

interactive



Accident avoidance by active intervention for Intelligent Vehicles

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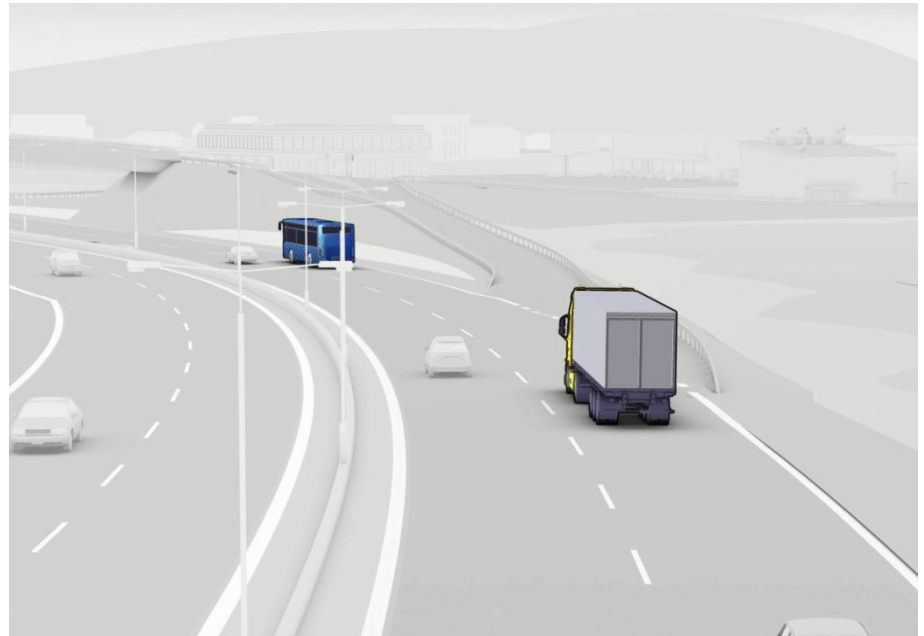
Information, Warning and Intervention strategies
– an overview of the Human Factors work done in interactive

Emma Johansson, Volvo Group Trucks Technology
interactive Final Event

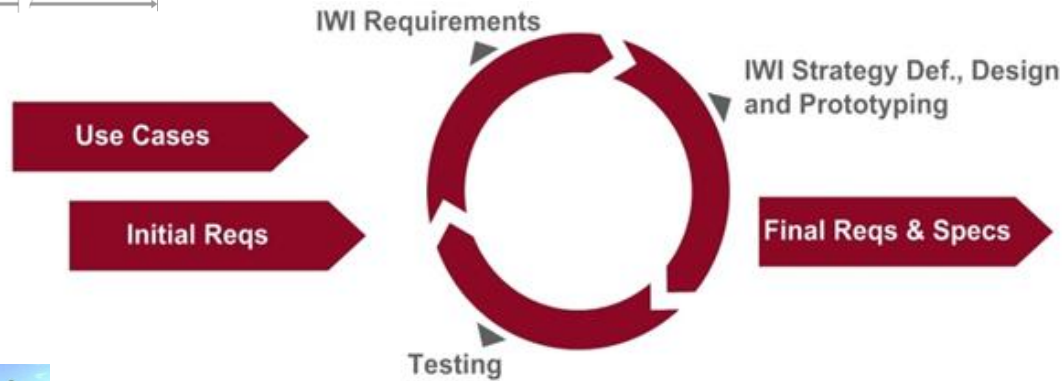
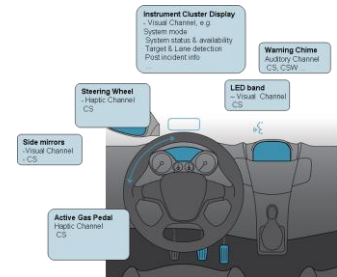
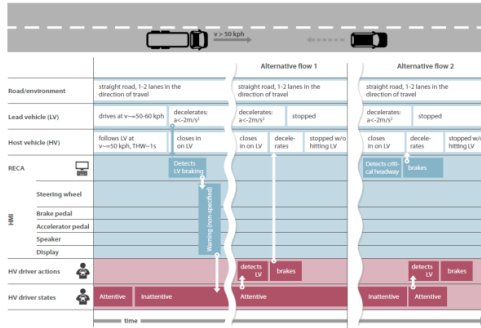
20th-21st November 2013

Outline

- Work process
- Information, Warning and Intervention (IWI) strategies
- Testing (lab, test tracks)



Work process

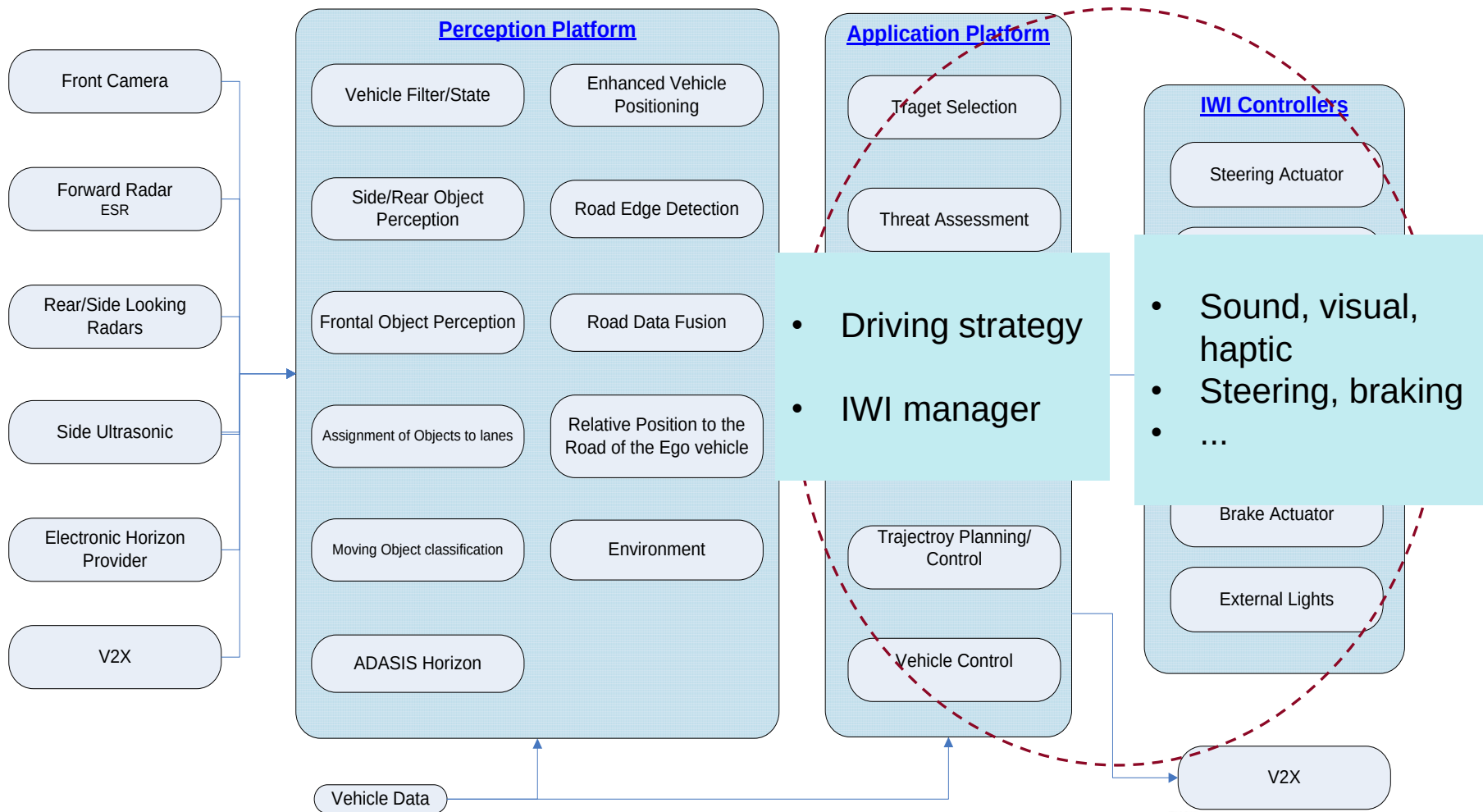


Information, Warning and Intervention (IWI) strategies

- **IWI** strategies should:
 - **define the actual function** from a driver's perspective
 - explain **how, when** and **where** information, warnings and interventions should be activated
 - specify the appropriate **type** of interaction
 - Information and Warnings, which can be **visual, acoustic_or haptic**
 - Interventions via active **steering, braking** or **accelerating**

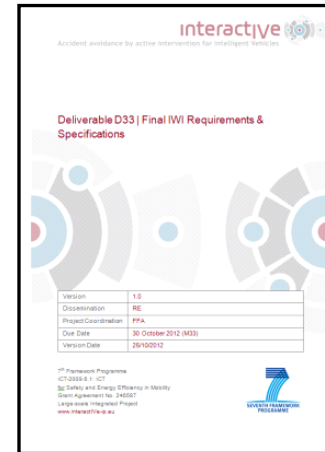


Information, Warning and Intervention (IWI) strategies

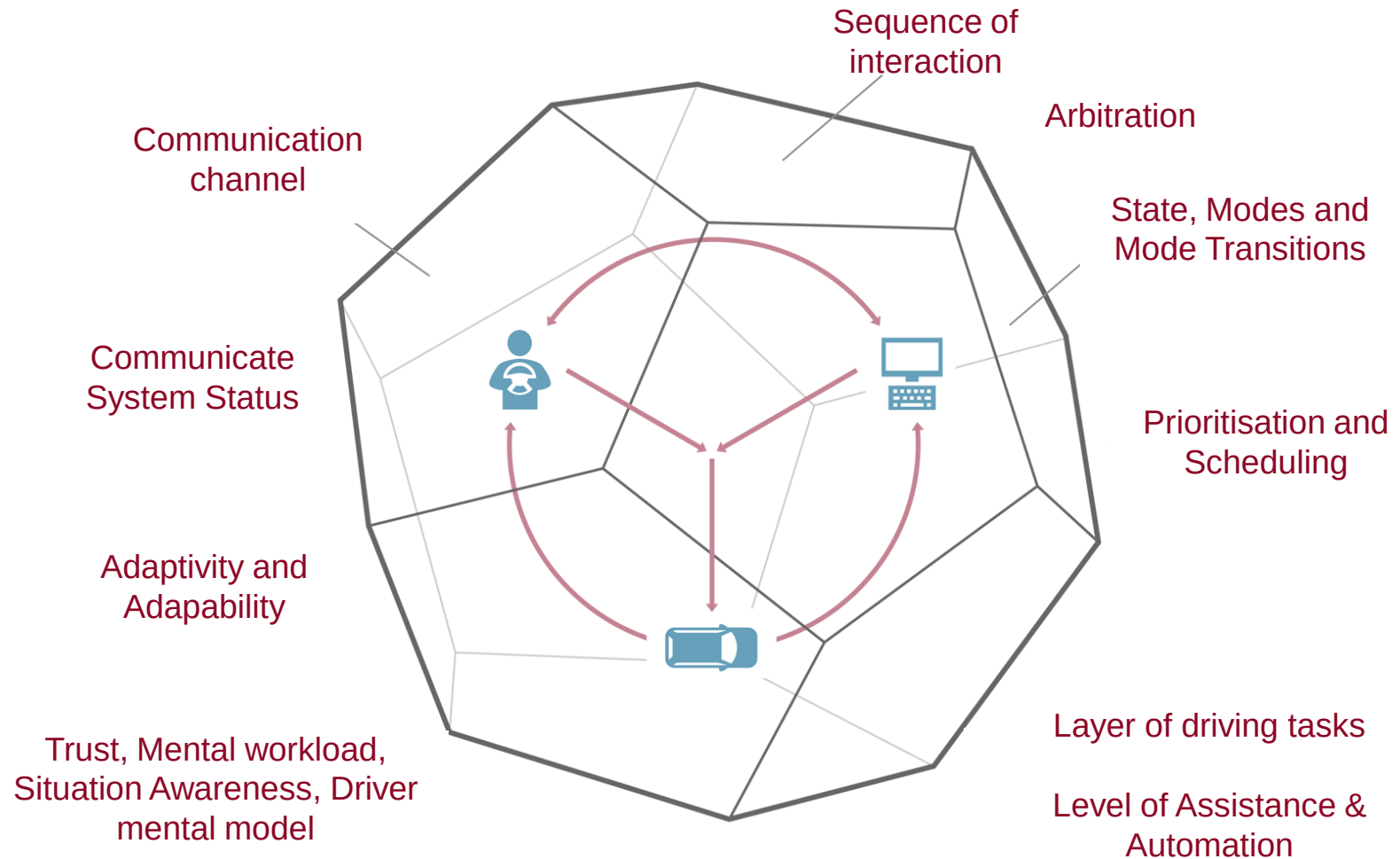


Information, Warning and Intervention (IWI) strategies

- **General** IWI strategies → Design Handbook with Human Factors related requirements
 - Main issues and Research questions
 - Findings in literature and expert opinion
 - Strategies
- IWI strategies **applied** to demonstrators → Functional Requirements



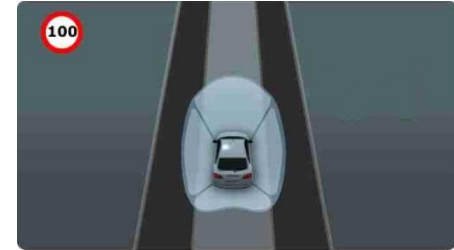
Information, Warning and Intervention (IWI) strategies – design categories



Information, Warning and Intervention (IWI) strategies – examples

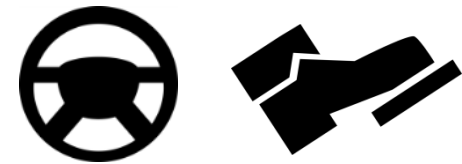
- **Range of Operation and Availability:**

- 'Indicate system availability status' [ROA02]



- **Communication channel**

- 'Use the output channel that should be used for performing the wanted action by either the driver or the system' [CC25]



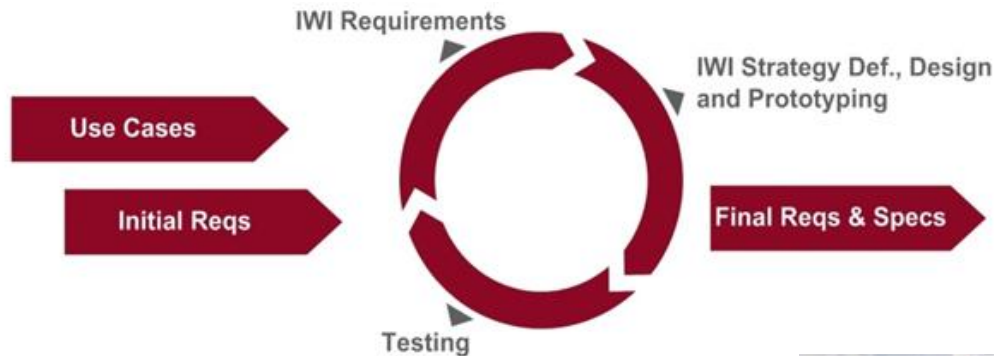
- **States, Modes and Mode Transitions**

- 'Single assistance functions and their states are grouped into one concept' [SMT05]
- Use interlocked transitions [SMT08]



ID	General strategy	Explanation with references
CC x	Locate auditory warning signals so that they appear to come from in front of the operator if this is where the hazard is. Locate the warnings close to head height.	Directional warnings have shown to decrease response times ([Ho et al. (2005)]).
CC y	Position visual display/labels/ warnings to ensure proper association	Drivers will assume a relationship between objects based on their spatial proximity ([Salvendy (1997)]). “The law of proximity”: We tend to group things together that are close to each other. If a button is marked TC and is placed near the climate panel, it might as well be Temperature Control.
CC z	Keep consistency in semantics for all functions indicating same thing. Distinct signals for distinct meaning.	In order to harmonise interfaces and to save physical space, If for example a vibration is used to indicate “danger”, then it should not be used in another context such as an indication or a question [Kelsch (2011)]. Another example is audio or haptic vibration and/or force in steering wheel for lateral support ([ISO17361 (2007)]). Visual information close to or in frontal windshield along with auditory information for longitudinal support. Or make use of distinct output and input channels E.g. lateral problems by haptic information on steering wheel, longitudinal problems by haptic information on pedals. Different beeps for lateral/longitudinal. Make the same functions use the same output/input devices, e.g. forward collision warning the same for different systems e.g. CMW (warning part) and RECA.
CC n	Do not use one master alarm for all warnings, nor too many different warnings.	Results from a study [Green et al. (2008)] ruled out the use of four individual warnings (one each for LDW, CSW, FCW, and LCM). An analysis that led up to the experiment discouraged the use of a single warning to represent all subsystem warnings collectively. Solution: using two warnings, one for longitudinal and one for lateral threats.

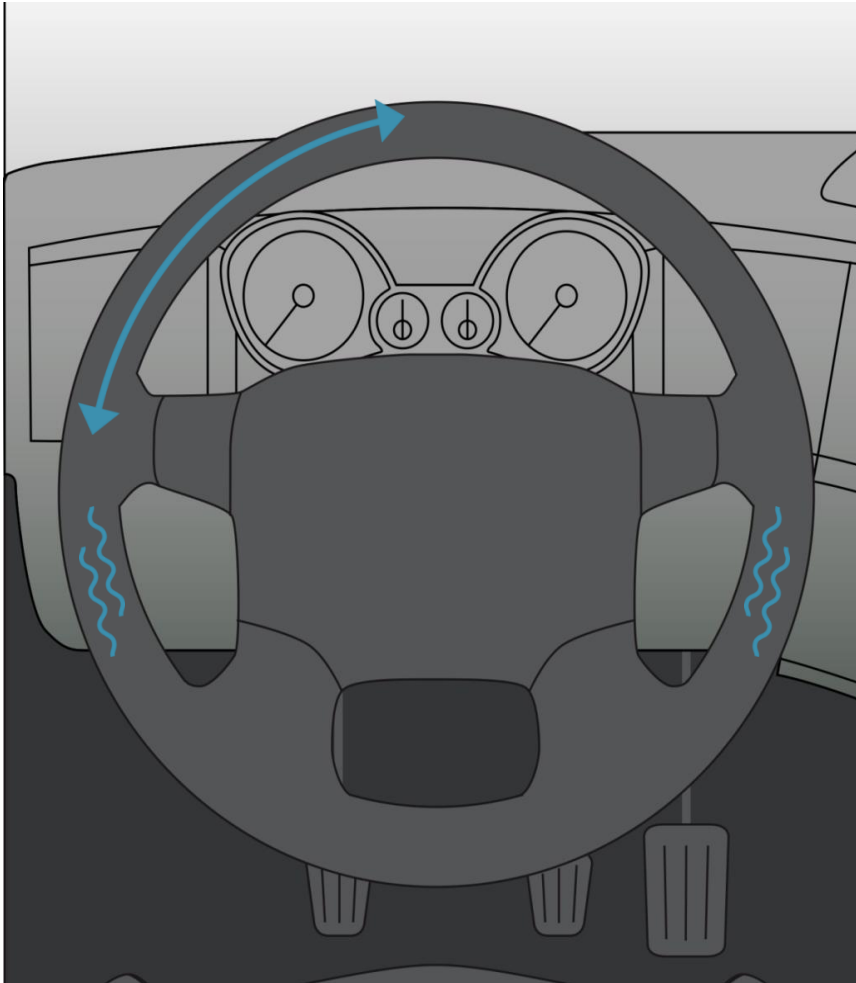
Testing IWI strategies



- 10 simulator and test track experiments +
- Experiments in collaboration with demonstrator owners



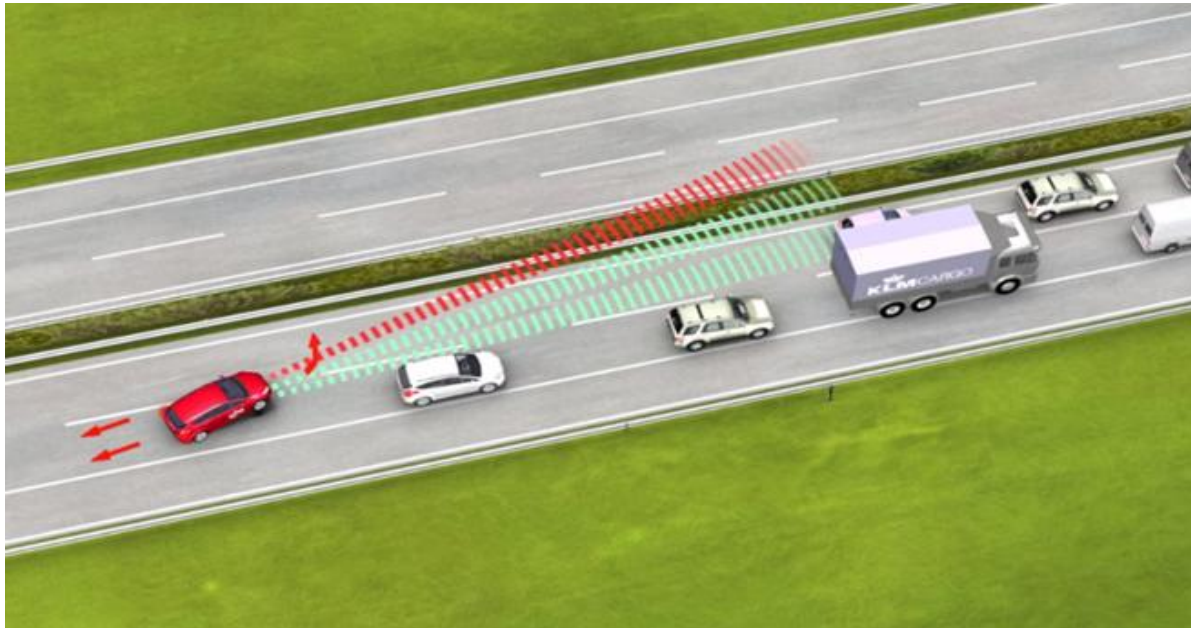
Testing IWI strategies: **Steering avoidance**



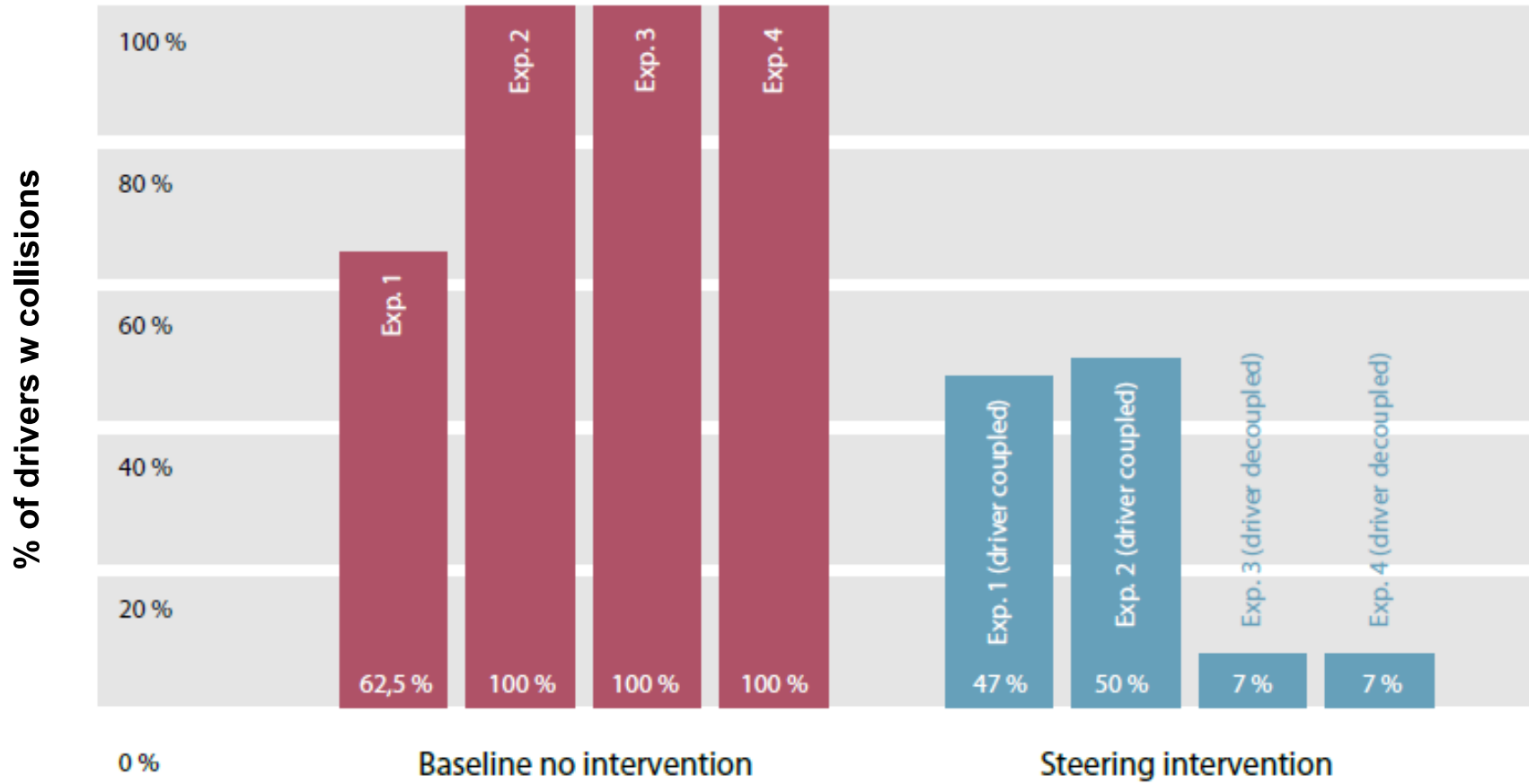
Research questions

- Does drivers accept a **sudden** steering avoidance maneuver?
- Can drivers be **convinced** of system initiated steering maneuver by **prompts/ directed warnings** before intervention (directed double ticks in steering wheel, acoustic warning)
- Can drivers be **de-coupled** for a short period in order not to counteract the system intervention?
- **Controllability** issues?

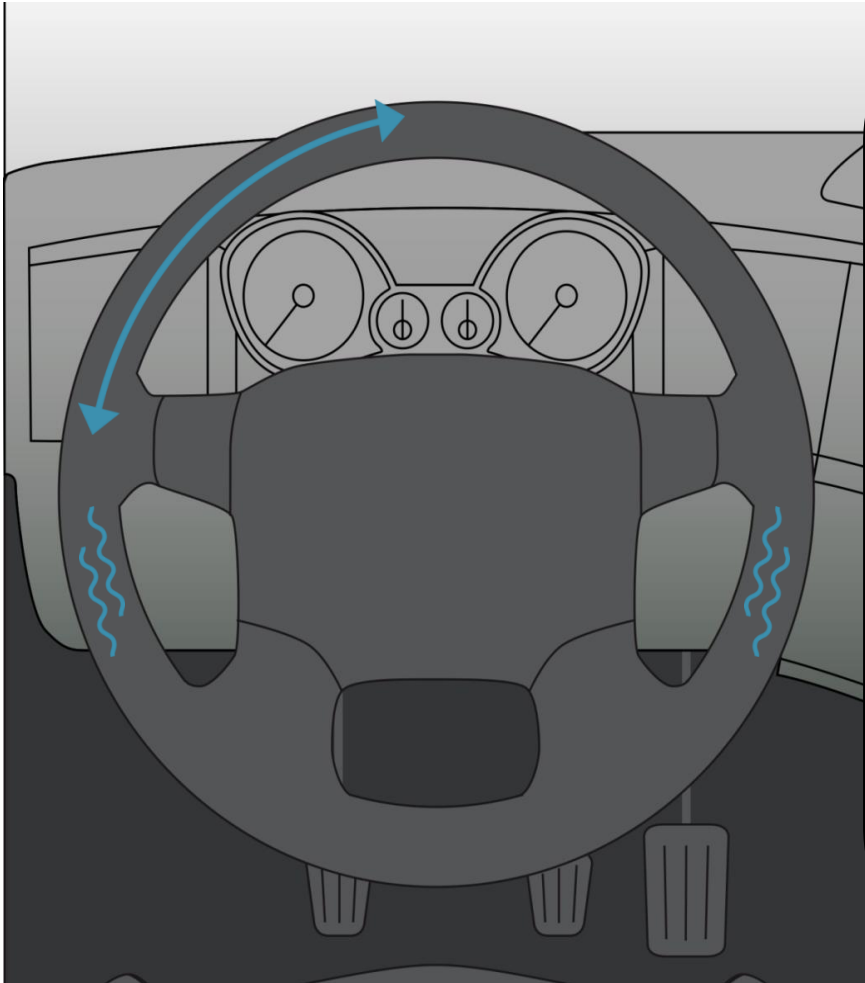
Testing IWI strategies: **Steering avoidance**



Testing IWI strategies: **Steering avoidance**



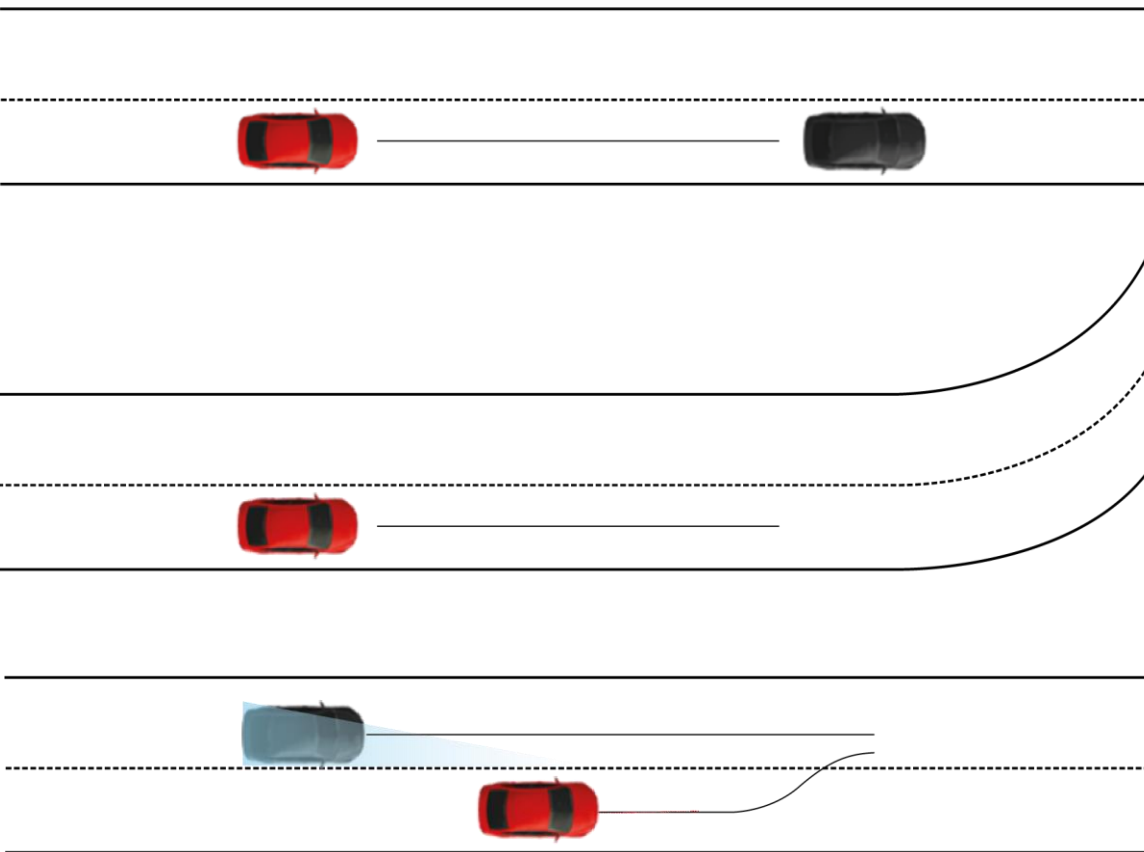
Testing IWI strategies: **warning modalities** in single and multiple threat events



Research questions

- **What warning modalities** are effective in different use cases and **compatible** with drivers' reaction?
- **How many modalities** are useful for each function and in **multi-event** scenarios?
- Are there different **warning modalities** suitable for **early** and **late** warning stages?

Testing IWI strategies: warning modalities in Single-Event scenarios



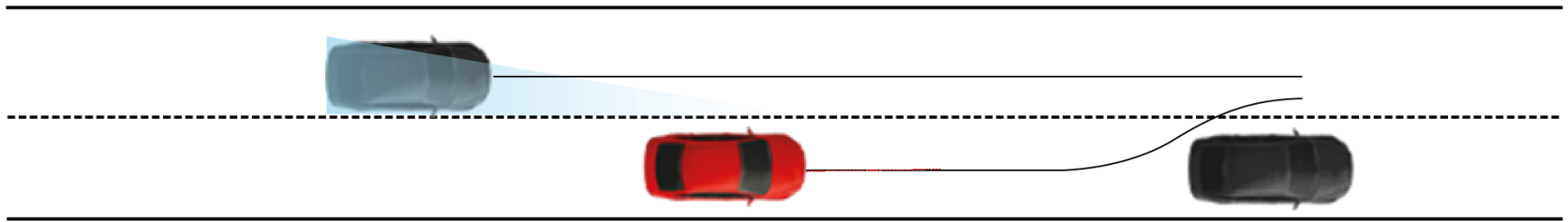
- Rear End Collision
- Dangerous Curve
- Blind Spot

Testing IWI strategies: warning modalities in Single-Event scenarios

Scenario	Performance data	Subjective data	Final Recommended
Rear-end Collision 	- Visual & - Haptic	- Visual - Pedal or - Acoustic	
Dangerous curve 	- Visual & - Pedal	- Visual - Pedal or - Acoustic	
Blind spot 	- Visual & - Acoustic	- Visual - Wheel or - Acoustic	

Testing IWI strategies: warning modalities in Multiple-Event scenarios

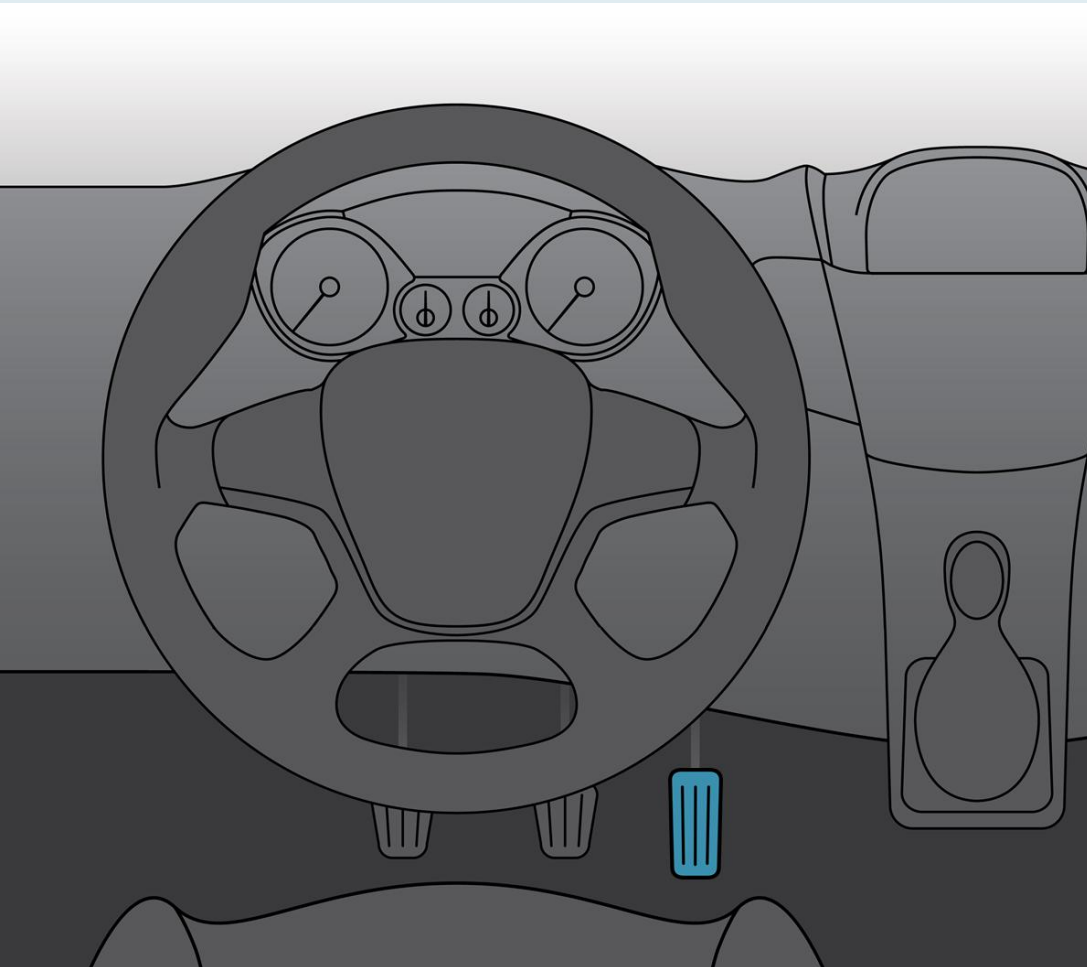
Rear End Collision and Blind Spot



Testing IWI strategies: warning modalities in Multiple-Event scenarios

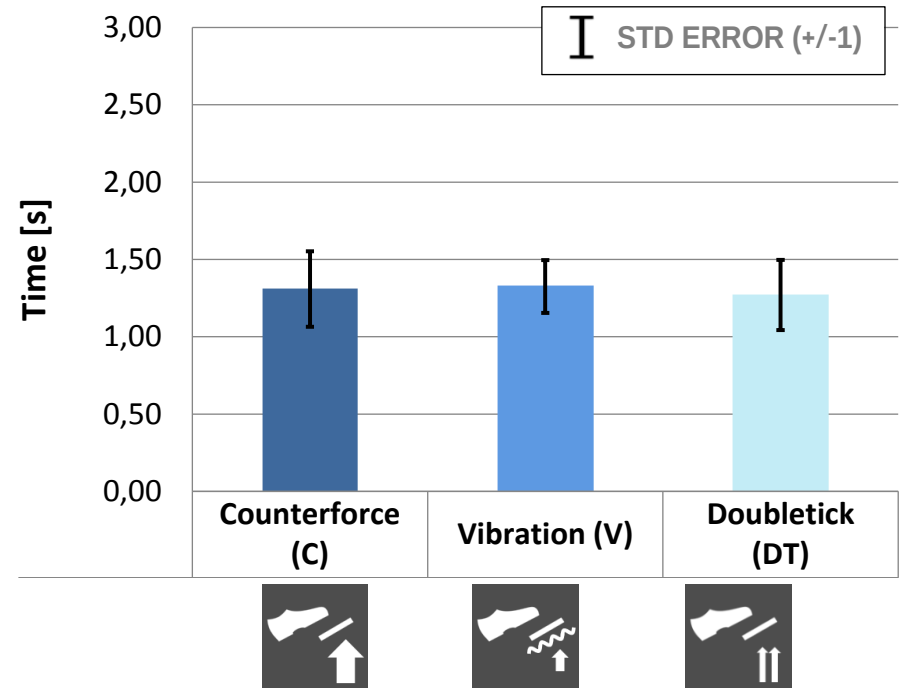
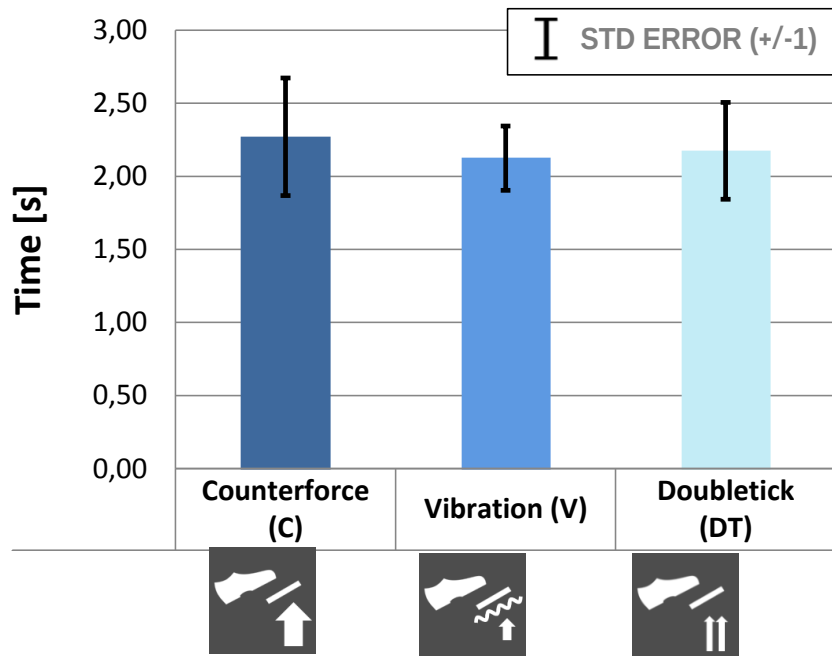
Scenario	Performance data	Subjective data	Final Recommended
Late “Red” warning Rear End and Blind Spot	- Visual & - Haptic pedal	- Visual - Haptic pedal	
Early “Yellow” warning Rear-end	- Visual & - Haptic Pedal	- Visual	  - Soft Haptic Pedal only when fatigued

Testing IWI strategies: **Haptic Pedal Warnings**



- Driver reaction in a **Curve Speed Warning** scenario
 - **with or without additional acoustic and visual feedback**
- **Haptic signal at the accelerator pedal** either:
 - **Double Tic,**
 - **Vibration, or**
 - **Counterforce**
- $V = 120\text{km/h} > V_{\text{max}}(\text{curve})$
- **Pedal Warning**
 - issued 2 seconds before

Testing IWI strategies: Haptic Pedal Warnings



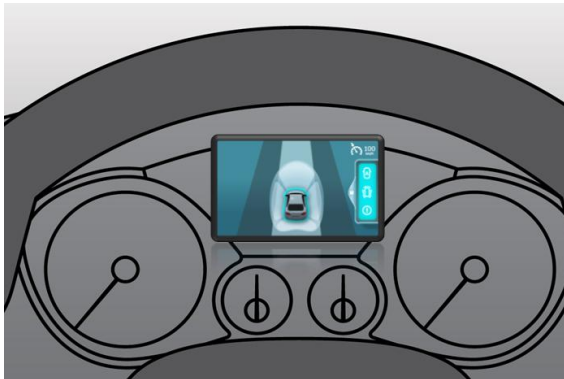
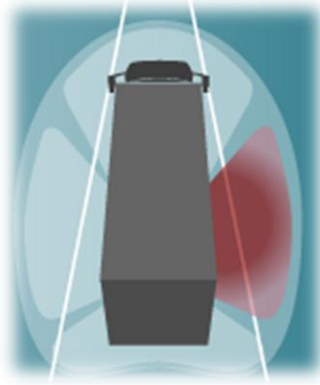
Common design elements: challenge!

interactiVe functions

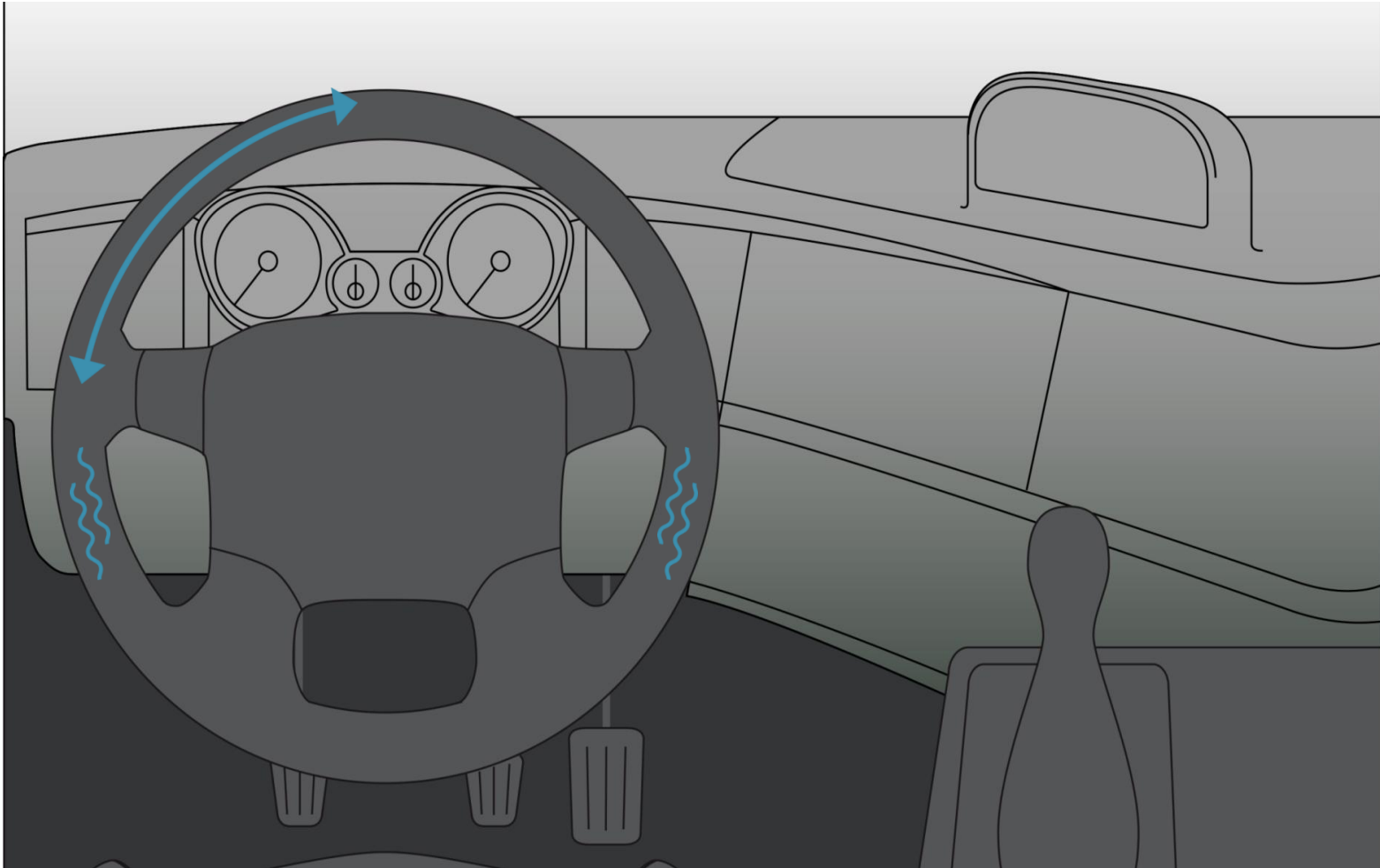
CS Continuous Support (CRF)	CS Continuous Support (FFA)	SC Safe Cruise	CSW/CSC Curve Speed Warning / Control	RORP Run off Road Prevention	RORP in curve	SIA Side Impact Protection	LCCA Lane Change Collision Avoidance	RECA Rear-end Collision Avoidance	CMS Collision Mitigation System	ESA Emergency Steer Assist	OVCA Oncoming Vehicle Collision Avoidance/Mi tigation	eDPP enhanced Dynamic Path Predictor
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Integrated design concept

Visual design elements



Haptic design elements



Auditory design elements

- Common **auditory** elements for information, warnings and interventions
 - Function status sounds (e.g. functions activated/de-activated, transition refused)
 - Warning sounds
 - Lateral:
 - E.g. Run-off road (RORP), Blind spot (SIA)
 - Longitudinal:
 - E.g. Rear-end collision (RECA), oncoming vehicle collision (OVCA)



Testing: wrap up

- 10 experiments (9 in simulators, 1 on test track) + a range of tests in collaboration with the demonstrator owners
- 400+ test participants at 10 test sites



Research topics:

- Steering Intervention
 - in lateral threat situations
 - in rear end collision or intersection scenarios
 - with coupled & de-coupled drivers
- Acceptance and effectiveness
 - Multiple warning events,
 - Pre-warnings and Warnings
- Haptic pedal signals for longitudinal warning scenarios
- Evaluation of Visual Concepts
 - Comprehensibility & Mode Confusion