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VMÖ – A new strategic transport model for Austria

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Abstract

For the preparation of a new traffic forecast for several time horizons up to the year 2040 and beyond (Verkehrsprognose Österreich, VPÖ 2040+) an up-to-date transport model is necessary. Currently this new national transport model Austria (Verkehrsmodell Österreich, VMÖ) is developed.
The passenger model will be disaggregated tour-based model with 5 basic steps and some extensions for special applications, like for instance tourist traffic. The number of zones will be approximately 6000. In the model a special focus is on incorporating recent trends in mode choice like “park and ride” and other multimodal chains. The freight part of the model will be an Aggregated - Disaggregated - Aggregated (ADA) model with three steps: (1) the results of an input-output-model are transformed into firm-to-firm flows, (2) the choice of shipment size and transport chain is modelled and (3) the OD relations are aggregated for the individual modes and assignment to the networks.
For individual transport with passenger cars and road freight, a quasi-dynamic road transport assignment will be developed. Public transport assignment is based on timetables. For the forecasts of travel demand for future years a pivot-point approach (with the changes) on the base matrices will be applied.

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Keywords: transport model; disaggregated; tour-based; stated preference data; ADA; Österreich Unterwegs

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1. Introduction

1.1. Background

In Austria, comprehensive transport forecasts have been conducted since the 1970s. Dedicated transport models as a standard tool for national infrastructure planning and forecasting are in use since the 1990s. Since then transport models have been continuously established at the Federal Ministry for Transport, Innovation and Technology (FMTIT) as tools for forecasts and assessment of different planning processes. At the beginning of the 2000s, a cooperation with the goal of a joint development and operation of a new national transport model (VMÖ – German: Verkehrsmodell Österreich – Transport model Austria) and the national forecast 2025+ (VPÖ – German: Verkehrsprognose Österreich – Transport forecast Austria) between the FMTIT, the highway operator (ASFINAG) and the railway operator (ÖBB-INFRA) has been formed. One underlying idea is for all parties responsible for the development of the national infrastructure to use the same base data and to develop a common understanding of future developments in regard to the setup of scenarios for the forecasts and an increased sense of ownership.

Having published the results of the forecast 2025 in 2010, the effects of the financial crisis on the transport sector made a useful interpretation of the results difficult. A secondary study on how the results could be interpreted in the light of the most plausible path at the time helped, but it was clear that a new forecast, also with a further reaching horizon, would have to be conducted. Several improvements in available data (network, timetables) and the latest data from the mobility survey "Österreich Unterwegs" became available which also marked the right moment to update not only the forecasts but also the national transport model.

In 2017, in preparation of the tendering process, a pilot study has been conducted by Significance in which the specifics of the model have been developed. Within this context, the development of a new transport model has been tendered in 2018. The work on the model and the forecast has started in April 2019 and is expected to be completed in the first quarter of 2022. The first application of the new transport model will be a comprehensive national forecast for 2040.

1.2. Objectives and planned applications

The project aims to fulfil multiple objectives. In one dimension, the results of the forecast are the foundation for the work on the national infrastructure development plans for road and rail. This also includes the planning and development of concepts for future supply in public transport and of specific future timetables. The suitability of the results as an input into standardised evaluation methods (Cost-benefit-Analysis, Environmental Impact Assessment, modelling of noise and emissions, etc.) is a further important factor. Also, the model is expected to help planning and estimating the effects of policy measures in the transport sector and analyse the requirements concerning current challenges and developments, for example the decarbonisation of the transport sector or new forms of mobility that may arise. The questions involved lay a strong emphasis on the reliability of the results and ensuring acceptance towards the results.

The model data (e.g. networks, matrices) is also provided to external partners – in general to regional and local governments, as well as to other countries – for reference and/or integration into their own models.

The model is jointly operated and maintained by the Ministry and the infrastructure operators. This allows assessing planning scenarios and the effects of proposed measures directly and at short notice. Additionally, this setup allows for easier iterative planning processes and in-depth analysis in-house.

Also, the concept envisages a change from developing a new model from scratch in bigger intervals towards a "living" system where single elements could be updated depending on new, better data and new methods becoming available or on whether certain applications change, or additional questions need to be answered. From the experience of the last financial crisis it seems necessary to be able to estimate possible changes at short notice, where a system build with updating in mind helps a lot. Beneficial effects on the operative side are a higher level of continuity and familiarity with the characteristics of the model. Experience shows that a focus has to be laid on the model being structured in a way that allows for shorter update cycles (e.g. every two years). This leads to the requirement that the model will be more open and data driven.

Table 1. Overview of objectives for the VMÖ.

Validity of the model Reliability and stability of the results Transparency (methods, assumptions for the forecasts)	The model, the underlying assumptions and the results are able to stand up to a critical examination in the course of cost-benefit-analysis, environmental impact assessments and other formal assessment procedures. An extensive documentation is foreseen and the publication of statistical benchmarks describing the quality to provide the public insight into the workings and about the limits of the model.
High usability on the level of the interface Elimination of black boxes	On an operative level the model can be managed well. It is clear how the model mechanisms and different models interact, so questions at hand can be translated to the logic of the model and the results are valid. The model can be adopted and updated in-house.

1.3. Overview of the scope of the model

The scope of the model in terms of its spatial extent and the transport systems that are included is defined by the requirements of the planned applications as a national model and also by considerations concerning the available data, complexity in development and operation (especially updates) and the time needed for a model run.

The new VMÖ aims at modelling all the transport that is relevant for transport flows on Austrian infrastructure. Corridors outside Austria that might impact flows inside Austria are to be modelled as well (e.g. analysing route shifts caused by differences in fuel cost, effects of opening major new foreign infrastructure links, etc.).

The demand models in general include all modes. For some modes, only trip generation, distribution and mode choice will be conducted. Especially pedestrians and bicyclists are not assigned to the networks. The usage of different transport modes (especially Park & Ride) is of relevance and incorporated.

The resulting model outputs are: generated trips (distinct OD-matrices for each mode, travel purpose, population group, etc.), the distribution of different key variables (time, distance, cost, etc.) and transport performance both for freight and passenger transport (tonne-kilometres, passenger-kilometres).

Certain applications concerning the rail-infrastructure (freight and passenger) and the supply regarding public transport require results in terms of the number of passengers embarking and disembarking at each station on the rail network. For the intermodal freight transport model capacity restraints of intermodal hubs will be included in the demand model.

The different applications for the transport model are based on results for an average working day as well as the annual average. Thus the demand models are giving results for the average daily traffic (workdays, no holiday seasons) and are expanded to the annual average daily traffic.

The overall new national model system contains a passenger transport model and a freight transport model. Both models will be used to produce changes between the base year and a future year (for different scenarios), which are applied to base matrices for passenger and freight transport. In the network models, the assignment will be carried out jointly for passenger and freight vehicles.

1.4. Contents of this paper

In section 2 of this paper, the passenger transport model within the new national transport model is discussed, followed by the freight transport model in section 3. Section 4 introduces the concepts of the base matrix and the pivot point method, and how these are applied in this project. The networks and the networks assignment methods that will be used are presented in section 5. All these new model components can to some extent be based on existing data, but also new data collection is required, which is discussed in section 6. Section 7 deals with the construction of scenarios for model application to future years. Finally, section 8 provides a short summary and conclusion.

2. PASSENGER TRANSPORT MODEL

The passenger transport model will be a disaggregate tour-based model with five basic model stages and some extensions for special applications. The basic stages are: tour generation, tour distribution, mode choice (for the main mode of transport of the tour), departure time choice and the network assignment. Figure 1 gives a schematic overview.

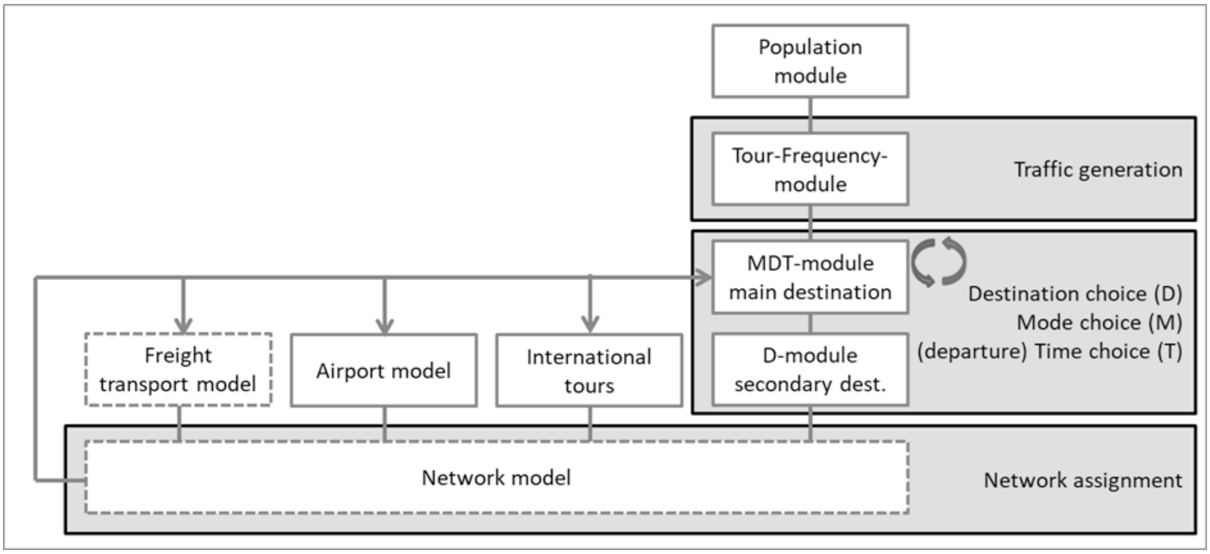

Figure 1. Schematic overview of the passenger model within the VMÖ.

Using these steps, the traffic of Austrian residents will be estimated based on the trip diary survey "Österreich Unterwegs".

The extensions mentioned relate to traffic of persons whose residence is not in Austria or for whom no behavioural data are available from the survey (for example: tourist traffic, transit traffic, destination traffic from abroad).

The goal is to describe the travel behaviour on the average working day (Monday to Friday). The annual total will be calculated by assigning different weights to the travel purposes during the weekend and in this way approximating the travel behaviour on Saturdays and Sundays. For the weekdays and the weekend, the survey "Österreich Unterwegs" will be the benchmark as all weekdays have been surveyed. The number of zones will be approximately 5500 within Austria and 500 abroad covering the rest of Europe. In the model a special focus is on incorporating recent trends in mode choice like "park and ride", "car sharing" and other multimodal chains. The demand model will be developed in a scientific programming language to meet all requirements of the client and only for the network assignment the standard commercial traffic planning software PTV VISUM (PTV AG, 2018) will be used. In the following model description, we will outline the general structure of the model and discuss a few important design choices in detail. Decisive for all the choices were the requirements of the Austrian ministry and its partners.

The travel diaries of "Österreich Unterwegs" allow the estimation of disaggregate models for the individual modelling steps for several travel purposes. This implies that no segments of passengers with similar travel behaviour have to be defined in advance and that the maximum amount of information from the available data is used during the estimations. The result of the estimation of the discrete choice models are a number of significant parameters describing the travel behaviour of all individual travellers of the survey. Afterwards passenger segments are defined that on the one hand incorporate the observed differences in travel behaviour and on the other hand allow flexibility in the definition of political measures to calculate effects. The passengers per segment for the base and future years are determined using the method of iterative proportional fitting.

A tour-based approach means that the individual trips are connected to roundtrips, starting and ending at the same model zone. This link between outbound and return leg of the tour (including a maximum of two intermediate stops on each way) allows for a realistic transport modelling as the interactions between different trips within one tour are incorporated in the choice of transport mode, departure time and destination. This realistic approach[2] leads to reliable forecasts and accurate sensitivities to macroeconomic developments, transport policy measures and social trends.

[2] In this model the interaction of different activities during the day is neglected.

The first step of the model is the tour generation. The number of tours for different travel purposes is estimated with 0/1+ and stop-repeat-models, describing the probability of doing a specific number of tours of the same purpose on one day. In a second step the probabilities of intermediate stops are calculated.

The tour distribution, mode choice and departure time choice are estimated simultaneously in a mode-destination-time (MDT) model. Explanatory variables are the level-of-service of the different modes, the person type and the attraction variables of the zones depending on the individual travel purpose. All zones of the model are considered as possible destinations. The following modes are included: car-driver, car-passenger, train, other public transport, cycling and walking. Train and local public transport are distinguished as separate modes as passengers value them differently. This has for instance been shown in the Dutch value-of-time study (Kouwenhoven et al, 2014), where the value-of-time for rail was found to be 9.25 Euro and the one of other public transport alternatives only 6.75 Euro.

Which of the modes are available for a specific tour depends on the one hand on the origin and destinations of the tour (e.g. is public transport available; distance not too long for walking) and on the other hand on characteristics of the person (e.g. ownership of a driving license). For simplification, it is assumed that one mode of transport is used for the whole tour (no switch between outbound and return and no switch after intermediate stops). This assumption is correct for 91% of all tours within the survey "Österreich Unterwegs". However, for public transport, the whole transport chain is estimated including access and egress to the stations, effects of interchanges and waiting times. For the car alternatives also park-and-ride and car-sharing are modelled in subsequent modelling steps. For both car-sharing and park-and-ride, realistic costs, access times and availabilities (car sharing available close to origin zone of the tours and number of parking lots) are considered.

As mentioned above not only mode and destination choice is modelled simultaneously, but also departure time choice is incorporated in the same model. The advantage is that the interactions between the three choices of MDT can be estimated which allows to take into account behavioural changes due to congestion, peak pricing and crowding.

The results of the demand model for passenger transport are a set of matrices with the dimensions: origin zone, destination zone, time period, and mode. Before aggregation information is also available on travel purpose, and passenger segment.

3. THE FREIGHT TRANSPORT MODEL

As part of the pilot study for a new national transport model for Austria, two different approaches for freight transport modelling were compared to each other in terms of their advantages and disadvantages:

- An aggregate four-step and trip-based model. Examples of this approach are the strategic freight models of The Netherlands (BasGoed; see de Jong et al., 2011) or Flanders (see Grebe et al., 2016).
- An Aggregate - Disaggregate - Aggregate (ADA) model (see de Jong and Ben-Akiva, 2007; Ben-Akiva and de Jong, 2013). This model consists of three steps (see Figure 2). In the first aggregate step the goods flows between production and consumption (PC) zones are modelled based on the results of an input-output type model. These goods flows between P and C are transport chains, which can consist of several modes of transport (e.g. the sequence road-rail-road). These flows are disaggregated to firm-to-firm flows. In the second step (D in ADA), the choice of shipment size and transport chain is modelled at the level of these disaggregate flows (the 'logistics' model). Each change of the mode of transport creates a new origin-destination (OD) relationship. In the third step, the OD relations are aggregated for the individual modes and assignment to the networks. The ADA model has been implemented for Sweden, Norway and Denmark.

The ADA approach has the following key advantages:

- Aggregate models for modal choice assume an optimization at the level of all zone-to-zone flows for a certain commodity category. In reality, such a decision-maker does not exist and the modal split is the outcome of many decisions by individual firms. In the ADA model, these decisions are part of the logistics decisions that are taken at the level of flows between individual firms.
- The choice of shipment size is treated jointly with that on the modes in the transport chain. There are indications from game theory and experimental economics that a joint modelling of these choices is most appropriate (Holguin-Veras et al., 2011).

- The advantage of distinguishing between the PC and the OD level (as in the ADA model) becomes clear when it comes to forecasting. Freight transport depends on economic development in different countries and zones. The issue here is to which zones the freight flows will be linked. Many flows do not go directly from P to C; there can be ports, multimodal terminals and distribution centres in between, and changes of mode or of vehicle type within a mode. This concerns the choice of transport chain, which depends on the total logistics costs (including transport, loading and unloading and inventory costs). Trip-based models use ports and multimodal terminals as origin and destination and therefore link the goods flows to intermediate zones (and their economic growth) instead of to the relevant production and consumption zones. Also the network assignment can be improved if the locations of the terminals used in the transport chain are taken into account. The ADA approach thus leads to an inherently multimodal and intermodal model.

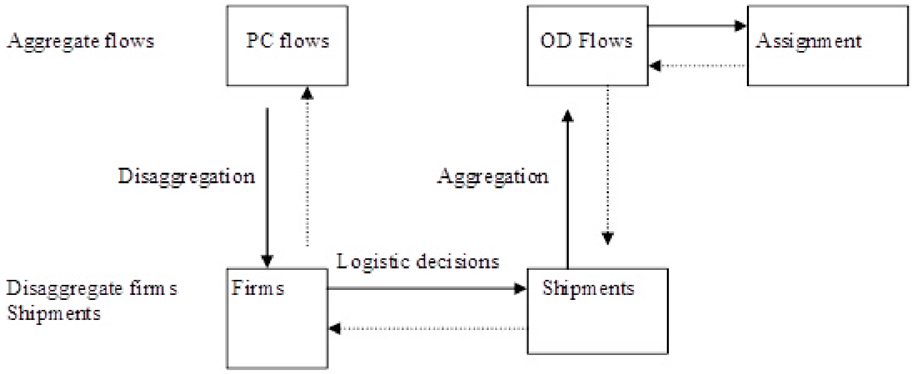

Figure 2. Structure of the ADA model (Source: Ben-Akiva and de Jong, 2013).

The main disadvantage of the ADA approach is that for the econometric estimation of the logistics model for transport chain and shipment size choice, data is required about goods flows at the shipment level (such as the Commodity Flow Surveys (CFS) in the USA or Sweden, or the ECHO survey in France). An alternative that does not require econometric estimation is to implement the logistics model in a deterministic fashion (choosing the lowest logistics cost solution for every firm-to-firm flow). Estimation of the logistics model (as a random utility logit model) within ADA is preferred over a deterministic model, because the latter could lead to unreasonably large sensitivities for transport time and costs changes (Abate et al., 2018). In Austria, such a disaggregate freight transport database is not available.

In discussion between the clients and the consultants of the pilot study, the ADA approach was chosen for the new VMÖ, because its advantages are considered to be very worthwhile. In order to estimate the logistics model, new SP and RP data at the shipment level will be collected as part of the VMÖ development project (see section 6). The sample that will be collected in Austria will be much smaller that the CFS in the USA or Sweden, because such a large database (containing millions of shipments) is not required for the estimation of mode and shipments size choice models.

The new freight transport model will use the NST 2007 commodity classification and have around 500 zones (including the zones abroad). The PC flows will be generated by an input-output based model for the Austrian economy, that distinguishes between economic sectors (ÖNACE classification) and the nine federal states (Bundesländer) in Austria and will use around 250 foreign zones. This requires a considerably smaller effort than developing a new computable spatial equilibrium (SCGE) model but uses more information on the economy (sectoral linkages) than a gravity model. It does require a conversion from a coarser zoning system and another goods classification to the around 500 zones and to NST2007 that will be used in the new freight transport model for Austria.

The following indicative list gives the modes and vehicle types (which will be combined to form transport chains), to be included in the shipment size and transport chain choice model:

Modes:

- Road transport:
  - Light duty vehicles (<3,5 t)
  - Solo lorry
  - Articulated lorry/tractor and trailer
- Rail transport
  - Combined/intermodal rail transport (containerised)
  - Wagon load traffic
  - System train
  - Rolling highway (Rollende Landstraße, RoLa)
- Inland waterway transport (possibly with several vessel types).

The OD matrices that result from the logistics model (after the aggregation step) will be used in a pivot-point fashion, in combination with base matrices (see section 4), and after having added the predicted empty vehicles.

For assignment to the networks, the OD flows from the freight transport model will first be allocated to the finer zoning system of the passenger transport model, and then there will be a joint assignment of passenger and freight traffic.

For the model implementation, the model will be programmed in a scientific programming language, which can communicate with PTV VISUM and Excel and can be operated from the general user-friendly shell (graphical user interface) to be developed specifically for the VMÖ.

4. MODEL CALIBRATION WITH BASE MATRIX AND PIVOT POINT

The transport models uncalibrated synthetic matrices for passenger and freight transport are estimated for each future year S^1 and the base year S^0. The passenger and freight matrices can be added and compared to traffic counts. Usually rather large differences are found when doing this comparison, as the general modelling approach is estimated on relatively small general samples that cannot adequately cover the complex, often local, patterns of transport flows between all origin and destination zones. To be able to take the local characteristics into account and to be able to describe the real traffic patterns in the base year and to predict realistic patterns for future years a calibration of the synthetic model is needed. In the VMÖ, it is not foreseen to implement calibration factors in the demand model as these can affect the sensitivity of the model to changes in costs, travel times and (other) transport policy measures. As an alternative approach, calibrated base matrices B^0 will be generated for passenger cars, different truck types and for public transport. Starting point for the base matrices are Apriori matrices. These Apriori matrices can be a first estimation result of the demand model or can be calculated with a different approach. The calibration itself is the process to find the best fit to all available traffic counts by manipulating the traffic flows between the different zones in a smart way. Matrices B^1 for future years will then be calculated by applying the pivot point method. The best-known form of pivoting, that is also used as the main or default pivoting method here, is multiplicative pivoting (or 'factor pivoting'):

$$B^1 = (S^1/S^0) \cdot B^0$$

The models are only used to give change-factors S^1/S^0, which are applied to the base matrix. These numbers are then all by origin, destination, travel purpose and mode (and possibly also by person type), but subscripts are omitted for simplicity.

In practical applications, the pivoting procedures are more complicated than above. The main reasons for this are:

- Values for B^0, S^0 and/or S^1 may be 0;
- Extreme growth S^1/S^0 (e.g. when between the two years greenfield sites are used to build houses).

In such cases, rules like B^1=0, applying additive growth (S^1-S^0) to the base matrix or B^1=S^1 might be more appropriate. Daly et al. (2005, 2011) developed a method that distinguishes eight different cases, and that has been applied successfully in several countries. It is planned to also apply these eight cases approach in the VMÖ.

For this approach it is necessary that the uncalibrated demand model already fulfils high quality standards including realistic tour-rates per purpose and realistic distance and time-of-day distributions. The local patterns are expressed by the base matrices.

5. NETWORK MODEL AND ASSIGNMENT

The assignment procedures for all modes will be performed in PTV VISUM, so finally the network model must be created in PTV logic. In VMÖ a multi-modal network for all modes of passenger and freight transport will be developed. This will be done for the purpose of an easier handling of the model, to reduce the probability of network errors by manual adaptions and to ensure consistent assumptions for transport supply across all modes.

The network model represents the comprehensive transport system and therefore describes the spatial and temporal structure of transport supply. Since the VMÖ will be zone-based, the spatial refinement of the zoning, the density of the network and the distribution of the connectors must be properly aligned to each other. Given the model requirements and the planned model applications a distinction between the analytical network and the complementary network will be introduced. Reliable model results will be expected for the analytical network. This will be ensured by the complementary network in terms of spatial refinement of route choice and spatial distribution of trip generation/attraction on the subnetwork.

The inner study area of the VMÖ is defined by the federal territory of Austria. Additionally, competing corridors for cross-border trips and cross-border freight transport (incoming, outgoing and transit traffic) must be implemented properly in terms of route choice of international transport. Subsequently the network model will be as fine-grained as necessary for the inner study area and will get coarser with increasing distance to Austria and its economic and urban centres.

The zoning used for demand modelling will be different for passenger and for freight transport. However, for all modes the assignment procedures will be applied on the fine-grained zoning of the passenger model.

In general, the zoning of the passenger model for Austria will be based on the municipal boundaries. Municipalities with approximately more than 8.000 inhabitants and working places and/or large extensions combined with a polycentric structure will be disaggregated. For this procedure the edges of census parishes ("Zählsprengel", about 8.800 administrative units as partial surfaces of municipalities with an average size of 1.000 inhabitants) and grid data on the spatial structure (inhabitants, working places and other attractors) will be considered. Additionally, artificial and natural barriers e.g. transport infrastructure, land use and rivers will be considered. Airports with an appreciable number of passengers as well as Park and Ride facilities will be implemented as autonomous zones.

Outside Austria the zoning will be based on the geocode standard of NUTS 3 to NUTS 1. However, with respect to regular border crossings further refinements close to the Austrian border will be necessary. For this, additional data from Eurostat and national statistical offices will be gathered and harmonized, to create a fluent transition of the zone sizes. Finally, approximately 5.500 zones are expected for Austria and for the foreign countries about 500. The zoning for the freight model will be generated by aggregating zones of the passenger model, which must adhere to pre-defined standards and guidelines.

The rail and road network for Austria will be based on the Graphic Integration Platform (GIP, 2018), which covers fundamental transport supply data for these two transport modes (and, also distinguishing different vehicle types within each mode). The platform is continuously updated by an eGovernment process, whereas each infrastructure manager is responsible for the quality and completeness of the provided data (e.g. ASFINAG, federal states, municipalities, ÖBB-INFRA). Taking the GIP graph as a basis firstly ensures the usage of up-to-date information, which is coordinated within the Austrian administration. Secondly, the standards and the interfaces for future model updates are clearly defined and assessable.

The network of analysis for road transport is defined by the functional road classes 0 to 4 of the GIP graph and additionally covers all roads maintained by the federal states. This determination includes all road classes of international, national and regional relevance as well as connecting roads of municipalities. Most of the relevant characteristics of the links and nodes will also be taken from the GIP graph. These are geometry, number of lanes, speed limits and - except for road freight transport - permitted modes of transport. Driving restriction for lorries, data on average speed based on floating car fleets (FCD), tolling system and maybe gradient information will be added from external sources. Regarding the intersections, it was decided to implement turning restrictions but not to consider capacities and impedances of the nodes. It would exceed the level of detail of a strategic national transport demand model and would cause an inappropriate effort of maintenance for future model updates.

In the preliminary study it was planned to develop the foreign network based on TT3 and refine the areas close to the border based on the GIP and other available sources. At the current stage of the project it is more likely that it will mainly be based on OpenStreetMap since OS is more topical and the use of fewer data sources makes it easier to develop as well as update a consistent and harmonized graph.

PTV VISUM offers the possibility of dividing links with the same properties to link types. Each link belongs to one single link type. In terms of the assignment and the calculation of the skim matrices the most relevant attributes of link types are permitted modes of transport, capacity, free flow speed and the corresponding capacity restraint function; road class, urbanity and gradients have to be considered as well for the strategic model applications and subsequent analysis. This hierarchical structure supports the development of a consistent network model for the base year. It also makes changes in transport supply easier and more transparent in the case of different scenarios. Link types will be deduced based on the given link attributes to make use of these advantages. This process will be worked out jointly with the definition and calibration of the capacity constraint functions, due to their mutual dependence.

Rail infrastructure will be implemented with its track layout, the stops of passenger transport and the freight yards. GIP data will be the basis for ÖBB-INFRA and most private railroads in Austria. For the remaining Austrian private railroad and railway lines abroad TT3 and ETISplus will be used. The level of detail for the characterisation of the rail infrastructure is deduced from the requirement of a relatively accurate calculation of average transport distance and transport time for freight transport. In this way, several additional attributes like the number of tracks, capacity, permitted axle loads, gradient, weight and length limits will be added to the graph.

The graph for inland waterways will entirely be developed based on external sources such as TT3 and/or the graph provided by DLR Clearing House Transport, Germany[3]. For each river section the capacity of ships, the ships´ loading capacity and the average transport time will be the relevant attributes of the final IWW graph.

Freight terminals of all transport carriers will be characterised by their location, their handling capacity and the operated modes of transport.

The whole process of the model development, including quality assurance, will be set up in automated processes as far as reasonable possible. This will be done firstly to reduce the need of manual manipulations and the probability of related errors, but mostly for the purpose of developing reproducible processes for regular model updates. Currently such updates are planned in cycles of two to three years.

As for private road transport, an analytical network and an analytical transport supply will be specified for public transport, too. It will contain the overall rail network and bus lines of inter-regional relevance. Timetable-based assignment will be used for public transport. This approach enables to consider different characteristic values of public transport supply via the utility functions of the demand models including the assignment. Therefore, a more reliable assessment of public transport scenarios (e.g. integrated interval timetable) becomes possible. On the other hand, this advantage requires a significant amount of effort to establish consistent scenarios. Strictly spoken, for each scenario of the high-level infrastructure a comprehensive concept of public transport supply ought to be developed and implemented into the model. Since this is not feasible for a strategic model on national scale, an approximation method will be elaborated and applied. The idea is to combine the skim data of the supplementary feeder network (e.g. transport time, waiting time, number and time of transfers) from the base year's timetable with the scenario-based skims of the network of analysis. This approach ensures that also for scenarios the accessibility of regions aside the network of analysis is as good as for the base year.

The timetable of the base year will be imported via a HAFAS interface for rail, tram, trolley bus and bus service for an effective date in 2018. In general, the stops of public transport will not be modelled in detail. Nevertheless, for big stations the hierarchical PTV VISUM concept of stop, stop area and stop point will be applied to consider transfer time and transfer distance more realistically.

For road transport, the assignment will be performed simultaneously for private car and road freight transport by applying a quasi-dynamic procedure. With this approach, congestion effects can be modelled more realistically than in static models without running into the problem of very long computation times of dynamic assignments. The quasi-dynamic assignment procedure implemented in PTV VISUM only considers the congestion effect for the final step of iteration. However, this restraint can be bypassed by a clever and iterative control of the assignment procedure.

The detailed modelling of freight train composition and rail freight assignment will be performed by ÖBB-INFRA.

[3] https://www.dlr.de/cs/en/desktopdefault.aspx/tabid-699/

This will be done with the passenger rail service as background occupancy and the final matrices of the demand model, using the Network Evaluation Model NEMO[4]. However, rail freight transport will be assigned additionally in PTV-VIUSM. The realistic implementation of the production system of wagonload transport in the assignment process will be one challenging task. Inland waterways and rail freight transport will be assigned by using a static approach.

6. New SP and RP data collection

Data on travel behaviour of persons is available in Austria from the national travel survey 'Österreich Unterwegs' (ÖU), which was carried out in 2013/2014. Also, data on zonal characteristics, networks, traffic count data and speed measurements (floating car data) are available. This is sufficient for the estimation and application of the proposed passenger transport models, with the exception of models for the choice of time period and modes that are not (yet) used on a large scale (car sharing, park and ride). For freight transport, information is available to estimate and apply the input-output model, but not for the estimation of the transport chain and shipment size models. Also the assignment of the passenger and freight flows does require new data sources.

The implication of the above is that new data is required in the following areas:

- Passenger transport: behavioural data on the choice of time period (in combination with mode choice to link it to the models on the ÖU data) and of the use of car sharing and park and ride alternatives.
- Freight transport: data at the level individual shipments on the transport chain and shipment size choice.

To fill these gaps, for passenger transport a stated preference (SP) survey will be carried out on time period and mode choice, car sharing and park and ride. This is an additional database for estimation, on top of ÖU. For freight there will be a combined RP and SP survey, which will be the main database for the estimation of the models for transport chain and shipment size choice. Below we discuss these two surveys.

6.1. The new SP survey for passenger transport

RP data can often not provide reliable information on the variation in travel time and travel cost between time periods. Furthermore, in RP data, the non-chosen alternatives are not explicitly known and travel time and cost are often correlated. Because of these problems, an SP survey has been selected to obtain the required time period choice information.

This SP survey will collect information on actual travel behaviour, which will then form the context for the SP experiments and also provide the reference levels for attribute values. Since the new VMÖ will be a tour-based model, the SP survey and its experiments are also tour-based. In total, up to four SP experiments are carried out in each interview:

- An SP experiment on the choice of the main mode of the tour (1250 interviews).
- An SP experiment on the choice of mode and time period (departure time). This experiment is similar to SP experiments carried out almost twenty years ago in The Netherlands (de Jong et al., 2003) and repeated recently (de Jong et al., 2019). Also, in Flanders, a similar experiment is carried out at the moment to yield data for the estimation of time period choice models for the strategic passenger model for Flanders (the model is described in Verlinden et al., 2015). This experiment will be carried out in 1.000 interviews.
- A mode choice experiment with car sharing (100 interviews).
- A mode choice experiment with park and ride (100 interviews).

6.2. The new RP-SP survey for freight transport

For passenger transport, the key RP data source will be ÖU, but for freight transport, such a data source in missing in Austria. Therefore, a combination of an RP and an SP survey will be carried out to obtain data to estimate the models of shipment size and transport chain. The interviews will take place with shippers and logistics service

[4] https://www.ivembh.de/softwareprodukte/simulation/nemo.html

providers, who usually are the dominant party in these decisions.

The RP part consists of questions on the mode chains used, origins, destinations and commodities transported for five different individual shipments of the interviewed firm. This part is rather similar to a CFS, but the sample size is much smaller: 1500 interviews giving 7500 shipments. This should suffice for the estimation of the models, with a distinction by NST2007 commodity type.

For one of the five shipments, additional information is asked (e.g. transport time and cost, transport time reliability), to get the context and reference levels for the SP experiments.

The SP experiments are carried out to get additional information for disaggregate model estimation, notably choice data where the researcher can control the amount of correlation between attributes such as transport time and cost. There are two SP experiments in this survey:

- A within-mode SP experiment, with two alternatives referring to the same mode and varying in terms of time, cost, reliability and either frequency or probability of damage.
- A mode choice experiment, with labelled alternatives using road, rail and inland waterway and the same attributes as the first experiment (similar to BVU and TNS Infratest, 2014).

For both experiments the target for the total number of successfully concluded experiments is 400.

7. MODEL APPLICATION AND SCENARIOS

7.1. Model application in general

The different components described above will all be integrated into a model that can be used for forecasting the impact of scenarios and policy measures. During the construction of the model it will be necessary to build in some flexibility, because there can be new developments that might have to be incorporated into the application. Also it is important to build the model in such a way that it can easily be updated later, as new data becomes available. This consideration relates to every single parameter value, but also to large data files like current and predicted population. Setting values and import of data files must be possible in the model without complications. The generation of different scenarios as input to the traffic forecasting model and the translation and processing of these scenarios in the traffic model will constitute the first large application of the new national model. This implementation will start directly after the model development is completed, but preparatory work will start earlier.

7.2. Scenarios

Already during the development phase of the traffic model, three scenarios will be designed. The first is the reference scenario (main or principal scenario), which represents business-as-usual conditions: exogenous changes that have a high likelihood, infrastructure projects than have already been decided upon, similar transport costs as now, etc.. It will be calculated for several time horizons between 2013/2014 (when the Austrian mobility survey ÖU took place) and 2050. The model base year is 2018. At the time the new model will be completed, the year 2020 will no longer be a future year. This offers the chance to review the accuracy of the first results and allows an update of the base matrices. In addition to the base year, forecast for 2030, 2040 and 2050 will be provided.

The other two scenarios are meant to reflect developments that are more uncertain, but might have a large impact on mobility and logistics. These alternative scenarios will be created only for the year 2050. They are meant to cover most of the foreseeable range of uncertainty in the model inputs, without assuming really extreme changes.

All scenarios will be developed by involving experts and stakeholder using scientific methods. It is necessary to set reasonable values for general and global influencing factors, like economic growth, and more specialised drivers of passenger and freight transport, such as cost and time by mode and region, that within the same scenario should also be internally consistent.

8. SUMMARY AND CONCLUSIONS

The development of a new national transport model for Austria (VMÖ) has started in in 2017, with a pilot study that yielded a proposed specification for the new model. The actual development of the model, along these lines has begun in April 2019. The new model should produce valid, reliable and stable results for cost-benefit analysis and other assessments and needs to be transparent, and easily managed, adapted and updated.

The proposed disaggregate and tour-based passenger transport model has choice models for tour generation, destination choice, mode choice and time-of-day choice and special routines for representing car-sharing and park and ride. These will be based on existing individual travel diary data, together with new stated preference data.

For freight transport, an aggregate-disaggregate-aggregate approach was selected. This includes input-output modelling for generating the trade flows and a disaggregate model for transport chain and shipment size choice on new stated and revealed preference data at the shipment level.

Both the passenger and freight model will be applied using the pivot point approach. Base matrices for both passengers and freight will be constructed, based to a large extent on count data. For the future years 2030, 2040 and 2050, three scenarios will be developed, including a reference or business-as-usual scenario. There will also be a network model for joint assignment of passenger and freight vehicles to the networks.

The work on the zoning system, the networks and the zonal data is well underway now and the questionnaires for the new SP and RP data collection in passenger and freight transport have been developed and are now used in the field. Also, the first model estimation work (tour formation for tour frequency models for passengers) has started. The plan is to have the model running and the forecasts for the three scenarios ready in the first quarter of 2022.

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