interactIVe

Accident avoidance by active intervention for Intelligent Vehicles

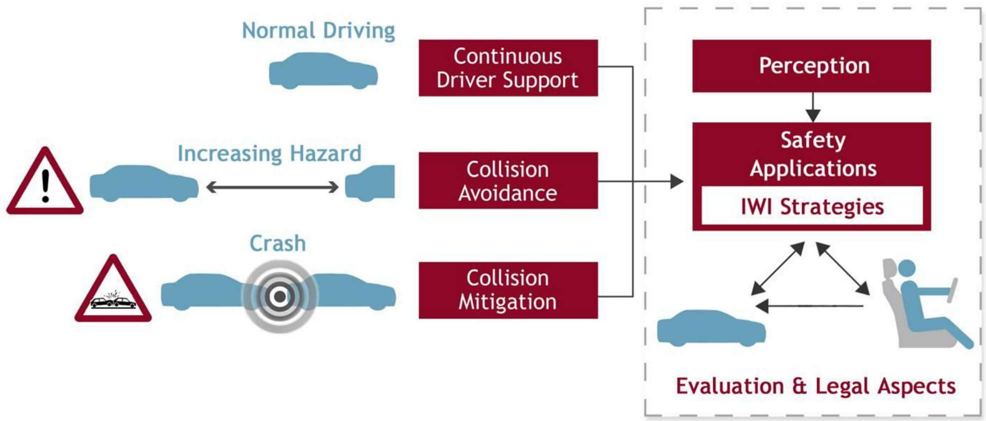
SIMPATO – the Safety Impact Assessment Tool of Interactive

Martijn van Noort (TNO)
Taoufik Bakri (TNO)
Felix Fahrenkrog (IKA)
Jan Dobberstein (BASt)

interactIVe - Project overview

The interactIVe vision:
Accident-free traffic and active safety systems in all vehicles

- Facts:
  - Duration: 48 months (January 2010 – November 2013)
  - 29 partners of 10 countries
  - Budget: 30 Million € (Founding by the European Commission: 17 Million €)
- interactIVe systems:
  - SECONDS (Safety enhancement through continuous driver support)
  - INCA (Integrated collision avoidance and vehicle path control)
  - EMIC (Cost-efficient emergency intervention for collision mitigation)



interactIVe Demonstrators

SECONDS

- **Continuous Support**
- Curve Speed Control
- Enhanced Dynamic Pass Predictor
- **Safe Cruise**

INCA

- **Lane Change Collis. Avoid.**
- Oncoming Vehicle Collis. Avoidance/Mitigation
- **Rear End Collis. Avoidance**
- **Side Impact Avoidance**
- **Run-off Road Prevention**

EMIC

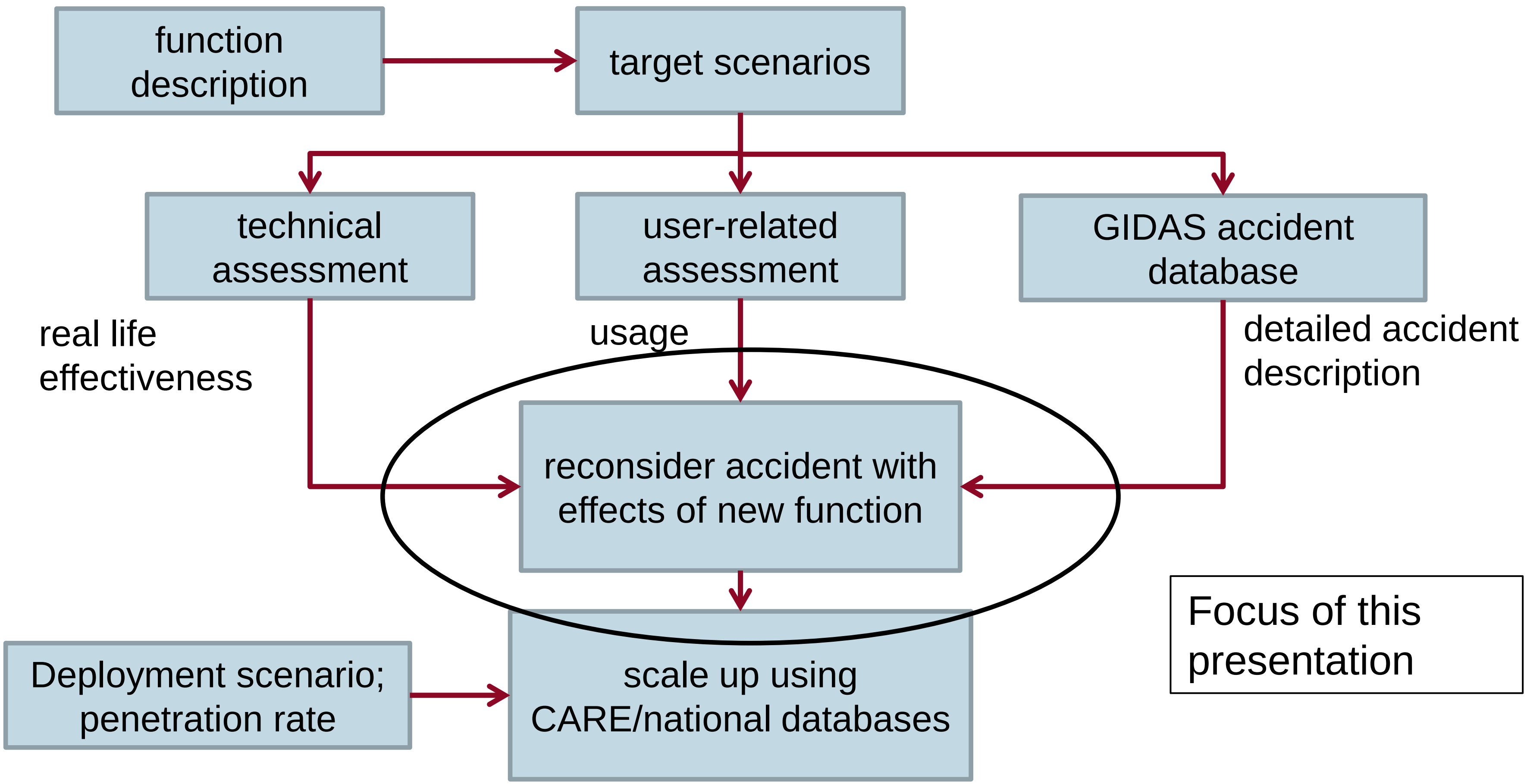
- **Emergency Steer Assist**
- **Collision Mitigation**

Safety impact assessment

- What would be the effect of these functions on the number of fatalities and injuries if they were deployed in Europe?

- Characteristics
  - Prototype systems → Limited amount of test results available on technical performance and user behaviour → ex ante evaluation
  - Many different functions, combinations of functions, and demonstrators → evaluation of the functions
  - Need in-depth accident data to define accident scenarios, but not available on EU level
  - Three of the most relevant accident types are
    - Rear end
    - Road departure
    - Lane change
    → Consider only these

Approach


function description
target scenarios
technical assessment
user-related assessment
GIDAS accident database
real life effectiveness
usage
detailed accident description
reconsider accident with effects of new function
Deployment scenario; penetration rate
scale up using CARE/national databases
Focus of this presentation

Safety Impact Assessment – Methodology

Focus of this presentation

- Literature review on impact assessment methodologies:
  - Safety Mechanisms
  - Accident Reconstruction
  - Neural Network
  - FOT – Approach
- Chose appropriate methodology by considering the available data as well as advantage and disadvantages of the methodologies:
  - Nine Safety Mechanisms

- **Direct effects**
  1. Direct in-car modification of the driving task,
  2. Dire[illegible]ications,

Only in-car functions

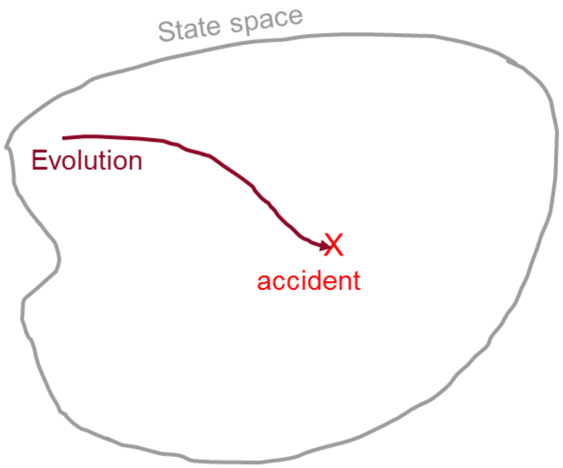
- **Indirect effects on user**
  3. Indirect modification of user behaviour,
- **Effects on non-users**
  4. Indirect modification of non-user behaviour,
  5. Modification of interaction between users and non-users,
- **Exposure effects**
  6. Modification of road user exposure,
  7. Modification of modal choice,
  8. Modification of route choice,

Exposure effects, typically small

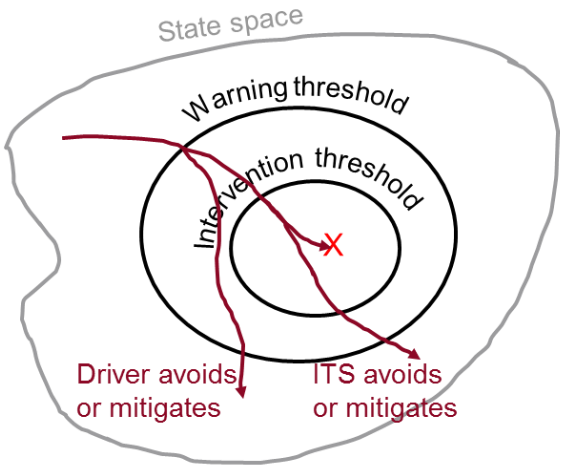
- **Effects on post-accident consequence modification**
  9. Modi[illegible]quences.

Only post-collision

Direct effect – Accident evolution



Reference case

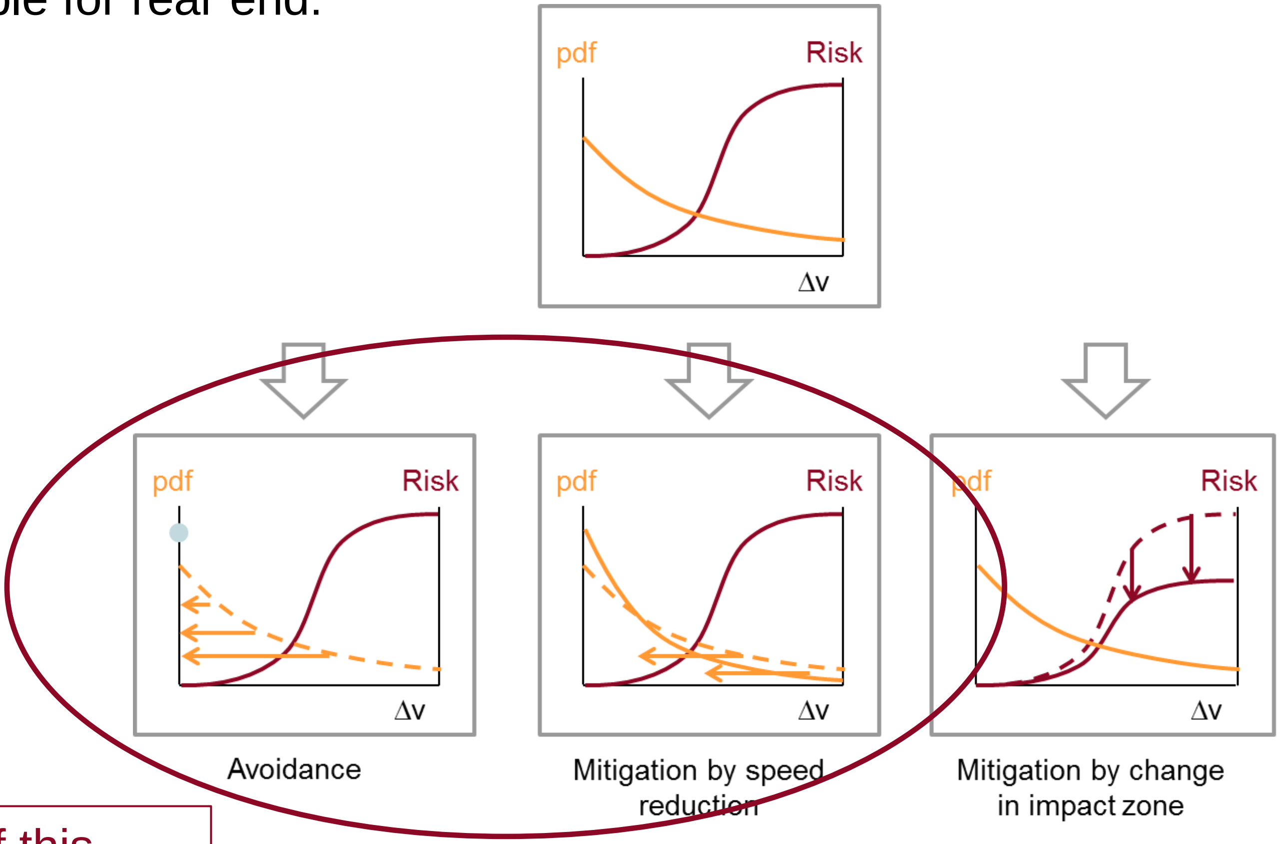


Equipped case

- Function may warn or intervene; driver may react to warning
  - Warning and intervention time points: technical assessment
  - Driver reaction time and reaction strength: user related assessment & literature review
  - Function intervention strength: technical assessment

Direct effects - Possible effects of an interactIVe ADAS

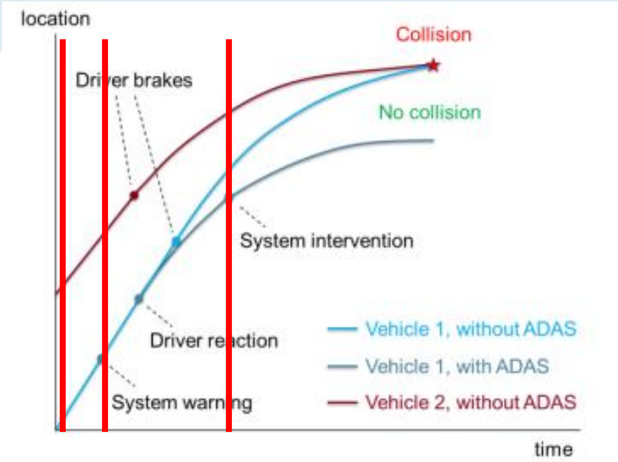
- How can a interactIVe function affect the an accident?
- Example for rear end:

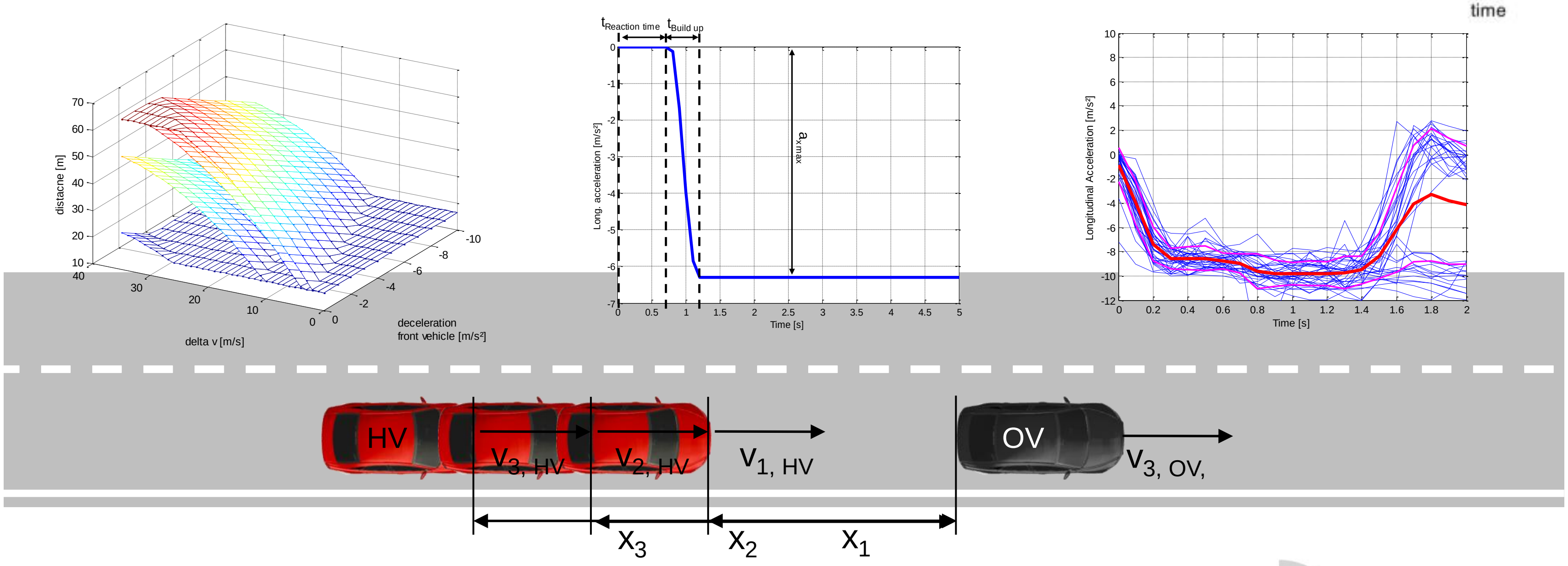


Focus of this presentation

Direct effects – Rear-end scenario (Braking)

- Initial condition (in-depth accident database)





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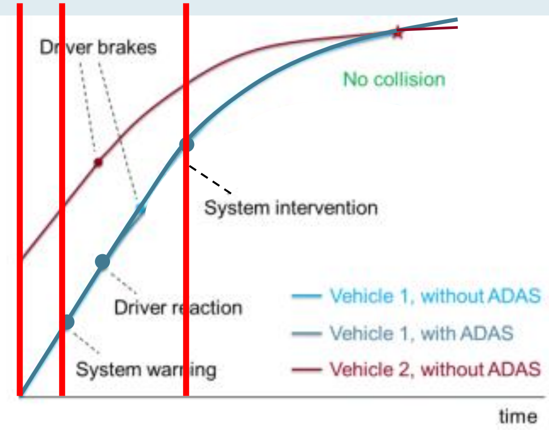
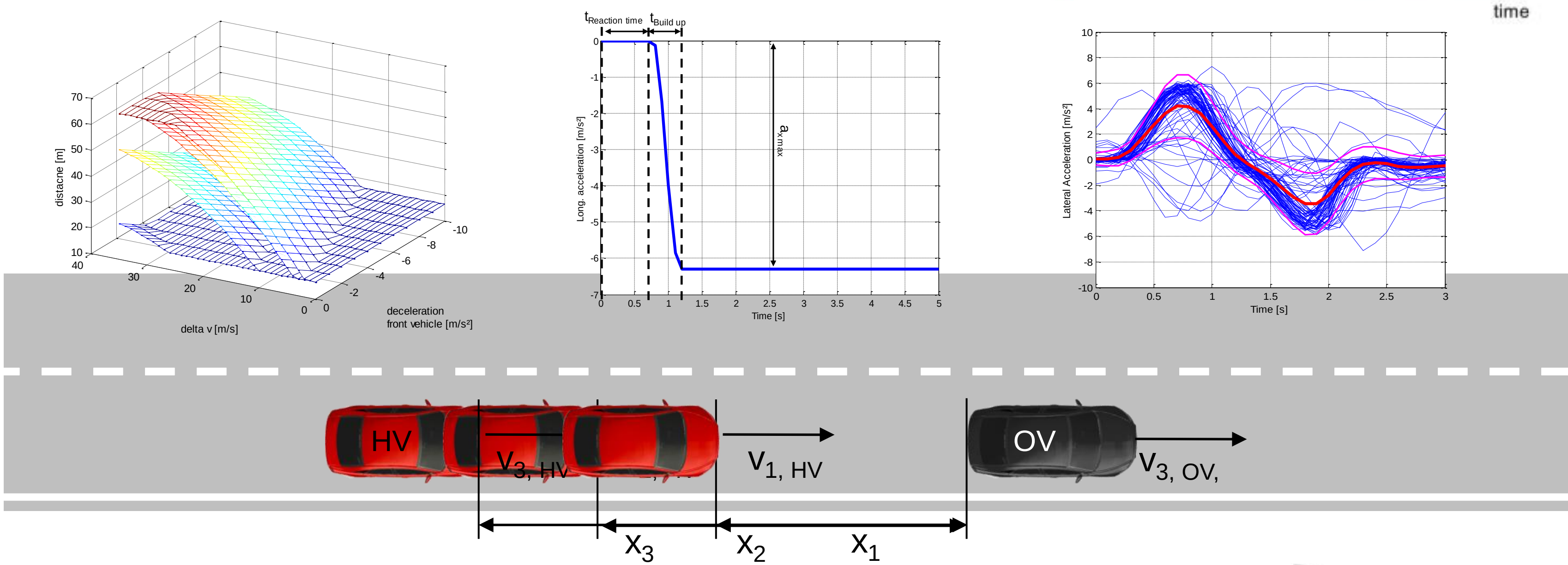
Direct effects – Rear-end scenario (Evade)

- Initial condition (in-depth accident database)





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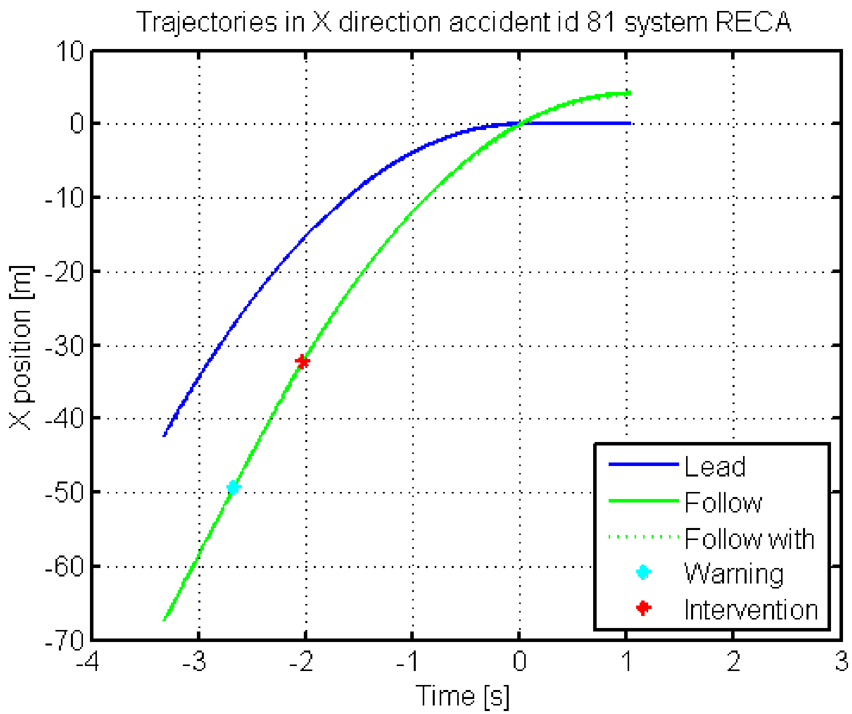
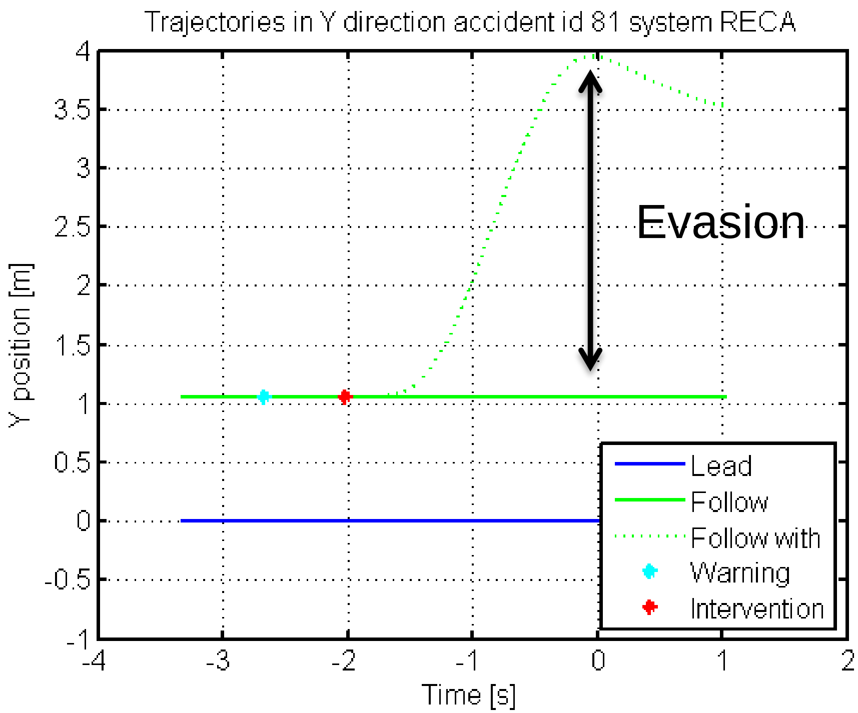
Accident reconstruction for rear end

- Example rear end accident scenario
- With RECA function

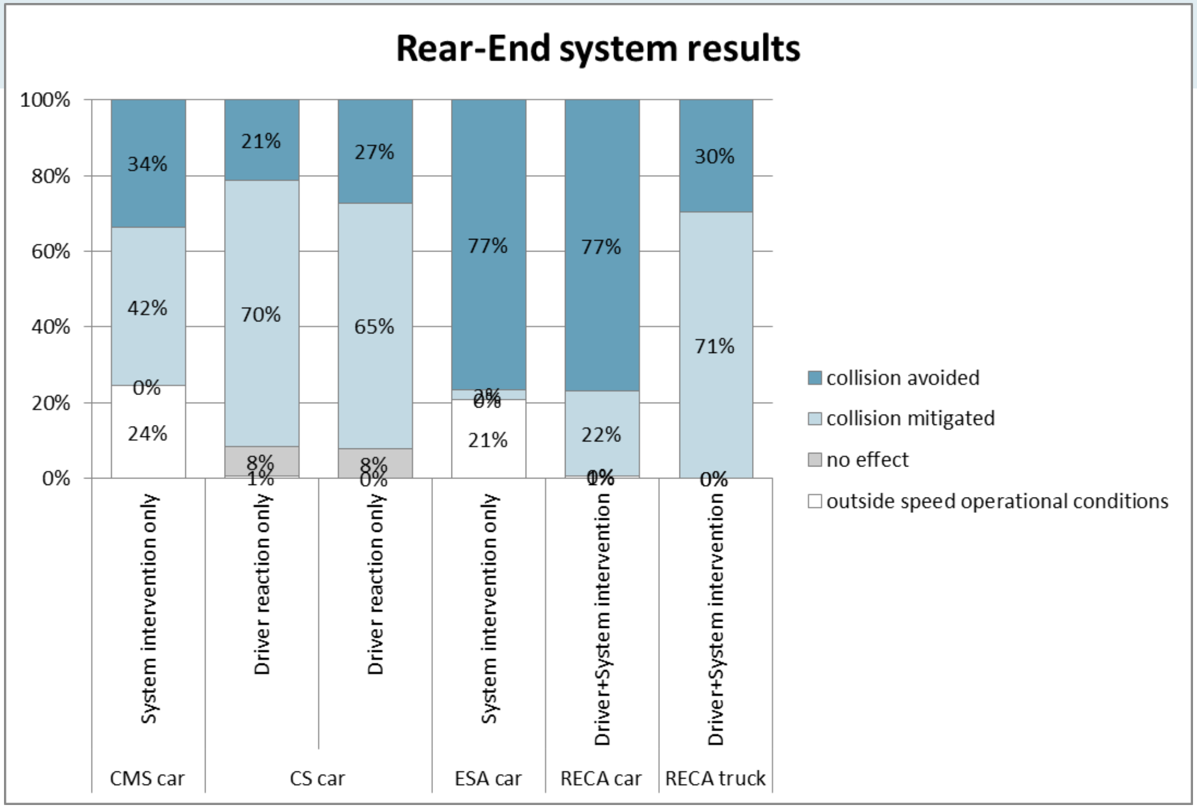
Longitudinal motion



Lateral motion



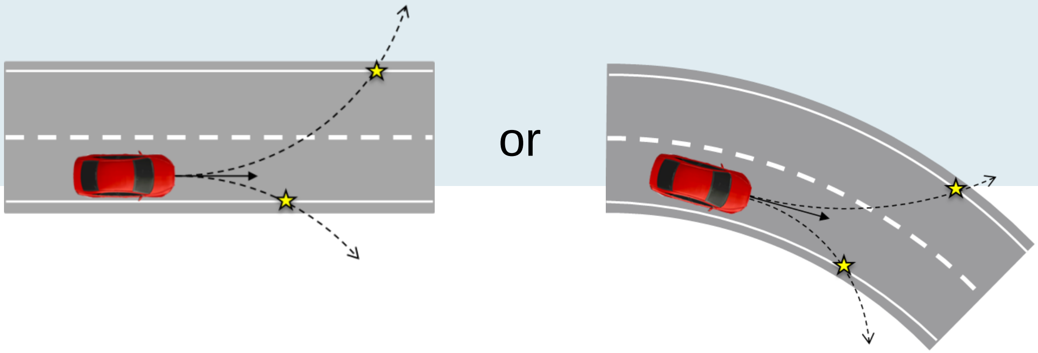
SP7 preliminary results for rear end

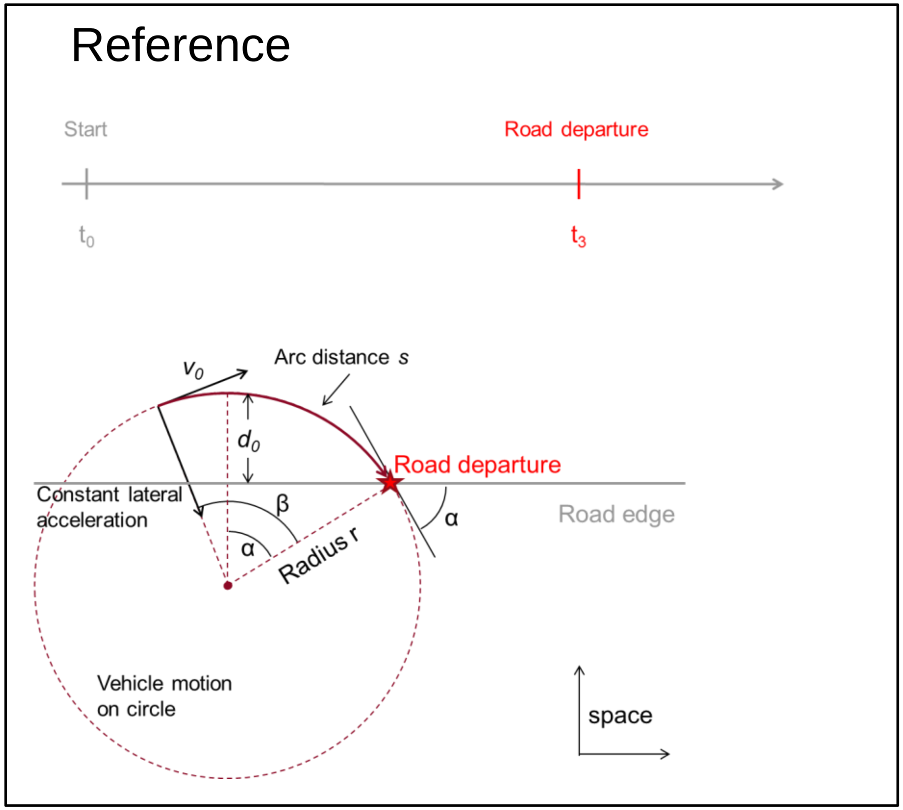


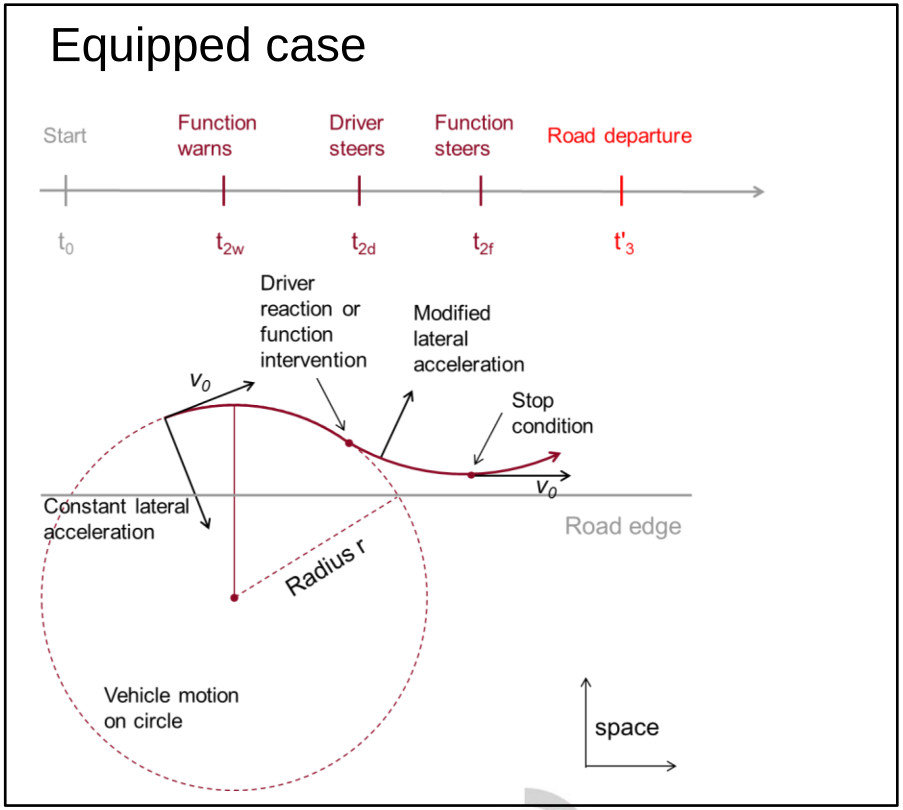
- 364 in-depth accident cases analysed
- Relevant for 4 functions
- Varying results: 21%-77% rear ends *potentially* avoided, others mitigated
- This holds for selection of GIDAS scenarios → need to be scaled up

Road departure

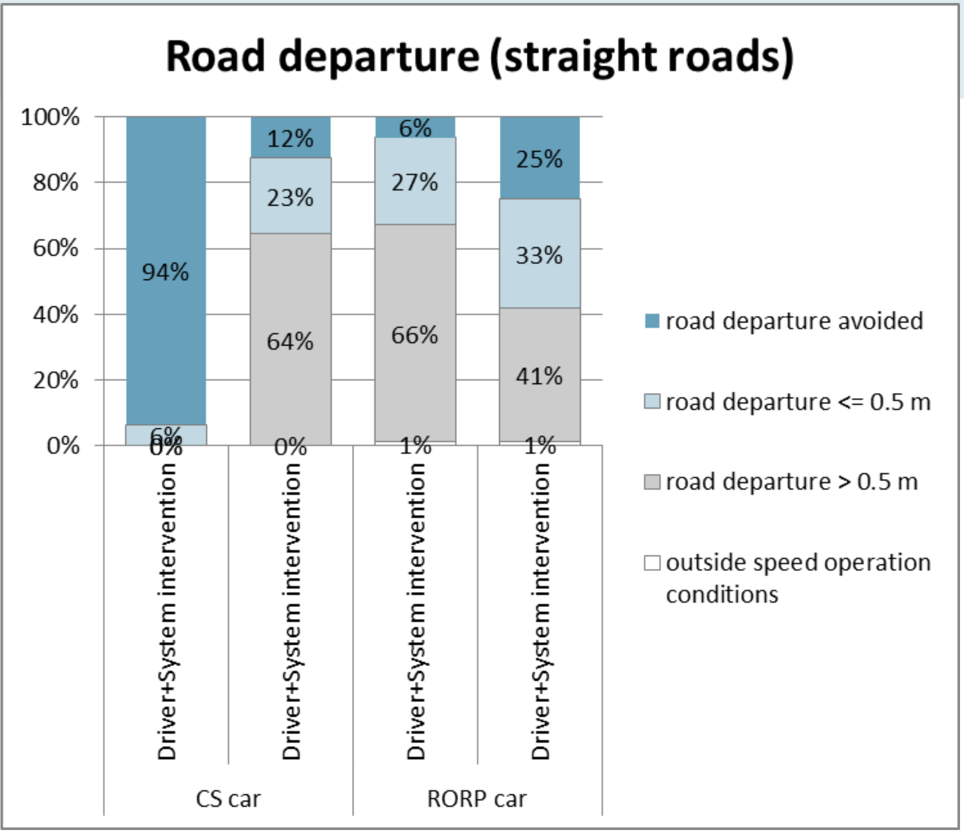
- Only avoidance
- Only steering
- Similar for curved roads

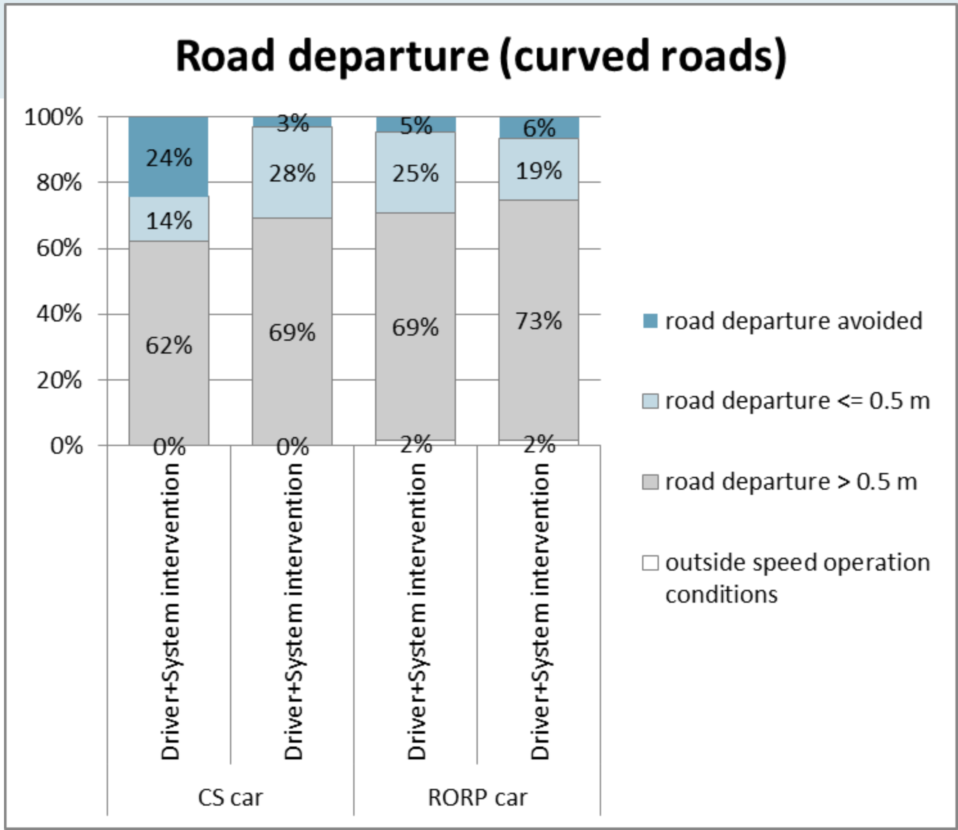






SP7 preliminary results for road departure





- 150 in-depth accident cases analysed, relevant for 2 functions
- Departure (over lane marking): 3-94% *potentially* avoided
- Departure 50 cm outside lane marking: 25-100%
- More effective on straight roads than curved, due to timeliness of warning and intervention time points

Conclusions

- interactIVe safety functions have significant potential to improve safety by avoiding or mitigating accidents
- Results are widely varying between functions. For the GIDAS data:
  - 21%-77% rear ends potentially avoided, many others mitigated
  - 3%-94% road departures potentially avoided
- This will be scaled up to EU level

- Accident reconstruction method is suitable for ex ante study. Limitations:
  - Accident evolution is first approximation: fits with available data, no consideration of impact zones, body mechanics, etc.
  - Modelling of realistic driver reactions needs more data: attention, workload, risk compensation, …
  - GIDAS accident scenarios are for Germany
  - Nr of fatal accidents in GIDAS is low, especially for rear end
- Thus, method provides safety *potential* rather than “real” safety impact.

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Accident avoidance by active intervention for Intelligent Vehicles

Final Event:
20-21 November 2013 in Aachen, Germany

www.interactIVe-ip.eu

Thank you.

Co-funded and supported by the European Commission

SEVENTH FRAMEWORK PROGRAMME

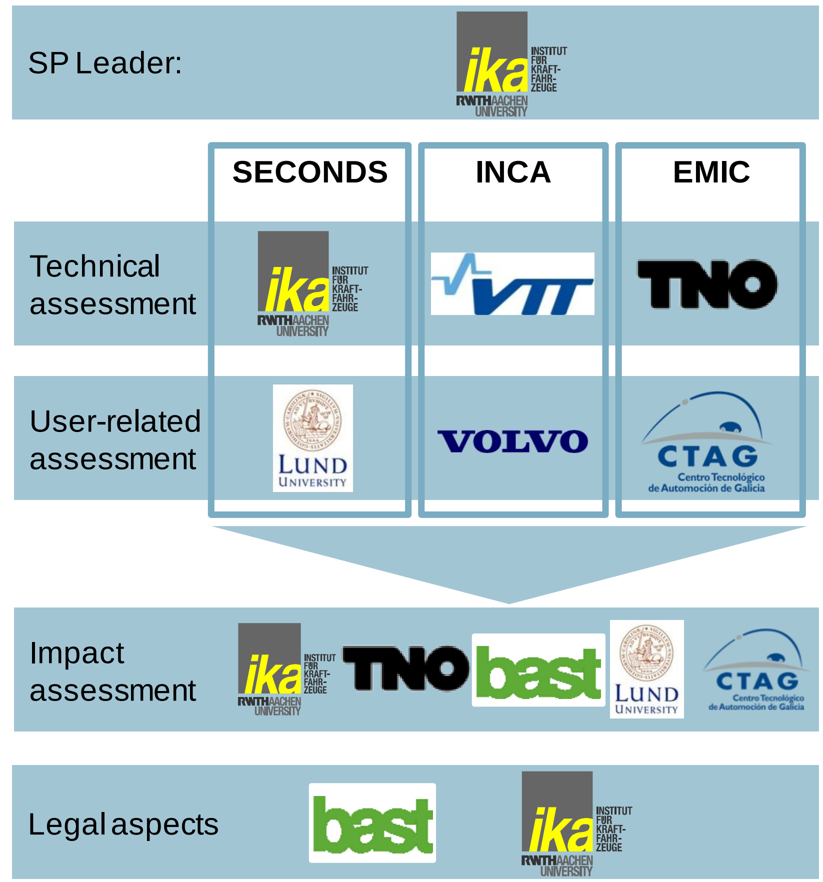
Martijn van Noort (TNO)
Taoufik Bakri (TNO)
Felix Fahrenkrog (IKA)
Jan Dobberstein (BASt)

Backup slides

SP7 “Evaluation and legal aspects” - Overview

SP7 role in interactIVe:

- Definition of a test and evaluation framework for each application with respect to human factors and technical performance
- Development of test scenarios, procedures, and evaluation methods
- Provision of tools for evaluation like equipment, test catalogues, questionnaires or software and support for testing
- Definition of test and evaluation criteria
- Analysis of legal aspects for broad exploitation of the applications



Evaluation for interactIVe is divided into:

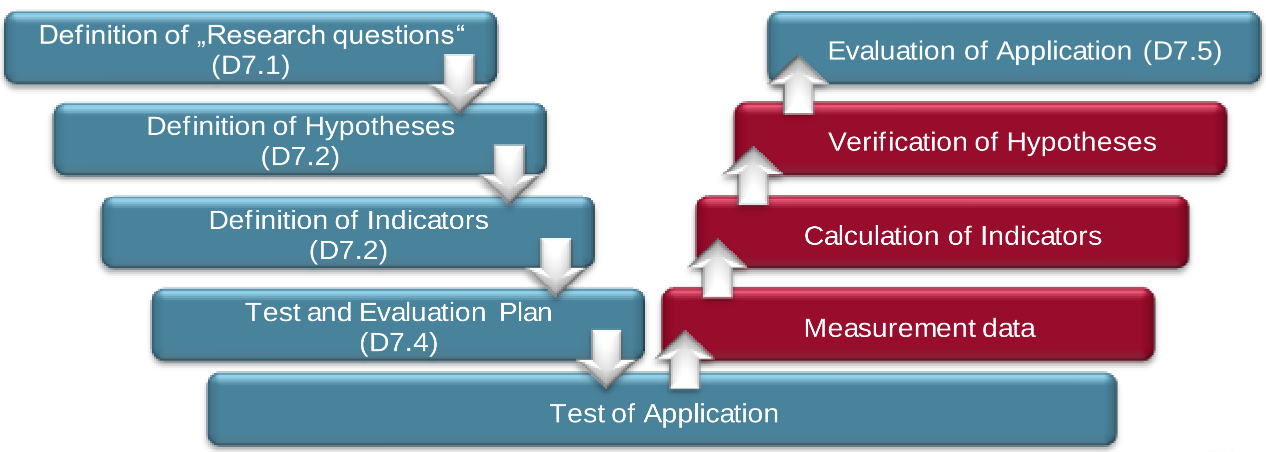
- Technical assessment
- User-related assessment
- Impact assessment

SP7 “Evaluation and legal aspects” - Methodology

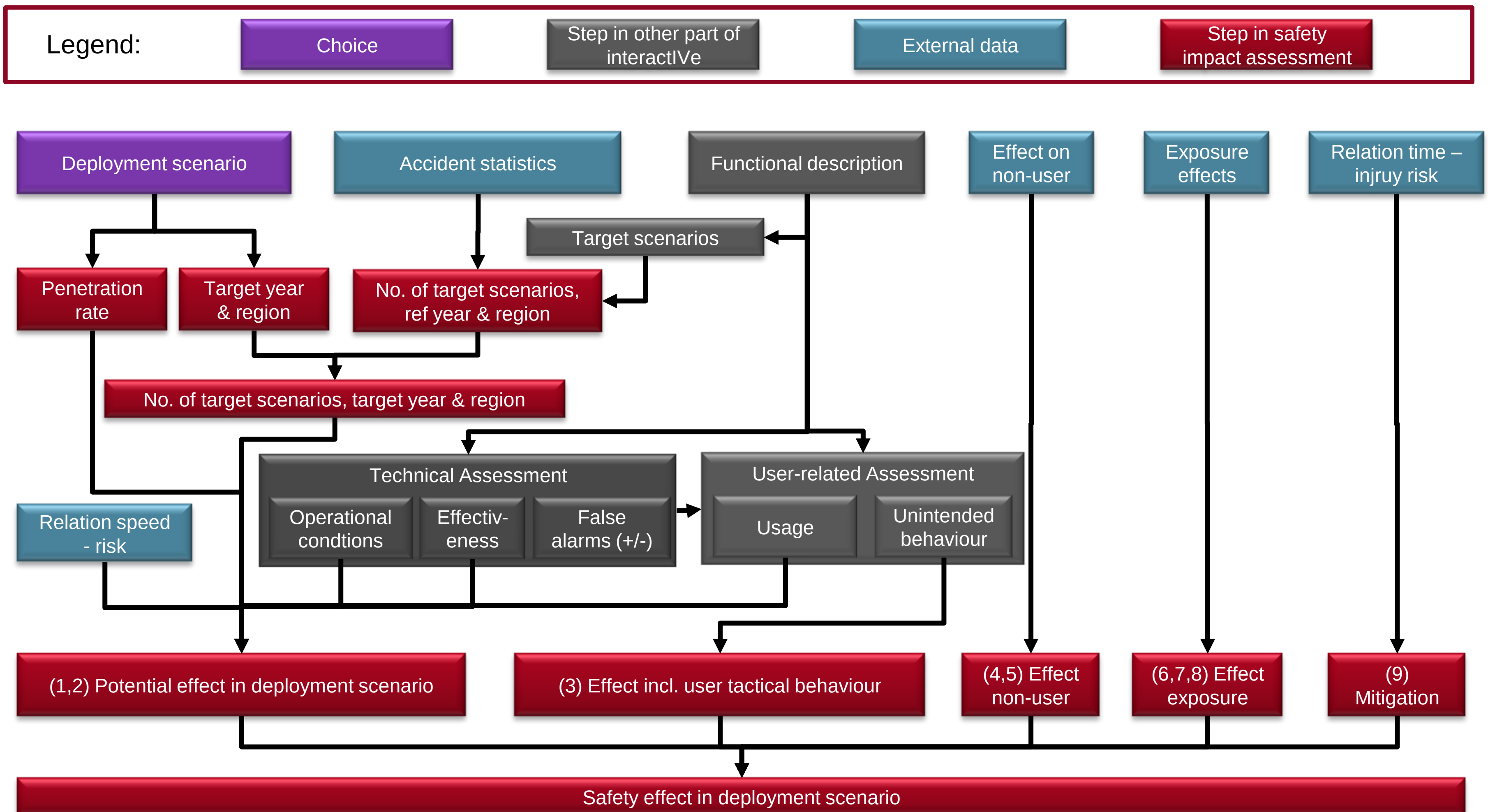
Methodology for the evaluation bases mainly on the PReVAL methodology:

- Step 0: System and function description
- Step 1: Expected impact and hypotheses
- Step 2: Test scenario definition
- Step 3: Evaluation method selection
- Step 4: Measurement plan
- Step 5: Test execution and analysis

Assessment of the whole functions (not components)



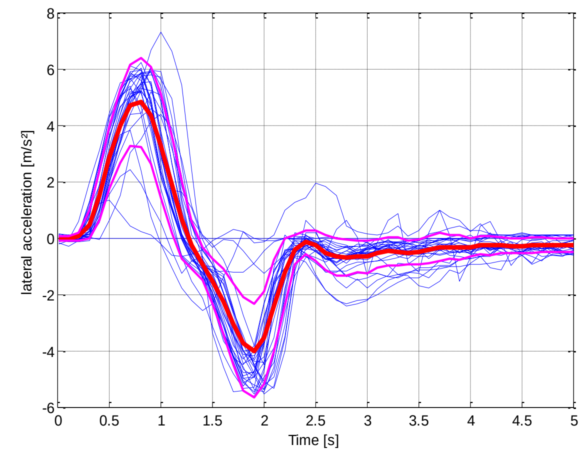
Safety Impact Assessment – Approach

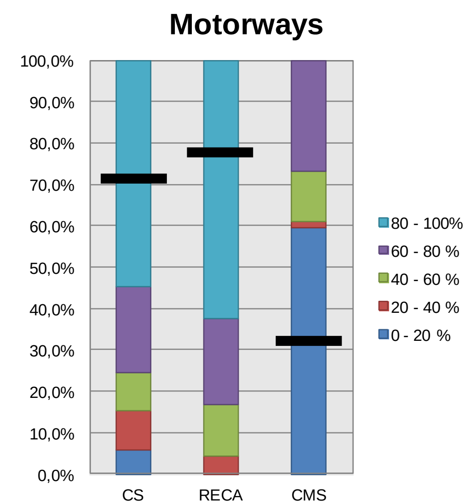


Input data from technical and user-related Assessment

- Input from the technical assessment:
  - warning / intervention point in time
  - intervention strength (longitudinal lateral acceleration)
  - Overall 908 test runs considering 8 accident related test scenarios (e.g. rear-end, blind-spot or run-off road conflicts)
- Input from the user-related assessment
  - Intended usage of the functions for motorways, urban and extra urban road
  - Results base on the questionnaires during the interactIVe user studies.
  - Literature review on long term effects of ADAS

Lateral acceleration for evasive manoeuvre



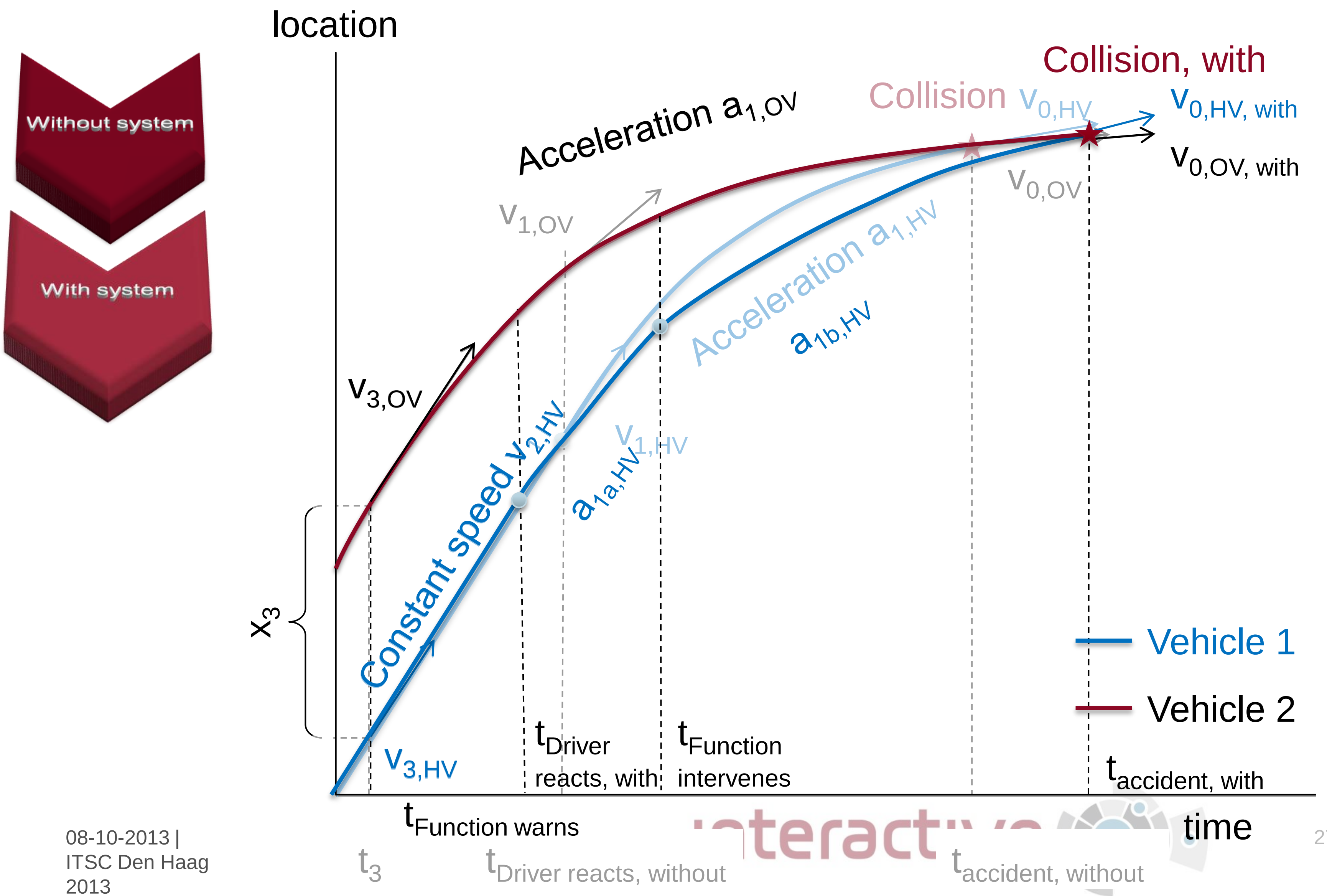


Use of accident database for the Impact Assessment

- GIDAS Database
  - Real Accidents are used in order to re-simulated real accidents with the interactIVe functions
    - Rear-end conflicts
    - Blind-spot conflicts
    - Run-off road conflicts
    - Accident for the re-simulation must fulfil certain requirements
  - Determine the change in the accident risk base

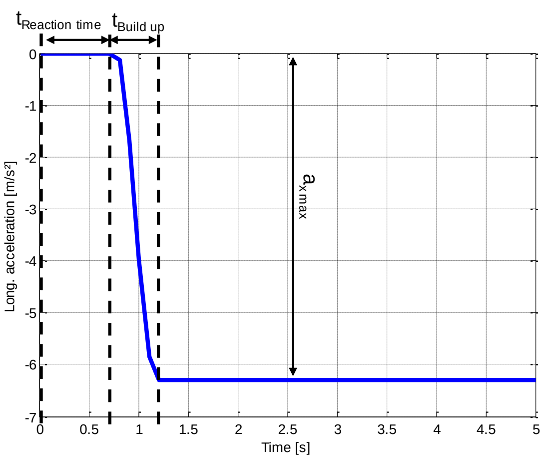
- CARE Database / National accident databases
  - Scaling up of the reconstruction results on European level
  - Identify potentially affected accidents for the interactIVe function, for which reconstruction was not possible (e.g. Speed related accidents, pedestrian accidents).

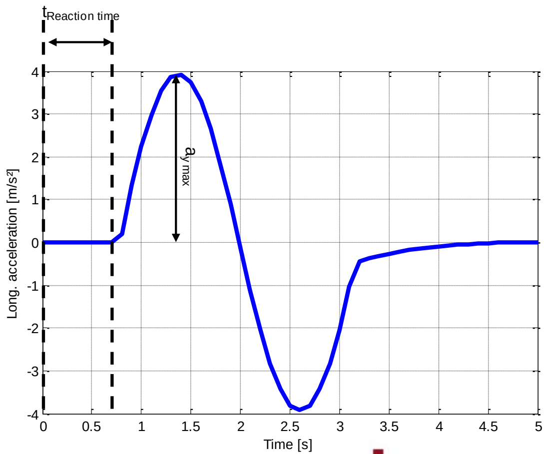
Direct effects – Accident re-simulation

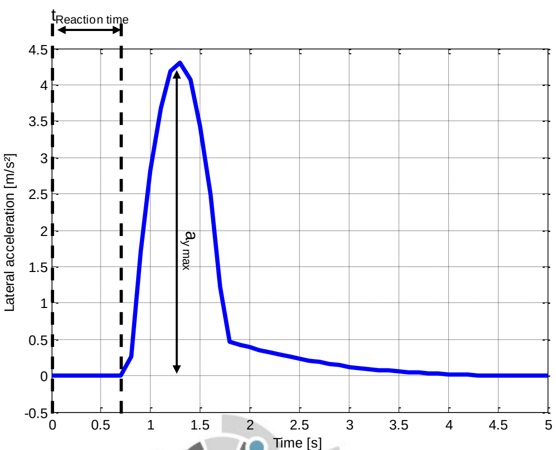


Direct effects – Driver Reaction

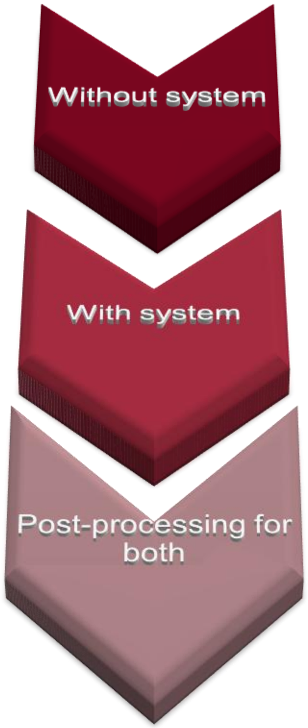
- In order to consider the effect of a warning driver reactions are defined
- Basis for the driver reaction are the interactIVe user-related tests and a literature review:
- Three different reactions were defined:
  - Rear-end: braking (90 %) and evading (10 %)
  - Run-off road and blind spot: steering (100 %)
- In order to consider different drivers the relevant parameter (max. acceleration and reaction time) are varied
- For each case 100 different driver reaction are generated

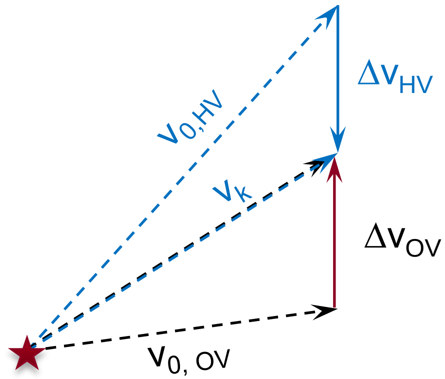




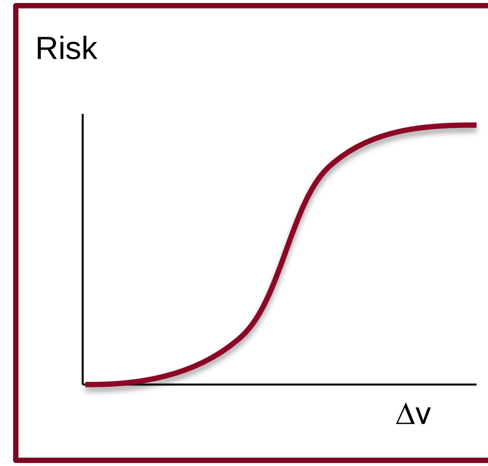


Direct effects – Rear-end (collision mitigation)





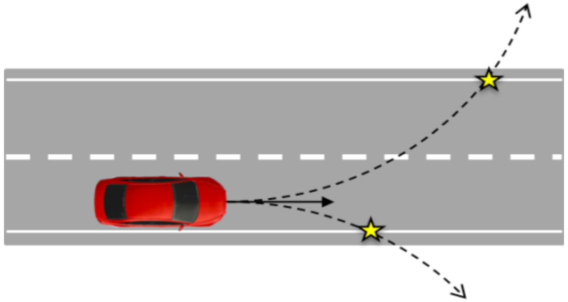
$$(m_{HV}+m_{OV})\, w_k = c_k\, (m_{HV}\, v_{0,HV} + m_{OV}\, v_{0,OV})$$



- Speed $v_{0,HV}$ and $v_{0,OV}$ collision are known!
- Derive speed w_k from just after collision based billiard mechanics (corection faktor c_k)
- Calculate $\Delta v_{HV} = w_k - v_{0,HV}$ and $\Delta v_{OV} = w_k - v_{0,OV}$, the change of speed at collision for the host and the other vehicle, with and without the system
- Use known relations between Δv in order to calculate injury risk…

Direct effects – Run-off road scenario

- In the run-off road scenario it is only checked, whether the accident is avoided or not
  - No mitigation, because the depend on the location, which can not be considered due to missing data in the re-simulation with the system

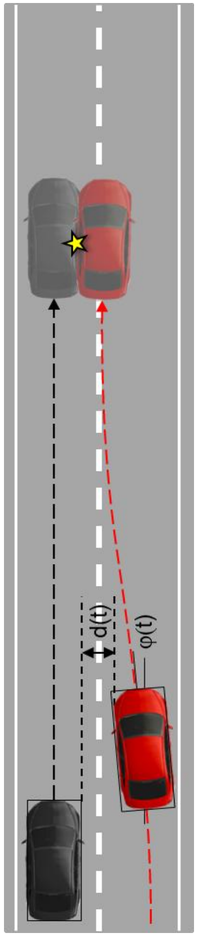


Direct effects – Lane chane scenario

- In principle same approach as for the run-off road scenario
- Only collision avoidance is analyse
- Time based avoidance is not considered by the re-simulation
- In contrast to the run-off road scenario the trajectory of the vehicle before the intervention needs to be changed:
  - A sinusoidal shape is presumed

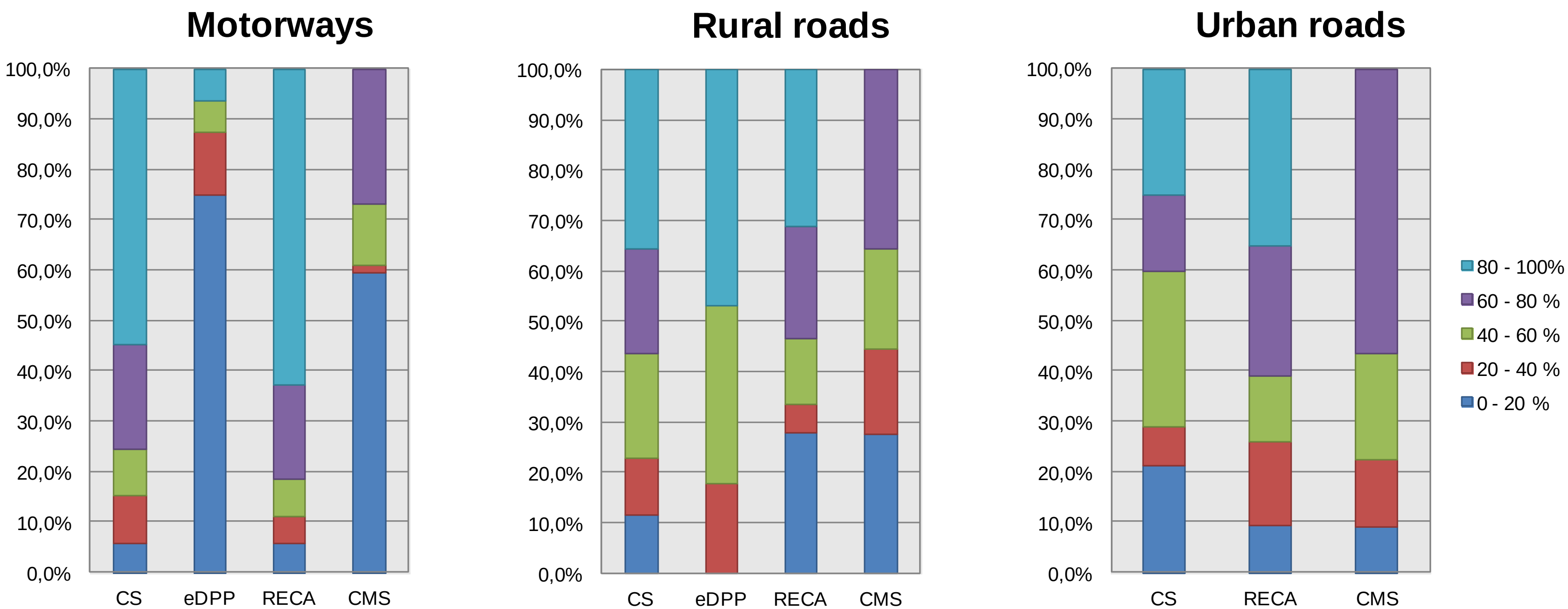
$$y(x) = w_{\text{lane}} \left(\frac{x}{L} - \frac{1}{2\pi} \sin\left(\frac{2\pi x}{L} \right) \right), \text{for } 0 \le x \le L$$ [SPO98]

  - Length of the lane change L = v_0 T (deceleration due to steering manoeuvre is not considered)
- Distributions of the lane change time can be found in [SCH07, PFE07] for different vehicle types. From this one can draw the conclusion that
  - for passenger cars the mean lane change time is approximately 5 s, and in 95 % of the cases is between approximately 3 s and 7 s.
  - for trucks the mean lane change time is approximately 7 s, and varies between 4 s and 11 s.



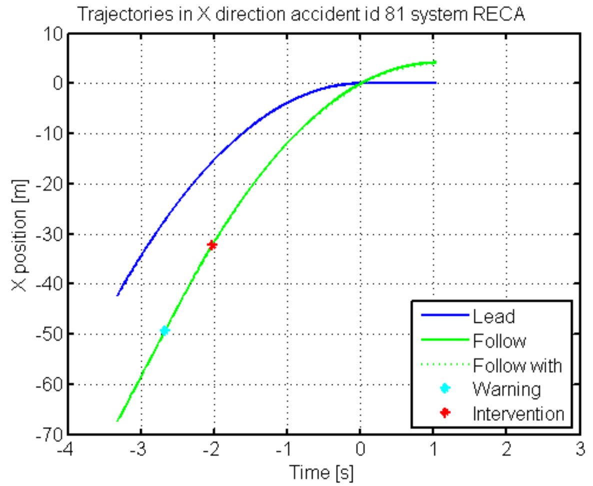
Indirect effect

- Different indirect effects are know (e.g. Distraction, Workload, Usage, Misues)
- Consideration of indirect effects in interactIVe is difficult:
  - Most of the indirect effects are difficult to quantify
  - Based on the short term test in interactIVe long-term effects could not be derived
- Only the usage of the function is considered

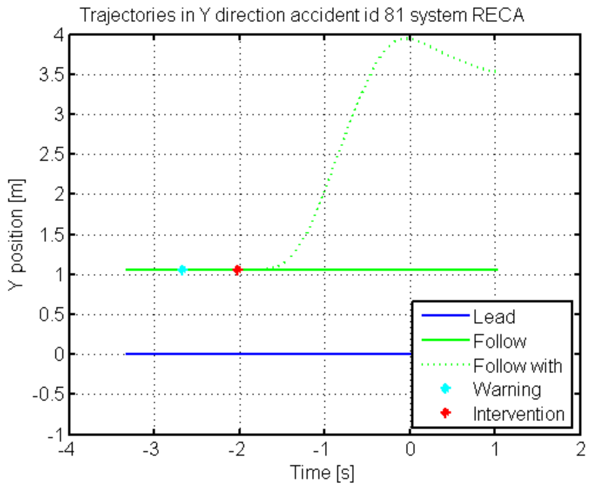


Example (Preliminary) Results

- Sample result for a rear-end collision avoidance system (warning & intervention):
  - 364 in-depth rear end accident scenarios analyzed
  - Avoided: 24,2 % (with driver reaction) / 22,4 % (without driver reaction)
  - Mitigated: 75 % (with driver reaction) / 76,8 % (without driver reaction)
  - 100% deployment in EU would save XX % fatalities and XX % injuries per year



- Sample result for a rear-end collision mitigation system (no warning):
  - 364 in-depth rear end accident scenarios analyzed
  - Avoided: 33,5 %
  - Mitigated: 42 %
  - 100% deployment in EU would save XX % fatalities and XX % injuries per year

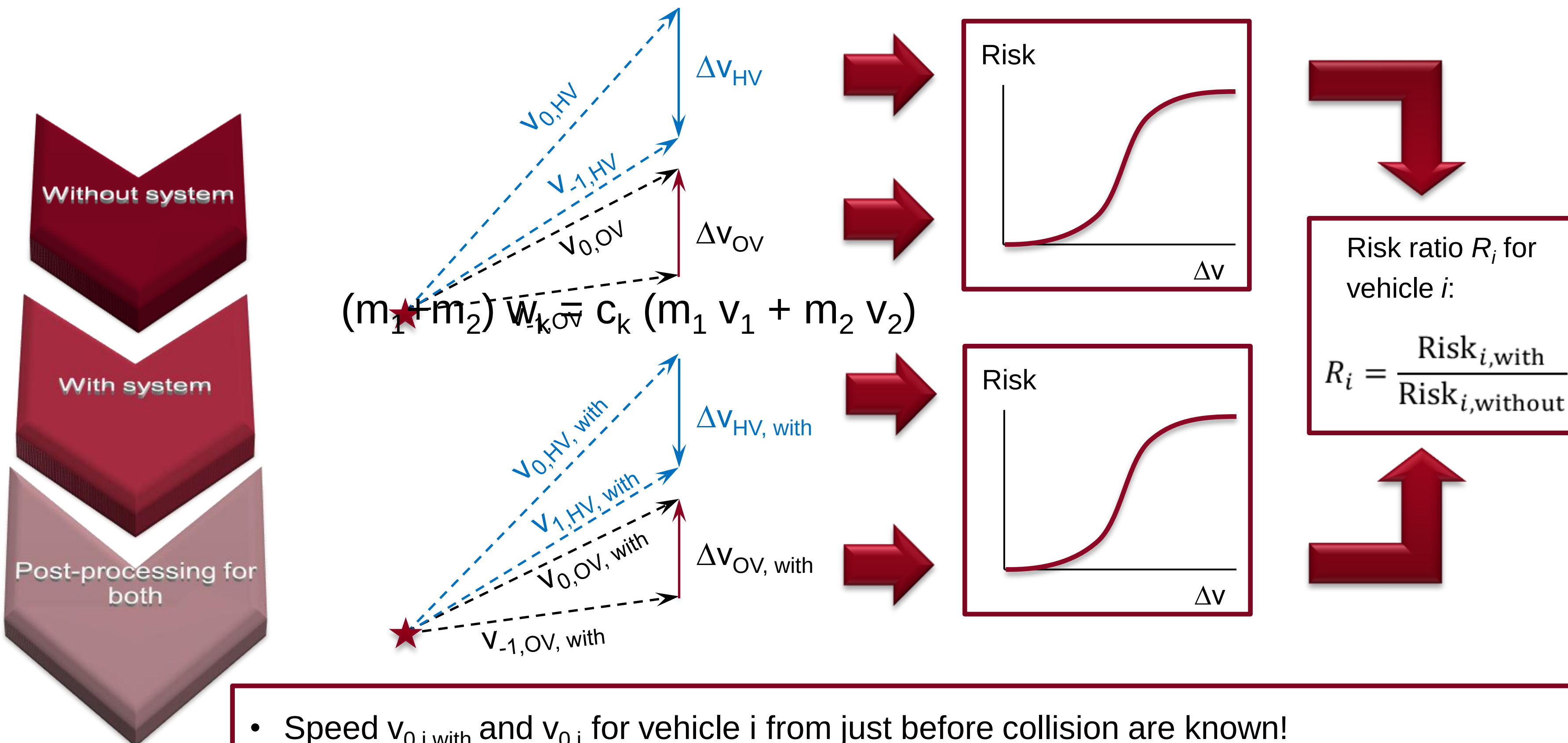


Summary & Next steps

- Impact Assessment for the interactIVe function was conducted
- The effect of the interactIVe was analysis in detailed in three accident scenarios by the re-simulation of real accident scenario
- Results were scaled up to European Level by means of the CARE Database
- Analysed function showed a positive effects with respect to the European road safety

- **Final Event:**
  - 20-21 November 2013 in Aachen
  - Joint event with eCoMove
  - November 20: Presentations & Exhibition in Aachen
  - November 21: Demo drives on Ford Proving Ground in Lommel
  - Subscription is open at the interactIVe website: http://interactive-ip.eu

Direct effects – Collision Mitiation



$$(m_1+m_2)\, w_k = c_k\, (m_1 v_1 + m_2 v_2)$$

- Speed $v_{0,i,with}$ and $v_{0,i}$ for vehicle i from just before collision are known!
- Derive speed $v_{-1,i,with}$ and $v_{-1,i}$ from just after collision based billiard mechanics
- Calculate $\Delta v_{i,with} = v_{1,i,with} - v_{0,i,with}$ and $\Delta v_i = v_{1,i} - v_{0,i}$, the change of speed at collision for the host and the other vehicle, with and without the system
- Use known relations between Δv and injury risk…
- … to determine change in risk R_i between with and without, for both vehicles

Project overview: Facts

• Budget:	EUR 30 Million
• European Commission:	EUR 17 Million
• Duration:	48 months (January 2010 – November 2013)
• Coordinator:	Aria Etemad, Ford Research and Advanced Engineering Europe
• 10 Countries:	Czech Republic, Finland, France, Germany, Greece, Italy, Spain, Sweden, The Netherlands, UK

European Commission
Information Society and Media

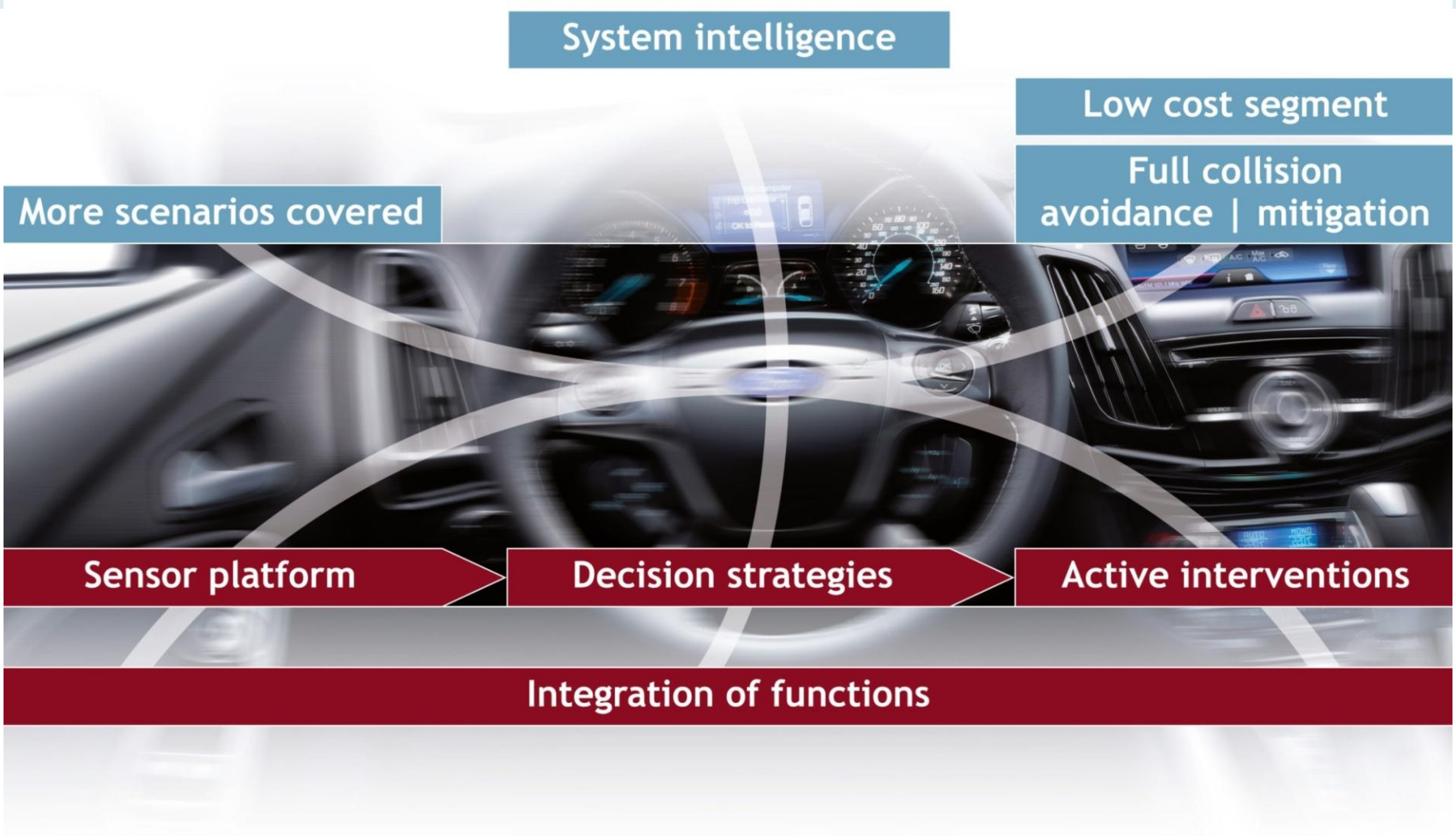
EUCAR
EUROPEAN COUNCIL FOR AUTOMOTIVE R&D

interactIVe

Consortium

- OEMs
- Suppliers
- Research
- SMEs

Objectives


System intelligence
Low cost segment
Full collision avoidance | mitigation
More scenarios covered
Sensor platform
Decision strategies
Active interventions
Integration of functions

interactIVe - Project overview

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Accident-free traffic and active safety systems in all vehicles

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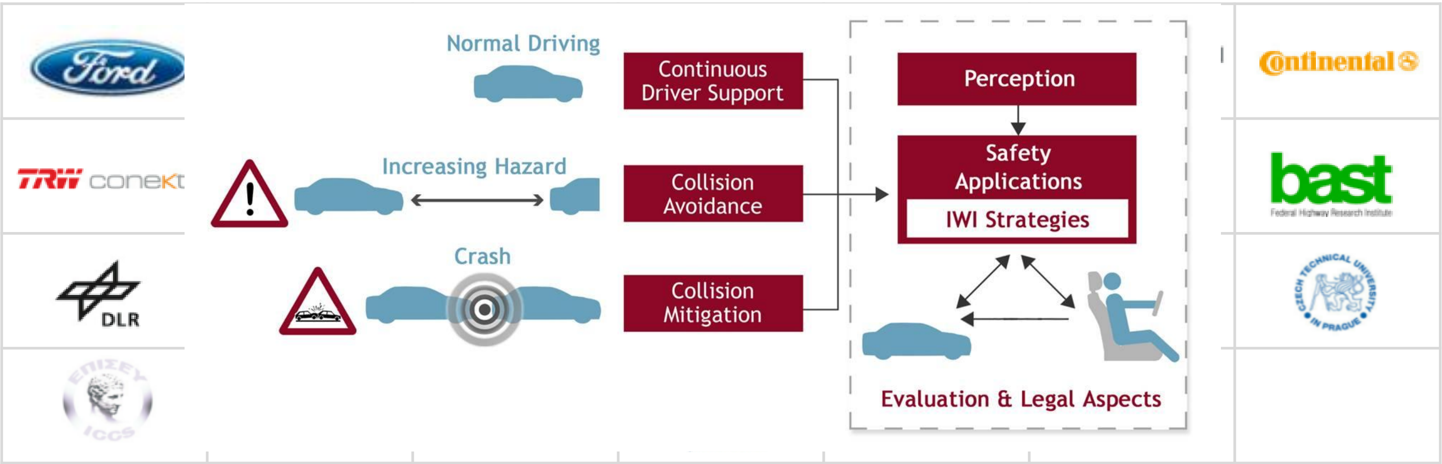

Project structure

Sub-project 1: **Integrated project (IP) management**

Integrated advanced driver assistance systems (ADAS) for continuous support and emergency intervention

Sub-project 2: **Perception**
Specifications for sensor interfaces and fusion modules

Sub-project 3: **Information, warning and intervention (IWI) strategies**
Definition of use cases and requirements | Specifications for IWI strategies

Sub-project 4: **SECONDS**
Safety enhancement through continuous driver support

Sub-project 5: **INCA**
Integrated collision avoidance and vehicle path control

Sub-project 6: **EMIC**
Cost-efficient emergency intervention for collision mitigation

Seven demonstrator vehicles: six passenger cars and one truck

Sub-project 7: **Evaluation and legal aspects**
Test and evaluation framework for interactIVe applications | Analysis of legal aspects