	Map
Change of level of service indicator for passenger road	2015	0	count			
Change of net time for passenger road	2015	97	percentage (100 = baseline)			
Technology related additional cost for B30 bus	2015	95	eur_veh (100 = baseline)			
Technology related additional cost for battery electric car	2015	95	eur_veh (100 = baseline)			
Technology related additional cost for battery electric van	2015	95	eur_veh (100 = baseline)			

Figure 19: Editing a Transport Policy Measure

The variable editor is organised by rows, where each row corresponds to an input. The available options are, from left to right (see Table 16).

Table 16: Available options in the HIGH-TOOL model variable editor

Option	Interface Display
A help icon and the name of the input parameter or variable	 Better use of truck capacity
A selector for the year that the policy comes into full effect. By default this is always set to 2015.	<input type="text" value="2015"/>
A slider allowing the user to select a value for the input parameter in the year chosen with the previous selector. Moving the slider left or right will set out a new value. Minimum and maximum values are established for each particular input field. By default it is assumed that the selected value is applied uniformly from 2015 up to 2050.	70  100
A colour semaphore. The colour of the semaphore is a linear gradient between the predefined value and the maximum and minimum values for the input field. Dark tones indicate that the selected value for the input field is far from the default value, whereas lighter tones indicate being close to the predefined value	
A quantitative reference value for the input field as orientation for the user. This value corresponds to "baseline" policy intensity, which could be identified in HIGH-TOOL with 2011 White Paper policy aims and actions. This value can be manually updated.	<input type="text" value="90"/>
A visual indicator of how far the chosen value is from the reference value, measured in %. Thus a +20% indicates that the chosen value is 20% higher than the proposed reference value for that parameter.	-20% 0 +20% 
The unit of the indicator.	eur_vkm (100 = baseline)
The reset button, that returns all values to its initial state for a given policy lever.	
The TIME Editor icon allows determining the evolution or trajectory of the input field in the interval 2010–2050 as a table	
The TRAJECTORY Editor icon allows determining the evolution or trajectory of the input field in the interval 2010–2050 in a graphical way.	
The MAP Editor icon allows determining the geographic distribution of the input across Europe.	

Each policy lever on the interface targets a specific variable and a set of different dimensions (e.g. "Load time for rail" affects the average loading time of freight on rail mode).

Most of the policy levers are measured in relative terms with respect to the baseline, but there are a few policy levers that are expressed in absolute terms (e.g. road tolls per country). In any case, this is indicated on the units of the lever.

A special TPM works differently from all the others: "Acceleration of TEN-T implementation". It does not have any explicit policy levers, as it internally changes the transport impedances to simulate a faster implementation of the TEN-T networks. It can be activated by clicking **Save this TPM** on the box of this special TPM.

6.3.2 Defining Combined Transport Policy Measures at Aggregated EU Level

HIGH-TOOL allows the user building a more complex simulation of transport policies by combining different predefined TPMs. This option presents the list of available TPMs and by ticking the checkbox of each TPM they will be added to the simulation. For each TPM added, the interface will display the policy levers related to it (see Figure 20 and Figure 21).

HIGH-TOOL Framework Conditions Policies Run Outputs Export HI, HIGH-TOOL Test user

Define a new Combined TPM package

Save

Policy Selector Lever Editor

☒ **Opening the internal rail market**
Open the domestic rail passengers market to competition, including mandatory award of public service contracts under competitive tendering.

☐ **Maritime traffic management system**
Integrate the use of monitoring tools by all relevant authorities responsible for maritime traffic, ensure the full interoperability between ICT systems in the waterborne sectors, guarantee the monitoring of vessels and freight (Blue Belt) and set up appropriate port facilities (Blue Lanes).

☐ **Enhance service quality at ports**
Eliminate restrictions on provision for port services (by time and cost reductions).

Figure 20: Selecting a combination of TPMs on the interface

HIGH-TOOL Framework Conditions Policies Run Outputs Export HI, HIGH-TOOL Test user

Define a new Combined TPM package

Save

Policy Selector Lever Editor

Variable	Start year	Select value	-20%	0	+20%	Unit	Reset	Time	Map
1 Average load rate for road freight	2015	99	105	100		count (100 = baseline)	↺	⌚	📍
2 Average waiting time for rail freight	2015	98	105	100		h (100 = baseline)	↺	⌚	📍
3 Change of access/ egress time for passenger rail	2015	80	105	100		percentage (100 = baseline)	↺	⌚	📍
4 Change of level of service indicator for passenger rail	2015	0	0.03	0		count	↺	⌚	📍
5 Other costs for diesel railcar train	2015	90	102	100		eur_tkm (100 = baseline)	↺	⌚	📍
6 Other costs for electric locomotive train	2015	90	102	100		eur_tkm (100 = baseline)	↺	⌚	📍
7 Other costs for electric railcar train	2015	90	102	100		eur_tkm (100 = baseline)	↺	⌚	📍

Figure 21: The policy levers for the Combined TPM package

Some policy levers are common to different TPMs, but the interface will show only one instance of these repeated policy levers in order to avoid the possibility of entering contradictory information. The lower and upper limits that the combined policy lever can take depend on the TPMs being combined.

The HIGH-TOOL consortium has analysed all possible TPM combinations in WP4 and found that, while most of times the combined effect of TPMs is purely additive, in some cases, it has a limited effect. The interface handles this information on the possible combinations and delivers common extended value ranges for the combined policy levers:

Whenever a combined policy lever is purely additive, then the lower and upper limits are increased by adding the limits of each instance of the policy levers (e.g. if one instance of the policy levers has $\pm 5\%$ and another has $\pm 10\%$, then the combination will show $\pm 15\%$).

If the combination of TPMs has a limited effect, then one out of three possible formulations is applied to calculate the combined lower and upper limits of the policy lever (the one chosen depends on the nature of the combination and is not controlled by the user):

- From all possible instances of the policy lever, the maximum upper and minimum lower values are chosen.
- A combined limit calculated by adding the limits of the widest instance first, then adding the 50% of the limits of the second widest range, then adding a 25% of the third widest instance and so on for each instance (e.g. there are two instances of the same lever, one with $\pm 5\%$ limits and the other with $\pm 10\%$ limits, then the combined limits will be $\pm 12.5\%$)
- A mix of the two previous formulations for some combinations of three TPMs. First, a combined limit is calculated from two instances of the policy lever and then we select the maximum between this value and the third instance.

Apart from this special behaviour on the policy lever limits, the interaction of the user is equal to that of the Single TPM menu and contains the same tools: the user can modify the values for each policy lever globally, edit the time trajectories or apply different values across the EU map for countries or NUTS-2 regions.

6.3.3 Defining Customised Policy package at Aggregated EU Level

The interface includes a third option for defining a policy scenario that gives more freedom to the user. The customised TPM allows selecting any combination of all available individual policy levers. The policy levers are organised in tabs according to the module they belong to, and their exact number and classification is shown on Table 17.

Table 17: Available policy levers by module on the Customised Policy package interface

Module	Number of individual levers
Economy and Resources	3
Vehicle Stock	430
Passenger Demand	100
Freight Demand	79
Environment	127
Safety	60

Figure 22 shows the arrangement of the interface for Customised Policy package.

The screenshot shows the HIGH-TOOL interface for building a Customised Policy package. The top navigation bar includes 'HIGH-TOOL', 'Framework Conditions', 'Policies', 'Run', 'Outputs', 'Export', and a user profile 'Hi, HIGH-TOOL Test user'. Below this, a section titled 'Define a custom Transport Policy Measure (TPM)' is active, with a breadcrumb trail: « DEM Module ECR Module VES Module **PAD Module** FRD Module ENV Module SAF Module Policies without levers ». A 'Save as a new package' button is visible. The main content area shows a table of policy levers under the 'PAD Module'.

Use	Variable	Start year	Select value	-20%	0	+20%	Unit	Reset	Time	Map
<input type="checkbox"/>	Average toll costs for coaches in Austria	2015	0	<input type="range"/>	0.05	<input type="text" value="0"/>	eur	<input type="button" value="Reset"/>	<input type="button" value="Time"/>	<input type="button" value="Map"/>
<input type="checkbox"/>	Average toll costs for coaches in Belgium	2015	0	<input type="range"/>	0.05	<input type="text" value="0"/>	eur	<input type="button" value="Reset"/>	<input type="button" value="Time"/>	<input type="button" value="Map"/>
<input type="checkbox"/>	Average toll costs for coaches in Bulgaria	2015	0	<input type="range"/>	0.05	<input type="text" value="0"/>	eur	<input type="button" value="Reset"/>	<input type="button" value="Time"/>	<input type="button" value="Map"/>
<input type="checkbox"/>	Average toll costs for coaches in Croatia	2015	0	<input type="range"/>	0.05	<input type="text" value="0"/>	eur	<input type="button" value="Reset"/>	<input type="button" value="Time"/>	<input type="button" value="Map"/>
<input type="checkbox"/>	Average toll costs for coaches in Cyprus	2015	0	<input type="range"/>	0.05	<input type="text" value="0"/>	eur	<input type="button" value="Reset"/>	<input type="button" value="Time"/>	<input type="button" value="Map"/>

Figure 22: Interface for building a Customised Policy package

The way of interacting with the policy levers is identical to that of the interface for Single TPM but, in order to use any given policy lever, the user must first tick on the checkbox of that lever so that it becomes active.

The list of available policy levers is more extensive than that of the Single TPM interface, as there are some levers that are not used in any predefined TPM but exist nonetheless as possible inputs for HIGH-TOOL (e.g. "Load capacity for rail" or "Purchase VAT for electric cars").

The lower and upper limits for each policy lever are in general wider than the ones appearing on the Single TPM interface, so that the user has a higher degree of freedom for defining more intense policies.

6.4 Definition of Time Evolutions 2010–2050 for Input Variables

The default behaviour of the interface for all policy levers is that the policy has a time profile defined only with two inputs by the user: the final value and the year of application.

A resulting profile example is shown on Figure 23. In this case, the user has selected 80 as the value for the policy and 2020 as the year of application of the policy.

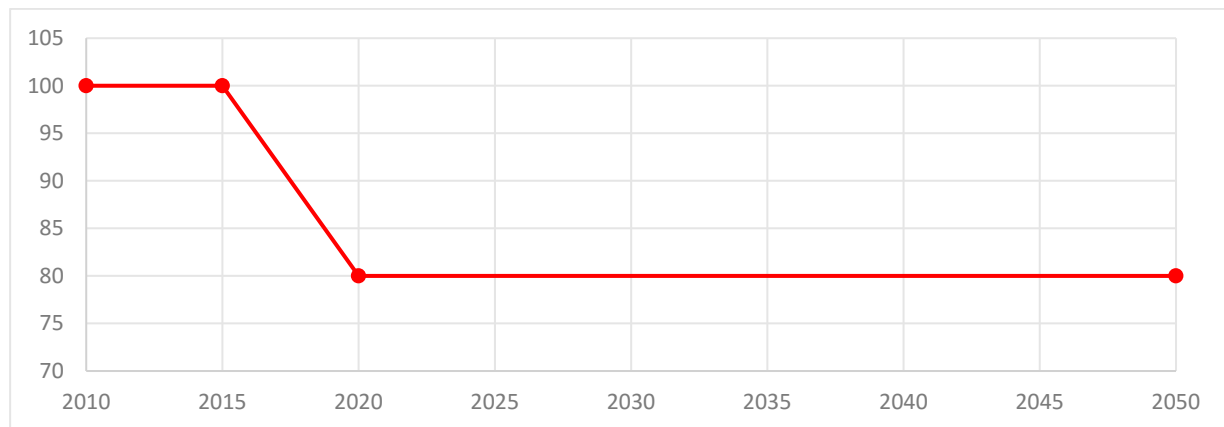




Figure 23: Default time profile of a policy lever

However, the interface has two tools to modify the time profile, which will appear for any policy lever available on the interface:

- The first one is the numerical editor, selectable by clicking on the icon 
- The second one is the graphic editor, selectable by clicking on the icon  (see Figure 24).

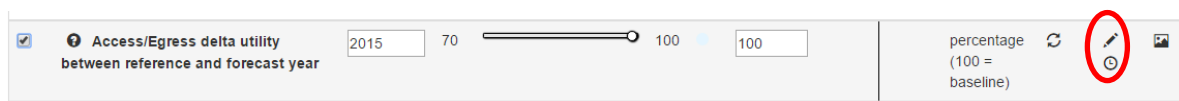
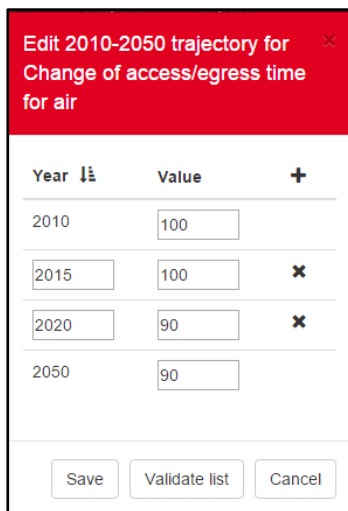


Figure 24: Accessing the numerical and graphic editors

The **numerical editor** is a table allowing introducing intermediate years and values for the selected policy lever. This way the policy implementation can be progressive as certain policies may be introduced stepwise. The path from the current situation in 2010 (e.g. *current level of road investments*) until the final policy level (year 2050) can be reflected (e.g. *level of road investments in 2050*).

The following options are available (see Figure 25):

- To add a new row click on the icon **+** and on the boxes that appear you can write a year and a value.
- Click on the icon **≡** to reorder the rows chronologically.
- Click on the icon **×** to remove any row.
- Click on **Validate list** to correct automatically the values if they are beyond the bounds, to remove duplicate rows having the same year and to order them chronologically.
- By clicking **Save** all the modifications are stored in the policy scenario being built.



Year ≡	Value	+
2010	<input type="text" value="100"/>	
<input type="text" value="2015"/>	<input type="text" value="100"/>	×
<input type="text" value="2020"/>	<input type="text" value="90"/>	×
2050	<input type="text" value="90"/>	

Figure 25: Interface for the numerical trajectory editor

For a more accurate and visual definition of the time trajectory of a policy lever, the interface offers the **graphical editor** that will launch an editable graphic with the years in the horizontal axis and the policy intensity on the vertical axis (see Figure 26).

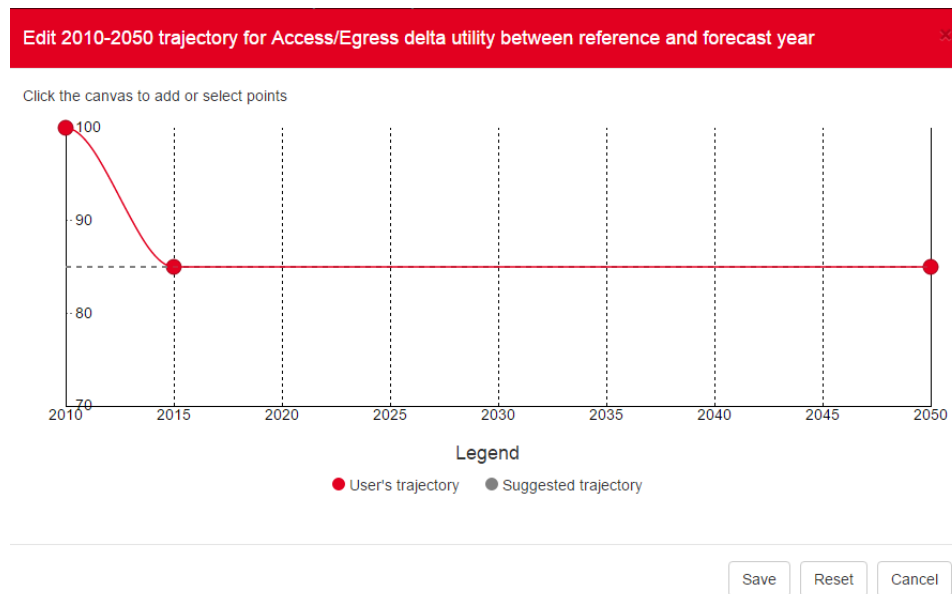


Figure 26: Interface for the graphical trajectory editor

The graphical editor allows users to change any value shown on the graphic by selecting and moving the existing red dots (except the value for 2010 which is fixed), or to insert a new control point by clicking at any point in the canvas. After adding a point, the application interpolates using Bezier curves.

By clicking on a control point and pressing the delete key, the point will be removed.

Upon opening the trajectory editor for the first time in a given policy lever, it will show the default trajectory defined in the TPM editing interface or, if it has been used, the one created with the numerical trajectory editor.

As a reference, a grey dotted trajectory is provided to show the initial suggestion.

The trajectories defined by the numerical and graphic editors are applied uniformly to all EU28 countries. The shown curve is sampled at the exact calculation years (2015–2050 every five years) for use by the model, so any maximum or minimum value at any year not being a multiple of five will not be considered in the calculations.

After saving a new trajectory, the icon on the main interface will become red to indicate that values differ from the default ones. By clicking on the reset button on the main interface, all changes on the graphical editor will also be removed.

6.5 Definition of Input Variables at Country and Regional Level


The map editor will appear when clicking the icon  for any given policy lever available in the Transport Policy Measures editor (see Figure 27).



Figure 27: Accessing the map editor

Using the map editor, values can be particularised at regional level for the different regions in Europe. For example, the level of road investments may be set higher in Eastern European countries in comparison with Western European countries.

After clicking the map editor icon, the application canvas opens showing a map of Europe (see Figure 28). By default, all the European territory will be displayed equally meaning that the input parameter or variable is being considered uniformly applied across Europe. Therefore, the colour is homogeneous reflecting an equal intensity.



Figure 28: Geographic distribution of a parameter (homogeneous)

As some policies might be more or less appropriate for some Member States, selectors of the dialog can be used to change the distribution of the policy based on different criteria (see Figure 29):

- Homogenous distribution (default setting)
- Proportional/inversely proportional to population density
- Proportional/inversely proportional to income per capita.

For example, the intensity of road pricing can be set more intense in wealthy territories while less intense in lagging ones. Alternatively, the intensity of CO₂ taxation can be set more intense in most densely populated areas in Europe and less intense in sparsely populated areas).

These predefined settings are applied always in the same direction independently of what "more intensity" of the policy means. So when choosing for instance directly proportional to population density, the policy will take higher values on more densely populated regions and lower on the less dense ones, but irrespectively of the fact that higher values might imply less intensity. If the effect obtained by using a predefined setting is contrary to the one desired, please choose the opposite pre-set setting.

Territorial distributions of input parameters can be automatically defined based on NUTS-0 or NUTS-2.

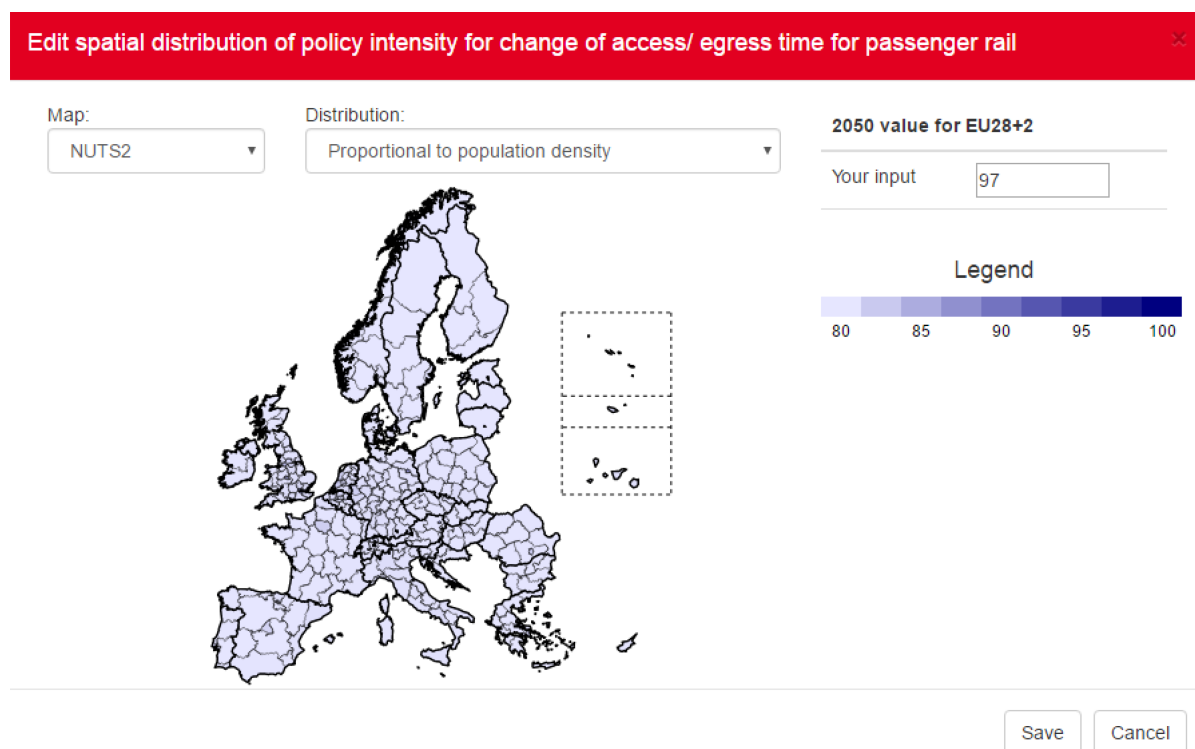



Figure 29: Geographic distribution of a parameter (proportional to population density of NUTS-2 regions)

Users can also manually change a specific country or region's value by clicking on the country/region and changing its input parameter on the right side of the map editor ("Your input" option, see Figure 30). While hovering the mouse over a region, the region name and parameter value in 2050 will be displayed. Double clicking an area of the map allows zooming in for better visualisation of territorial detail.

Whenever a country/region has a manual input of data, it is changed to a striped pattern for the sake of keeping track of the active modifications.



Figure 30: Manual modification of a value for a specific region

Whenever a specific country or region is selected, there is also the option to input a time trajectory by clicking on the  icon. This will launch a new window with a graphic editor that works in the same way as the feature explained on chapter 6.4.

The country/region time editor is shown on Figure 31. Apart from setting the trajectory in the canvas by adding/removing control points, the user needs to click on the **Set** button to save the changes. There is a button **Reset to EU28** to reset the trajectory to the general one applied for the whole EU28 and finally the button **Done** will return to the map.

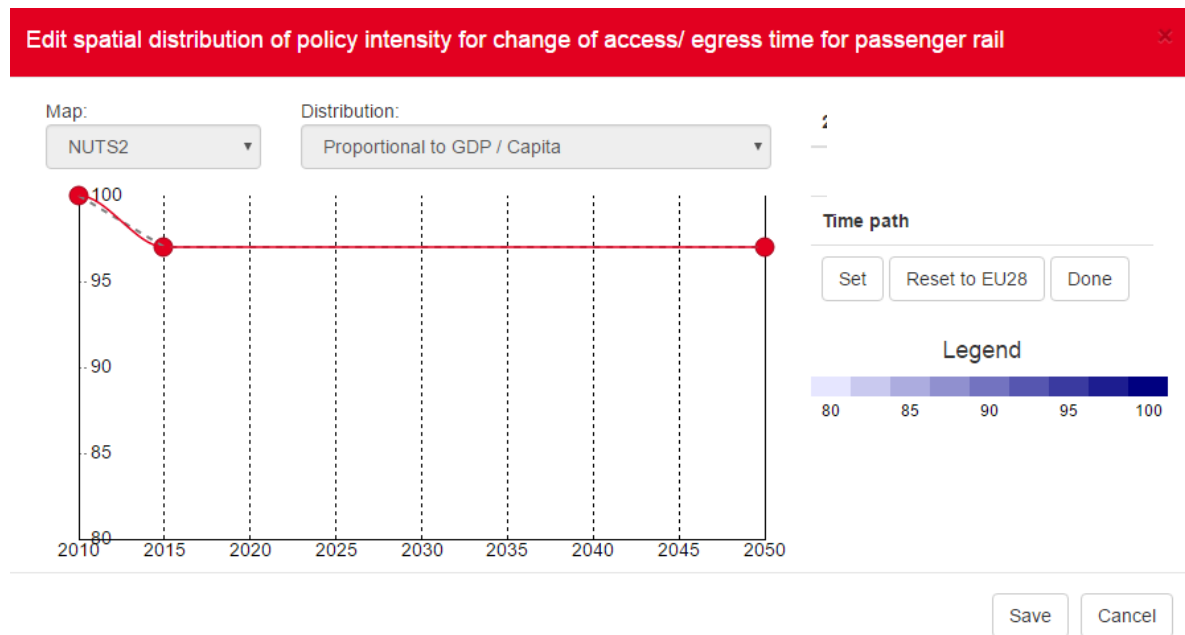


Figure 31: Graphic time editor for country/region

After saving a new map, the icon on the main interface will become red to indicate that values differ from the default ones. By clicking on the reset button on the main interface, all changes on the map editor will also be removed.

6.6 Running HIGH-TOOL

The **Run** menu allows selecting any previously saved policy package and running it. To run a policy package, users will select the option from the menu **RUN >> Run a policy package**.

Choose the policy package to run from the list by clicking on it and then press the **Select** button on the bottom right in order to send the package to the run queue of HIGH-TOOL (see Figure 32).

Before sending the package to run, the user may choose to enable the expert mode. This will give the option of manually editing inputs in the Data Stock. The expert mode is enabled by ticking on the left bottom option (see chapter 6.7 for more information).

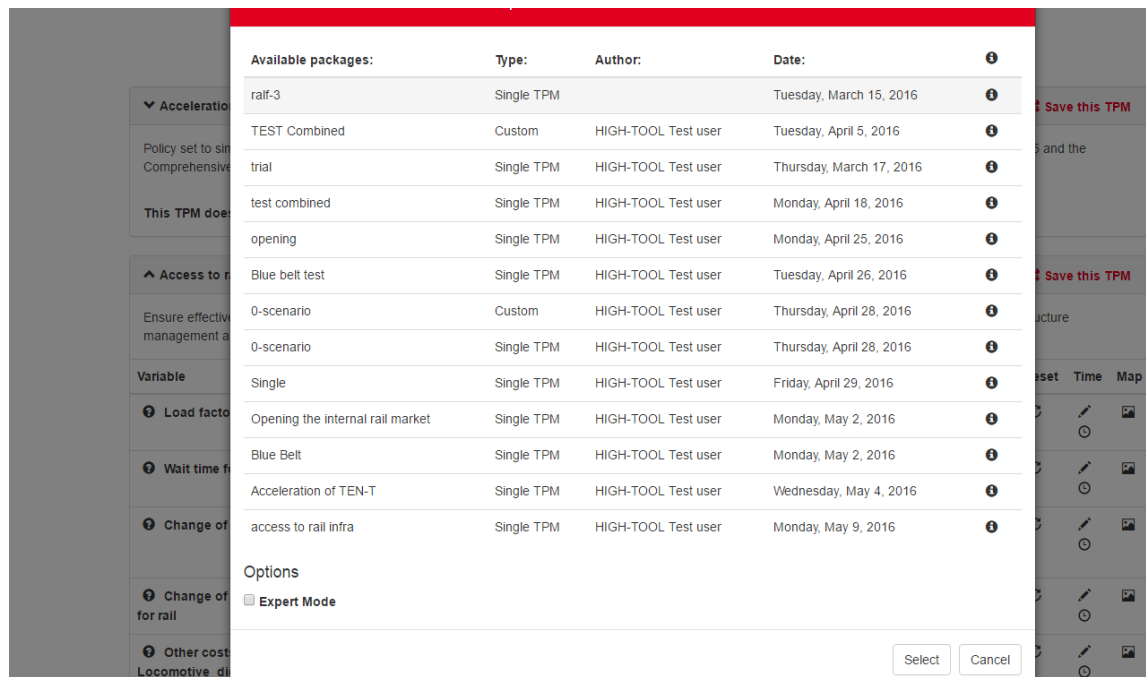


Figure 32: Selecting a policy package to run

6.7 Expert Mode

After having defined any transport policy measure through one of the three available procedures (Single TPM, Combined TPM package, Customised Policy package), the user can then enter the expert mode with which to edit input tables of the model at a low level and/or edit the Hyper-Network to control the impedances used in the model. This feature is optional and reserved to users that wish to make some advanced editing to the actual database values before running the model.

The expert mode comes after having made changes to the TPMs using the main interface, because these need to be applied in advance so that they show up on the raw tables. Thus, the logical flow of work in the model is as displayed in Figure 33.

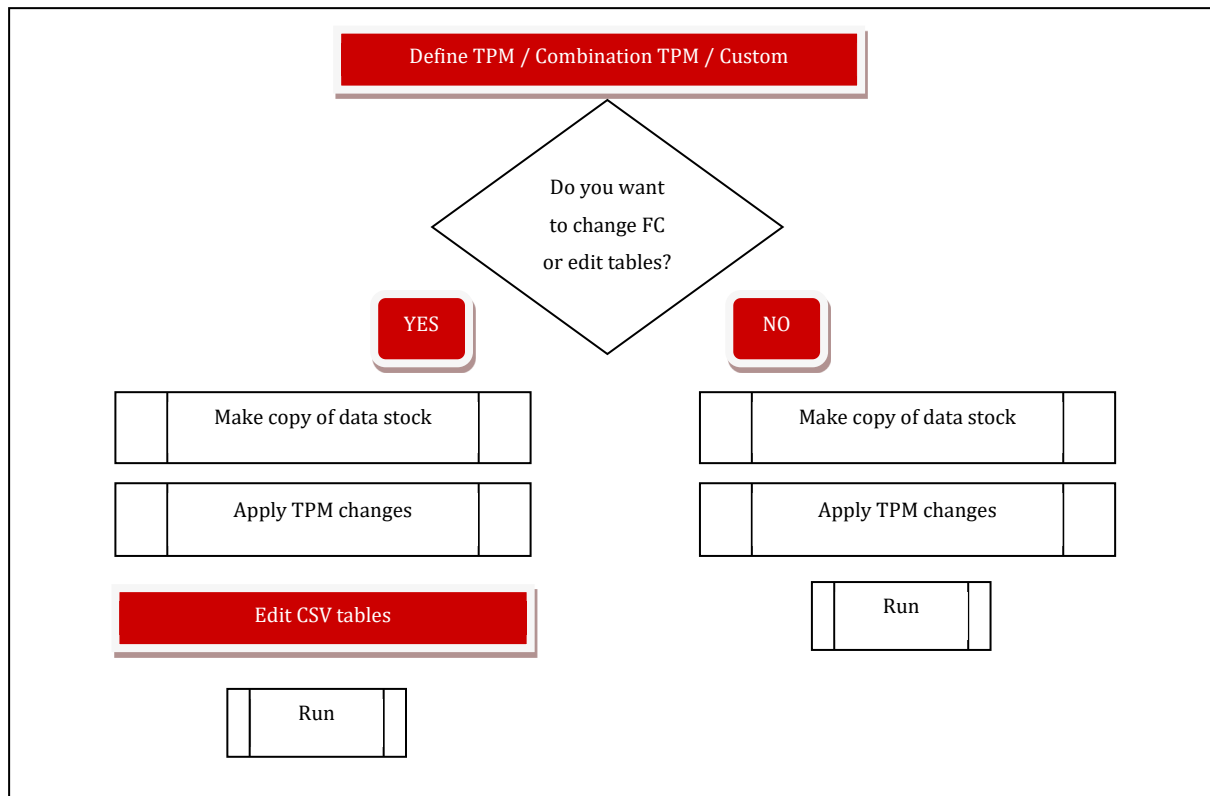


Figure 33: Workflow of the Interface

Using the expert mode, the user can check and adjust the variables that have been previously affected by the changes in policy levers, as well as change other model parameters or inputs such as Framework Conditions. To get to the expert mode, tick on the checkbox at the window for selecting a policy package to run (see Figure 34).

Select the element to add to the run queue ✕


Available packages:	Type:	Author:	Date:	ⓘ
	Single TPM	HIGH-TOOL Test user	Friday, March 11, 2016	ⓘ
	Single TPM	HIGH-TOOL Test user	Monday, March 14, 2016	ⓘ

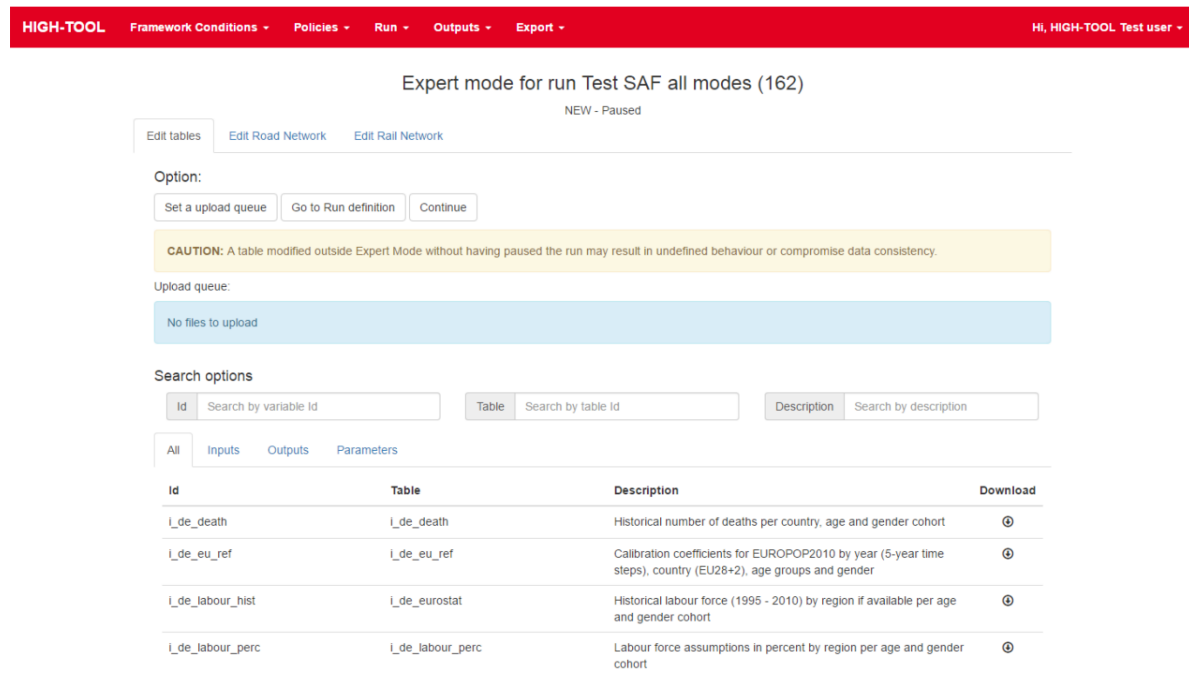
Options

☒ Expert Mode

Select Cancel

Figure 34: Enabling the expert mode

After launching the policy package to run with the expert mode enabled, the system will start the process of copying the data stock including the modifications from the policy package. Once the copy is ready, you may enter the expert mode by clicking on the  icon in the "View and manage your model runs" window or by choosing the option **RUN >> Packages ready for Expert Mode** and selecting the policy package to edit from the list. This will open a new window (see Figure 35).



Expert mode for run Test SAF all modes (162)

NEW - Paused

Option:

Set a upload queue Go to Run definition Continue

CAUTION: A table modified outside Expert Mode without having paused the run may result in undefined behaviour or compromise data consistency.

Upload queue:

No files to upload

Search options

Id Search by variable Id Table Search by table Id Description Search by description

All Inputs Outputs Parameters





Id	Table	Description	Download
i_de_death	i_de_death	Historical number of deaths per country, age and gender cohort	
i_de_eu_ref	i_de_eu_ref	Calibration coefficients for EUROPOP2010 by year (5-year time steps), country (EU28+2), age groups and gender	
i_de_labour_hist	i_de_eurostat	Historical labour force (1995 - 2010) by region if available per age and gender cohort	
i_de_labour_perc	i_de_labour_perc	Labour force assumptions in percent by region per age and gender cohort	

Figure 35: Expert mode interface


On the expert mode interface we can access two different tools, the table editor and the Hyper-Network editor, using the tabs on the upper part of the interface.

6.7.1 Edit Tables

The "Edit tables" tool (see Figure 35) offers a direct connection to the Data Stock, showing the full list of available input variables, the table they belong to, and a description. Three search fields allow a fast and easy filtering of the displayed items.

The available inputs are policy levers but also Framework Conditions and model parameters. Manually modifying any of these inputs might result in non-meaningful results of the model if the chosen values are outside the limits of applicability, as this might imply the need of a recalibration of the equations inside each module. Please refer to D4.3 and consult the metadata of the tables in the Data Stock before using this feature.
















In order to make a change to any input value:

- Find it on the list by using the search fields.
- Download the table by clicking on the icon .
- Open the downloaded CSV file with a spreadsheet editor, modify the desired values and save it (please refer to the Data Stock documentation to obtain a list of the codes used on each table).
- Upload the table by clicking on the button **Set upload queue** and then selecting the modified CSV file using the file explorer.

These steps can be repeated for any number of inputs. Once all desired variables are modified, the simulation scenario is ready to continue by clicking on the **Upload all valid tables** button (this button appears once there is at least one table in the upload queue). Finally, on the run window (see Figure 36) click on the resume icon so that the model carries on with the simulation.

HIGH-TOOL
Framework Conditions ▾
Policies ▾
Run ▾
Outputs ▾
Export ▾
Hi, HIGH-TOOL Test user ▾

View and manage your model runs

Id	Alias	Status	Step Id	Step Description	Run progress	Actions
153	Introducing alcolocks in Car, Truck and PT vehicles	Idle	DONE ▾	Finished. Ready to produce reports	<div></div>	    
157	Case1_FT	Idle	DONE ▾	Finished. Ready to produce reports	<div></div>	    
162	Test SAF all modes	Active	NEW ▾	In queue to create schema	<div></div>	    

View and manage other users' runs









Schema	Alias	Owner	Status	Step	Run progress	Actions
137	Reduction of loading/unloading and waiting time for rail freight	Guest	Idle	<div></div>	DONE ▾	Finished. Ready to produce reports    
138	Improvement of Magistrale rail corridor	Guest	Idle	<div></div>	DONE ▾	Finished. Ready to produce reports    

Figure 36: Resuming a run after having used the expert mode

6.7.2 Edit Hyper-Network

HIGH-TOOL offers an aggregated way of changing the network impedances of the different transport modes, through the policy levers available in the TPM interfaces.

However, if the user wishes to explore and make detailed changes to the network, the expert mode has the Hyper-Network interface, which is a graphical simplified representation of the road and rail connections between NUTS-2 regions (see Figure 37).

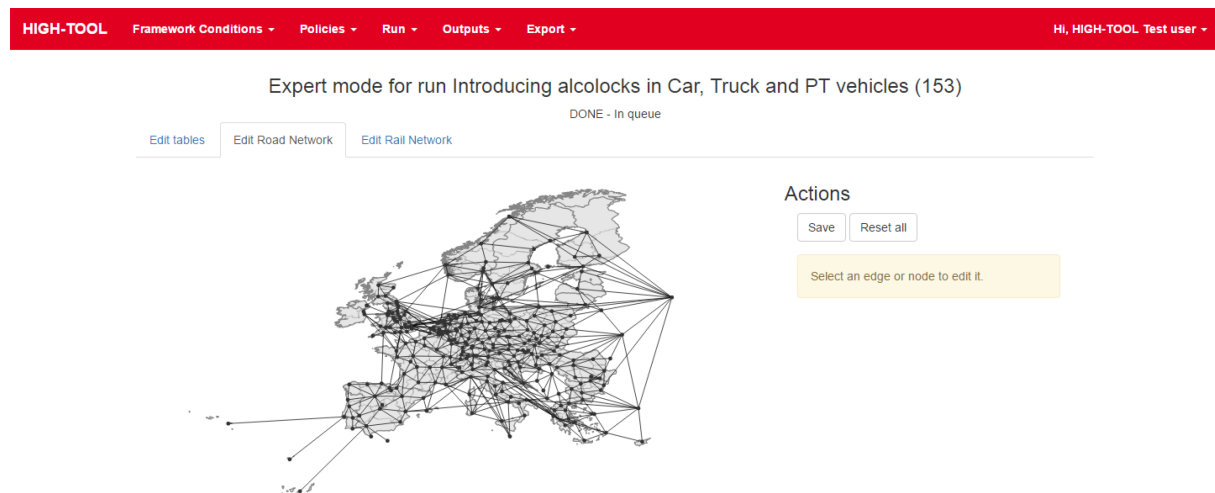


Figure 37: Editing the road Hyper-Network

The Hyper-Network editor has a navigable map that can be zoomed using the mouse wheel. Clicking on an edge will show its associated data at the right side of the screen. In addition, the user can input data on the fields for the relative time and distance weights for the different years. Therefore, the user cannot change the absolute values of time and distance for a given relation, but can affect it by setting the relative change.

Clicking on a node will also show its associated data at the right side of the screen. In addition, the user can input data on the fields for the relative access/egress time and distance weights for the different years. Therefore, the user cannot change the absolute values of time and distance for a given relation, but can affect it by setting the relative change.

The button **Save** stores the values, edited edges and nodes are shown in red. The reset button returns the values to their initial state.

All changes done to the edges and nodes will be used by HIGH-TOOL to compute new impedances for the Passenger module.

6.8 Policy Assessment Report

The full simulation results are available in a report on MS EXCEL format, downloadable from the server through the User Interface. This report is generated automatically by the HIGH-TOOL model User Interface and designed as an interactive Excel report. Tables, graphs or single values can be imported to a presentation tool (MS PowerPoint) or a text editor (MS Word, OpenOffice) by using the ordinary copy and paste functionalities.

The full Policy Assessment Report contains the following elements:

Contextual Information which includes the name of the Scenario and its abstract.

Model inputs. Contains a list of all the inputs to the simulation that have been entered using the TPM editors. For each policy lever active in the simulation it shows the intensity of the policy for the 2010–2050 period, a map with the changes in policy intensity across the EU territory (if any) and the specific policy intensities 2010–2050 for each country/region having custom changes (if any).

Full Results by thematic area. Results of each thematic area (Demography, Economy and Resources, Passenger Demand, Freight Demand, Vehicle Stock, Environment, Safety) produced by the HIGH-TOOL model are presented by tables and charts, each on a separate page. Results are shown in absolute value and also in comparison against the baseline scenario.

The following sequence of figures illustrates the assessment report configuration (Figure 38 to Figure 41).

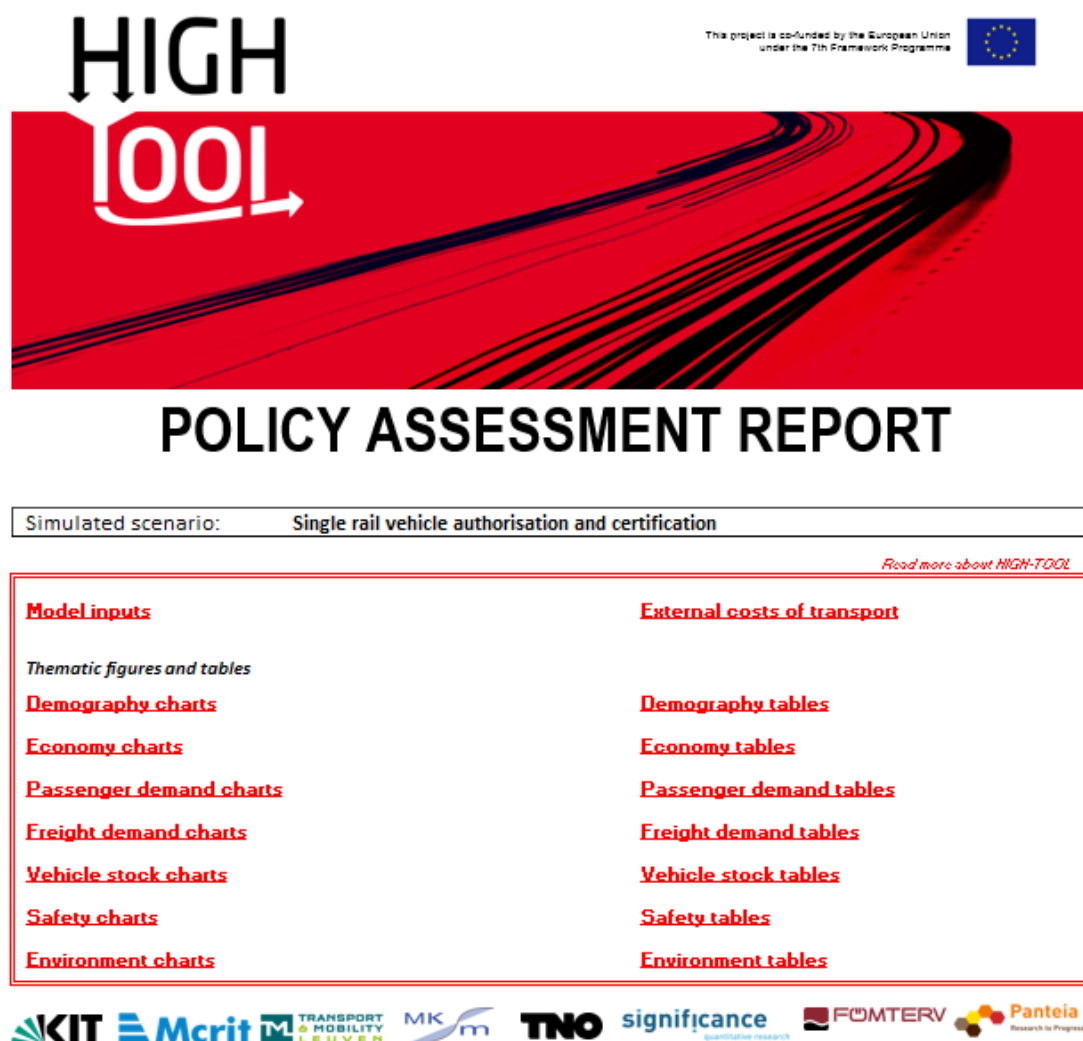


Figure 38: Main menu of the Policy Assessment Report in MS Excel

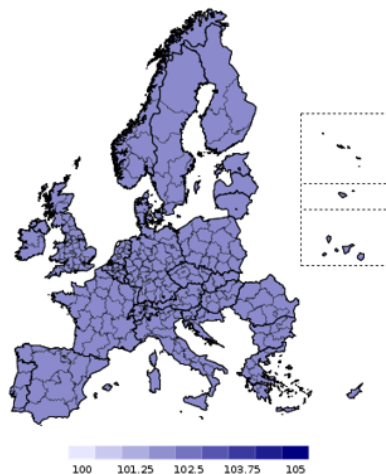

[Go to main page](#)

MODEL INPUTS

Load factor for rail in count (100 = baseline)

Year	EU28 Value
2010	100
2015	102
2020	102
2025	102
2030	102
2035	102
2040	102
2045	102
2050	102

EU28 + NO + CH at NUTS2 Level



Custom region values

Figure 39: Model inputs on the Policy Assessment Report


[Go to main page](#)

DEMOGRAPHY TABLES

European population by gender (in million) SCENARIO

Year	Male	Female	Total	% Male	% Female
2010	268	253	519	51.7%	48.3%
2015	258	269	527	48.9%	51.0%
2020	262	272	534	49.1%	50.8%
2025	265	275	540	49.1%	50.8%
2030	267	276	543	49.2%	50.8%
2035	268	278	546	49.1%	50.8%
2040	269	278	547	49.2%	50.8%
2045	269	278	547	49.2%	50.8%
2050	269	277	546	49.3%	50.7%

European population by gender (in million) BASELINE

Year	Male	Female	Total	% Male	% Female
2010	268	253	519	51.7%	48.3%
2015	258	269	527	48.9%	51.0%
2020	262	272	534	49.1%	50.8%
2025	265	275	540	49.1%	50.8%
2030	267	276	543	49.0%	50.8%
2035	268	278	546	49.1%	50.8%
2040	269	278	547	49.0%	50.8%
2045	269	278	547	49.0%	50.8%
2050	269	277	546	49.3%	50.7%

European population by gender (in million) DIFFERENCE

Year	Male	Female	Total
2010	0	0	0
2015	0	0	0
2020	0	0	0
2025	0	0	0
2030	0	0	0
2035	0	0	0
2040	0	0	0
2045	0	0	0
2050	0	0	0

European population by age cohort (in millions) SCENARIO

Year	0-19	20-39	40-59	=>60	% (0-19)	% (20-39)	% (40-59)	% (>=60)
2010	110.8	141.1	146.3	119.7	21.4%	27.2%	28.0%	23.3%
2015	109.9	136.9	143.2	130.1	20.8%	26.0%	28.4%	24.7%
2020	110.6	132.1	143.3	141.0	20.7%	24.6%	28.0%	26.6%
2025	110.8	127.3	147.3	153.0	20.6%	23.6%	27.4%	28.4%
2030	109.2	124.3	144.0	164.8	20.1%	22.8%	26.6%	30.4%
2035	106.8	123.5	140.5	174.0	19.6%	22.7%	25.8%	31.8%
2040	105.4	124.1	136.0	180.8	19.3%	22.7%	24.8%	33.1%
2045	105.1	124.1	131.4	186.0	19.2%	22.7%	24.0%	34.0%
2050	105.4	122.1	128.4	189.6	19.3%	22.4%	23.8%	34.5%

European population by age cohort (in millions) BASELINE

Year	0-19	20-39	40-59	=>60	% (0-19)	% (20-39)	% (40-59)	% (>=60)
2010	110.8	141.1	146.3	119.7	21.4%	27.2%	28.0%	23.3%
2015	109.9	136.9	143.2	130.1	20.8%	26.0%	28.4%	24.7%
2020	110.6	132.1	143.3	141.0	20.7%	24.6%	28.0%	26.6%
2025	110.8	127.3	147.3	153.0	20.6%	23.6%	27.4%	28.4%
2030	109.2	124.3	144.0	164.8	20.1%	22.8%	26.6%	30.4%
2035	106.8	123.5	140.5	174.0	19.6%	22.7%	25.8%	31.8%
2040	105.4	124.1	136.0	180.8	19.3%	22.7%	24.8%	33.1%
2045	105.1	124.1	131.4	186.0	19.2%	22.7%	24.0%	34.0%
2050	105.4	122.1	128.4	189.6	19.3%	22.4%	23.8%	34.5%

Figure 40: Full results displayed in tables, on a per theme basis

PASSENGER DEMAND GRAPHS

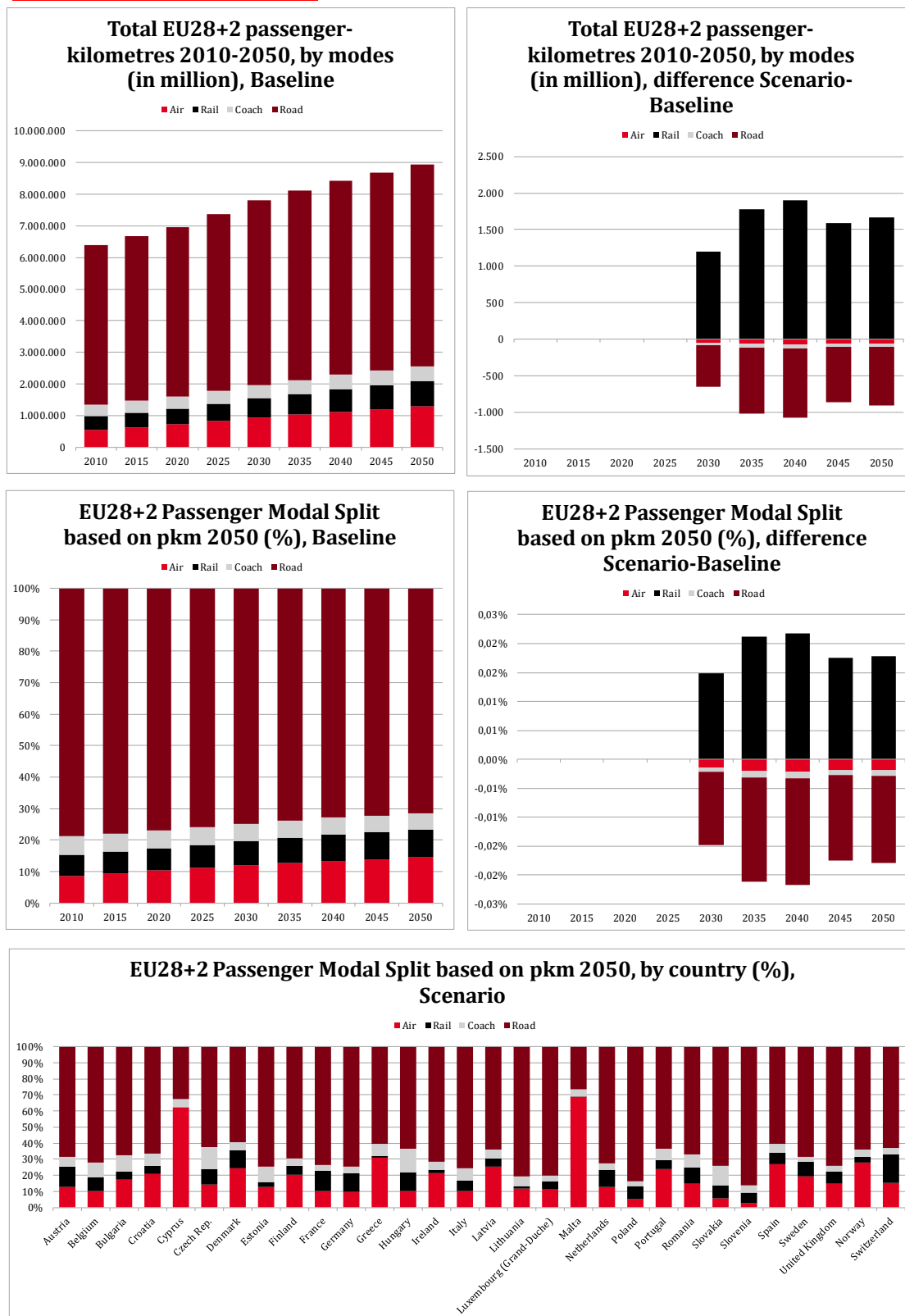


Figure 41: Full results displayed in charts, on a per theme basis

6.9 Export of Results

The export menu allows exporting raw data from tables contained in the HIGH-TOOL database. Exported data is sent to users in CSV format.

Users need to select a HIGH-TOOL database corresponding to an already existing model run. For a specific run, the User Interface shows all variables available. Users can filter such variables by restricting the search to specific strings in the variable name, the table name where the variable belongs to, or parts of the description of such variable.

Users can retrieve the variable contents by clicking on the rightmost icon **Download**.

HIGH TOOL Framework Conditions Policies Scenario Run Policy Reports Export Hi High Tool Test user

Export table contents

Select database schema:
High-Tool Baseline (high_tool) --- Status : Idle

Search options

Id Search by variable Id Table Search by table Id Description Search by description

Inputs Outputs Parameters

Variable	Table	Description	Download
i_de_labour_hist	i_de_eurostat	historic labour force (1995 - 2010) by age and gender cohort	⬇
i_de_labour_perc	i_de_labour_perc	labour force assumptions	⬇
i_de_death	i_de_death	historic number of deaths per country per age and gender cohort	⬇
i_de_pop_disag	i_de_pop_disag	historic shares of population 2010 at nuts-2 level per age and gender	⬇
i_de_pop_eurostat	i_de_eurostat	historic population (1995 ? 2010) by age and gender cohort	⬇
i_de_life_men	i_de_europop_ass	projected life expectancy for men for eu27 countries +ch +no from 2010 ? 2050 (5-year time step)	⬇
i_de_life_women	i_de_europop_ass	projected life expectancy for women for eu27 countries +ch +no from 2010 ? 2050 (5-year time step)	⬇
i_de_net_migration	i_de_europop_ass	projected net migration (emigration-immigration) for eu27 countries +ch +no from 2010 ? 2050 (5-year time step)	⬇
i_de_tot_fert_rate	i_de_europop_ass	projected total fertility rate for eu27 countries +ch +no from 2010 ? 2050 (5-year time step)	⬇
i_de_eu_ref	i_de_eu_ref	the calibration coefficients for europop2010 by year (5-year time steps), country (eu27 countries + no + ch), agegroups (0,5, 75) and gender (0,1)	⬇
i_de_urban	i_de_urban	urbanisation proxy per nuts-2 region	⬇
i_fd_region_share	i_fd_region_share	region shares by o/ d and mode for travelled distance	⬇
i_fd_imp_dist	i_fd_imp	distance impedances od and mode based	⬇
i_fd_route_choice	i_fd_route_choice	tonne share by route chains using two transshipment points	⬇

Figure 42: Export raw data control panel

7 Specific Instructions for the Online Version

7.1 Access

Current version of the HIGH-TOOL model operates online with a connection to a remote server (<http://www.high-tool.eu/model>). Contact with the system administrator is needed to obtain a user name and an access password.

7.2 Hardware and Software Requirements

When working remotely, client computers can be standard (as they will not undertake model calculations), but a reliable internet connection and 'evergreen' web browsers (latest versions of Chrome, Firefox or Internet Explorer/Edge) are a strong requirement.

8 Specific Instructions for the Stand-alone Version

On this chapter we present the specific instructions to install and run the stand-alone version of HIGH-TOOL in a desktop computer. This is a procedure requiring technical knowledge, so please contact your IT administrator to perform it.

8.1 Hardware Requirements

The model needs a minimum amount of RAM to be able to run and requires a very fast disk, as I/O is the main bottleneck.

- Minimum 32 GB RAM
- Processor Intel Core i5 at least (with motherboard able to handle PCIe disks)
- SSD hard disk drive with at least 256 GB. Ideally with PCIe interface instead of SATA.

8.2 Software Requirements

The stand-alone version of the HIGH-TOOL targets the following platform:

- Windows 7 Professional 64-bit
- Oracle Java v8 RTE (Run Time Environment)
- Postgresql with the PostGIS extension.

8.3 Instructions to Install the Third Party Software

8.3.1 Oracle Java v8 RTE

The HIGH-TOOL interface needs a Java v8 compatible RTE to:

- Compile the Excel version of the Policy Report Assessment
- Run the HIGH-TOOL modules.

To install the Java v8 SDK,

- Download the Windows 64-bit .exe executable from:
<http://www.oracle.com/technetwork/java/javase/downloads/jdk8-downloads-2133151.html>
- Run, with administrator privileges, the downloaded executable
- Follow the screen instructions.

The installable should add the Java Path to the system variables. Please check it by doing the following:

- Launch a Power Shell
- Write
java -version
- The shell should report the Java RTE installed with a message similar to this one:
Java version "1.8.0_66"
Java(TM) SE Runtime Environment (build 1.8.0_66-b17)
Java HotSpot(TM) 64-Bit Server VM (build 25.66-b17)
The reported version may vary, but you should ensure that the version is, at least, 1.8.xxx.
- If the java path was not exported, follow the annex "How to modify the System \$PATH variable".

8.3.2 Postgresql + PostGIS

To install Postgresql:

- Download the latest package from <http://www.enterprisedb.com/products-services-training/pgdownload#windows> Choose the one you need according to the OS and between 32/64-bit
- Run, with administrator privileges, the downloaded executable.
- Before exiting the setup wizard tick on the box to select Stack Builder option.
- On the Stack Builder window select "PostgreSQL X.X..." from the dropdown list and click **Next**.
- From the available options select "Spatial extensions" and tick on "PostGIS...", choosing the appropriate version 32/64 bit. Select **Next** and install the extension.

8.3.3 Instructions to install the HIGH-TOOL Data Stock

- Open pgAdmin III, the GUI that comes bundled in the Postgresql package
- Connect to the local database
- Right click on the name of the local database and select **Restore** from the menu
- Select the file containing the HIGH-TOOL data stock
- Choose the appropriate role from the list
- In the options tab #1 check the box **Do not save owner**
- Click on **Restore** and wait until the process is finished (might take at least 30 minutes).

8.4 Installing the HIGH-TOOL Interface

The HIGH-TOOL interface is delivered in two flavours:

- A server side instance using Node v4
- A Windows 7 64-bit installable.

Windows 7 64-bit installable

Download the .exe installable from:

HIGH-TOOL FTP under the folder */Interface* "HIGH-TOOL Setup.exe"

The installable is not signed and Windows will ask three times for administrator privileges,

- To open the .exe
- To install the interface
- The first time it runs to allow the interface to connect to Internet (this is likely not to happen in future updates).

The installation wizard is very simple and will delete any previous versions and install the HIGH-TOOL interface in the 64-bit programs' folder. Usually:

C:\Program Files\HIGH-TOOL

The installed programme does not use any packaging or code obfuscation technique. This means that all the JavaScript files are exposed and can be modified to change the programme behaviour if the user desires to.

The remarkable folders that advanced user should be aware of, are:

- *C:\Program Files\HIGH-TOOL\resources\app*
 - *.tmp*: Contains the file localDiskDB.db. This file is a json with all the interface data (users, TPMs, runs, etc.). Should be backed-up to restore the data.
 - *.tmp\public*: This folder contains a copy of the UI. This folder is updated every time that the programme is launched. All modifications here will be lost.
 - *java_modules*: Contains the HIGH-TOOL Java modules, configuration files, logs and dependencies (Excel files, CSV with default data, etc.).
 - *assets*: This folder contains the HTML client of the HIGH-TOOL interface. This folder is copied to *.tmp\public* in every start up.

- *config*
 - *connections.js*: This exports a JavaScript object with the credential to connect to the Data Stock.
 - *jwt-variables.js*: This file exports the secret key used to sign the token used to authenticate and authorize the users. If the instance of the HIGH-TOOL interface will be exposed to insecure networks, the key **MUST** be changed or an attacker can create tokens with administrator privileges or impersonate any user using this key.
- *ooo-templates/HTPolicyReportTemplate.xlsx*: This Excel file is the template of the Policy Assessment Reports.

8.5 Launching the Interface for the First Time

Upon launching the interface it will check and download the latest version for each module from the HIGH-TOOL server, as shown on Figure 43.

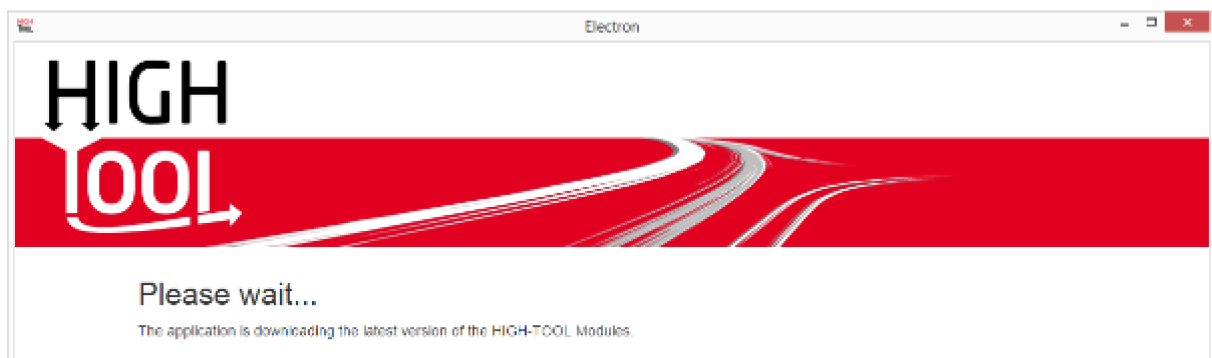


Figure 43: Stand-alone version downloads the HIGH-TOOL Modules

In every start-up, the interface tries to connect to the Data Stock. If the Data Stock is not found or the credentials are not correctly set, which is likely to happen during the first time, the interface will launch a configuration utility. This utility allows to:

- Set the credentials to connect to the Data Stock.
- Set specific module options. In particular, it exposes the option to use Excel or Open/LibreOffice. See the chapter “SAF specific” to understand those options.

Once you have changed the credentials and the module specifics to match your environment, switch to the **Actions** tab and press the button **Save**. The **Save** button will trigger a routine to modify all the involved interface and module files at once: you don't need to modify any file by your own.

After saving your configuration, press the **Reload** button to try again to connect to the Data Stock. If the interface still fails to connect to the Data Stock, the configuration utility will be launched again.

This user must be changed when using the stand-alone version if the interface will be exposed to insecure networks.

8.6 Debugging the Stand-alone User Interface

The HIGH-TOOL stand-alone user interface does not pipe stdout or stderr to any file. To see the console outputs of the programme, you can launch it in a Power shell running the programme

```
C:\Program Files\HIGH-TOOL\HIGH-TOOL
```

To save this output to a file, you can redirect the stdout using the > operator:

```
C:\Program Files\HIGH-TOOL\HIGH-TOOL > output.txt
```

The produced output.txt will have all the console outputs of the programme.

9 References

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