# Safety impact of dedicated lanes for connected and autonomous vehicles – a traffic microsimulation study

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Location: Athens
Date: June 2022

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# LEVITATE

Societal Level Impact of Connected & Automated Vehicles

€ 6,4 million project funded by the European Commission under the Horizon 2020 research framework programme

| | |
|---|---|
| Project coordinator: | Loughborough University |
| Start date: | 1st of December 2018 – 3.5 years |
| Partners: | 12 – from 10 countries |

# Scope – Connectivity & Automation related services

| Use case | Sub-use cases | | | | | |
|---|---|---|---|---|---|---|
| Urban mobility | Single point to point shuttle | Point to point shuttle across wide area | On demand anywhere to anywhere shuttle | On demand last mile shuttle | On demand e-hailing service | |
| Passenger cars | Dedicated lanes for CAVs | Road use pricing | Parking space regulations | Parking Price Policies | Automated ride sharing | Green light optimal speed advisory |
| Freight and logistics | Automated urban delivery | Automated freight consolidation | Hub to hub automated transport | Platooning on urban bridges | | |

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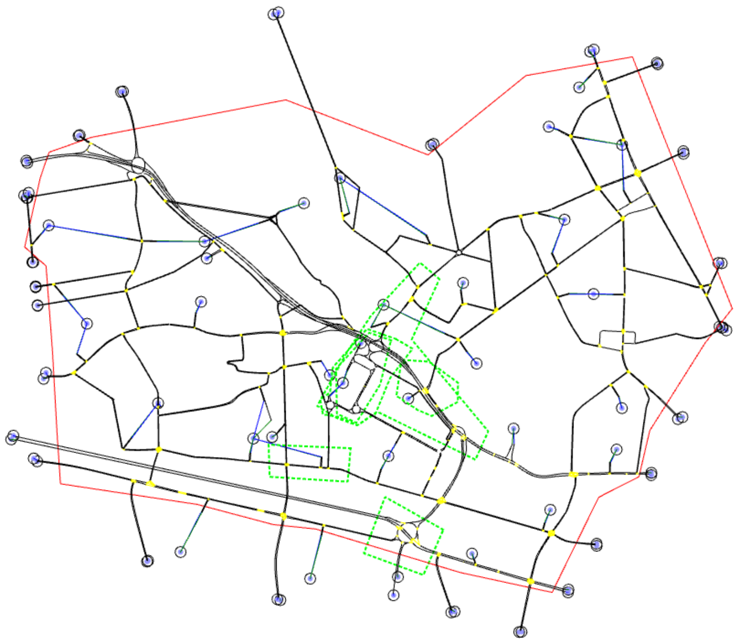
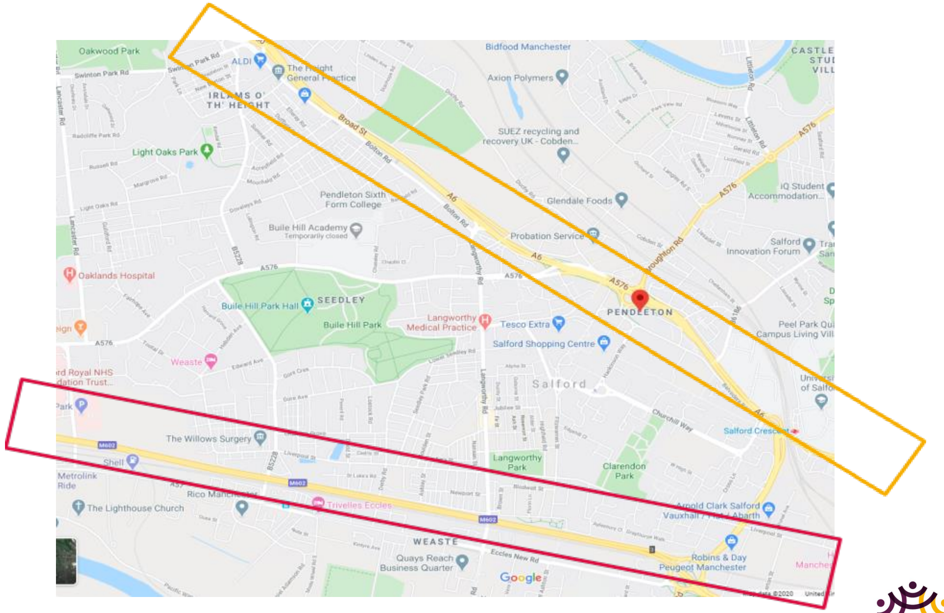
# Manchester Network

- An arterial – A road (A6) which leads to the centre of Manchester
- A motorway M602 which leads to the centre of Manchester
- An extensive network of small roads in between






Area: 13 km²

Nodes: 308

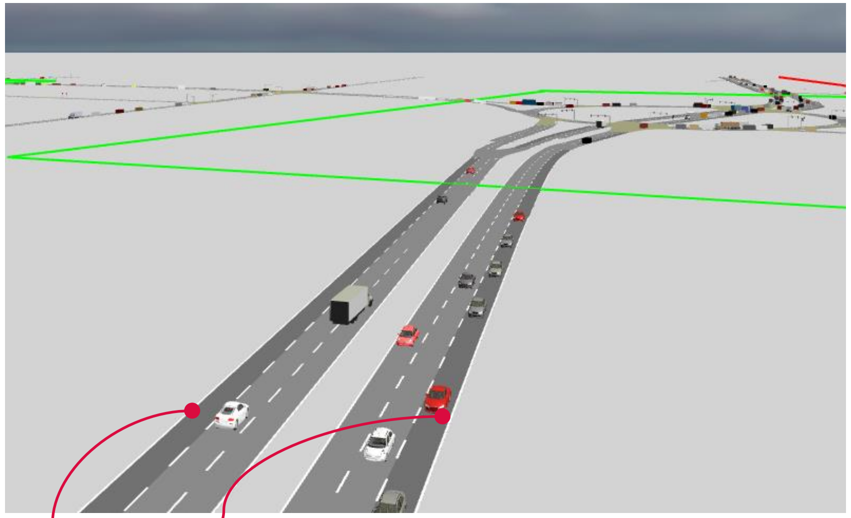
Sections: 732

Traffic Characteristics:

- Car: 23226 trips
- LGV: 1867 trips
- HGV: 763 trips

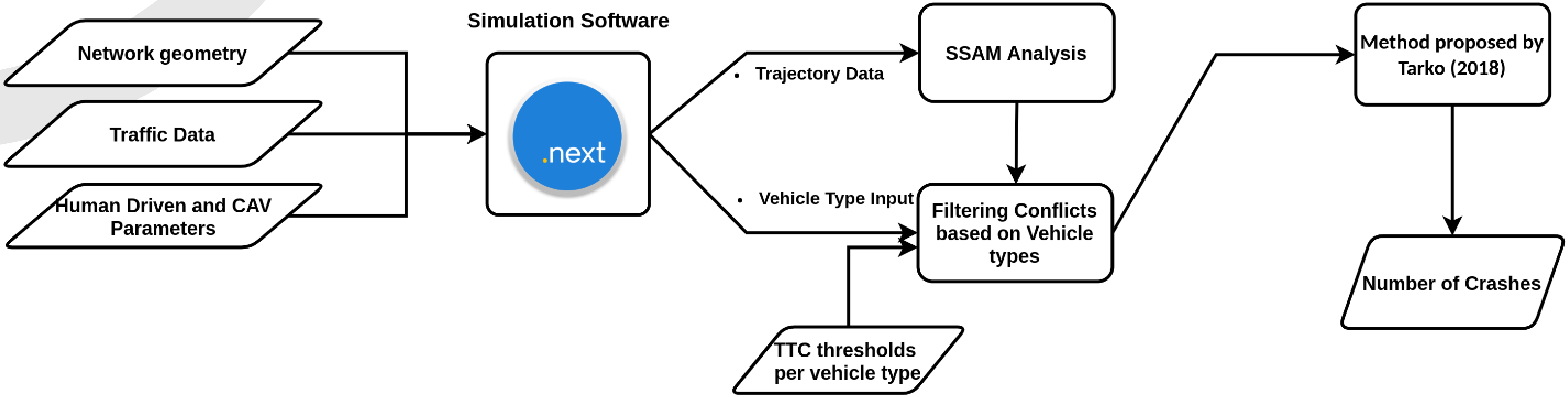
# Scenarios

- Baseline scenario – CAV implementation without a dedicated lane
- Motorways only – CAVs use a dedicated (innermost) lane in the motorway
- Motorway & A-roads – CAVs use a dedicated (innermost) lane in the motorway and the A-road
- A-roads left most lane – CAVs use a dedicated (innermost) lane in the A-road
- A-road right most lane – CAVs use a dedicated (outermost) lane in the A-road

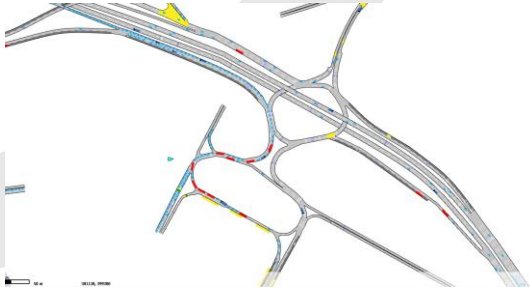


Dedicated lane for AVs

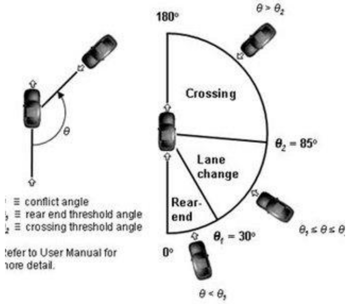
# Methodology



# Conflicts to crashes

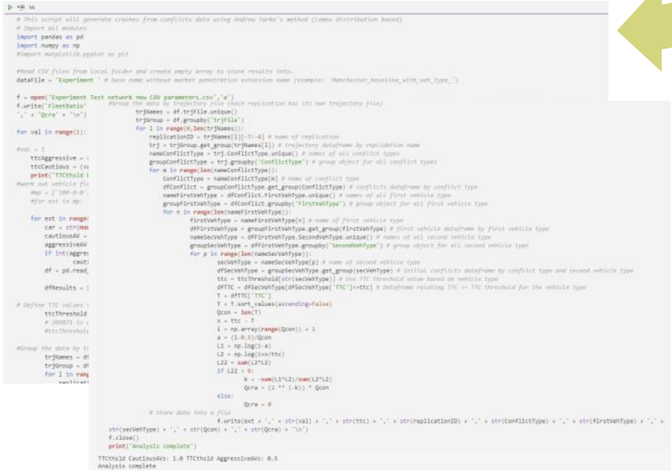


Trajectory file

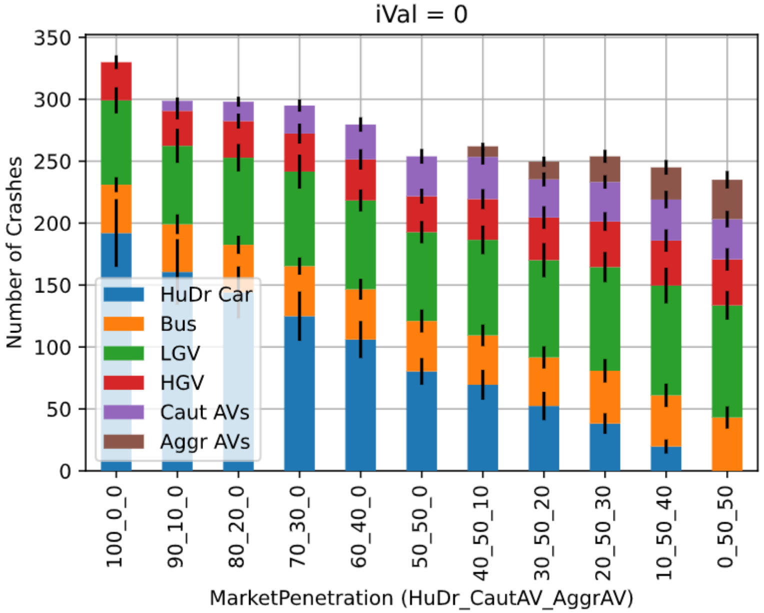



SSAM

Conflicts file



Post analysis and conversion conflicts to crashes based on Andrew Tarko's method

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# CAV parameters and deployment scenarios

**Within LEVITATE, two types of CAVs were considered: 1st Generation (Gen) CAVs and 2nd Gen CAVs. Both types are assumed to be fully automated vehicles with level 5 automation.**

- 1st Gen: limited sensing and cognitive ability, long gaps, earlier anticipation of lane changes than human-driven vehicles and longer time in give way situations.
- 2nd Gen: advanced sensing and cognitive ability, data fusion usage, faster decision making, smaller gaps, earlier anticipation of lane changes than human-driven vehicles and less time in give way situations

CAV Deployment scenarios in LEVITATE project

| Type of Vehicle | CAV Deployment Scenarios | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | A | B | C | D | E | F | G | H |
| Human-Driven Vehicle - passenger vehicle | 100% | 80% | 60% | 40% | 20% | 0% | 0% | 0% |
| 1st Gen (Cautious) CAV - passenger vehicle | 0% | 20% | 40% | 40% | 40% | 40% | 20% | 0% |
| 2nd Gen (Aggressive) CAV - passenger vehicle | 0% | 0% | 0% | 20% | 40% | 60% | 80% | 100% |
| Human-Driven LGV | 100% | 80% | 40% | 0% | 0% | 0% | 0% | 0% |
| LGV-CAV | 0% | 20% | 60% | 100% | 100% | 100% | 100% | 100% |
| Human-Driven HGV | 100% | 80% | 40% | 0% | 0% | 0% | 0% | 0% |
| HGV-CAV | 0% | 20% | 60% | 100% | 100% | 100% | 100% | 100% |

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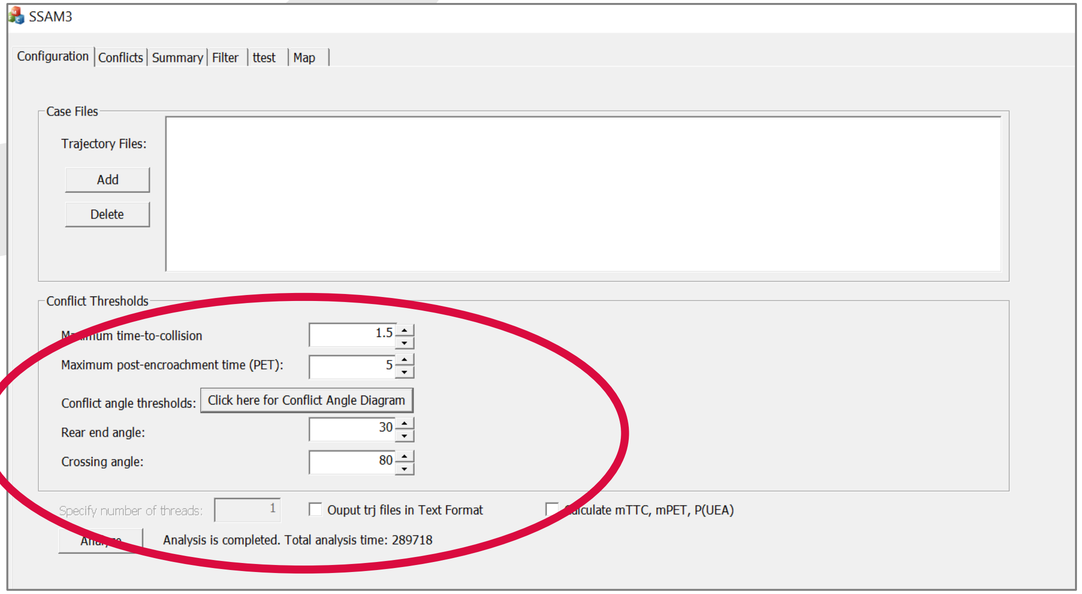
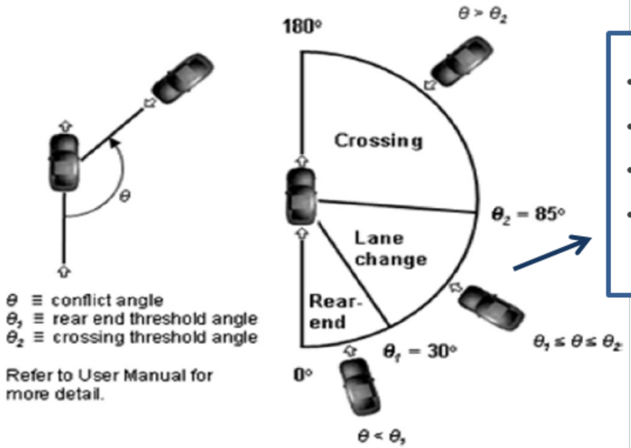
# Identifying traffic Conflicts

In SSAM, conflicts are identified based on the specific thresholds for TTC and PET and the conflict angle.




- Unclassified: Conflict angle unknown;
- Rear-end: ‖conflict angle‖ < 30°;
- Crossing: ‖conflict angle‖ > 85°,
- Lane change: 30° ≤ ‖conflict angle‖ ≤ 85°.

**Within LEVITATE, the TTC threshold was set to 1.5s for human-driven vehicles, 1.0s for 1st Gen CAVs, and 0.5s for 2nd Gen CAVs based on existing studies (Morando et al., 2018; Sinha et al., 2020; Virdi et al., 2019).**

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# Converting the number of conflicts to number of crashes –Tarko method

**Within LEVITATE, the number of conflicts was converted to the number of crashes by applying a probabilistic method proposed by Tarko (2018).**

$$F(x) = \begin{cases} 1 - (1 + \theta x)^k \ if \ \theta > 0 \\ 1 - e^{-k\theta x} \ if \ \theta = 0 \end{cases}$$

- There is unavailability of suitable empirical crash data involving automated vehicles.
- It provides a theoretical and numerical basis for justifying the Lomax distribution.
- It relies on TTC distribution and does not require crash data.

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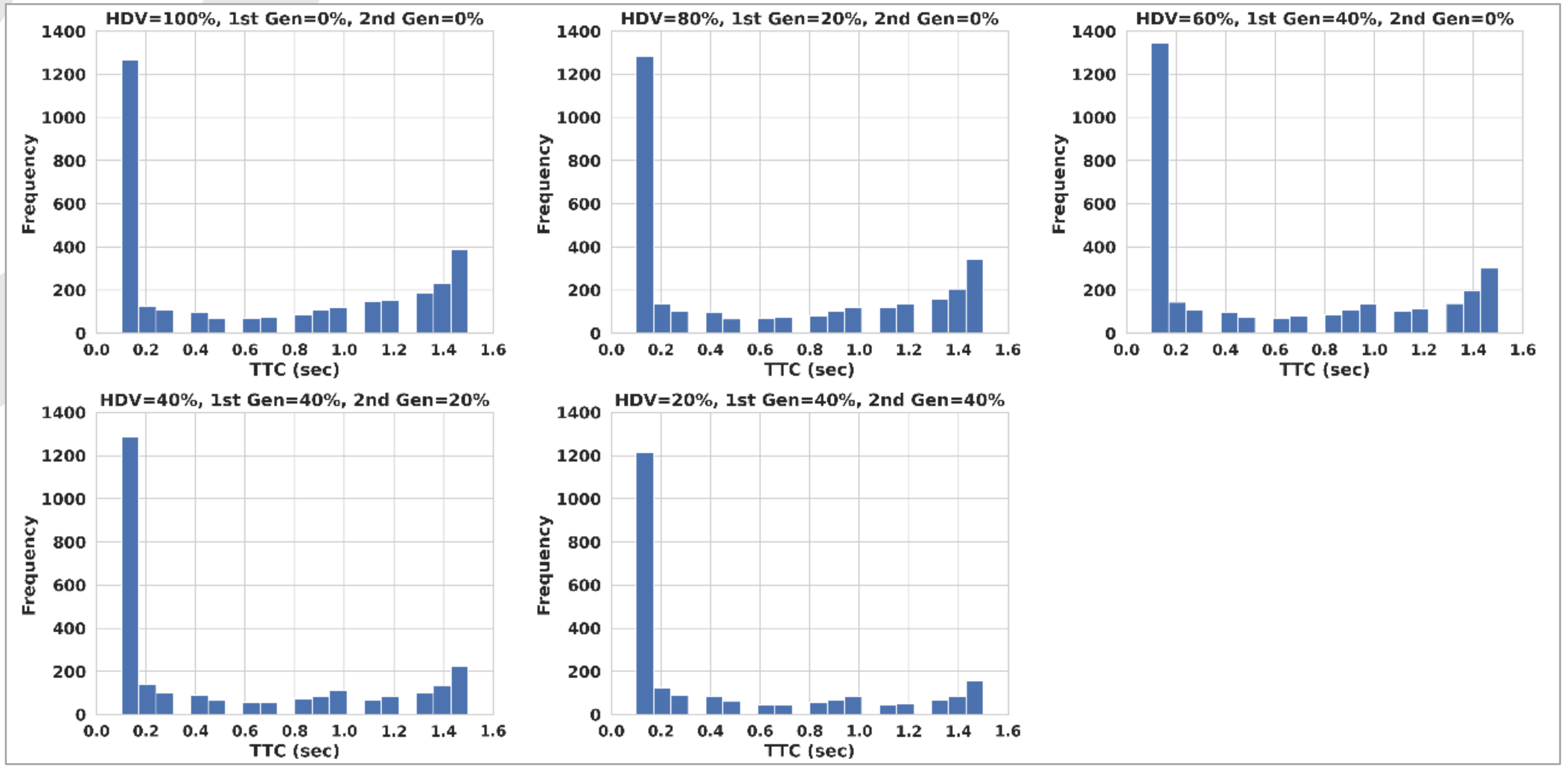
# TTC distribution




- A significant number of events are falling at very low TTC values i.e., at 0.1s.
- SSAM is likely to mark even safe interactions involving CAVs as conflicts due to shorter headways.
- Thus, the number of events with very low values of TTC (0.1) can be considered as noise/systematic bias which could be either from AIMSUN Next or/and SSAM.
- It is decided to remove the noise in the conflicts data with very low TTC values.

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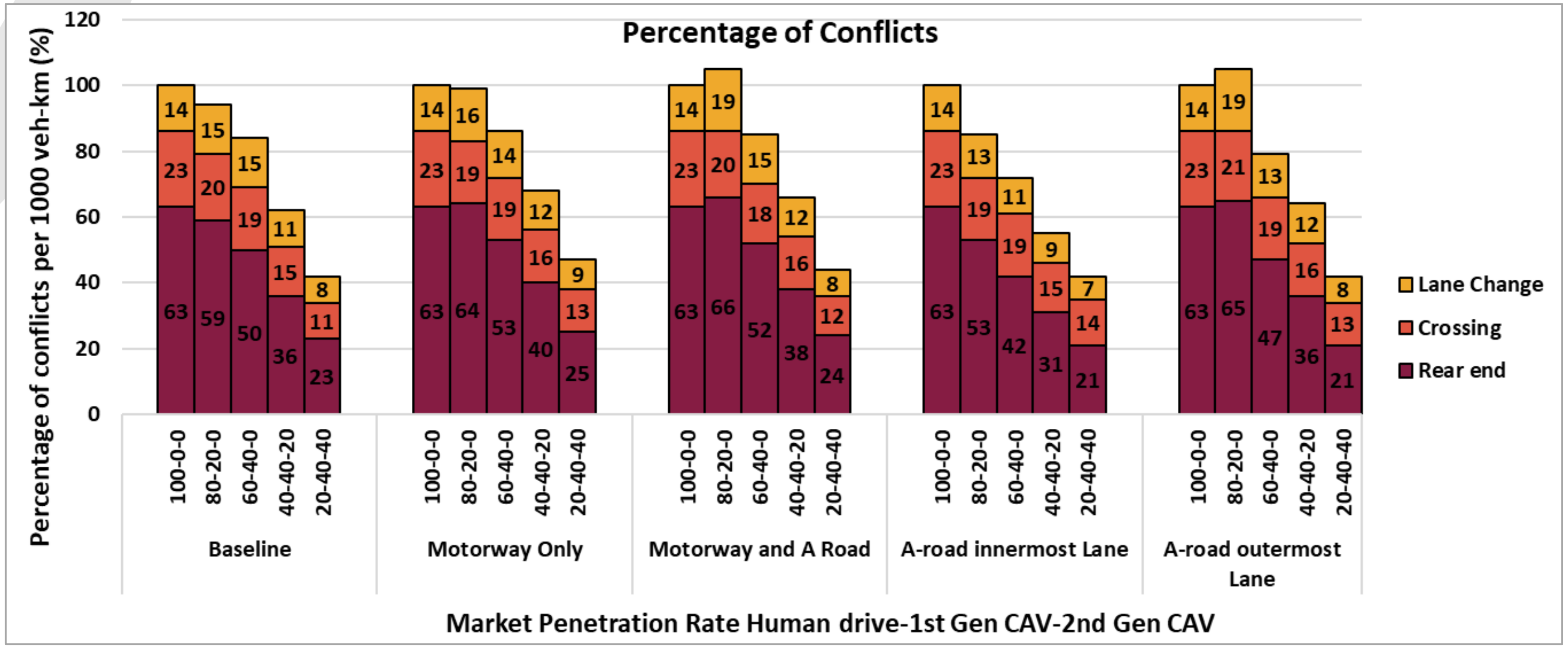
# Identified traffic conflicts




- The overall decreasing trend for all tested scenarios in conflicts with higher MPR of CAVs can be observed.
- A reduction between 53% to 58% in conflicts can be achieved for all scenarios.
- The rear-end type conflicts contribute to the majority of the conflicts across all scenarios, this is consistent with the finding from previous studies that rear-end conflicts happen more often with autonomous vehicles in both simulation experiments and in the real world.

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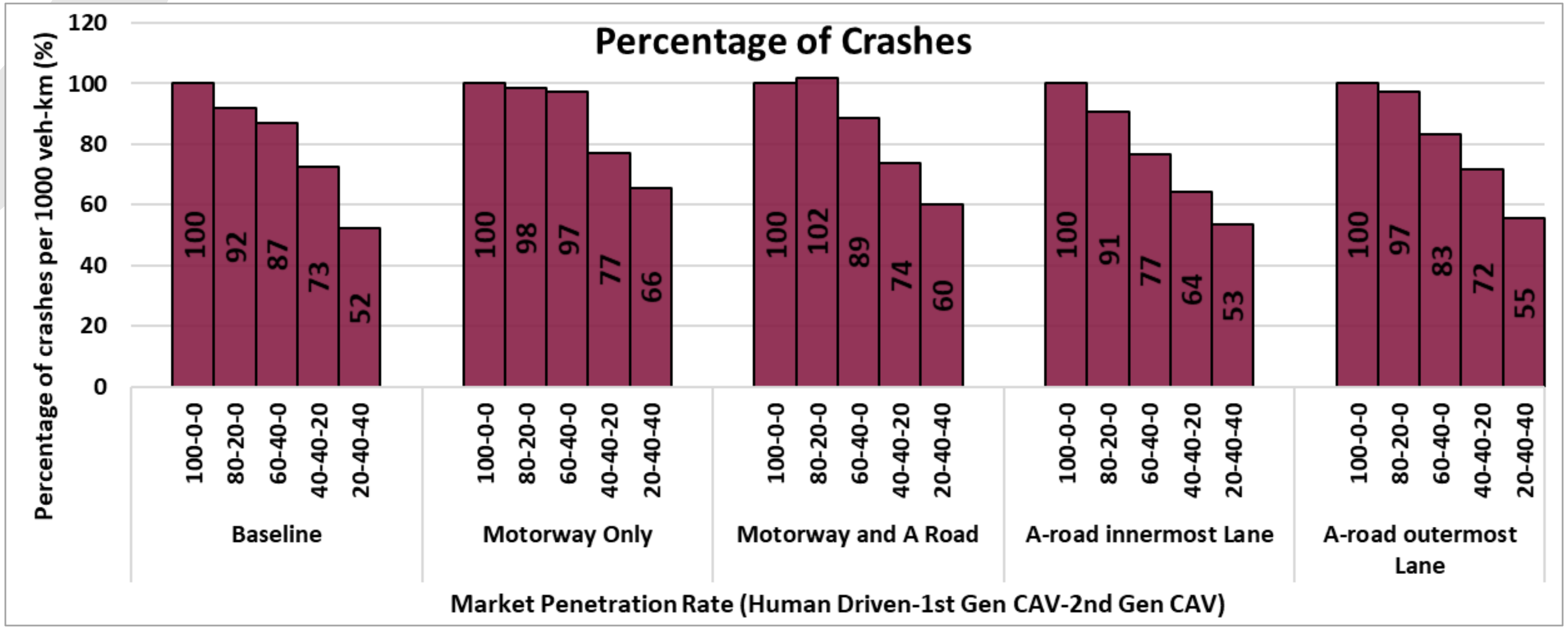
# Estimation of crashes from conflicts




- The percentage reduction in crashes at full market penetration rate of CAVs is estimated between 34% and 48% for all tested scenarios.

# Key Findings

- The results showed a decrease in crashes with increasing MPR of CAVs under all tested configurations of CAVs;
- With respect to the baseline (without dedicated lanes for CAVs), only the A road innermost scenario showed a reduction in crashes.
- Dedicated lanes are expected to increase the number of crashes per km travelled compared to the baseline scenario (no dedicated lane) at low and high MPR levels.
- When CAV penetration rates are very low (<= 20%), a dedicated lane is predicted to result in up to 17% more crashes than the baseline scenario.
- When the vehicle fleets are more equally split, a small benefit can be seen of dedicated lanes when implemented on A-level roads.

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