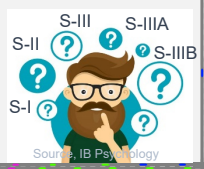
Evaluation of the Impact of Bus Lane Preemption on Traffic Flow in Highways

Abstract: Recently, most of the transport planning authorities around the world are planning for more sustainable transport modes where public transportation is becoming an increasingly important part of the modern traffic networks to deliver the expectation of the planning authorities. Due to the rapid growth of motorisation, the number of private vehicles is also increasing, which reduces the efficiency of public transportation. This thesis aims to develop new driving strategies to increase the efficiency of public transportation which can eliminate dedicated bus lanes while providing the same benefits for bus transportation by creating minimal impact on private vehicles. Therefore, a freeway traffic network is developed with three driving strategies using microscopic traffic simulation software PTV Vissim for the final evaluation; mixed traffic strategy as scenario I, dedicated bus lane strategy as scenario II and connected vehicles strategy as scenario III where the communication range is set 300m downstream. Besides, the model is simulated for various connected vehicles penetration rate to test the sensitivity of the model. A python script is developed to establish the communication between vehicles and incorporated in Vissim as an event base script to obtain the lane changing behaviour of connected cars.

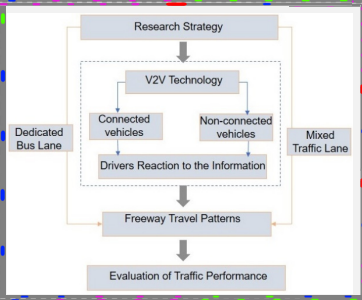
Research Objectives

The main objective of this research is investigating different driving approaches to prioritize public transport as dedicated bus lane by creating minimal impacts on private vehicles.

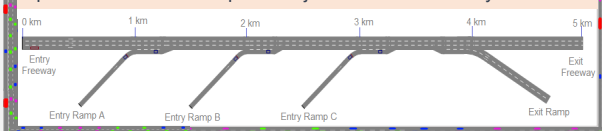


Research scenarios

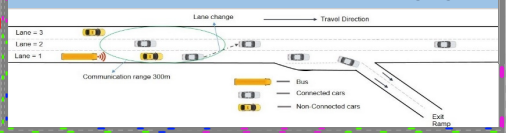
- **S-I** — cars are allowed to drive in any lane
- **S-II** — cars are not allowed to drive in the bus lane
- **S-III** — cars are allowed to drive in the bus lane and assigned to move from the bus lane in the presence of the bus.
- **S-IIIA** — Connected cars are assigned to change lane and no-connected cars will not change lane in the presence of the bus
- **S-IIIB** — Connected cars can only use lane one and will change lane in the presence of the bus. Non-connected cars drive in lane-two or lane-three.

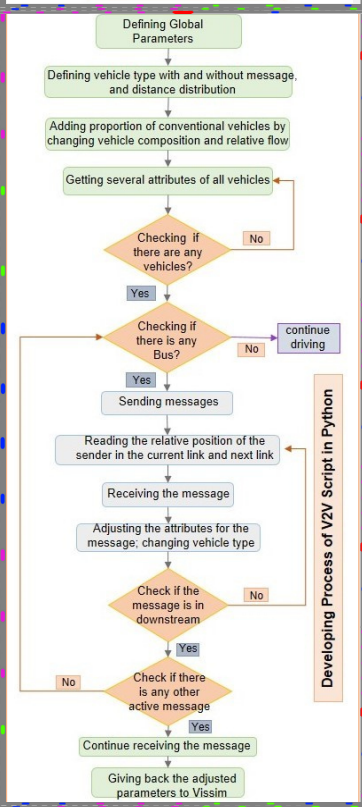


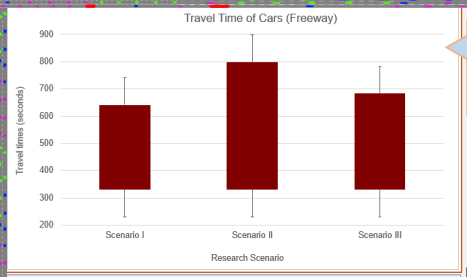
Model Development: A three-lane freeway is selected for the test model which consist of three on-ramps and one off-ramp spaced one kilometer apart that join the entire freeway.



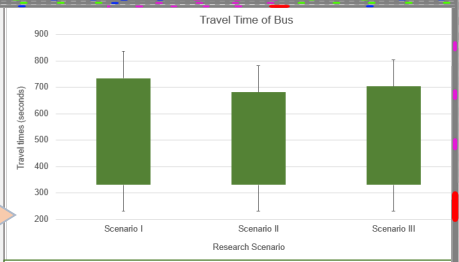
V2V Control Technique: Connected car changes lane after receiving the signal from the bus to prioritize bus and non-connected cars drive without receiving signal.



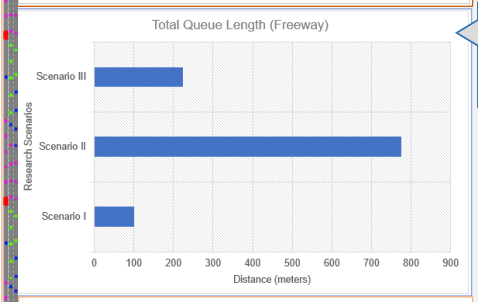




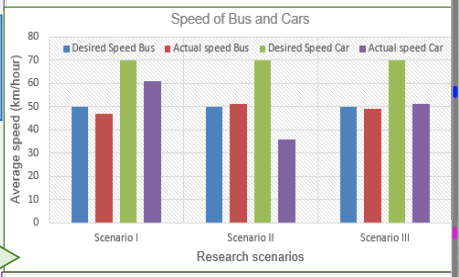
S-III improved cars travel time 24% compared to S-II and increased 13% compared to S-1



S-III improved bus travel time 7% compared to S-I and decreased 6% compared to S-II

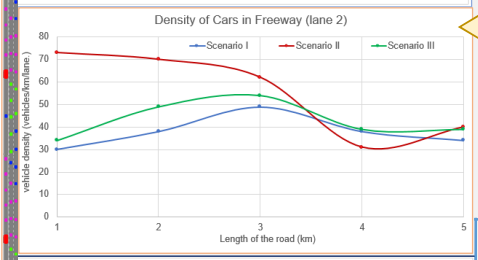


The queue length for S-I, S-II and S-III is respectively 100m, 200m and 776m on the freeway within 5km

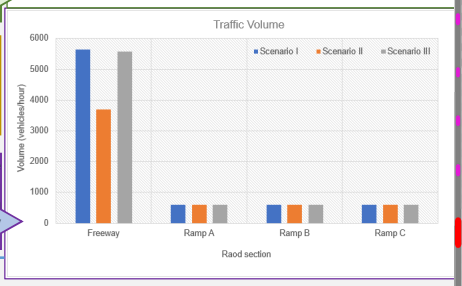


Evaluation Results

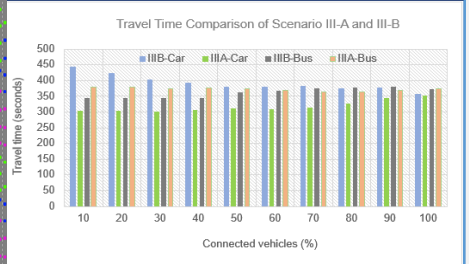
S-III improved actual speed of the bus compared to S-I and actual speed of cars compared to S-II



S-III ensures almost the same traffic density as S-I where S-II shows a higher density.



S-III and S-I shows the same traffic volume on the freeway which decreases significantly in S-I.

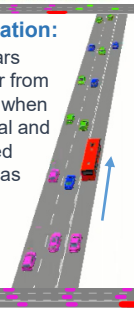


Conclusion:

From the analysis, the findings can be summarized as follows; significant improvement of bus and cars' travel times is possible with applying connected vehicles driving strategy. The application of a fully connected environment showed that a 7% reduction of bus travel time and a 13% increase of cars travel time compared to the mixed traffic-driving strategy, and a 24% improvement of cars travel time and 6% increase of bus travel time compared to the dedicated bus lane strategy. Fully connected environment decreases the travel time of bus but increases the travel time of cars slightly due to the frequent lane changing behaviour of cars in the presence of a bus. Application 60% connected vehicle ensures the same travel time for cars as a mixed traffic-driving strategy and also reduces the travel time of bus about 9%. Therefore, CV can improve the speed, travel time, densities, queue length in the network by ensuring the same traffic volume as mixed traffic strategy.

Model Validation:

Connected cars changes color from pink to green when receives signal and non-connected cars remains as their original color blue.



*S, stands for scenario
*CV, connected vehicle

Application of 50% to 60% CV ensures improvement of bus travel time without having any impact on the cars travel time.

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