Adapting Road Infrastructure for Lane-Free Movement in the Era of Connected and Automated Vehicles

Master‘s Thesis of Kathrin Birkmair

Mentoring:
Prof. Dr.-Ing. Klaus Bogenberger
Dr.-Ing. Florian Dandl
Dr. Ing. Milad Malekzadeh

Goal and Methodology

In the era of **connected and autonomous vehicles (CAV)**, fundamental reconsiderations of traditional traffic concepts have become increasingly important. One such paradigm shift is **lane-free traffic (LFT)**, which enables more flexible vehicle movement by abandoning fixed lane structures. The current infrastructure, however, is not designed with the intention of such a system. This thesis focuses on the relationship between lane-free traffic and infrastructure, and the distribution of the vehicles on the road.
In the first part of the thesis the **load distribution on the pavement** is investigated with data from a SUMO (Simulation of Urban MObility). The second part is a discussion about how infrastructure needs to be prepared for lane-free traffic.

SUMO Simulation

The SUMO simulation of a highway stretch provides the data for the load calculations.

Length: 5 km

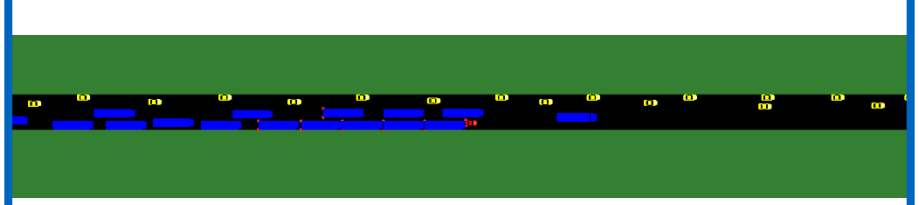
Width: 10.2 m (corresponds to a three-lane highway)

Vehicles: cars and trucks (100 % CAVs)

Scenarios:

A. No disruptions

B. Obstacle (stationary vehicle) at 2 km



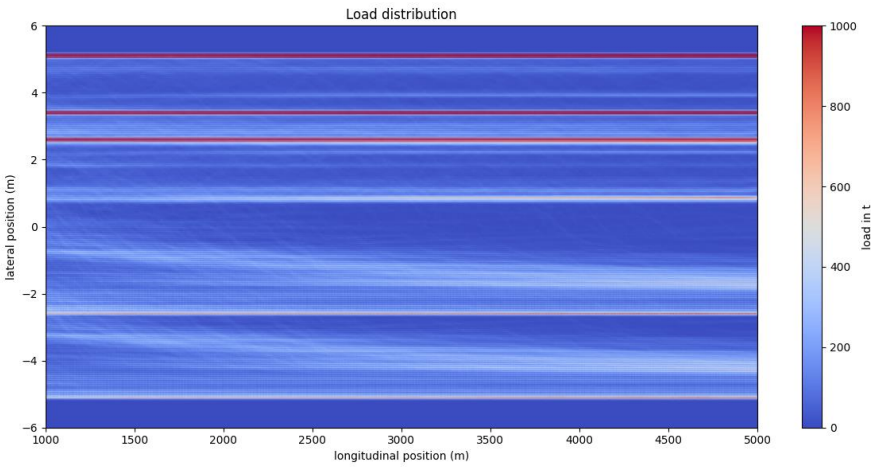
Adaptation of Infrastructure

- Many aspects of today’s physical infrastructure can be reduced and replaced virtually.
- Fixed **lane markings** become obsolete (other forms of markings for orientation of the vehicles possible).
- Hard directional separations need removal to allow **tidal flow**, where the width of the road for each direction is variable based on the relative densities.
- The infrastructure needs to enable connectivity and automation.
- AVs require infrastructure that fosters **sensor vision**.
- LFT **increases the capacity** of the road which enables space re-allocation (e.g. to VRUs), but asks for increased bearing capacity for bridges, for example.
- One significant difference will be the amount of **data** that is collected, processed, and stored.
- The increased quantity of data offers numerous opportunities, such as **predictive maintenance**, but also requires a secure and reliable framework.

Load Distribution

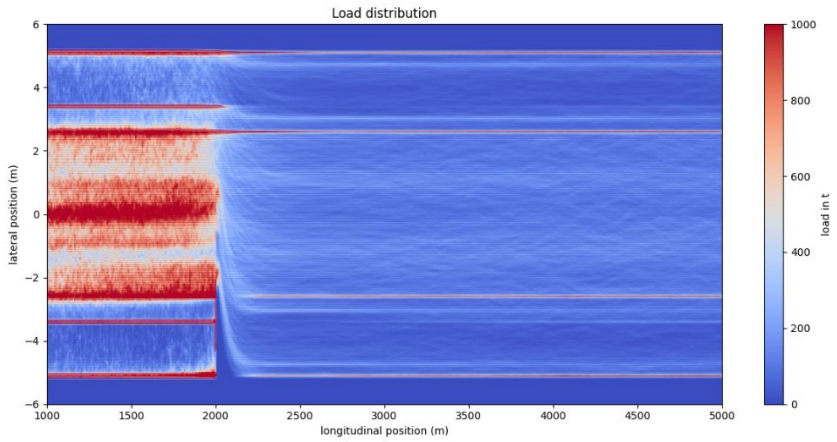
The heatmaps shows how the load of the vehicles is distributed. The load is applied where the vehicles are in contact with the pavement.

Scenario A: undisturbed traffic



The load is more dispersed than in current lane-based traffic. The wheel paths concentrate at the edges of the road.

Scenario B: Obstacle



Before the bottleneck, a congestion is forming. The density increases in congested areas and the vehicles stay at their position for a longer period, which leads to a higher load.

Maximum Load:
In the free-flow scenario the maximum load on the highway sections is on average 3,900 tons for LFT and 5,100 tons for lane-based traffic.
⇨ LFT reduced the maximum load and the wheel paths are more dispersed