Testing of L2 driving functions regarding their system functionality and human-machine interaction on rural roads

Maria Fleischer MSc
KFV (Austrian Road Safety Board)
E-Mail: maria.fleischer@kfv.at | www.kfv.at

OVERVIEW

56TH CIECA CONGRESS
DUBAI 2024

1. Introduction
2. Project - Testing of L2 driving functions regarding their system functionality and human-machine interaction on rural roads
3. Project Phase 1 – Tests in Real Traffic
4. Project Phase 2 – Tests on Test track
5. Results

ADAS
HUMAN BEHAVIOUR AND ATTITUDE

56TH CIECA CONGRESS
DUBAI 2024

Automation of the driving task progresses → the human driver is gradually freed from the responsibility of actively controlling the vehicle's dynamic driving functions.

Decreasing participation in the active performance of the driving task → exposed to higher competence requirements.

Solid basic knowledge & a high level of acceptance of all ADAS → full advantage of support & increase road safety

ADAS
RISK FACTORS

Risk factors of Level 2 ADAS :

- Loss of routine
- Excessive demands
- Reduction of vigilance / fatiguing continuous monitoring
- Lack of situational awareness
- Overconfidence or misuse of the systems.

ADAS
CRUCIAL QUESTIONS

How can this assistance be finely tuned to seamlessly involve the human in the supervisory role, without making them feel that the vehicle has taken over full control?

How do drivers react to safety-critical situations?

How do today's assisted L2 driving functions operate on rural roads and can they really be reliable and safe?

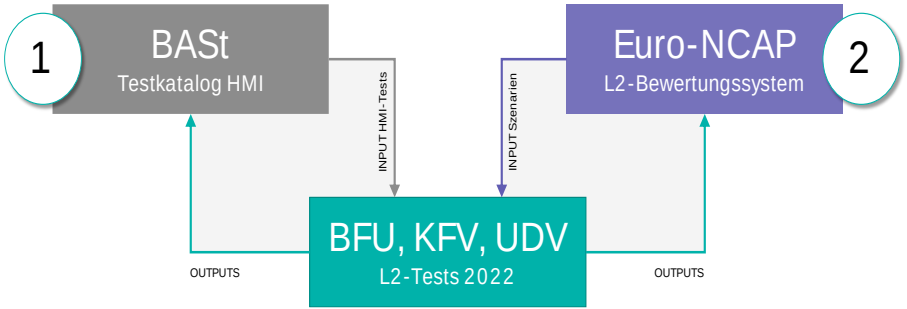
Drivers:

- Technically and legally fully responsible
- Serve as a safety-related fallback level

PROJECT

Project Partner:

- Austrian Road Safety Board (KFV)
- Swiss Council for Accident Prevention (BFU)
- German Insurers Accident Research (UDV)



Focus:

Evaluation of the functionality on rural roads & the involvement of the driver in the driving task in the monitoring process of the SAE - L2 driving functions.

PROJECT OBJECTIVES

Evaluation of the driver engagement while using SAE L2 systems on rural roads → **creation of new risks for road safety?**

The project comprises driving tests in real traffic & on a test track and was carried out in two phases.

PHASE 1

- Preparation of the road tests on public roads
  - literature & developing methodology
- Detailed test planning, implementation & test evaluation
- Driving tests in real traffic by experienced drivers
- Proposal for suitable test scenarios for the test track (Phase 2)

PHASE 2

- Preparation of the test track
- Recruiting of participants
- Detailed planning of scenarios & organisation to ensure the appropriate setting conditions
- Driving tests on the test track
- Evaluation of results
  - By experts
  - By participants

PHASE 1
TEST SETTING

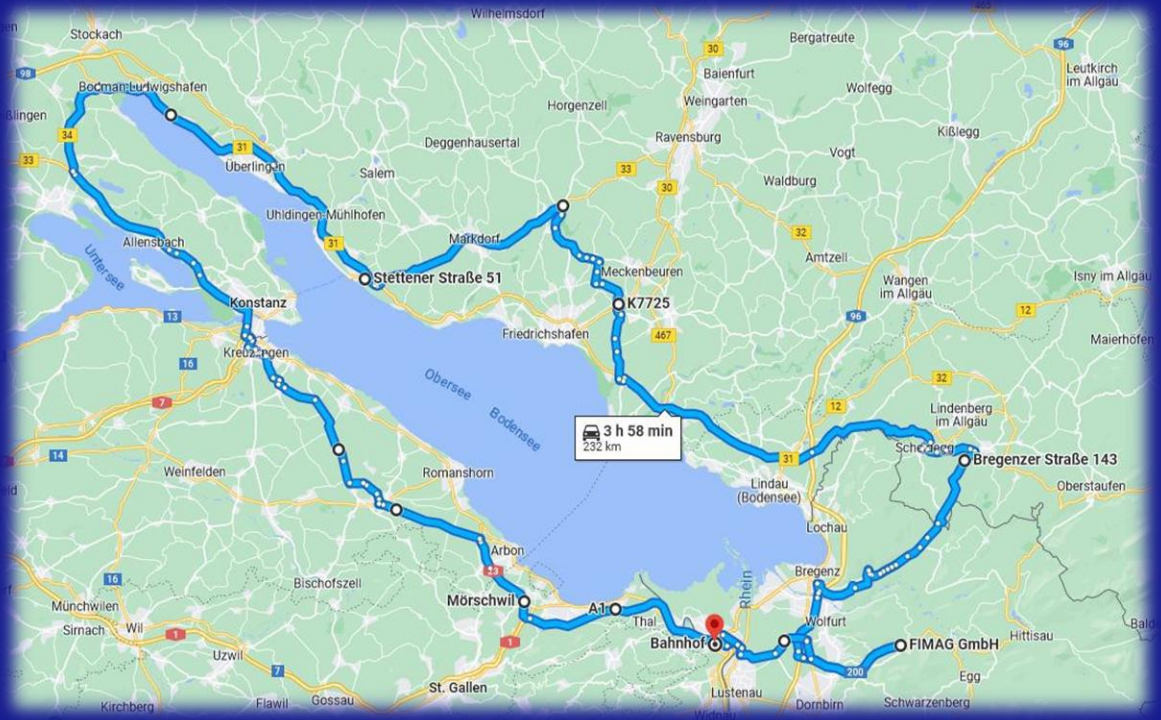
56TH CIECA CONGRESS
DUBAI 2024

Preparation of the road tests on public roads

Challenge: different road conditions on rural roads – various categories

L2KAT 1	L2KAT 2	L2KAT 3	L2KAT 4	L2KAT 5
				

PHASE 1
TEST SETTING



Test track:
Border triangle
AT, CH, DE

Mainly rural roads
(min. speed: 60km/h)

2 experienced drivers

PHASE 1
VEHICLE SELECTION

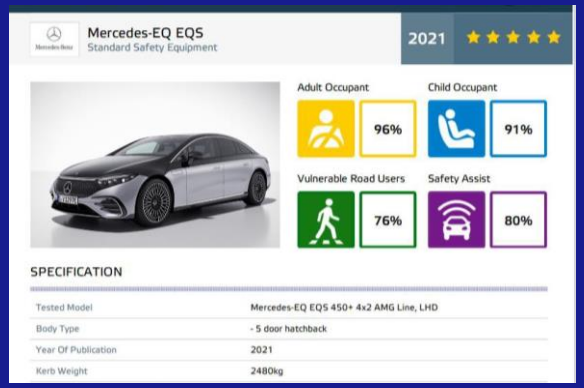
Selection requirements:

- **Most comprehensive ADAS** available on the market (include the specified L2 systems)
- **Volume model, premium segment & pioneer** in technology
- The **design of the functions and the HMI should differ** from one another
- The vehicles should have a current **EuroNCAP rating**

PHASE 1
VEHICLES

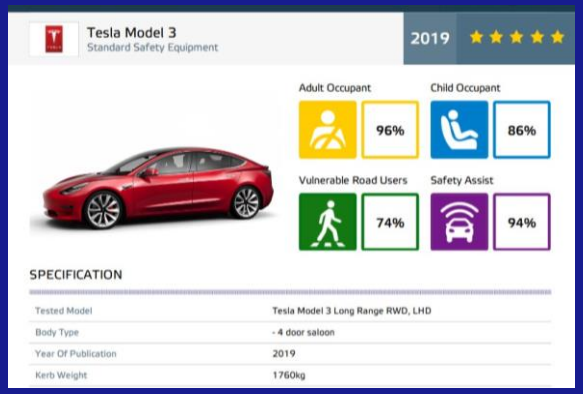
56TH CIECA CONGRESS
DUBAI 2024

Vehicle A



Vehicle B

Vehicle C



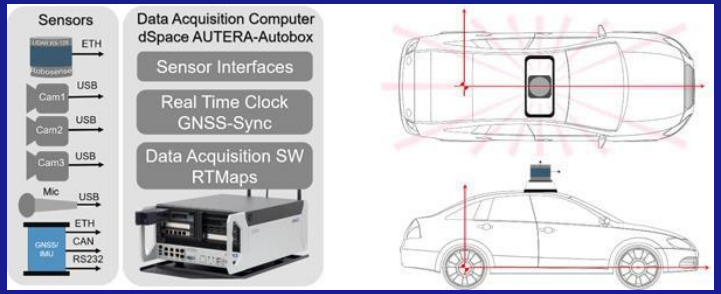
PHASE 1
REAL TRAFFIC TESTS

56TH CIECA CONGRESS
DUBAI 2024

3 separate measurement technology systems installed in the vehicles

Video/audio measurement technology

Dynamic ground truth system (DGT)



Eye tracking measurement system

PHASE 1
REAL TRAFFIC TESTS

56TH CIECA CONGRESS
DUBAI 2024

Vehicle A

Vehicle B

Vehicle C

PHASE 1
TEST RESULTS

- Duration of driving tests: ~ 36 hours
- Test route length: 236 km
- **262 traffic safety critical events (139 on rural roads)**

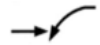
Some events & system outputs were **sometimes incomprehensible even for experienced drivers**

- <u>Most frequent incidents:</u>
  - Lane keeping functions (~40%)
  - Inadequate braking and acceleration & unsatisfactory choice of speed before cornering
  - Traffic Sign Recognition and the Adaptive Cruise Control (ACC)

PHASE 1
SCENARIO RESULTS

56TH CIECA CONGRESS
DUBAI 2024

	Grundszenario	Szenario ICON	Anzahl Trigger Situationen	Häufigkeit	Kritikalität
H1	SameTrafficway/OppositeDirection Forward Impact-Head On Road Curve		24	17,3%	5,4
H2	Single Driver Left/Right Roadside Depart Road Curve		24	17,3%	4,7
H3	Speed Not Adapted to Road Features		19	13,7%	5,1
H4	Deceleration of System In A Trigger Event		12	8,6%	3,6
H5	Removal Speedlimit Not Detected, Set Speed To Low		12	8,6%	1,6
H6	Speed Limit Sign Not Detected, Change Of Set Speed To Late		10	7,2%	3,4
H7	SameTrafficway/OppositeDirection Forward Impact-Head On Road Straight		8	5,8%	3,6
H8	Free Travel Trigger Event, Overruling/Self Deactivation		6	4,3%	2,3
H9	Target Vehicle Leaves Traffic Way, Ego Vehicle Brakes Inappropriately		5	3,6%	2,8
H10	Car-To-Car Rear Stationary CCRs		3	2,2%	3,5

	Grundszenario	Szenario ICON	Anzahl Trigger Situationen	Häufigkeit	Kritikalität
H11	Ego Vehicle Accelerates Inappropriately		2	1,4%	5
H12	Single Driver Left/Right Roadside Depart Road Straight		2	1,4%	6,5
H13	Driver Demands Trigger Event During Car Following Situation		2	1,4%	4
H14	Cut-In No Collison		2	1,4%	5,5
H15	Stop+Go		2	1,4%	1,5
H16	Pedal Cyclist As An Obstacle		2	1,4%	-
H17	Change Trafficway/Vehicle Turning Turn across Path OppositeDirection		1	0,7%	8
H18	Red Light Recognition Fail		1	0,7%	-
H19	Static Pederstrian Target		1	0,7%	7
H20	Lane Change Event (Freiland)		1	0,7%	4

PHASE 2
CONTENT

- Planning, realisation and evaluation of road tests on a suitable test track.
- Preparation of the test track, recruiting of the volunteers and a detailed test plan is drawn up.
- Driving tests on the test track: Testing of the driving manoeuvre test scenarios developed in phase 1 → applicability
- Evaluation of results
  - By experts
  - By participants

PHASE 2
TEST TRACK

Test track / Proving ground:

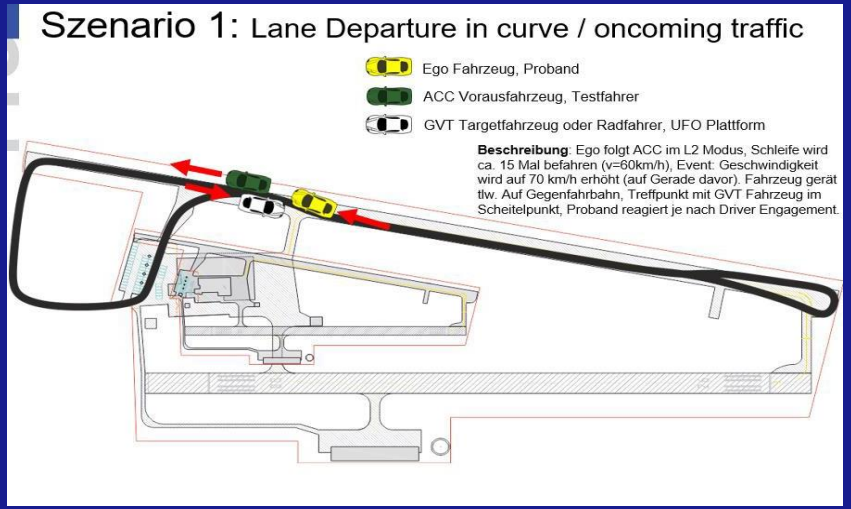
SafetyLabs Austria - test area of the company DSD in Hofkirchen near Linz (Upper Austria)

PHASE 2
TEST SCENARIOS

56TH CIECA CONGRESS
DUBAI 2024

Scenario 1:

Lane Departure in curve with oncoming traffic (right-hand bend)

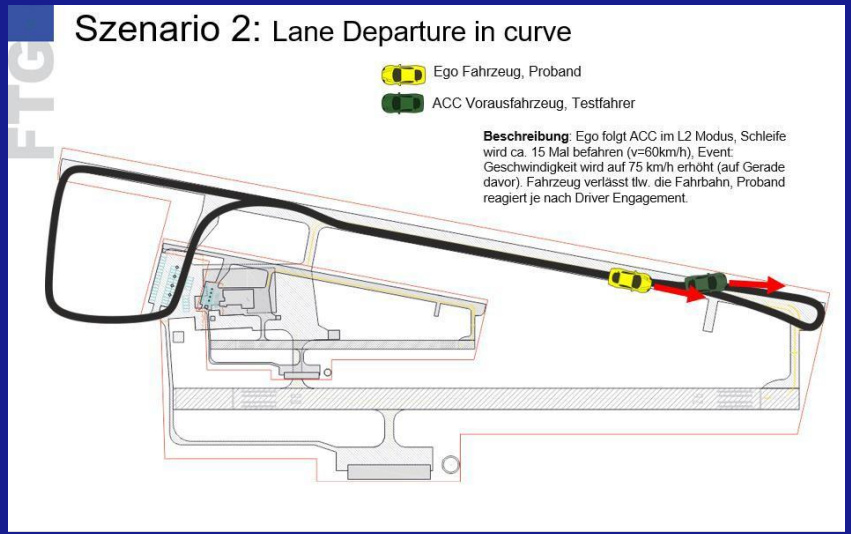


PHASE 2
TEST SCENARIOS

56TH CIECA CONGRESS
DUBAI 2024

Scenario 2:

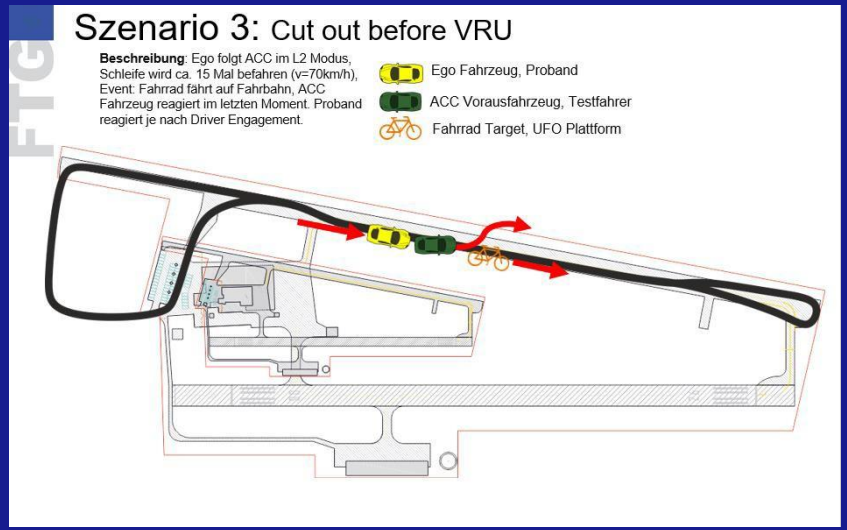
Lane Departure in curve (left-hand bend over the edge of the road)

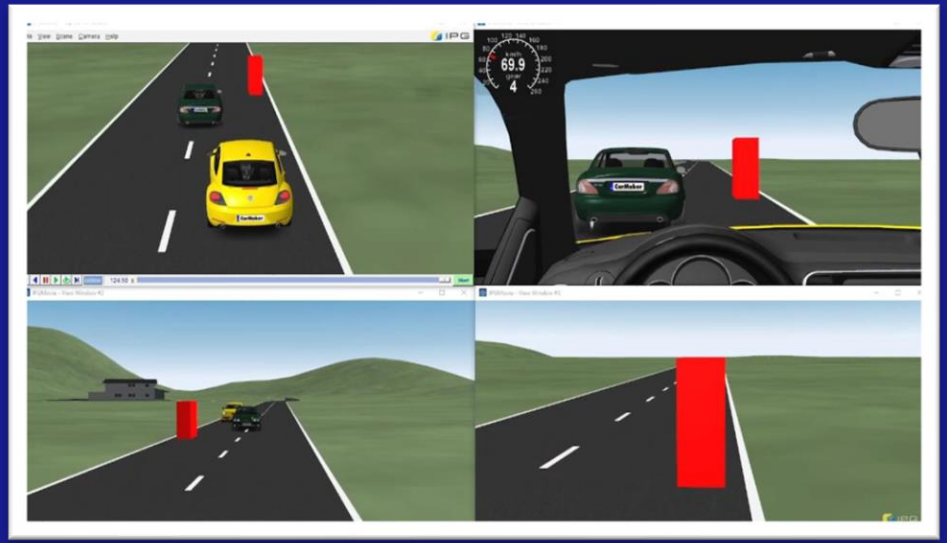


PHASE 2
TEST SCENARIOS

56TH CIECA CONGRESS
DUBAI 2024

Scenario 3
Cut out before VRU





PHASE 2
TEST PARTICIPANTS

56TH CIECA CONGRESS
DUBAI 2024

Sample: n=**24**

Gender: Male = **18** Female = **6**

Age:

- 35: **4**
- 36-55: **9**
- < 55: **11**

The average mileage/year: 10,000km - 20,000km

Experience with SAE L2 systems before the test drives: n= **19**

PHASE 2
EXPERIMENTAL DESIGN

56TH CIECA CONGRESS
DUBAI 2024

		Scenario 1: Lane depature in curve / oncoming traffic		Scenario2: Lane depature in curve		Scenario3: Cut out before VRU	
Day 1							
		Familiarisation	Test	Familiarisation	Test	Familiarisation	Test
Sequence		Mo3	Mo3	EQS	EQS	ID3	ID3
	8:00	TP1					
Scenario 1	8:30		TP1	TP2			
Scenario 2	9:00				TP2	TP1	
Scenario 2	9:30	TP2					TP1
Scenario 3	10:00		TP2	TP1			
Scenario 3	10:30				TP1	TP2	
Scenario 1	11:00	TP3					TP2
Scenario 2	11:30		TP3	TP4			
Scenario 1	12:00				TP4	TP3	
Scenario 3	12:30	TP4					TP3
Scenario 2	13:00		TP4	TP3			
Scenario 1	13:30				TP3	TP4	
Scenario 3	14:00	TP5					TP4
Scenario 3	14:30		TP5	TP6			
Scenario 3	15:00				TP6	TP5	
Scenario 1	15:30	TP6					TP5
Scenario 1	16:00		TP6	TP5			
Scenario 2	16:30				TP5	TP6	
Scenario 2	17:00						TP6

PHASE 2
OBSERVATION & ASSESSMENT

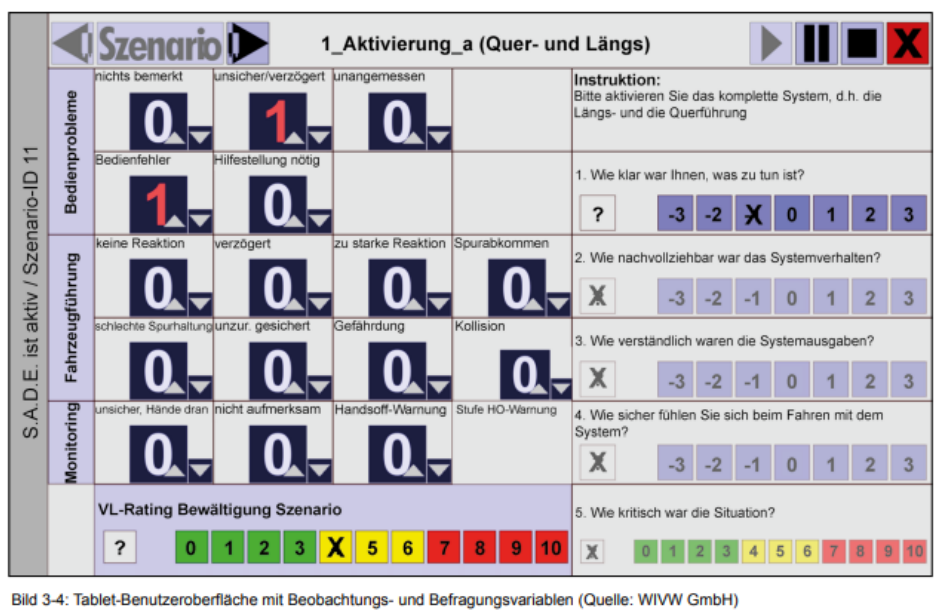


Bild 3-4: Tablet-Benutzeroberfläche mit Beobachtungs- und Befragungsvariablen (Quelle: WIVW GmbH)

Schömig et al.

- Questionnaires
- Observation variables
- Test administrator rating: activation of the L2 functions
- Test administrator rating: coping with the test situation

PHASE 2 –
OBSERVATION & ASSESSMENT

56TH CIECA CONGRESS
DUBAI 2024

2 Questionnaires

- **Preliminary Questionnaire:**
  Sample description (gender, age, annual mileage and general experience,..)

- **Subjective Questionnaire/ Assessment of test scenarios:**
  - How clear was it to you what to do in the situation?
  - How comprehensible was the system behaviour in the situation?
  - How understandable were the system outputs in the situation?
  - How safe did you feel in this situation?

- **Criticality → How critical was the situation for you?**

PHASE 2 – RESULTS

56TH CIECA CONGRESS
DUBAI 2024

- SAMPLE: Men (N=18) Women (N=6)
  Gender → Women performed slightly worse than men in activating the systems → coping can be rated as good.

- SAMPLE: ADAS + (N=19) ADAS - (N=5)
  Knowledge → ADAS + participants performed better than ADAS - participants regarding activation & handling. Similar performance of ADAS + & ADAS - in the test scenarios.

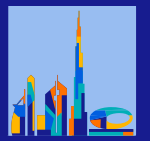
- All 3 vehicles were rated similarly by participants → Clarity, Comprehensibility, Understandabiltiy…

- **Main system issues**: Lane departure, delayed or insufficient/no reaction

- **Scenario 3** (Cut out before VRU) was the **most difficult** scenario for the participants

PROJECT FINDINGS

56TH CIECA CONGRESS
DUBAI 2024



- L2 systems on rural roads is **potentially dangerous** → **almost always possible to activate** with sufficient lane markings
- **L2 systems should not be used on rural roads –** only on well-developed and less winding rural roads with high-quality road markings.
- System errors: **inadequate lateral control**, especially in bends, and various errors in **speed selection**
- There are differences between vehicles (depending on the manufacturer) when it comes to involving drivers in the driving task.

PROJECT FINDINGS
HMI

- Head-up display
  - View can remain forwards on the road -> Reduced distraction
  - Compact and condensed information
  - Information on the HUD → Clearly recognisable whether the system is active

- System information :
  - Steering wheel vibration
  - Acoustic signal when systems are switched on or off/when take over needed

PROJECT FINDINGS
HMI

- Imprecision & information overload → Uncertainty regarding system activation
- Higher distraction → all/selective information in the centre on “main” display
- No clear information → object recognition
- System warnings: late / last moment
- Ergonometry issues → difficulties system activation
- Not intuitive → requires familiarisation (~15min)

PROJECT FINDINGS

Requirements for technical & HMI design of L2 driving functions

- Combine hands-off monitoring with driver status monitoring (eyes on the road against distracting activities or fatigue)
- Standardised HMIs & larger symbols
- System warnings ⇾ system limits
- Avoidance of mode confusion ⇾ appropriate communication & information (operating instructions, sales talks, information at car hire companies, driving schools, driver safety training, advertising for the vehicles)

PROJECT FINDINGS

- The human-vehicle interfaces (HMI) and integration concepts of the L2 function should be standardised across all vehicle manufacturers.
  SAE-L2 systems require an attentive driver & a suitable design of the HMI (e.g., display, symbols,..)

- Drivers should be kept in the loop, e.g. with only slight steering assistance while driving, so that they remain attentive at all times and are always alert.

PROJECT FINDINGS

56TH CIECA CONGRESS
DUBAI 2024

L2 systems are generally only intended to support the driver

- Manufacturers refrain from issuing predictive warnings to the driver
- Ensure that car drivers do not become accustomed to behaviour (looking away until a warning sound appears) → impermissible when using L2 systems.

56TH CIECA CONGRESS
DUBAI 2024

THANK YOU

Maria Fleischer MSc
KFV (Austrian Road Safety Board)
E-Mail: maria.fleischer@kfv.at | www.kfv.at