



# Safety impact assessment method for cooperative systems

The Fourth Annual Scientific Seminar of the  
Nordic Traffic Safety Academy

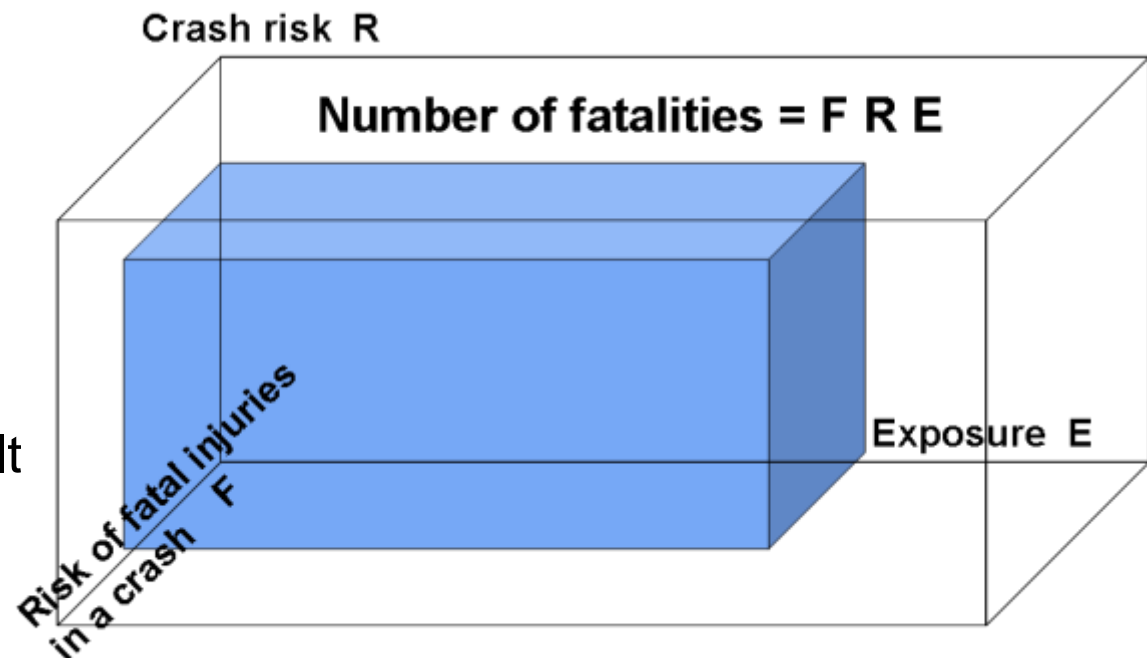
Satu Innamaa & Pirkko Rämä, VTT

# ERiC – European Risk Calculation Tool for safety impact assessment

- Tool for assessing impacts in number of fatalities and injuries on European level
- Development started in EU projects eIMPACT, PreVAL and CODIA but was carried on by VTT including later projects like INTERSAFE2, Minifaros, DRIVE C2X and VRUITS
- The method applied in ERiC is based on the theory that safety assessment of ITS should (Kulmala 2010):
  1. Cover all three dimensions of road safety
  2. Cover the effects due to behavioural adaptation in addition to the engineering effect
  3. Be compatible with the state of the art road safety theories

# System nature of transport

- The approach is based the system nature of transport (Kulmala 2010)
  - When one element of the system is affected, the consequences may appear in several elements and levels of the system
- Road safety is regarded as a multiplication of three orthogonal factors:
  - Exposure
  - Risk of a collision to take place during a trip
  - Risk of a collision to result in injuries or death
 (Nilsson 2004)



# Nine mechanisms via which ITS affects safety

1. Direct in-car modification of the driving task
  2. Direct influence by roadside systems
  3. Indirect modification of user behaviour
  4. Indirect modification of non-user behaviour
  5. Modification of interaction between users and non-users
  6. Modification of road user exposure
  7. Modification of modal choice
  8. Modification of route choice
  9. Modification of accident consequences
- (Draskóczy et al. 1998, Kulmala 2010)

# ERiC for cooperative functions in DRIVE C2X

- Excel version 2.0 of ERiC was made for DRIVE C2X
  - New accident database
  - Target years 2020 and 2030
  - EU-28 area
- Cooperative functions
  - Approaching emergency vehicle warning (AEVW)
  - Car breakdown warning (CBW)
  - Electronic emergency brake light warning (EEBL)
  - Green light optimal speed advisory (GLOSA)
  - In-vehicle signage (IVS)
  - Road works warning (RWW)
  - Traffic jam ahead warning (TJAW)
  - Weather warning (WW)

## Accident database

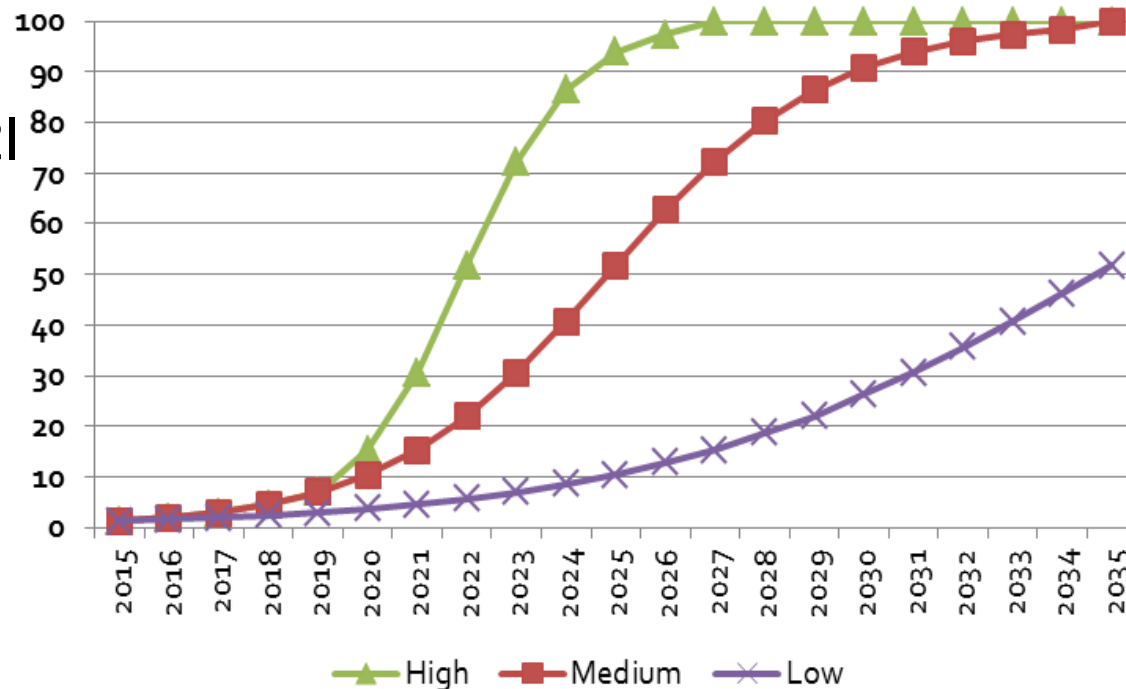
- Statistics from CARE database for number of injuries and fatalities in EU28
  - Accident data from 2010 was used
  - Lithuanian data was not in CARE, local statistics were used
  - Fatalities and injuries caused by an accident where at least one party was a heavy vehicle were separated from those accidents where all parties were light vehicles
- The total number of fatalities in CARE for 2010 was 29% smaller for EU28 than in the Statistical Pocketbook, and 7% in injuries
  - For the calculation of the prevented fatalities and injuries, the CARE based totals were increased by these factors

## Accident database

- A forecast for 2020 and 2030 was made for road safety development following the same trends as the INTERSAFE2 (and eImpact) projects taking into consideration that the prediction period was 5 years shorter in DRIVE C2X
- Accidents classified by
  - Collision type
  - Road type
  - Weather condition
  - Lightning condition
  - Location of accident

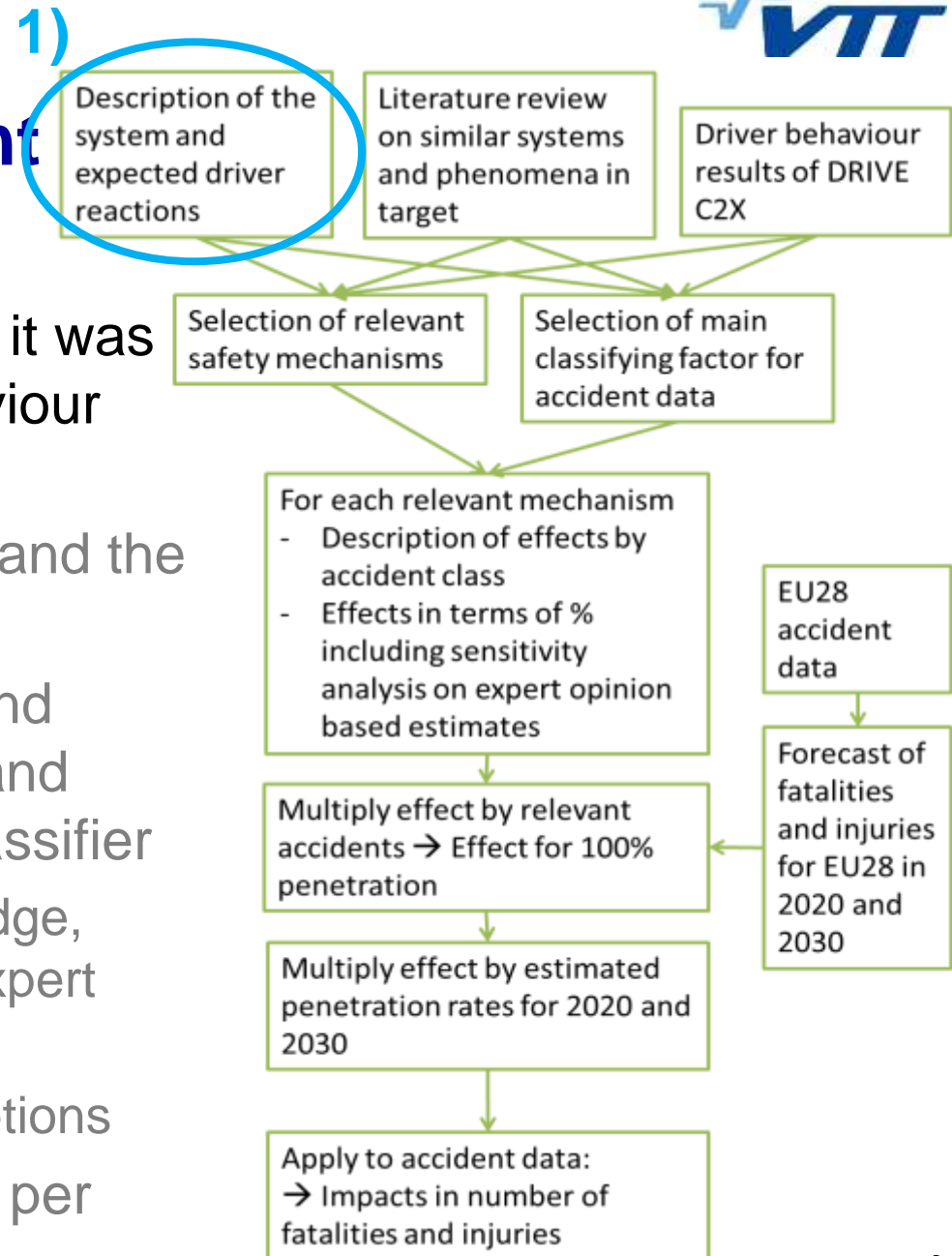
# Penetrations of cooperative functions

- Penetrations given for passenger cars, 0% assumed for other vehicle types
  - System penetrations in traffic assessed based on annual kilometres travelled
- Number of warned vehicles with V2V and V2I applications assessed based on WILLWARN project results
- 100% infra penetration
- Three scenarios, two target years



# Safety impact assessment procedure in practice

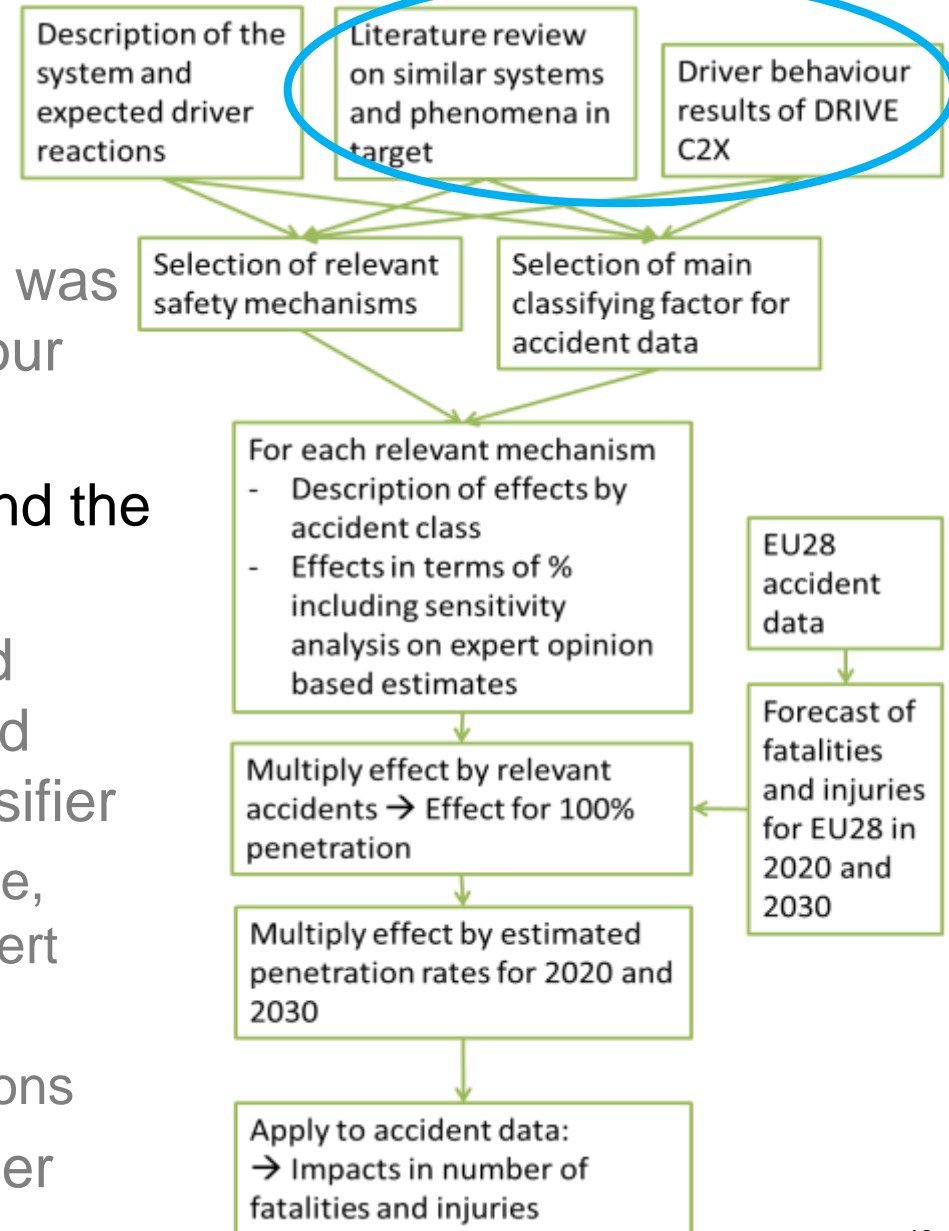
- 1) Describe the function and how it was expected to affect driver behaviour and safety
- 2) Study driver behaviour results and the literature related to function
- 3) Assess impacts on fatalities and injuries by safety mechanism and classes of the chosen main classifier
  - Combination of old knowledge, field measured facts and expert assessment
  - Range given for all assumptions
- 4) Calculate overall impact range per safety mechanism (ERiC)



2)

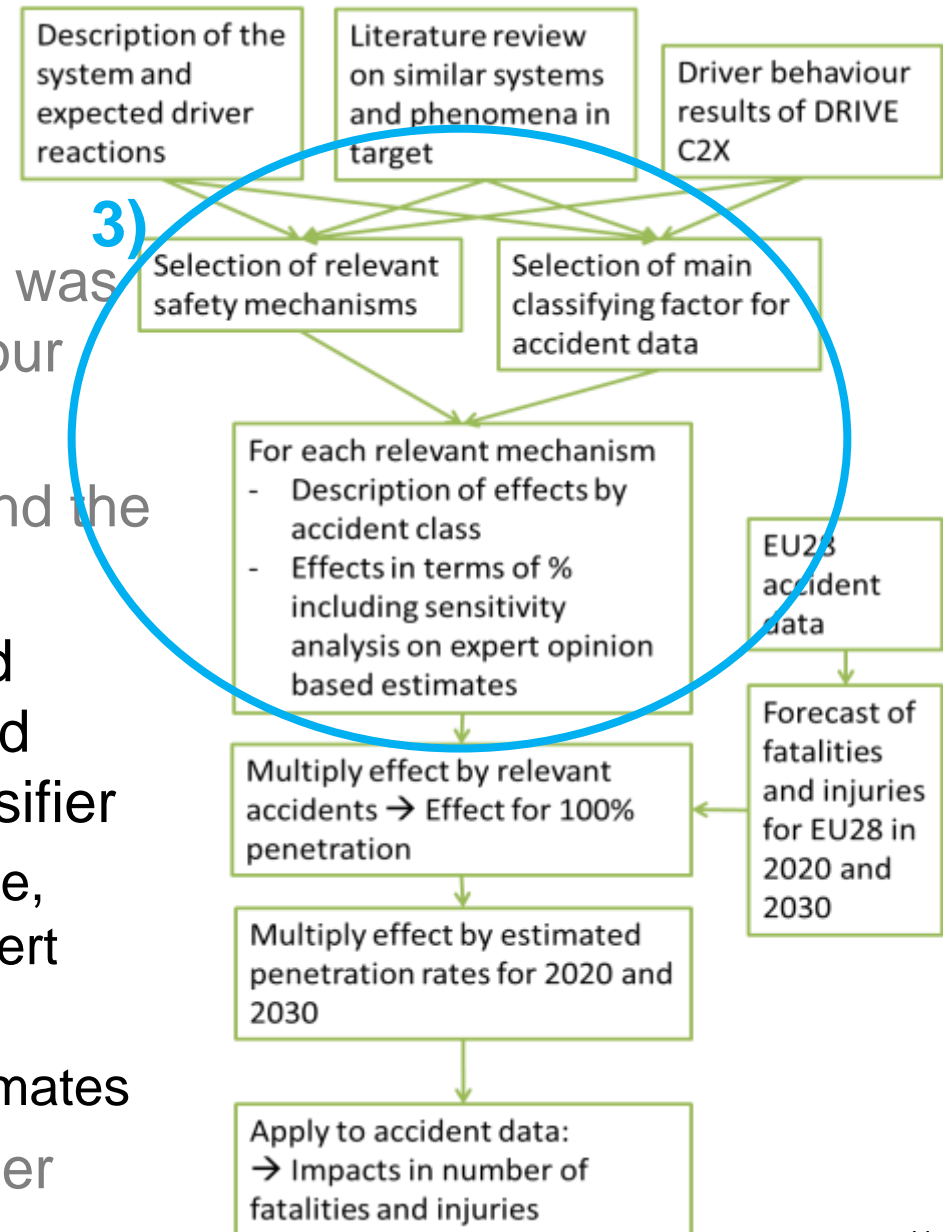
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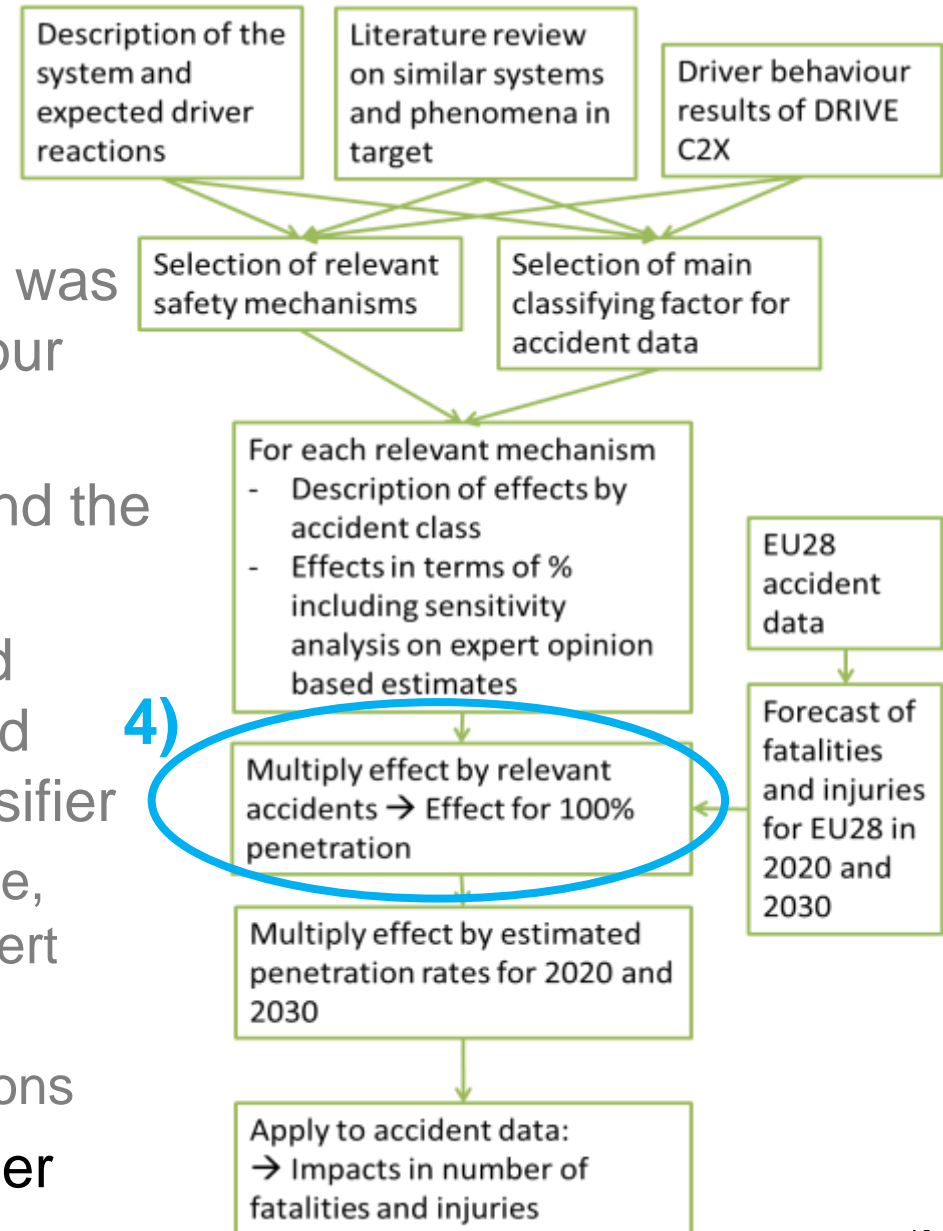
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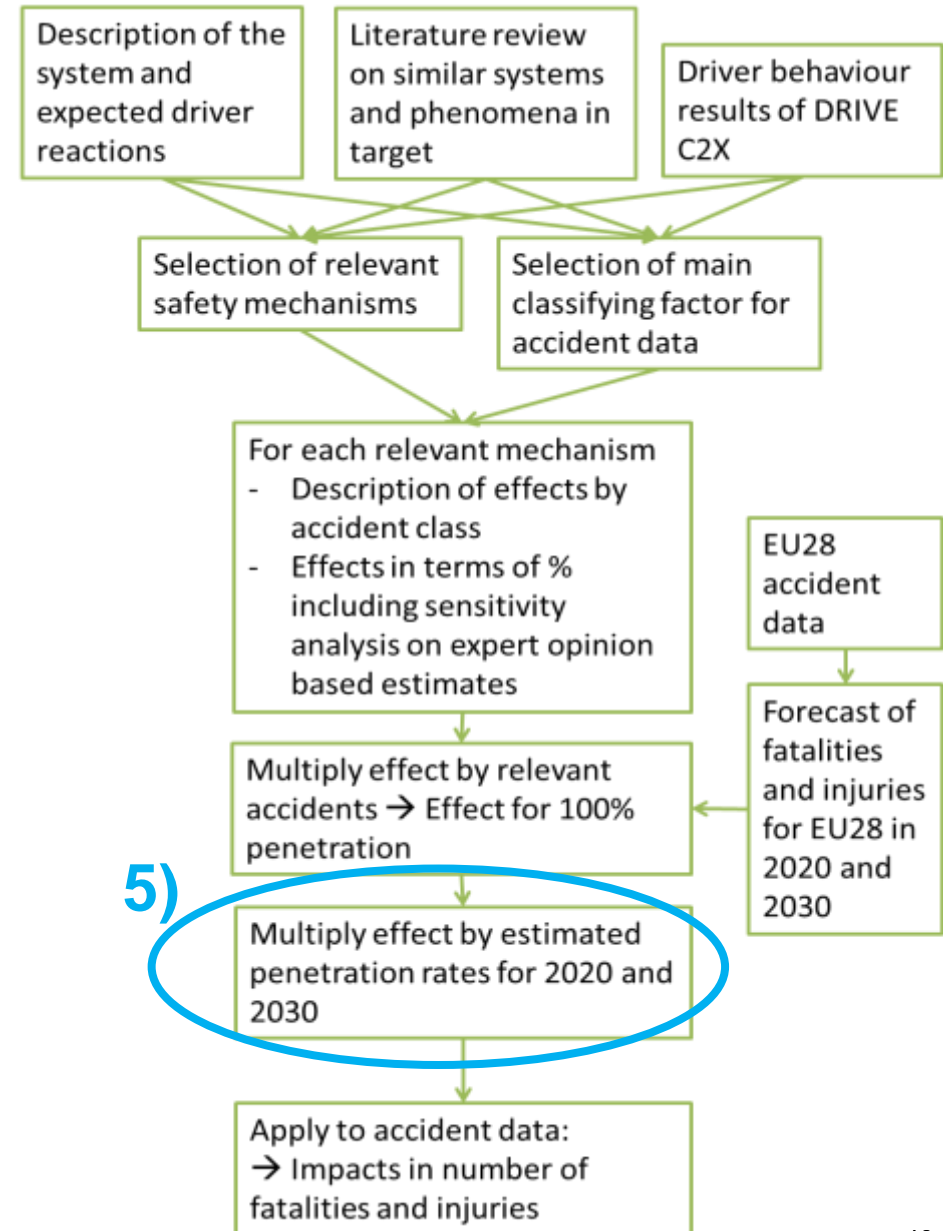
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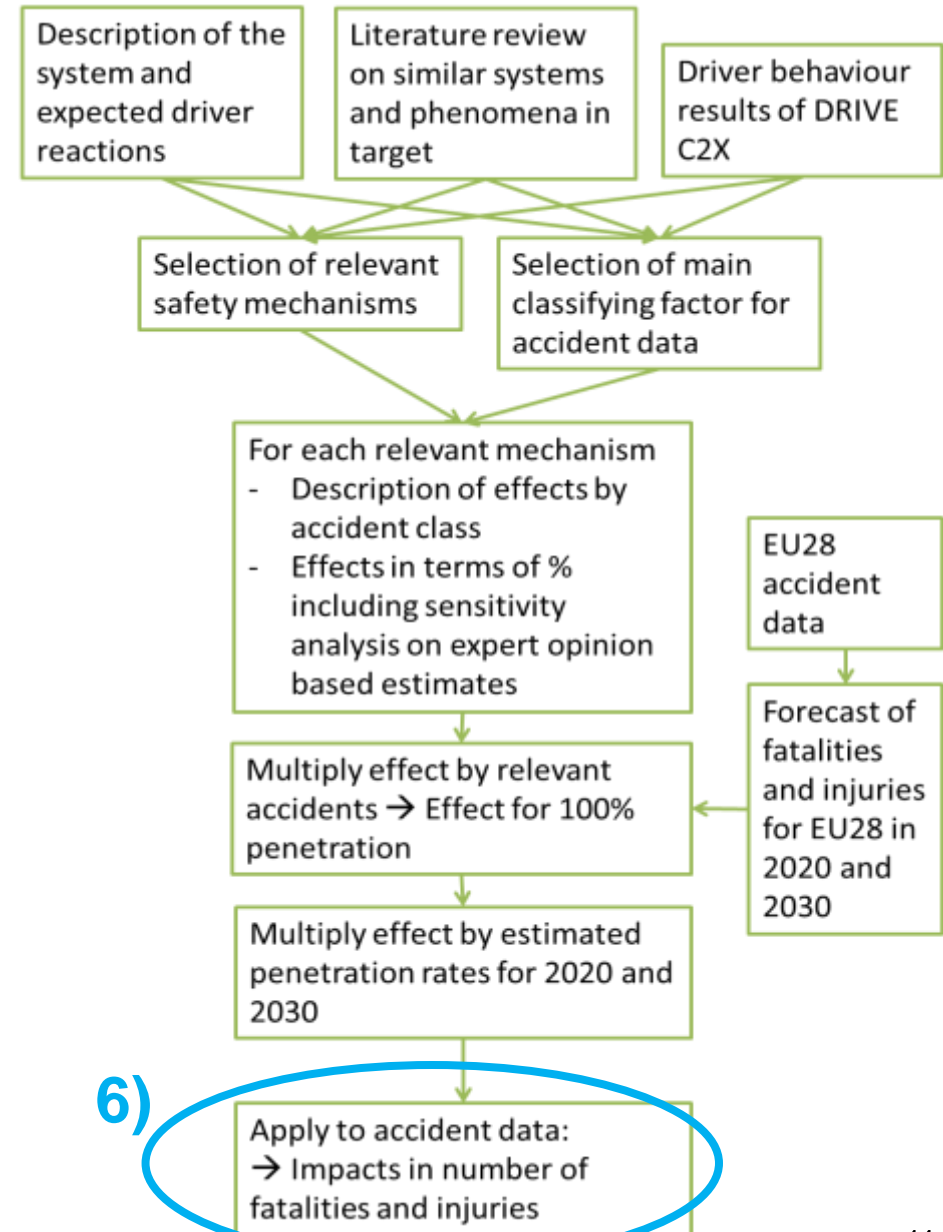
# Safety impact assessment procedure in practice (2/2)

- 5) Include system penetration rates (ERiC)
  - Lowest estimate to be combined with low penetration scenario, average estimate with medium scenario, and high with high
- 6) Calculate overall impacts for fatalities and functions over all conditions and mechanisms for all scenarios (as % and number/year) (ERiC)



# Safety impact assessment procedure in practice (2/2)

- 5) Include system penetration rates (ERiC)
  - Lowest estimate to be combined with low penetration scenario, average estimate with medium scenario, and high with high
- 6) Calculate overall impacts for fatalities and injuries over all conditions and mechanisms for all scenarios (as % and number/year) (ERiC)



# Example: Cooperative Road Works Warning

- Impact on fatalities
  - Mechanism 1: Direct in-car modification of the driving task
    - Accident type: Rear collision
      - Driver behaviour impacts:
        - Aver. speed -1.1 to -5.5 km/h, all test sites
        - Less sudden manoeuvres
      - Literature:
        - 3% of fatal accidents take place at a road work site
        - 34% of accidents that take place at a road work site are rear collisions
        - 80-90% of such accidents are caused by inattention
      - Statistics:
        - 13% of fatalities are caused in rear collisions
      - Expert opinion based estimate:
        - 80-90% of theoretical maximum of fatalities to be prevented will be prevented for used of the RWW
      - Impact on fatalities: -5.0% to -5.6% (full penetration)
    - Mechanism 5: Modification of interaction between users and non-users
      - Expert opinion based estimate:
        - Milder impact for non-users: 20-30% of the impact on users

## Example: Cooperative Road Works Warning

	Overall impact 2020			Overall impact 2030		
	Low	High	Medium	Low	High	Medium
<b>Fatalities</b>	-0.07%	-0.44%	-0.25%	-0.52%	-1.96%	-1.62%
	-14	-84	-48	-58	-217	-180
<b>Injuries</b>	-0.06%	-0.34%	-0.19%	-0.40%	-1.51%	-1.24%
	-526	-3 113	-1 784	-2 628	-9 939	-8 217

# Example: Cooperative In-Vehicle Signage – Child Sign and Pedestrian Crossing Ahead Sign

- Impact on fatalities
  - Mechanism 1: Direct in-car modification of the driving task
    - Accident type: Single vehicle collision with pedestrian
      - Driver behaviour impacts:
        - Spot speed reduction 1.1 to 1.5 km/h (typically 1.4 km/h)
      - Literature:
        - 50% of accidents due to lack of attention
        - Decrease in fatality risk due to speed decrease -0.5%
      - Expert opinion based estimate:
        - Function prevents 55-75% of accidents that are due to lack of attention
        - 3-8% of single vehicle collisions with pedestrian take place in locations that are equipped with a child sign or pedestrian crossing ahead sign
      - Impact on fatalities: -1.3% to -3.5% (full penetration)
    - Mechanism 3: Indirect modification of user behaviour
      - Expert opinion based estimate:
        - 5-10% of users pay more attention on pedestrian also when function is not activated
        - They do so 10-25% of time

## Example: Cooperative In-Vehicle Signage – Child Sign and Pedestrian Crossing Ahead Sign

	Overall impact 2020			Overall impact 2030		
	Low	High	Medium	Low	High	Medium
<b>Fatalities</b>	-0.01%	-0.16%	-0.07%	-0.09%	-1.04%	-0.63%
	-2.5	-31	-14	-10	-115	-70
<b>Injuries</b>	0.00%	-0.07%	-0.03%	-0.03%	-0.46%	-0.27%
	-41	-658	-281	-207	-3 063	-1 750

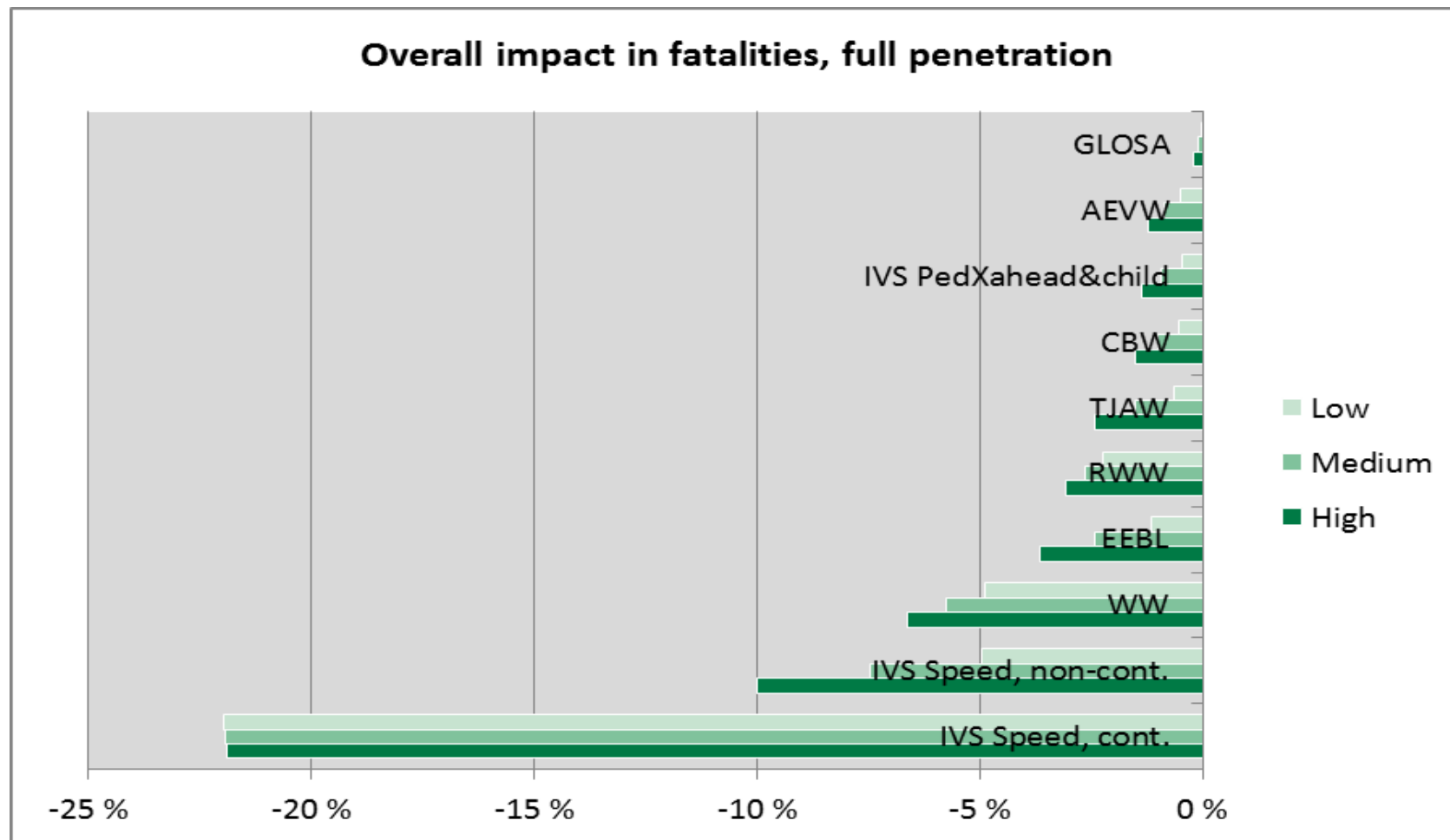
# Example: Cooperative Weather Warning

- Impact on fatalities
  - Mechanism 1: Direct in-car modification of the driving task
    - Weather: Adverse weather conditions
      - Driver behaviour impacts:
        - Speed reduction from 54.3 to 49.7 km/h
      - Literature:
        - Nilsson's formula
        - Impact due to longer headway: 4%
        - Impact due to increased awareness: 11%
      - Expert opinion based estimate:
        - Proportion of most adverse condition accidents: 15-30%
        - Milder impact in less adverse conditions: 0-30%
      - Impact on fatalities: -1.3% to -3.5% (full penetration)
    - Mechanism 5: Modification of interaction between users and non-users
      - Expert opinion based estimate:
        - Milder effect for non-users : 40-60% of M1 in adverse conditions, 0% in normal weather conditions

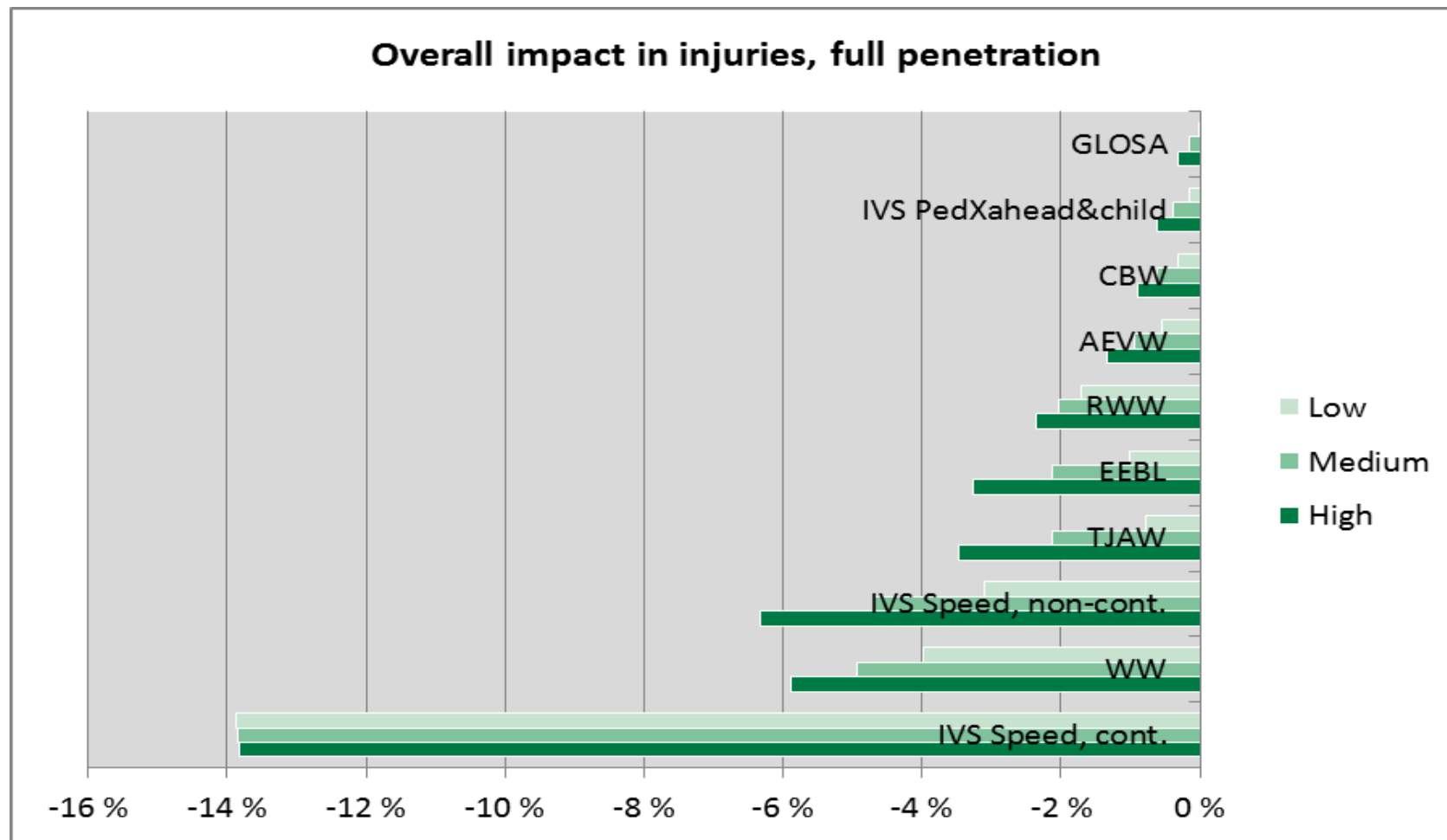
## Example: Cooperative Weather Warning

	Overall impact 2020			Overall impact 2030		
	Low	High	Medium	Low	High	Medium
<b>Fatalities</b>	-0.10%	-1.10%	-0.55%	-1.24%	-3.43%	-3.13%
	-19	-209	-105	-138	-380	-347
<b>Injuries</b>	-0.15%	-0.95%	-0.52%	-1.02%	-3.35%	-2.78%
	-1 350	-8 757	-4 841	-6 740	-22 088	-18 344

# Overall result: Safety impacts of cooperative systems / Fatalities



# Overall result: Safety impacts of cooperative systems / Injuries



DRIVE



Accelerate cooperative mobility

## Acknowledgements

**DRIVE C2X project and its  
safety impact assessment  
task partners**

# More details and information on DRIVE C2X results

D11.4 Impacts of cooperative systems and user perception:

[http://www.drive-c2x.eu/tl\\_files/publications/Deliverables%20and%20abstracts/DRIVE%20C2X\\_D11.4\\_Impact\\_Assessment\\_v1.0\\_full%20version.pdf](http://www.drive-c2x.eu/tl_files/publications/Deliverables%20and%20abstracts/DRIVE%20C2X_D11.4_Impact_Assessment_v1.0_full%20version.pdf)



Vehicle-to-infrastructure communications



Vehicle-to-vehicle communications



# TECHNOLOGY «FOR BUSINESS»

