

3rd Electric Road Systems Conference 2019
Frankfurt am Main, Germany, 7th to 8th of May 2019

Verification of the ELISA eHighway Evaluation Concept

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Summary

One of the recent technologies to overcome environmental issues brought along by road freight transport is deploying an electric road system with overhead wires on motorways, called eHighway. Within this scope, three projects – including the project ELISA – are launched in Germany to build and operate test tracks and to evaluate the overall eHighway system. In ELISA, the construction of the first eHighway test track between Frankfurt am Main and Darmstadt was completed in late 2018, and the start of regular operation is scheduled for the second quarter of 2019. During the funding application and the first phase of the ELISA project, a comprehensive evaluation concept for the eHighway system was developed. The main research question addressed by this contribution is to verify that the proposed evaluation concept can be applied with available datasets. For that purpose, a preliminary analysis of available data needs to be conducted for each item of the evaluation concept. The data analysis process is checked for feasibility and efficiency, and the results are checked for plausibility. This contribution demonstrates the general methodology of this verification process by using the example of impacts on traffic flow resulting from eHighway construction works.

1 Research Question

Road freight transport is having significant advantages compared with other modes like railways and waterways in terms of flexibility and accessibility. According to the recent European Commission report, road transport carries three-quarters of the goods in the EU, and this ratio has an increasing trend by years [1]. On the other hand, road freight transport significantly contributes to CO₂ emissions and air pollution, in some situations even reaching up to a critical level for human health. Therefore, new regulations and policies are released by the European Commission to reduce emission values of heavy vehicles running on fossil fuel. Within this scope, European countries are under pressure to implement new technologies to reduce greenhouse gas emissions from the transport sector in accordance with the 2015 Paris Agreement.

One of the recent technologies to overcome environmental issues for road freight transport is the electric road freight transport system with overhead wires on motorways, called eHighway. This system offers both, renewable energy consumption and flexible operation ability for freight transport. In this respect, three eHighway implementation projects are supported by The Federal Ministry for the Environment, Nature Conservation and Nuclear Safety (BMU). One of them is the project ELISA in the German Federal State of Hesse to build and operate a test track and to evaluate the overall eHighway system. The construction of the 5 km length test track (both directions) on the motorway A5 between Frankfurt am Main and Darmstadt was completed by the end of 2018. The ELISA eHighway test track is ready for operations starting in April 2019.

During the funding application and the first phase of the ELISA project, the evaluation concept for the eHighway operation was developed by the project team, based on comprehensive data collection [2]. That comprehensive evaluation concept covers engineering, ecological and economic criteria, and it is related to numerous research questions which will be answered in the course of the ELISA project.

The main research question addressed by this contribution is to verify that the proposed eHighway evaluation concept can be applied with available datasets. For that purpose, a preliminary analysis of available data needs to be conducted for each item of the evaluation concept. The data analysis process is checked for feasibility and efficiency, and the results are checked for plausibility. This contribution demonstrates the general methodology of this verification process by using the example of impacts on traffic flow resulting from eHighway construction works.

2 Methodology

The verification process for the ELISA eHighway evaluation concept is developed for each measurement within the concept, depending on the availability of the data. Datasets from different sources, such as traffic data, vehicle data, traffic flow detector data, environmental data, accident data and incident data, are organized for further analysis including data management, data clean-up and data merging processes. Figure 1 shows the general algorithm for a measurement extracted from the evaluation concept charts [2].

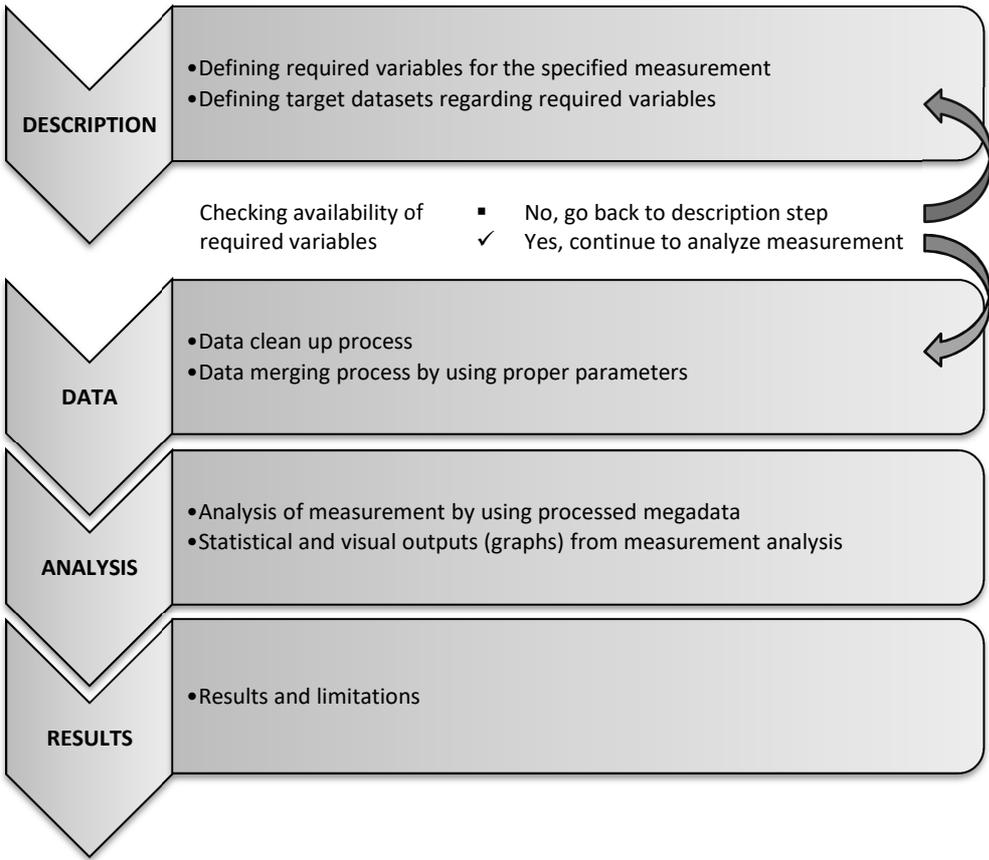


Figure 1: General Step-by-Step Verification Algorithm for a Measurement

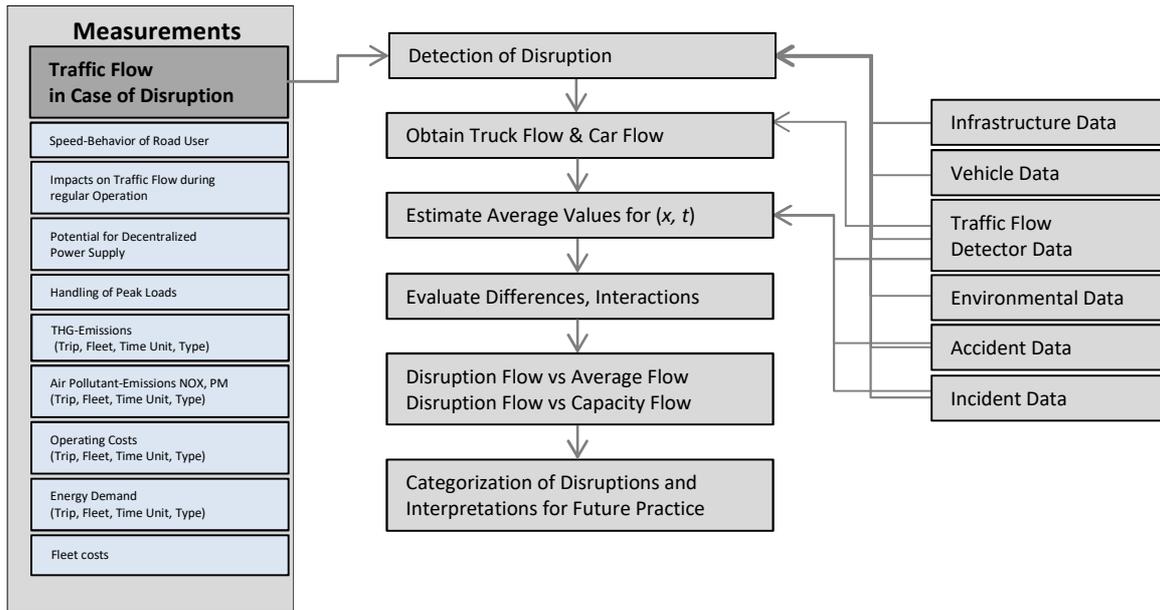


Figure 2: Step-by-Step Verification Algorithm for the Specific Measurement (Sample)

A step-by-step algorithm for an example measurement – a traffic flow in case of disruption – is shown in Figure 2. The methodology for the evaluation is a systematic comparison of the parameters regarding different aspects after or during construction of the eHighway system with reference values extracted for conditions without the eHighway system. For example, the impact of the eHighway infrastructure on traffic flow is investigated by using before-after analysis of traffic volume data, which is transferred from detectors located on the measurement cross sections.

3 Results

Comprehensive datasets from different sources are managed to evaluate measurements regarding predefined evaluation criteria. Preliminary findings from regarding measurements are provided.

Firstly, findings from the initial analysis of the impact of the eHighway construction on traffic flow are presented. Lane closure due to a construction site is essential for safety and capacity. Therefore, understanding the flow patterns for such disruption or closure is essential for future implementations. Traffic volume is obtained through detector data provided by Hessen Mobil. Locations of the measurement cross sections (MCS) and the location of the eHighway test track regarding these stations are shown in Figure 3. Two of the detector groups (MCS3, MCS4) are located within the eHighway test track, and another three groups are located upstream and downstream of the test track.

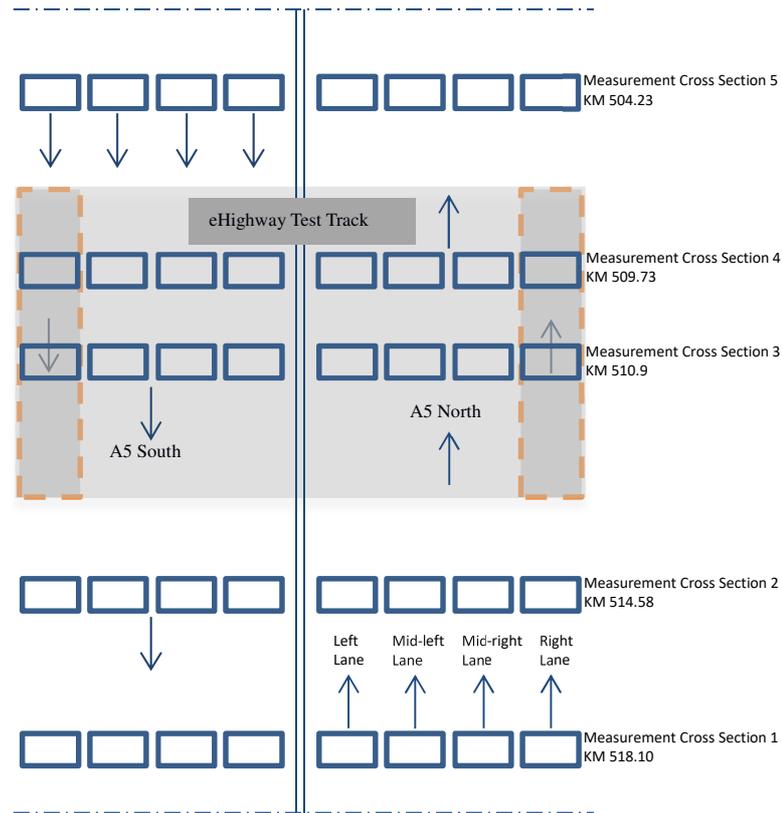


Figure 3: Location of the Measurement Cross Sections

Data from detectors are processed by using R software [3]. One minute interval data is aggregated to 15 minute values for truck volume. Lane-based truck volumes per 15 minutes (on 14.08.2018) are shown for the 5 different measurement cross sections in Figure 4. Following interpretations are extracted from the graphical analysis of sample data on 14.08.2018:

- There was no lane closure detected on MCS2 and MCS5 for the given day, and flow patterns from these locations represent the average distribution of lane-based daily truck volume.
- On the eHighway test track section, the right lane closure on MCS4 is observed from the graph between 08.³⁰ and 18.⁰⁰ hours. Truck volume from the right lane was shifted to the mid-right lane due to that closure.
- On the eHighway test track section, there was no lane closure on the MCS3; however, there was still high truck volume on the mid-right lane due to the upstream lane closure. MCS3 and MCS4 are located with 1.2 km distance to each other. Therefore, it is reasonable that traffic flow is affected by the upstream lane flow.
- MCS1 is located approximately 5 km outside the eHighway test track. Daily lane closure was observed from the graph that explains right and mid-right lanes were closed entirely and truck traffic was shifted to the mid-left lane and left lane. This was due to another road construction on this location which is confirmed by incident data.

To better understand the reason for the traffic merging, datasets from different sources are aggregated and investigated carefully. Distribution of daily total truck flow for normal condition has a sinuate pattern since daily truck volumes on Monday and Friday are lower relative to Tuesday, Wednesday, and Thursday. Average daily truck volumes of the measurement cross sections (for North direction) are about 10.000 trucks per day, and 80% of this volume is streaming on the right lane of the motorway.

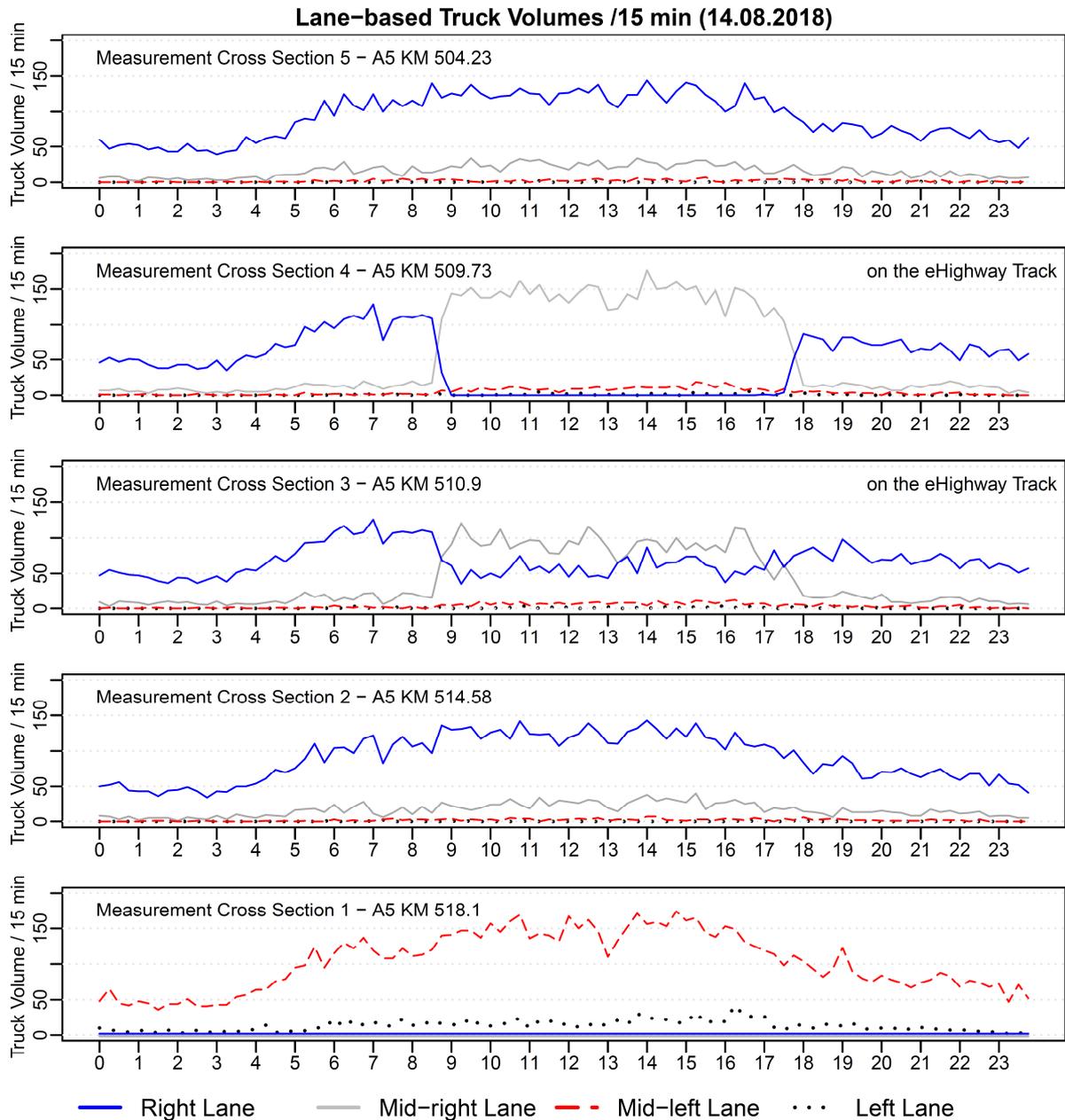


Figure 4: Lane-based Truck Volumes at Measurement Cross Sections on A5 North (14.08.2018)

“Traffic flow in case of disruption” is analyzed as a sample measurement from one of the evaluation concepts, and it is successfully investigated by using available datasets. The traffic flow detector dataset shows a plausible performance to detect disruptions inside and outside the eHighway test track. Flow patterns can be recognizable for normal traffic conditions and daily and temporal lane closures. Due to widely automated data processing, the efforts of such analyses have proven to be reasonable.

This initial data analysis also indicates clearly that it will be possible to analyze another important potential impact of the eHighway system. By comparing historical data from the time before start of the eHighway construction with data under the eHighway, any shift of traffic among the lanes can be investigated. It is expected that even smaller shifts can be identified by using methods of statistical analysis.

Acknowledgements

The authors express their gratitude to the German Federal Ministry for the Environment, Nature Conservation, Building and Nuclear Safety for supporting the ELISA Project. They also appreciate the project partners Hessen Mobil, ENTEGA AG, Siemens AG and all of the associated partners for their continuous and fruitful cooperation.

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Manfred Boltze (61) is a civil engineer and since 1997 head of the Institute of Transport Planning and Traffic Engineering at Technische Universität Darmstadt. He is the scientific director of the research project ELISA since 2017. His research covers a broad range of topics like fundamentals of transport planning, traffic management, passenger guidance in rail traffic, mobility pricing, traffic signal control, and effects of traffic on human health. He supervised 35 doctoral theses and more than 200 final theses in various diploma and master programs. 195 publications, memberships in editorial boards and advisory boards, as well as numerous international activities, reflect his extensive commitment to promoting research and teaching in his discipline. Detailed information about his publications and activities are available at www.tu-darmstadt.de/verkehr.