FACULTY OF TRANSPORTATION SCIENCES CTU IN PRAGUE

# Enhancing intelligent urban road transport network and cooperative systems for highly automated vehicles

## MAVEN expert group meeting

## Impact assessment

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Czech Republic

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MAVEN

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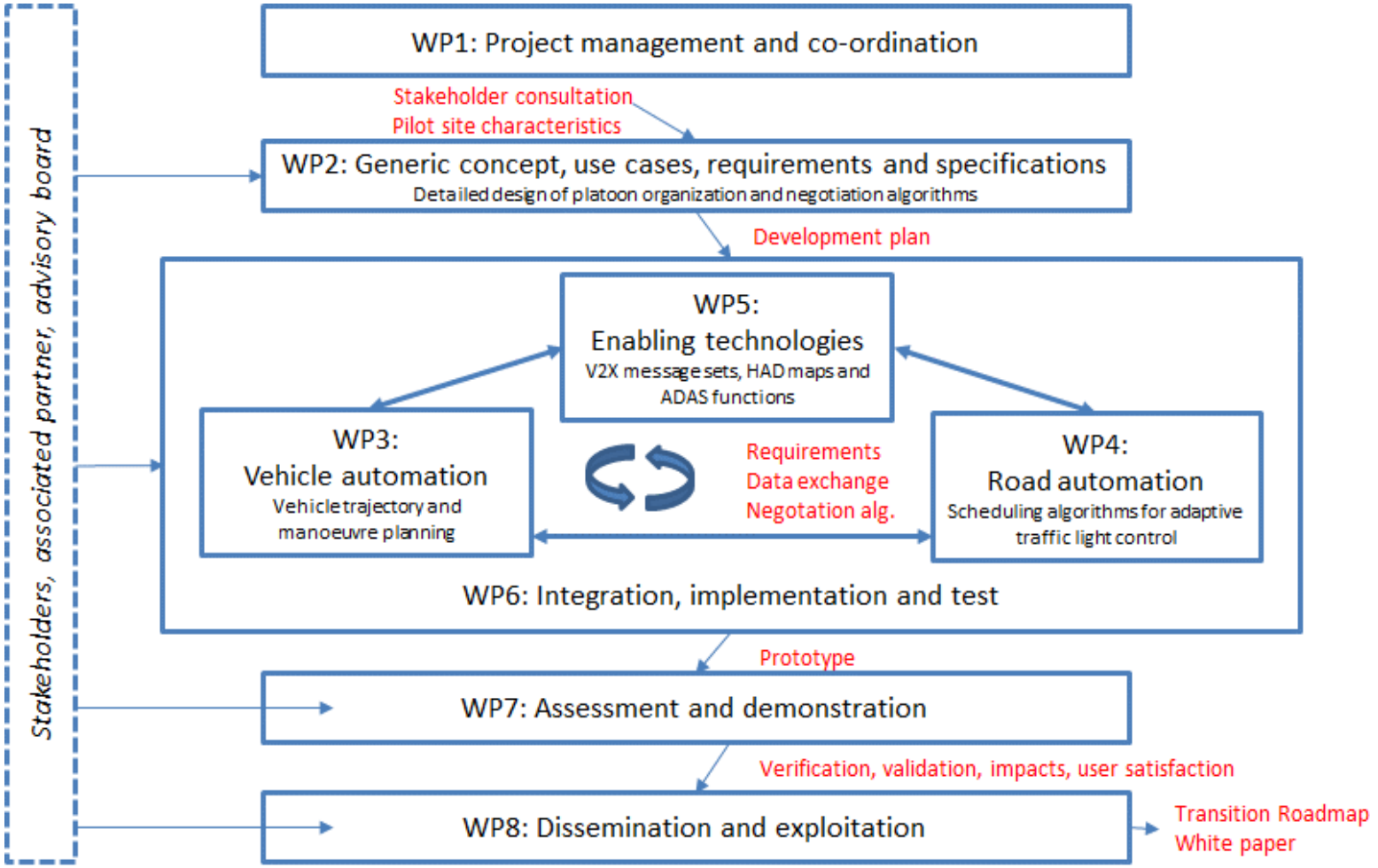
# WP7 builds on the results of other WPs

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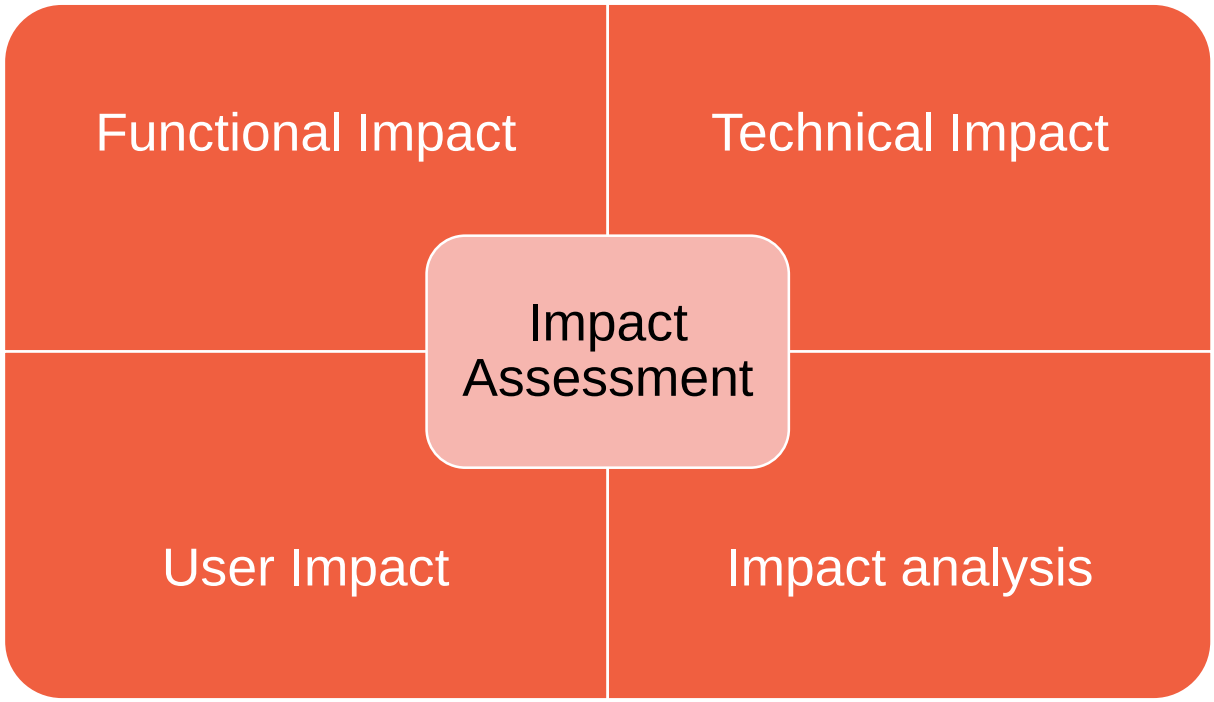
# Dimensions of Impact assessment in MAVEN

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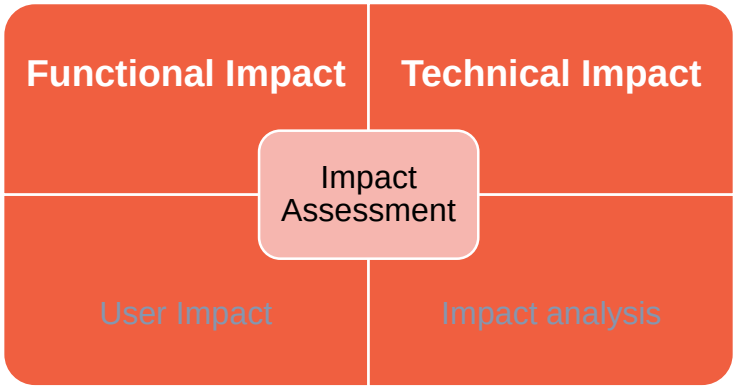
# Link among the particular Use Cases, Locations and Verification Methods

| | Simulation | | | Field Tests | | Emulation |
|---|---|---|---|---|---|---|
| | Braunschweig | Helmond | Prague | Braunschweig | Helmond | Braunschweig |
| UC1: Platoon initialization | x | x | | x | | x |
| UC2: Joining a platoon | x | x | | x | | x |
| UC3: Traveling in a platoon | x | x | | x | | x |
| UC4: Leaving a platoon | x | | | x | | |
| UC5: Platoon break-up | x | | | x | | |
| UC6: Platoon termination | x | | | | | |
| UC7: Speed change advisory | x | x | x | x | x | |
| UC8: Lane change advisory | | x | | x | x | |
| UC9: Emergency situations | | | | | | x |
| UC10: Priority management | | x | | | x | |
| UC11: Queue length estimation | x | x | x | | x | |
| UC12: Local level routing | | | x | | | |
| UC13: Network coordination - green wave | | x | | | x | |
| UC14: Signal optimization algorithms | | x | x | | x | |
| UC15: Negotiation | | x | | | x | |
| UC16: Detect non-cooperative road users | | | | x | | x |




# 1. Verification of requirements

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# Verification plan

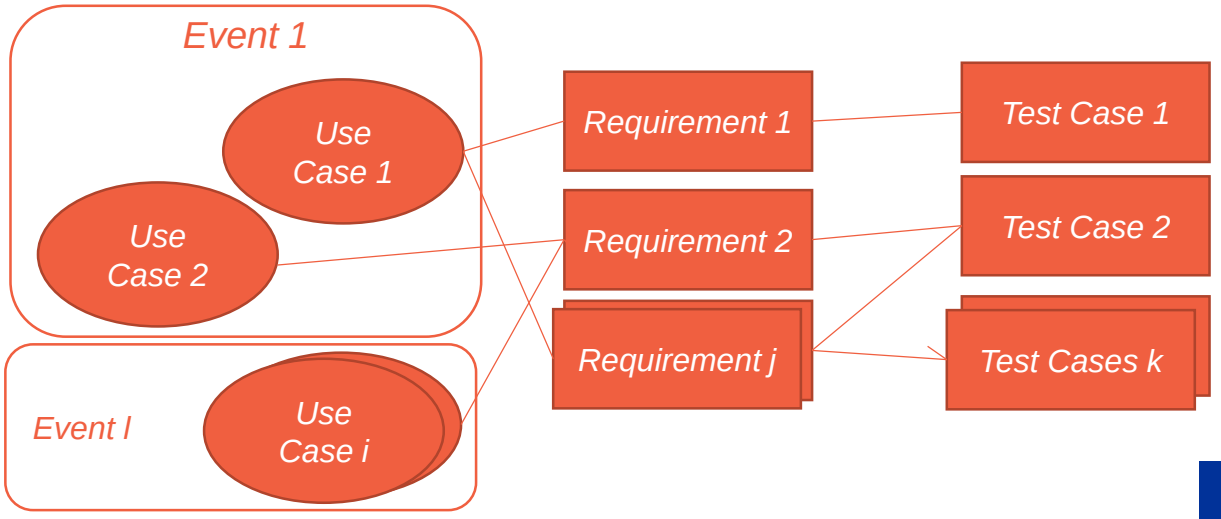
## (Full traceability)

1. MAVEN Use Cases identified (D2.1)
2. Requirements (SR) identified for particular Use Cases (D2.1)
3. Test Cases (TC) identified for particular requirements (D7.1)
4. Events identified for particular sprints and linked to SR & TC (Matrix)
5. Test execution at events

MAVEN - Managing Automated Vehicles Enhances Network

**Test Protocol**

| | | | |
|---|---|---|---|
| **Event identification** | | | |
| Event Name: | | Event ID: | |
| Event location: | | Date: | |
| | *Major* | *Minor* | *Internal* |
| Event significance | ☐ | ☐ | ☐ |
| | *Name* | *Organization* | *Role* |
| Participants | | | |
| **Introduction and prerequisites** | | | |
| Event objectives | | | |
| HW and SW configurations | | | |
| **Test results** | | | |
| | *Number* | *Proposed measure* | |
| Fail | 1 | | |
| Pass | 1 | | |
| Inconclusive | 1 | | |
| Not executed | 3 | | |
| **Conclusions** | | | |



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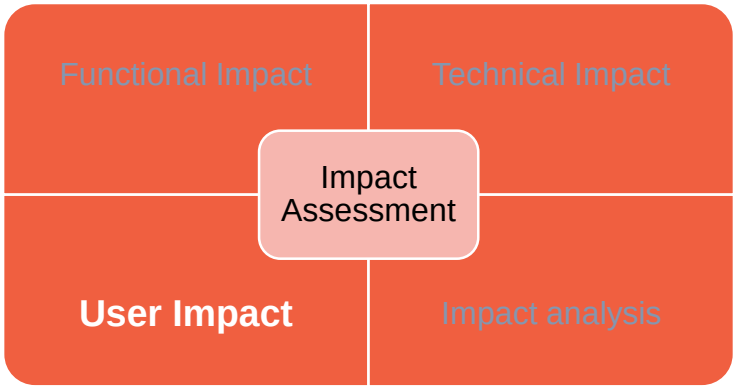


# 2. Surveys

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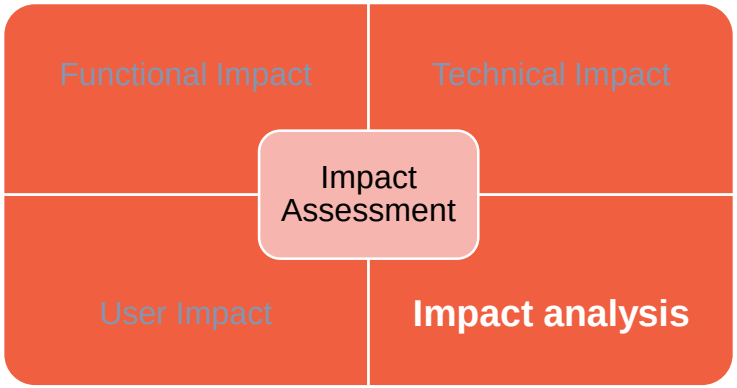
# Surveys *(User assessment)*

| Target Group ID | Target group | Means | Key user impact |
|---|---|---|---|
| 1 | Drivers of equipped vehicles | Computer assisted personal interviewing (CAPI)<br><br>*- Qualitative analysis* | Meeting of the research objectives<br>Comfort when using automated driving<br>Trust in the automated driving<br>Perceived impact<br>Key perceived issues |
| 2 | Drivers of unequipped vehicles | Computer assisted personal interviewing (CAPI)<br><br>*- Qualitative analysis* | Meeting of the research objectives<br>Trust in the automated driving<br>Perceived impact<br>Key perceived issues |
| 3 | Passengers of equipped vehicles | Computer assisted personal interviewing (CAPI)<br><br>*- Qualitative analysis* | Meeting of the research objectives<br>Comfort when using automated driving<br>Trust in the automated driving<br>Perceived impact<br>Key perceived issues |
| 4 | Other indirect participants of the field test and trials | Computer assisted personal interviewing (CAPI)<br><br>*- Qualitative analysis* | Meeting of the research objectives<br>Trust in the automated driving<br>Perceived impact<br>Key perceived issues |
| 5 | Citizens and municipality representatives of the pilot cities | Internet survey<br><br>*- Quantitative analysis* | Meeting of the research objectives<br>Comfort when using automated driving<br>Trust in the automated driving<br>Perceived impact<br>Expectations on future development<br>Key perceived issues |




# 3. Traffic Simulation in SUMO

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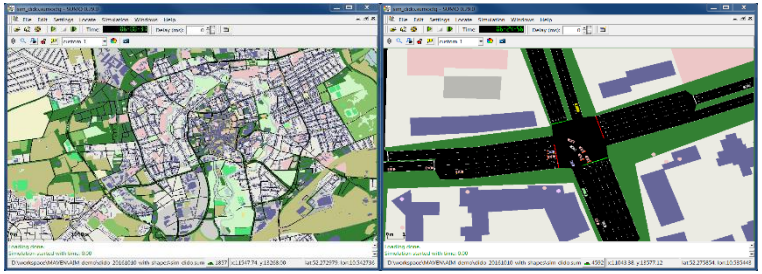
# Traffic simulation

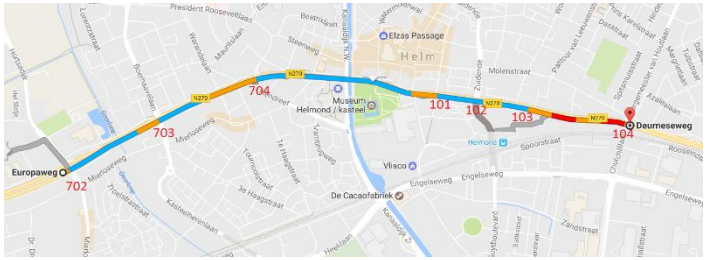
## Overview

- Microscopic traffic simulation
- Tool SUMO
- Suitable to model cooperative and autonomous vehicles

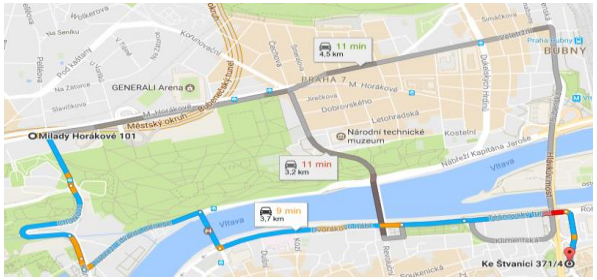
### Braunschweig (DE)



### Helmond (NED)




### Prague (CZ)



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# Task 7.2 – Simulation SUMO

## KPIs

| KPI ID | KPI description with units | Expected impact |
|---|---|---|
| KPI 1 | Number of stops at traffic lights (-) | Reduction |
| KPI 2 | Control delay time (s) | Reduction |
| KPI 3 | Produced emissions (g) | Decrease |
| KPI 4 | Fuel consumption (l) | Reduction |
| KPI 5 | Throughput (veh) | Increase |
| KPI 6 | Travel times (s) | Reduction |
| KPI 7 | Minimum time to collision (s) | Increase |
| KPI 8 | Number of human interventions for safety (-) | Decrease |

- KPI 7) *Minimum time to collision (s)*

Time to collision is defined as the time it takes before two traffic participants collide if their current speed is not adjusted.

This is a safety measure, where a higher value is better.

However, aiming for a value that is too high, will negatively impact traffic efficiency and will not add any safety. Therefore, a predefined threshold is used.

- KPI 8) *Number of human interventions for safety (-)*

The ultimate safety measure would be the number of accidents and while MAVEN will of course report on it should an accident happen, the project does not expect any accidents to happen during the tests.

Especially because trained human drivers will closely watch the vehicles behaviour and intervene if necessary.

Therefore, the number of human interventions for safety reasons is a measure that is more likely to show differences.



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# Test scenarios

- *Different penetration levels of autonomous vehicles*
- *Different flows*
- *Particular use cases*
- *Control algorithms used*
- *Intersection layout*
- *Sensor Sampling rate*
- *Vehicle type effect*
- *Vehicle turn direction*
- *Isolation effect*
- *And others*

| Use Cases | 7 Speed change advisory & 13 Network coordination | | | | | | | | | | | | 8 | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Conditions/ sim runs | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 | 19 | 20 |
| **Intersection layout** | | | | | | | | | | | | | | | | | | | | |
| One lane | | | | | | | | | | | | | X | X | | | | | | |
| Two lane shared right turn | | | | | | | | | | | | | | | X | X | | | | |
| Two lanes shared left turn | X | X | X | | X | X | X | X | X | X | X | X | | | | | X | X | | |
| Three lane | | | | X | | | | | | | | | | | | | | | X | X |
| **Penetration rates (AV)** | | | | | | | | | | | | | | | | | | | | |
| 0% | X | X | X | X | X | X | X | X | X | X | X | X | | | | | | | | |
| 20% | | | | | | | | | | | | | X | | X | | X | | X | |
| 40% | | | | | | | | | | | | | | | | | | | | |
| 60% | | | | | | | | | | | | | | X | | X | | X | | X |
| 80% | | | | | | | | | | | | | | | | | | | | |
| 100% | | | | | | | | | | | | | | | | | | | | |
| **Traffic flow (veh/h)** | | | | | | | | | | | | | | | | | | | | |
| Low 900 | X | | | | | | | | | | | | | | | | | | | |
| Medium 1800 | | X | | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X |
| High 3600 | | | X | | | | | | | | | | | | | | | | | |
| **Sensor Sampling (s)** | | | | | | | | | | | | | | | | | | | | |
| 1 | | | | | | | X | | | | | | | | | | | | | |
| 5 | | | | | | | | X | | | | | | | | | | | | |
| 10 | X | X | X | X | X | X | | | | | | X | X | X | X | X | X | X | X | X |
| 60 | | | | | | | | | X | | | | | | | | | | | |
| 90 | | | | | | | | | | X | | | | | | | | | | |
| 120 | | | | | | | | | | | X | | | | | | | | | |
| **Vehicle type effect (bus/car** | | | | | | | | | | | | | | | | | | | | |
| car | | | | | | | | | | | | | | | | | | | | |
| 20/80 | X | X | X | X | X | X | X | X | X | X | X | | X | X | X | X | X | X | X | X |
| 40/60 | | | | | | | | | | | | | | | | | | | | |
| 60/40 | | | | | | | | | | | | | | | | | | | | |
| bus | | | | | | | | | | | | X | | | | | | | | |
| **Vehicle turn direction** | | | | | | | | | | | | | | | | | | | | |
| dedicated turn left | | | | X | | | | | | | | | | | | | | | | |
| shared turn left phase | X | X | X | | | | X | X | X | X | X | X | | | | | | | | |
| going straight | | | | | X | | | | | | | | | | | | | | | |
| turn right | | | | | | X | | | | | | | | | | | | | | |
| **Isolation Effect** | | | | | | | | | | | | | | | | | | | | |
| Isolated intersection | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X |
| In a network | | | | | | | | | | | | | | | | | | | | |
| Tested for: | | | | | | | | | | | | | | | | | | | | |
| Single vehicle | | | | | | | | | | | | | | | | | | | | |
| Whole network | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X |



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# Summary & Discussion

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# Objectives of the WP7

**To evaluate the (potential) impact of autonomous driving based on the MAVEN Use Cases.**





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# Topics for discussion with experts

1. What experiences do you have with respect to impact assessment in your project?
2. Have you considered different dimensions, such as simulations, user involvement, technology verification or others? How have you done it in the past? What are the best practices?
3. In your view, what is the state-of-the-art in the field of impact assessment of automated driving?
4. What driver model(s) for AV's and CAV's should be used in simulation?
5. What are the most critical issues when simulating automated vehicles in urban environment and mixed traffic?



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# Topics for discussion with experts (cont.)

6. What needs to be taken into consideration in the models and simulation process to ensure validity?
7. Should there be any special consideration with respect to calibration of the simulation model and should we aim for a harmonised approached across projects?
8. Are there any special concerns with respect to simulation scenarios (penetration rates of AV, road layout, traffic flow, and others)?
9. What KPIs would you recommend to use to capture the impact of automated vehicles?
10. How to address safety using simulation environment?



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# *Thank you!*

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