Hochschule Kempten University of Applied Sciences

Adrive livinglab

Vehicle Technology SS 21
Lecture 4

FT30 – Advanced Driver Assistance Systems

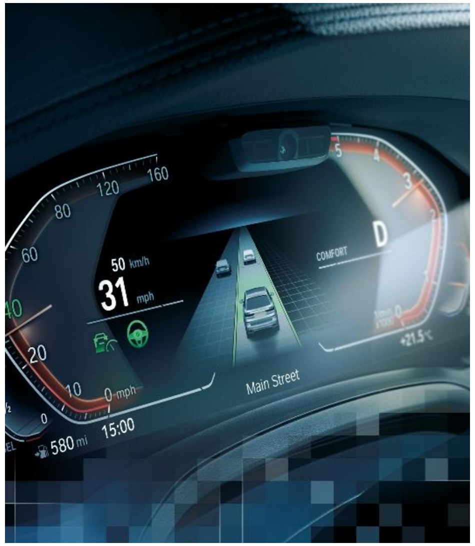
ADAS/AD for Automated Parking

Thomas Boscher & Adrian Günther

Agenda

Nr.	Datum	Inhalt
1	23.04.	Introduction Advance Driver Assistance Systems and Automated Driving
2	07.05	ADAS/AD for Longitudinal Guidance
3	14.05.	ADAS/AD for Lateral Guidance
4	28.05.	ADAS/AD for Automated Parking
5	11.06.	User Experience with ADAS
6	**18.06**	**Track Day**
7	TBD	Exam Questions

Main categories for FAS are LFAS, QFAS and Parking



LFAS

Adaptive Cruise Control (ACC)

Predictive Cruise Control (PCC)

Forward Collision Prevention Systems (FVCX)

QFAS

Lane Departure Warning (LDW)

Lane Keep Assist System (LKAS)

Lane Change Assist (LCA)

Parking

Guided Parking Assist

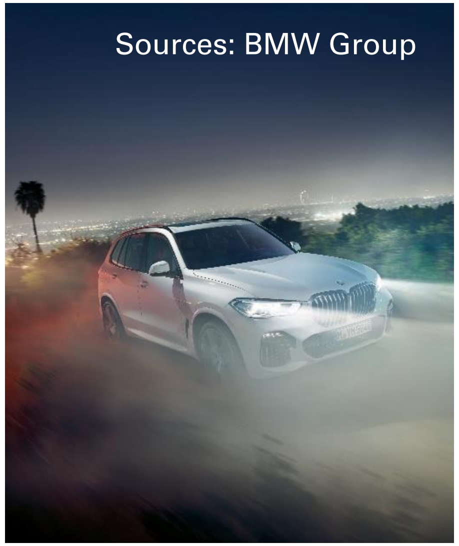
Semiautomatic Parking Assist

Autonomous Parking Assist

Mix between LFAS and QFAS

Traffic Jam Assist

Full autonomous driving



Vision aid

High beam Assist

Night Vision Assist

Agenda

- Introduction
  - Definition
  - Types
  - Motivation
  - HMI concepts
- Workshop customer need & KPIs
- Functionality
  - Sense
  - Plan
  - Act
- Workshop time model & maneuver
- PMA Study Human vs. PMA
  - Procedure and conditions
  - Measurement setup
  - Level model
- Workshop Human vs. PMA
- Results of the subjective study

Parking Assistance (PA)

Parking assistants park the vehicle in both longitudinal and transverse parking spaces and also park out of longitudinal parking spaces. These systems support the driver by choosing the right steering angle. They also take over the measurement of the parking space beforehand. In new system the driver himself do not need to accelerate or brake.

History of parking assistant

Passive Systeme

Aktive Systeme

www. wikipedia.org

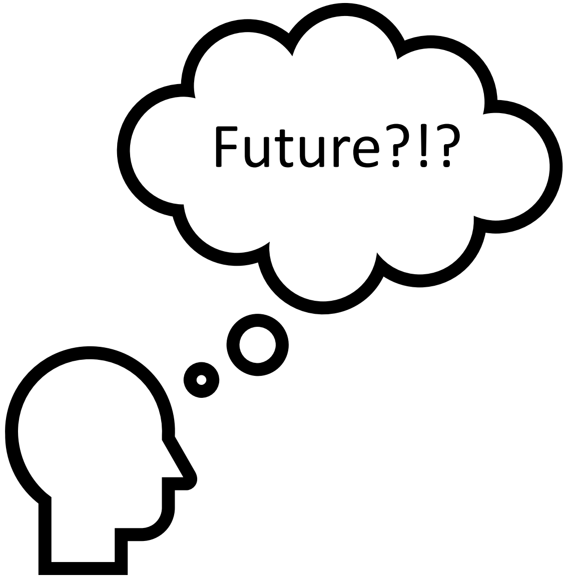
www.wissen.de

www. wikipedia.org

www. ff-tuning.de

www. bmwblog.com

www.auto-motor-und-sport.de



Next steps for parking assistant systems

www.bmwblog.com

Auto Parking | Xpeng G3 - YouTube

The journey from assisted parking to fully automated parking

Guided Parking Assist

www.sixt-neuwagen.de

Semiautomatic Parking Assist

www.autobild.de

Fullautomated Parking Assist

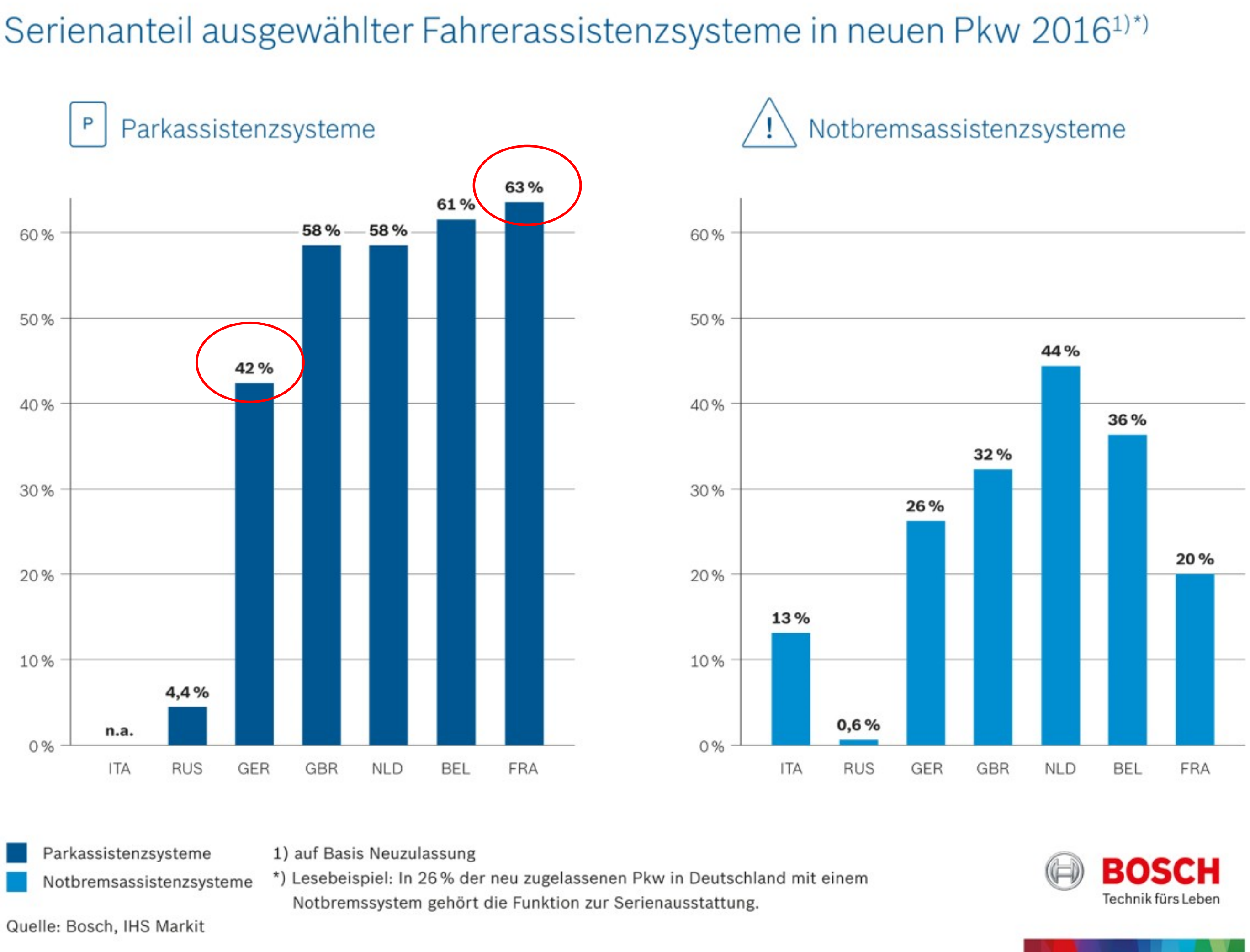
How to Use BMW Parking Assist | BMW Genius How-To | BMW USA - YouTube

Perfect parallel parking - Guinness World Records - YouTube

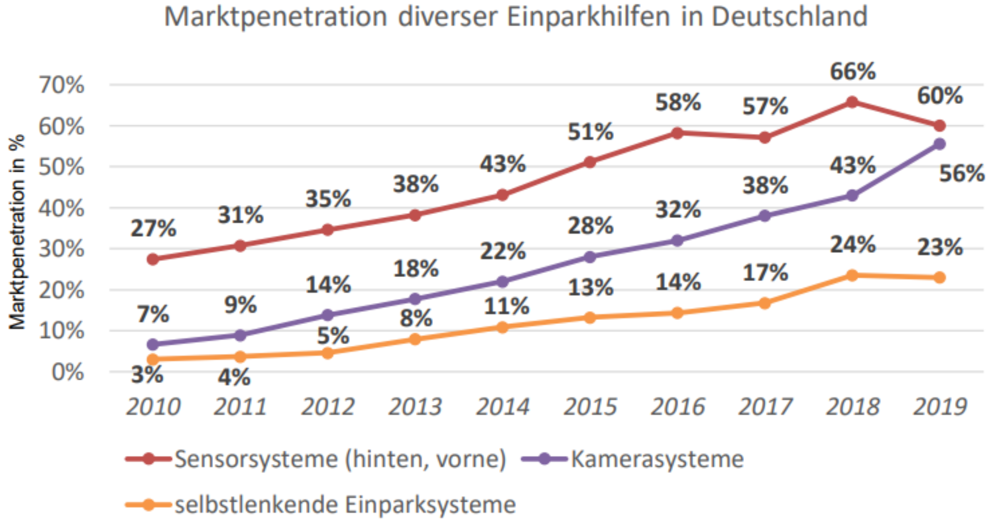
Motivation - Problems

[Parking fail! UK driver REPEATEDLY smashes into vehicles while trying to park outside a KFC | SWNS - YouTube]()

Market distribution of parking assistance systems



https://www.bosch-presse.de



Frank Baumeister, Bachelorthesis

Motivation

www.istockphoto.com

Less demages

www.bosch-mobility-solutions.com

More comfort

www.adac.de

Greater safety

3.4 billion euros per year

2/3 of damage could be avoided with parking assistants

Less time spent looking for a parking slot

Less stress for parking

Significantly better all-round visibility

Less accidents while parking

The further development of the HMI concept


www.kufatec.com

Rudimentary and low budget

www.ff-tuning.de

Medium class vehicles

www.mercedes-benz.de

High class vehicles

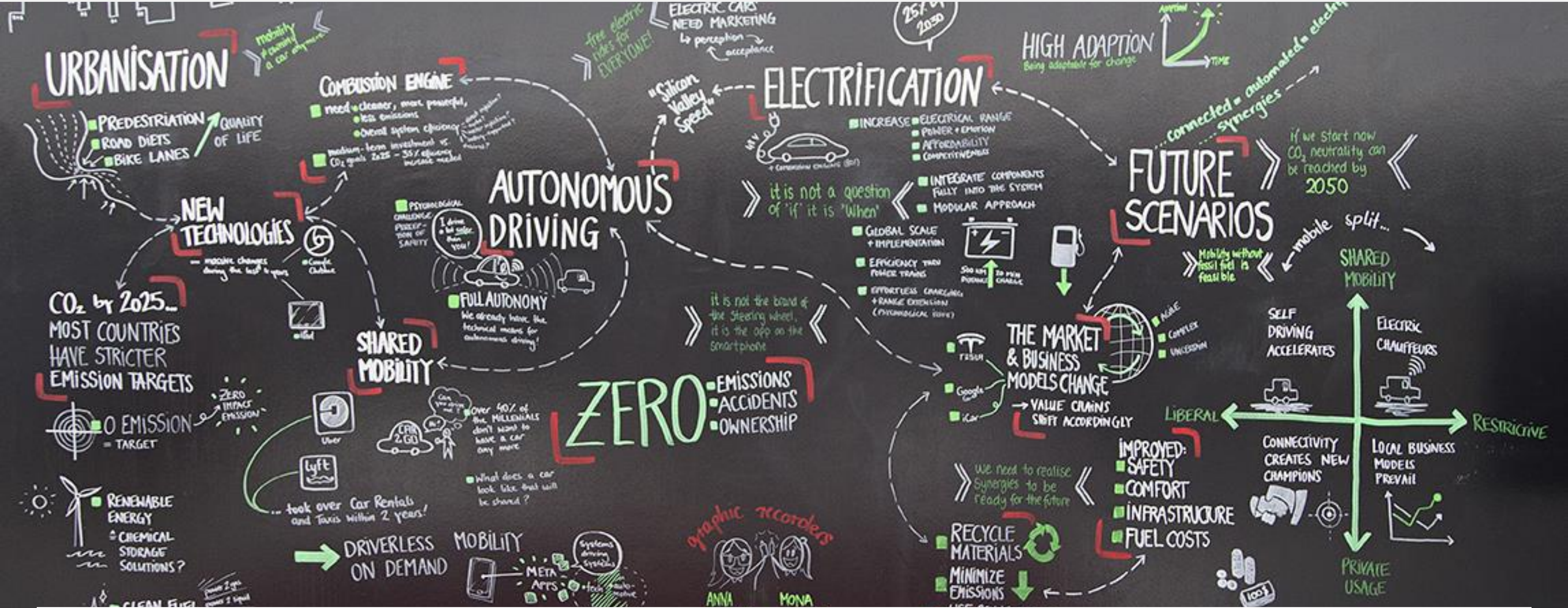
HMI concepts

How to Use BMW Parking Assist | BMW Genius How-To | BMW USA - YouTube

HMI concepts

PEUGEOT 508 FASTBACK | FULL PARK ASSIST - YouTube

Workshop 1 customer needs & KPIs



Workshop 1: customer needs & KPIs

Workshop 1 customer needs & KPIs- Tasks

- Customer profiles and reasons
- Define use cases for the function
- Define customer needs
- Define the objective KPIs

Workshop 1 customer needs

Tasks

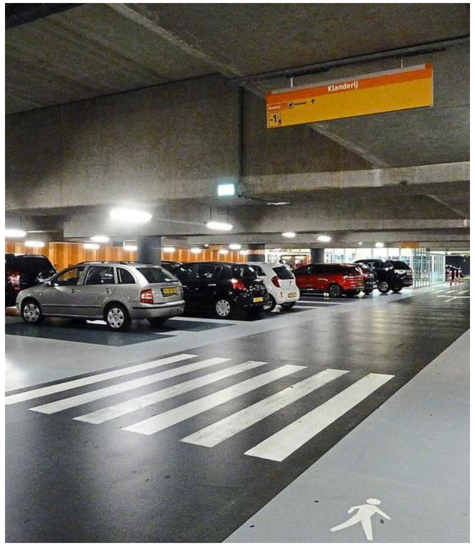
1. Define use cases / parking situations

2. Create 5 different personas

3. Define the individual needs of the personas for a parking assistant and mark the most prioritized one

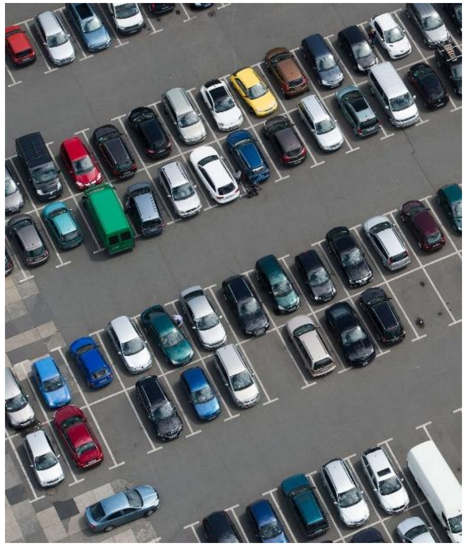
4. Define the adequate objective KPIs for the evaluation of a parking maneuver

Workshop 1 Use cases



www.wn.de

- Parking garage



www.merkur.de

- Parking area

www.muenchen.de

- City

www.tagesspiegel.de

- Critical parking slot

www.mercedes-fans.de

- Home

Workshop 1 Personas

Verena, 28
- Architect
- Urban
- In a relationship
- Does not own a vehicle, but uses car sharing

Michael, 18
- Student
- Urban
- Single
- Beginner driver and uses the family car

Erwin, 50
- Salesman
- Country
- Married
- Commuter and user of rental and company vehicles

Hilde, 75
- Pensioner
- Countryside
- Married
- Many years of experience, but age-related limitations

Jonas, 25
- Engineer
- Urban
- Single
- Tech-savvy and uses his vehicle daily

Workshop 1 Benefits & Needs

Verena, 28

- \+ Comfort
- \- Damage
- \+ Safety

Michael, 18

- \+ Safety
- \- Damage
- \+ Excitement
- \+ Status

Erwin, 50

- \+ Less stress
- \+ Comfort
- \+ Time
- \- Damage

Hilde, 75

- \+ Safety
- \+ Less stress
- \+ Comfort

Jonas, 25

- \+ Excitement
- \+ Individuality
- \+ Performance
- \+ Status

Personas usually share many needs, but each persona sets a high value on individual needs.

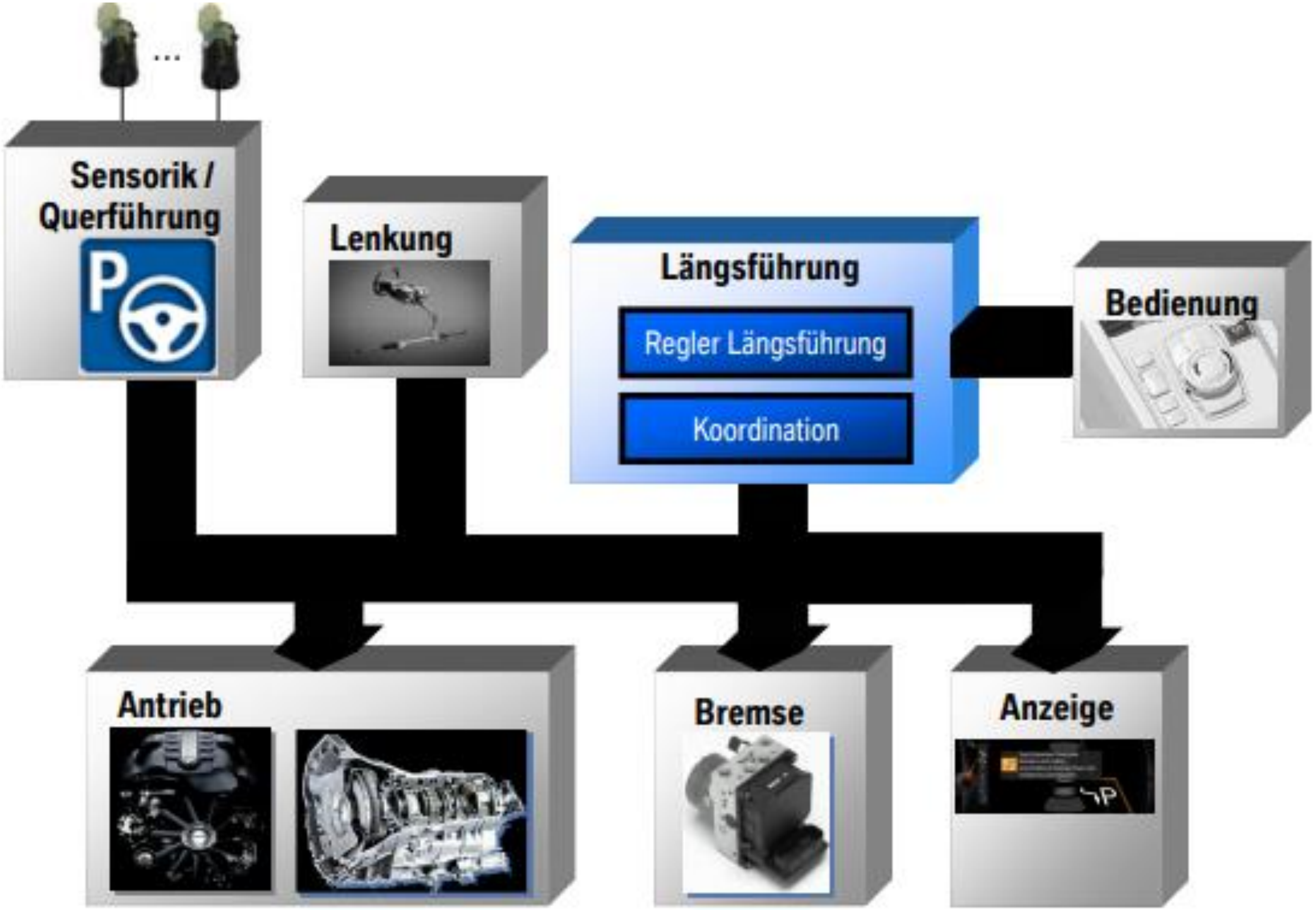
Workshop 1 KPIs

Customer-Level

1. HMI
(Operation / Display / Monitoring / Warning)

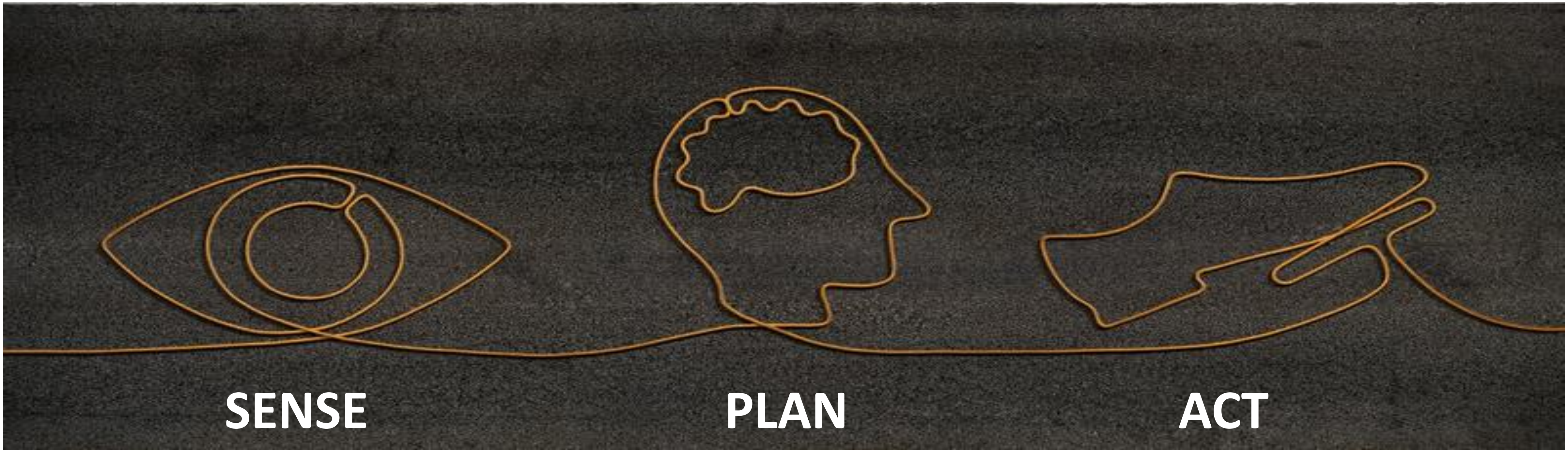
2. Functional performance	3. Vehicle reaction / comfort	4. Steering response	5. Availability	6.Safety feeling	7.Degree of relief

System architecture



Dirk Ahrens, Parkassistent mit Längs- und Querführung, BMW

ADAS paradigm



Ultrasonic

Trajectory

Steering
Powertrain
Break

Comparison ADAS/HAD sensor technologies

	Kamera	Laserscanner	Radar	Ultraschall
Blickfeld	↑	↑	↗	→
Messbereich, Reichweite	↗	↑	↑	↘
Geschwindigkeitsauflösung	→	↗	↑	↘
Radiale Auflösung	↑	↗	→	↘
Betrieb unter schlechten Witterungsbedingungen	→	↗	↗	→
Betrieb bei Nacht, Störung durch Umgebungslicht	↗	↑	↑	↑
Objektklassifizierung, Semantische Information	↑	↗	→	↘

J. Schrepfer et. al.; Automatisiertes Fahren und seine Sensorik im Test; ATZ 01/2018

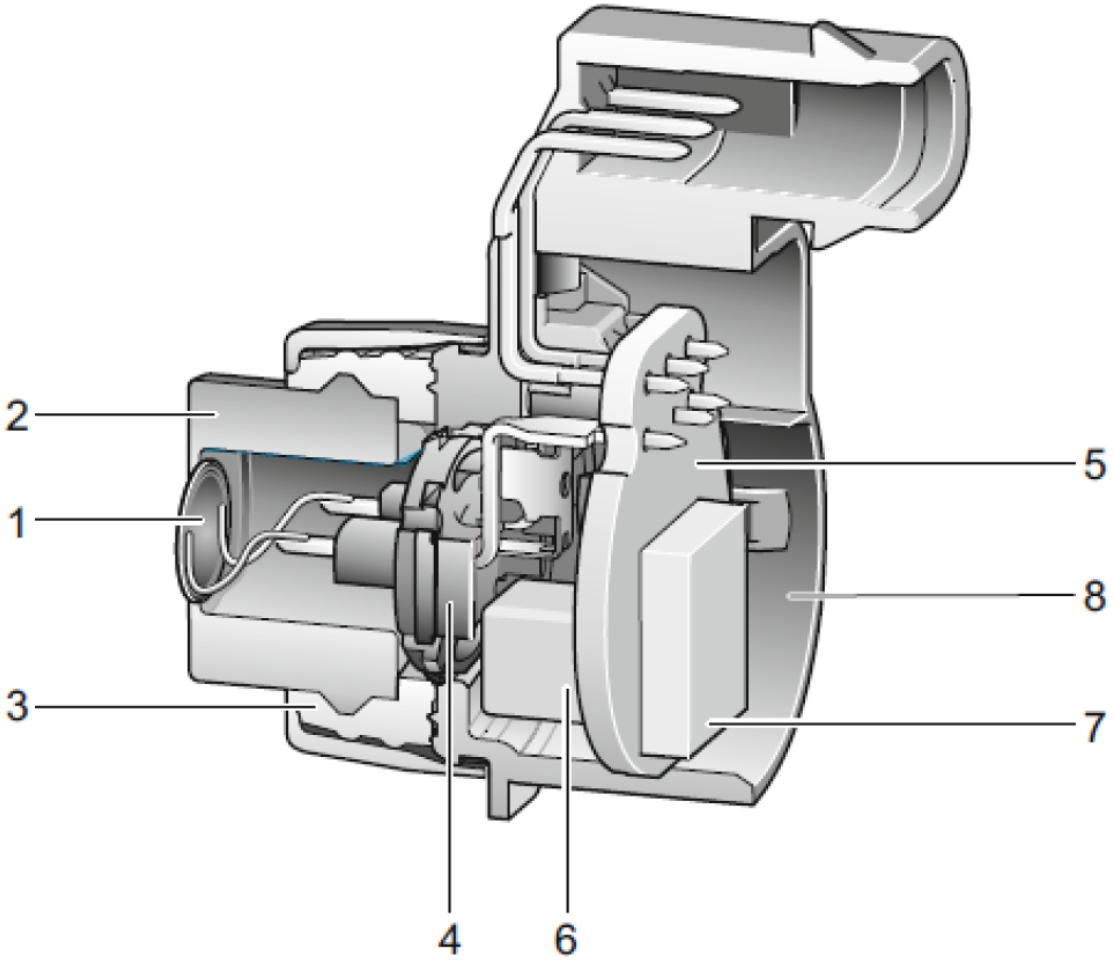
Comparison ADAS/HAD sensor technologies

Bewertungsmatrix FAS-Sensoren						
	++ : optimal ; + : gut ; o : mögliche Beeinträchtigung ; - : zusätzliche Einrichtung(en) notwendig ; -- : nicht geeignet					
	Short Range Radar (SRR)	Long Range Radar (LRR)	Lidar	Ultrasound	Mono Camera	Stereo Camera
Entfernungsmessung < 2m	o	-	o	++	-	++
Entfernungsmessung 2 – 30 m	+	++	++	-	-	o
Entfernungsmessung 30 – 200 m	-	++	+	--	-	-
Winkelmessung < 10°	+	+	++	-	++	+
Winkelmessung > 30°	o	-	++	o	++	+
Winkelauflösung	o	o	++	-	++	+
Geschwindigkeitsmessung	++	++	--	o	--	--
Robustheit Umwelt:						
Regen	++	+	o	o	o	o
Nebel, Schnee	++	++	-	+	-	-
Staub	++	++	o	++	--	--
Nacht	++	++	++	++	-	o

Prof. Dr. Thomas Zeh; Vorlesung Sensorik Hs-Kempten; WS2016;

Sense

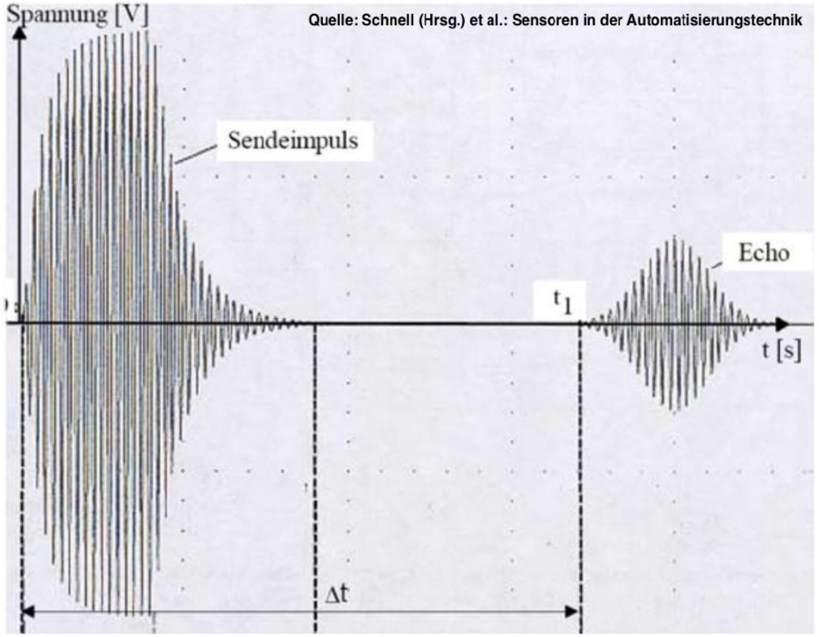
Ultrasonic functionality



K. Reif; Automobilelektronik; ATZ/MTZ Fachbuch; Springer; 2014

1 Piezokeramik
2 Membrantopf
3 Entkopplungsring
4 Kontaktträger
5 Leiterplatte
6 Übertrager
7 ASIC*-Baustein
8 Gehäuse

Ultrasonic principle



[Faustformel: Faktor 2 im Abstand bewirkt ¼ der reflektierten Amplitude]

$$\boxed{\Delta t = \frac{s}{v}} \quad (1)$$

$$\boxed{c = c_0 \cdot \sqrt{1 + \frac{\vartheta}{273{,}15°C}}} \quad (2)$$

$$\boxed{d = \frac{c \cdot \Delta t}{2}} \quad (3)$$

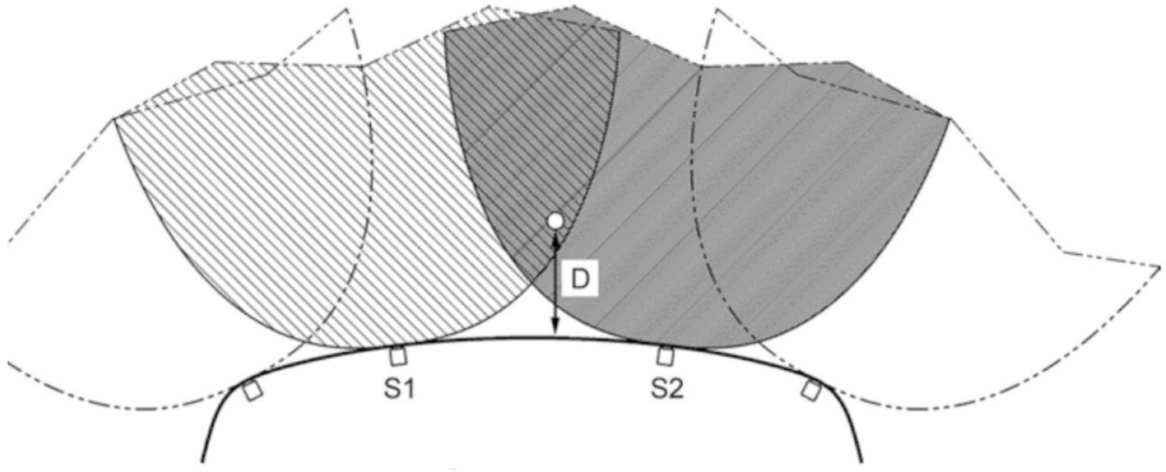
$c_0: Schallgeschwindigkeit\ 0°C\ [m/s]$ →

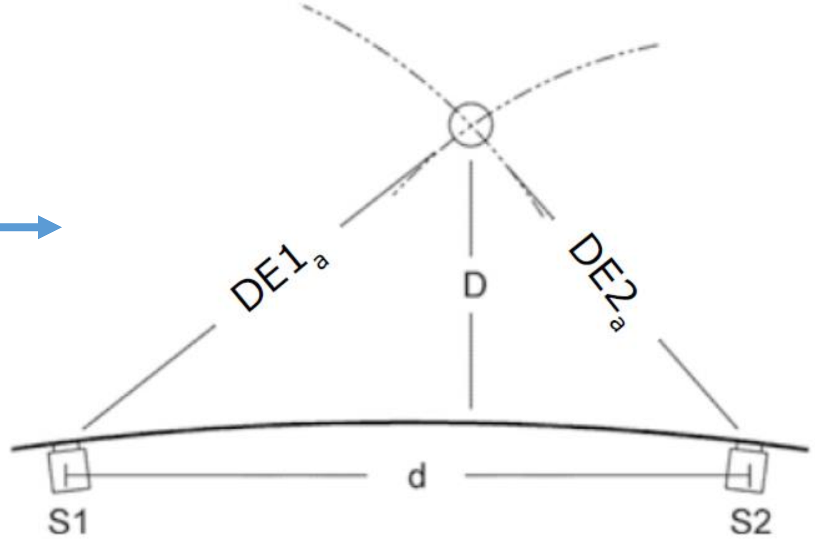
$\vartheta: Lufttemperatur\ [°C]$

ϑ [°C]	c [m/s]
-10	325,4
0	331,5
20	343,4

K. Reif; Automobilelektronik; ATZ/MTZ Fachbuch; Springer; 2014

Trilateration direct echo





$$\boxed{D = \sqrt{DE1_a^2 - \frac{(d^2 + DE1_a^2 - DE2_a^2)^2}{4 \cdot d^2}}} \quad (4) \quad [DE1_a, DE2_a\text{: } euklidischer\ Abstand]$$

Plan

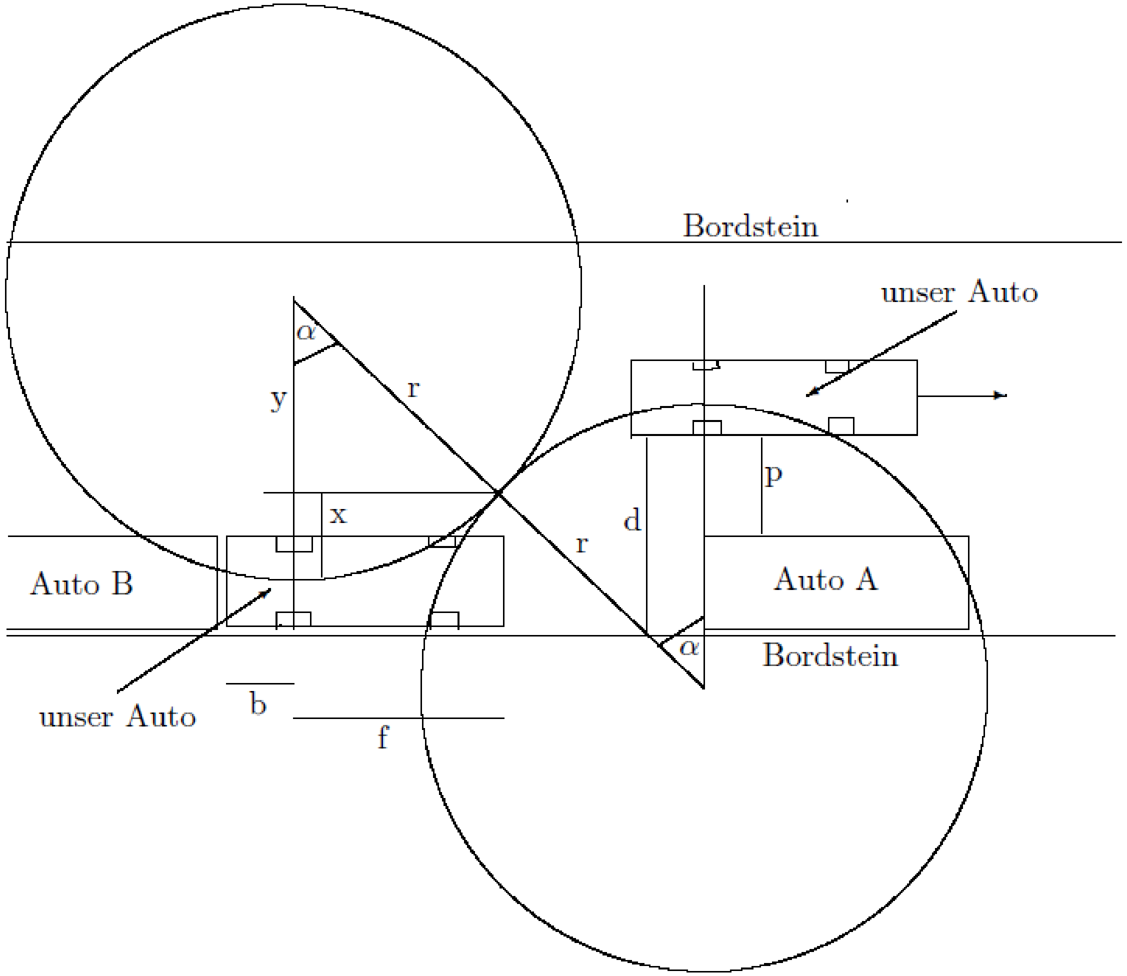
Driving school approach parking process

1. Position your car directly next to the front car A at a distance p from this car
2. Drive straight backwards until the center of our car, related to the four tires, is at the same height as the end of the car A in front.
3. Now turn the steering wheel completely to the stop so that you enter the gap. Thereby a circular arc is driven, to which the angle α belongs.
4. Then turn the front wheel completely in the opposite direction to get parallel to the road again and drive the opposite arc with the same angle α.
5. Finally, you drive a little bit forward so that the rear car B does not get jammed.

<u>Questions:</u>

What is the minimum width of the gap so that we can get in?
At what distance p do you start the game?
Which arc should you drive, so what is the angle α?

Mathematical approach parking process



N. Herrmann, Ein mathematisches Modell zum Parallelparken; Univ. Hannover; 2003

$$\boxed{d = 2x = 2(r-y) = 2\cdot(r - r\cdot cos\alpha) = 2r\cdot(1-cos\alpha)} \quad (5)$$

$$\boxed{p = d - w = 2r\cdot(1-cos\alpha) - w} \quad (6)$$

$$\boxed{g \geq 2r\cdot sin\alpha + b} \quad (7)$$

$$\boxed{\alpha = arccos\frac{2r-w}{2r}} \quad (8)$$

Mit α:

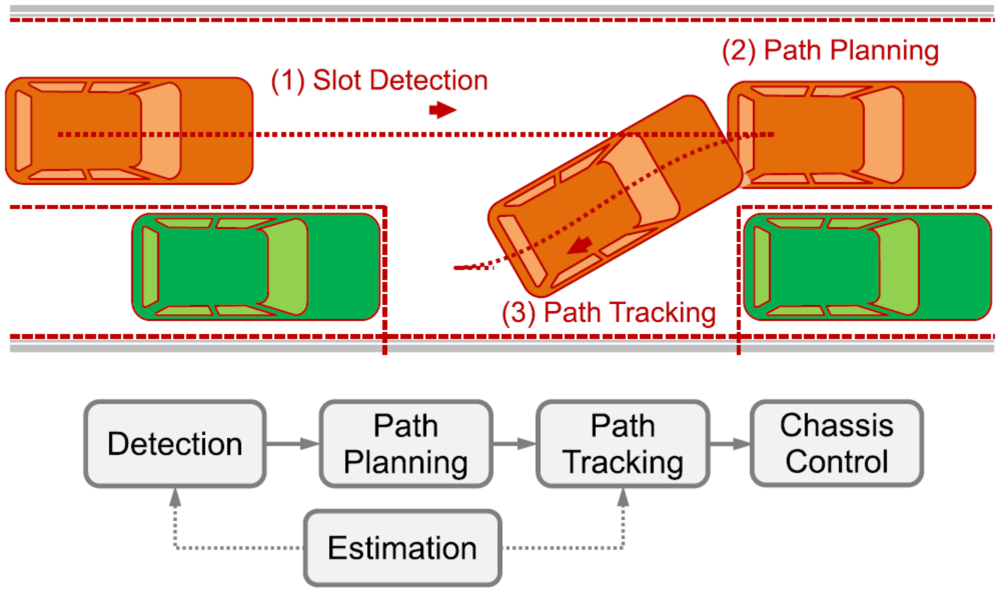
$$\boxed{g \geq \sqrt{2rw + f^2} + b} \quad (9)$$

g: *Länge Parklücke*
w: *Breite Auto*

Plan

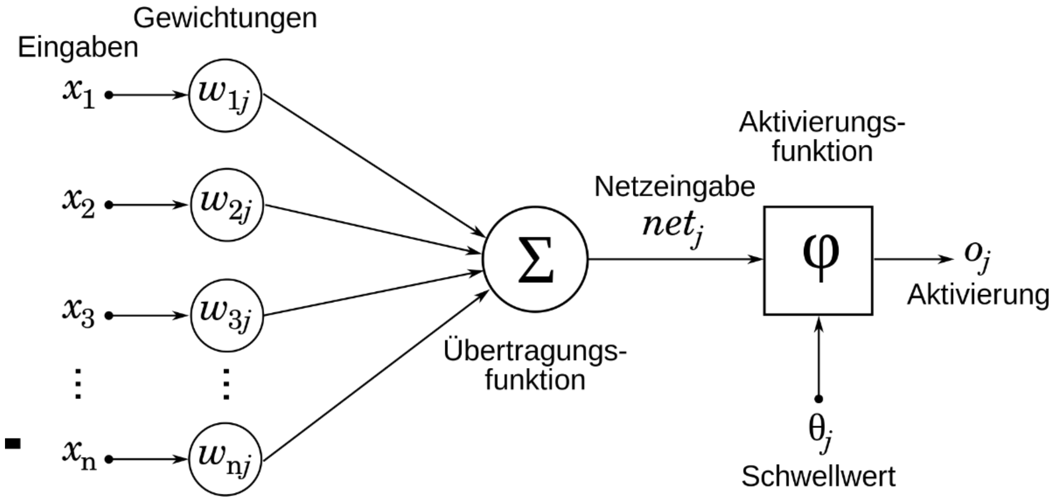
Trajectory/Motion planning

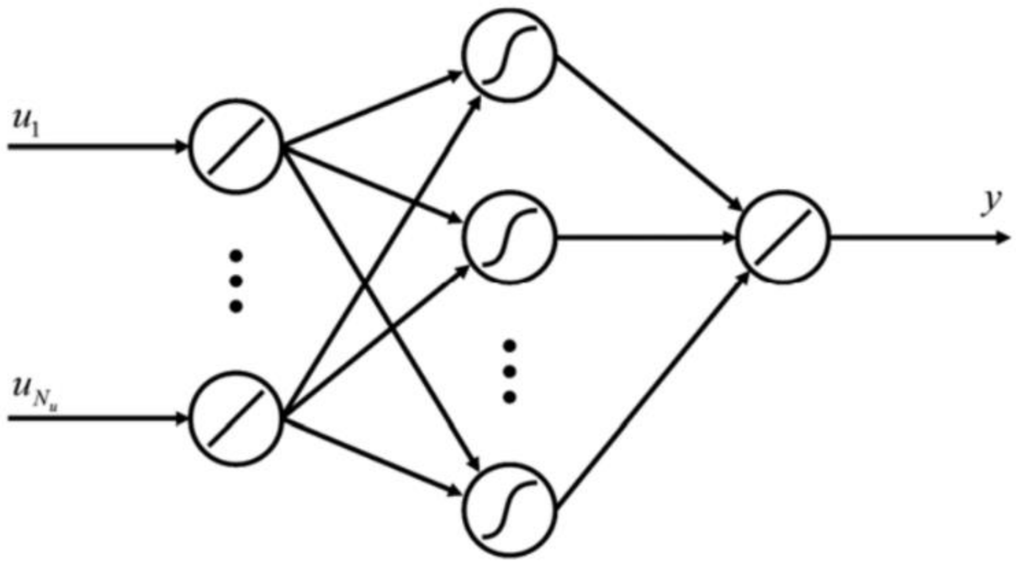
Multi-objective optimization should be considered:
- safety
- comfort
- efficiency
- final parking position



Traditional: based on geometric curve
Latest: learning-based

Neural Networks





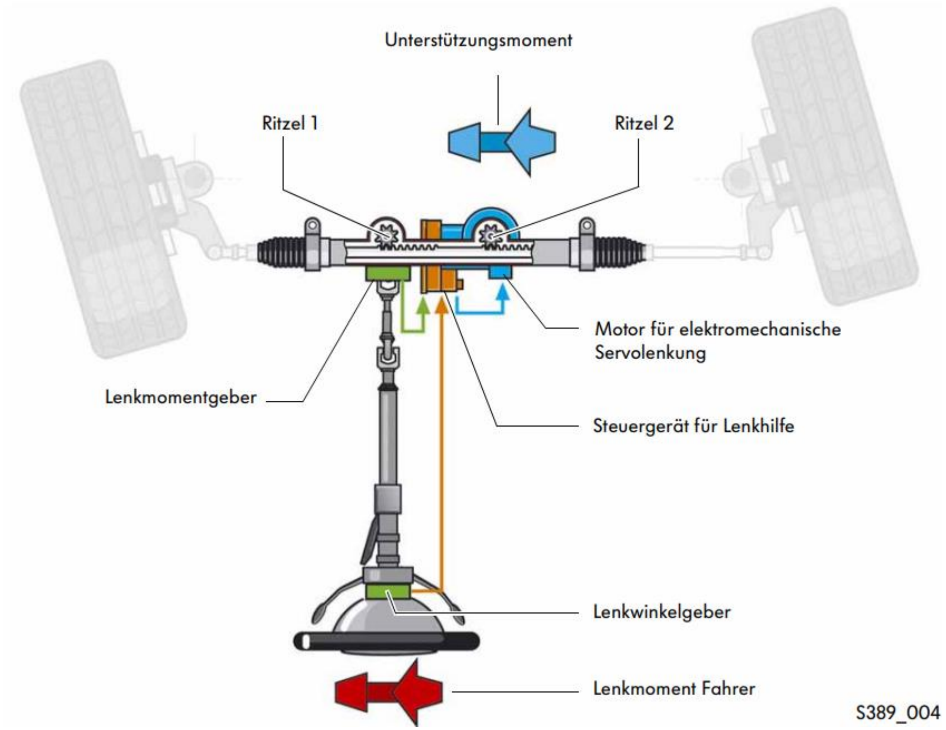
$$y = f_{MLP}(u, w) := b_2 + W_2\, \sigma(b_1 + W_1\, u)$$

<u>NN learning</u>:

- Change of weights
- Change of treshhold
- More/less neurons
- Modification in activation/propagation/output function

Actuators

Steering

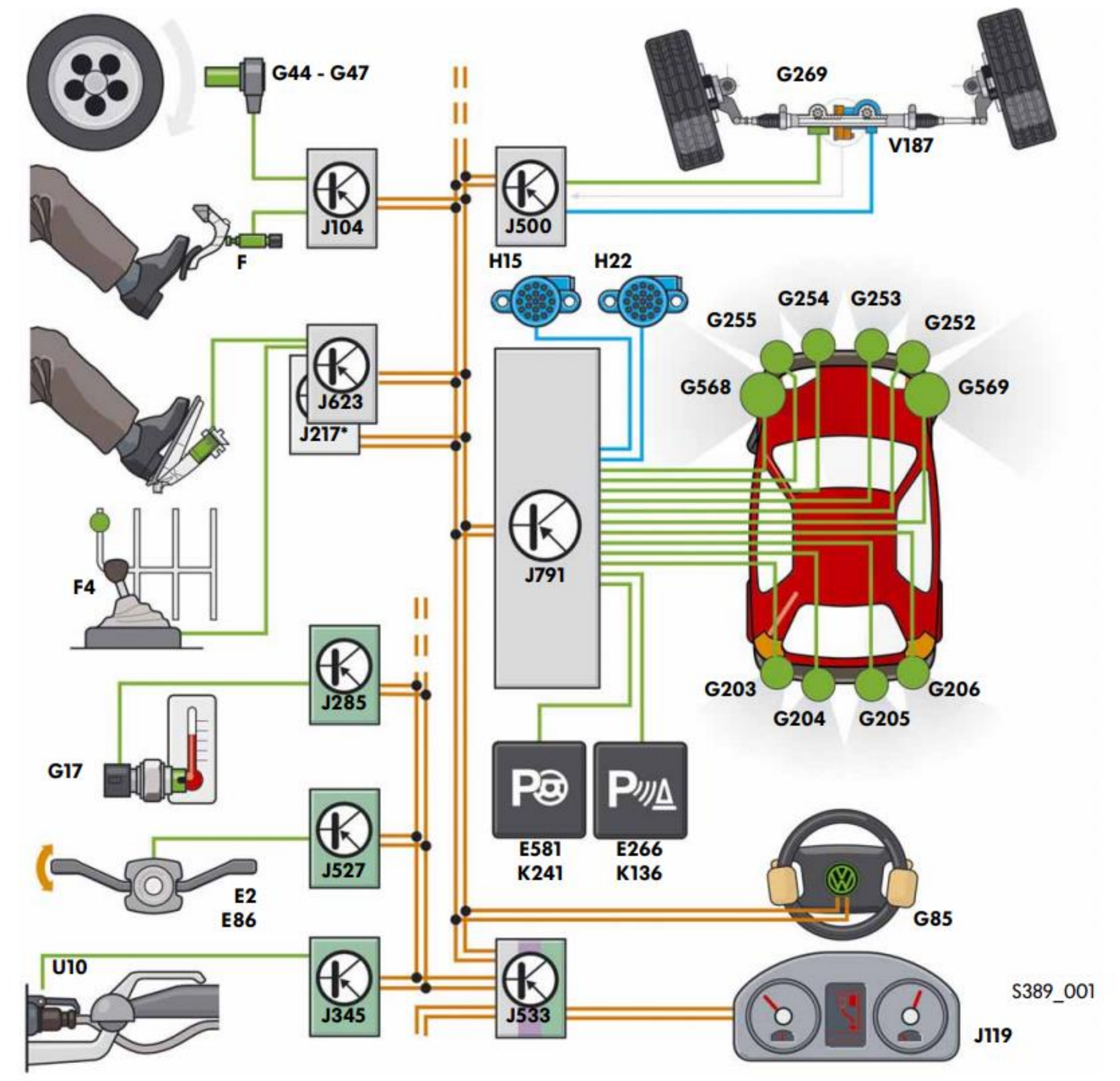


Powertrain

Braking

Act

Architecture example



Folgende Bauteile der genannten Fahrzeugsysteme arbeiten für die Funktion der Parklenkhilfe zusammen:

Parklenkassistent
E266 Taster für Einparkhilfe
E581 Taster für Parklenkassistent
G203 Geber für Einparkhilfe hinten links
G204 Geber für Einparkhilfe hinten Mitte links
G205 Geber für Einparkhilfe hinten Mitte rechts
G206 Geber für Einparkhilfe hinten rechts
G252 Geber für Einparkhilfe vorn rechts
G253 Geber für Einparkhilfe vorn Mitte rechts
G254 Geber für Einparkhilfe vorn Mitte links
G255 Geber für Einparkhilfe vorn links
G568 Geber vorn links für Parklenkassistent, linke Fahrzeugseite
G569 Geber vorn rechts für Parklenkassistent, rechte Fahrzeugseite
H15 Warnsummer für Einparkhilfe hinten
H22 Warnsummer für Einparkhilfe vorn
J791 Steuergerät für Parklenkassistent
K136 Kontrollleuchte für Einparkhilfe
K241 Kontrollleuchte für Parklenkassistent

Elektromechanische Servolenkung
G269 Lenkmomentgeber
J500 Steuergerät für Lenkhilfe
V187 Motor für elektromechanische Servolenkung

Bremssystem
G44 Drehzahlfühler hinten rechts
G45 Drehzahlfühler vorn rechts
G46 Drehzahlfühler hinten links
G47 Drehzahlfühler vorn links
G85 Lenkwinkelgeber
J104 Steuergerät für ABS

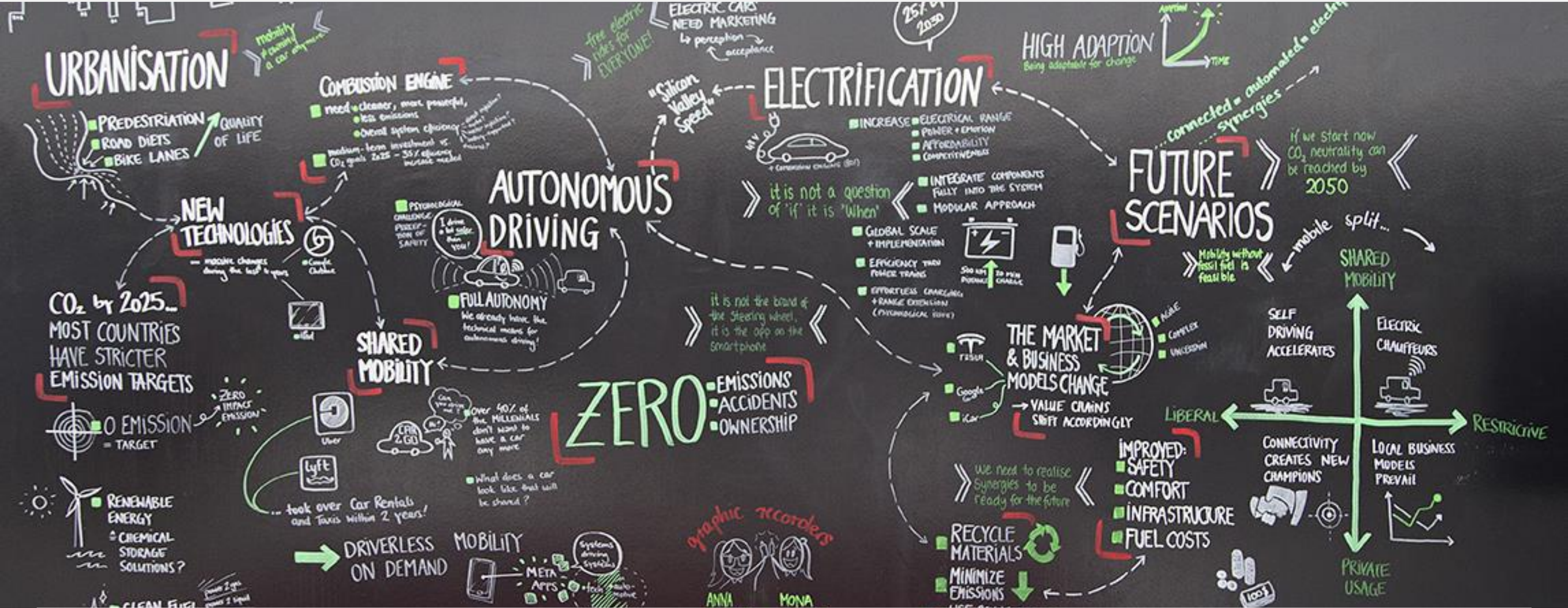
Motor- und Getriebemanagement
F Bremslichtschalter
F4 Schalter für Rückfahrleuchten
J217* Steuergerät für automatisches Getriebe
J623 Motorsteuergerät

Schalttafel und Lenksäulenelektronik
E2 Blinklichtschalter
E86 Abruftaste für Multifunktionsanzeige
G17 Temperaturfühler für Außentemperatur
J119 Multifunktionsanzeige
J285 Steuergerät im Schalttafeleinsatz
J527 Steuergerät für Lenksäulenelektronik
J533 Diagnose-Interface für Datenbus

Anhängererkennung**
J345 Steuergerät für Anhängererkennung
U10 Steckdose für Anhängerbetrieb

* nur Automatikfahrzeuge
** nur bei Fahrzeugen mit Anhängerkupplung und Anhängererkennung

Workshop 2 time model & maneuver



Workshop 2: time model & maneuver

Workshop 2 time model & maneuver

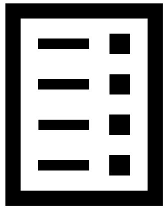
- Create a time model for the PMA function
- create a maneuver catalog for the PMA function

Tasks

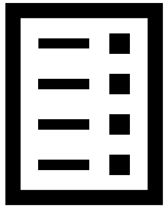
1. Create a time model for the PMA function

Phase 1	Phase 2	Phase xx
•Start..	•Do..	•..

2. Create a maneuver catalog for the PMA testing including requirements for parallel and perpendicular parking



3. create a maneuver catalog for maneuvers for special cases



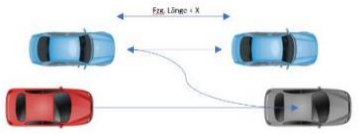
Workshop 2 time model & maneuver

Example

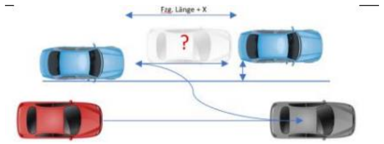
Phase 1	Phase 2	Phase 3	Phase 4	Phase 5
1.Passive activation PMA	1. Active activation completed 2. Response HMI appeared 3. Driving instructions completed 4. Free parking space recognized 5. Free parking space confirmed 6. Additional driving tasks completed	1. Driving task handed over to system 2. Initial parking move (IPM) 3. Parking move n (PMn) 4. riving task handed over to driver	1. Engine turned off 2. Ignition turned off 3. VUT locked	1. VUT unlocked 2. Ignition turned on 3. Engine turned on 4. Active activation PMA completed 5. Response HMI appeared 6. Driving task handed over to system 7. Initial parking move (IPM) 8. Parking move n (PMn) 9. Driving task handed over to driver

Maneuver Catalog parallel & perpendicular

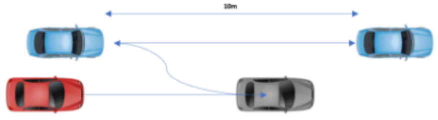
1 standard parking slot



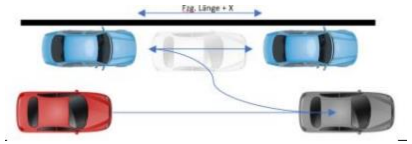
2 Offset objects



3 Oversized parking slot



4 Parking curb



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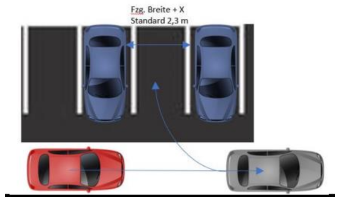
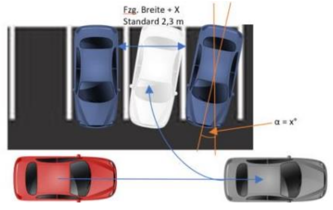
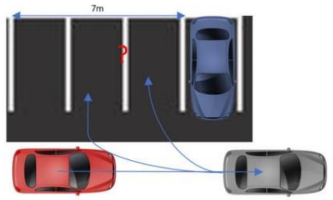
1 standard parking slot



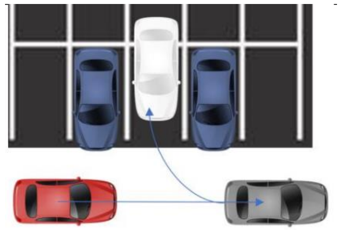
2 Offset objects



3 Oversized parking slot



4 Depth of insertion



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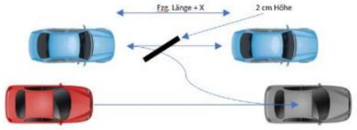
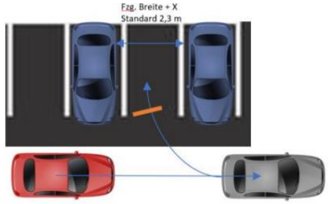
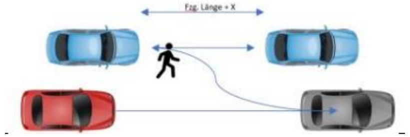
Special cases

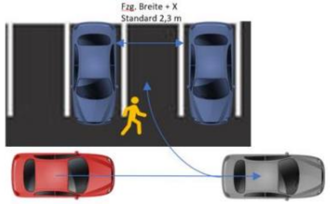
1 Crossable obstacle



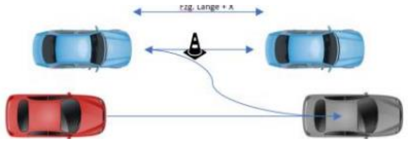


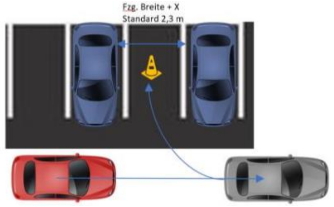
2 Suddenly appearing obstacle





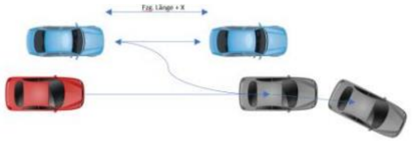
3 Unobtrusive obstacle



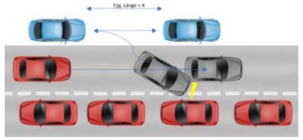


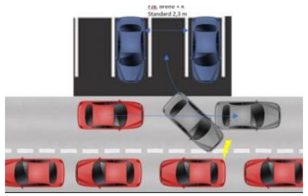
4 Driver interaction

5 Misalignment after recognizing the Parking slot

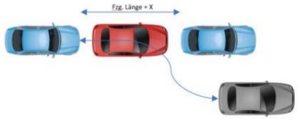


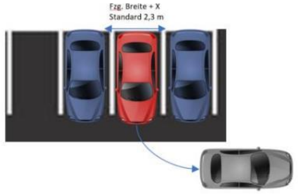
6 Keeping in your own lane



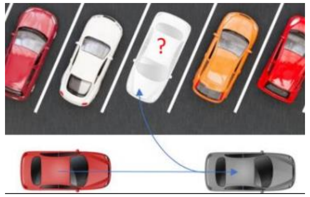


7 Parking out





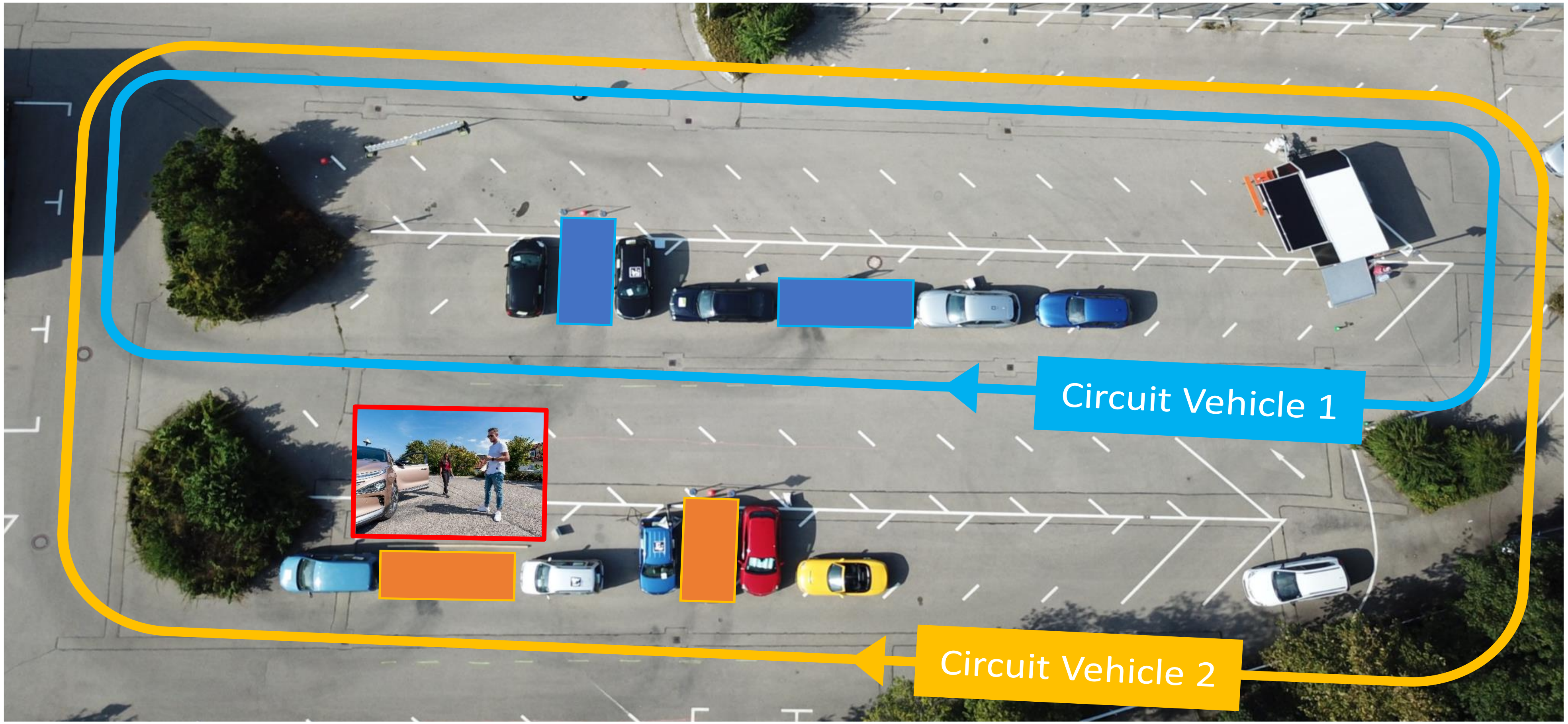
8 45° parking slot



...

Parking: human vs. machine

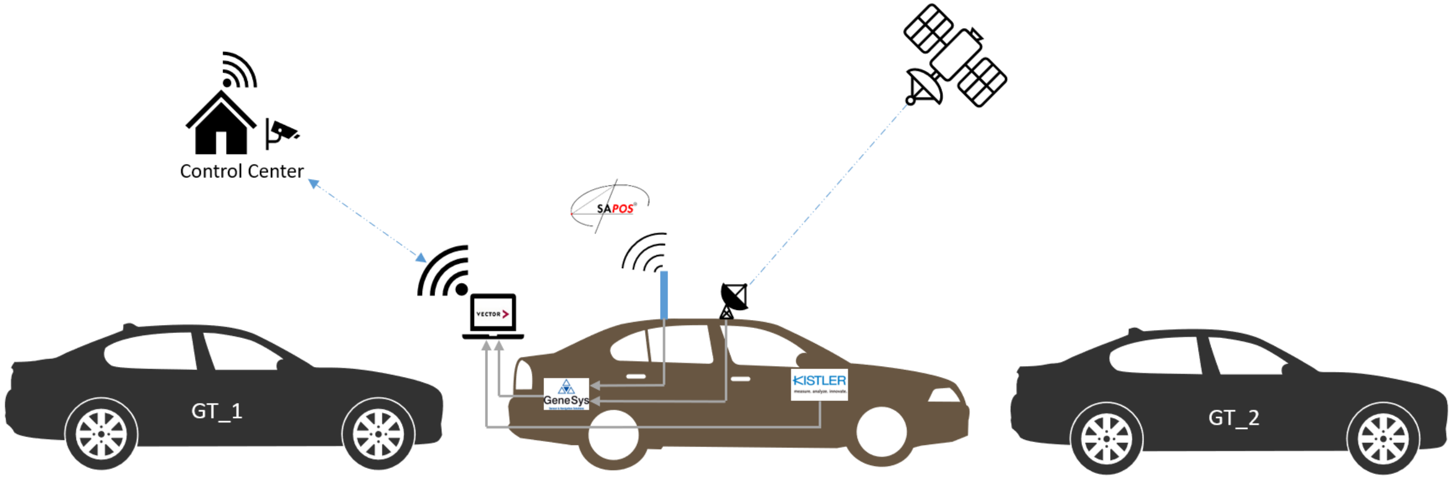
Study design

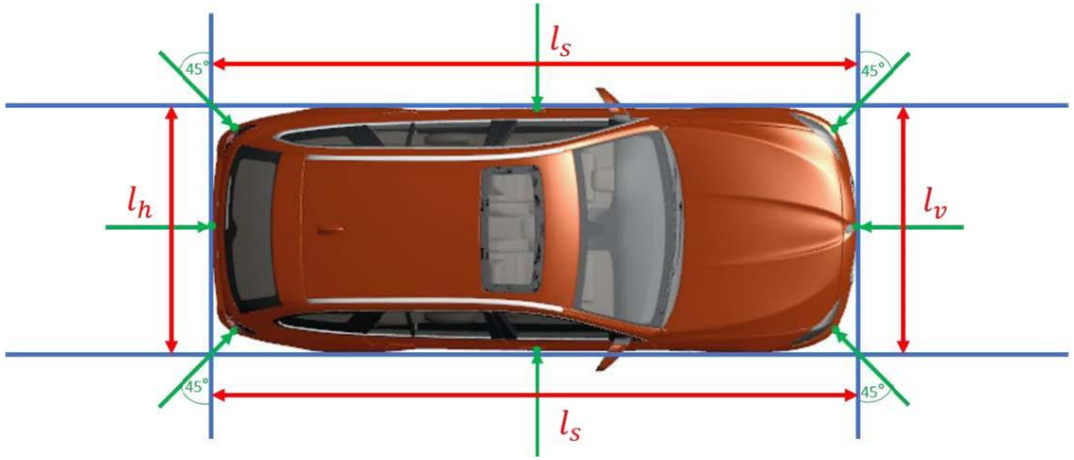


Male	Female	Average age	Range of age	Non-experts	Semi-experts
17	4	31	23 – 51	10	11

Parking: human vs. machine

Measurement setup





Parking: human vs. machine

Ground truth

Parking: human vs. machine

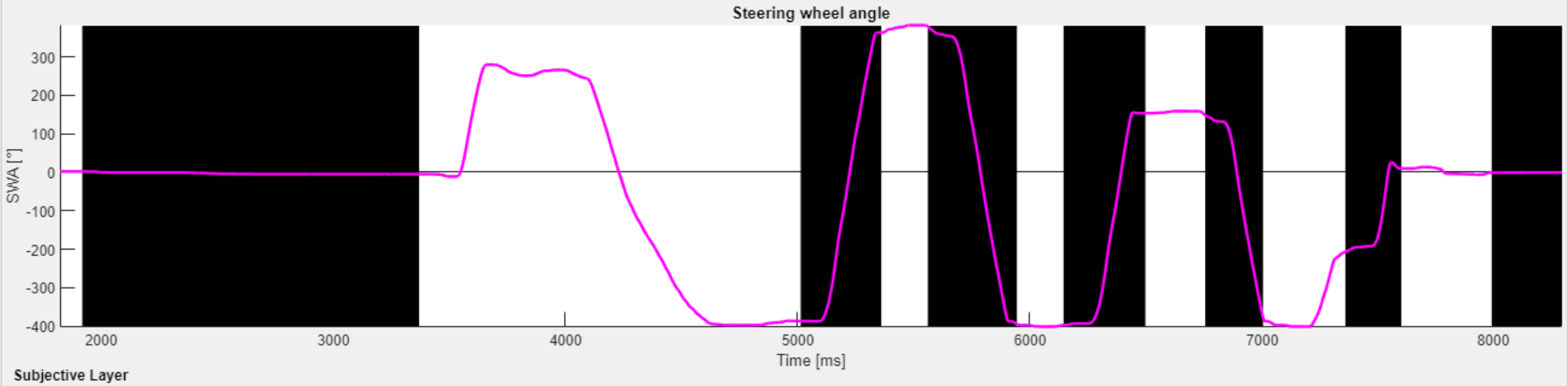
Evaluation process

MATLAB App

EvalData | General Information | Single_File_Eval | Multi_File_Eval

Settings | 1. HMI | 2. Funktionsperformance | 3. Fahrzeugreaktion / Komfort | 4. Lenkverhalten | 5. Verfügbarkeit | 6. Sicherheitsgefühl | 7. Entlastungsgrad

4.1 Lenkradwinkel | 4.2 Lenkradgeschwindigkeit | 4.3 Lenkradbewegungskonstanz | 4.4 Lenkradbeschleunigung | 4.5 Standlenken | 4.6 Finaler Lenkradwinkel



Subjective Layer

SubQ	Ans	Norm	Emotion	Classification	Category
HMI	7	6,7	Pos	+ Ueberwachungsmoeglichkeit;	ueberwachungs
Lenkradbewegung	6	6,9	Neg	+ Lenkradbewegung im Stand; lenkt sehr zuegig	Standlenken
Einparkkomfort	6	6,4	Info	+ Anfahrruck; + Geschwindigkeitsverhalten (Konstanz);	Ruck
Dynamische Performance	-7	6,7	Info	+ Ruck;	Geschwindigkei

Objective Layer

	Duration Stillst [s]	Duration Motion [s]	SWA_kum_SS each move [°]
M1	14.46	16.50	8.53
M2	3.42	2.06	752.90
M3	3.78	2.07	772.94
M4	3.47	2.63	555.03
M5	2.44	3.60	519.41
M6	2.36	3.94	249.21

KPI Layer

Vehicle.Steering.Ang.Standing.Cum [°]	2858
Vehicle.Steering.Ang.Moving.Cum [°]	1324
Vehicle.Steering.Ang.Total. RatioSSMove [°]	2.159

Definition | Bewertung | Berechnungsvorschriften | Info

$$\delta_{Sw.Cum.SS\_Total} = \sum_{i=S(S3.2)}^{S(E3.2.1)} |SWA(i) - SWA(i-1)| + \sum_{j=1}^{n-1} \sum_{k=S(S3.3)}^{S(E3.3.1)} |SWA(k) - SWA(k-1)|$$

$$\delta_{Sw.Mean.SS\_Move} = \frac{1}{n} \sum_{i=S(S3.2)}^{S(E3.2.1)} |SWA(i) - SWA(i-1)| + \sum_{j=1}^{n-1} \sum_{k=S(S3.3)}^{S(E3.3.1)} |SWA(k) - SWA(k-1)|$$

Legende

(Sw) Steering wheel
(Cum) Cumulated
(SS) Still standing
(i) Laufvariable Initialzug
(j) Laufvariable Zug
(n) Gesamtanzahl der Züge
(k) Laufvariable Züge 2..n
(S) Sample
(E3.3.3) Start Phase_ID 3.4 (Driving task handed over to driver)

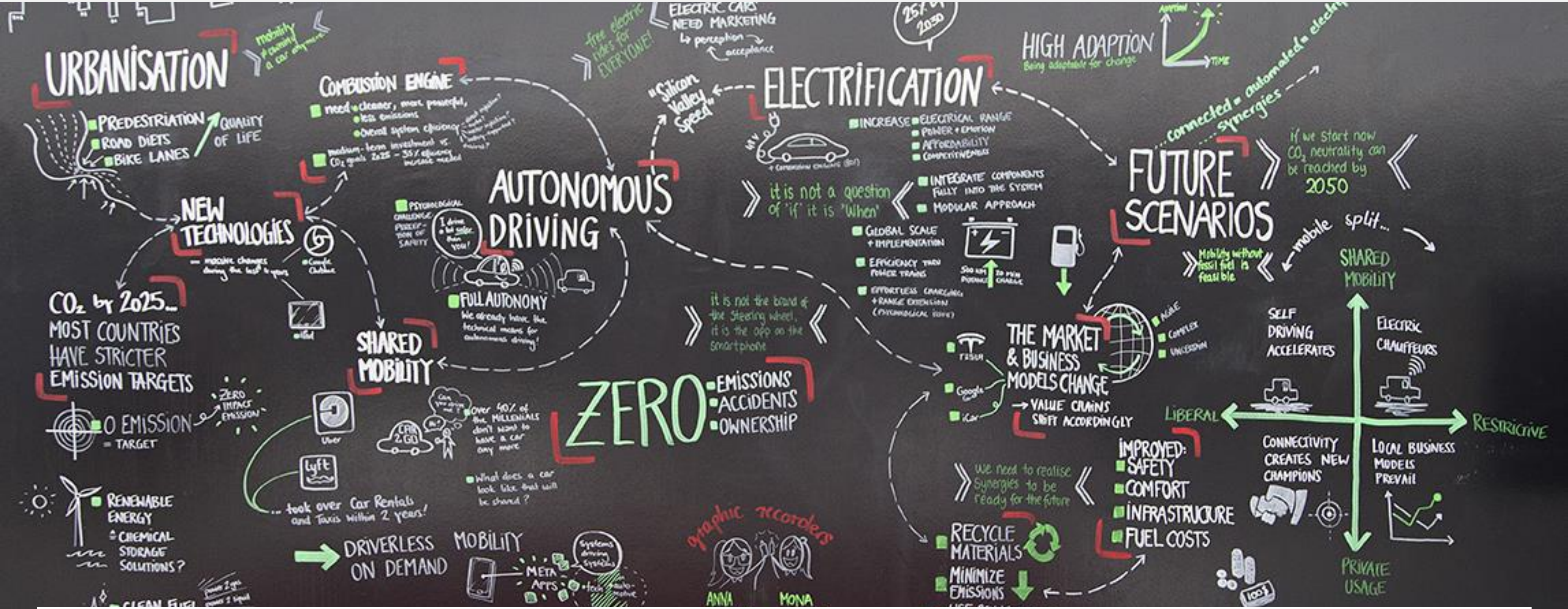
Fenster ausschneiden

Parking: human vs. machine

Evaluation demo

EVAL-DEMO

Workshop 3 : Human vs. PMA



Workshop 3 : Human vs. PMA

Workshop 3 : Human vs. PMA

- Peformance analysis human vs. PMA, in which situation do you see the advantages with the human and where with the PMA?
- KPI Evaluation of the human and the PMA
- Reasons for the different performance?

Tasks

1. Conduct a peformance analysis human vs. PMA, in which situation do you see the advantages with the human and where with the PMA?

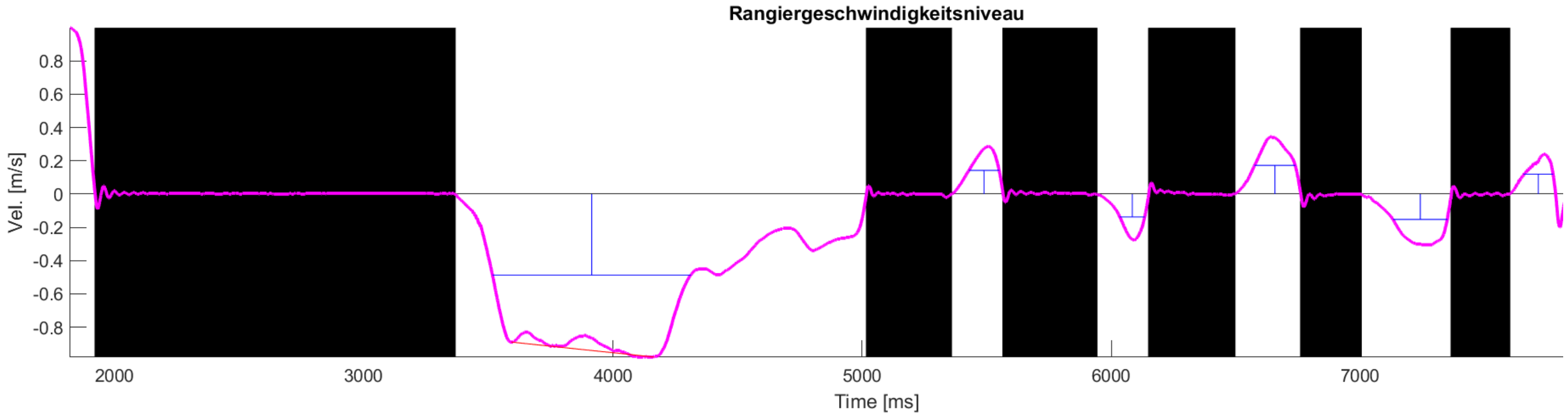
2. Conduct a KPI evaluation of the human and the PMA.
   - Shunting Speed
   - Number of moves
   - Steering while stand still
   - Duration

3. Justify their arguments for the performance of humans and PMAs.

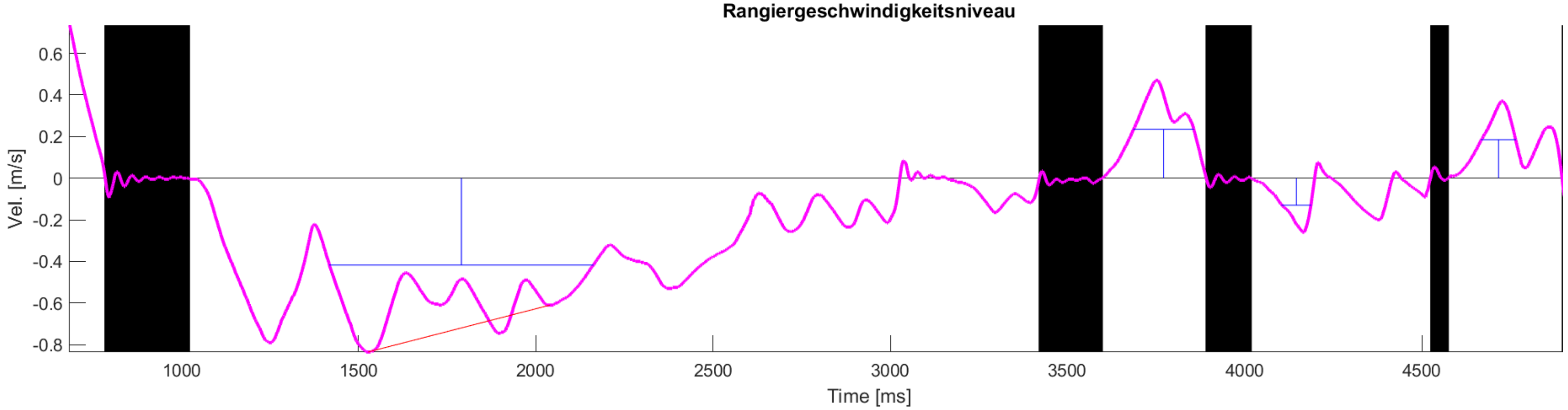
Parking: human vs. machine

Evaluation results: shunting speed (single eval)

Machine:

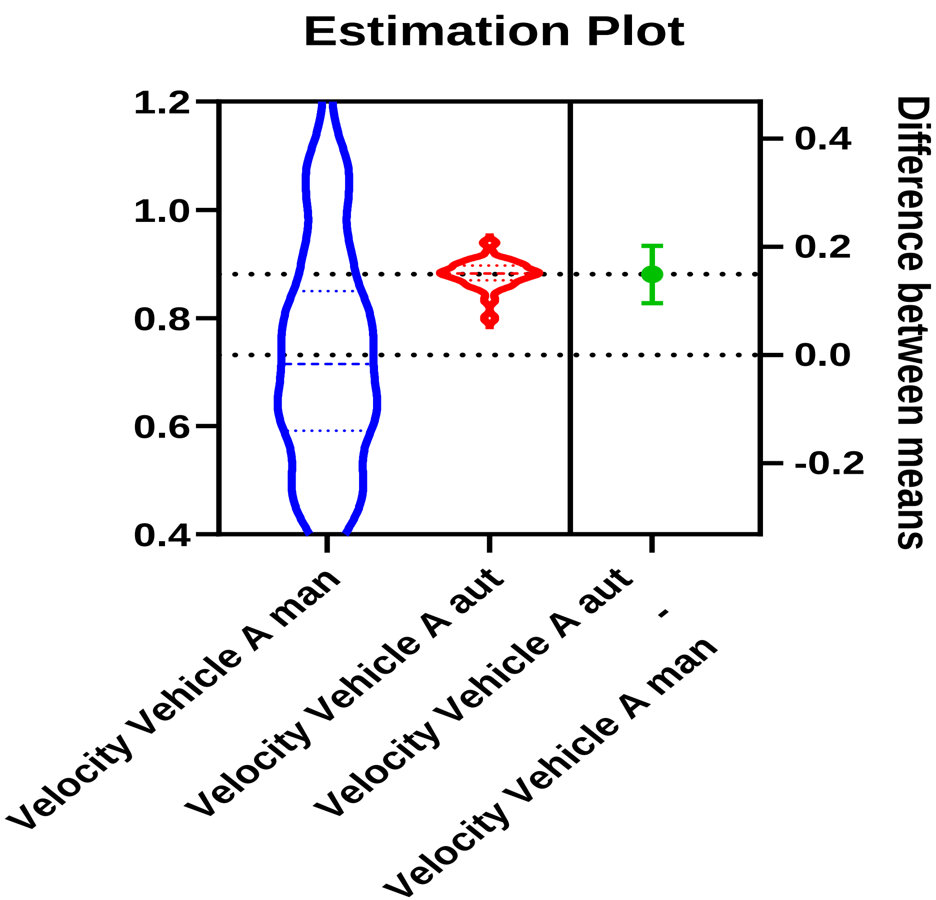


Human:



Parking: human vs. machine

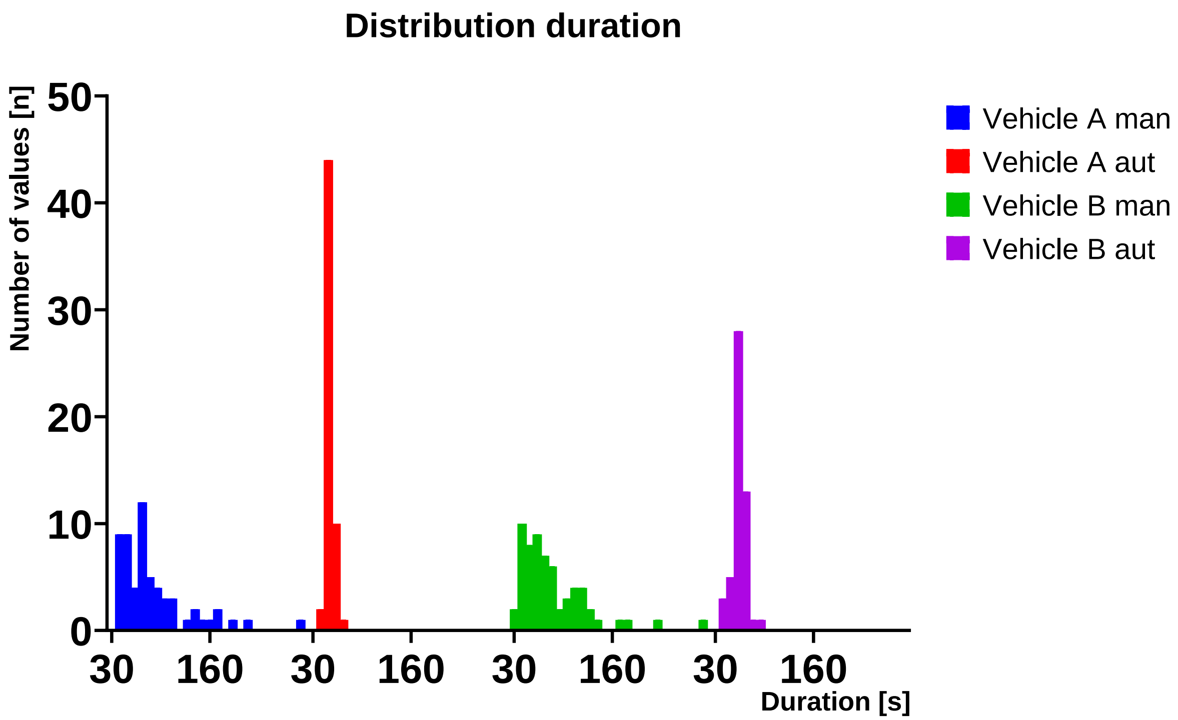
Evaluation results: shunting speed (deskriptiv)



	Velocity Vehicle A man	Velocity Vehicle A aut	Velocity Vehicle B man	Velocity Vehicle B aut
Number of values	59	57	62	51
Minimum	0,402	0,797	0,4126	0,6174
Maximum	1,194	0,9394	1,644	0,7734
Range	0,7918	0,1424	1,231	0,156
Mean	0,7316	0,8808	0,7769	0,7138
Std. Deviation	0,2005	0,02637	0,2434	0,02842
Std. Error of Mean	0,02611	0,003493	0,03091	0,003979

Parking: human vs. machine

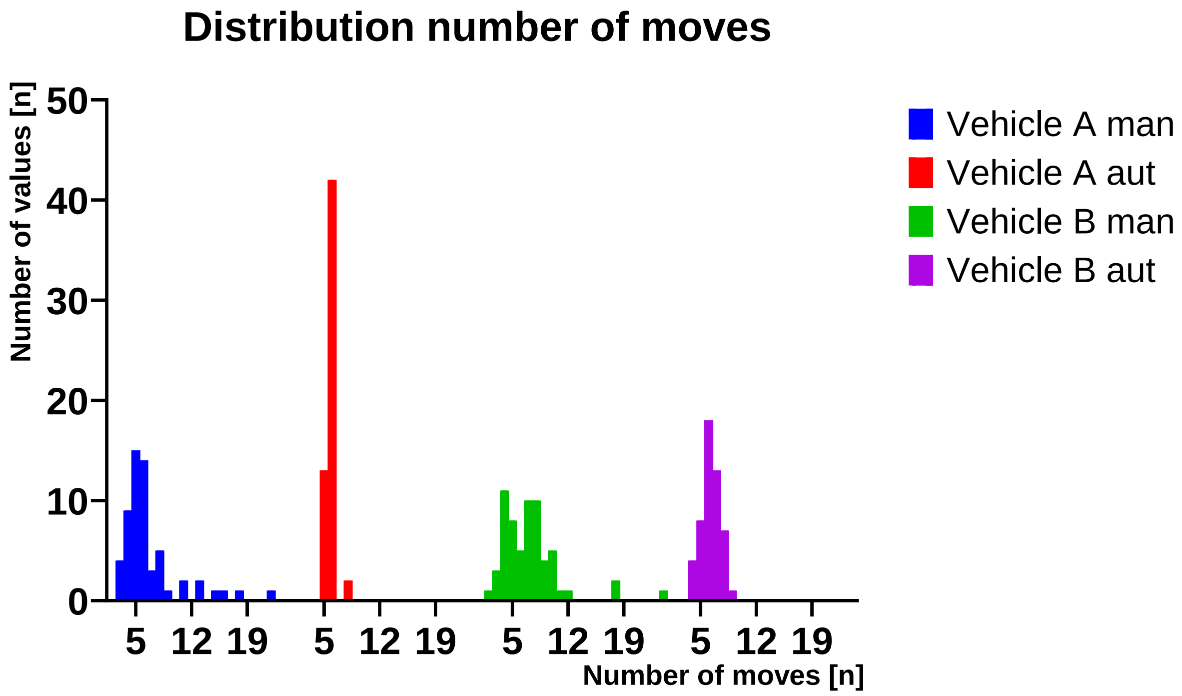
Evaluation results: duration(deskriptiv)



	Duration Vehicle A man	Duration Vehicle A aut	Duration Vehicle B man	Duration Vehicle B aut
Number of values	59	57	62	51
Minimum	36,15	43,91	31,12	42,4
Maximum	276,1	65,1	277,8	94,59
Range	240	21,19	246,7	52,19
Mean	84,55	51	81,12	60,58
Std. Deviation	47,85	4,59	46,17	9,069
Std. Error of Mean	6,23	0,6079	5,863	1,27

Parking: human vs. machine

Evaluation results: number of moves (deskriptiv)

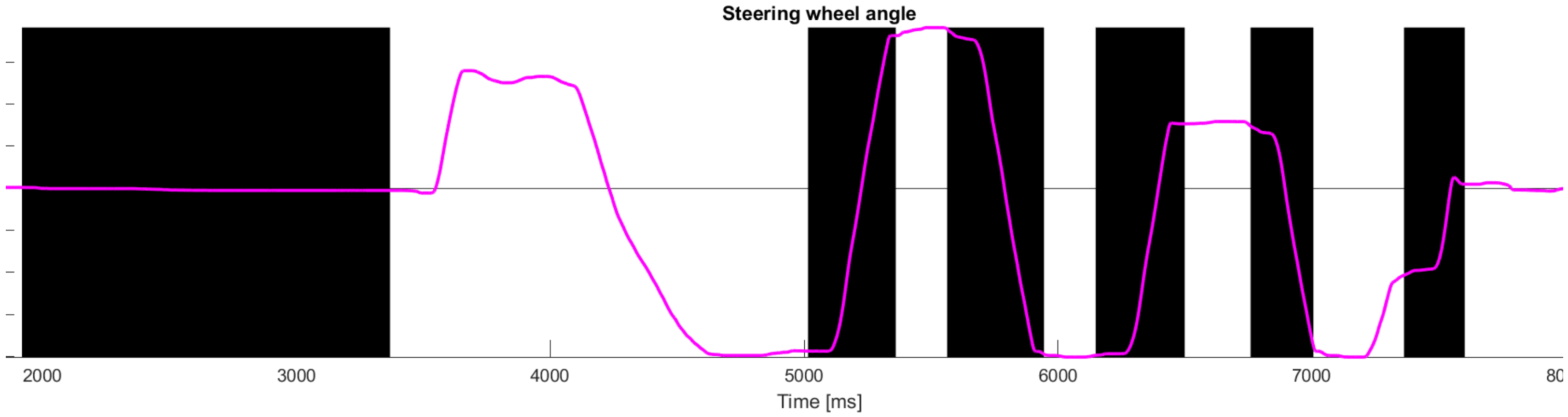


	Number of moves Vehicle A man	Number of moves Vehicle A aut	Number of moves Vehicle B man	Number of moves Vehicle B aut
Number of values	59	57	62	51
Minimum	3	5	2	4
Maximum	22	8	24	9
Range	19	3	22	5
Mean	6,712	5,842	7,161	6,275
Std. Deviation	3,756	0,5913	3,734	1,185
Std. Error of Mean	0,4889	0,07832	0,4742	0,1659

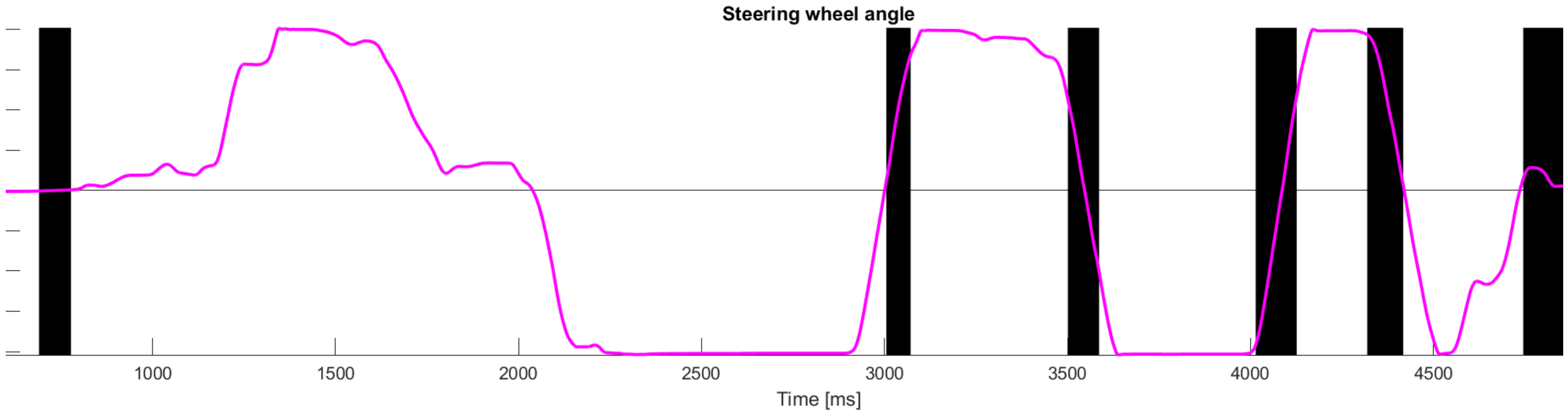
Parking: human vs. machine

Evaluation results: steering wheel angle change while stationary (single eval)

Machine:

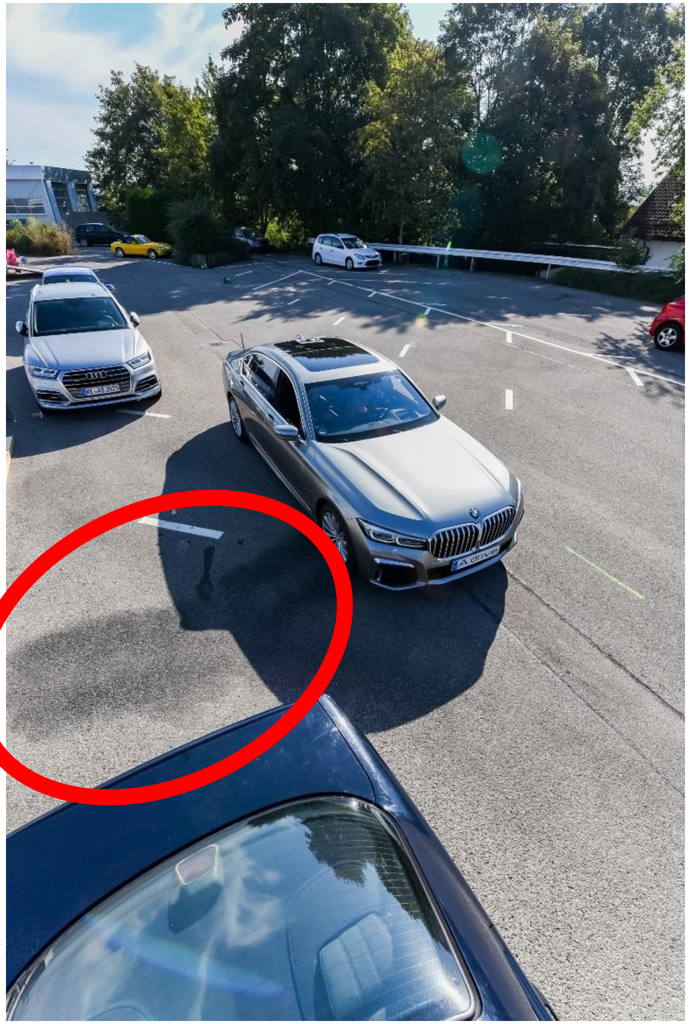


Human:



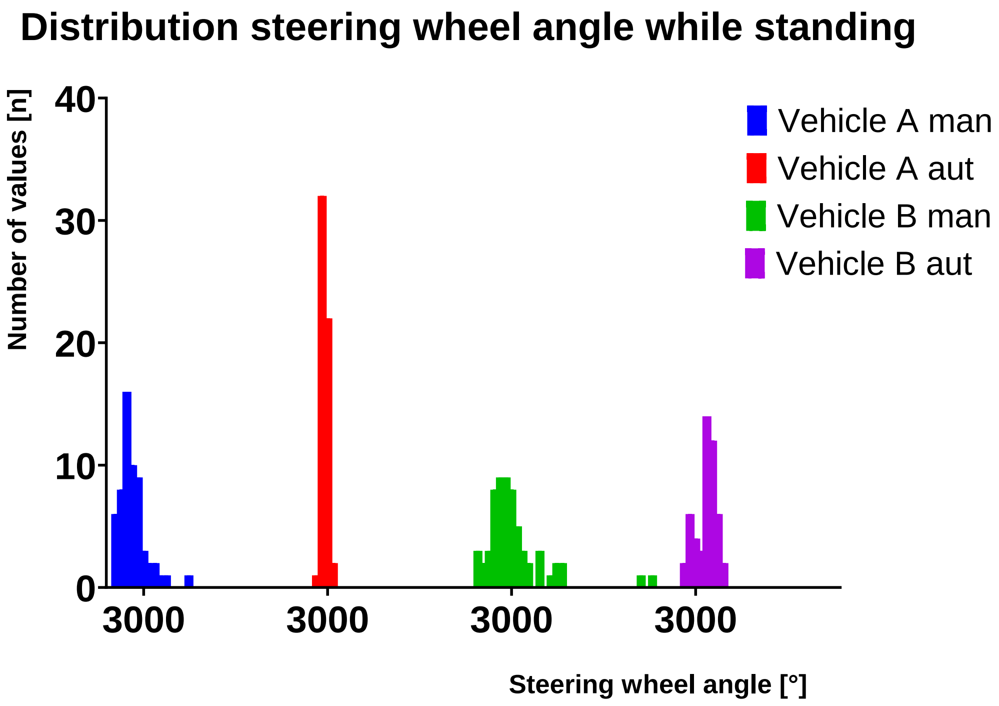
Parking: human vs. machine

Evaluation results: steering wheel angle change while stationary



Parking: human vs. machine

Evaluation results: steering wheel angle change while stationary (single eval)



	SWA cum Vehicle A man	SWA cum Vehicle A aut	SWA cum Vehicle B man	SWA cum Vehicle B aut
Number of values	59	57	60	50
Minimum	258,3	2223	150,7	2075
Maximum	7088	3454	7554	8509
Range	6829	1231	7403	6434
Mean	2027	2676	2846	4041
Std. Deviation	1197	241	1773	1108
Std. Error of Mean	155,8	31,92	228,9	156,6

Conclusion

Agenda

Nr.	Datum	Inhalt
1	23.04.	Introduction Advance Driver Assistance Systems and Automated Driving
2	07.05	ADAS/AD for Longitudinal Guidance
3	14.05.	ADAS/AD for Lateral Guidance
4	28.05.	ADAS/AD for Automated Parking
5	11.06.	User Experience with ADAS
6	**18.06**	**Track Day**
7	TBD	Exam Questions

Hochschule Kempten University of Applied Sciences

A drive. livinglab

Vehicle Technology SS 21

Lecture 5

FT30 – Advanced Driver Assistance Systems

User Experience with ADAS

Seda Aydogdu & Kevin Schuler