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Effects of truck guiding networks on the sustainability of urban freight transport

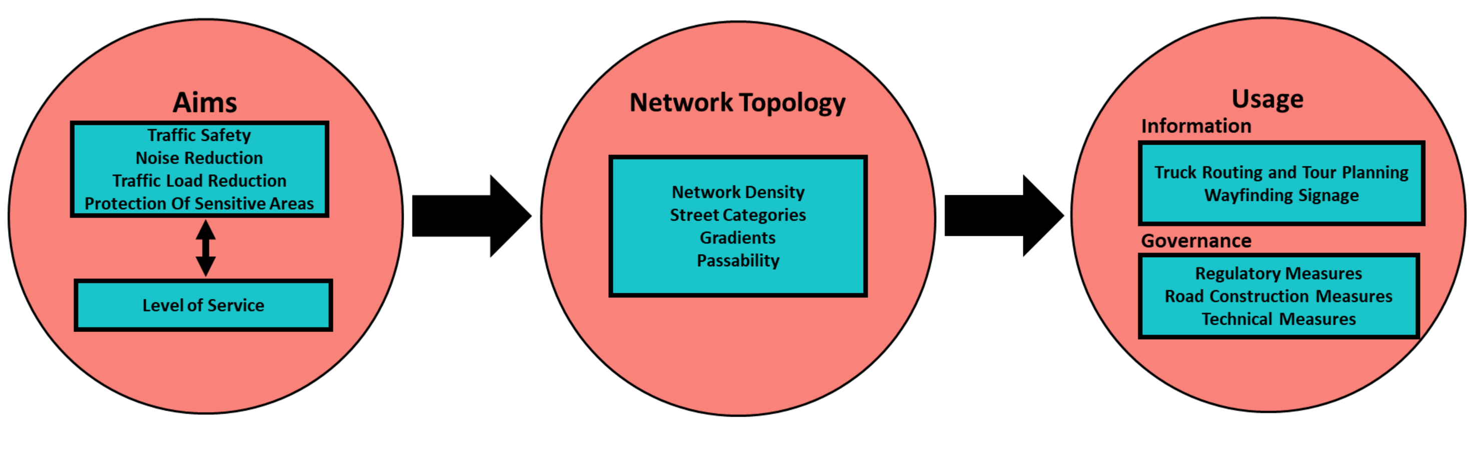
Aim

Due to the larger vehicle dimensions and higher specific noise and air emissions the efficient routing of freight traffic is of particular importance, especially in urban areas[1]. In order to reduce the environmental impact of truck traffic, separate truck guiding networks exist in some municipalities. The designation of truck guidance networks is based on different criteria depending on the municipality resulting in different network designs[2]. The aim is to evaluate existing guiding networks with regard to their network topology and to identify the effects and conflicting goals regarding mileage, noise and CO_2/NO_x emission reduction as well as getting insights on optimal truck guiding networks in urban areas.

Truck Guiding Networks & Approach

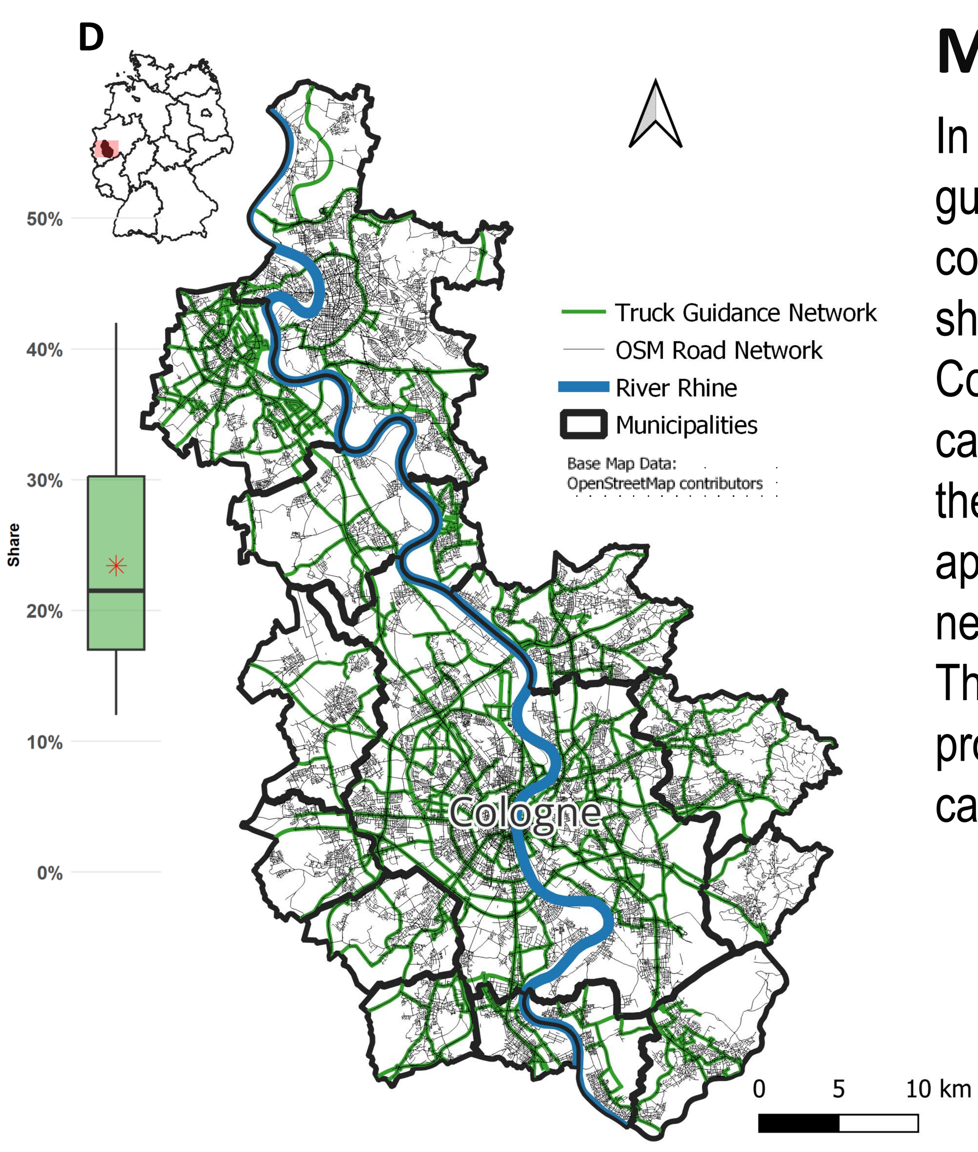
Existing truck guiding networks are mostly based on political decisions or as measures in noise action or clean air plans. These networks can be used for digital maps, routing service and tour planning of logistic providers and carriers as well as a strategic planning tool for municipalities to develop target oriented governance measures.

The common feature of these truck routing concepts is that they aim to reduce the environment impact of truck traffic or individual aspects of this target corridor. This results in different network structures as well as approaches to the designation of truck networks.



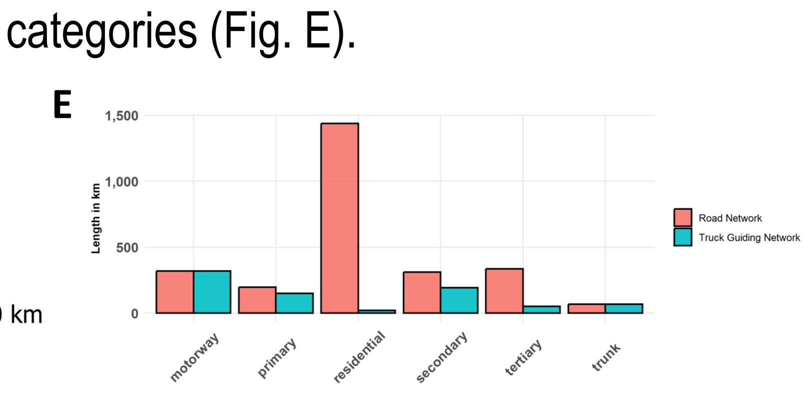
Due to the different embedment of the networks, different network typologies and thus interactions between possible target corridors of the networks exist.

In this context, the designation and optimization of truck networks requires an iterative procedure in which, through a step-by-step reduction of the overall network with an integrated impact analysis on the target variables (e.g., emissions, mileage, protection of sensitive areas), a balance can be achieved between environment aspects and the practical requirements of logistic providers in terms of network density and directness.



Model Region Cologne

In order to map the impact of truck guiding networks, the Cologne region is considered as a first example. Fig. D shows the truck guiding networks of Cologne and the surrounding cities. It can be seen that the network density of the guiding networks ranges from approx. 12 % to over 40 % of the network accessible to motorized traffic. The density of the network is proportionally varying on different road categories (Fig. E).



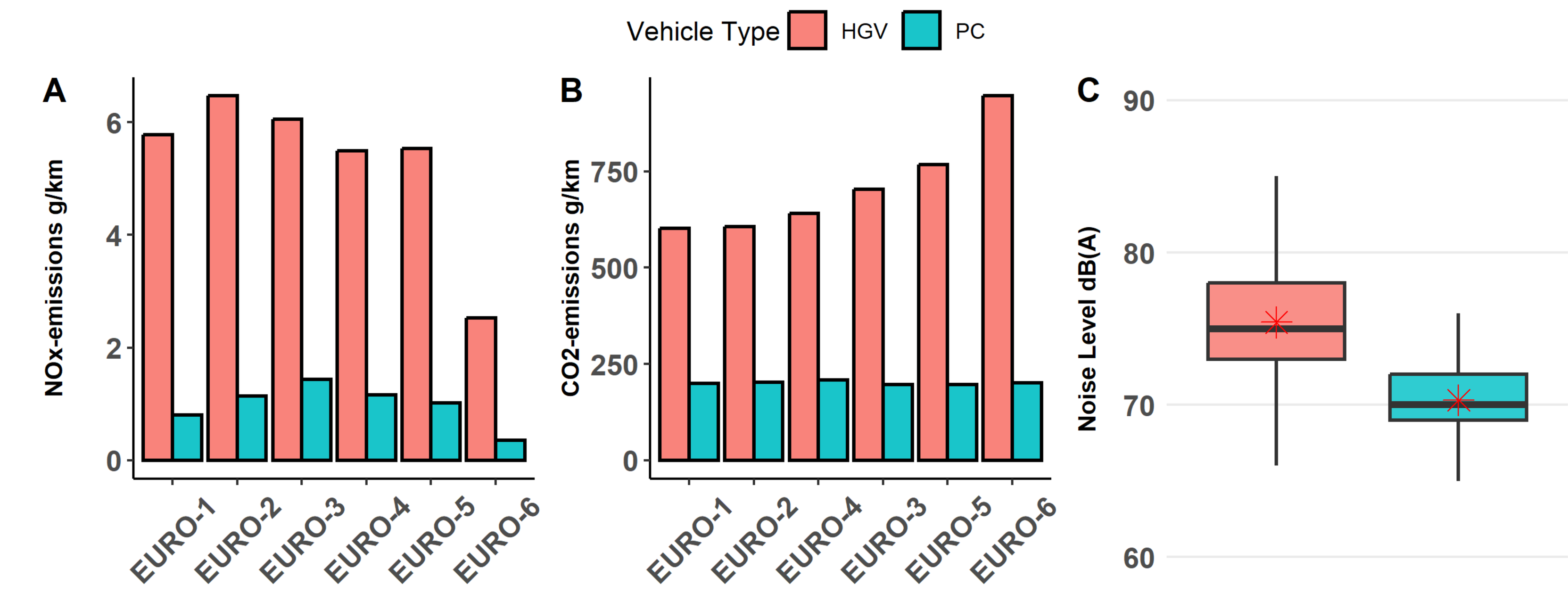
Future Work

In the further course of the work, the network model is enriched with more environmental parameters. In an iterative procedure, interactions between different optimization parameters are identified and optimal network topologies with regard to road categories, network density and vehicle-side hierarchy as well as their effect on the optimization parameters are determined.

Environmental Impact of Goods Vehicles

Goods vehicles (with a payload of more than 3.5 t) account for 7% of the mileage of cars and trucks in urban areas in germany[3]. Nevertheless due to the high specific vehicle emissions significant shares of the total emissions are accounted for by freight transport. While nitrogen-oxide (NO_x) emissions of HGVs are decreasing with newer emission standards, even EURO-6 NO_x emissions are approx. 7 times higher than the NO_x emissions of EURO-6 diesel passenger cars (Fig. A). CO_2 emissions of HGVs are increasing and approx. factor 5 higher comparing EURO-6 emission standards (Fig. B).[4]

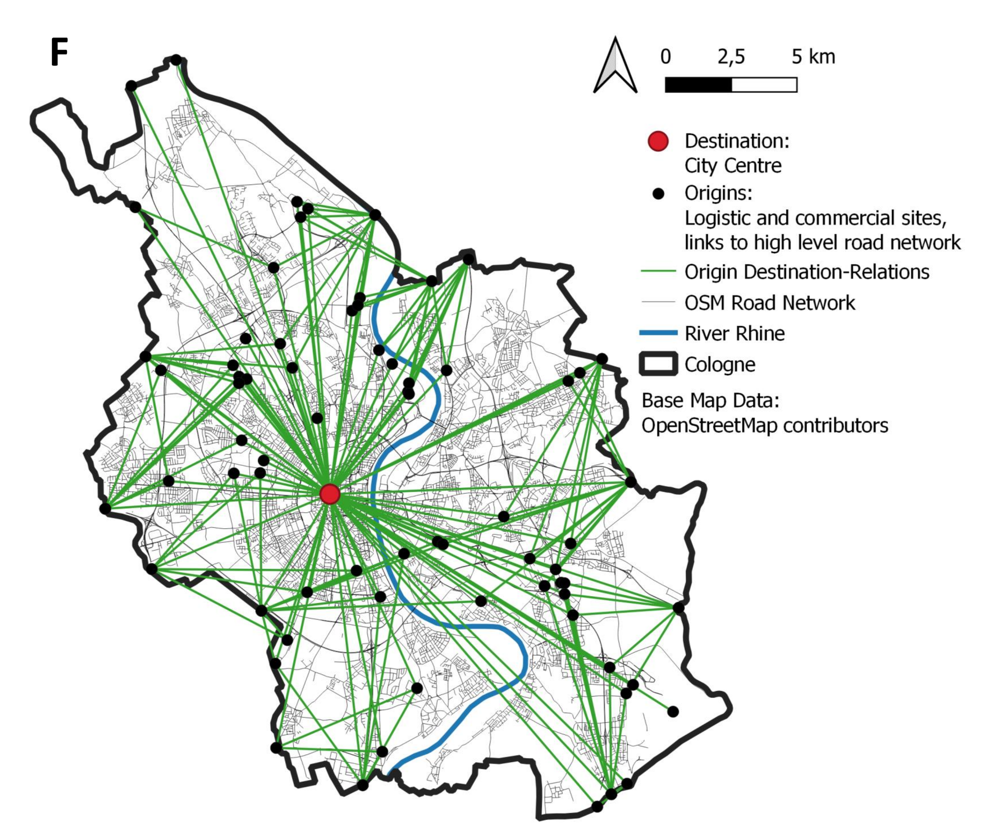
Noise limits and driving noises are significantly higher for HGV than for passenger cars (Fig. C). For example, a 33 t truck may truck may be twice as noisy as a standard passenger car.[5]



Modelling & First Results

In order to be able to evaluate the effect of the truck guiding network, a first model for the city of Cologne was set up. In the model, the relevant source-destination relationships of freight transports to the city center were mapped. Then truck routes have been calculated using OSM street network parametrized with truck restrictions, i. e. weight and height limits. Routing is then performed with and without using the truck guiding network. As metrics for the effect of the truck guiding network, mileage, CO_2 emissions as well as the load on the road network per road category were used in a first approach. The modeling steps and results are shown below.

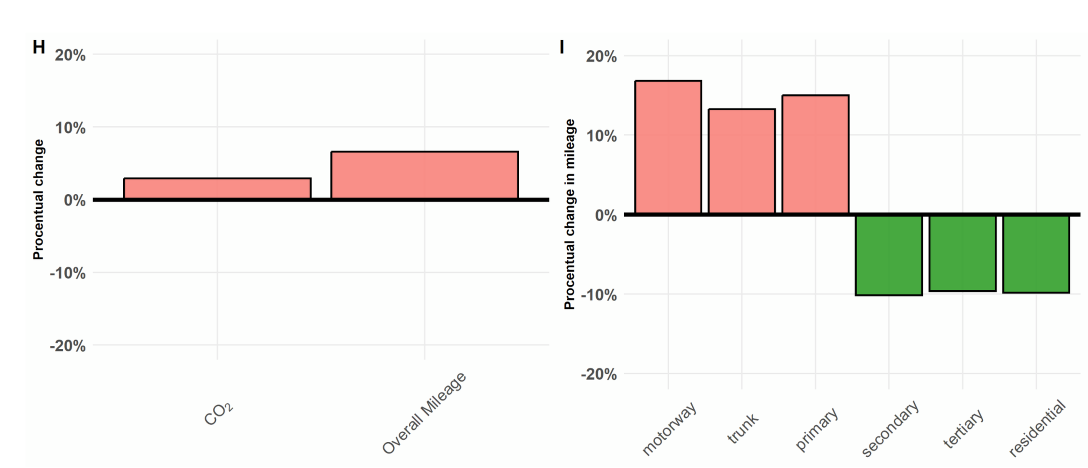
1. Creation of origin-destination matrix based on freight surveys from 2018 – 2022[6] that include information on freight generation and freight trip generation in several inner city areas, as well as on land uses and logistic destinations.



2. Routing based on routing model using OSM-network parameterized with truck access restrictions, road gradients, noise and emission measeunts

3. Evaluation of the effects of truck guiding networks regarding emissions, mileage and network usage.

Fig. H shows a increase in mileage due to the bundling of the truck traffic caused by the truck guiding network. Consequently CO_2 emissions also rise. Since the emissions were calculated based on traffic flow on the different road categories[7], the increase in CO_2 emissions is significantly lower, as the superordinate road network is increasingly used (Fig. I).



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[1] Browne, Michael; Allen, Julian; Nemoto, Toshinori; Patier, Daniele; Visser, Johan (2012): Reducing Social and Environmental Impacts of Urban Freight Transport: A Review of Some Major Cities. In Procedia - Social and Behavioral Sciences 39, pp. 19–33. DOI: 10.1016/j.sbspro.2012.03.088.

[2] Leerkamp, Bert; Luczak, Olivia (2012): Lkw-Führung als Bestandteil der Luftreinhalteplanung. In Straßenverkehrstechnik (4/2012), pp. 226–231.

[3] Agora Verkehrswende (2020): Liefern ohne Lasten:
Wie Kommunen und Logistikwirtschaft den städtischen Güterverkehr zukunftsfähig gestalten können

[4] Federal Office for the Environment; German Environment Agency; French Agency for Ecological Transition; Trafikverket; Norwegian Environment Agency (Eds.) (2019): HBEFA 4.1 Development Report. infras; Institut für Energue- und Umweltforschung Heidelberg; Forschungsgesellschaft für Verbrennungskraftmaschinen und Thermodynamik mbH. Bern.

[5] Kraftfahrt-Bundesamt (2022): Bestand im Zentralen Fahrzeugregister 2020 (Off-Site, Variante S)

[6] Goebe, Claus; Holthaus, Tim; Thiemermann, Andre; Mayregger, Patrick (2019): Survey of freight traffic in Cologne, Düsseldorf and Wuppertal. unpublished.

[7] Federal Office for the Environment; German Environment Agency; French Agency for Ecological Transition; Trafikverket; Norwegian Environment Agency (Eds.) (2019): HBEFA 4.1 Development Report. infras; Institut für Energue- und Umweltforschung Heidelberg; Forschungsgesellschaft für Verbrennungskraftmaschinen und Thermodynamik mbH. Bern.

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