Space-Time Footprint
— a metric to capture space efficiency?

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Background:
It is often hypothesised that the introduction of automated vehicles (AV) will enable a more efficient use of the road space due to shorter headways etc.

It would therefore be desirable to develop metrics that estimate how much space the traffic "claim" in order to investigate if AVs will be able to free up space.

One way suggested by Olstam et al. (2019) would be to study how much space-time that would be needed to transfer the demand from its origin to its destination. A decrease in used space-time would be an indication when it is possible to reduce the space.

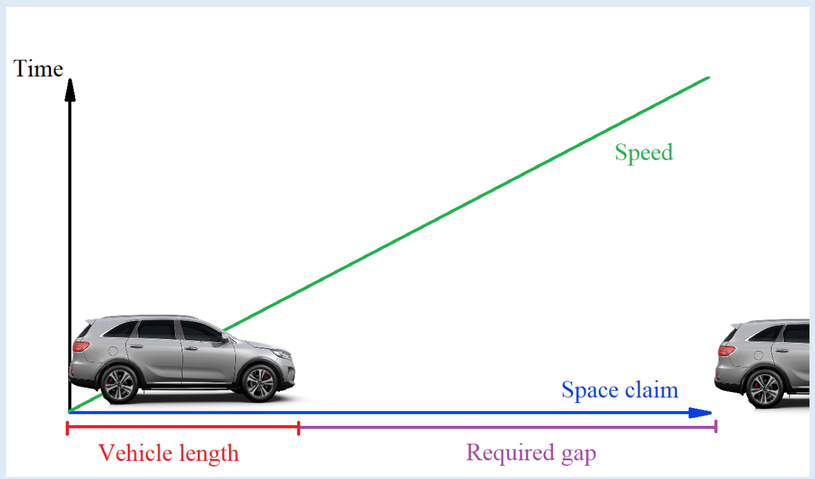
Olstam, J., Johansson, F., Liu, C., Pereira, I., Fléchon, C., Dahl, A., Burghout, W & Thiebaut, R. 2019. Definitions of performance metrics and qualitative indicators. Deliverable D3.2 of the project CoEXist project.

Aim:
The aim of this work is to evaluate the new metric: space-time footprint, as a metric for evaluation of space efficiency from microscopic traffic simulation-based evaluations.

Research method:
Experiments with microscopic traffic simulation in PTV Vissim. Scenarios with mixes of CV and AVs with the AV driving logic called "all knowing". Using Wiedemann 99 car following model.

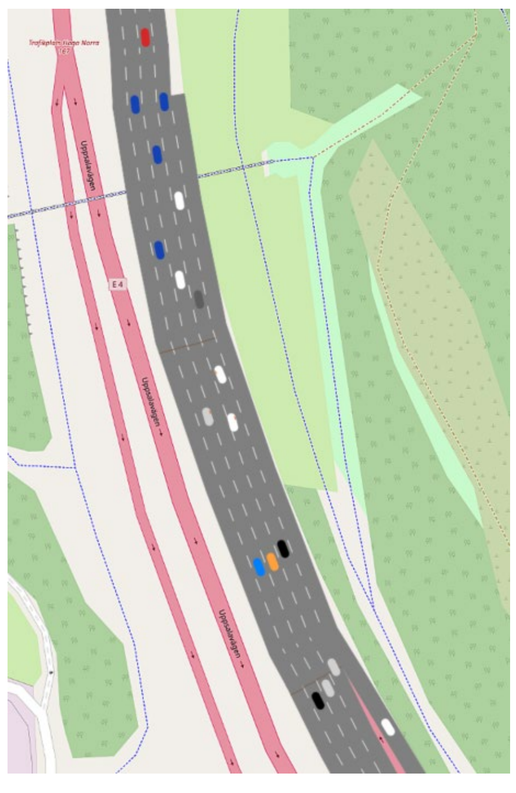
Road segment:
The simulated segment is a 1.2 km long part of the motorway stretch of E4/Uppsalavägen north of Stockholm. The segment include one off- and one on-ramp.

Definition of space-time footprint (STF):
[in meter x second]: product of
- Mean space claim of a given vehicle
- Time during which the vehicle is in the simulated network



Space-time footprint characterizes the space claimed by a vehicle while moving through a network. The smaller the average space-time footprint for a vehicle class, the more efficiently the vehicles use the available space and time.

The STF is sensitive to the length of the path and thus comparing different paths are problematic. STF is therefore divided with the total space and the study time period, this new dimensionless measure is called ***Space-Time Footprint Utilization***.



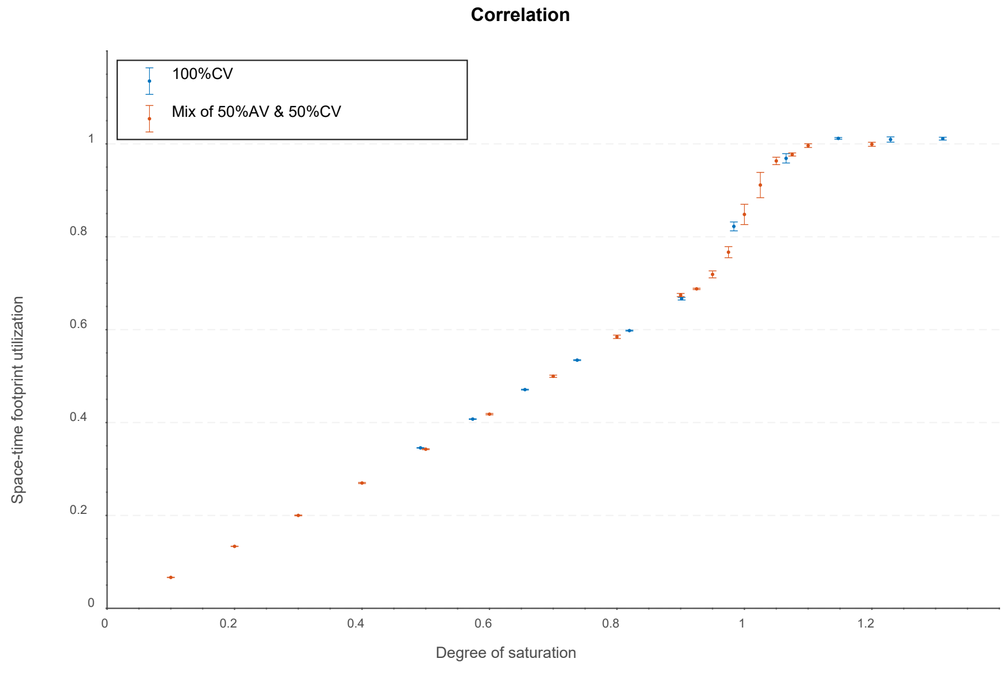
Part of the simulated network with individual vehicles

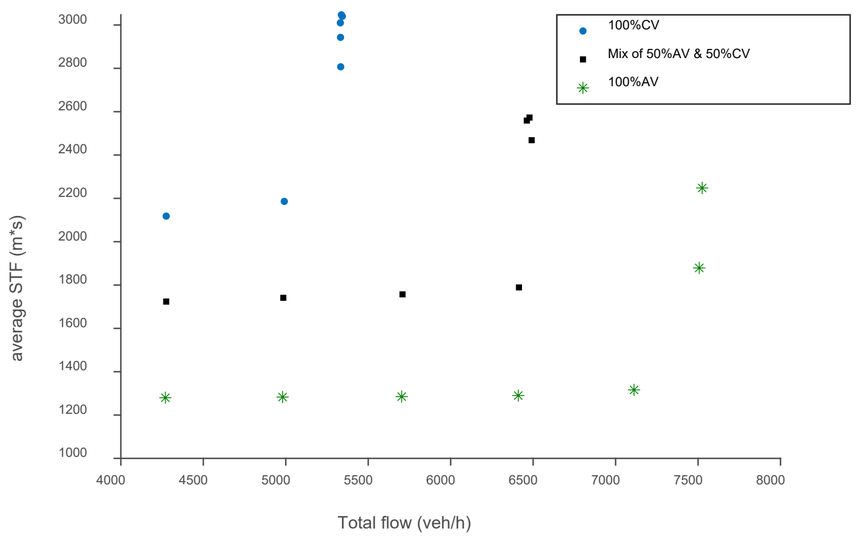
Research questions
- Is there any correlation between the degree of saturation and the space-time footprint utilization?
- Could the automated vehicles make a road lane redundant, and can it be predicted with the use of the space-time footprint?
- Evaluate if the space-time footprint metric provide additional information or if other metrics already provide enough information to estimate space time efficiency?

Discussion
The figure below shows the result of different flows and vehicle mixes. As expected, the STF has a lower value when the amount of AVs increases, since these requires a smaller safety distance than CVs. Estimation of the capacity can be made from the graph, by observing when the STF has a large spike

Conclusion
The conclusion so far is that there is a correlation between the STF-utilization and the degree of saturation in the studied network, see correlation graph.

There is a linear correlation until the system reaches its capacity. At that critical point it significantly increases until it reaches its maximum of 1.





Next
The project work is in progress. The next step is to study the effects on STF when removing a lane. This will be investigated for with different mixes of AVs and CVs. Comparisons of the metric and other traffic performance metrics will also be conducted.

Master thesis project related to the CTR-SMART and CoEXist project

CTR day, 14 May 2019