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## ***Deliverable 6.1 – “Scenario generation and management”***

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**Abstract:**

The deliverable describes the comparative static forecasting approach which is essential for understanding how the model works when forecasting. A second objective is to describe the general form of the scenario data. We include a basic description of the population data, the employment data, GDP data, and monetary travel cost and baseline value-of-time tables. We also provide a brief overview of the different GIS data to be included in scenario building.

The deliverable does not provide a detailed description of the reference scenario as this to be covered in WP 11. However, to understand how reference scenarios can be edited to form new scenarios we provide a brief explanation related to the generation of the scenarios in general.

Further to this, the deliverable does not describe the practical construction, selection, processing and analysis of scenarios as this is now handled in a dedicated model user-interface which has been carefully described in D4.1.

**Keywords:**

*Scenario data, scenario generation and processing.*



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## Executive Summary

The deliverable describes the generation of scenarios in Transtools 3. In the deliverable we focus on three main issues.

### **Understanding of the way scenarios are formed in Transtools**

The Transtools framework is a static comparative model framework, which can only process one scenario at the time. Hence, when comparing different scenarios it is important to distinguish between baseline scenarios, which form a basis for comparison, and policy scenarios which investigate policies relating to a specific baseline. There can be many different baseline scenarios referring to, e.g. different visions of the infrastructure or demographical developments.

### **Understanding of scenario data**

Transtools makes it possible to investigate a range of different policies through the editing and construction of scenario data. Scenario data will refer to a master database and different sub-scenario databases can be applied in different scenarios. In the report we briefly describe the different types of scenario data.

### **The generation of new scenarios**

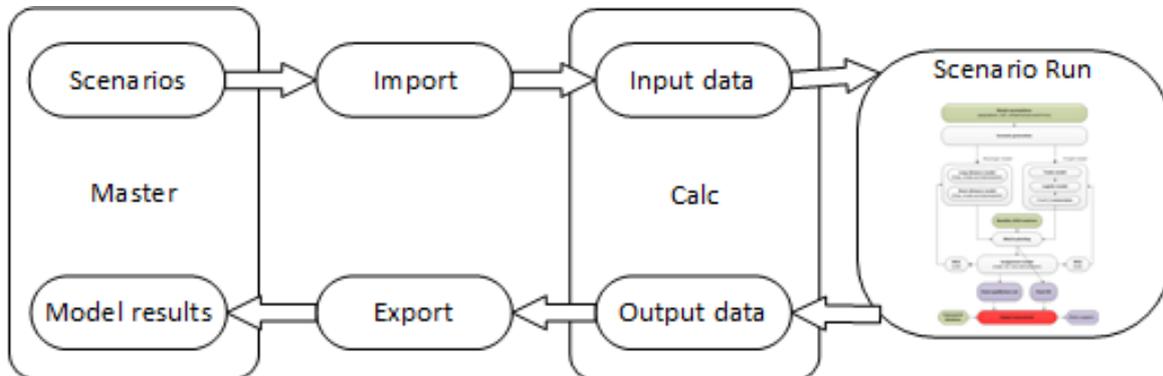
We provide an overview of how new scenarios can be developed from the reference scenario or from alternative scenarios. As there are in principle an infinite number of possible scenarios and an infinite number of way these can be generated it is neither possible nor recommendable to provide generic software for constructing scenarios. The software for managing Transtools, however, provides an efficient way of composing different scenarios from all the different scenario data elements whenever these are available.

## 1. Introduction

The TT3 model applies a static comparative prediction framework<sup>1</sup>. This implies;

- The scenarios are always measured relative to a baseline.
- We do not model the “dynamic path” from a baseline (reference year) to a given scenario (forecast year).
- For those elements that are exogenous to the model, these needs to be defined for the reference year as well as for the forecast year.
  - o As the model is pivoted with respect to a baseline matrix the model will always replicate the baseline matrices for a neutral scenario run.

The fundamental workflow of scenarios is described in Deliverable 4.1 Section 2. Generally, the scenarios can be thought of as a collection of database tables hosted in a master database. The scenario data, which can be edited, is then imported to the calculation system, and after processing of the input data (in the transport model system), results is then subsequently exported from the calculation system for further analysis and processing. The “model manger” is the software user interface which supports the editing and selection of scenarios before and after each scenario run. Figure 1 below illustrates the data flow.



**Figure 1: TT3 technical model structure (also refer to deliverable 4.1).**

Each scenario consists of several scenario types of data which all relates to certain subpart of the model, e.g. the road network scenario (link and connector tables) is connected to the route-choice models and the air trip matrix scenario is linked to the demand model. For each data scenario type it is possible to specify an unlimited number of scenarios and these can be created and maintained from the Transtools Manager.

Before a model run can be executed a specific data scenario for each data scenario type must be chosen for the calculation. This is done by creating a main scenario in which the different parts are selected. The benefit of this approach is that everything in the scenario database can be re-used and

<sup>1</sup> Refer to D7.2, D8.2 and D9.2 for detailed descriptions of the freight model, the passenger model and the route choice models.



it means for example, that a specific road-network can be combined with different combinations of zone data or transport cost data.

## 2. The different types of scenarios

Because the model is a static comparative model only one scenario can be run at the time. However, there are two different types of scenarios

### 2.1 Baseline scenarios

Baseline scenarios describe a reference situation in a specific year. A common way to use TRANSTOOLS is to investigate a series of different future infrastructure projects and/or transport policies. These are then evaluated against a shared baseline scenario. Typically, the baseline represents the situation for a given year without any project or policy changes. Therefore, the baseline scenario is also often referred to as the business-as-usual situation.

### 2.2 Policy scenarios

From the perspective of the model, policy scenarios are not different from the baseline scenarios and they require the same amount of input. However, conceptually, policy scenarios can be thought of as a situation where for a given year, certain assumptions and/or infrastructure changes takes place. When future scenarios are evaluated, these are often examined under different assumptions regarding general infrastructure changes, demographic and economic development as well as transport policies. Often future infrastructure projects are also examined with different implementations of the new infrastructure. All the different variants are referred to as policy scenarios and are evaluated against the relevant baseline scenario.

### 3. Scenario data

The model does not have a software module, which is dedicated to creating scenarios. It would be very difficult to construct a general approach, which would fulfil all the different requirements. However, it is easy to generate new scenarios on the basis of existing reference scenarios by simply editing these tables in the SQL database environment<sup>2</sup>. However, when scenario data has been constructed and is imported to the SQL database the model does have a software user interface which makes it easy to select and combine the different data sources for the different scenarios.

The experience with the Danish National Model which has a similar design is that when the model entering the application phase where many different users build and edit scenarios, then after some time, the “pool” of scenario components becomes quite big and diverse. It means that the main part of developing new scenario runs is actually to select appropriate scenario parts from the master database. The model comes with a master database.

This note is not about the construction of reference scenarios but provide a general description of how alternative scenarios may be constructed on the basis of these. There are potentially a large number of scenario inputs and the inputs are essentially divided into two types of input:

- Database tables which can be edited and accessed by SQL server.
- Arc/GIS databased which can be edited and accessed through Arc/GIS (typically Arc/Map).

The most relevant database tables are;

- National tables for, e.g. specific transport costs and indicators.
- Zone data representing, e.g. population, employment, workplaces and others.
- Networks data, e.g. road and rail networks.

All of these ordinary tables (national tables and zone data) can be edited through database manipulations such as SQL queries. The remaining data sources can be manipulated through the ARC/GIS interface.

The most relevant GIS tables are related to the different networks. By accessing these tables it is possible to edit transport costs as attached to the links to the network. This can be defines as, e.g. a “flat-rate” or by selecting links for specific corridors or countries. As it is described in Deliverable 4.1 a network can provide a basis for many different scenarios by having many different columns for a given attribute.

Below we will briefly discuss key inputs for the model.

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<sup>2</sup> Refer to D5.2 for a detailed description of model tables and inputs.

### 3.1 National data

Data regarding fuel prices, tax shares and diesel share of diesel vehicles should be provide on national level. The attributes required are:

- Fuel costs per kilometre
- Diesel share of vehicle fleet
- Fuel tax share for gasoline
- Fuel tax share for diesel

Fuel cost per kilometre is important for calculation of transportations costs for both person cars and trucks. It will also have an impact on the chosen routes in the road assignments. Diesel share of fleet is for calculating environmental impacts, while tax share is for calculating the public revenue. The assumptions can be changed for any given forecast year and it is therefore possible to examine how changes over time in, say the diesel composition, affect the transport demand.

### 3.2 NUTS3 data

Demographic and socioeconomic data is given on a NUTS3 zone level. The required attributes are:

- Population
- Jobs
- Gross domestic product (GDP)
- Car ownership
- Hotel capacity (bed places)

In addition we have for rail an exogenous ticket price matrix and a frequency matrix.

### 3.3 Networks

TRANS-TOOLS operates on 5 separate networks. In each of the networks' exogenous attributes will affect the route choice behavior and thereby the transportation costs. In the following sections the key attributes for each network are listed.

#### 3.3.1 Air network

The air network should include all flight connections between airports as well as possible ground transfers between nearby airports. The key attributes in the flight network are:

- Flying times
- Service type
- Service frequencies
- Ticket fares (segmented by trip purpose)
- Transfer times

#### 3.3.2 Rail freight network

The RailFreight network must describe the part of the rail network which has freight service. It should also include rail freight ferries. The key attributes are:

- Speed
- Border times

### 3.3.3 Rail passenger network

Rail passenger network must describe the part of rail network used for passenger service. Ferries serving rail passengers should also be included. The key attributes are:

- Speed
- Service frequency
- Border times

### 3.3.4 Road network

The road network must include major roads in the area covered by the model and should also include road vehicle ferries. The key attributes are:

- Speed
- Road class (to determine speed/flow relation)
- Number of lanes (in each direction)
- Capacities per lane per hour (in each direction)
- Toll costs including ferry prices and road pricing (in each direction)
- Border times (in each direction)
- For ferry links the service frequency must be known as well

### 3.3.5 Waterway networks

The waterway network must include all navigable rivers and canals where cargo can be transported by ship. The attributes are:

- Sailing speed
- River/canal type (in regard to allowed CEMT ship classes)

### 3.3.6 Rail ticket price matrix

Rail passenger ticket prices are specified on a zone-to-zone level (NUTS3). These are drivers for the passenger model. They must be provided for each trip purpose and must represent a return ticket price (price going from one zone to another and back again).

## 4. The generation of new scenarios

The way the different inputs for the possible scenarios are specified is in principle outside the model framework. It is simply not possible to generate a generic model for how to do this as there are an infinite number of possible scenarios and different ways of generating these input data. In the following we will therefore briefly describe how the most important data can be edited with reference to a reference scenario.

### 4.1 Population

The population growth is a main driver in the transport model. This is measured at the zone level. One possible data source is the official Eurostat population projections represented by table “proj\_13rpms3” and referred to as “Main scenario - Population on 1st January by age, sex and NUTS 3 regions”. This table is available for 2015, 2020, 2030, 2040 and 2050 and even for age and gender dimensions as well.

As the zone system for the Eurostat tables is based on NUTS3 it is not entirely consistent with the zone system of the model. Hence, we propose that alternative scenarios are based on the Transtools population tables as these are consistent with the general Eurostat forecasts. Alternatively, keys between the zone system of the model and the NUTS3 system exist if alternative forecasts are required.

A key reference for the scenarios is the official reference scenario based on the PRIMES model. As this model operates at the level of the countries our reference scenario will be produced in two steps by;

- 1) Apply the detailed Eurostat distribution at the NUTS3 level.
- 2) Ensure consistency at the country-level with the 2013 reference scenario.

The generation of new population tables can be carried out as a simple database or excel operation and the model does not support specific tools for this. There are no restrictions to other input data.

### 4.2 GDP

In the model we operate with GDP measured as the “annual gross domestic product”. The model operates on a zone level and GDP needs to be measured at this relative detailed spatial level as well. This is a challenge as there are no long-term GDP forecasts at this level.

The construction of the reference scenarios for 2020 and 2030 is based on the 2013 reference scenario projection in which GDP projections per country is available for these countries. Based on this scenario we calculate a general change in GDP / Capita for each country and apply this growth rate to all zones by using the detailed population projection at the level of the zones. Hence,

$$GDP_{2020,zone} = \frac{GDP_{2020,country}/Pop_{2020,country}}{GDP_{2010,country}/Pop_{2010,country}} Pop_{2020,zone}$$

This estimate is uncertain and is based on the premise that the growth in GDP / capita is evenly spread across the country, which we know is not true. In fact this is likely to underestimate the GDP growth in cities for which the productivity is likely to be higher.

Again, the generation of GDP scenarios can be managed by simple manipulations to the zone database and we do not support specific tools for this. Specifically, the adaptation of new reference scenarios at the country level from the PRIMES model is easy including using the above calculation principle.

### 4.3 The number of jobs

The number of jobs is represented in the zone database. These are no official projections of the number of jobs in the reference scenario and the reference scenarios as applied in the model are therefore relative simple in that we assume a constant job/population share in future years.

Again, this premise can be changed in various ways depending on available input data.

### 4.4 The number of bed-places

The number of bed-places is also represented in the zone database. These are no official projections of the number of bed-places in the reference scenario and the reference scenarios as applied in the model are therefore relative simple in that we assume a constant bed-place/population share in future years.

Again, this premise can be changed in various ways depending on available input data.

### 4.5 GDP and value-of-time

An important link is between the GDP and the value-of-time estimate. For the estimation we have applied a meta-model<sup>3</sup> to calculate the value-of-time per country and the link between GDP growth and VoT. The following formula will be applied ;

$$(1) \quad VoT = \exp(-9.805 + 1_C 0.136 + 1_{TU} 1_{EB} 0.254 - 1_{BU} 0.363 + 1_{AU} 0.294 + 1_{AV} 0.65 + 1_{InterZ} 0.426) GDP^{0.705 + 1_{EB} 0.128 + 1_{CU} 0.029}$$

*VoT* is expressed in Euro per minute. In the above formula  $1_C$  denotes an indicator for commute,  $1_{EB}$  indicate business whereas  $1_{TU}$ ,  $1_{BU}$ ,  $1_{AU}$ ,  $1_{CU}$  indicate train user, bus user, air user and car user respectively.  $1_{AV}$  Indicates air values whilst  $1_{InterZ}$  denotes an inter-urban trip. In this model GDP is measured as the annual gross domestic product per capita. Hence, it is straightforward to calculate the value-of-time for any scenario using this formula on the basis of i) the zone population (Section 4.1) and, ii) the GDP (section 4.2).

We acknowledge that there may be a difference between a social value-of-time and a perceived value-of-time. Currently we assume these to be identical; however, this should be considered by the user.

<sup>3</sup> Refer to D8.2.

In the model we provide VoT tables for all reference years, which can be changed prior to any execution. However, VOT tables are not specified explicitly the model will calculate the elasticities internally due to the changes in GDP and apply these values in the calculations.

## 4.6 GDP and transport costs

The monetary travel costs by the various transport modes are assumed to follow the real-growth in GDP. Hence, we assume a 1-to-1 between real-GDP growth and transport costs. However, as described in the beginning of the previous section the models make it possible to change costs in various ways.

## 5. Data Scenario Types

Refer to Deliverable 4.1 in which the different types are described in more details and the operation of these in the Transtools manager.

## 6. Main scenarios

Refer to Deliverable 4.1 in which the composition of the main scenario is described.

## 7. Setting up new scenarios

Refer to Deliverable 4.1 in which it is described in details how scenarios can be defined and specified.

## Literature

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