Hi-Drive
FINAL EVENT
25 NOVEMBER 2025

IMPACT ASSESSMENT RESULTS

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#Effects and Impact Assessment

Research questions

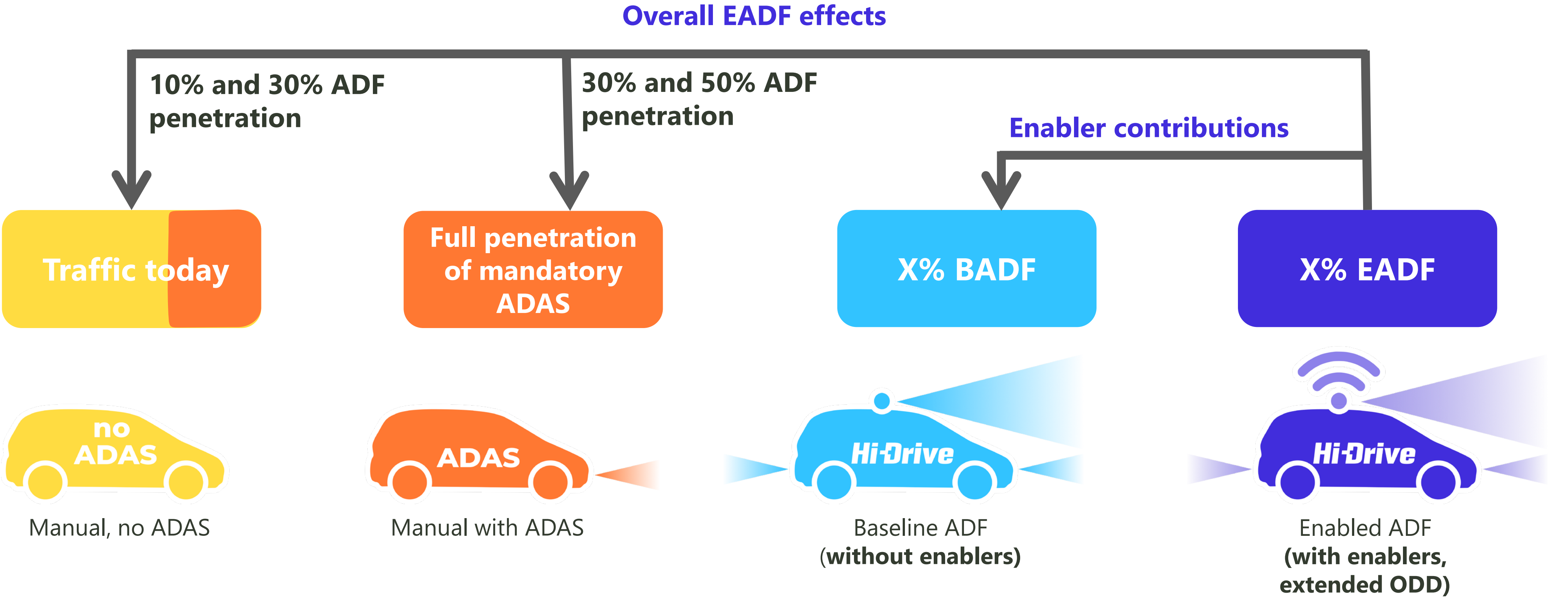
What is **the impact of Automated Driving and its Enablers** on…

- safety?
- energy demand?
- emissions?
- traffic efficiency?
- personal mobility?
- transport system?
- socioeconomics?

Focus on

- The impacts between **Automated Driving** and manually driven fleet
- Contribution of the **Technology Enablers** to these impacts

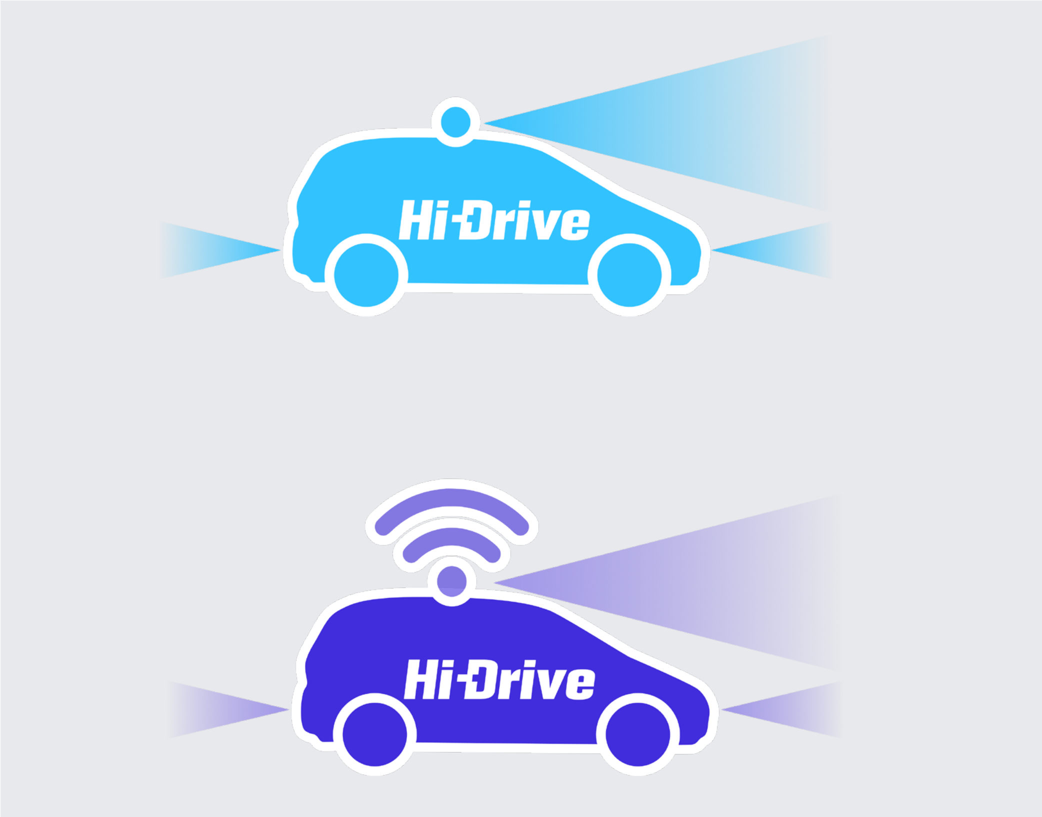
Hi-Drive baselines and treatment



**ADF = Automated Driving Function*

Common parametrisation for simulations

- **Joint Hi-Drive ADF model** for all simulations, regardless of impact area
  - Shared parameters, same foundational algorithms and behavioural logic
- Resulting ADF model
  - Delivers **operational realism** and **regulatory compliance**
  - Aligns with **design practices** employed by automotive manufacturers



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SAFETY

Safety impact assessment methodology

Scenario results

Simulation of driving scenarios → **Change in crash probability per driving scenario**

×

Simulation of traffic scenarios → **Change in frequency of driving scenario**

×

Injury risk functions → **Change in severity of accidents**

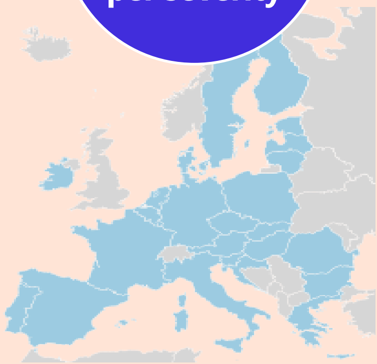
×

Annual EU impacts

Accident databases → **Number of target accidents**

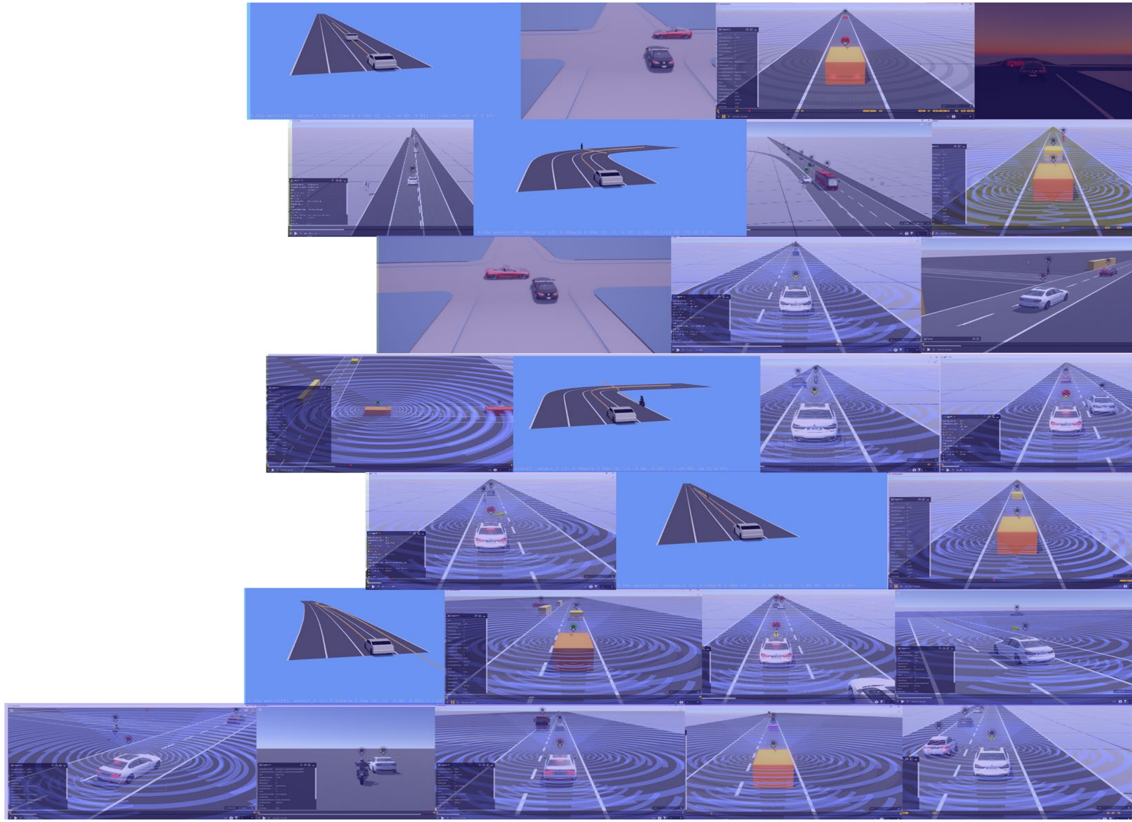
=

Impact on the number of accidents per severity



40 driving scenarios | 3 environments | 4 vehicle types

Effect of automated driving on road safety

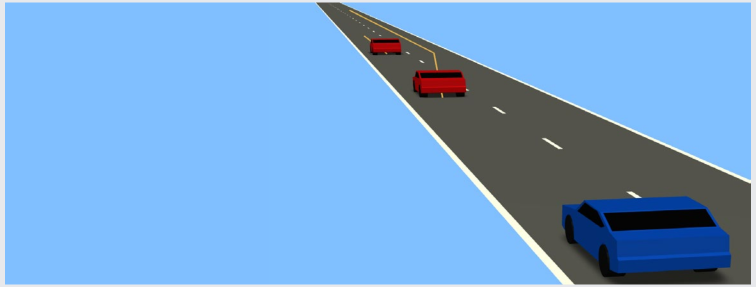


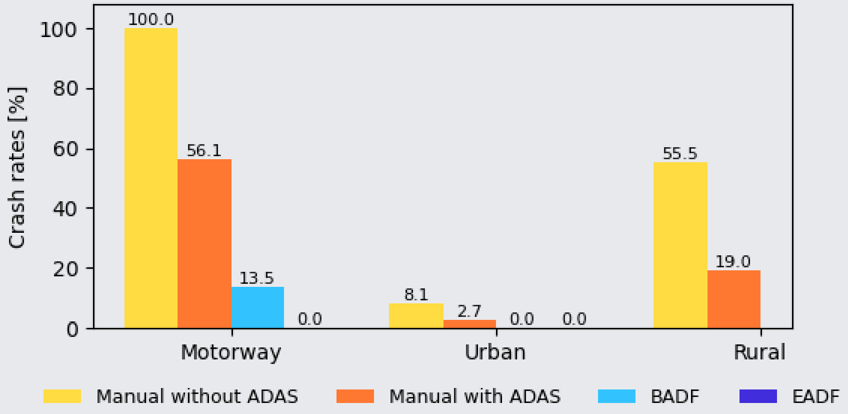
- Conflict-related **driving scenarios** and **traffic scenarios**
- ODD on **motorways** and **urban roads**, and indirect effects by improved ADAS on **rural roads**
- **Four simulation tools** (openPASS, esmini, 2 x in-house)
  - **Re-simulation** of scenarios and **stochastically generated** scenarios
- **OEM-neutral** BADF, EADF and ADAS (AEB, ACC, ISA,…)

Example: 01|06 Rear end conflict, cut-out

- Objective: Investigate crash risk reduction of ADAS (ACC, AEB, ISA), BADF & EADF
- Baseline approach: C2P (ALKS-Performance Model)
- Considered EADF: V2X communication + adapted driving strategy
- Considered Roads: motorway, urban, rural (only ADAS)

- **Reduction of the crash rates for ADAS/ADFs**
  - Overall: Quicker reaction compared to human
  - EADF: Earlier reaction than BADF, because of V2X information
  - Urban: Low speeds allow for quick standstill

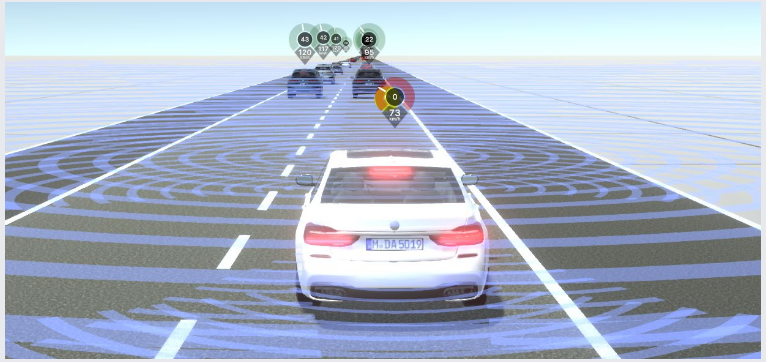


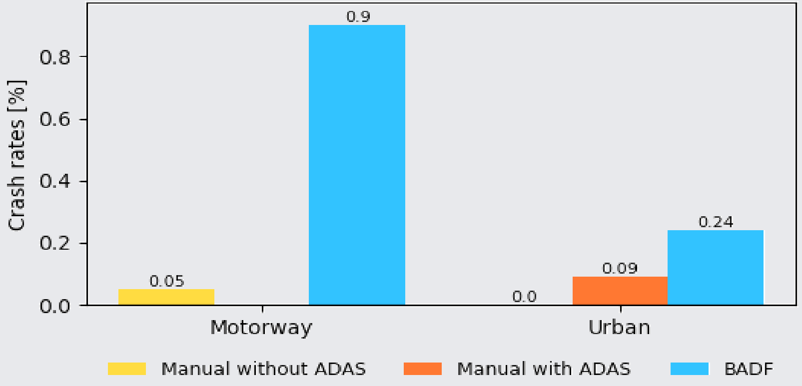


Example: 01|19 Minimum risk manoeuvre

- Objective: Analyse risks induced by an MRM
- Baseline approach: C2I (SCM model)
- Considered EADF: None (BADF = EADF)
- Considered Roads: Motorway and Urban
- MRM: braking with 2 m/s² (in case of low TTC: 5 m/s²)

- **Small increase in crash rates for ADFs**
  - Overall: An increase of crash risk during an MRM compared to the baseline with no MRM
  - Urban: Smaller increase in crash risk than on motorways due to lower speeds
  - Assumed frequency of MRM for scaling up: 1 MRM per 30 h (BADF) | 45 h (EADF)





Outcome of driving scenarios simulations

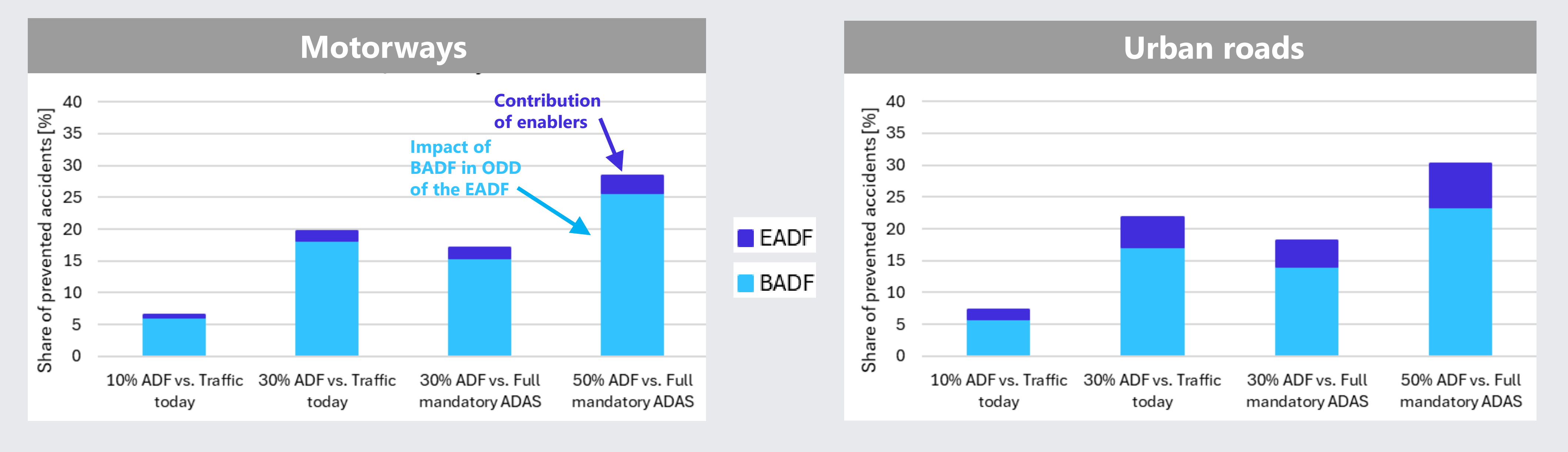
- ADFs has the **potential to improve traffic safety** in nearly all driving scenarios – actual effect depends on the AD design
- Notable difference between **EADF and BADF** not always observed, ODD extension of EADF addressed in scaling up
- **ADAS** delivers already considerable safety benefit in some driving scenarios

Scenarios in which the EADF performs better than the BADF

Motorway:
- 01|06 rear-end after cut-out
- 02|01 & 02|02 discretionary lane change
- 02|03 motorway entrance

Urban:
- 01|09 moving from private garage/alley
- 01|10 Entering/exit conflict (private lane/garage close to curve)
- 03|03 crossing f. left
- 03|04 crossing f. left (other veh. left turn)
- 03|05 crossing f. right
- 03|07 crossing f. right (other veh. right turn)
- 04|02 turn left + conflict w. standing vehicle
- 04|14 turn left w. crossing traffic from right
- 05|07 turn right w. crossing traffic from left
- 05|10 turn right w. straight going VRU

Scaled-up impact of EADF on prevented fatal accidents in EU



- Impacts on other severities are of similar size
- Minor addition to accidents due to MRM
- Additional benefits outside ODD due to better ADAS enabled by the sensors

2 EFFICIENCY & ENVIRONMENT

Efficiency & environmental impact assessment methodology

Simulation in **enabler-centric** traffic scenarios

2) EADF

Simulation in **road-type-centric** traffic scenarios

1) BADF

Effect per vehicle-km-travelled in specific traffic scenario

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Road infrastructure data

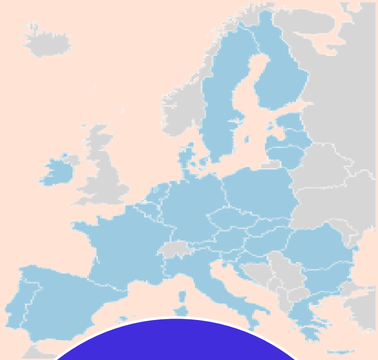
Traffic data

Weather data

Vehicle-km-travelled inside ODD in specific traffic scenario

=

3) Annual EU impacts



Impact on energy demand / emissions / traffic efficiency

Scenario-specific results, motorway

BADF without enablers, road-type-specific scenarios

4 networks | 8 speed limits | 5 traffic volumes

- **Travel time** increased with higher BADF share and traffic volume
- **Tractive energy use** decreased with growing BADF share
- **CO_2 emissions** showed mixed results
  - Increase: high volumes, low speed limits
  - Decrease: high speed limits, highest traffic volumes

Cooperative merging enabler

- Benefits for **travel time**, **CO_2 emissions** and **tractive energy use** at 50% EADF, moderate motorway volumes
- **Hard braking events** reduced
- Negligible impacts for lower penetration rates

Dynamic speed limits enabler

- Increased **delay** at high traffic volumes and higher penetration rate
- Reduced **CO_2 emissions** at 50% EADF, except in high traffic volumes
- Effect on **tractive energy use** small

Scenario-specific results, urban

BADF without enablers, road-type-specific scenarios

5 networks | 2 speed limits | 6 traffic volumes

- **Travel time** increased with BADF share, higher speed limit and traffic lights amplified increases
- **Tractive energy use** decreased consistently with BADF share
- **CO_2 emission** showed mixed results
  - Increase: low/moderate traffic volumes
  - Decrease: high traffic volumes

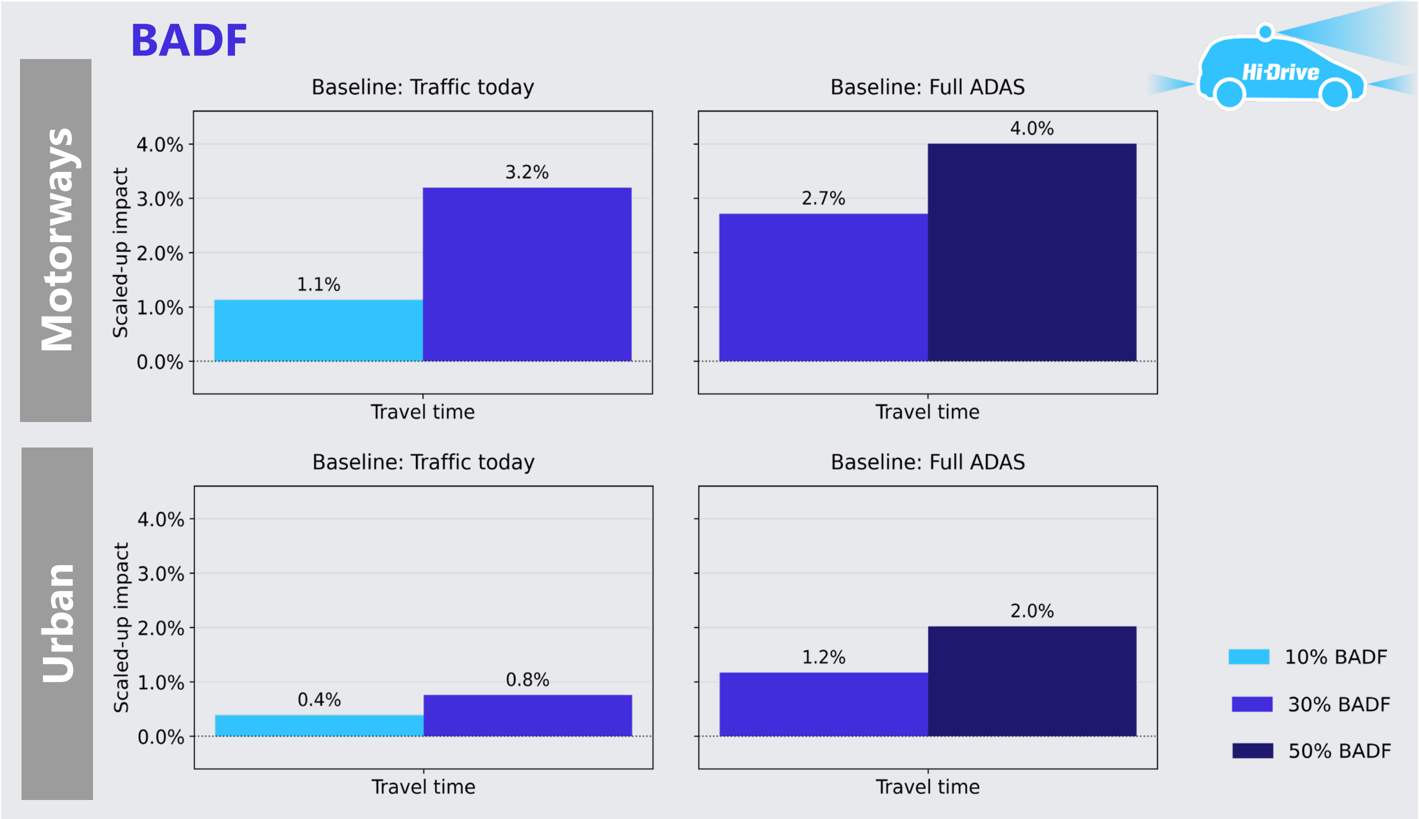
GLOSA

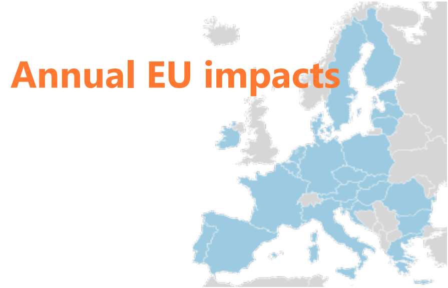
- Small decreases in **travel time**
- **Stop delay** reduction, with effects growing at higher penetration and traffic volumes
- Reductions in **CO_2** and **tractive energy use**, most pronounced at high penetration and traffic volumes

Complex intersection enabler

- Reductions in **travel time**, **number of stops** and **delay**
- Small reductions in **energy use** and **CO_2 emissions**
- Benefits larger with higher EADF share and with high traffic volumes

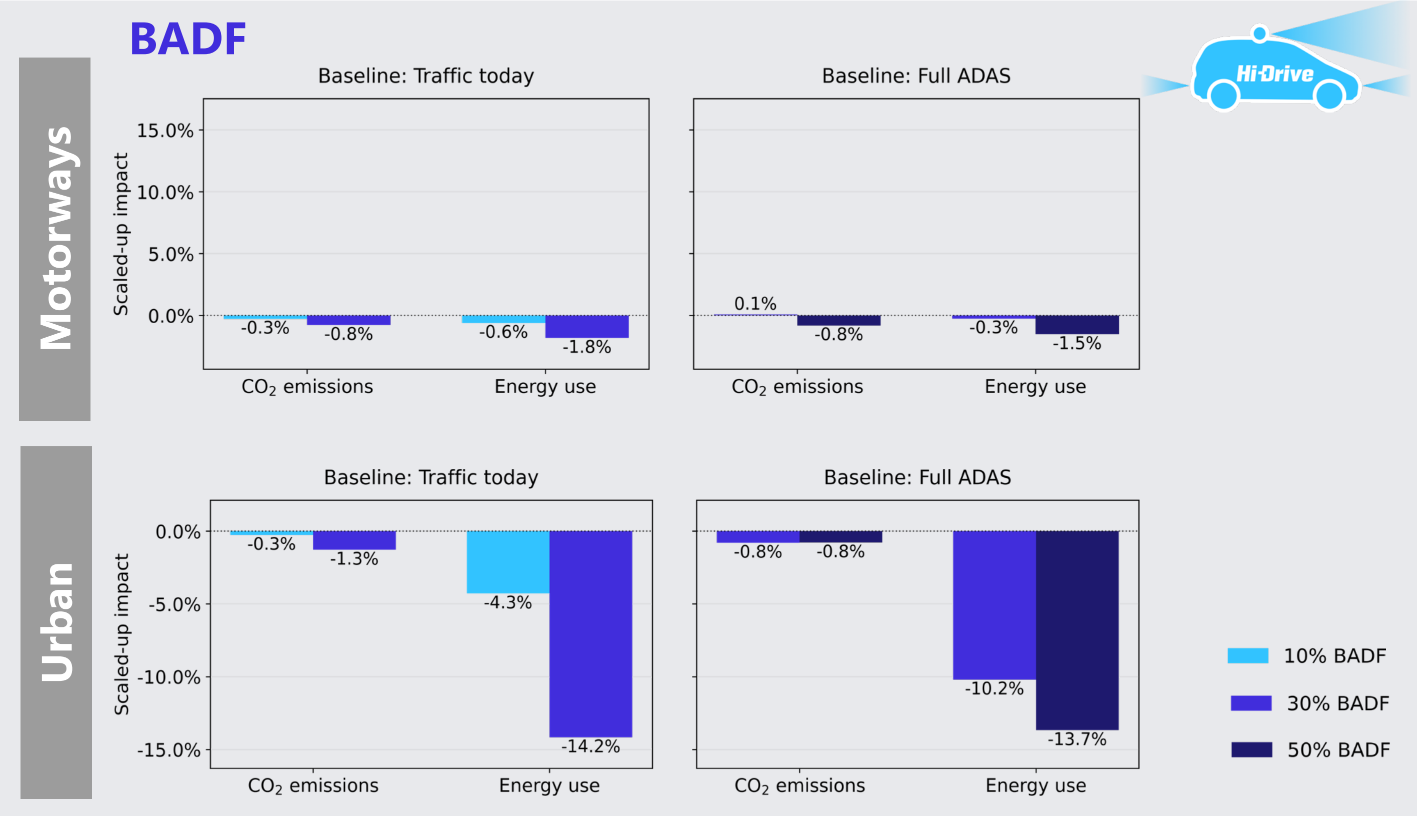
Scaled-up impact on travel time in EU

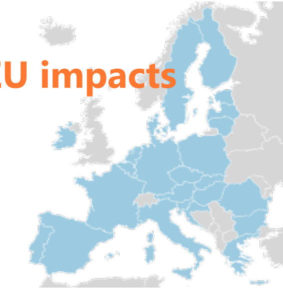




- **EADF impact in comparison with BADF**
  - Enablers affect only locally
  - Similar magnitude of impacts at the EU-level

Scaled-up impact on energy use and emissions in EU





- **EADF impact in comparison with BADF**
  - Motorways:
    Similar magnitude of impacts
  - Urban areas:
    Slightly larger reduction for energy use, slightly smaller for CO_2

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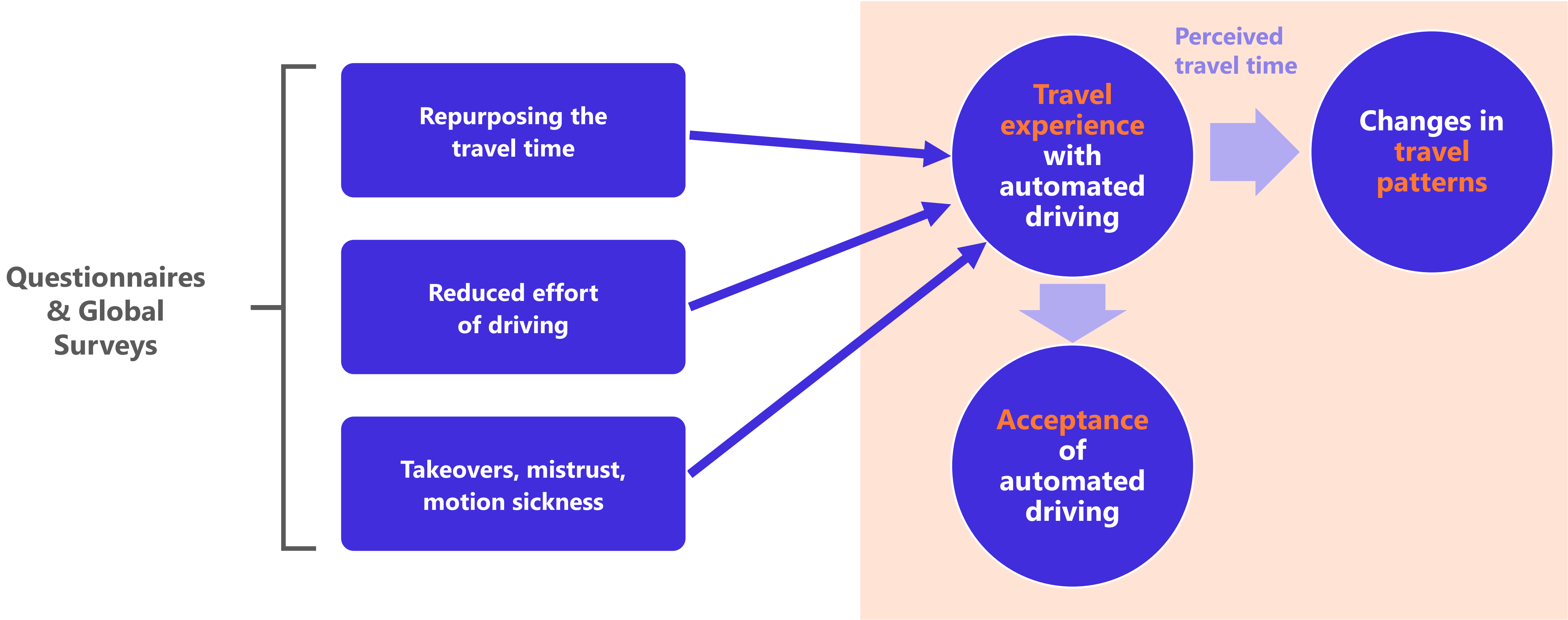
PERSONAL MOBILITY

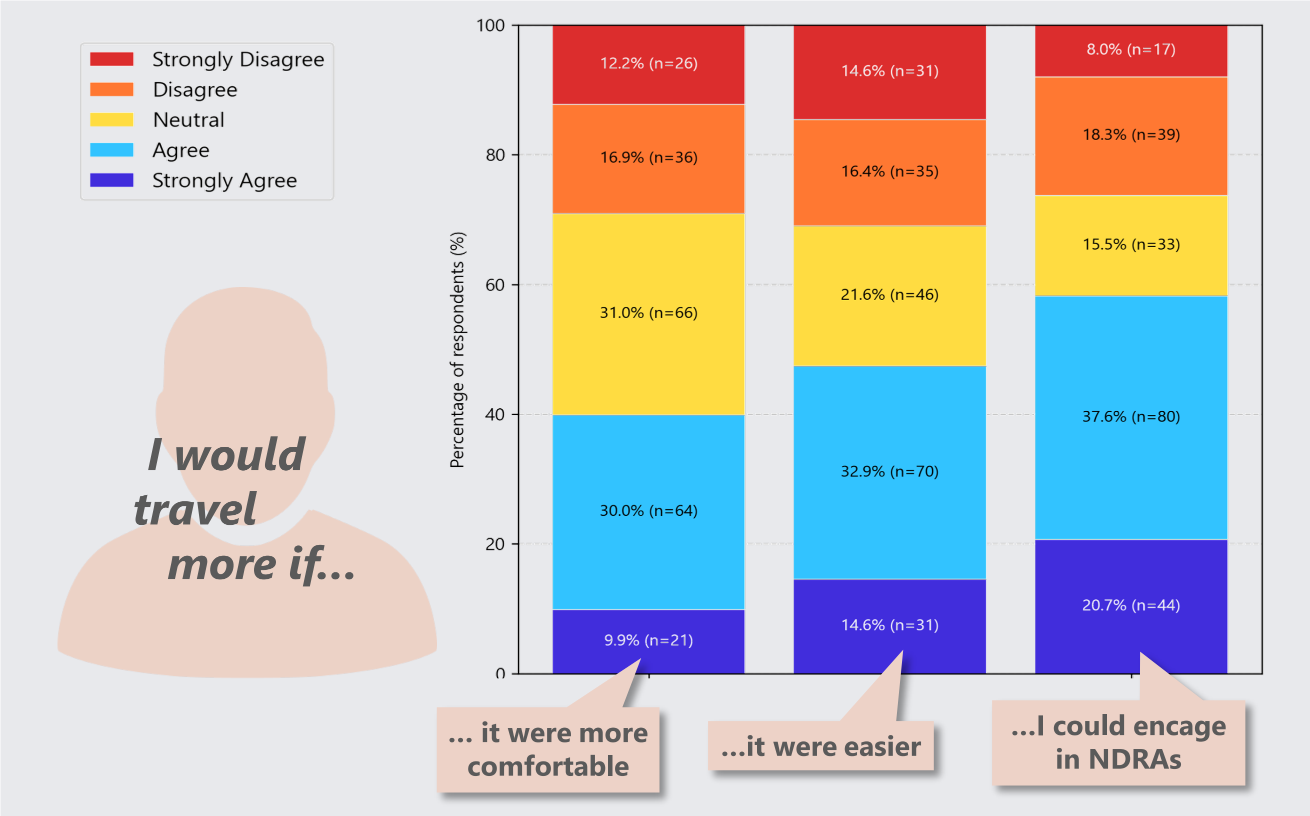
Mobility impact assessment methodology



Impacts on travel behaviour

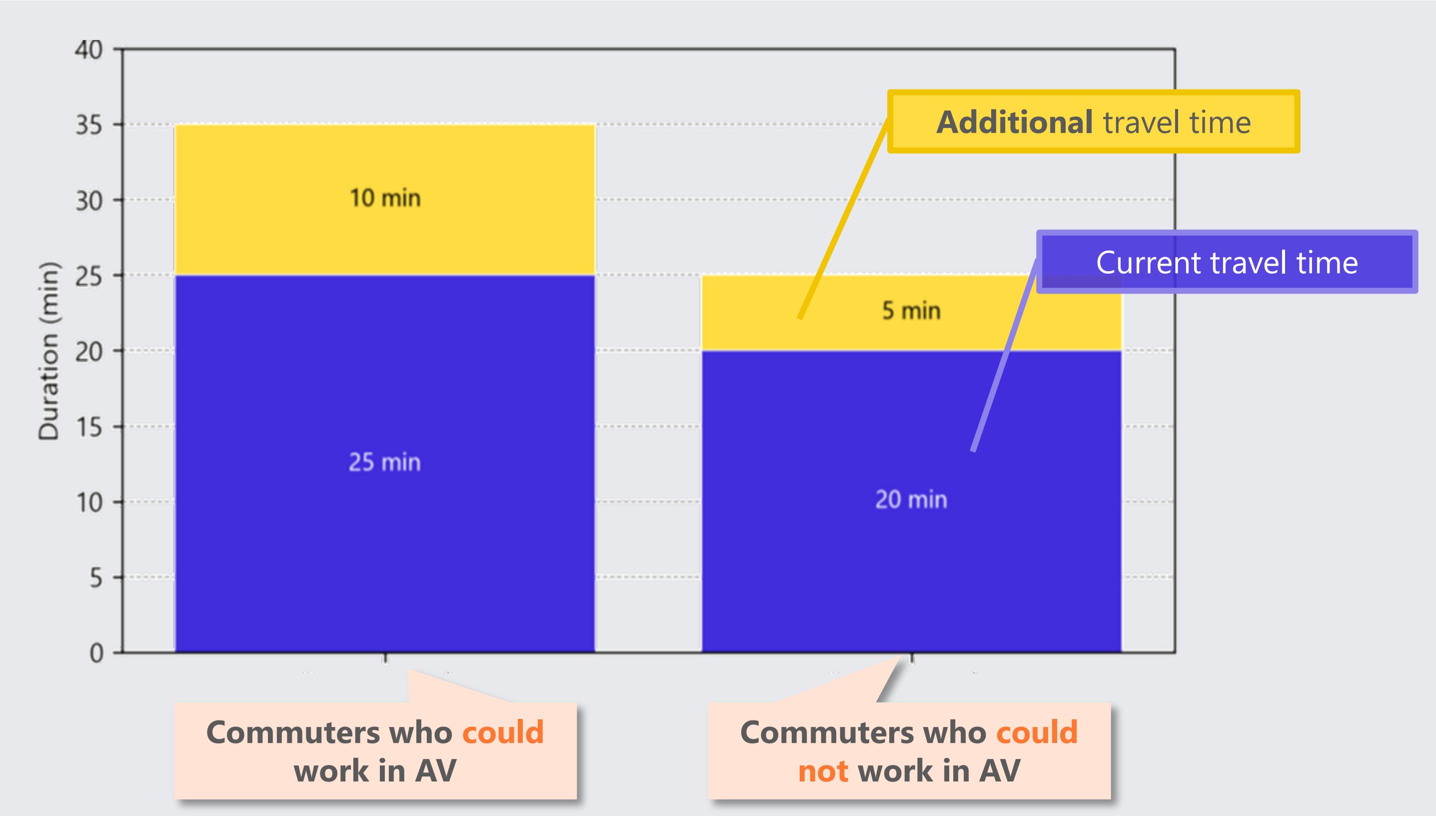
- Automated driving systems can enhance travel quality by enabling users to engage in **non-driving related activities** during automated driving

- This may lead to **more frequent or longer trips**



Hi-Drive

Ability to work while commuting may encourage to accept longer commutes (Global surveys)

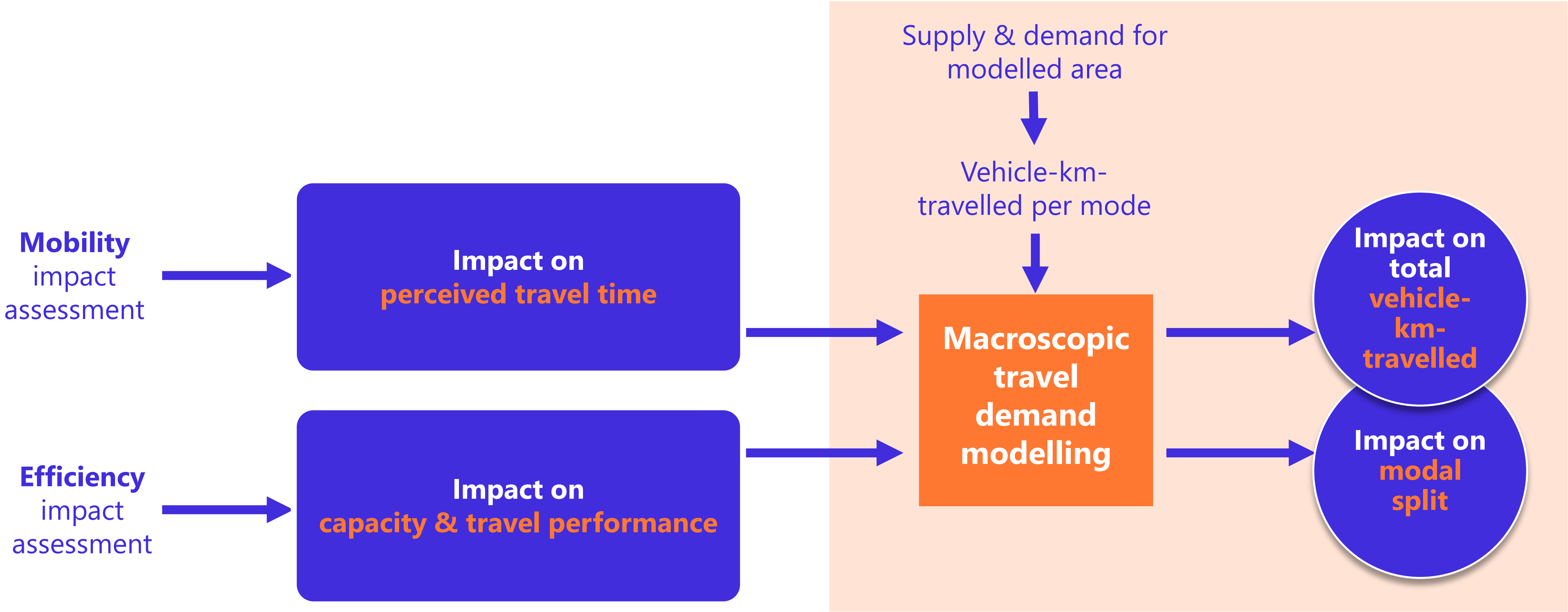


- Correction factor for perceived travel time

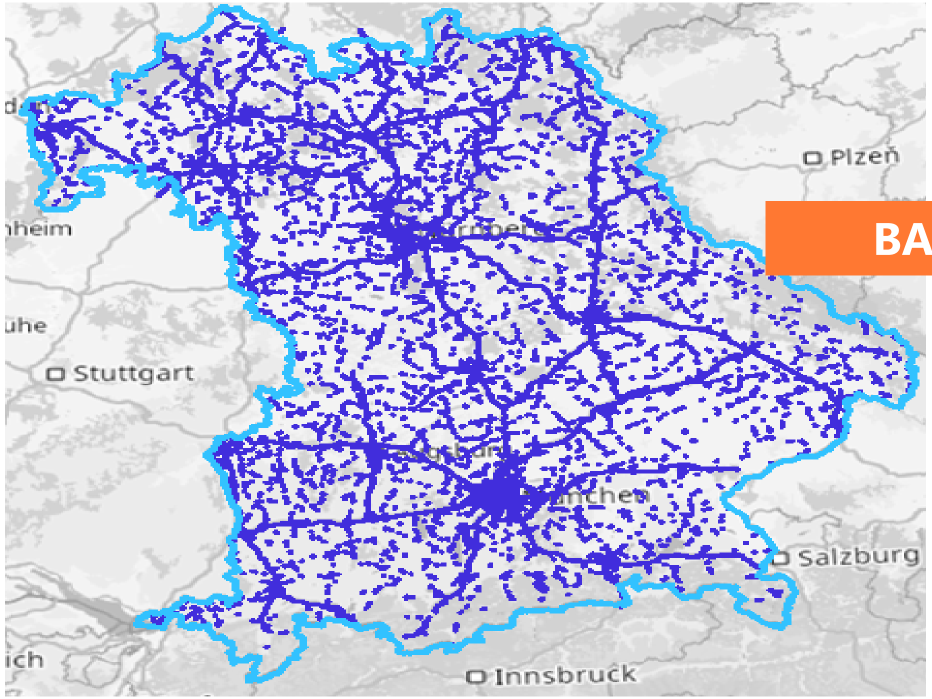
  AD *vs* **Manual driving: 0.8**

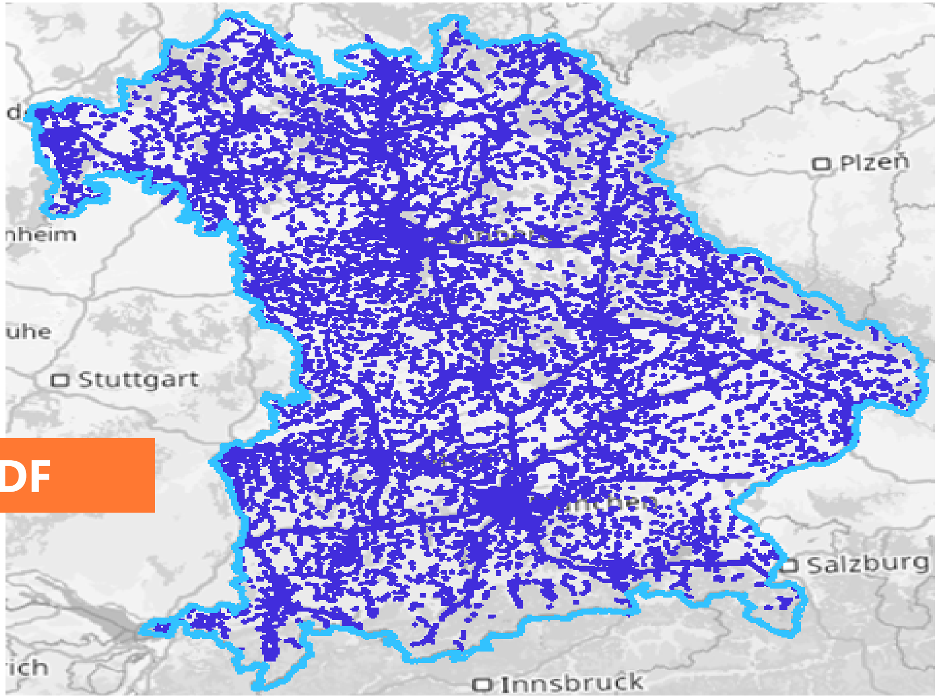
4 TRANSPORT SYSTEM

Transport system impact assessment methodology



Operational Design Domain (ODD)

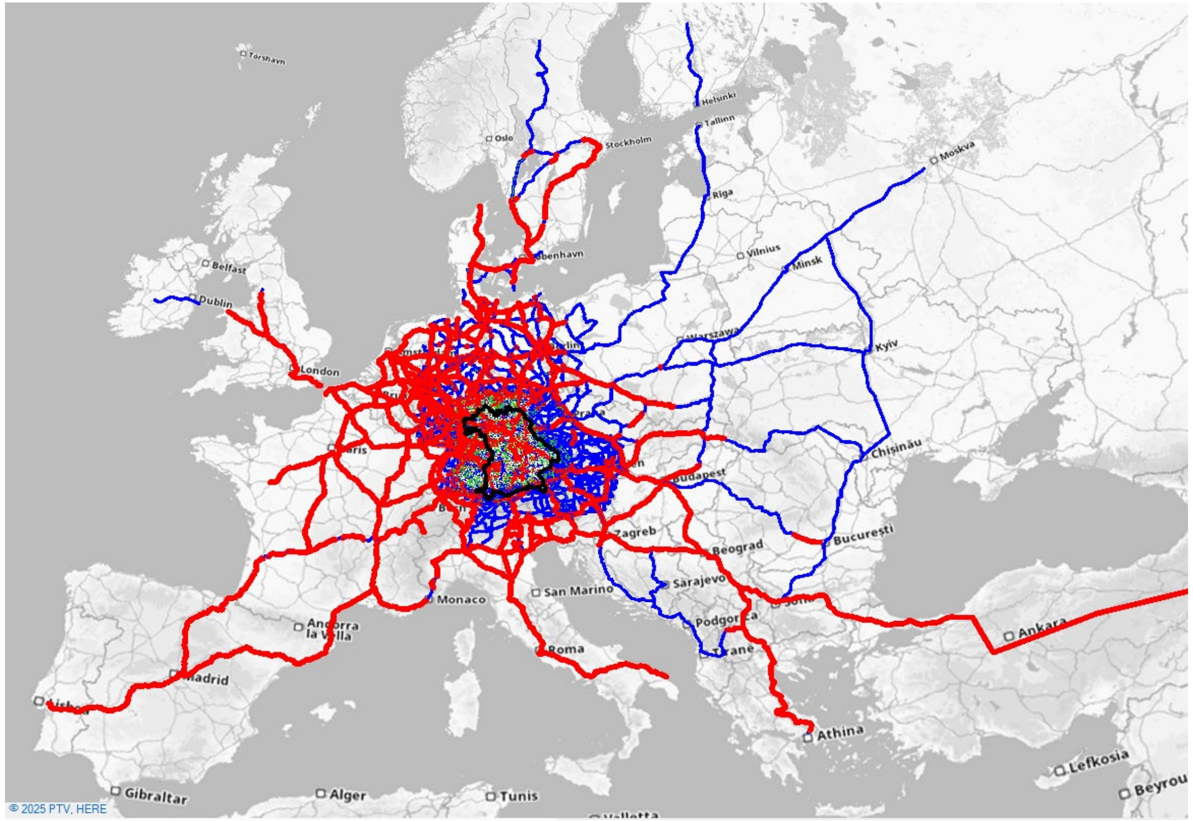




Extension of ODD for EADF:
Narrow urban roads & motorway ramps

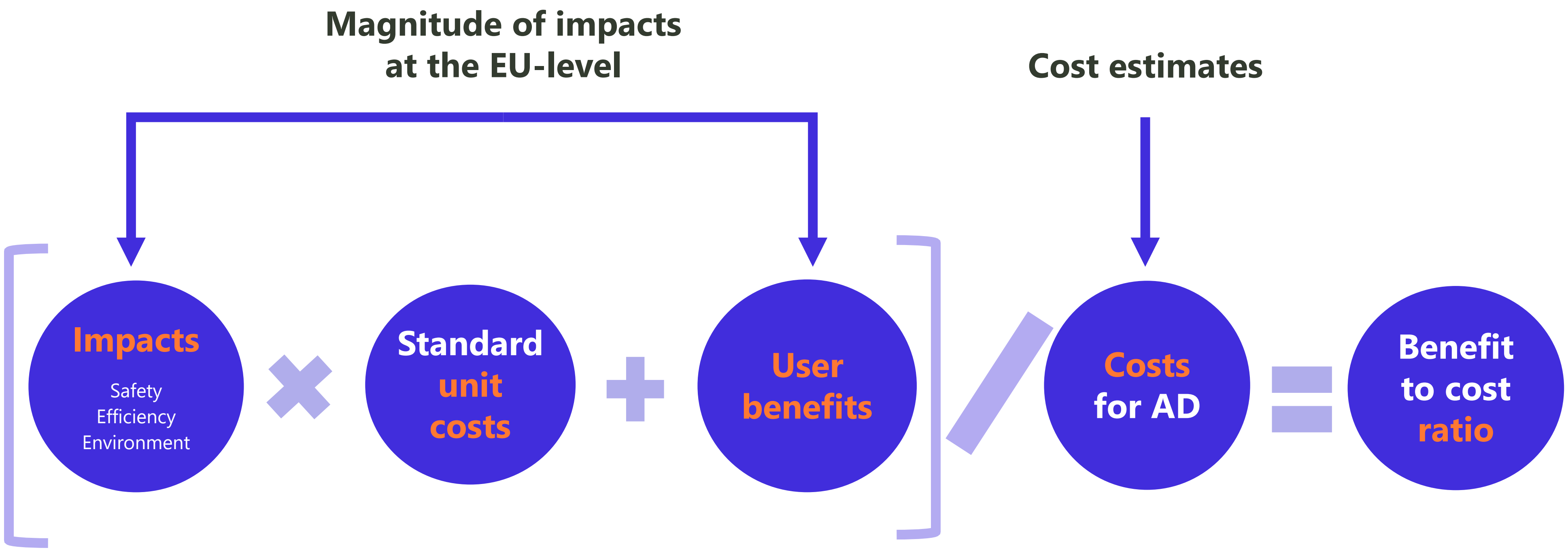
Impacts on modal split and travel performance

- A reduction in **perceived value of travel time** and an increase in **passenger-car units** required for automated vehicles balanced their effects on modal split
  - Negligible impact on **modal split**
- Slight increase in **vehicle-km travelled**, larger outside ODD than inside it
- 5% increase in **vehicle-hours travelled**



5 SOCIOECONOMICS

Method for socioeconomic impact assessment



User benefits: Relative importance

Relative importance of different attributes for respondents with **willingness to pay >0**

Hi-Drive Global Survey:

	Relative importance (%)
Increased safety	40.6
Increased comfort (less stressful driving)	22.6
Spending travel time on recreation	12.2
Fewer and shorter delays	11.2
Spending travel time on work-related activities	10.7
Other	2.7
N	3,372 = 100%

Costs and benefits of implementing 30% EADF in the EU

Full ADAS scenario, 30% EADF			
Impact		**Million €**	
• Total accident cost savings		21,800	
• Travel time efficiency		-7,500	
• Consumption of fossil fuels		200	
• CO_2 emissions		200	
• Users' benefit: comfort		11,300	
• Users' benefit: relax instead of driving		6,100	
• Users' benefit: work instead of driving		5,400	
Economic value of all impacts in total		**37,600**	
	Minimum cost estimate	Maximum cost estimate	Average cost estimate
Cost of implementing CAD	**19,200**	**43,800**	**31,500**
Net benefits	18,400	-6,200	6,100
Benefit/cost ratio	**2.0**	**0.9**	**1.2**

Costs and benefits of implementing 30% EADF in the EU

Traffic today scenario, 30% EADF			
Impact		**Million €**	
• Total accident cost savings		39,900	
• Travel time efficiency		-6,800	
• Consumption of fossil fuels		900	
• CO_2 emissions		900	
• Users' benefit: comfort		11,300	
• Users' benefit: relax instead of driving		6,100	
• Users' benefit: work instead of driving		5,400	
Economic value of all impacts in total		**57,800**	
	Minimum cost estimate	Maximum cost estimate	Average cost estimate
Cost of implementing CAD	**19,200**	**43,800**	**31,500**
Net benefits	38,600	14,000	26,300
Benefit/cost ratio	**3.0**	**1.3**	**1.8**

CONCLUSIONS

Conclusions

- Summary of impacts
  - Substantial benefits with reduced **number of accidents**
  - Small increase in **travel time**
  - Small decrease in **CO_2 emissions**
  - Substantial decrease in **tractive energy use**
  - Enhancement in **travel quality**
  - Negligible impact on **modal split**
  - **Rerouting** to outside ODD with increase in vehicle-km and hours travelled
  - Profitable from **society**'s point of view
- For **limitations**, see Hi-Drive Deliverables D7.3-5
- **Most complex and extensive** impact assessment for ADF with advancements in state of the art

Hi-Drive

Hi-Drive

FINAL EVENT

25 NOVEMBER 2025

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Find impact assessment results in the **Hi-Drive Deliverables D7.2-5**

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