FORSCHUNGSINITIATIVE
KO-FAS

Benefit Analysis of Automated Safety Systems

Nutzenanalyse der automatisierten Schutzkonzepte

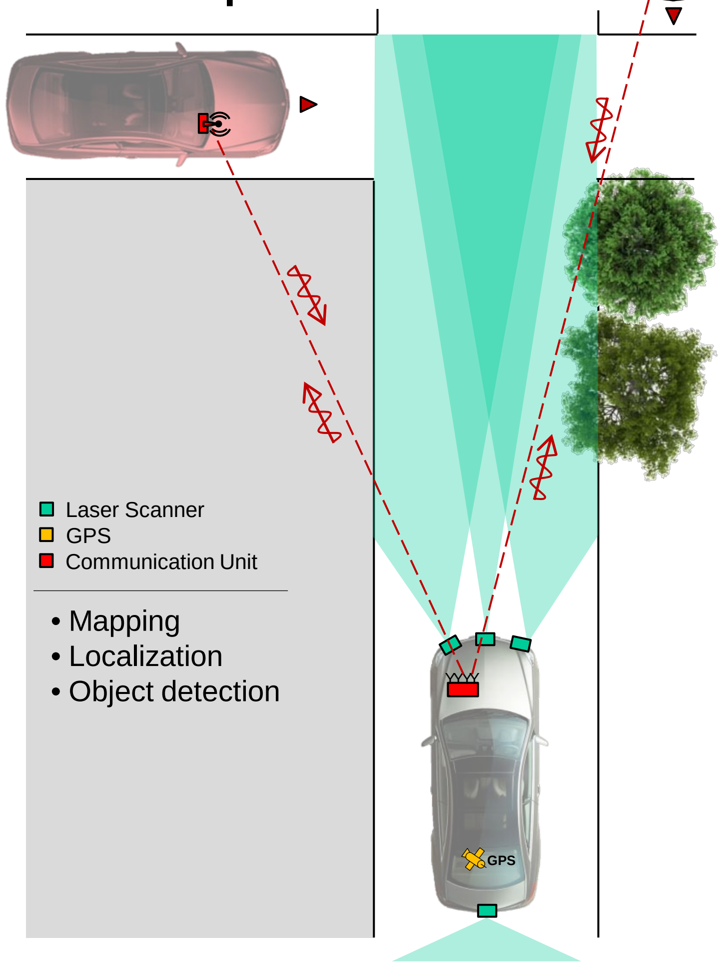
Mohsen Sefati, M.Sc.
Fachgebiet Fahrzeugtechnik, TU Darmstadt

Supported by:
Federal Ministry of Economics and Technology
on the basis of a decision by the German Bundestag

System Benefit
cooperative sensor technology

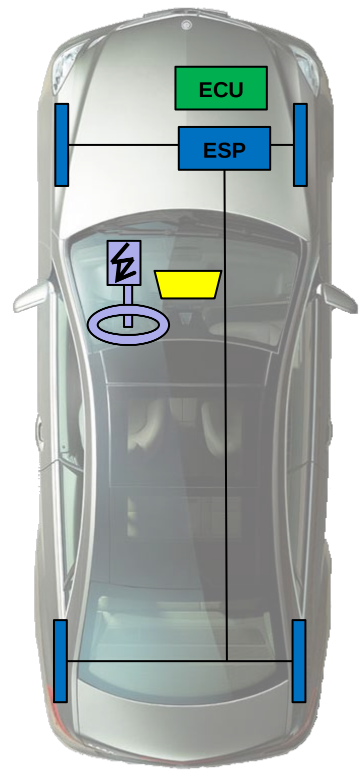
FORSCHUNGSINITIATIVE KO-FAS

Cooperative Sensors



Other Essential Components

- Brake Actuator
- Electronic Control Unit
- Steering Torque Actuator
- Human Machine Interface



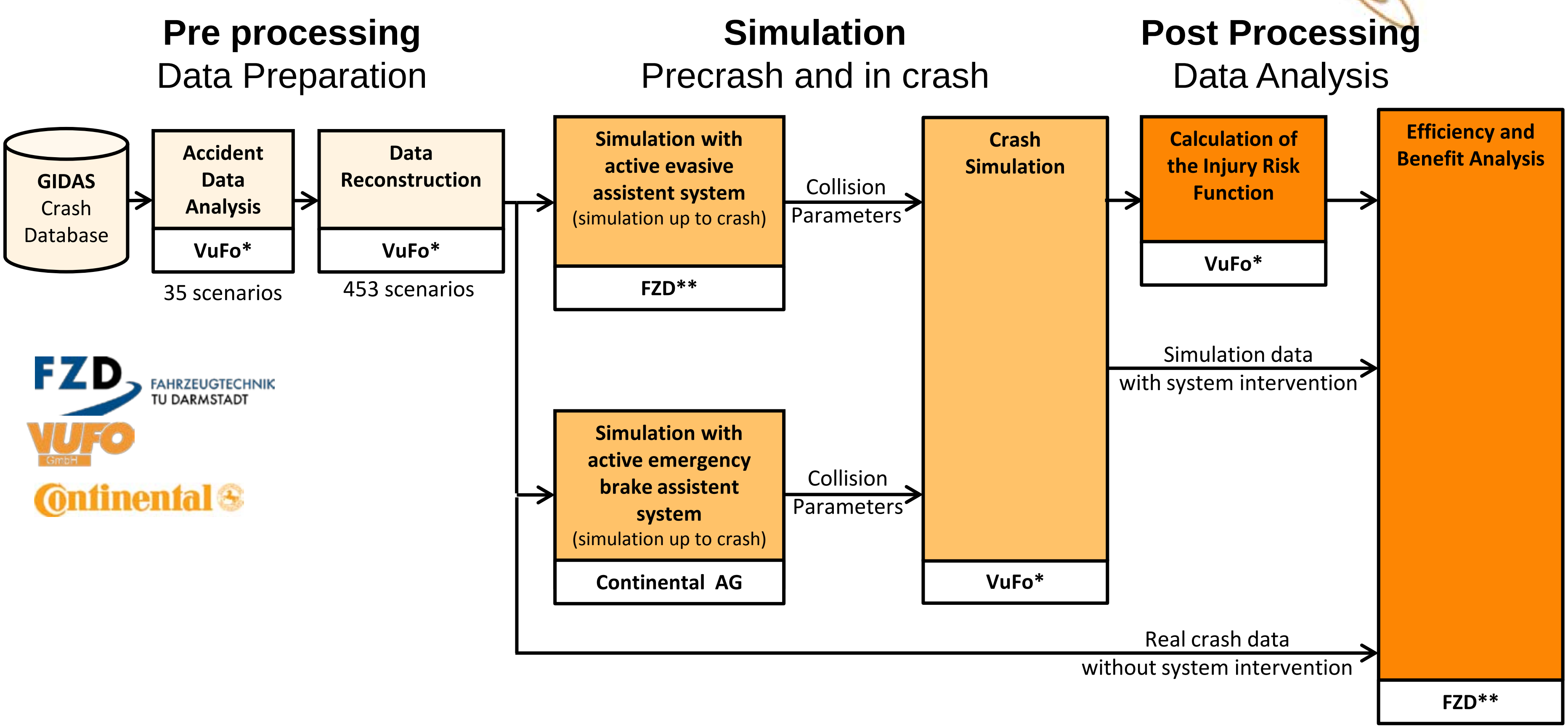
System Benefit

- Precise environment perception
- Fast detection of hidden obstacles
- Reliable and fast information about acceleration of obstacles
- Fast recognition of critical traffic situations
- Take advantage of maximal transmittable wheel forces
- Situation dependent active reaction of system

- **Collision avoidance or mitigation by preventive measures**
- **Optimization of the crash compatibility**

- **Reducing the number of**
  - **death,**
  - **heavily injured,**
  - **slightly injured**
  - **and also physical damages**

Procedure
Benefit and Efficiency Analysis



453 Crash Scenarios, 906 Vehicles and 1654 Persons are taken into acount.

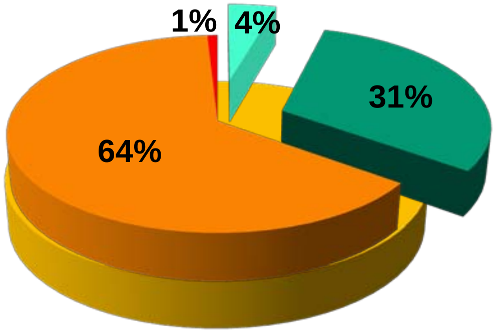
* VuFo: Die Verkehrsunfallforschung an der TU Dresden ** FZD: Fachgebiet Fahrzeugtechnik der TU Darmstadt

Benefit and Efficiency Analysis
Concerned Scenarios

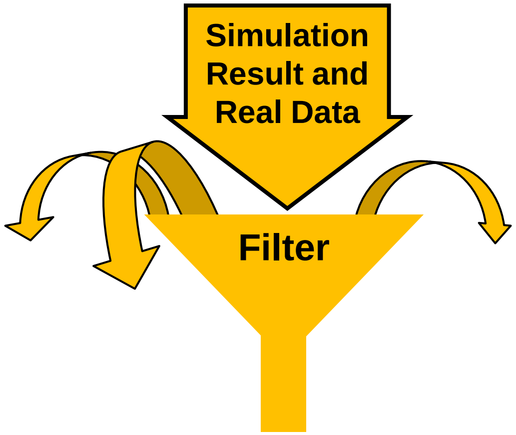
FORSCHUNGSINITIATIVE KO-FAS

Evasive Assistant

- **no change in scenario**
- **affected by evasive assistant**
- not suitable for evasive maneuver
- avoided by driver reaction



Number of scenarios concerned for evasive assistant is <u>159 (~35%)</u>



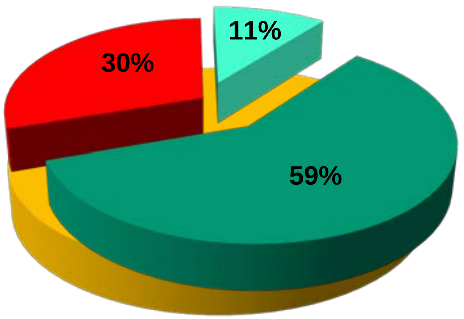
Related Data
with respect to crash scenario

Using the calculated injury risk function

Calculation of injury reduction potential in intersection accidents

Emergency Brake Assistant

- **no change in scenario**
- **affected by emergency brake assistant**
- avoided by driver reaction



Number of scenarios concerned for emergency brake assistant is 318 (~70%)

The brake assistant and the evasive assistant system <u>have different system design</u> and <u>address different crash scenarios</u>, therefore <u>no direct system comparison</u> is possible.

Collision Parameters and Injury Risk Function

Injury Risk Function: how crash severity influences injury risk in vehicles crashes

Dynamic Variables	Priority Class
dv in km/h	1
EES in km/h	2
Impact momentum in Ns	3
Average acceleration in m/s²	3
Rotational velocity in °/s	4

Boolean Variables	Priority Class
Seat place (near/far)	1
Passenger compartment crashed (yes/no)	1

Parameter Study and Correlation Analysis (VuFo)

X_1=dv in km/h

X_2=Seat Place [0,1]

X_3=Passenger Compartment Crashed? [0,1]

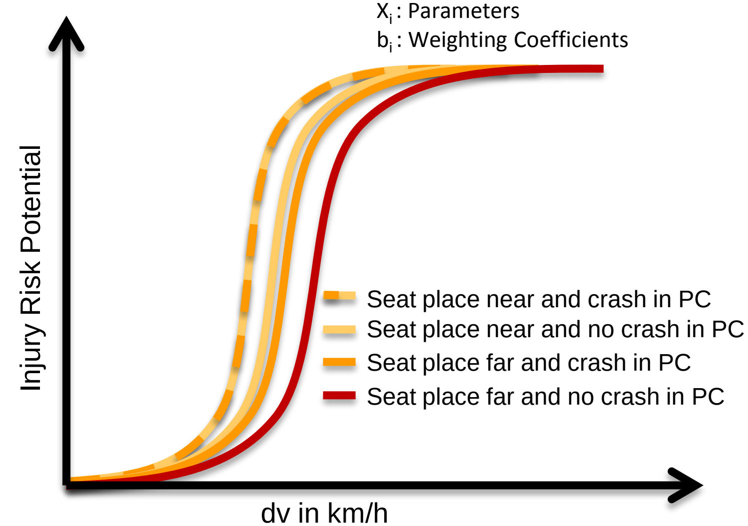
Parameter with Priority Class 1 (VuFo)

Injury risk probability assumed as sigmoid function:

$$P(X) = \frac{1}{1 + e^{-\sum_{i=1}^{3} b_0 + b_i \cdot X_i}}$$

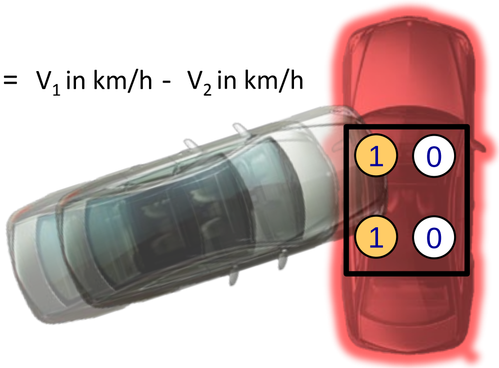
X_i : Parameters

b_i : Weighting Coefficients



Multiple Logistic Regression Analysis (VuFo)

dv = V_1 in km/h - V_2 in km/h



Injury Risk Function
Different Injury Severities are Taken into Account

FORSCHUNGSINITIATIVE KO-FAS

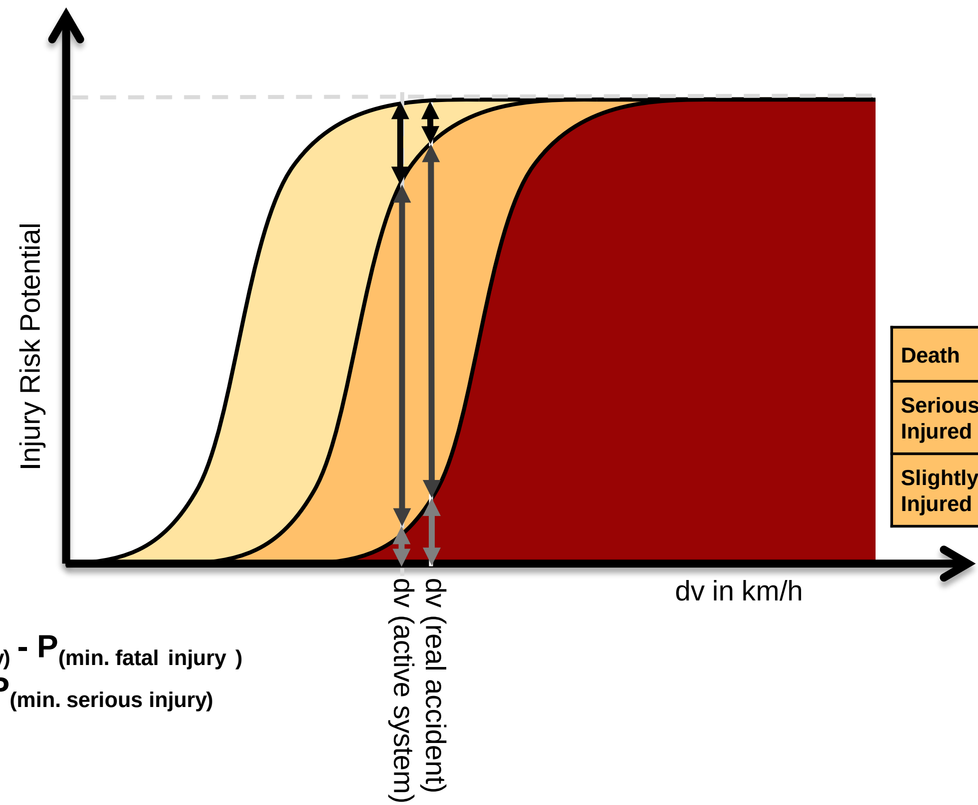
Different Injury Severities:

- No Injury
- Slight Injury
- Serious Injury
- Fatal Injury

$P_{(\text{min. slight injury})}$
$P_{(\text{min. serious injury})}$
$P_{(\text{min. fatal injury})}$

$P_{(\text{fatal injury})} = P_{(\text{min. fatal injury})}$
$P_{(\text{serious injury})} = P_{(\text{min. serious injury})} - P_{(\text{min. fatal injury})}$
$P_{(\text{slight injury})} = P_{(\text{min. slight injury})} - P_{(\text{min. serious injury})}$

Injury Risk Function



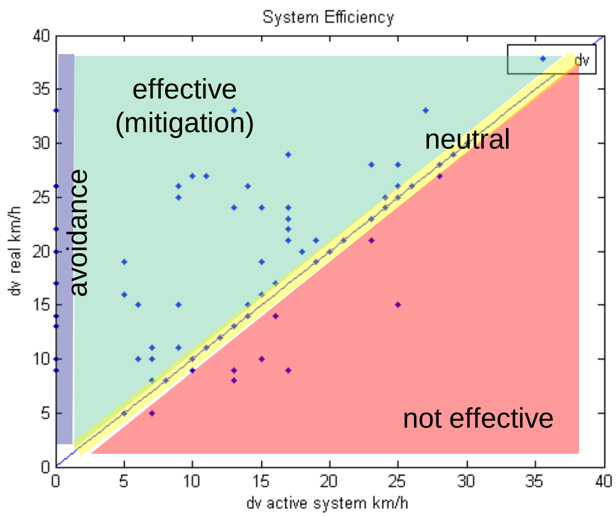
Reduction Potential:

	Reduction Potential for Evasive Assistant [%]	Reduction Potential for Emergency Brake Assistant [%]
Death	38%	59%
Seriously Injured	33%	57%
Slightly Injured	21%	54%

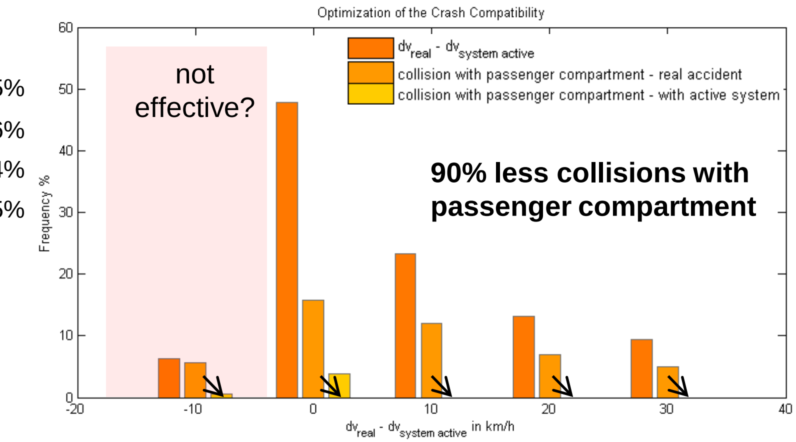
Efficiency Analysis
Optimization of the Crash Compatibility

FORSCHUNGSINITIATIVE KO-FAS

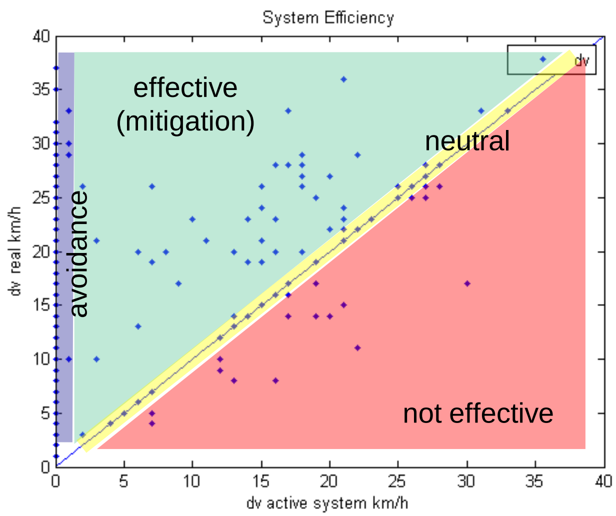
Evasive Assistant



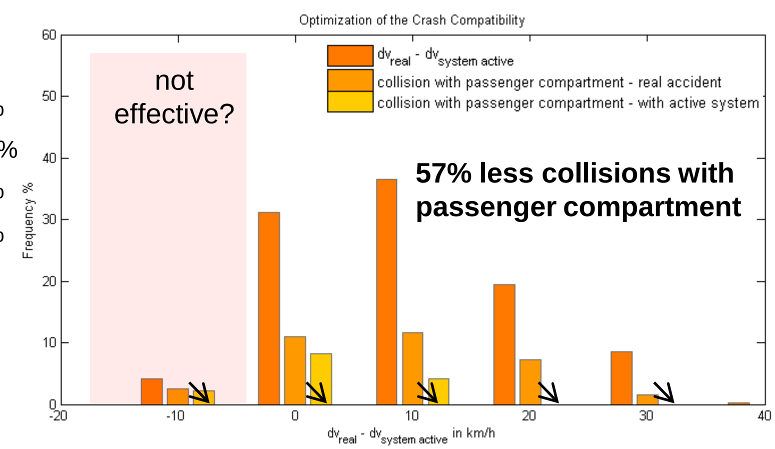
- 72/159~45%
- 41/159~26%
- 22/159~14%
- 24/159~15%



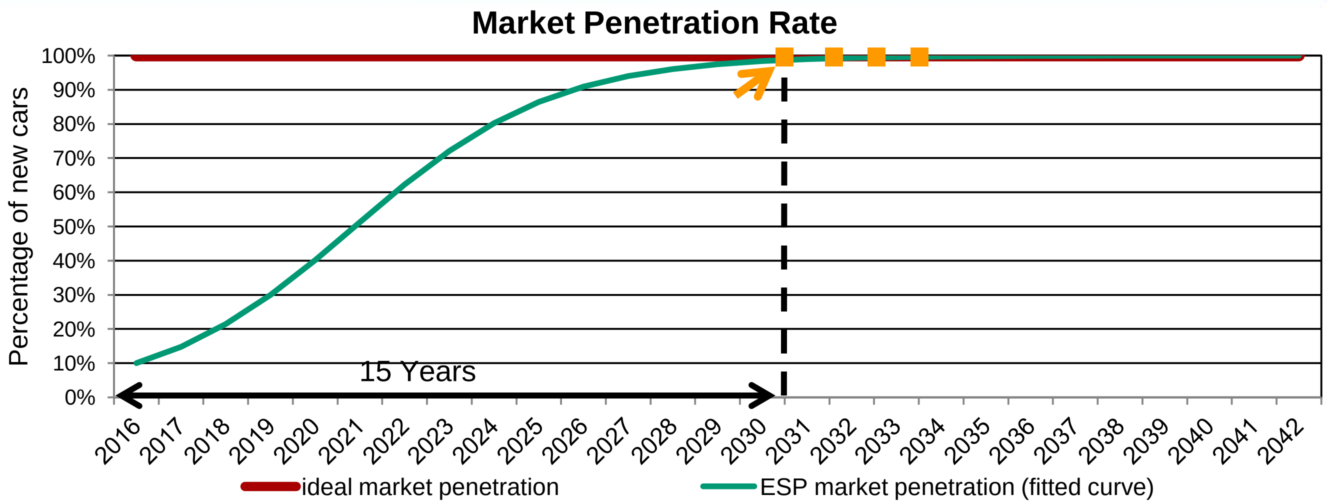
Emergency Brake Assistant

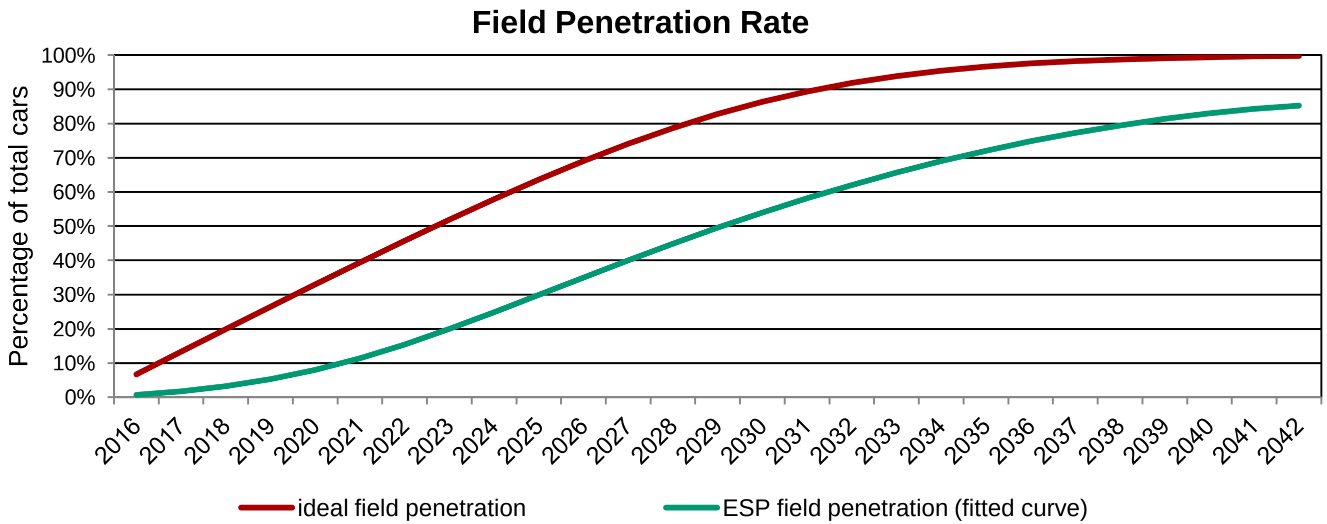


- 76/318~24%
- 155/318~48%
- 57/318~18%
- 30/318~10%



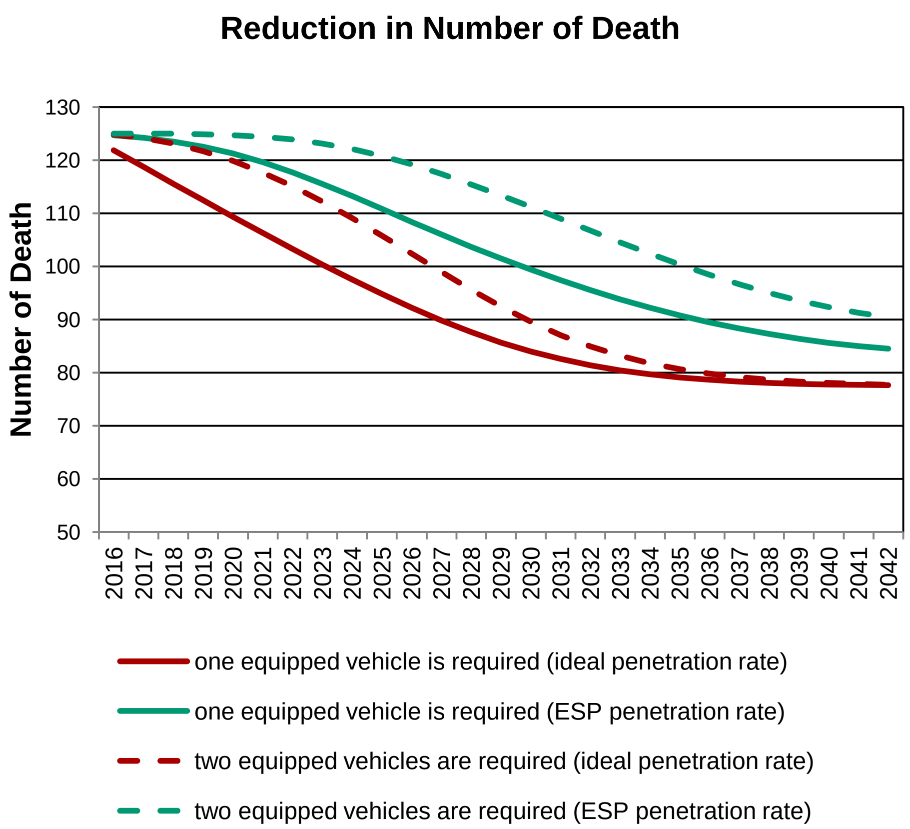
Market and Field Penetration



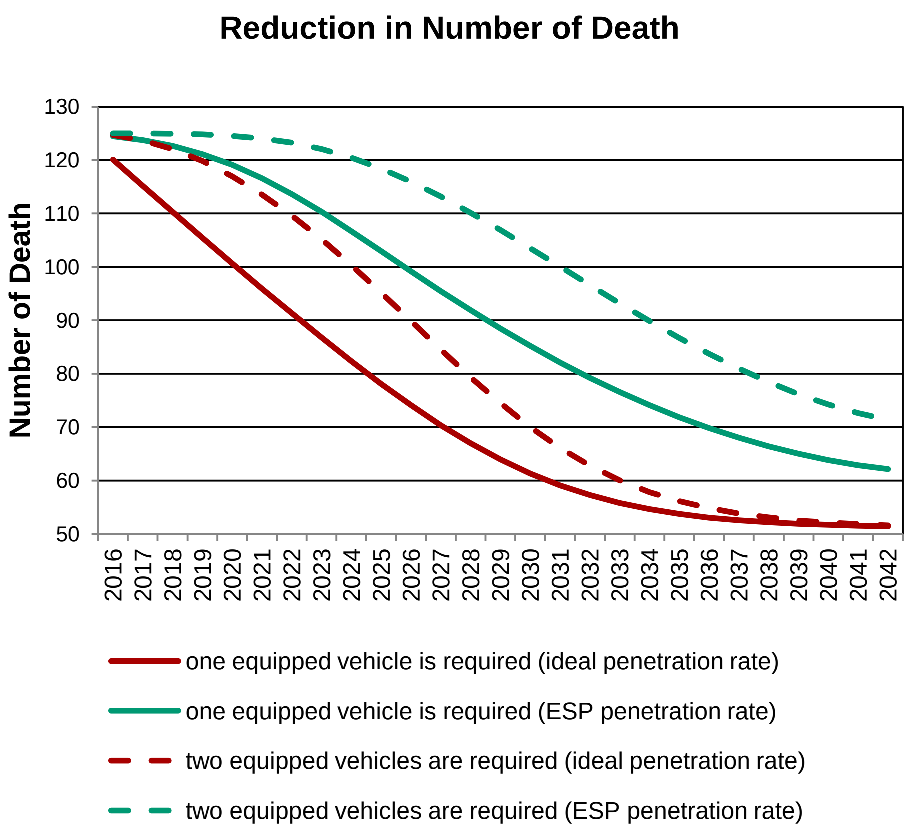


Efficiency Analysis
Reduction in Number of Death

Evasive Assistant



Emergency Brake Assistant



Potential Benefit of the System

FORSCHUNGSINITIATIVE KO-FAS

$$P_{\text{Slight Injury}} = \frac{\text{number of slightly injured}}{\text{number of cars}} \approx \frac{28200}{43\text{ Mil.}}$$

$$P_{\text{Serious Injury}} = \frac{\text{number of seriously injured}}{\text{number of cars}} \approx \frac{3500}{43\text{ Mil.}}$$

$$P_{\text{Fatal Injury}} = \frac{\text{number of death}}{\text{number of cars}} \approx \frac{125}{43\text{ Mil.}}$$

Source: GIDAS 2011

Injury Probability

,

$$PRR_{\text{Slight Injury, EA}} = 21\%$$
$$PRR_{\text{Serious Injury, EA}} = 33\%$$
$$PRR_{\text{Fatal Injury, EA}} = 38\%$$

$$PRR_{\text{Slight Injury, EBA}} = 54\%$$
$$PRR_{\text{Serious Injury, EBA}} = 57\%$$
$$PRR_{\text{Fatal Injury, EBA}} = 59\%$$

Potential Risk Reduction

,

$$Cost_{\text{Slight Injury}} = 4416\text{ Euro}$$
$$Cost_{\text{Serious Injury}} = 110571\text{ Euro}$$
$$Cost_{\text{Fatal Injury}} = 996412\text{ Euro}$$

Source: BASt 2009

Insurance Cost

→

$$Benefit_{EA} = \sum P_i \times PRR_i \times \text{Time of use in year} \times \text{Insurance Cost in Euro} \approx 70\text{ Euro.Year}$$
$$Benefit_{EBA} = \sum P_i \times PRR_i \times \text{Time of use in year} \times \text{Insurance Cost in Euro} \approx 126\text{ Euro.Year}$$

Potential Benefit

The <u>Potential Benefit</u> of the system for the average time of use of 15 years in Germany could be estimated for Evasive Assistant as 70 Euro.Year and for Emergency Brake Assistant as 126 Euro.Year .

Thank you for your attention!