Traffic Simulation-based Analysis of Operational Requirements for a Fleet of Autonomous Shuttles (HEAT) in Hamburg HafenCity

Master‘s Thesis of Ashhar Husain

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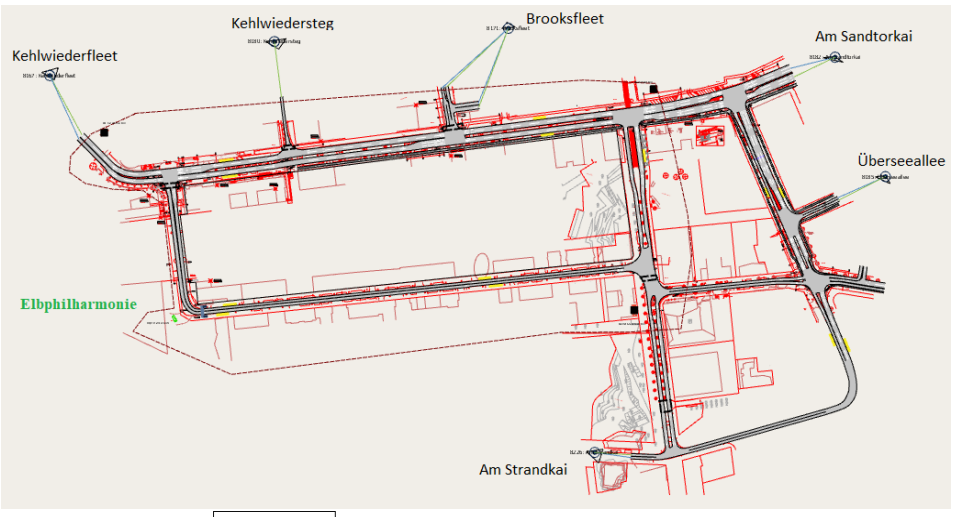
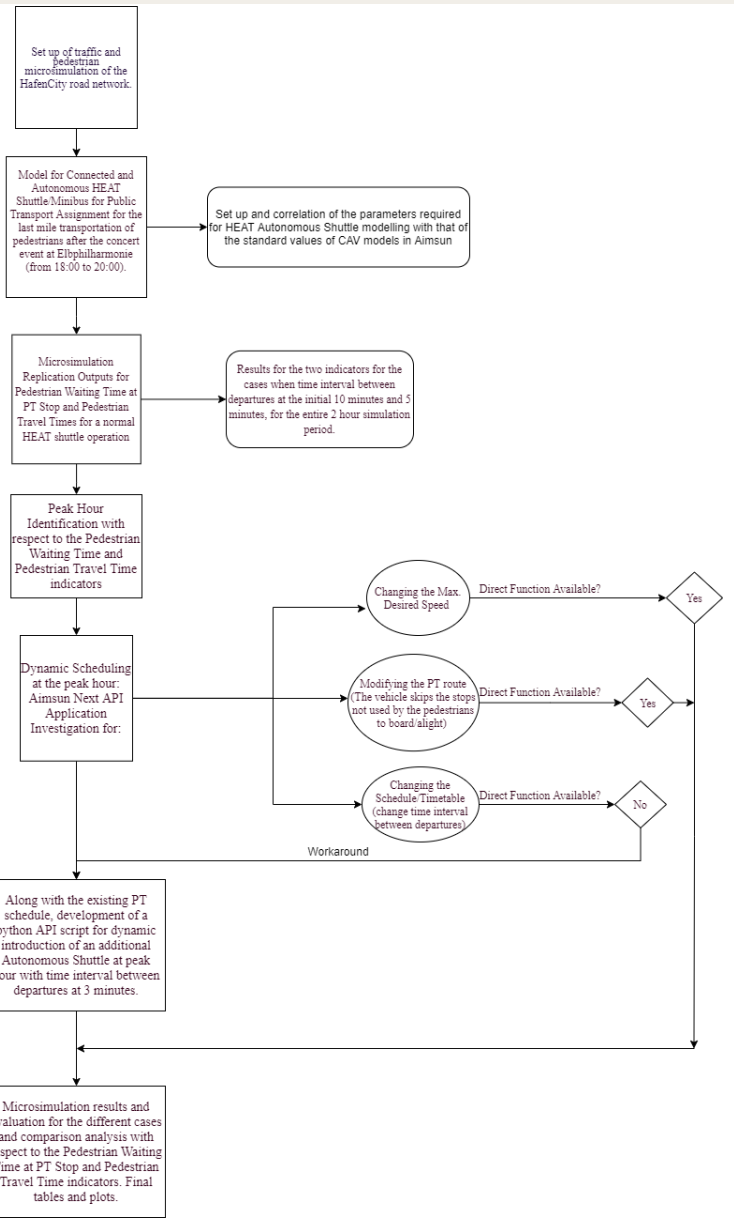
The HEAT (Hamburg Electric Autonomous Transportation) project is a pilot in HafenCity, Hamburg, in which an autonomous shuttle system is tested. It is a research and development project that aims for integration of a HEAT autonomous shuttle (mini bus) into the regular street traffic in HafenCity. The project was first formulated and developed by the Hamburger Hochbahn AG which is a transportation and mobility based company in Hamburg. It was among the first in the world that focuses on realizing the defined-route autonomous operations in the public transport sector. The advanced in-vehicle and infrastructure technologies further enhance the interaction between the vehicle and its surroundings, with a centralized Hochbahn control center.

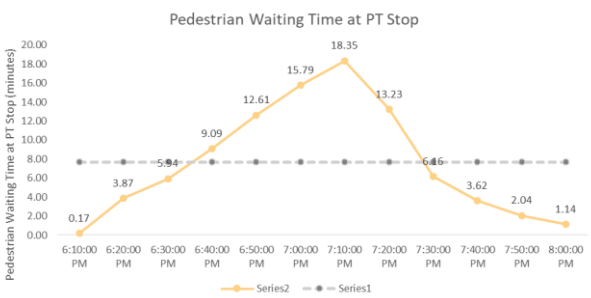


Objectives of the Study

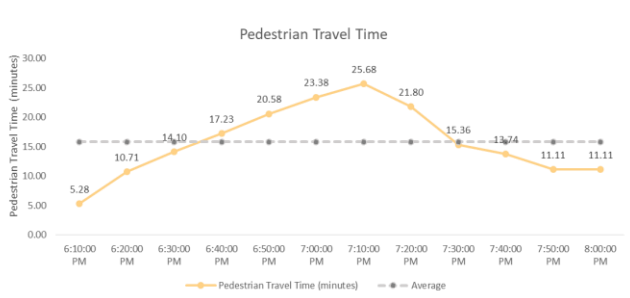
The aim or the primary objective of this thesis is to build a simulation framework that models the operation in HafenCity, and which could also be transferred to models of other cities. The following objectives form a part of the thesis:

- Generation and development of a microsimulation model for the entire road network of Hamburg HafenCity.
- Inclusion of autonomous shuttle parameters for the public transport modelling in the pedestrian simulation environment along with public transportation assignment.
- Modeling and analysis done for the simulation runs for the public transport operation based on the Pedestrian Waiting Time at PT Stop and the Pedestrian Travel Time indicators.
- Study and investigation of Aimsun Next API module functions which could be used for the implementation of a dynamic scheduling method for the HEAT autonomous shuttles to service the increasing pedestrian demand based on the two indicators.
  - The relevant public transport data is extracted using the Aimsun Next API. The waiting time of the pedestrians at the PT stop and the time taken by the pedestrians to reach their respective destinations is determined for the two existing scenarios of the network.
  - As the demand for the services of pedestrians, coming into the network from Elbphilharmonie, increases during an identified "peak hour", a workaround is also investigated which uses the API functions for solving the problem at the peak hour for next three scenarios.
  - API implementations and results for all the five scenarios.
- Finally, investigating and understanding how the use of self-driving vehicles in public transport affects the daily activities of the people and its prospects into changing or shaping the control center workplaces in the future.





Pedestrian Waiting Time at PT Stop - Time Interval between departures (5 minutes) from 18:00 to 19:00, Introduction of an additional vehicle using Aimsun Next API with time interval between departures (3 minutes) from 19:00 to 20:00



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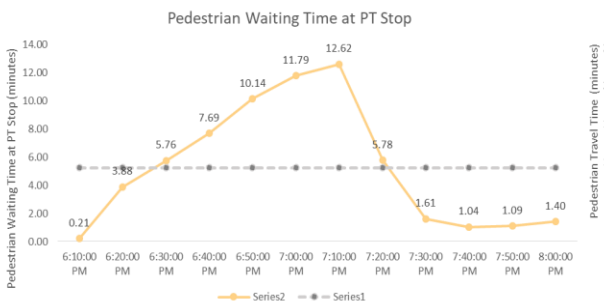
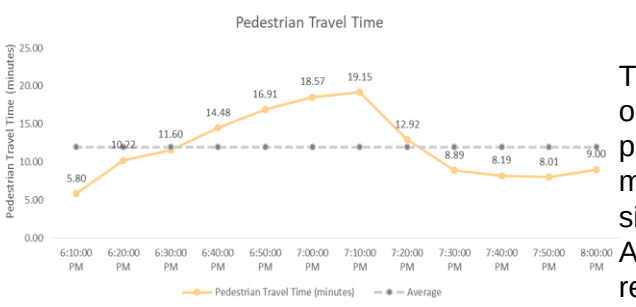


Pedestrian Waiting Time at PT Stop - Time Interval between departures (5 minutes) from 18:00 to 19:00; Changing the Max. Desired Speed, Modifying the Vehicle Route and Introduction of an additional vehicle using Aimsun Next API with time interval between departures (3 minutes) from 19:00 to 20:00



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The results and plots for the evaluation of scenario 5 of the operation of HEAT autonomous shuttles, with average pedestrian waiting time and pedestrian travel time of 5.25 min and 11.98 min, respectively, depict the optimal situation with respect to the increasing pedestrian demand. A careful examination and comparison analysis of the results of the API implementation during peak hour makes ground for an effective use case of the HEAT autonomous shuttle service as shared autonomous mobility on the HafenCity network, even in a special-event scenario such as the one considered in this thesis.