RobPos4VApp

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Artificial Intelligence for Connected Vehicle Traffic Safety

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Introduction (1/2)

- Road transport is responsible for the majority of transport fatalities, with 1,3 million fatalities worldwide each year.
- Road safety is a field with typically high risk of important investments but not matching results.
- Absence of monitoring and accountability limits seriously road safety performance.
- Very often we use to look where the data are and not where the problems and solutions are.

Introduction (2/2)

- Innovative data-driven solutions could contribute to a proactive approach of addressing urban road safety problems, being a core principle of the Safe System Approach.
- The rise of smartphones, sensors and connected objects offers deeper and broader transport data.
- The interpretation of these data can be made possible thanks to progress in computing power, data science and artificial intelligence (AI).

AI in Driver Monitoring

- In-cabin AI can prevent fatigue and distraction by monitoring eye movement, gaze patterns, head or hand position, and reaction times (personalized by driver).
- AI can predict personalized proactive safety measures by analyzing historical driver data aiming at predicting potential safety risks (e.g., aggressive driving or stress).
- AI can be employed in AVs to continuously monitor the driver attentiveness in real-time especially during Take Over Requests (TORs).
- AI can personalize the AV experience by adapting the Human-Machine Interface (HMI) based on the driver preferences and patterns.

AI in Automated Driving

- Depth perception (e.g., LiDAR, radar, etc.)
- Data fusion from environment data (from cameras, lidar, radar, etc.)
- Object recognition and movement prediction.
- Dynamic Decision-Making algorithms (real-time trajectory planning, optimization and response).
- Vehicle-to-Everything (V2X) communication between a vehicle and any entity that may affect, or may be affected by, the vehicle (data exchange).
- Machine Learning for personalized adaptation in-cabin and driving experience.

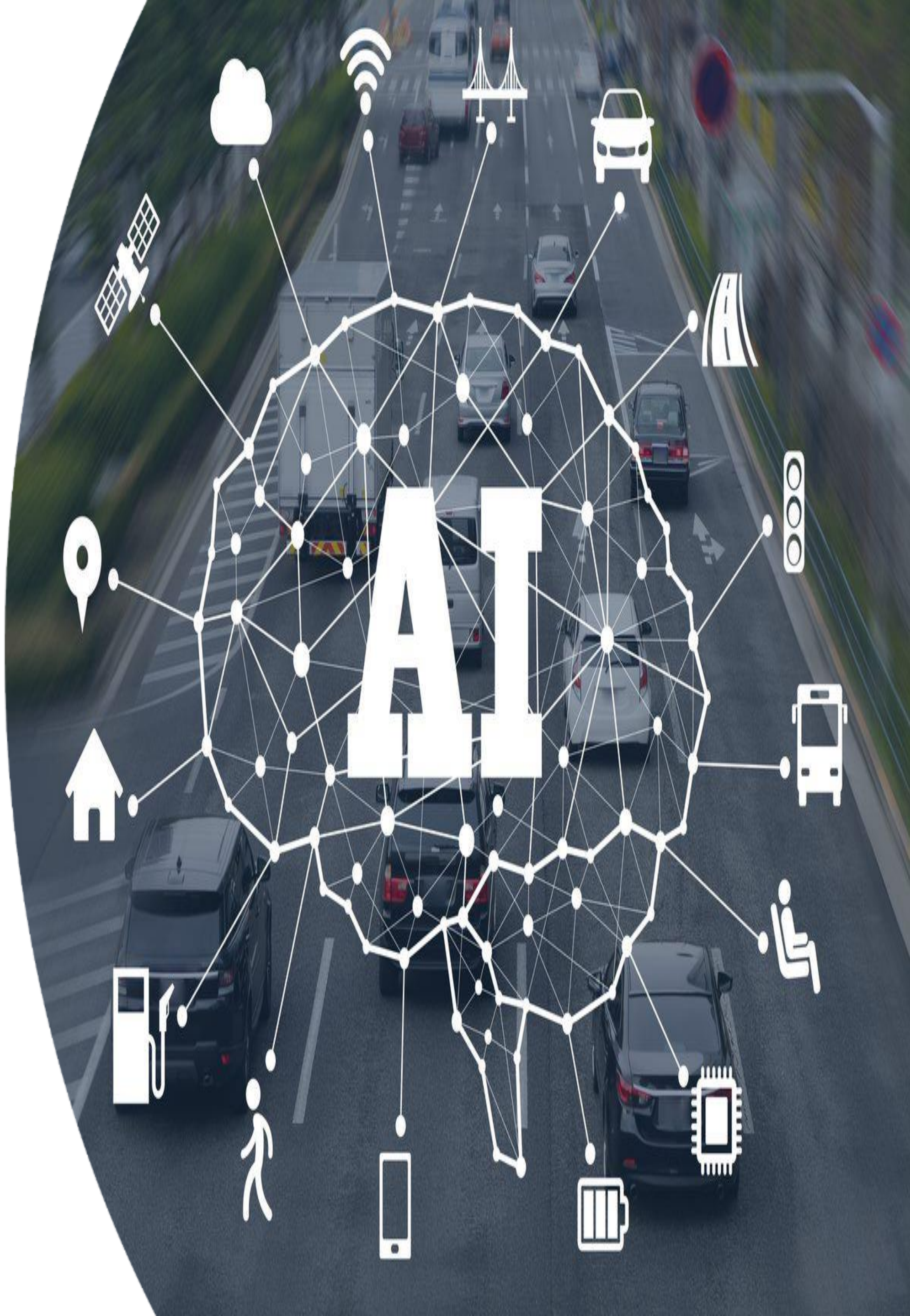
AI Advances in Road Safety Risk Estimation

- Methods related to Artificial Neural Networks are the most promising for road safety, contributing to ADAS.
- Apart from incident detection, all other problems addressed are mode-specific.
- Knowledge could be transferred from the safety field of AVs to other modes.
- Pattern recognition has received heightened attention (e.g. 85% accuracy of pedestrian detection from video recording using Convolutional Neural Networks)
- However, it remains a challenge to detect and block intentional malicious manipulation of training datasets.

AI + Big Data = Road Safety

AI facilitates the proactive management of traffic safety in various ways:

- Collection of data on road infrastructure conditions and traffic events through wide and broad-scale sensors and systems such as real-time computer vision.
- Identification of high risk locations proactively, through predictive multi-layer models.
- Enabled by multiparametric big data, AI pushes the limits of pattern recognition and reaction times beyond human capabilities and may thus uncover new crash-prone road configurations.
- Recent developments in the field of so-called "explainable AI (XAI)" begin to cope with the challenge of the "black box" phenomenon.



Localization in CCAM

Localization is at the heart of SAE Level 2-5 vehicles, with an array of features:

- Road determination for feature geofencing
- High-level routing
- Lane determination for advanced driver assistance
- In-lane positioning for full vehicle control

Probabilistic methods for lane determination (Laconte et al. 2022):

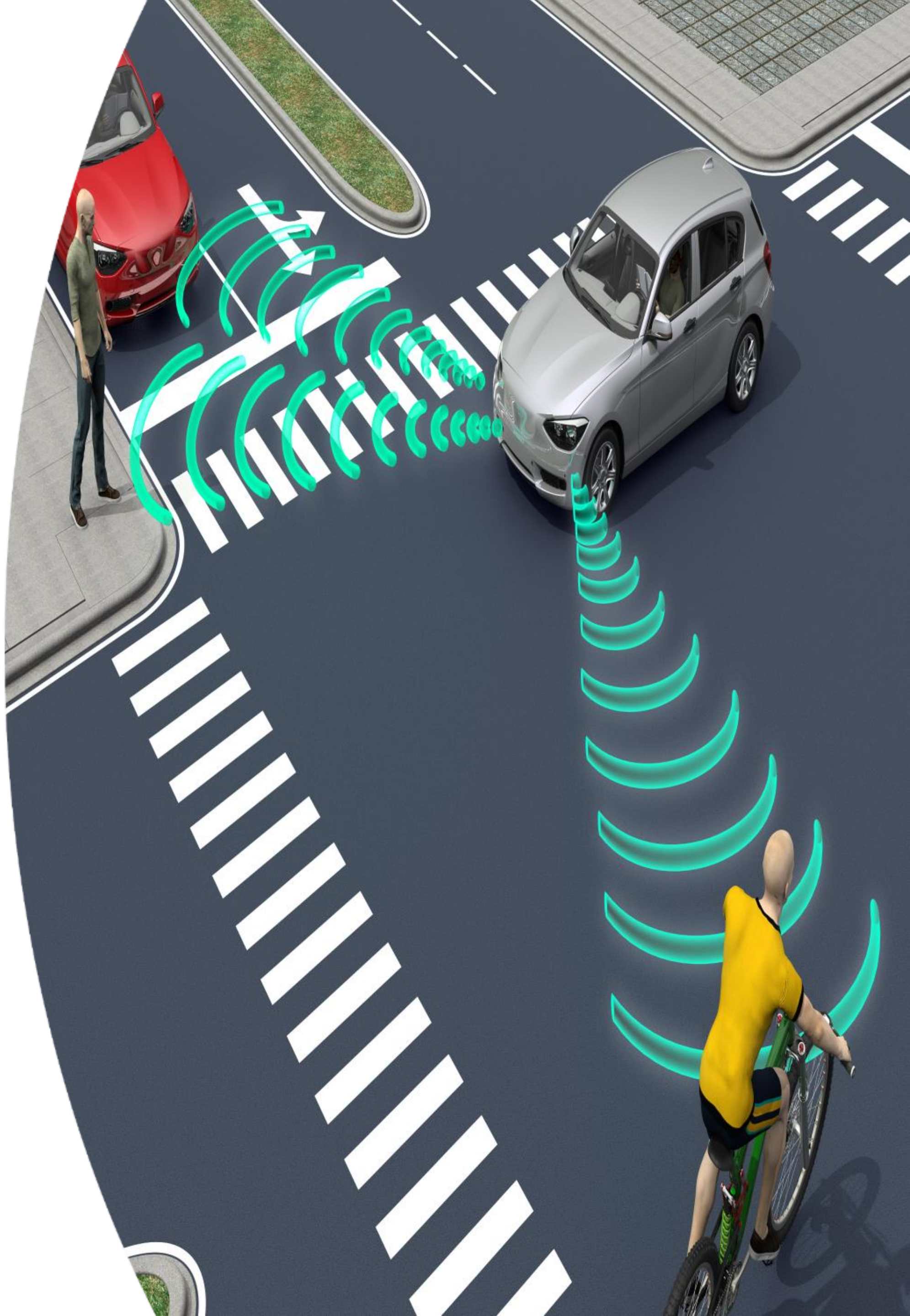
- Offer increased accuracy for higher computational cost
- Account for temporal dependencies (i.e. more fluid modelling of vehicle movement)

In-lane positioning: machine learning approach vs. modelling the lane environment

Localization and CCAM safety

Errors in localization are multiplied in subsequent tasks, thus strict requirements are needed.

- A cited threshold is localization accuracy ≥0.1 m with 95% confidence (Rehrl & Gröchenig, 2021).
- Levels comparable to commercial aviation are sought (Reid et al., 2019):
  $10^{(-8)}$ failures/mile, 0.01 fatal crashes/failure
- Challenges still exist for localization during dangerous events or at high speeds – research is still undergoing
- Vehicle positioning supported by the mobile network is investigated to boost localization precision assisting GNSS (Hetzer et al., 2019).



The HADRIAN project

HADRIAN
Holistic Approach for Driver Role Integration and Automation Allocation for European Mobility Needs

Website

- **Motivation:**
  Develop solutions for drivers to safely, comfortably, and acceptably use driving automation to meet their mobility needs.
- Designed a standardized set of **driving simulators**.
- Performed **22 empirical studies** in driving simulators with overall 863 participants:
  - Driver monitoring systems
  - Initial design iterations of fluid HMI (Human Machine Interface)
  - Final evaluations of fluid HMI
- **Field studies** on Level 3 with Non-Driving Related Activities (NDRAs) and Take-over requests

HADRIAN Demonstrations & Localization

- ➢ Demonstrated HADRIAN innovations on test tracks and open road environment.

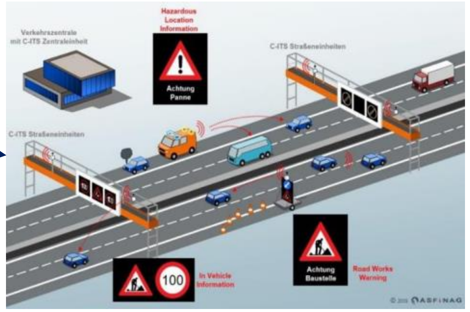
- ➢ Demonstrated user benefit of enhancing automated vehicle functionality with road infrastructure information:
  - ➢ Expanded vehicle time horizon from 5 to 15 sec (i.e., Take Over Request)
  - ➢ Provided predictable AD availability for increased user benefit
  - ➢ Demonstrated increased continuity of ADL 3

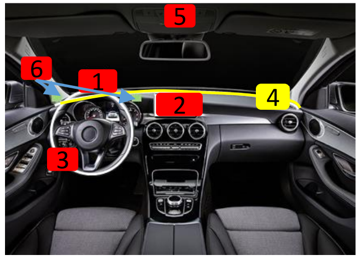
✓ *Localization is required to be accomplished in real-world applications (V2I communication and V2V communication with accurate vehicle position exchange).*

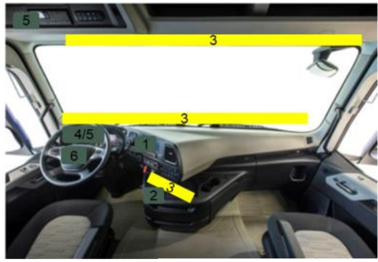
- ➢ Tested fluid driver feedback as important method to increase driver competences and trust.

✓ *AI could enhance feedback tailored to the driver performance.*

C-ITS







HADRIAN Results

HADRIAN
Holistic Approach for Driver Role Integration and Automation Allocation for European Mobility Needs

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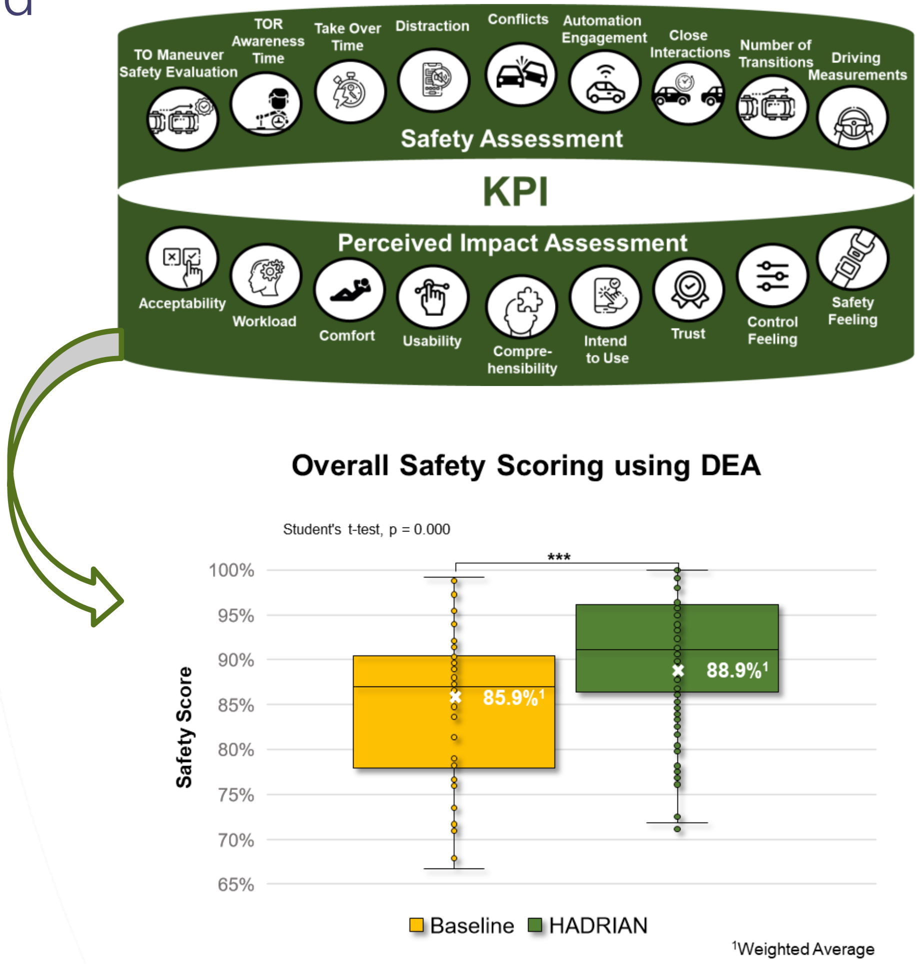
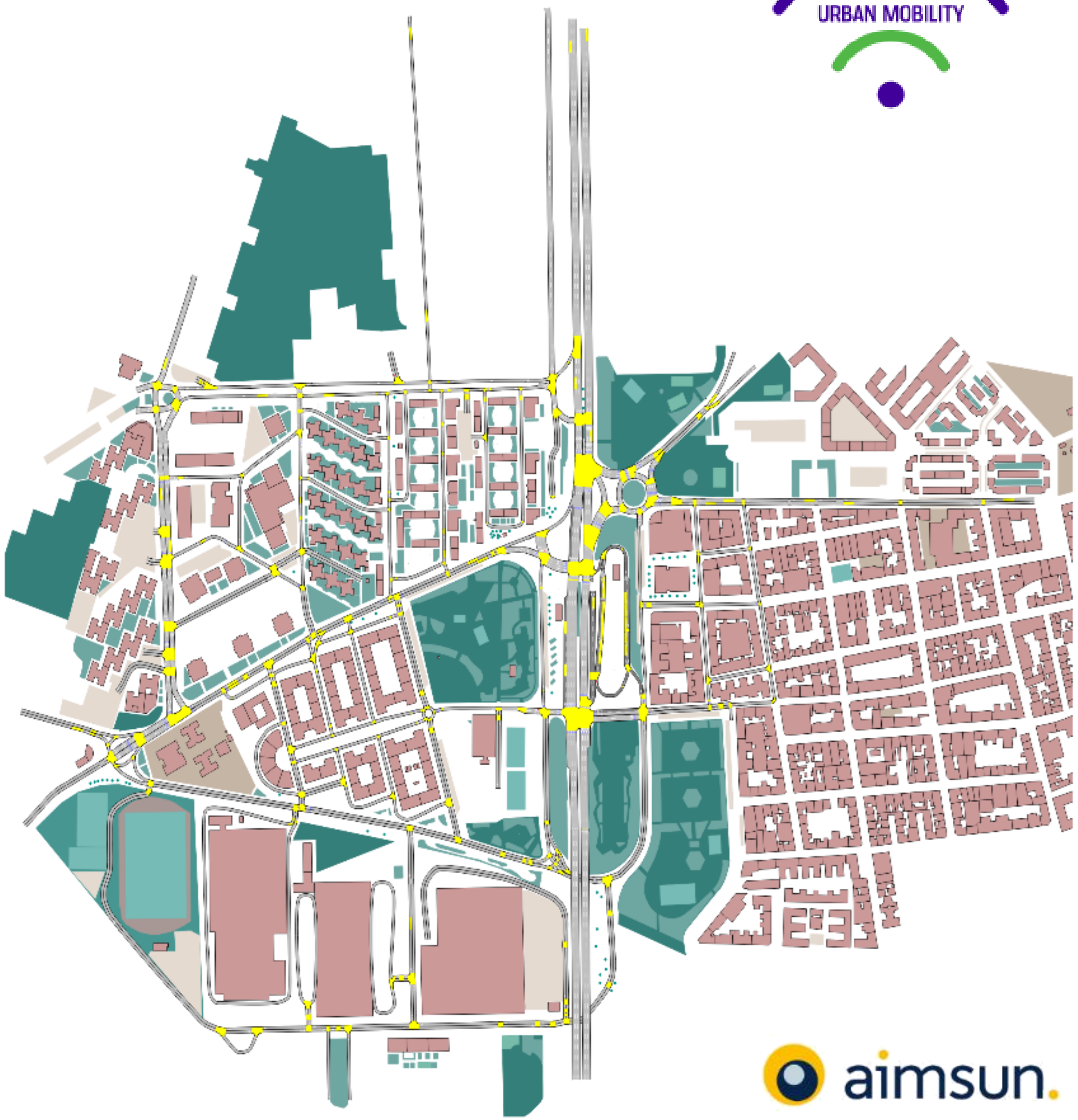
- NTUA led in **safety assessment efforts** and developed and applied two advanced safety analysis methods for automated driving benefits:
  - Safety and Impact Assessment
  - Human Reliability Analysis (HRA)
- The **HADRIAN innovations** safety score was improved statistically significantly.
- **Error probability** is reduced by 60% with HADRIAN innovations compared to state-of-the-art baseline.
- **Guidelines and recommendations** to AV manufacturers, regulators, and policymakers were developed.



The SHOW project

- SHOW aims to support the deployment of shared, connected and electrified automation in urban transport, advancing sustainable urban mobility.
- Naturalistic demonstrations and simulated environments are both deployed within the project.
- Microscopic simulation is employed (using AIMSUN Next), providing data for otherwise unattainable configurations (high CAV Market Penetration Rates).
- The study network was the Villaverde district of the city of Madrid, Spain, in which an Automated Shuttle Bus Service was introduced.

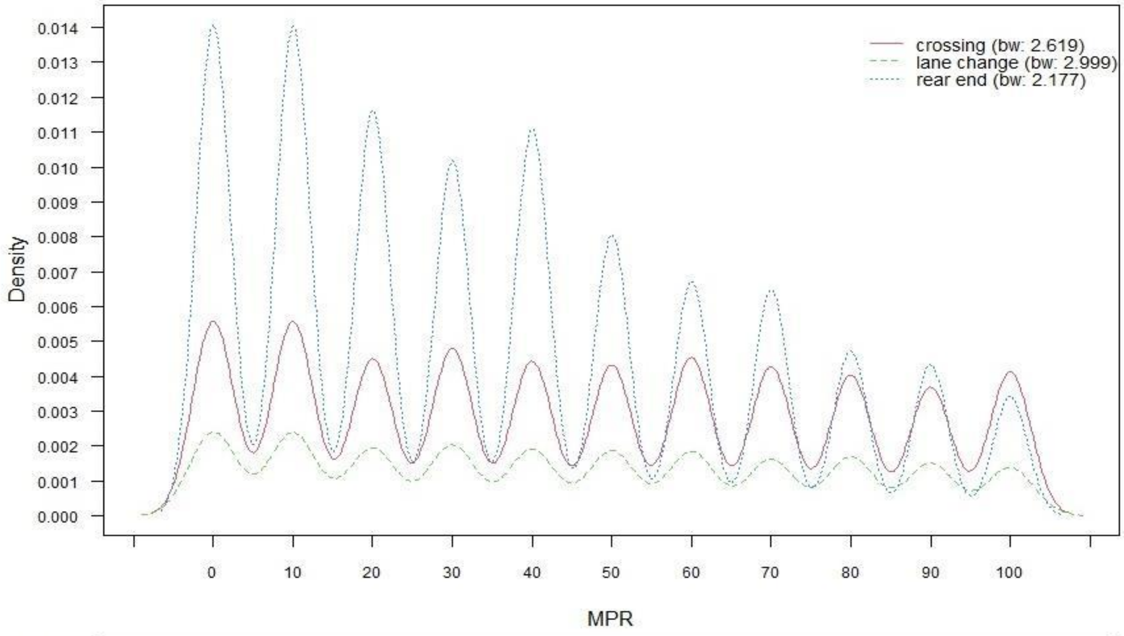


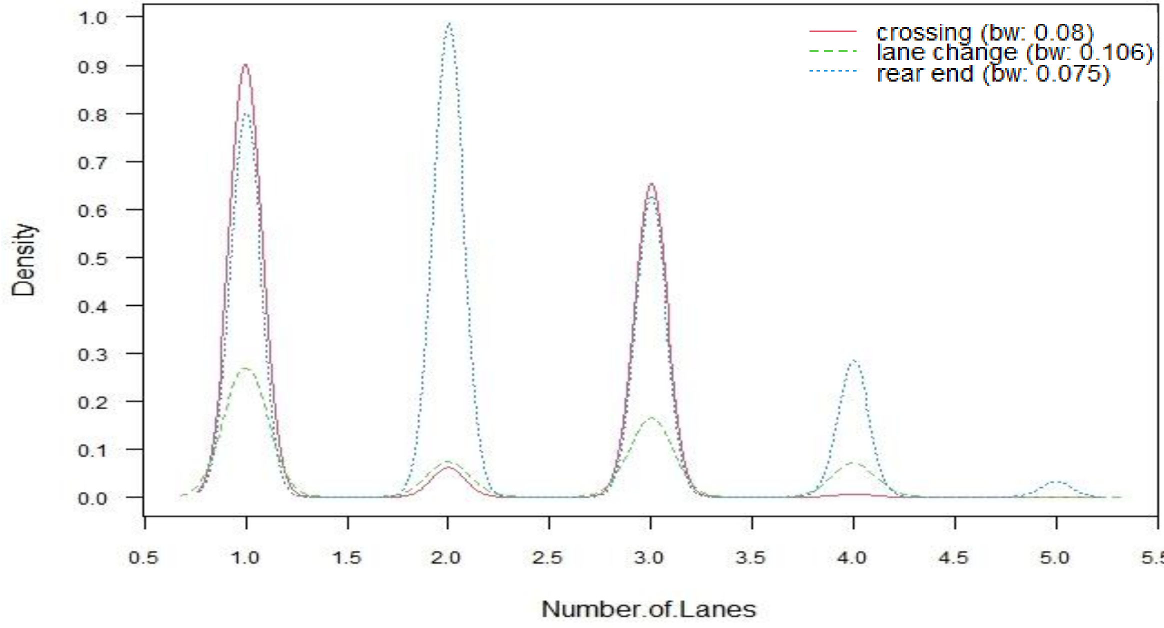
AI Safety within SHOW

33 simulation scenarios were formulated:
11 CCAM MPR x 3 different operational speeds
i.e. 15, 30& 45 km/h.

Trajectory data were analysed, showing that:

- Traffic conflicts will be observably fewer as MPR increases (especially rear-end conflicts)
- Lane-change conflicts are reduced at a lower pace, while crossing conflicts display fluctuations.
- Crossing conflicts are encountered on 1-lane and 3-lane segments, rear-end conflicts are encountered on 2-lane segments.
- Give way and Traffic light traffic control lead to increase conflict likelihood.
- Prediction Accuracy is 79.3%.



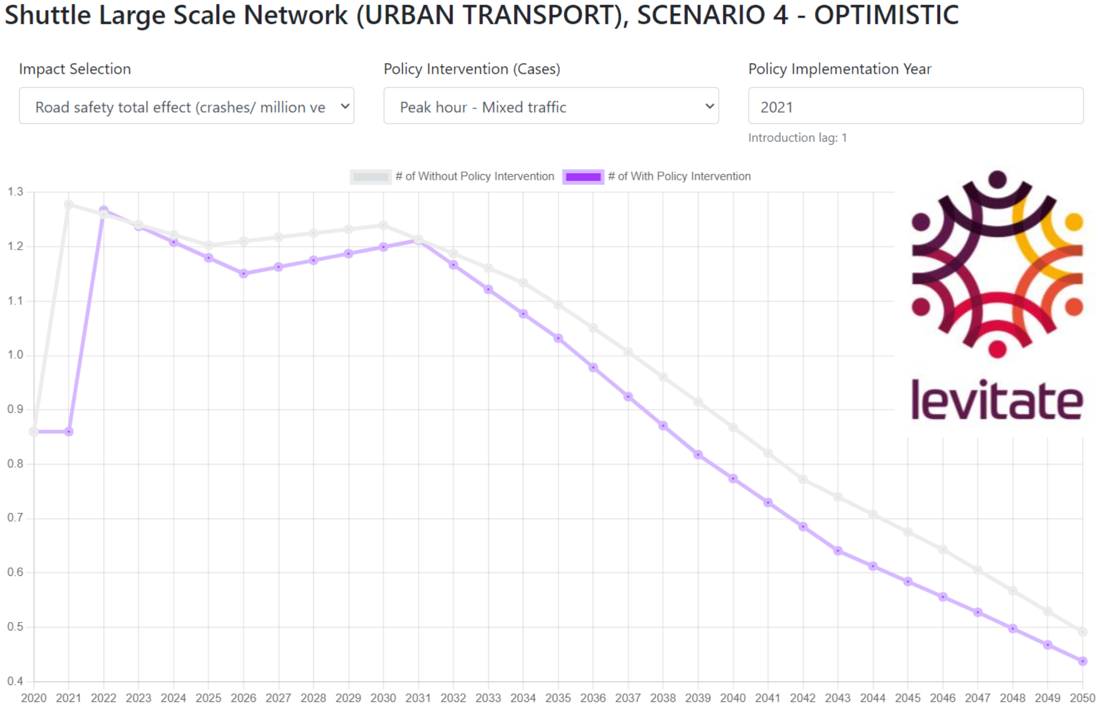


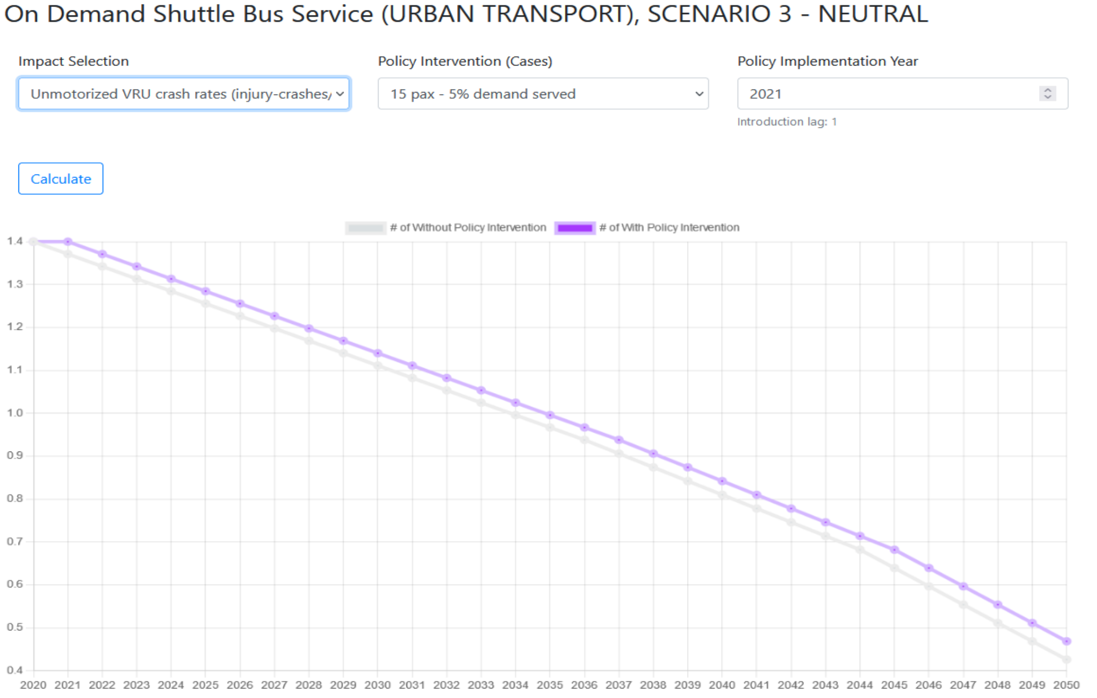
Societal impacts - Levitate

It is informative to ‘scale up’ to more aggregate safety evaluations of AI as well (i.e. **networks**).

Based on the **Levitate PST** (https://www.ccam-impacts.eu/):

- Road safety levels **will be significantly increased** after the introduction of automated vehicles and public transport shuttles in the urban environment.
- At larger shares of second generation vehicles (60-100%) the **crash rate of urban transport vehicles** can reach a reduction of up to 50%-70%.
- At similarly large penetration rates, on-demand options **reduce VRU crash rates** by up to 64%.





Pending Barriers for AI

- Safe, road-worthy AI systems face significant challenges that are only hesitantly tackled:
  - Interfaceability
  - Interoperability
  - Timelessness
  - Scalability
- Absence of monitoring and accountability limits seriously road safety performance. To counter this, increase acceptance and public trust by monitoring and reporting.
- Research and innovation efforts on the use of AI in computer vision and risk prediction needs more support.

Conclusions

- Artificial Intelligence can become an efficient catalyst for achieving Vision Zero road fatalities by 2050.

- AI brings multifaceted contributions to CCAM-based traffic safety:
  Sensor-based perception, piloting and decision-making, as well as data cleaning, microscopic and macroscopic modelling, among other tasks.

- Invest into training specialized CCAM safety-oriented computer science professionals.

- Balance carefully between accurate road user recording and protesting of the public due to privacy disruptions and AI-based control of CCAM.

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