# A Multi-Scenario Simulation Approach for Climate-Neutral Urban Corridors

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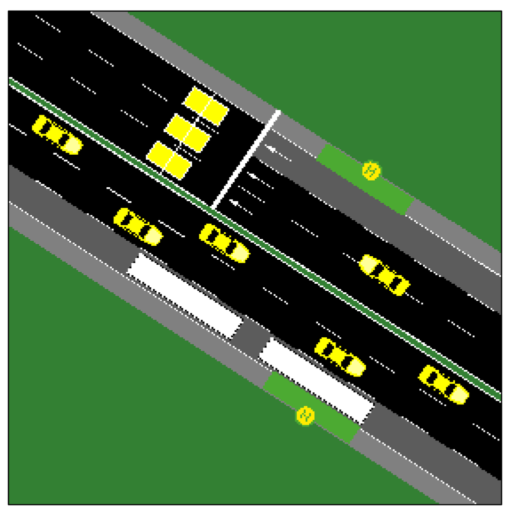
## Research Scope & Objectives

To achieve climate neutrality, dense urban environments must transition from car-centric layouts to multimodal corridors. This study, aligned with Thessaloniki's **Net Zero Cities** initiative, evaluates the transformation of a major urban arterial corridor using **SUMO microscopic traffic simulation**. The research compares four scenarios:

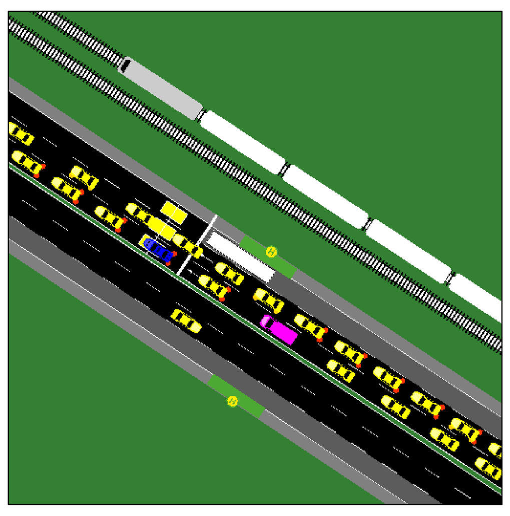
- **Baseline:** Existing road configurations.
- **Scenario 1:** Metro integration with existing road configurations.
- **Scenario 2:** Redesign featuring one general-purpose lane, one bus lane, and protected unidirectional bike lanes per side.
- **Scenario 3:** Redesign featuring a bidirectional central bike path, one general-purpose lane, and one bus lane per direction.

The analysis weighs vehicular efficiency against sustainable transport KPIs. While Metro integration alone maximizes current corridor performance, reallocation scenarios are essential for Net Zero modal shift targets. Findings suggest side-running bike lanes offer a balanced transition, whereas central bike lane configurations require sophisticated traffic signalling to mitigate delays and ensure safety. This provides a transferable roadmap for arterial interventions.

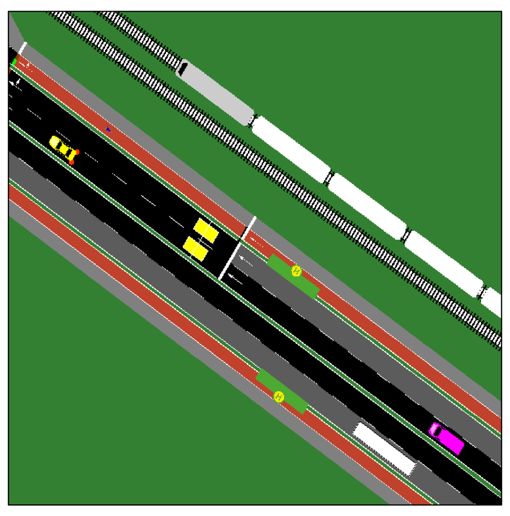
**Baseline**



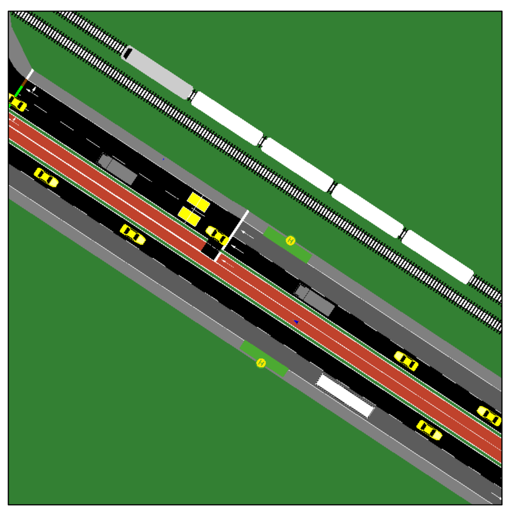
**Scenario 1**



**Scenario 2**



**Scenario 3**

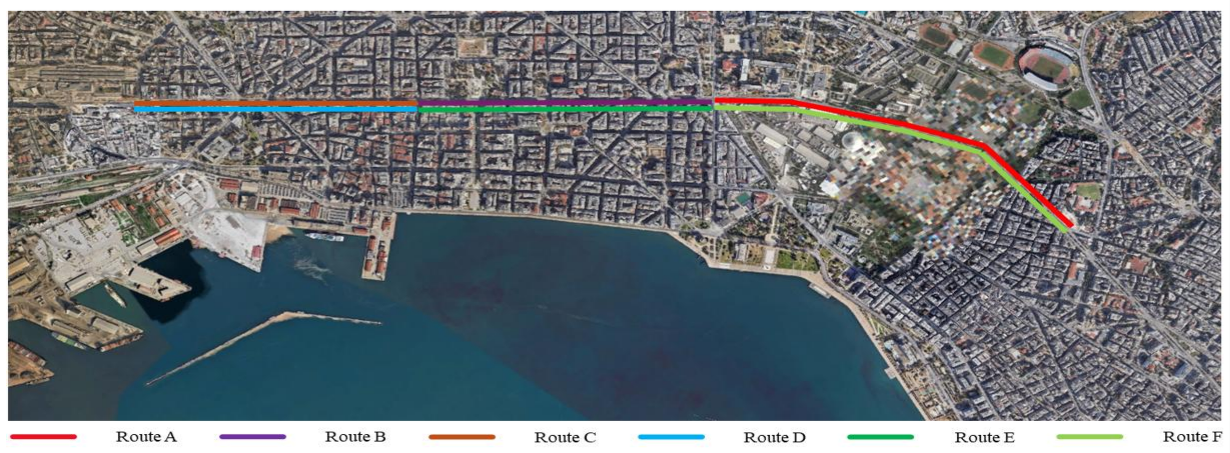


## Methodology & Data

**SUMO (Simulation of Urban MObility)** used for microscopic traffic modelling and simulations.

- Network topology imported from OpenStreetMap.
- Bus stops/lines/schedules imported via the GTFS information provided by the public transport authority TheTA.
- Traffic signal plans provided by technology providers in OCIT-C format and encoded in SUMO.
- Traffic flow and pedestrian counts estimated via:
  - ✓ 66 traffic detectors (magnetometers)
  - ✓ On-site traffic studies conducted by CERTH.
- Data validation and calibration
  - ✓ Trail-and-error approach
  - ✓ Simulated traffic flows and occupancies compared against real-world data from detectors
  - ✓ Simulated travel times compared vs travel times from real world FCD along 6 routes

**Study Area**




**Modal Splits across simulation scenarios**

| Mode | Baseline | Scenario 1 | Scenario 2 | Scenario 3 |
|---|---|---|---|---|
| Passenger Car | 55.6% | 46.22% | 41.68% | 41.68% |
| Taxi | 1.7% | 1.51% | 1.51% | 1.51% |
| LGV | 2.4% | 2.40% | 2.40% | 2.40% |
| HGV | 0.7% | 0.71% | 0.71% | 0.71% |
| PT | 18.5% | 22.42% | 24.09% | 24.09% |
| Walking | 21.1% | 24.10% | 24.10% | 24.10% |
| Bicycle | - | - | 1.61% | 1.61% |

## Key Findings

- ❖ **Metro integration with existing road configurations and a redesigned PT plan that reduces bus trips by 30% achieves best traffic performance;** it represents the optimal configuration for vehicular throughput when modal share remains stable.
- ❖ **Unidirectional side-running bicycle infrastructure scenario provides a balanced outcome**; traffic performance is acceptable when ≥ 40% of trips are made by PT and ≥ 2% by bike (neutral scenario).
- ❖ **Centralized bidirectional bicycle infrastructure scenario creates complex interactions at junctions requiring optimization of signal phases.** Extended green phases for bicycles under optimistic modal shift significantly improve traffic performance.
- ❖ **Modal shift is the key determinant;** sensitivity analysis of modal splits demonstrates that infrastructure reallocation allows bike infrastructure scenarios to achieve positive outcomes only when combined with substantial modal shift.
- ❖ Scenarios 2 & 3 under conservative modal split produce substantially high $CO_2$ emissions; **road space reallocation without demand management induces stop-and-go patterns and increasing emissions**.

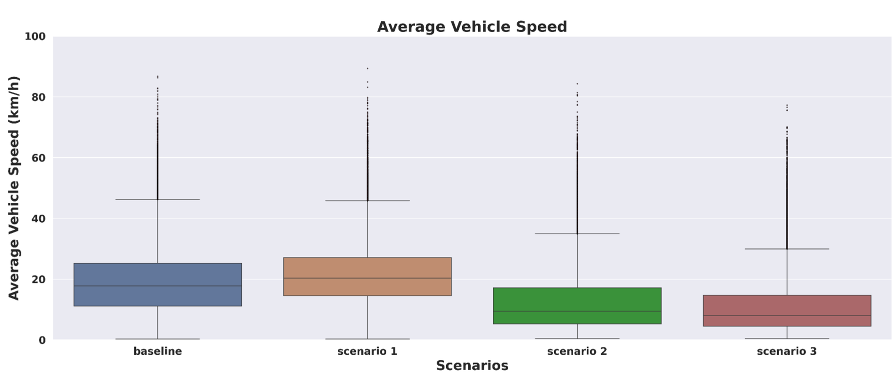
## Future challenges

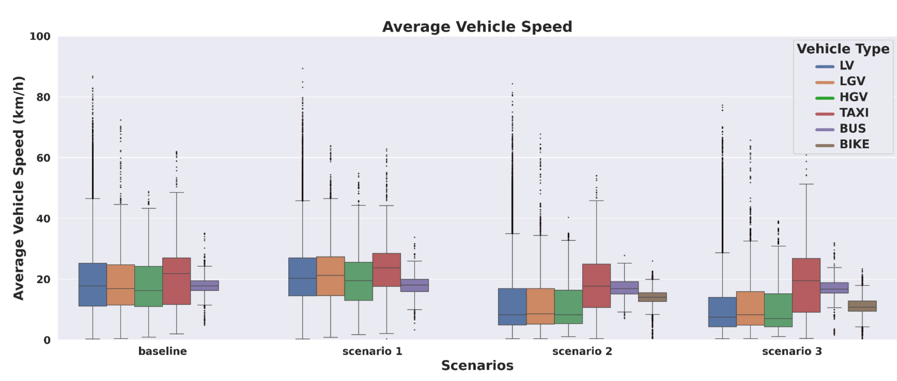
- ❑ Maintaining traffic capacity while introducing bike lanes, requires **optimization of signal control**.
- ❑ Achieving modal shifts to active mobility depends also on **demand management**, **behavioral incentives** and **public engagement**.
- ❑ Investigating **adaptive signal control strategies** capable of dynamically adjusting to multimodal flows.

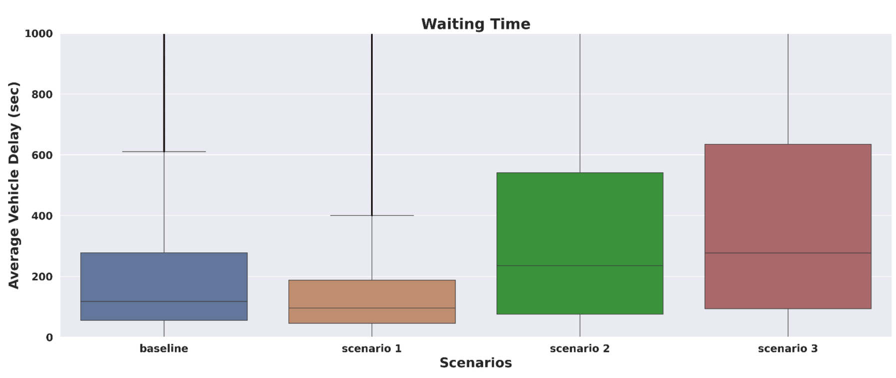
## Simulation Results

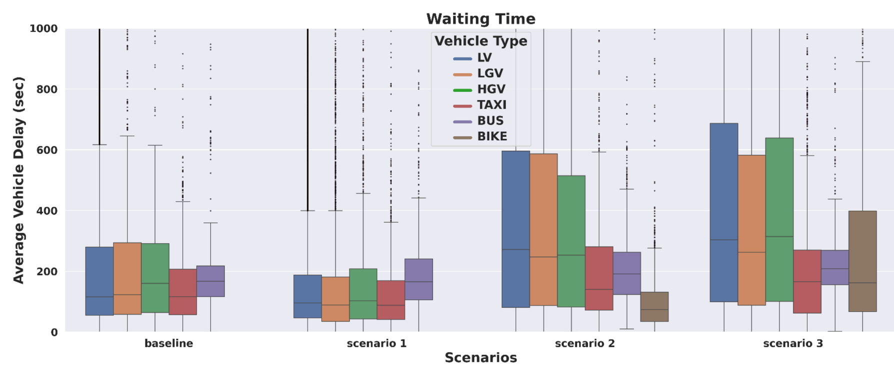
- ✓ Scenario 1 performs best, combining a new metro line with an optimized bus network, resulting in smoother traffic flow, higher network speed, resulting from the **expected modal shift toward PT** and the **reduction in bus trip frequency**.
- ✓ Average delay and number of stops increase in Scenarios 2 and 3, due to **reduced capacity for vehicular traffic** and **marginal shift towards sustainable modes**.
- ✓ Scenario 1 is the most environmentally efficient, while Scenarios 2 and 3 perform worse, due to road space reallocation worsening traffic conditions in the **absence of significant modal shift**.
- ✓ Scenario 3 performs worse compared to Scenario 2 due to to the **additional signal phases and control strategies** required to accommodate central cycling lanes.

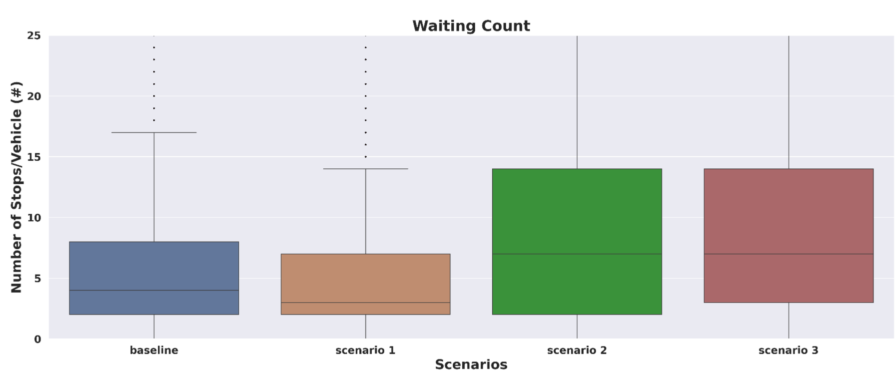
**Traffic Performance and Environmental KPIs**

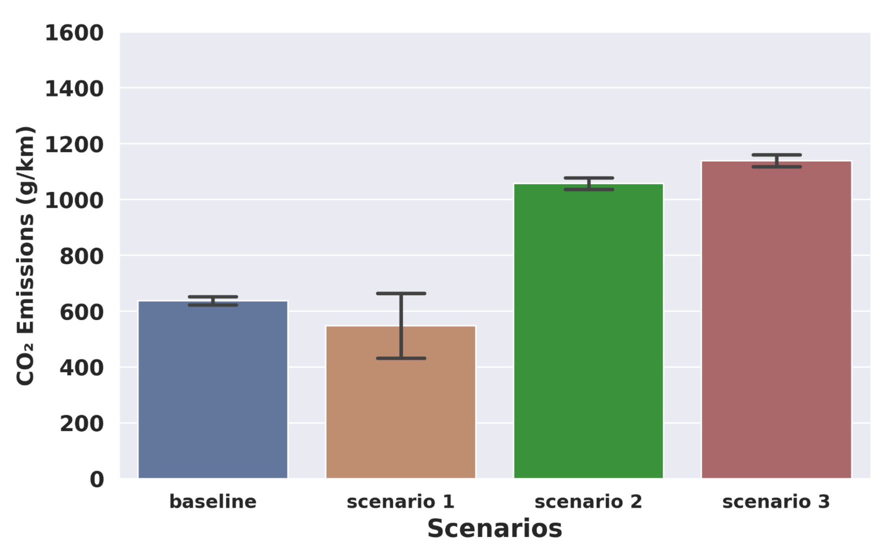


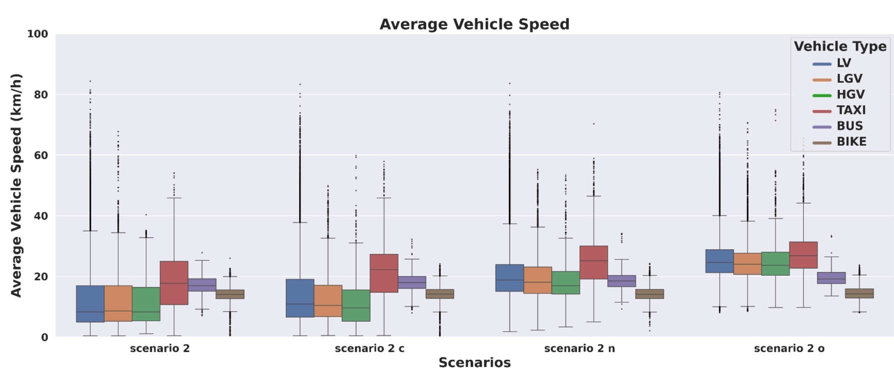




## Sensitivity Analysis on Modal Split

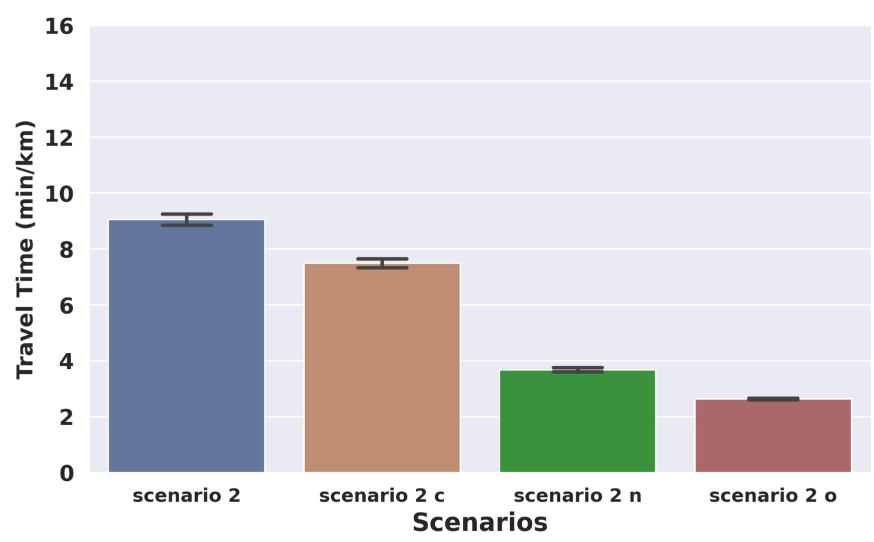
**Sensitivity Analysis on Modal Splits for Scenarios 2 & 3:**

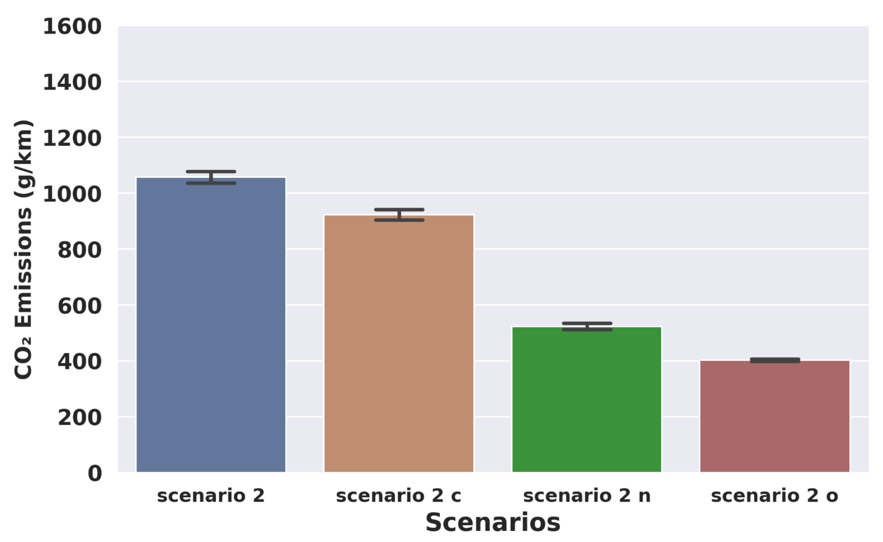
| Alternative MS | Passenger Car | Public Transport | Bike |
|---|---|---|---|
| Conservative (c) | 38.5% | 30.1% | 1.8% |
| Neutral (n) | 28.2% | 40.1% | 2.2% |
| Optimistic (o) | 17.8% | 50.1% | 2.5% |

**Comparison of alternative MS**








- ✓ Road network performance improves due **to substantial modal shift towards sustainable and active travel modes.**
  - ✓ Waiting times decrease, average vehicle speeds increase, and $CO_2$ emissions reduce.
- ✓ Negative traffic impacts can be reduced via modal shift, requiring **combined infrastructure and behavioral measures** for sustainable mobility.
- ✓ For Scenario 3, a second optimistic alternative (2o) with adjusted signal timing for bikes (12 instead of 8 sec min green phase) results in decreased delays, indicating that modal shift combined **with effective traffic signaling** could enhance network efficiency.