Scaling up –
Safety impact assessment

L3Pilot Final Event

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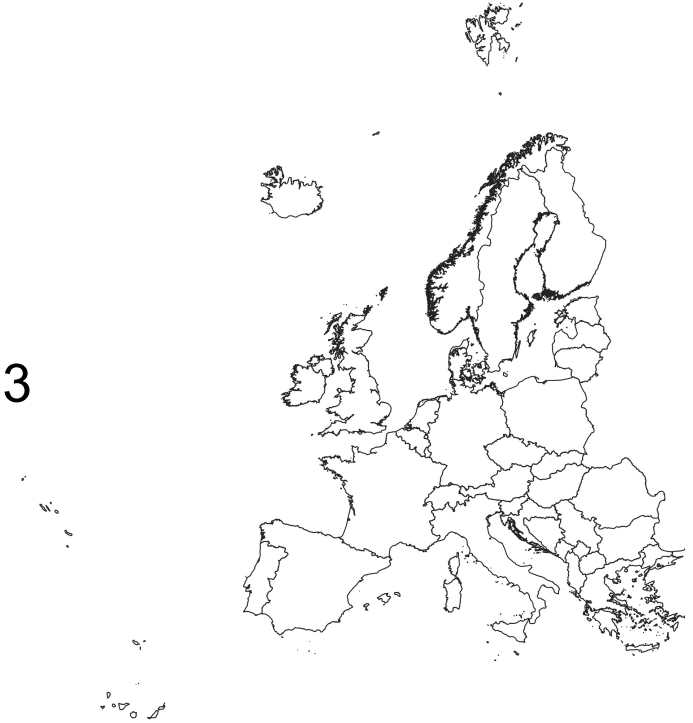
High level Research Question

What is the impact of ADF on traffic safety?

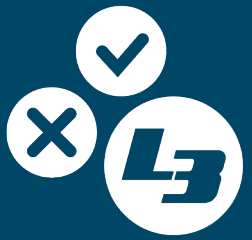
Scaling up to EU27+3

Impact in terms of number of accidents of different severities



Evaluation

Method

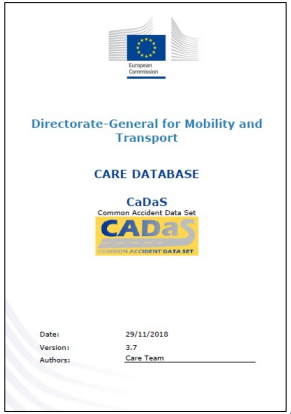


Safety scaling up process

- Target accident definition by processing of accident data
- Impact estimate calculation from safety simulation outcomes
    - Current accidents (motorway & urban ADF)
    - New accidents (motorway ADF)
- Impact estimation for non-simulated accident types
- Identification of other expected changes affecting road safety

Target accident definition by processing of accident data

- Identification of target accidents (taking place within the ODD requirements of mature ADFs) → potentially preventable with the use of ADF
- Road accidents from the **EU-wide CARE database** (EU27+3)
  - Includes most of the attributes needed for the scaling up
  - Challenge: missing values (not completed, ‘unknown’ or ‘not specified’)
  - Process needed to fill in these gaps:
    - Distribution of known values used for missing ones (few missing)
    - In-depth and national accident statistic when available (larger gaps)
    - EU averages when no other source available



Calculation of impact estimates from safety simulations − Current accidents as basis

The scaled-up safety impact was calculated per ADF separately for different severities (*i*) (fatal, serious and slight injuries) and for different penetration rates (*p*)

$$Impact_{i,p} = \sum_j \left(T_{total,j} \cdot \Delta f_{j,p} \cdot \Delta I_{total,j,p} \cdot \frac{A_{i,AT}}{A_{total,AT}} \cdot \Delta i_{i,j,p} \right) - \sum_j T_{i,j}$$

$T_{total,j}$ = Number of target accidents (injury accidents of all severities: slight, serious, fatal) for driving scenario *j*

$\Delta f_{j,p}$ = Change in the frequency of driving scenario *j* for penetration rate *p*

$\Delta I_{total,j,p}$ = Change in total injury accident risk for driving scenario *j* for penetration rate *p*

$A_{i,AT}$ = Number of accident severity *i* for target accidents of type AT linked to driving scenario *j*

$A_{total,AT}$ = Number of all injury accidents in total for target accidents of type AT linked to driving scenario *j*

$\Delta i_{i,j,p}$ = Change in share of accidents of severity *i* for driving scenario *j* for penetration rate *p*

$T_{i,j}$ = Number of target accidents with severity *i* for driving scenario *j*

Estimation of impacts for non-simulated accident types

- Some accident types were not addressed by any simulated scenario
  - ➢ Effect was evaluated based on mature ADF design principles and accident statistics (GIDAS, STATS19, Finnish Crash Data Institute)

Assumptions about mature ADF design principles:

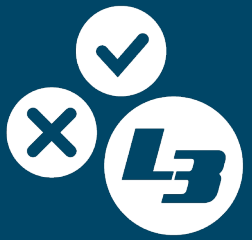
- ADF does not have unintended lane departures
- ADF brakes when another vehicle is approaching (head-on/reversing) from the opposite direction in the same lane
- Majority of accidents with opening doors of parked vehicles are very sudden situations → ADF cannot avoid these collisions

Identification of other expected changes per impact mechanism

Mechanism		Relevant	Input
M1	**Direct modification of the driving task, drive behaviour or travel experience**	**Yes**	• Simulations results and assumptions of effects for the non-simulated relevant accident types • **TOR simulator studies** • **Literature**
M2	Direct influence by physical and/or digital infrastructure	Yes	• Connectivity not relevant • Infrastructure impacts relevant, covered in simulations
M3	**Indirect modification of AV user behaviour**	**Yes**	• **Literature**
M4	**Indirect modification of non-user behaviour**	**Yes**	• **Literature**
M5	**Modification of interaction between AVs and other road users**	**Yes**	• Simulations results • **Literature**
M6	**Modification of exposure / amount of travel**	**Yes**	**Mobility results**
M7	**Modification of modal choice**	**Yes**	**Mobility results**
M8	**Modification of route choice**	**Yes**	**Mobility results**
M9	Modification of consequences due to different vehicle design	No	Assumption of identical vehicle design

Evaluation

Results



Number of target accidents in EU27+3 (2018)

Severity of accidents	Motorway ADF		Urban ADF		All injury accidents
	Target accidents inside ODD	Total	Target accidents inside ODD	Total	
Slight	37,898	55,138	370,168	609,575	868,523
Serious	6,327	10,976	67,547	124,680	206,263
Fatal	982	1,874	4,368	9,298	23,778
Total	**45,207**	**67,988**	**442,083**	**743,553**	**1,098,564**

Most common accident types

Motorway ADF

Accident type	Injury accidents inside ODD[1]
At least two vehicles - same direction - Rear end collisions	20,527
Single vehicle accident - Leaving straight road - Either side of the road	5,525
Single vehicle accidents with obstacles - Others	3,183
At least two vehicles - Same direction - Side collision	2,729
At least two vehicles - Others no turning	2,362

[1] Total of accidents with fatal, serious and slight injuries.

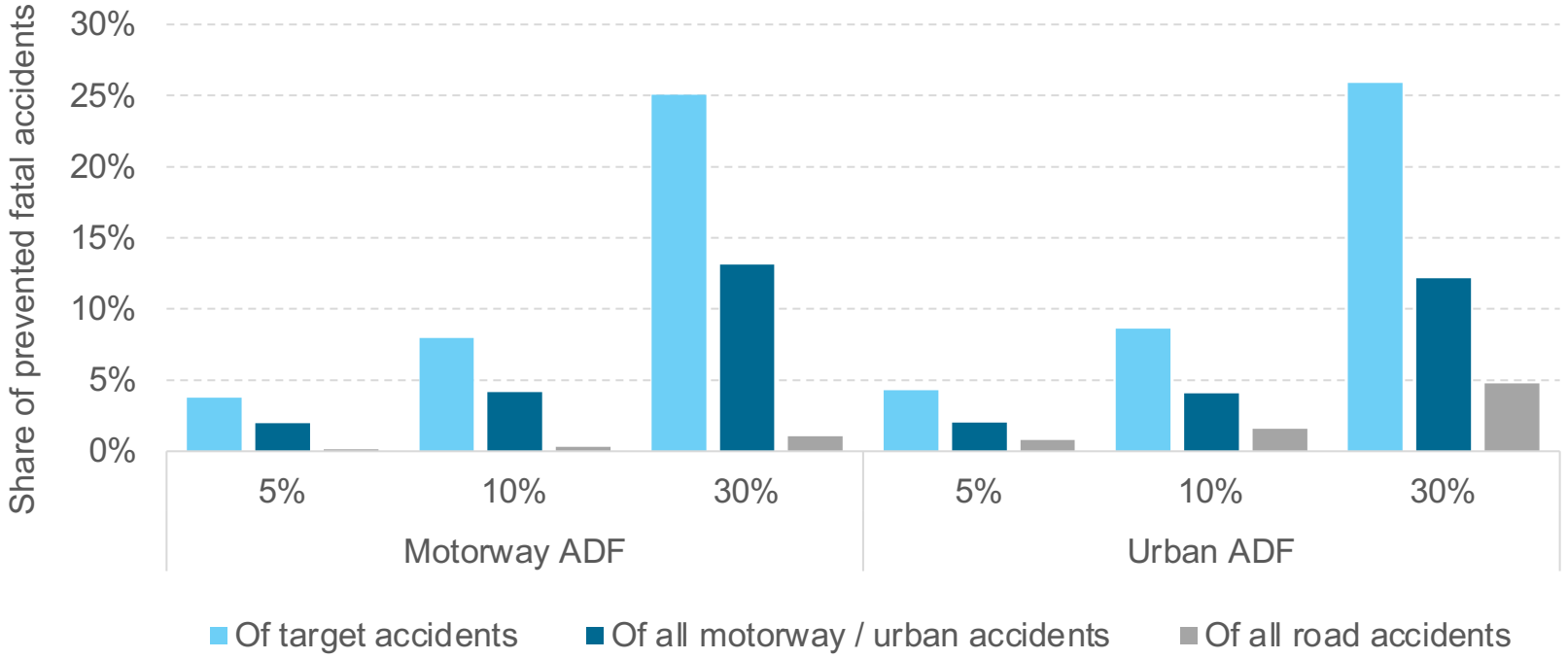
Urban ADF

Accident type	Injury accidents inside ODD[1]
At least two vehicles – Same direction - Rear end collision	59,061
At least two vehicles – Crossing or turning - Others	55,943
At least two vehicles - Crossing or turning – Others (accidents involving cyclists)	51,641
Pedestrian accident - Other	38,229
Pedestrian crossing street – No turning of vehicle – Outside a junction	25,832

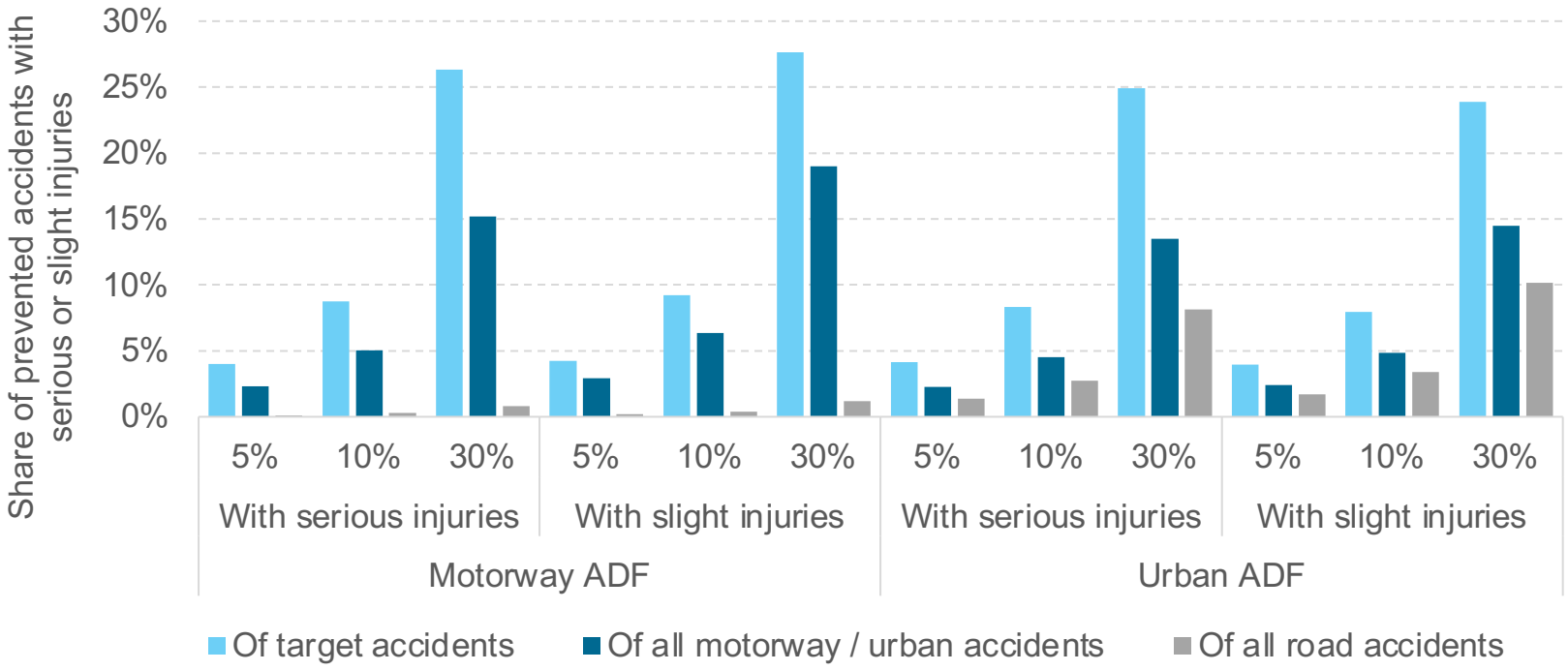
Scaled up results in EU27+3 (motorway + urban ADF)

Penetration rate	Number of current road accidents prevented annually		
	with fatalities	with serious injuries	with slight injuries
Motorway ADF			
5%	37	253	1,604
10%	78	555	3,492
30%	246	1,665	10,467
Urban ADF			
5%	188	2,805	14,730
10%	377	5,611	29,459
30%	1,130	16,833	88,377

Safety impact by penetration rate for EU27+3 − Fatal accidents



Safety impact by penetration rate for EU27+3 – Accidents with serious or slight injuries



Safety implications of impact mechanisms

Positive: Decrease in nr of accidents
Negative: Increase in nr of accidents

	Mechanisms	Estimated effects	Direction	Effect size
Direct effects	M1: Driving task, drive behaviour or travel experience	Number of road accidents to decrease; Challenges related to fatigue, engagement in other tasks, and lower situation awareness	Positive	Medium
	M2: Physical and/or digital infra	Infra impacts covered by simulations	–	–
Indirect effects	M3: AV user behaviour	Deskilling of driving skills and deterioration of driving performance	Negative	Small
	M4: Non-user behaviour	Lower volatility of speed and acceleration; smaller speed differences	Positive	Small
	M5: Interaction between AVs and other road users	Covered to a large extent by the simulations	–	–
	M6: Exposure / amount of travel	Increase in vehicle km travelled by car	Negative	Medium
	M7: Modal choice	More likely to use car	Negative	Medium
	M8: Route choice	Preference towards route inside ODD, such as motorways	Positive	Medium
	M9: Consequences due to different vehicle design	No effect assumed	–	–

Conclusions

- Both motorway and urban ADF are estimated to reduce the number of injury accidents at all penetration rates
- Reduction of all road accidents is larger for urban ADF compared to motorway ADF
- Only few potential new accidents caused by automation annually
- Some additional indirect safety effects can be obtained, for example
  - via sensors working during manual drive (positive effect), and
  - via increase in passenger car km (negative effect)

Thank you for your kind attention.

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