REQUIREMENTS AND CONDITIONS – Booth No. 09

IMPACT ANALYSIS

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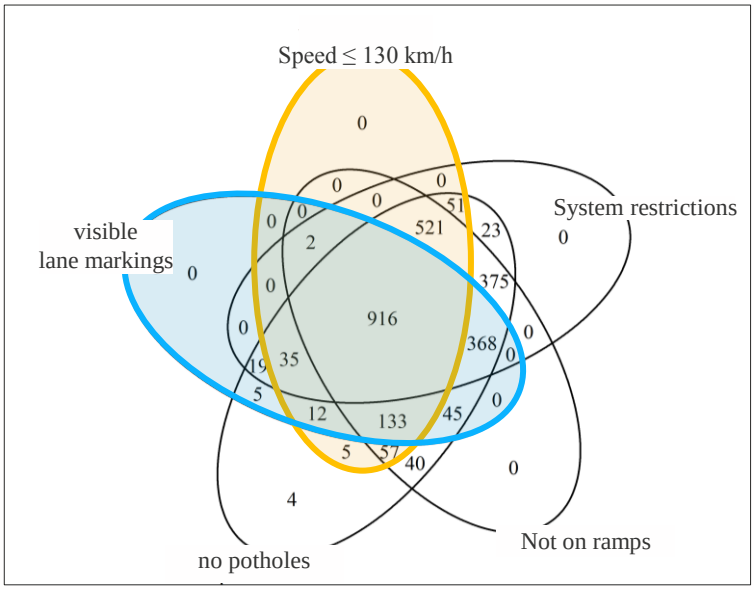
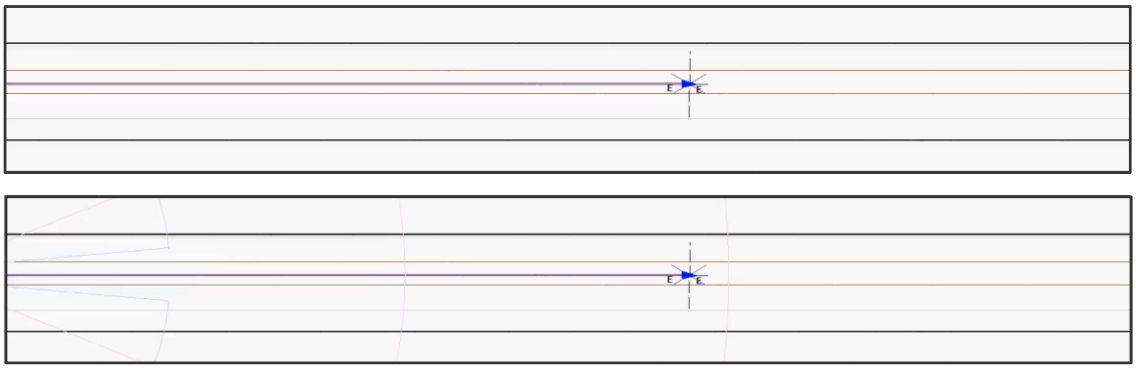
What is the target population and the effectiveness of the highway chauffeur? Are the used methods applicable to other scenarios?

- Target population of the highway chauffeur:
  ~35% of all cars in motor-ways crashes could have activated the highway chauffeur
  ~27% of all car fatalities on highways could have activated the highway chauffeur
- Effectiveness of the highway chauffeur in cut-in scenarios and comparison of the human driver (in the real-world crash) and the highway chauffeur
- Proof that the computation of the target population is transferable
- Proof that the computation of the effectiveness analysis is transferable



Venn diagram of the used filter to compute the target population: Each ellipse illustrates one (set of) filter and the numbers of the intersections are these cars which fulfill this filter, i.e. 916 cars fulfill all filter and, therefore, these cars could had activated the highway chauffeur during the crash.



Example of a real-world crash in GIDAS: The upper video shows the original situation with the human driver in the crash. The lower video shows an implementation of a highway chauffeur which could avoid the crash by increasing the safety distance and braking.

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Target population of the highway chauffeur

- Additional to domain restrictions (cars without trailer on highways and highway-style roads) five main filter are applied
  1. The velocity was ≤130 km/h
  2. Markings are in good cond.
  3. The road has no potholes
  4. No driving on a ramp
  5. No bad weather conditions

- With these system restrictions
  - 35% of cars on highways in GIDAS crashes could have activated the highway chauffeur,
  - 33% of injured persons in cars on highways in GIDAS crashes could have activated the highway chauffeur.

- Proposed extension based on this analysis is to ensure intact lane markings (or a function, which doesn't need markings any more). With that and increasing the ego speed to 160 km/h, the target population could be nearly doubled.

- An analysis of human factors shows that ~84% of these cases are caused by human factors and have a large potential to be prevented by the highway chauffeur.

	All	Highway Chauffeur		
	GIDAS	Target Population	Ratio to all highways	Ratio to GIDAS All
Cars	33 024	916	35%	2,8%
Injured Persons ISSx ≥ 1	3 671	184	33%	5,0%
Severe injured Persons ISSx ≥ 2,5	1 116	52	28%	4,7%
Fatalities	362	21	27%	5,8%

Excerpt of the results of computation of the target population: For four categories the total number in GIDAS (column "All") and of the target population (first column of "Highway Chauffeur") are given. The fourth column gives the ratio to highways and the fifth gives the ratio all cases in GIDAS.

	All	Highway Chauffeur		
Cars	33 024	1729	66%	5,3%
Injured Persons ISSx ≥ 1	3 671	387	70%	11%
Severe injured Persons ISSx ≥ 2,5	1 116	127	68%	11%
Fatalities	362	54	68%	15%

Excerpt of the results of the computation of the target population with an proposed extension to the highway chauffeur: The proposed extension excludes the filter "intact lane markings" and increases the speed limit to 160.

Human Factor		
Alcohol, drugs, fatigue, etc	329	37%
(maybe) Distraction	367	41%
Maybe Human Factor		
Lane change interactions, Leave the road, etc.	55	6%
No Human Factor		
Overtake, standing at the end of a traffic jam, etc.	138	16%

Excerpt of the human factor analysis: Alcohol, drugs and fatigue are directly evaluated on GIDAS variables, but we don't investigate the number of unreported cases. The distraction group is based on the assumption that all cases in which a car leaves the road or crashes to a preceding vehicle without any lane change manoeuvers are caused by distraction. Crashes caused by lane change interactions could be caused by distraction, but there could be several other reasons, therefore, it is not clear, if a human factor causes the crash.

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IMPACT ANALYSIS

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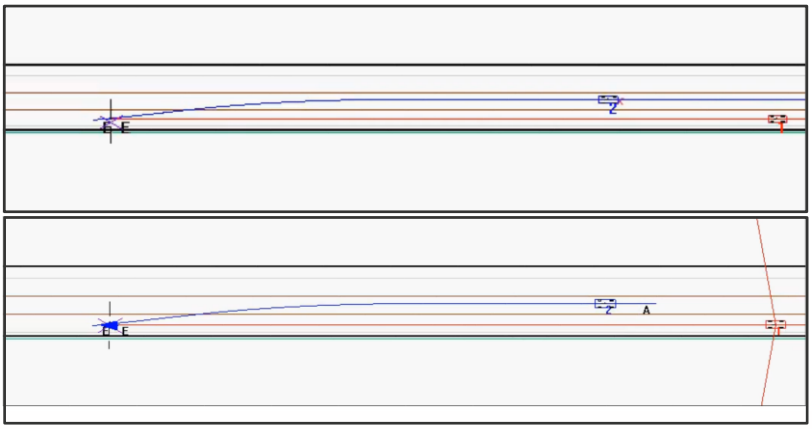
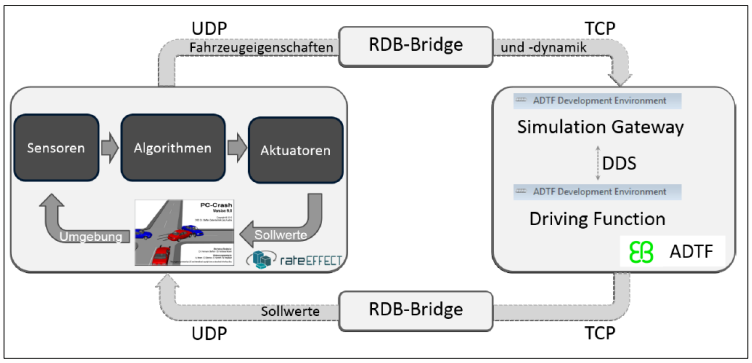
Effectiveness of the highway chauffeur

- The effectiveness of the HAF is determined by means of a simulation, in which challenging situations can be replayed and could be solved by the examined driving function.
- The start and target speed of the vehicle is set from the accident data. As soon as the initialization phase has expired, the highway chauffeur takes over the lateral and longitudinal control of the vehicle and drives the car in the simulation.
- The highway chauffeur is able to solve accident situations from the GIDAS database.
- There are situations where an intervention by the highway chauffeur does not prevent the collision from happening.
- The comparison is based on the original situation in the GIDAS database. As already shown in the human factor analysis, most of the accidents are caused by human factors (e.g. distraction). That shows that in GIDAS the human driver don't behaves 'normal' and, therefore, we don't compare with an normal driver in this consideration.



Cut-in scenario: The upper videos shows the original situation with the human driver form GIDAS and the lower videos shows an implementation of the highway chauffeur in the same scenario. It can be seen, that the highway chauffeur brakes early and can avoid the crash.



This flow chart illustrates the simulation framework. The closed-loop simulation in rateEFFECT is coupled with the framework ADTF, which contains the exemplary implementation of the driving function "highway chauffeur".

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Transferability of the computation of the target population

- The proof of transferability of the derived methods is done by on five functional scenarios, which are briefly described by:
  - E01: Free/Casual driving on rural roads
  - E02: Animal crossing
  - E03: Drive through a junction
  - E04: Turning left at a junction
  - E05: Overtake with oncoming traffic
- The method “computation of the target population” was tested and applied to these five scenarios and E01 was the scenario with the highest predicted benefit.
- 11% of all car collisions on rural roads happened while free driving and 19% of all fatalities on rural roads are in this scenario, if the system restrictions of the highway chauffeur are used.
- With this analysis the applicability of the computation of the effectiveness field to rural road scenarios is shown. Furthermore, we assume that this method is applicable to all other scenarios, if the used data is representative and detailed enough.

	All	Rural Chauffeur		
	GIDAS	Target Population	Ratio to all rural roads	Ratio to GIDAS All
Cars	33 024	1153	31%	3,5%
Injured Persons ISSx ≥ 1	3 671	348	27%	9,5%
Severe injured Persons ISSx ≥ 2,5	1 116	137	26%	12%
Fatalities	362	46	26%	13%

Excerpt of the results of computation of the target population on rural roads: For four categories the total number in GIDAS (column “All”) and of the target population (first column of “Rural Chauffeur”) are given. The fourth column gives the ratio to rural roads and the fifth gives the ratio all cases in GIDAS. The same system restrictions from the highway chauffeur are used, but no further restrictions to E01 – E05 scenarios are apllied.

	All	E01 Chauffeur		
Cars	33 024	388	11%	1,2%
Injured Persons ISSx ≥ 1	3 671	151	9,3%	3,3%
Severe injured Persons ISSx ≥ 2,5	1 116	51	9,7%	4,6%
Fatalities	362	14	7,9%	3,9%

Example of a target population of one of the five functional scenarios on rural roads. E01 includes all free driving scenarios on rural roads.

	All	E03 Chauffeur		
Cars	33 024	115	3,1%	0,3%
Injured Persons ISSx ≥ 1	3 671	31	2,4%	0,8%
Severe injured Persons ISSx ≥ 2,5	1 116	8	1,5%	0,7%
Fatalities	362	0	0%	0%

Example of a target population of one of the five functional scenarios on rural roads. E03 includes all scenarios of cars driving through a junction without turning. Because of the concrete description of the scenarios the target population becomes small. However, it can be seen that the most and severe crash on rural roads are while free driving and not at junctions.

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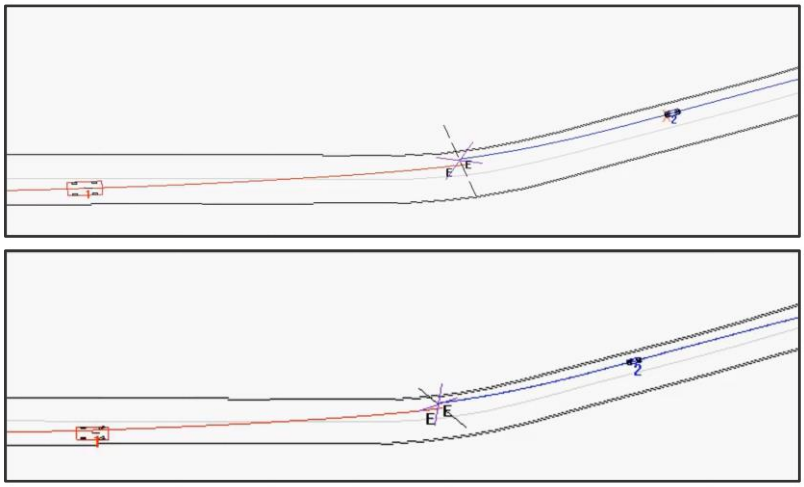
Transferability of the computation of the effectiveness of the highway chauffeur

- The proof of transferability of the derived methods is done by the same five functional scenarios.
- The E01 was exemplarily regarded and was simulated with an unchanged highway chauffeur.
- Most of the other scenarios cannot be evaluated, because of several reasons:
  - E02: GIDAS contains no simulatable case of crossing animals
  - E03/04: Because of missing traffic markings in the area of junctions the highway chauffeur could not be used.
  - E05: Overtake scenarios with oncoming traffic were only meaningful, if three participants could be simulated. In the GIDAS/PCM data only contains only two participants.
- With these simulation results the applicability of the computation of the effectiveness to rural road scenarios is shown. Furthermore, we assume that this method is applicable to all other scenarios in principle, if the data are available and the function is specified for these scenarios.

Name of Scenario / Description / Level	FS-E01 rural road with oncoming traffi	FS-E02 Animal crossing	FS-E03 Intersection – going straight (un- / protected)	FS-E04 Intersection – left turn (un- / protected)	FS-E05 Overtaking with oncoming traffic
L1: Road Geometry	EKL2 (1 lane per direction, dotted line)	EKL2 (1 lane per direction, dotted line)	EKL2 (1 lane per direction, dotted line)	EKL2 (1 lane per direction, dotted line)	EKL2 (1 lane per direction, dotted line)
L2: Guidance infrastructure (e.g traffic signs)	None (100km/h, guidance posts)	None (100km/h, guidance posts)	Traffic lights, signs, stop line	Traffic lights, signs, stop line	None (100km/h, guidance posts)
L3: Temporary restrictions (e.g. construction)	none	none	none	none	none
L4: dynamic objects	Car, truck, motorbike, bicycle	Car, truck, motorbike, bicycle, animals	Car, truck, motorbike, bicycle	Car, truck, motorbike, bicycle	Car, truck, motorbike, bicycle
L4: dynamic base maneuvers	Follow lane	Follow lane, safe stopping	Aproach, accelerate, pass	Approach, accelerate, turn, pass	Follow, accelerate, change lane, pass
L5: weather	n.a.	n.a	n.a	n.a.	n.a.

Definition of the five functional scenarios: E01 is the scenario with the highest target population and was tested exemplarily in the simulation framework.



Example of a scenario on rural roads: The human driver cuts the corner and collides with the oncoming motorcycle. The implementation of a highway chauffeur can be used unchanged and will avoid this crash.

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