

## **ELISA – Initial Analyses of Impacts of the eHighway System on Traffic Flow**

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### **Summary**

In the context of statutory emission reduction targets, the equipment of motorways with electrical overhead contact lines (eHighway) is tested in the German Federal State of Hesse in the project ELISA. Besides gaining experience with the electric infrastructure and monitoring the handling of eHighway trucks in forwarding companies, it is a major goal of ELISA to analyse the integration of this new infrastructure into real-live road and traffic operations. A major focus will be on traffic flow and driving behaviour analysis. Various road user groups will be considered with their specific reactions on the eHighway system. Impacts of changes in driving behaviour on regular traffic flow will be analysed, but also changes which result from the eHighway system during road maintenance services and in incident situations. This contribution presents the research methodology and also some initial results from preliminary studies. Finally, some hypotheses on expected traffic flow impacts of the eHighway system are exemplified as an outlook on further investigations.

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### **1 Research Questions**

Road freight transport, especially with heavy commercial vehicles as a necessary enabler for economic activities, is essential for most economies but simultaneously causing a large proportion of the greenhouse gas emissions and other pollutants accountable to the freight transport sector around the globe. According to a study by the Organization for Economic Co-operation and Development (OECD), the International Transport Forum issued a forecast for the development of global freight transport which predicts an approximately fourfold increase in freight traffic (+ 384%) from 6.4 bn tkm in 2010 to 30.9 bn tkm in 2050 [1]. Assuming that trucks equipped with diesel engines still account for the vast majority of commercial vehicles by then, the increase in traffic would be accompanied by an increase in CO<sub>2</sub> emissions of around 300% [1]. Due to the high and growing contribution of heavy commercial vehicles to greenhouse gas emissions and even noteworthy shifts of freight traffic to rail, a significant potential for enhancement in the road freight transport sector was identified [2]. Due to the limitation of the range of battery-electric powered heavy commercial vehicles, only comparatively few measures could be implemented so far to improve the situation for regional and long-distance freight traffic. For the near future, the energy supply of vehicles by an overhead contact line on motorways seems to be a promising alternative [3].

To open up this alternative, the German Federal Ministry for the Environment, Nature Conservation, Building and Nuclear Safety (BMU) promoted the development of the eHighway system. Recommendations, conditions and design guidelines derived from the preceding projects ENUBA I [4] and ENUBA II [5] laid the foundation for field trials concerning the eHighway system on public roads in Germany. For this purpose, the BMU decided to support three field trials. One of them is the project ELISA in the German Federal State of Hesse on the motorway A5 between Frankfurt am Main and Darmstadt where the eHighway infrastructure was built up in 2018.

ELISA aims to evaluate the eHighway system implemented in a realistic road and traffic operation environment using economic, technical, ecological as well as legal criteria. Besides gaining experience with the electric infrastructure and monitoring the handling of eHighway trucks in forwarding companies, it is a major goal of ELISA to analyse the integration of this new infrastructure into real-live road and traffic operations. A major focus will be on traffic flow and driving behaviour analysis. Various road user groups will be considered with their specific reactions on the eHighway system. Impacts of changes in driving behaviour on regular traffic flow will be analysed, but also changes which result from the eHighway system during road maintenance services and in incident situations.

## 2 Methodology

As a first step, ELISA developed a fundamental evaluation concept concerning aspects of traffic engineering, economic, legal and ecological aspects on the one hand and the respective actor-specific acceptance of the eHighway system on the other hand [6]. The comprehensive data collection will be enabled by a permanent, automated recording of traffic, vehicle, infrastructure and environmental data during the ELISA field trial. The analysis of collected data will allow accurate conclusions for the evaluation criteria, e.g. regarding the impacts of the eHighway system on traffic flow in its supposed operational environment. Subsequently, comprehensive datasets from different sources were collected to evaluate traffic flow conditions before the eHighway system was established, to compare it with the traffic situation during and after the eHighway construction. A preliminary analysis of the traffic flow during the eHighway construction was conducted, already. Macroscopic level of service calculations are conducted based on the German Highway Capacity Manual HBS 2015 [7]. To assess possible changes in specific driving behaviour caused by the eHighway, an initial microscopic simulation model was set up based on the current traffic situation. Further detailed traffic flow analysis will be done in the ELISA project during the eHighway operation from 2019 to 2022.

As a next step, environmental data and specific data on road user behaviour have to be merged with the traffic flow data in order to determine interdependencies between those aspects. Before doing so, the main focus is obtaining data on the specific driving behaviour of different road user groups under various environmental conditions as well as according to their specific acceptance of the eHighway system. As data on acceptance and driving behaviour of specific road user groups cannot be captured from the automated data recording system, other survey methods need to be applied, such as interviews or video analysis. To prepare for such surveys, potential impacts of the eHighway system on acceptance and driving behaviour of specific road user groups were determined considering traffic flow under regular operation, in case of road maintenance services and in case of different types of incidents.

Based on that, several hypotheses were formulated including general aspects of driving behaviour, the legibility of the traffic signs and the eHighway-specific driving behaviour during an overtaking, lane change or while allowing other road users to merge when they enter the highway. These hypotheses shall be proved during the ELISA field trial by further analysis of data captured from infrastructure, vehicles, interviews, video analysis and advanced microscopic traffic simulation.

## 3 Results

The main result of the first step was the development of the ELISA **evaluation concept**, presented at the 2<sup>nd</sup> Electric Road Systems Conference in 2018 [6] and adapted to new findings gained in cooperation with the ELISA project partners and other institutions involved in eHighway research.

As an example for the **macroscopic level of service calculations**, students did an initial analysis to estimate the impacts of winter maintenance service in case of an iced catenary. They used the method of the German Highway Capacity Manual HBS 2015 [7] and merged it with the method by Engelmann [8]. Of course, the climatic winter conditions in Germany are mild and ice on the catenary might not occur that often. Figure 1 shows that under such icy condition, the de-icing vehicles would certainly affect the occupancy rate on the motorway and diminish the quality of traffic flow. But the calculations based on

average traffic volumes for a typical working day also prove that the impact is reasonable and does not lead to congestion.

In a further step, to estimate the changes in specific driving behaviour due to the eHighway and their effects on traffic flow, an **initial microscopic simulation model** (figure 2) was set up based on the current traffic situation in the corresponding section of the motorway A5. For model calibration, several investigations were made and – since the eHighway was not in operation yet – some assumptions were needed.

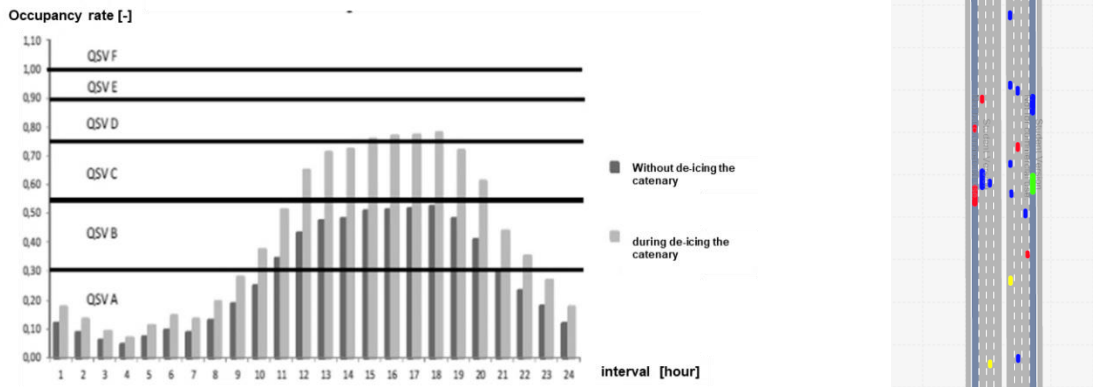


Figure 1: Occupancy Rate (cross-section) with and without De-icing Figure 2: Initial Simulation Model

To gather data on the acceptance and specific driving behaviour of road user groups various effects on the driving behaviour were addressed by surveys. A **pre-test for a face-to-face interview** was conducted on the A5 service area Gräfenhausen with 65 respondents and some interesting results:

- Most of the car drivers would not change their driving behaviour due to the eHighway system. 96 % of all stated that they will use the right lane in the same manner they did before.
- Even though 96 % of the respondents stated to feel insecure driving under the overhead contact lines, resulting changes in driving behaviour were largely negated by all of them. This is a quite interesting first finding, because driving behaviour and safety perception are usually linked closely.
- Regarding the legibility of the traffic signs, 13 % of the car drivers stated that they felt affected negatively. Whether this is due to the contact wires or due to cross beams was not queried, so far.

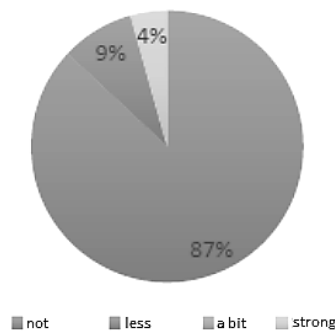


Figure 3: Stated Disturbance in Reading Traffic Signs [65 respondents]

Based on gained results, first **hypotheses on eHighway-specific driving behaviour** were formulated in terms of traffic flow during regular operation, during road maintenance services as well as in incident situations. Various road user groups were considered with their specific reactions on the eHighway system. Table 1 gives a brief impression by some example hypotheses which have to be proven in the course of the ELISA field trial by further analysis of data captured from infrastructure, vehicles, interviews, video analysis and advanced microscopic traffic simulation.

Table 1: Example Hypotheses on eHighway-specific Driving Behaviour

Car Drivers	Truck Drivers
During regular operation car drivers will change the lane in the same manner so that other vehicles can tailgate on driveways.	During regular operation eTruck drivers will not change the lane in the same manner so that other vehicles may not be able to tailgate on driveways.
The moment road users perceive the signage for the first time remains unchanged.	The moment road users perceive the signage for the first time remains unchanged.
The overtaking behaviour of car drivers will not change significantly.	eTruck drivers will not overtake other trucks so that they can remain under the overhead contact line.
The distance behaviour of car drivers will not change significantly.	The distance behaviour of truck drivers will increase.

The presentation will cover more details on the simulation model, the interview survey as well as other results, which are fundamental for further hypotheses and for an **extended traffic flow simulation model** considering all aspects of environment as well as acceptance.

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