Investigating the potential impact of Connected and Automated Vehicles in the Irish context

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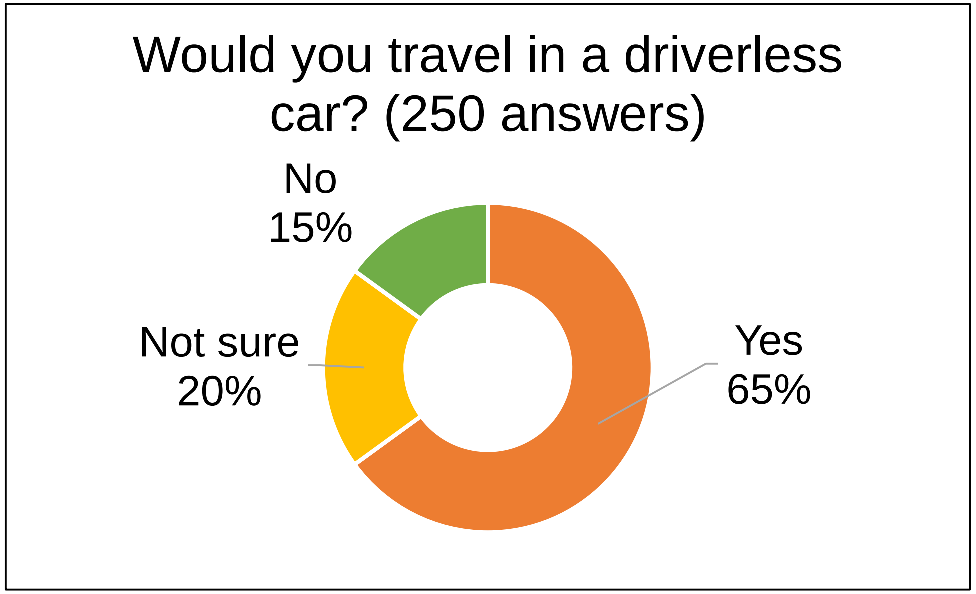
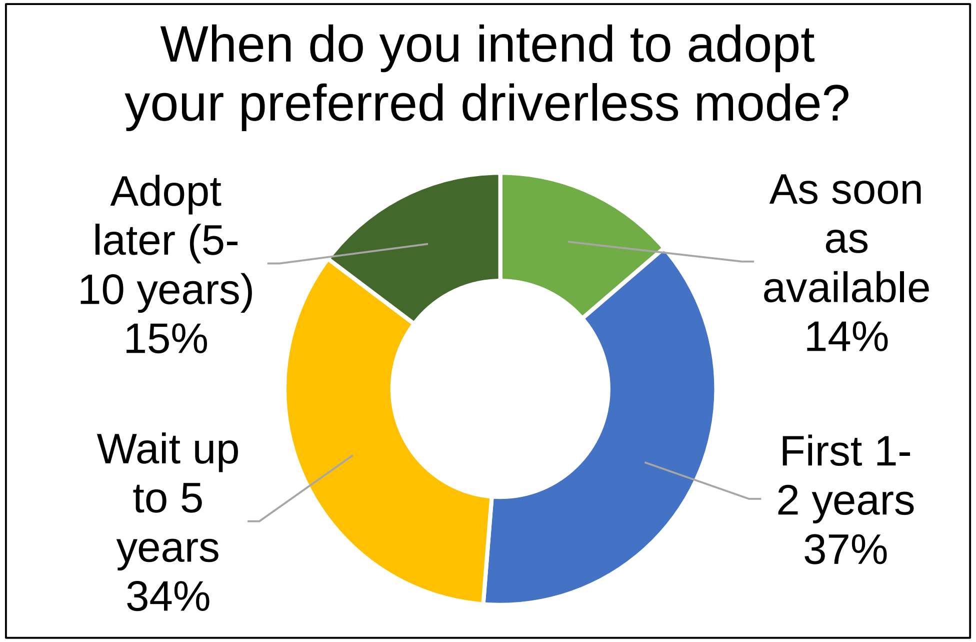
Context

- Growing interest of citizens towards the adoption of autonomous cars [1]
- Connected and Automated Vehicles (CAV) technologies are expected to have positive impact on traffic [2]
- This research investigates the potential effects of CAV on:
    - road safety,
    - traffic (efficiency, management),
    - and governance,
- in the Irish context, using real data.



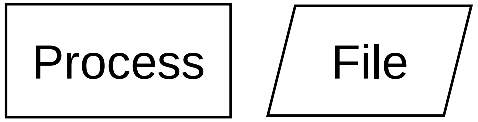


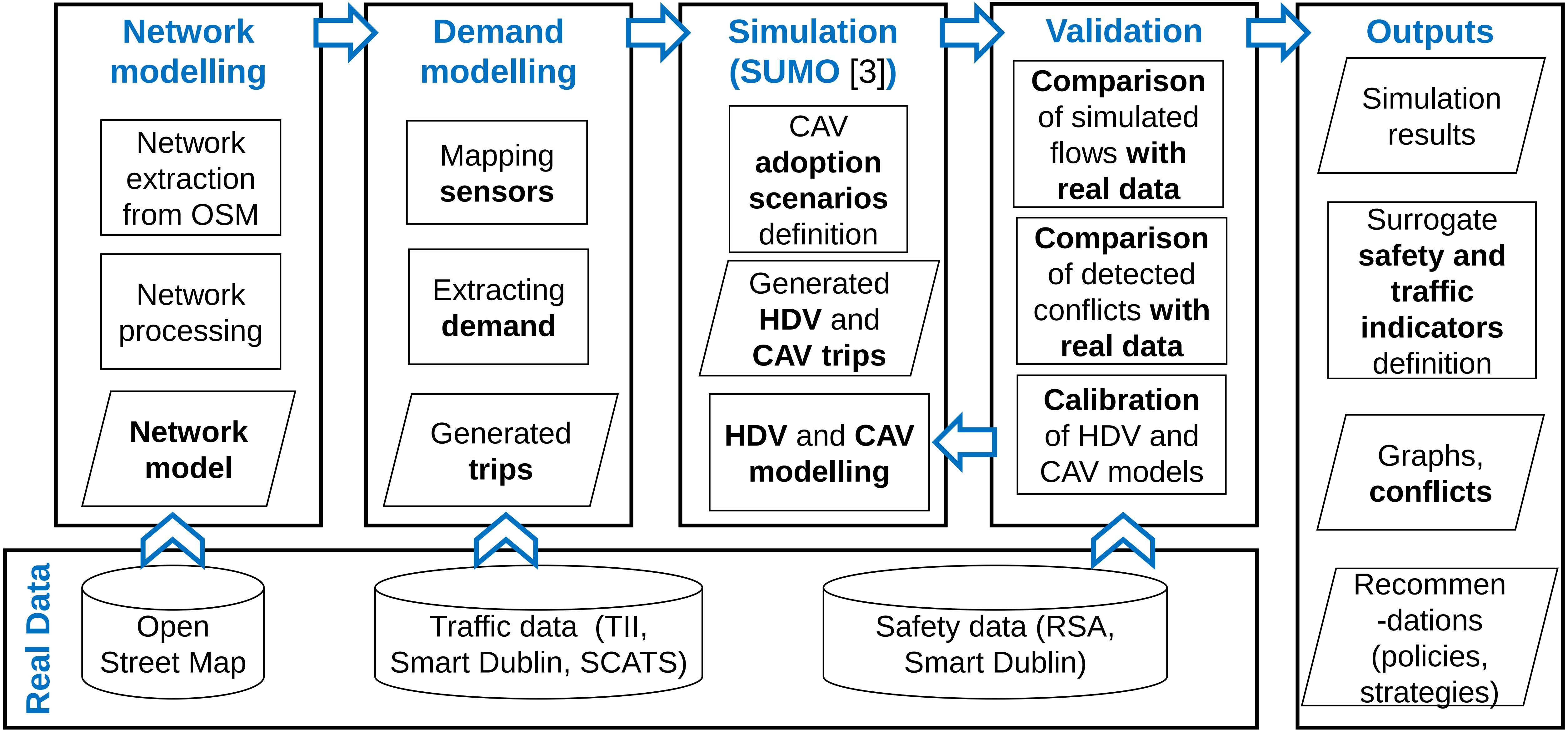
[1] Acheampong and Cugurullo (2019) Transportation research part F: traffic psychology and behaviour, *62*, 349-375.
[2] Guériau et al. (2016). Transportation research part C: emerging technologies, 67, 266-279.

Project team

	Principal investigator	Supervisor	
	Dr. Maxime Guériau Research fellow	**Dr. Ivana Dusparic** Ussher Assistant Professor	
Expertise	AI techniques for Cooperative ITS and smart mobility	AI algorithms for traffic optimisation, smart mobility	**Funding & partners**
Previous projects	Projet SCOOP: French pilot project for the deployment of C-ITS	COST: Wider Impacts of Autonomous Vehicles WISE-ACT	European Commission
	Surpass: how shared autonomous cars will change cities		Irish Research Council
Current project	ITS Ireland Research Bursary: CAV impact assessment on Irish roads through Multi-Agent traffic Simulation		ITS Ireland, RSA, TII

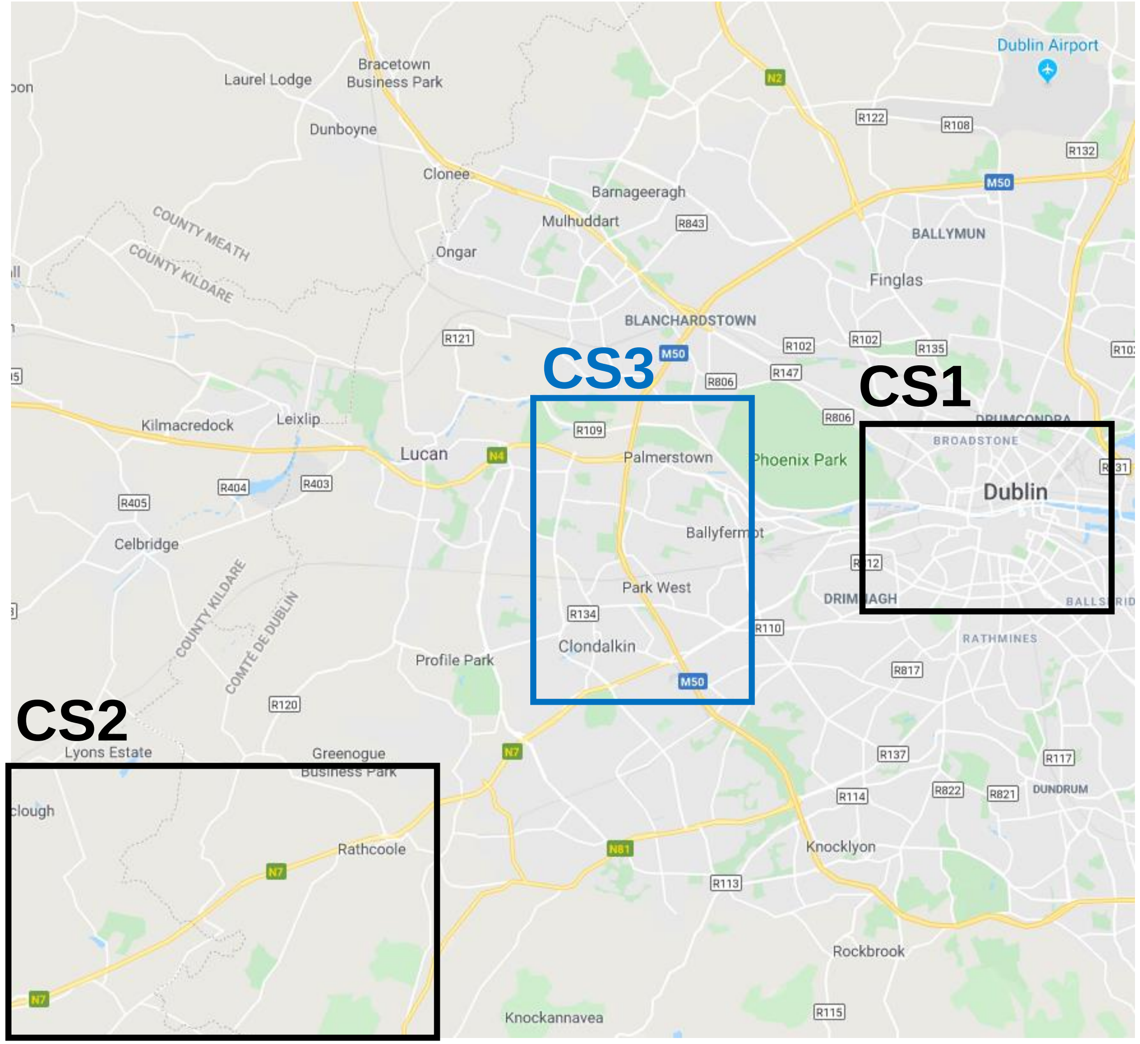
Methodology





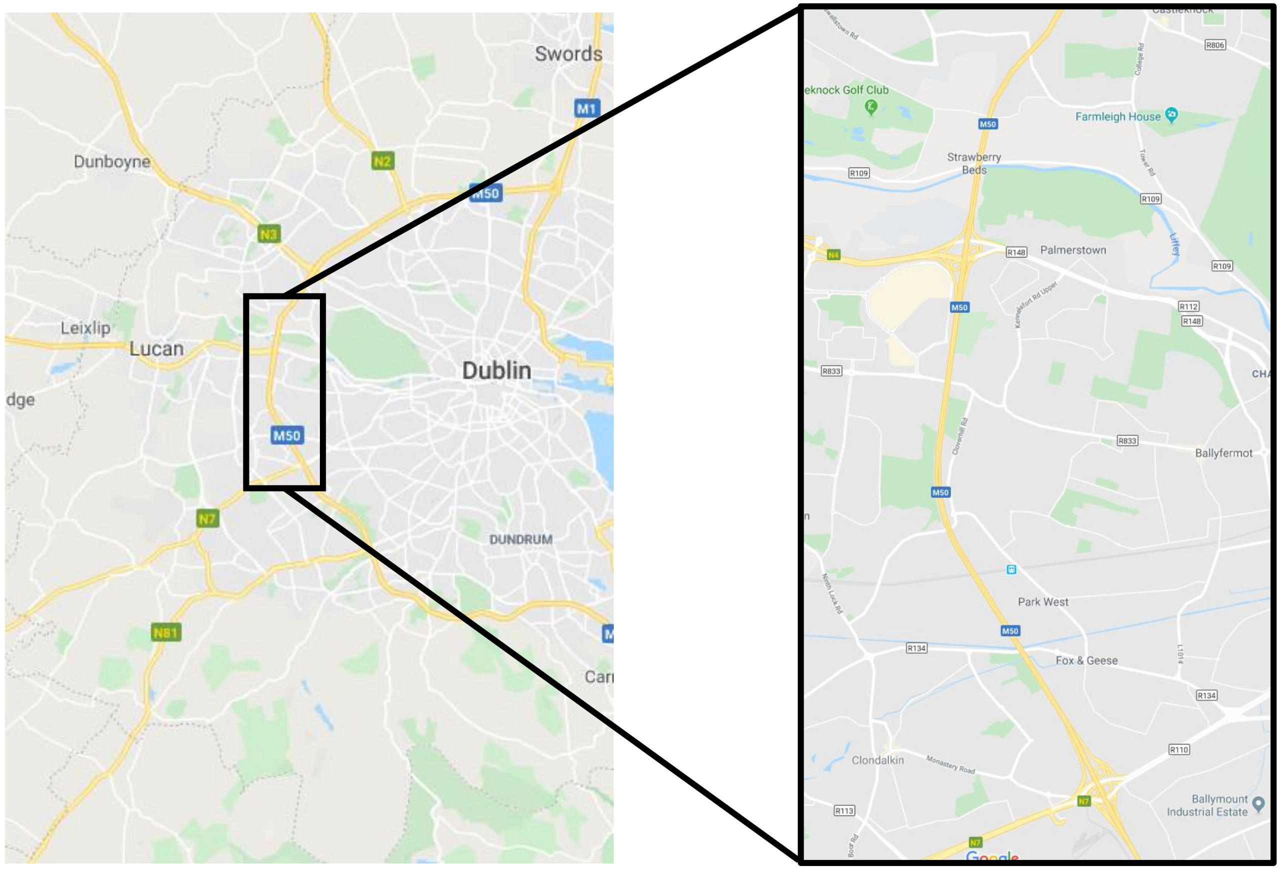
[3] Lopez et al. (2018). 21st International Conference on Intelligent Transportation Systems (ITSC), 2575-2582. IEEE.

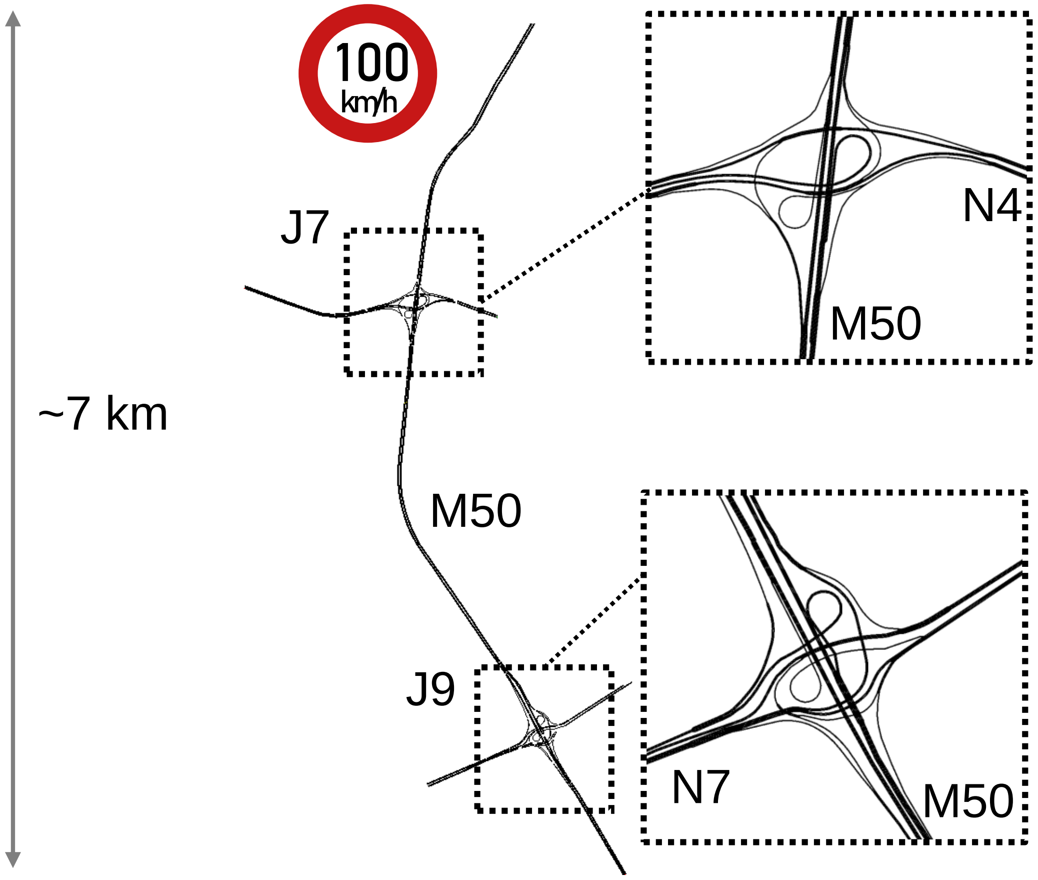
Case studies



CS1: **Urban network**	Dublin city centre	Complex intersections Traffic lights Reduced speeds
CS2: **National road network**	N7 Johnstown – Rathcoole	Higher speeds Multiple lanes Different safety concerns
CS3: **Motorway**	M50 J7 – J9	High speeds Complex junctions High traffic volumes High speed variability

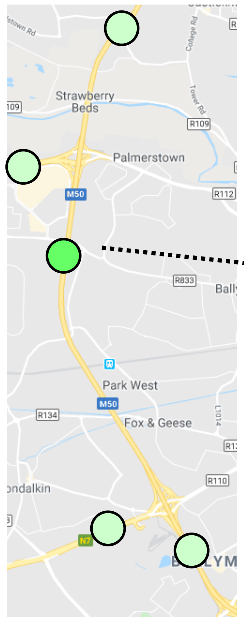
Simulation set-up: M50 network





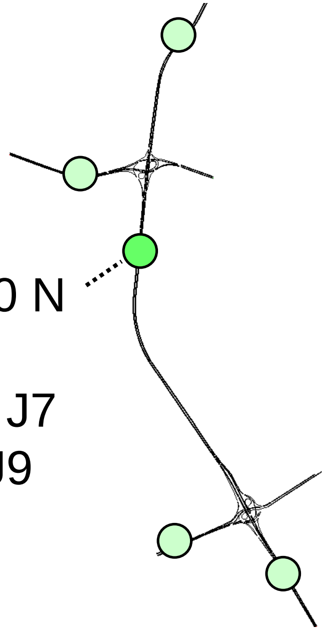
Simulation set-up: baseline scenario

- Flows are generated from TII loop sensor data (includes % of HGV, and flows per lane, every 5 min)



Sensor:
TMU M50 020.0 N

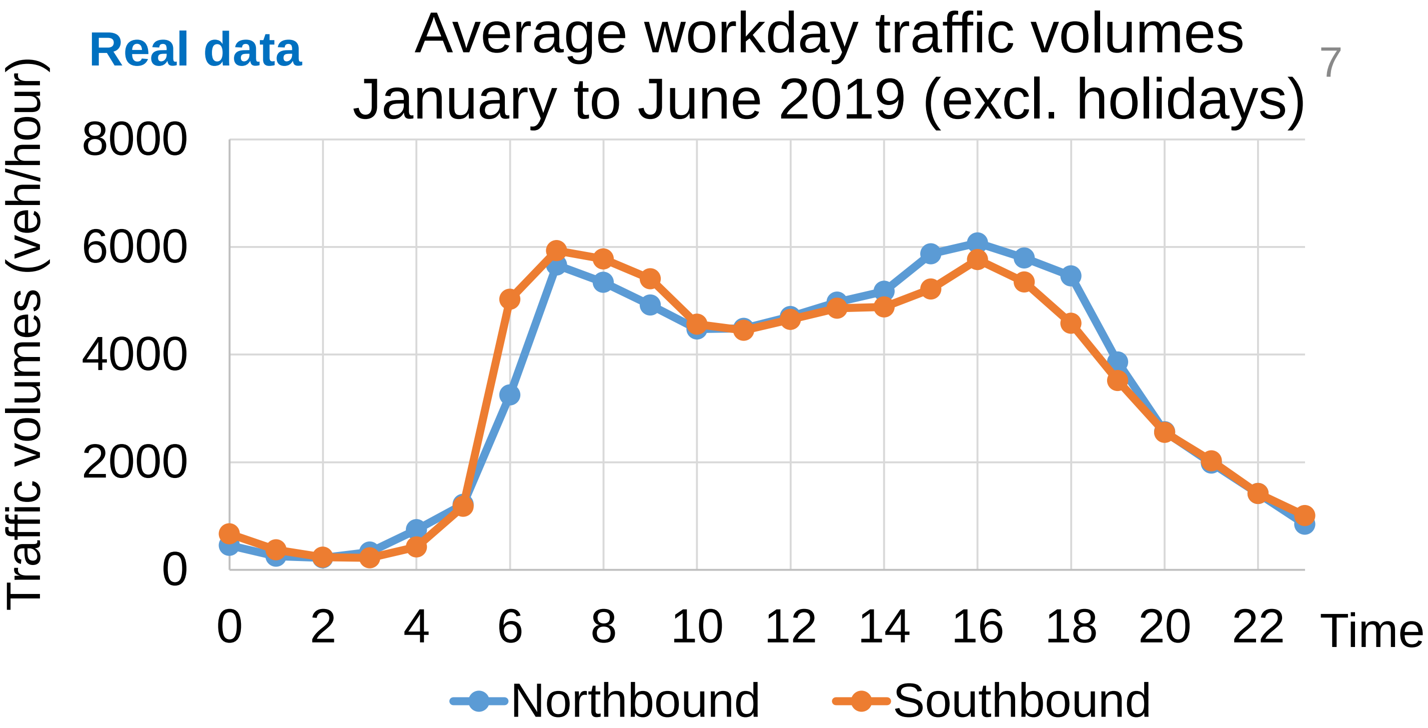
(M50 Between J7 N4/M50 and J9 N7/M50)

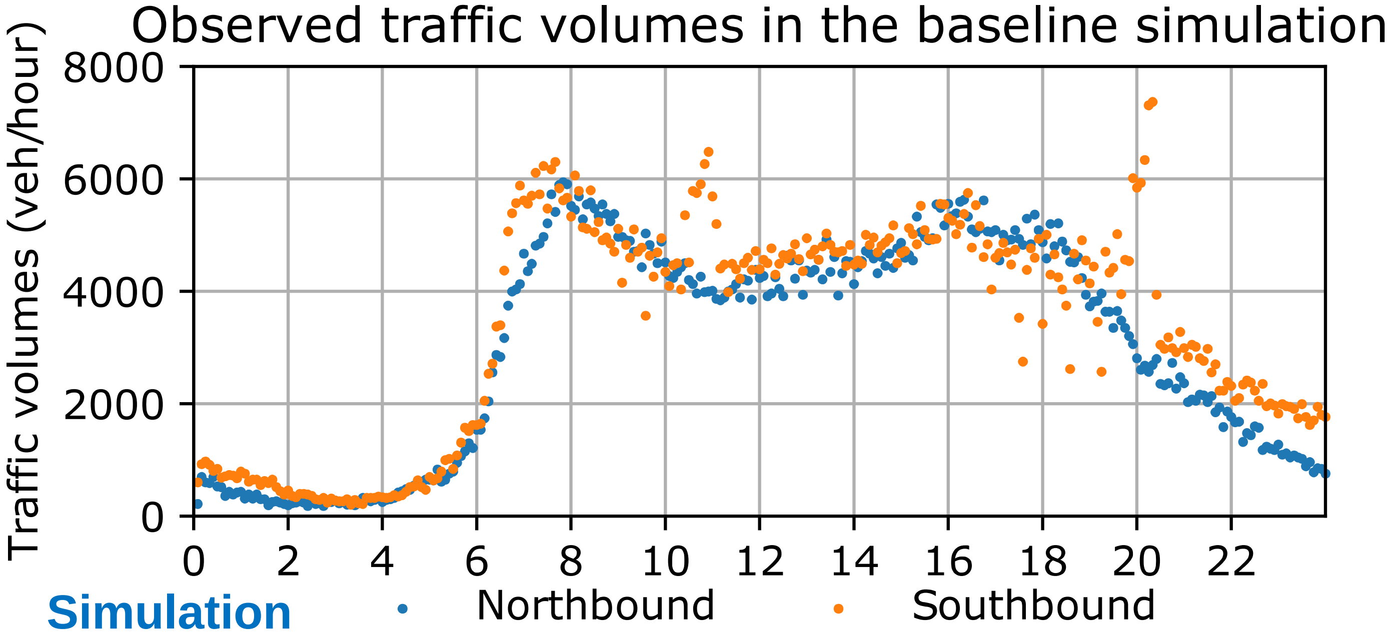


Real data **Simulation**

TII traffic data: https://www.nratrafficdata.ie/

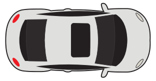
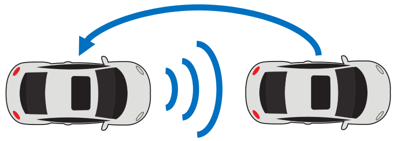
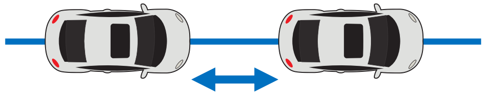
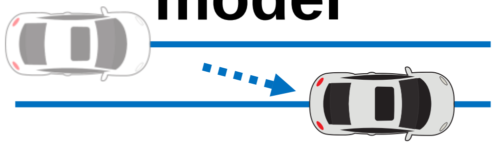
Real data





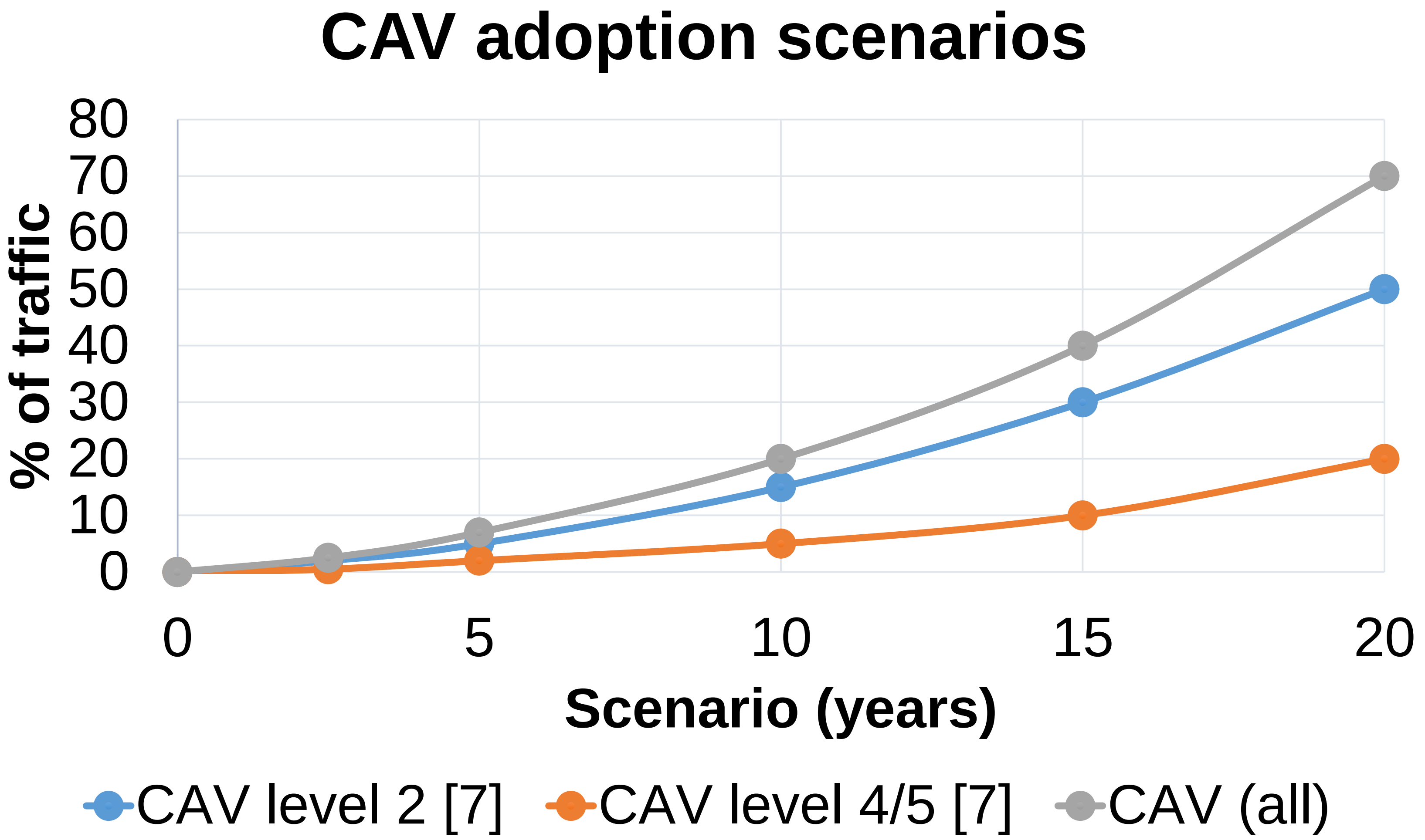
Simulation

Simulation set-up: models for HDV and CAV

	Human Driven Car/Truck 	**CAV (level 2)** 	**CAV (level 4/5)** 
Example	Human-driven cars and trucks	ACC or C-ACC enabled vehicles	Fully automated driving
Car-following model 	Krauss model [3,6] 1.5s headway [5] 50% variability	IDM [4,6] for (C)-ACC 0.8s headway [5] 5% sensor failure rate	IDM [4,6] for AV 0.6s headway [5] 5% sensor failure rate
Lane-changing model 	SUMO LC model [3,6] moderate cooperation and anticipation	SUMO LC model [3,6] moderate cooperation and anticipation	SUMO LC model [3,6] high cooperation and anticipation

[3] Lopez et al. (2018). 21st International Conference on Intelligent Transportation Systems (ITSC), 2575-2582. IEEE.
[4] Treiber and Kesting (2017). Transportation research procedia, 23, 174-187.
[5] Zhou et al. (2016). IEEE Transactions on Intelligent Transportation Systems, 18(6), 1422-1428.
[6] Do et al. (2019). Journal of Advanced Transportation.

Simulation set-up: CAV adoption scenarios



- A main challenge will be the short- and mid-term highly mixed traffic situation [2]
- Adoption scenarios are based on existing surveys [1] and literature [8]

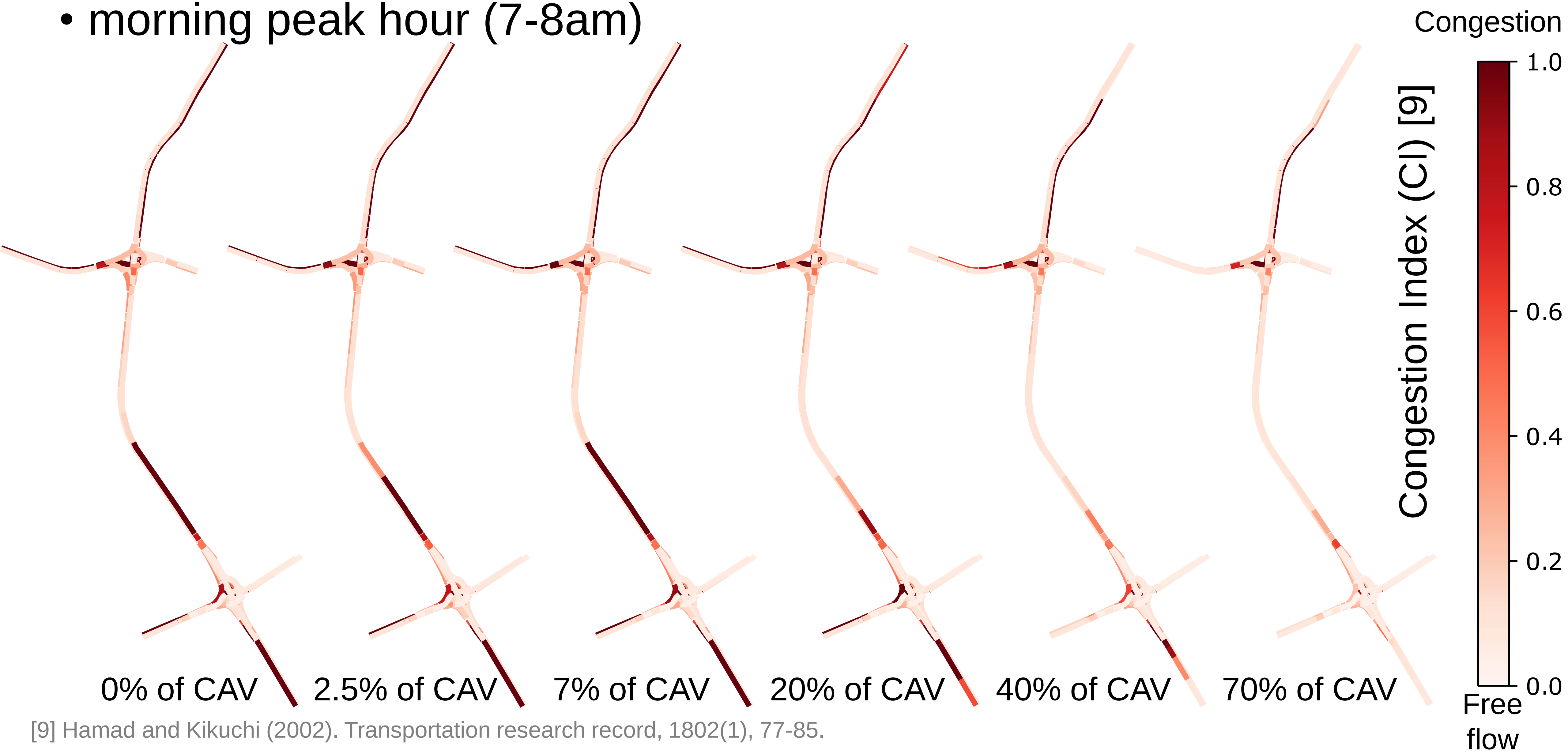
[1] Acheampong and Cugurullo (2019) Transportation research part F: traffic psychology and behaviour, *62*, 349-375.
[2] Guériau et al. (2016). Transportation research part C: emerging technologies, 67, 266-279.
[7] SAE international. (2016) - J3016.
[8] Bansal and Kockelman (2017). Transportation Research Part A: Policy and Practice, 95, 49-63.

Preliminary results:

- morning peak hour (7-8am)

Preliminary results: impact on traffic

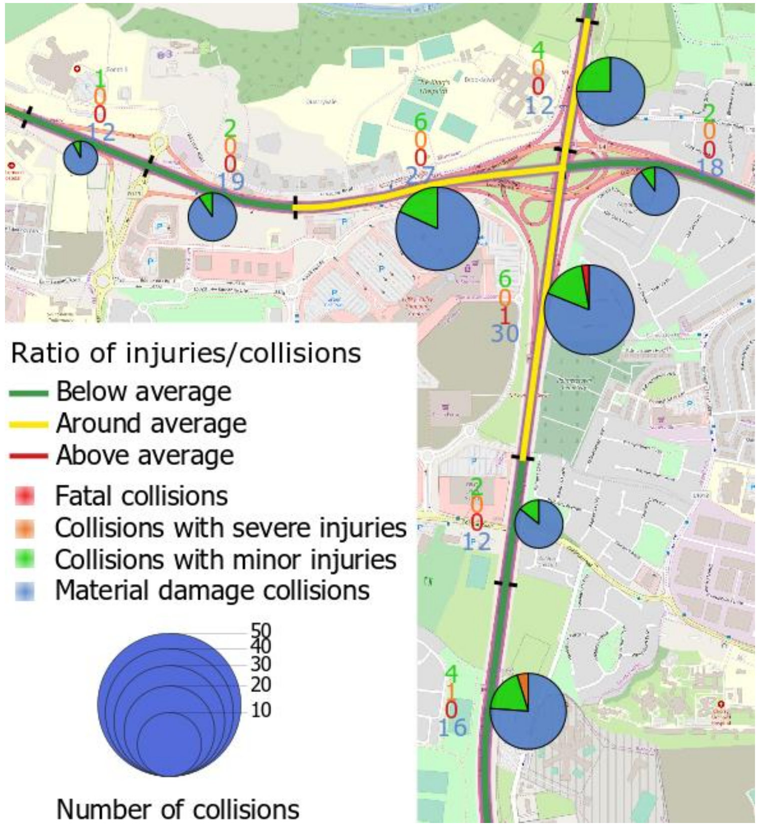
- morning peak hour (7-8am)



[9] Hamad and Kikuchi (2002). Transportation research record, 1802(1), 77-85.

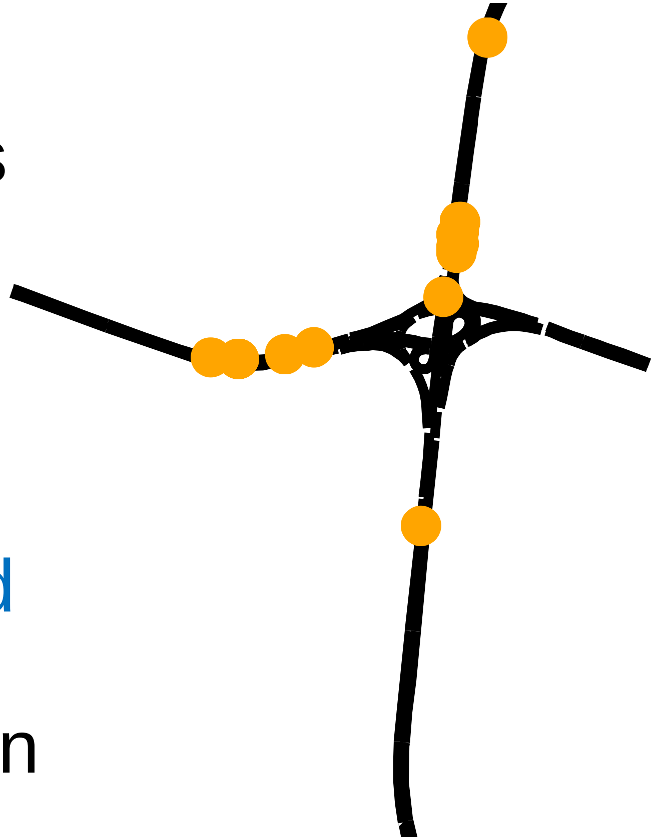
Preliminary results: impact on safety

- Surrogate safety indicators allow to detect conflicts [10] in simulation:



Real data

- for the motorway, Time to collision (TTC) is used, with specific thresholds:
  1.5s for HDV
  0.5s for CAV [11];
- the approach is validated by comparing detected conflicts with real collision data.



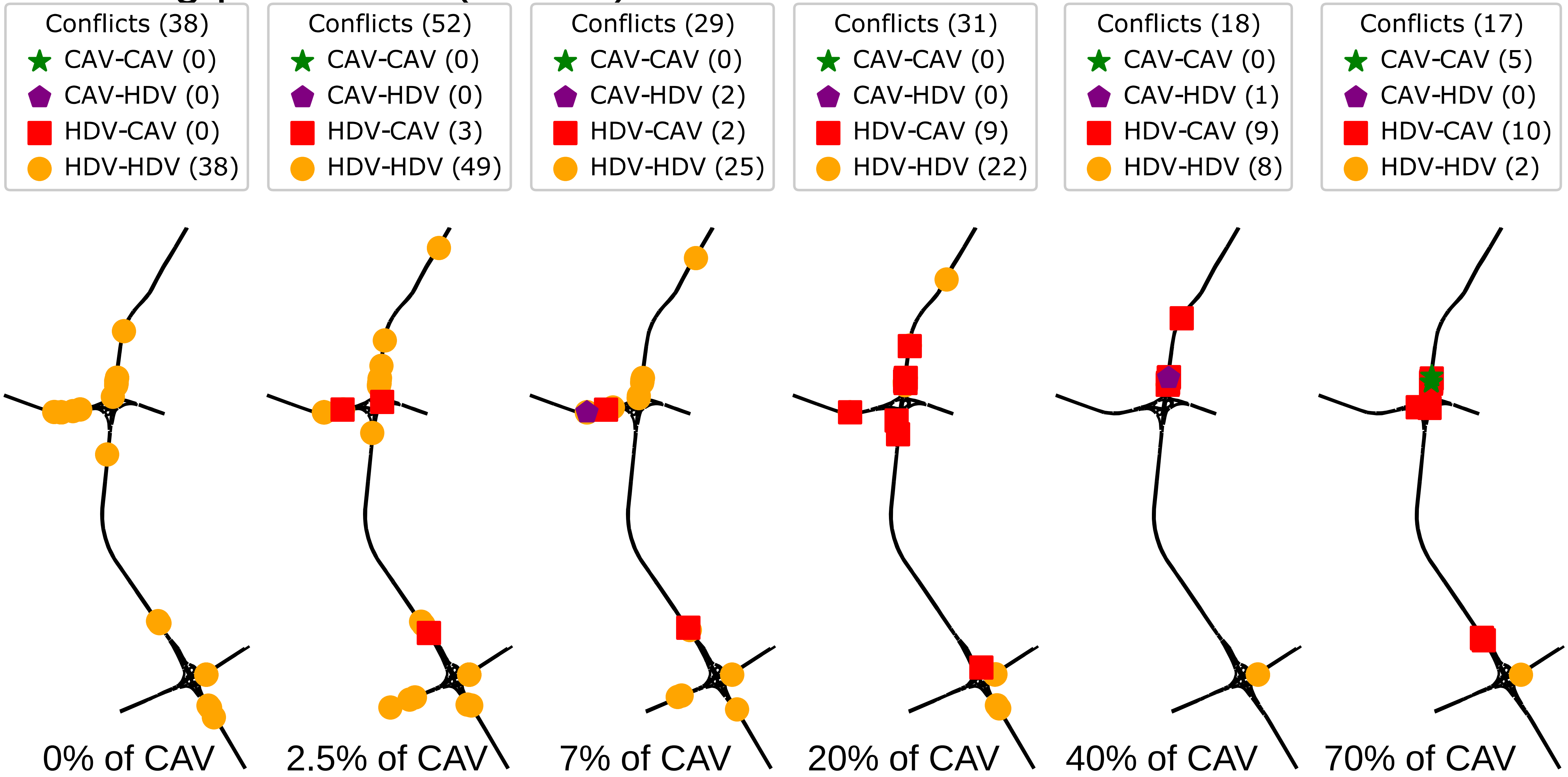
Simulation

RSA collision data: https://data.gov.ie/dataset/collision-rates-2014-to-2016

[10] Rahman et al. (2019). Transportation Research Part C: Emerging Technologies, 100, 354-371.
[11] Morando et al. (2018). Journal of Advanced Transportation, 2018.

Preliminary results: impact on safety

- morning peak hour (6-8am)



Conclusions and future work

- Availability of real data allows to build and validate realistic baseline scenarios, capturing specificities of the Irish network.
- State-of-the-art research models for CAV and HDV ensure realistic behaviours and variability.
- Preliminary results are consistent with literature [12,13], and show that while improvement is expected at long term, the short-term mixed traffic context would require more attention.
- New forms of mobility enabled by CAV like shared AV and dynamic ride-sharing [14] would affect the impact of CAV [15]

[12] Stern et al. (2018). Transportation Research Part C: Emerging Technologies, 89, 205-221.
[13] Ramin et al. (2018). Transportation Research Board Annual Meeting.
[14] Guériau and Dusparic (2018). International Conference on Intelligent Transportation Systems (ITSC). IEEE.
[15] Guériau et al. (2019). IEEE Intelligent Transportation Systems Magazine, in press.

Thank you!

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[1] Acheampong, R. A., & Cugurullo, F. (2019). Capturing the behavioural determinants behind the adoption of autonomous vehicles: Conceptual frameworks and measurement models to predict public transport, sharing and ownership trends of self-driving cars. Transportation research part F: traffic psychology and behaviour, *62*, 349-375.

[2] Guériau, M., Billot, R., El Faouzi, N. E., Monteil, J., Armetta, F., & Hassas, S. (2016). How to assess the benefits of connected vehicles? A simulation framework for the design of cooperative traffic management strategies. Transportation research part C: emerging technologies, 67, 266-279.

[3] Lopez, P. A., Behrisch, M., Bieker-Walz, L., Erdmann, J., Flötteröd, Y. P., Hilbrich, R., Lücken, L., Rummel, J., Wagner, P., & WieBner, E. (2018). Microscopic traffic simulation using sumo. In 2018 21st International Conference on Intelligent Transportation Systems (ITSC), 2575-2582. IEEE.

[4] Treiber, M., & Kesting, A. (2017). The intelligent driver model with stochasticity-new insights into traffic flow oscillations. Transportation research procedia, 23, 174-187.

[5] Zhou, M., Qu, X., & Jin, S. (2016). On the impact of cooperative autonomous vehicles in improving freeway merging: a modified intelligent driver model-based approach. IEEE Transactions on Intelligent Transportation Systems, 18(6), 1422-1428.

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[6] Do, W., Rouhani, O. M., & Miranda-Moreno, L. (2019). Simulation-Based Connected and Automated Vehicle Models on Highway Sections: A Literature Review. Journal of Advanced Transportation.

[7] SAE international. (2016). Taxonomy and definitions for terms related to driving automation systems for on-road motor vehicles. SAE International,(J3016).

[8] Bansal, P., & Kockelman, K. M. (2017). Forecasting Americans' long-term adoption of connected and autonomous vehicle technologies. Transportation Research Part A: Policy and Practice, 95, 49-63.

[9] Hamad, K., & Kikuchi, S. (2002). Developing a measure of traffic congestion: fuzzy inference approach. Transportation research record, 1802(1), 77-85.

[10] Rahman, M. S., Abdel-Aty, M., Lee, J., & Rahman, M. H. (2019). Safety benefits of arterials' crash risk under connected and automated vehicles. Transportation Research Part C: Emerging Technologies, 100, 354-371.

References III

[11] Morando, M. M., Tian, Q., Truong, L. T., & Vu, H. L. (2018). Studying the safety impact of autonomous vehicles using simulation-based surrogate safety measures. Journal of Advanced Transportation.

[12] Stern, R. E., Cui, S., Delle Monache, M. L., Bhadani, R., Bunting, M., Churchill, M., ... & Seibold, B. (2018). Dissipation of stop-and-go waves via control of autonomous vehicles: Field experiments. Transportation Research Part C: Emerging Technologies, 89, 205-221.

[13] Ramin, A., Kamrani, M., Khattak, A., & Rios-Torres, J. (2018). Safety impacts of automated vehicles in mixed traffic. 2018 Transportation Research Board Annual Meeting.

[14] Guériau, M., & Dusparic, I. (2018). SAMoD: Shared Autonomous Mobility-on-Demand using Decentralized Reinforcement Learning. In 2018 21st International Conference on Intelligent Transportation Systems (ITSC), 1558-1563. IEEE.

[15] Guériau, M., Cugurullo, F., Acheampong, R. A., Dusparic, I. (2019). Shared Autonomous Mobility-on-Demand: Learning-based approach and its performance in the presence of traffic congestion, IEEE Intelligent Transportation Systems Magazine, in press.