Long- and short-term effects of transport planning and logistics measures on urban freight transport

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Abstract. A transport modelling approach is shown, which feeds back an aggregated System Dynamics model with a disaggregated microscopic transport simulation. This approach enables to carry out long-term forecasts for strategic transport planning considering the short-term effects of behaviour and decisions of transport users at infrastructural level. In the framework of the case example CEP market in urban agglomerations, the operability of this modelling approach is verified.

1 Problem definition and research objectives

The transport system with its components transport demand and supply is influenced by social, economic, ecological and technical systems. This overall system is very dynamic. It changes continuously in the course of time. The long-term structural changes of social and economic systems and the technical progress have short-term effects on the behaviour and decisions of transport users at the infrastructural level and vice versa.

For this reason, it is necessary to develop a transport modelling approach which considers this feedback between the two different time horizons at macroscopic and microscopic level.

Hence, the overarching objective is to develop a modelling approach for the strategic transport planning, which links a macroscopic extrapolation with a microscopic transport simulation. By extrapolations at macroscopic level, long-term effects of the overall system on transport can be observed. By a transport simulation at microscopic level, the behaviour and decisions of transport users at infrastructural level can be considered and examined in detail. By this approach, long-term forecasts can be carried out, which consider the spatial context. [1,2]

2 Modelling approach

We develop a feedback approach, which links a System Dynamics (SD) model with a microscopic, agent-based transport simulation (MTS) to analyse the transport system in the course of time at an aggregated level and in detail at a disaggregated level. The two models are mutually adjusted by the feedback loop (see Figure 1). By SD, forecasts for long-term periods are carried out, which predicts the development of the observed system in the course of time [3]. By MTS, short-term simulations of agents' mobility behaviour and decisions at infrastructural level for a typical day are examined. [1] In the framework of this study, the Multi-Agent Transport Simulation (MATSim) developed by Balmer et al. [4] and the integrated logistics module developed by Schröder et al. [5] are used as reference models for a MTS.

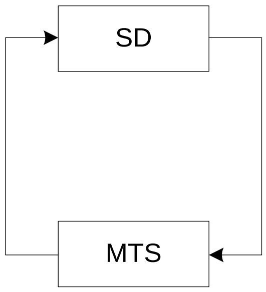

Figure 1. Feedback approach developed [1,2].

3 Case example

Within a case example, this approach is tested for the courier, express and parcel (CEP) market in urban agglomerations. In this way, the CEP service providers as suppliers as well as the private households and economic stakeholders as clients of CEP service providers are illustrated. By using scenarios, we could test the implementation of logistics and transport planning measures to assess its ecological and economic effects on CEP transports (e.g. package stations, city tolls, and e-mobility). By this approach, long-term effects at aggregated level and impacts of the implemented measures on the transport system at infrastructural level are examined.

3.1 SD model structure

First, the internal structure of the SD model developed is shown in Figure 2. This model is subdivided in eight modules, which are dependent on each other. The detailed description and the mathematical formalisation of this model are presented in [6,7]. This model has been comprehensively calibrated and validated.

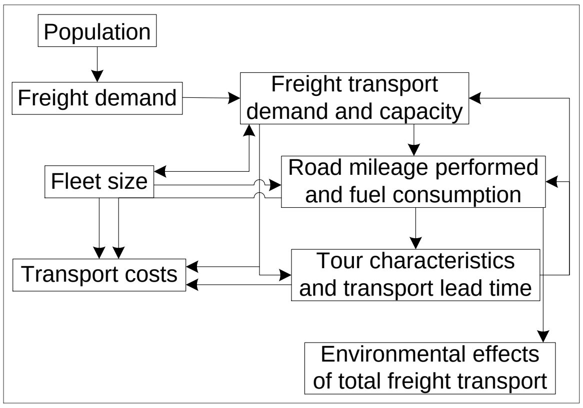

Figure 2. Overarching structure of the SD model developed [6,7].

3.2 Modelling and simulation procedure of MATSim

In the following, the modelling and simulation procedure of the MTS used, in this case MATSim and Jsprit, is presented in Figure 3.

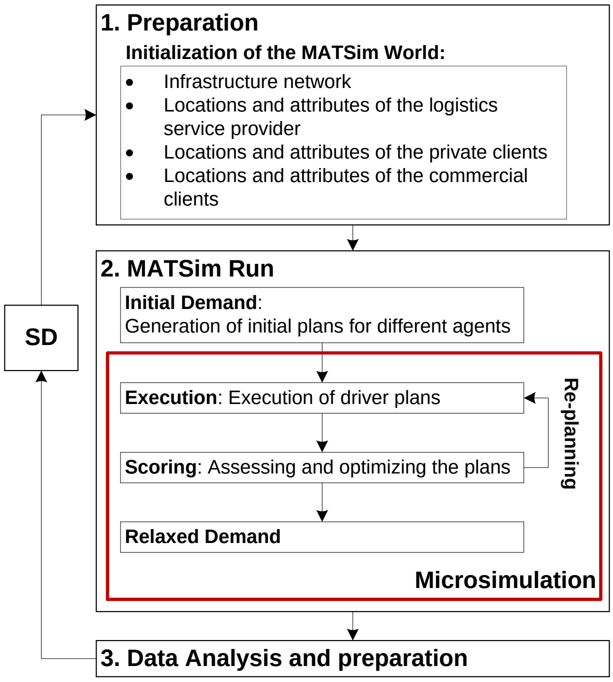

Figure 3. Modelling and simulation procedure of MATSim (Own diagram based on [4,5]).

In the first step, it is necessary to prepare the synthetic world of MATSim. For this reason, a secondary data collection is carried out to build up this synthetic world. For the case study, locations of the CEP service providers as well as private and commercial clients are collected and georeferenced. The attributes of these stakeholders in the system are adjusted in advanced by aggregated data provided by SD per time step or are externally determined. Based on the initial synthetic world, the initial plans of the CEP drivers are generated. Afterwards, the microsimulation is carried out. Finally, the results of MATSim run can be analysed in detail and prepared for the transfer to the SD model. [1,2,8]

3.3 Feedback approach

The initial world of MTS is adjusted by the output of the SD model runs.

- Population
- Private and commercial freight demand
- Transport costs
  - Variable costs per km
  - Fixed costs per truck
  - Time-dependent costs per hour
- Fuel consumption per km
- Conversion factors of emissions

- Number of trucks

The resulting spatial affected parameters generated by MTS are used to adapt the SD model.

- Transport distance per tour
- Deliveries per tour
- Average stop time
- Drop factor B2B and B2C/C2C
- Average velocity
- Number of transports

4 Scenario analyses

In the following, selected results of determined scenarios are examined. Time horizon for simulations is 2010 to 2030. Time step is 1 year. The feedback approach is parametrised with synthetic data in this case.

First, the scenarios observed have to be defined [1].

- Base scenario (B): without system regulation
- Scenario 1 (S1): Implementing package stations in the system; 23 % of private clients use this service
- Scenario 2 (S2): Implementing package stations in the system; 100 % of private clients use this service

In Figure 4 the results of the scenarios are shown, which illustrate the development in the course of time of transport costs of the CEP service providers. Scenario B shows that without a system regulation the transport costs are higher than in S1 and S2. Furthermore, the adjusted values per time step by the MTS are presented in Figure 4.

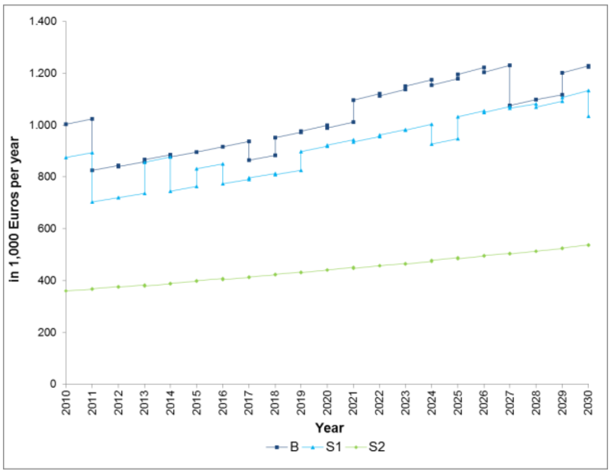

Figure 4. Scenario analyses focussing on transport costs.

Figure 5 shows the percentage deviation of S1 and S2 from the base run. The transport costs in S1 are in average 1-20 % lower than in B. S2 illustrates that 50-60 % of transport costs could be reduced per year in comparison to B if service of package stations would be used by all private clients.

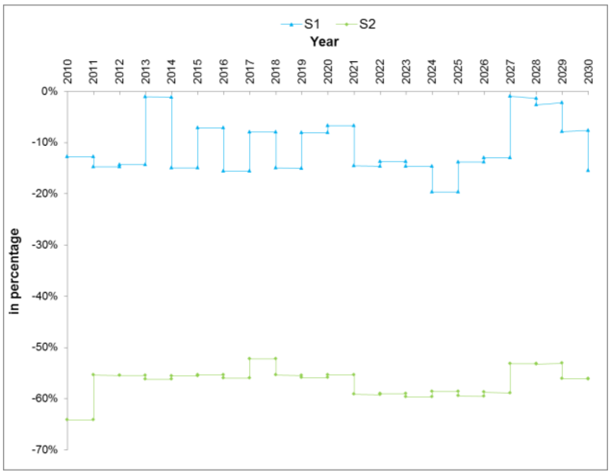

Figure 5. Percentage deviation of the scenarios 1 and 2 from the base run.

5 Conclusions

In this contribution, a modelling approach is shown, which feeds back an aggregated System Dynamics model with a disaggregated microscopic transport simulation. This approach enables to carry out long- and short-term forecasts for assessing the development of a transport system in the course of time and in detail at infrastructural level. In the framework of the case example CEP market in urban agglomerations, the operability of this modelling approach is verified.

Acknowledgements

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