

Generation of a realistic parcel demand for route planning and simulation of parcel delivery traffic in urban and rural regions

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Abstract

Efficient route planning and simulation of parcel delivery traffic require realistic demand generation. This study presents a methodology for generating and spatially distributing parcel demand within an existing passenger transport simulation framework (MATSim). The study evaluates different data sources and spatial distribution methods, comparing results in Berlin and the Lausitz region. Initial findings highlight the limitations of transport network forecast data and demonstrate the effectiveness of population-based demand distribution.

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1. Motivation and research objectives

The aim of this work is to determine a procedure that can be used to generate and spatially distribute the parcel demand for an existing passenger transport scenario in [Multi-Agent Transport Simulation \(MATSim\)](#) ([Horni et al., 2016](#)), so that realistic route planning and simulation can be carried out, e.g. for the evaluation of measures. The aim is to use an existing demand generation tool ([VSP Berlin, n.d.](#)), which will be adapted and finally adapted and ultimately verified as part of this work. The focus is on ensuring that the procedure can be transferred as easily as possible to other cities or scenarios in [MATSim](#) and does not depend on the quality of [Open Street Map \(OSM\)](#) data, for example. The differences between urban and rural regions should also be considered.

The following research question is derived from the objectives: How can parcel demand for route planning and simulation in urban and rural regions can be generated realistically and spatially distributed?

Methodology. The open-source software [MATSim](#) is used for the simulation. [MATSim](#) is mostly used for person transport simulation. With its *freight* extension, simulating freight transport is done ([Zilske et al., 2012](#); [Zilske and Joubert, 2016](#); [Martins-Turner et al., 2020](#); [Ewert et al., 2024](#)) as well as small-scale commercial transport ([Ewert and Nagel, 2024](#)). The route planning required for the simulation of freight traffic is carried out by the open-source toolkit [jsprit](#) ([jsprit, 2025](#)). Specific information regarding depot locations and fleet data must be determined as part of a literature research. For the sake of simplicity, deliveries should only be made by one service provider.

Two different approaches will be used to *determine the demand* per area under investigation: i) The packages per person parameter ([BIEK and KE-CONSULT, 2023](#); [Pitney Bowes, 2023](#)), ii) the Germany-wide data from the 2030 transport network forecast ([BVU et al., 2014](#)). The existing tool is extended to consider the regional differences and the population structure, including age.

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In the next step different approaches are explored for the *spatial distribution* of the parcel demand: a) per link of the road network without consideration of persons' home location, b) proportional to the person's home location (from an existing person transport scenario) c) as b), including the consideration of persons attributes (age).

If population data is to be included in the demand distribution, the "plans.xml" or "population.xml" files can be used by the MATSim passenger transport scenarios. These files describe the transportation demand of the agents and contain a list of people. Each person has at least one daily schedule. The files also specify the agent's place of residence and, if applicable, their age and gender (Horni et al., 2016). Since the population files in MATSim generally do not completely represent the population but only a representative proportion of the population, an "up-sampling" (up-scaling) must take place so that a 100 % simulation can be carried out.

Application. The approaches mentioned above are applied to two different regions: 1) Berlin, the largest city and capital of Germany, as use-case for an urban area; 2) The Lausitz region in Germany as a rural area.

2. Exemplary results

Based on the different data sources (see Section 1), the calculated amount of parcels per person per day varies significantly. The primary results show that the approach of using the Germany-wide data from the 2030 transport network forecast has some limitations for the generation of parcel demand. The reason is that the values are given as an annual demand per year in tons per district. This can be seen in the comparison of the values with the number of inhabitants in the districts, e.g. in Berlin this leads to a demand of around 0.1 tons per person per year, and in a rural area like the district Oberspreewald-Lausitz, the demand is around 0.5 tons per person per year. An explanation for this could be that in one district a hub can be located, which serves the whole district, while in another district the parcels are delivered by the neighboring district. Because the Germany-wide data only contains demand with vehicles with a weight of more than 3.5 tons, the demand in the districts is not distributed homogeneously. That's why the initial results indicate that the approach of using the packages per person parameter is more suitable for the generation of parcel demand.

The *spatial distribution* of demand within a study area based solely on the links available in the network has not proven to be meaningful. In urban areas such as Berlin, the demand was concentrated in intersection areas Figure 1a, while in rural regions, rural roads without proximity to residential areas were provided with demand Figure 1c. The distribution to the agents' places of residence therefore represents a significantly better variant Figures 1b and 1d.

The results of the first simulations show that the pipeline is working and that all parcels are being delivered by tours that are created by the jsprit toolkit. For a selected zip-code area in Berlin ten vehicles are used to deliver the parcels. Per tour, the vehicles deliver around 203 parcels each and the tour length is between 17 and 20 km. Compared to the results for the rural area with around 70 km per tour, the urban area has a higher density of parcels and shorter distances between the delivery points.

3. Discussion and Outlook

One main challenge beyond the generation of the parcel demand by the customers / consumers is everything related to the depots / hubs. Available (open) data sources vary in quality regarding the number, location, size of the depots, as well as their delivery area. Data source with some parameters like parcels per person per time, that can be used either as input or for validation face the challenge, that they did not only differ between urban and rural areas. Even within each of these areas, they can vary significantly. Moreover, there is fewer data available for rural areas, compared to urban areas, like Berlin. Using the Germany-wide data from transport network forecast leaks in accuracy, because they did not contain goods transport with smaller vehicles, thus there are transport cells with few demands, because the parcels are transported via the depot in the neighboring cell.

The selected approach is planned to be applied to other locations. In addition, the tool should be expanded to include demand locations in purely industrial and commercial areas. For this purpose, solutions must be developed for integrating company locations into the tool in addition to residential locations. All this should be done, while ensuring the transferability of the methods used.

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