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

Combined simulation of electric road traffic and power supply system of eHighway tracks

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Summary

In 2019 there are two eHighway field tracks already in operation or being built in Germany. These and similar foreign test tracks have proven the systems feasibility with limited capacity. Against the background of a planned roll-out of the eHighway-System, the questions remain to be answered whether the current electrical system design will be able to meet the operational demand by increasing number of eTrucks in the future and what influence individual suggestions for improvements can have. The TUD addresses this research gap with a simulation tool that combines the modelling of driving dynamics of eTrucks with an electric network model based on the exemplary track of the FeSH project.

1 Research Questions

The main objective of this project is to develop a simulation model that provides solid information on key electrical parameters of the eHighway-System such as current distribution, power losses or voltage droppings along the track for different scenarios of operation. Based on this, the following research questions were developed:

1. What is the maximum possible eTruck operation with the current electrical system design?
2. How do the operation and the electrical system design influence each other?
3. What are the effects of specific measures to improve voltage stability (extra feeder, higher feeding voltage, etc.)?
4. What are the effects of different eTruck types on the electrical infrastructure?
5. What are the system design requirements for the connection of multiple eHighway-Section?

2 Methodology

The methodological approach is given in Figure 1. The overall simulation model is composed of four sub-models *vehicle, track, electrical infrastructure* and *operation* interacting with each other. Together, they cover the entire process of operation of an eHighway-System. The modular design allows for quick changes to be made to parameters e.g. vehicle type and number/distance of running vehicles. After the parameters and the simulation scenarios have been set, the simulation is executed and afterwards analysed against the background of the above formulated research questions. The simulation is realised by a constant time step calculation.

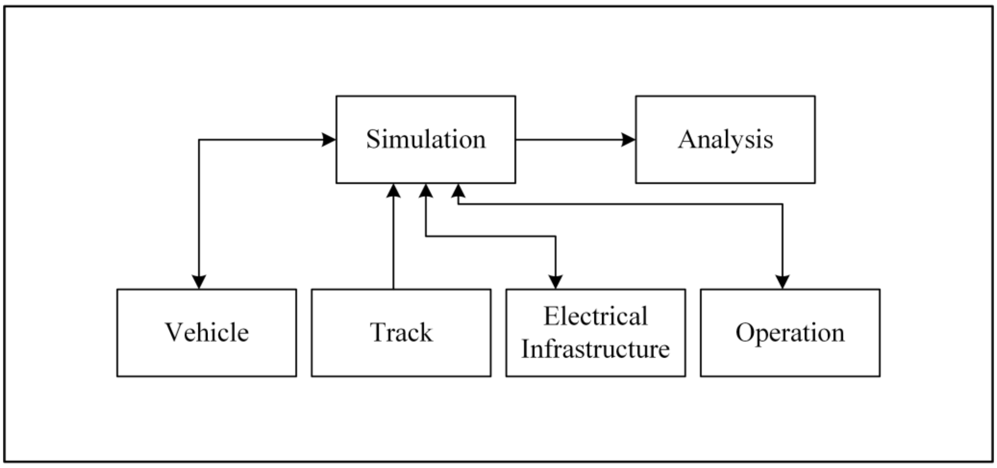

Figure 1: Methodological approach

The *vehicle* model consists of several parameters that cover the vehicles propulsion (engine) as well as its driving resistances and its superior properties like length and load. The engine is mainly described by its installed power and its traction force versus speed. The used parameters are those of a 40 tonnes semi-trailer, towed by a Scania R 450 Hybrid eTruck which is the truck type running in the german field trials. Other eTruck models are also available.

The *track* model describes the topographical parameters of the track and calculates a track resistant force. Its main influencing factor is the inclination of the track which is displayed in the upper left corner in Figure 2.

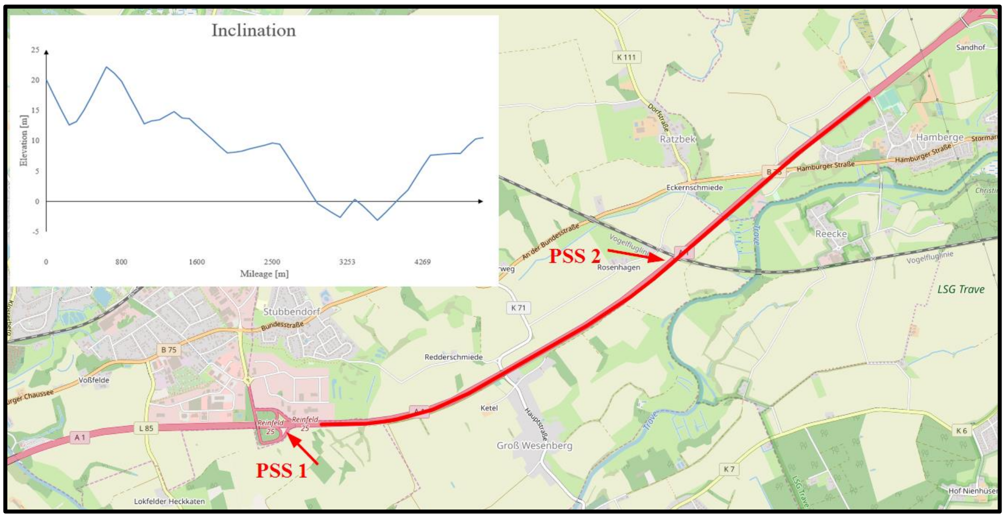

Figure 2: Simulated eHighway track in the FeSH-project

The used test track has a length of 5 km each for two running directions (Hamburg/Lübeck).

The *operation* is controlled by a timetable that manages the departure of vehicles at the beginning of the two track starting points. Each running vehicle is separately expressed by a Course ID with parameters such as vehicle type or entry speed. The basic timetable includes 4 eTrucks per direction starting at each track starting points with a delta time of one minute. Since the timetable can be adapted easily, complex routes of freight carriers can be implemented.

The *electrical infrastructure* is the most profound sub-model. Starting from the network feeding point at the medium-voltage level (e.g. 30 kV) the sub-model includes the DC Power Substation (PSS), the contact line system, the in-between connection cables and additional feeding cables.

In total, the components are expressed by a matrix of impedances and for every time step the voltages of the electrical network with the known vehicle positions and their requested efforts are calculated. An overview about the design of the electrical network is displayed in Figure 3.

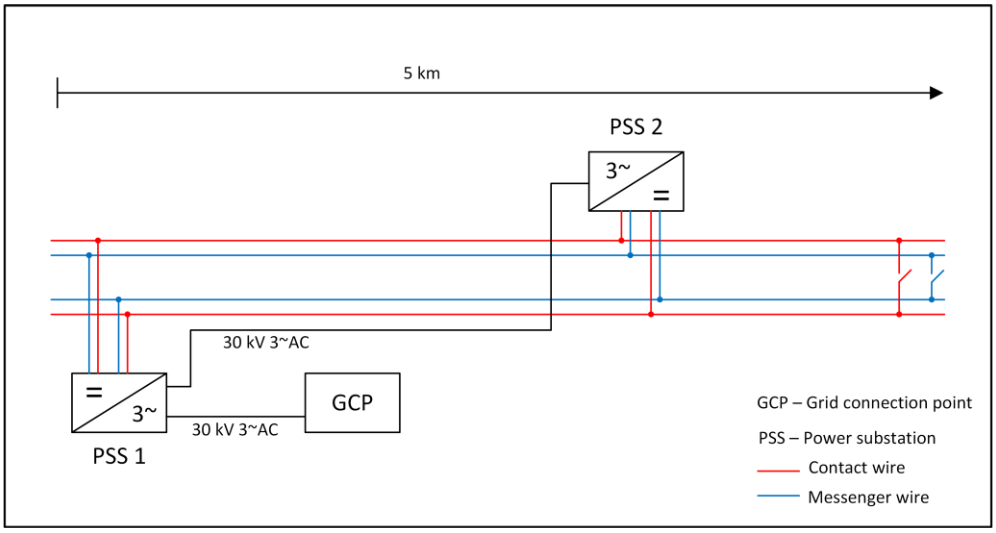

Figure 3: Simulated electrical power supply network

3 Results

At the ERS Conference the TUD will present the single parts of the simulation model, give a detailed overview about the simulation scenarios and also present a visualized analysis of the simulation results.

Since the process of defining scenarios and the analysis is still in progress the main results will be presented at the ERS Conference in May 2019 in Frankfurt. In order to present the results in detail and to comprehensively answer the research questions, the presentation at the conference, which is limited in time, will be accompanied by a full report on the simulation of eHighway-Systems.

As an exemplary output of the simulation model, the pantograph voltage as well as the busbar and feeder current of PSS 1 versus the time are shown in Figure 4 and Figure 5 for the operation scenario of one eTruck running.

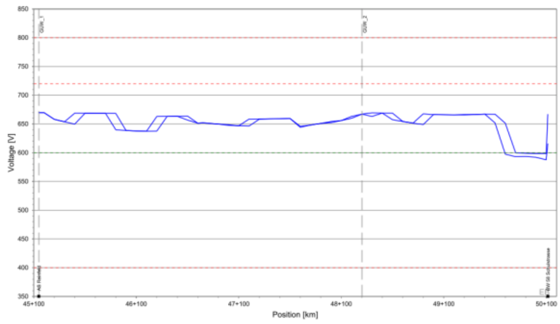

Figure 4: Pantograph voltage

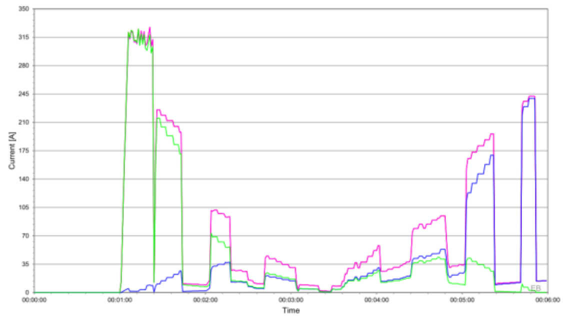

Figure 5: Busbar and feeder current

Author

Dipl.-Ing. Markus Staub has been a Scientific Associate at the TU Dresden's Chair of Electric Railways since 2017. He studied Transport Engineering with the focus on planning and operation of electrical transportation systems from 2011 to 2017. His main field of work is the TU Dresden's contribution to the FeSH project, primarily the electrical system design and the overhead contact line system. Besides, he also leads a project with the installation and operation of an arcing monitoring systems at Edinburgh Trams in the UK.

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