Study on Camera Monitor Systems

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Informal Group on Camera Monitor Systems in Reg. No. 46

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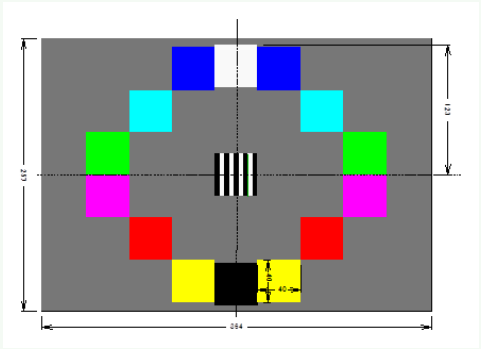
Bundesanstalt für Straßenwesen

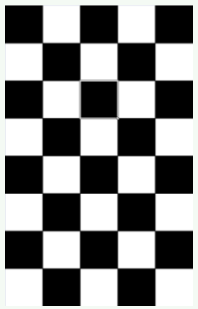
Background

- Camera Monitor Systems may replace classical outside rearview mirrors...
  - ...allowing new design concepts / reduction of vehicle width
  - ...allowing a reduction of aerodynamic drag
- Evaluation of technical aspects as well as aspects concerning human machine interaction (HMI) in **comparison to a conventional outside rearview mirror** necessary

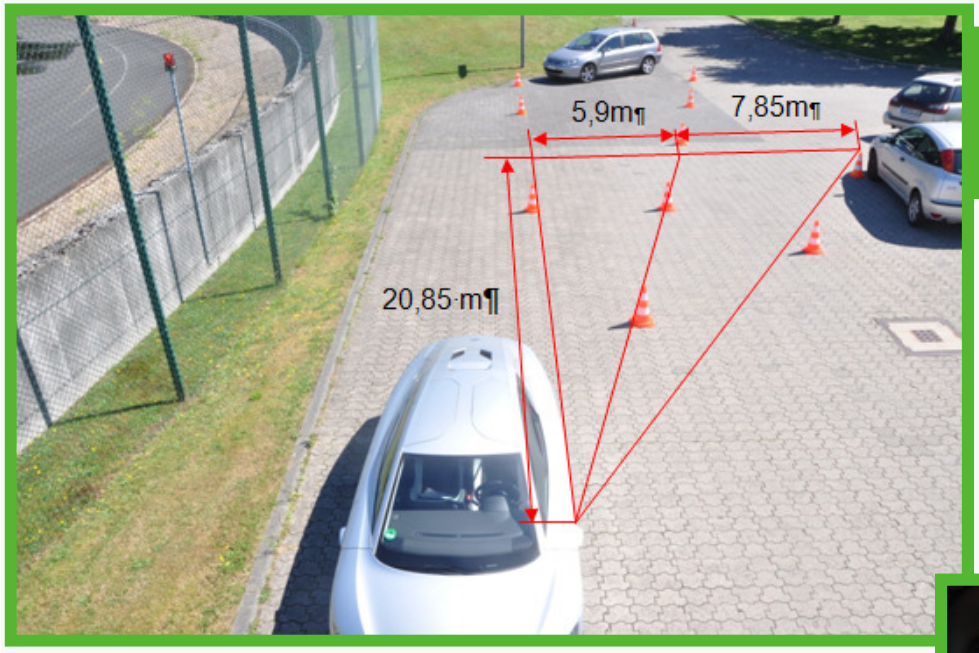
Technical Aspects

- Field of vision
- General day and night characteristics
- Image properties
- Glare
- Adjustability of camera and display
- Reliability
- Weather
- Robustness
- Exchangeability
- Energy Consumption

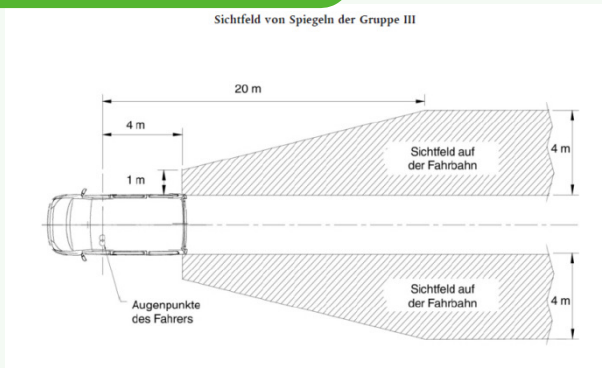




Field of vision (XL1)



The required field of vision is met



Blind spot is reduced

Tunnel

Vehicle „dissapears“ for t≈1s

Direct sunlight

No meaningful image on monitor for t≈2s

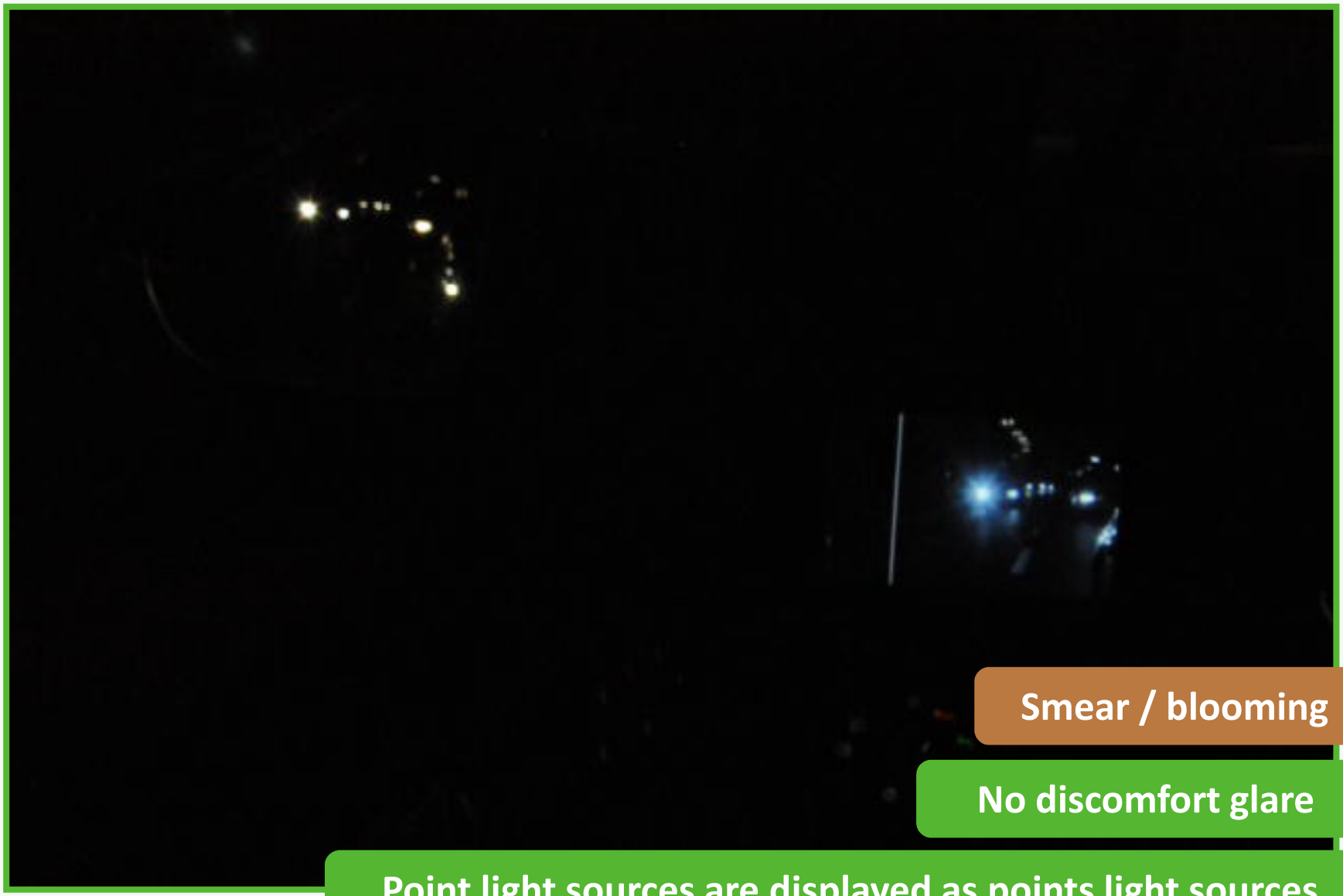
Direct sunlight

No discomfort glare

Rain

No disturbing rain drops

Night



Smear / blooming

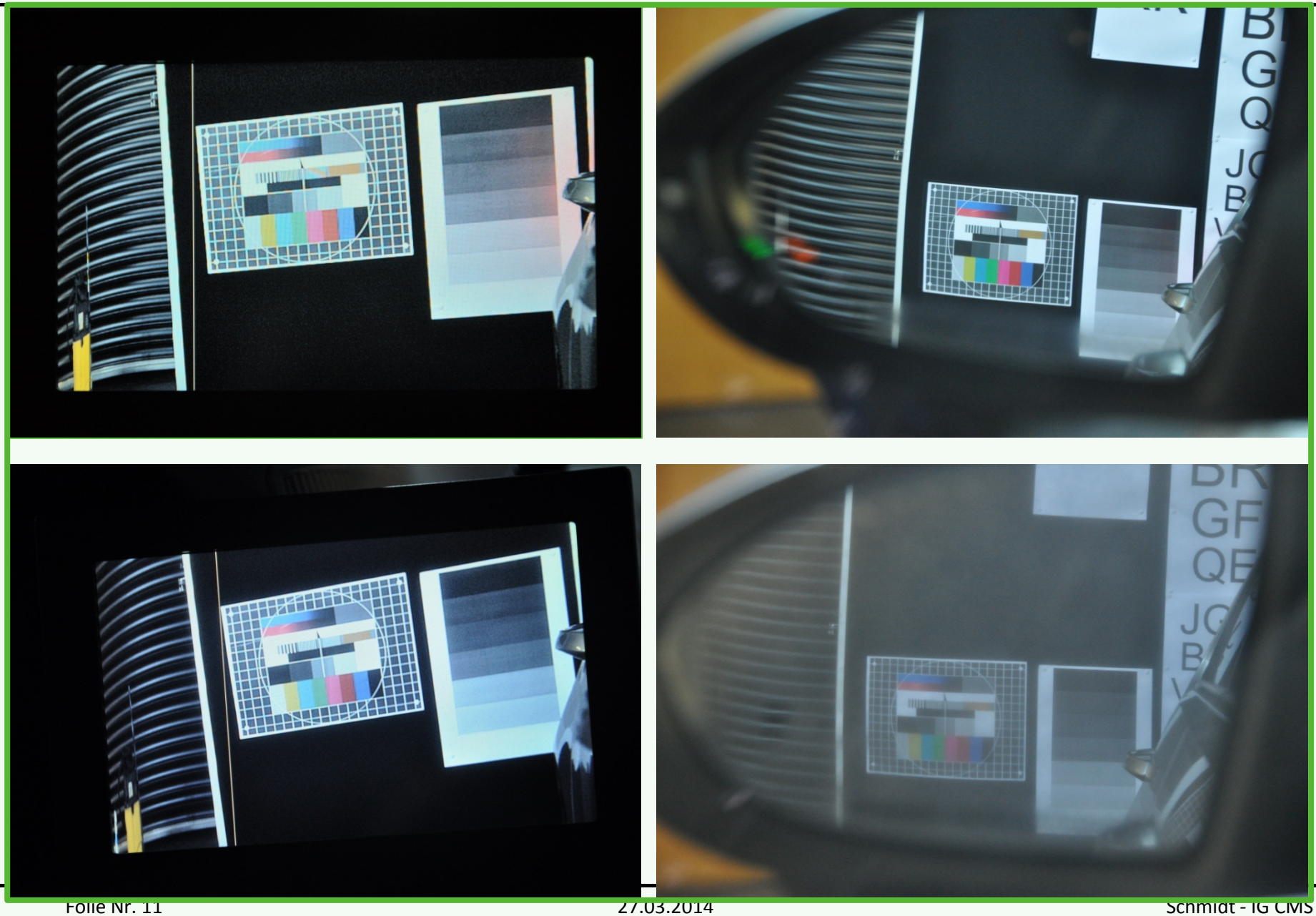
No discomfort glare

Point light sources are displayed as points light sources

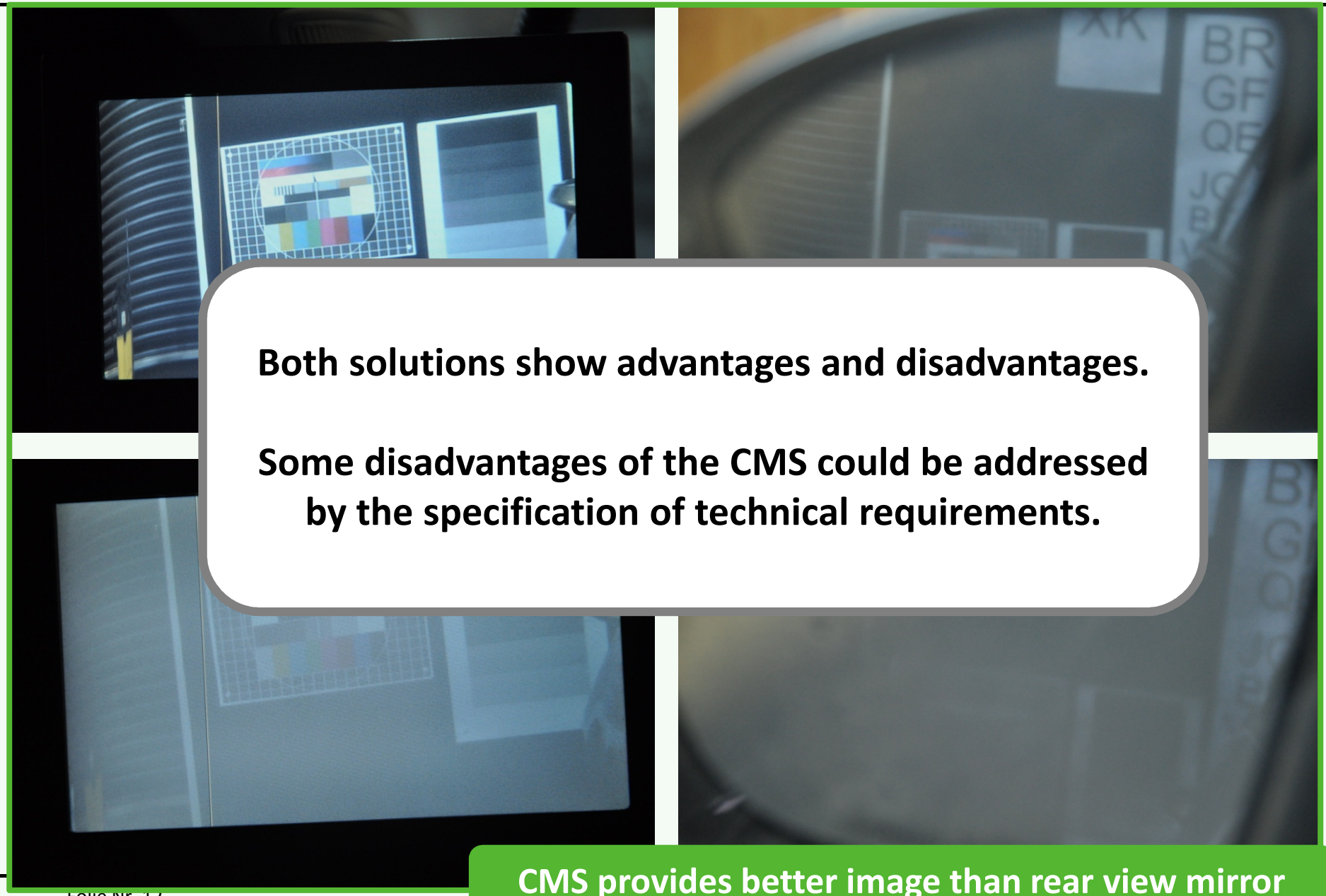
Reflections on display surface

Reflection of display should be reduced

Dirt



Dirt



Both solutions show advantages and disadvantages.

Some disadvantages of the CMS could be addressed by the specification of technical requirements.

CMS provides better image than rear view mirror

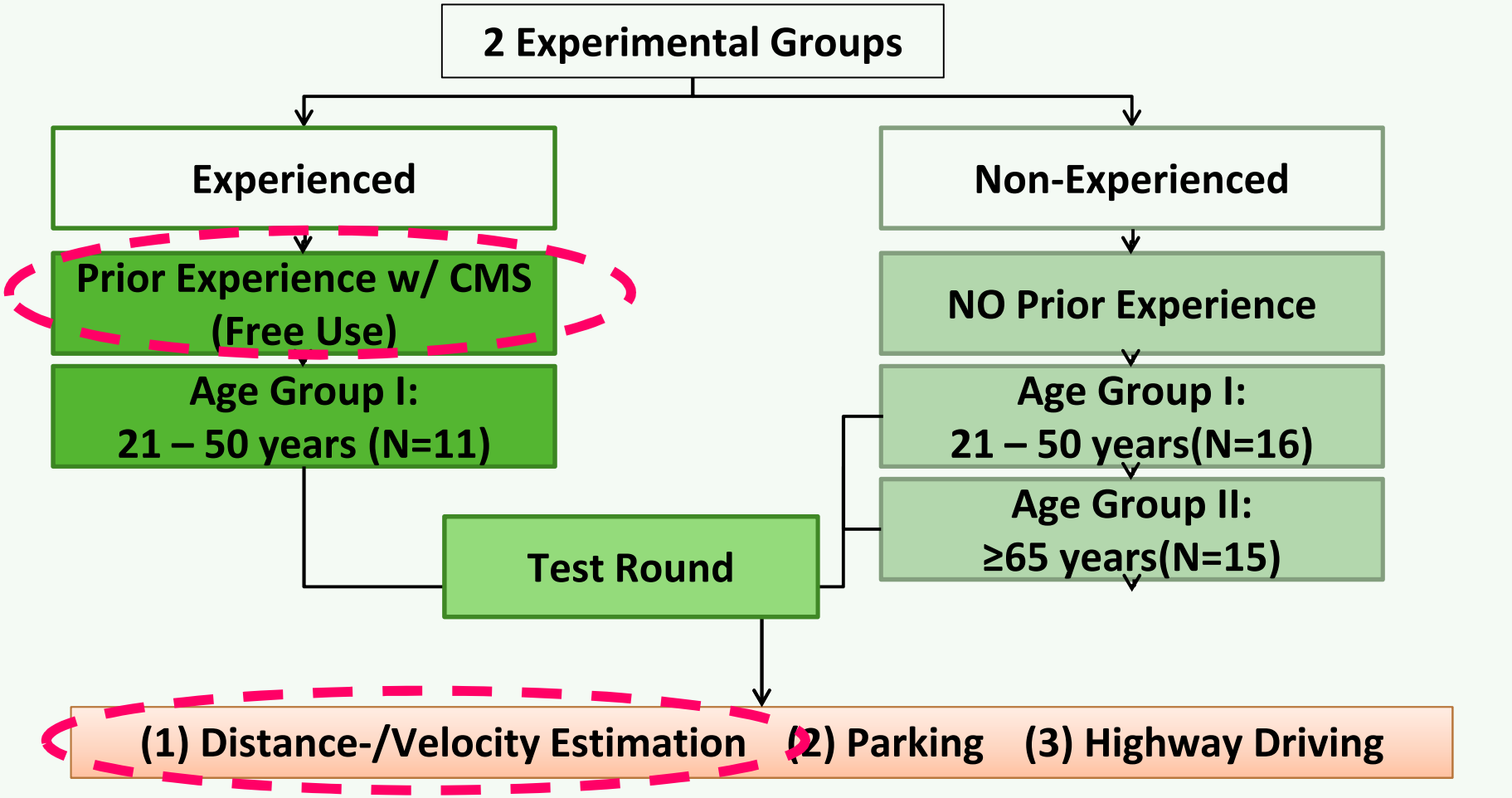
Aspects of Human Machine Interaction

- Field of vision tailored to traffic situation
- Individualization possible
- Option to highlight objects or persons
- Reduction of discomfort glare

Aspects of Human Machine Interaction

- Effect of varying display position on drivers' situation awareness (Endsley, 1995) not known:
  - Information closer to the central field of view
  - **Change of highly automated use patterns may have impact on assessment of relevant information**
- **Depth information is reduced**
- **Accommodation to closer distance necessary**
- **No possibility to adapt field of view by head movements**

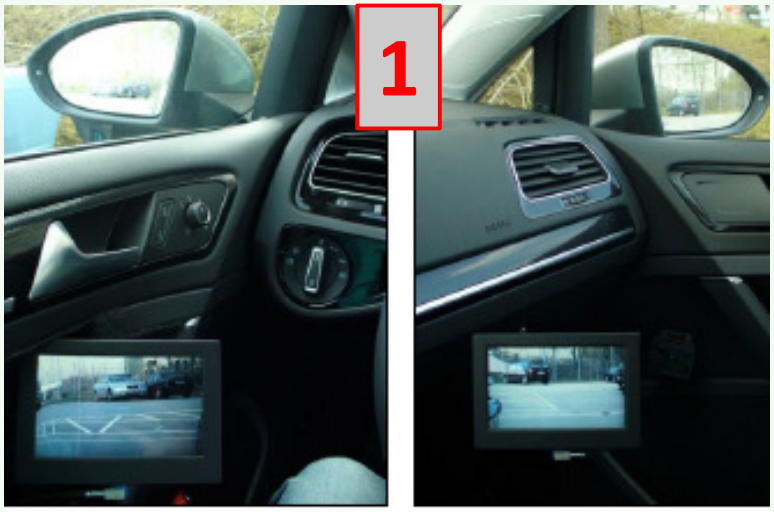
Study Design

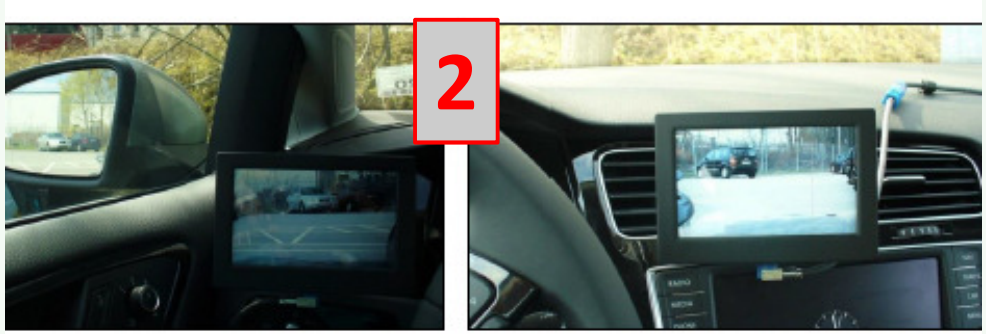


Subjective: Acceptance; Situational Awareness; Distraction

Objective: Performance Measures; Gaze Behavior; Speed Behavior

Display Positions





Evaluation by „experts“ after free use

0.1 FAHRTENPROTOKOLL – FREINUTZUNG

Datum: VPN Code:

Lieber Nutzer,
hier finden Sie einige Verkehrssituationen, die Sie in der freien Nutzung befahren könnten. Sie können diese Liste natürlich auch durch weitere Verkehrssituationen erweitern, die Sie in der Erprobung befahren haben. Gleichzeitig müssen Sie auch nicht jede der hier aufgeführten Situationen erproben. Bitte bewerten Sie nicht das Fahrzeug, sondern primär die Nutzung des Kamera – Monitor Systems in der Situation.

Verkehrssituation	**(1) Wie empfanden Sie die Nutzung des Kamera-Monitor-Systems?** **(2) Ist Ihnen etwas Besonderes aufgefallen?** **(3) Gab es einen Einfluss der Lichtverhältnisse** *(z.B. Tag/ Nacht/ Dämmerung)* **oder der Witterungsverhältnisse** *(z.B. Regen/ Nebel/Sonnen)?*
Aus dem Stand in den fließenden Verkehr einfädeln	
Abbiegen nach rechts	
Abbiegen nach links	
Kreisverkehr	
Tunnelfahrt	
Auffahren auf die Autobahn	
Fahren/Überholen auf der Autobahn	
Autobahnfahrt mit hoher Geschwindigkeit	

0.1 FAHRTENPROTOKOLL – FREINUTZUNG

Datum: VPN Code:

Fahrstreifenwechsel	
Fahrt auf Landstraße	
Rückwärts in beleuchtete/unbeleuchtete Garage einparken	
Rückwärtsfahren	
Signallichter (z.B. Ampel, Polizei/ Feuerwehr, Blinker usw.)	
Einparken (rückwärts Quer / Längsparken)	
Motor anlassen/ abstellen	
aus dem Fahrzeug aussteigen	

Weitere

_____gefahren Kilometer, davon ____ % Innerorts
_____ % Landstraße _____ % Autobahn auf eine Gesamtdauer von
_____ Stunden.

VIELEN DANK!

Evaluation by „experts“ after free use

Non-critical or rather unspecific statements:

- Driving on rural road
- Highway driving
- Turning
- Reversing
- Signal lights
- Start/stop of engine
- Leaving / entering vehicle
- Rain

Evaluation by „experts“ after free use

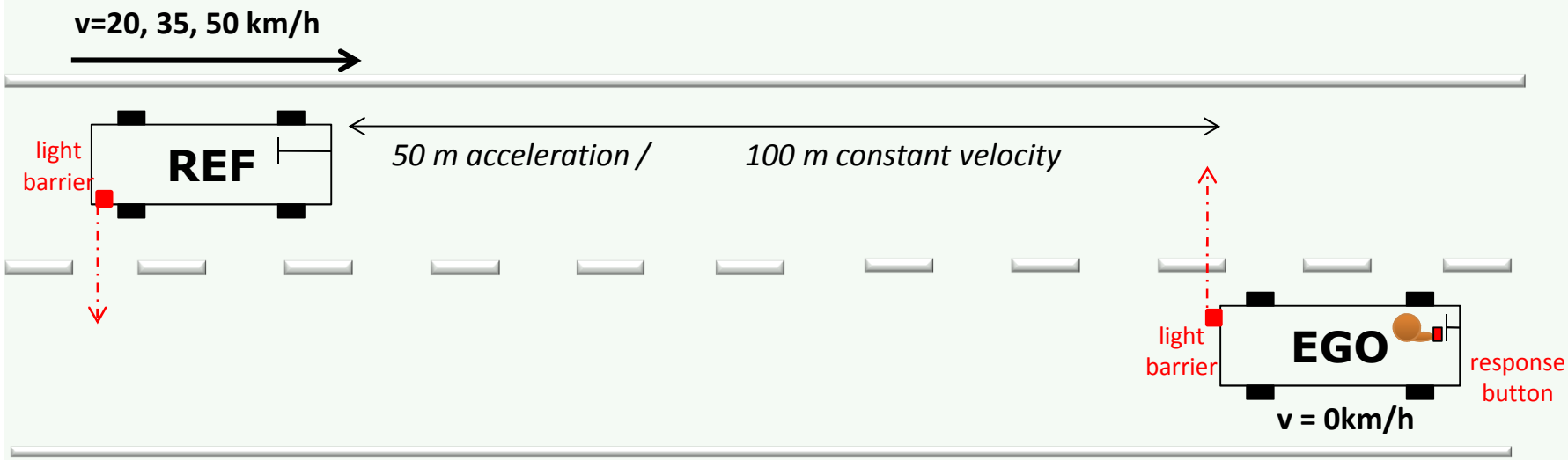
„Rather critical“ categories:

- P
-
-
-
-

The „experts“ ratings generally reflect the technical properties of the system

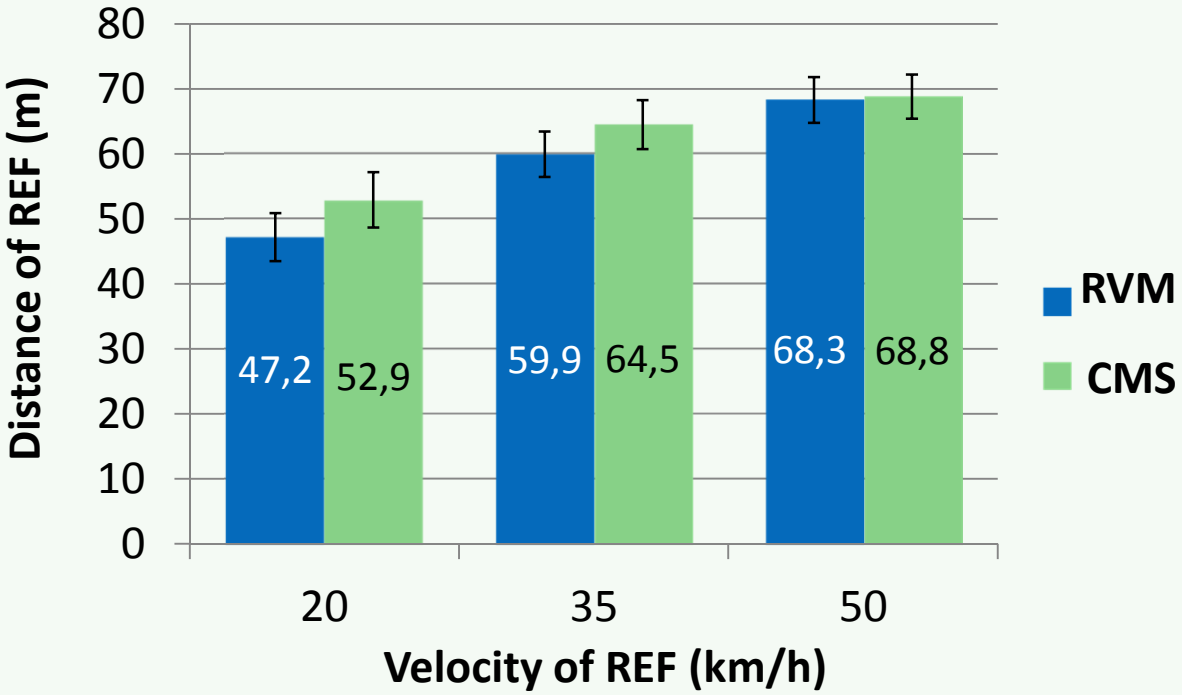
Question: Is there an objective effect on distance and velocity estimation?

Distance- and Velocity Estimation („Last Safe Gap-Method“)



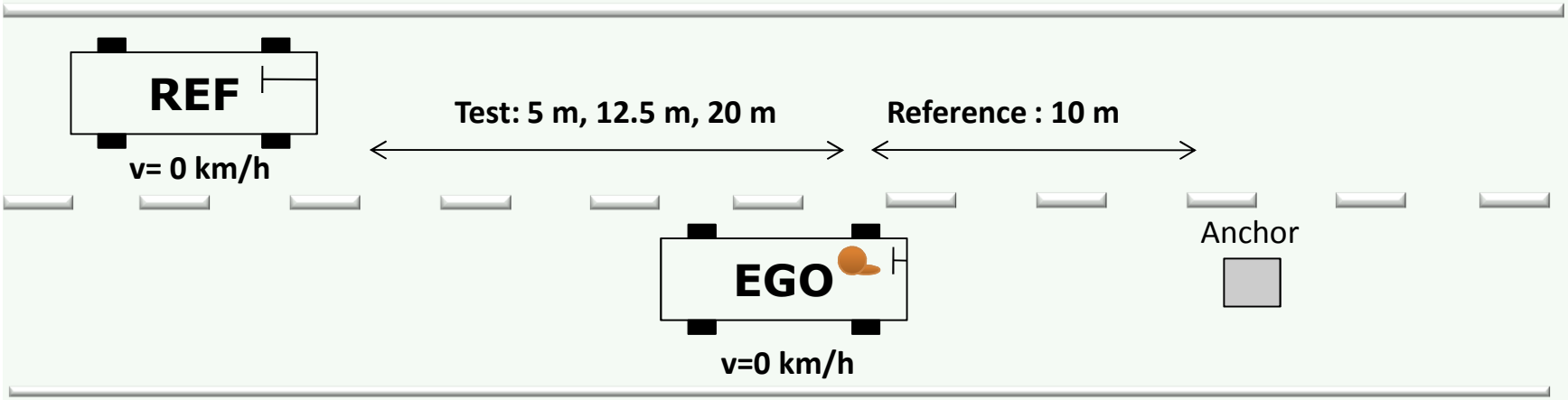
- Drivers (EGO) observe approaching vehicle (REF) through outside rearview mirror (RVM) or camera monitor system (CMS)
- Button press at the **latest moment where it is considered safe to pull out** in front of the approaching vehicle

Results: „Last Safe Gap-Method“ (N=34, within subject)



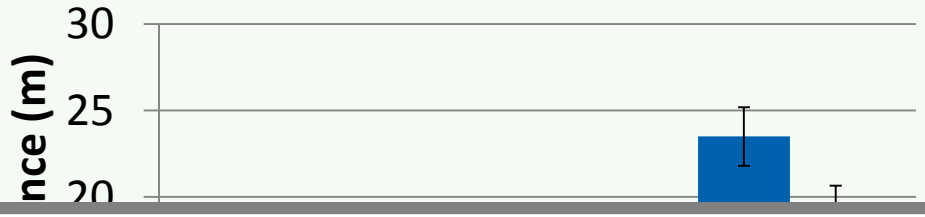
- The faster the REF-vehicle, the larger the „last safe gap“ (F (2;66)= 39.752, p = .000)
- Tendency of larger gap using CMS (F (1;33) = 3.646, n.s. [p = .065])
- No interaction between velocity and used device (F (2; 66) = 1.187, n.s. [p = .310])

Distance Estimation („Magnitude Estimation Method“)



- Drivers (EGO) observe vehicle positioned in the back (REF) through RVM or CMS
- Estimation of distance to relative to frontal „anchor“ distance („100“)

Results: „Magnitude Estimation“ (N=40, between-subject)

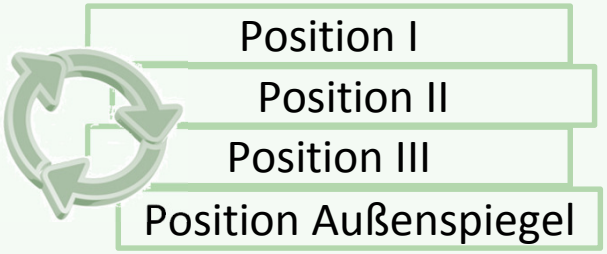


In general distances and velocities can be estimated by using the camera monitor system

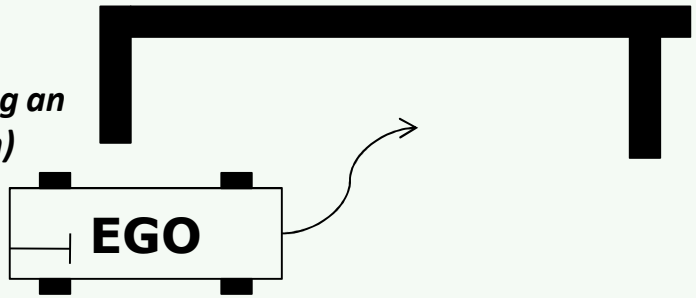
There is no significant difference in comparison to using an outside rearview-mirror

- The r… …3, p = .000)
- Shorter distances are estimated using CMS (F(1; 39) = 5.203, p= .028)
- No interaction between distance and used device (F(2,78) = 1.65, n.s., p = .207)

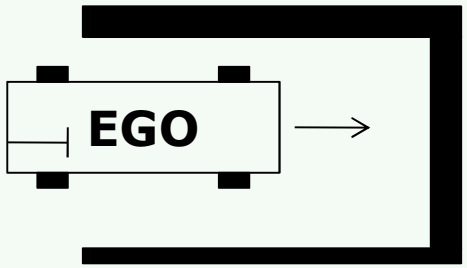
Reversing / Parking



Parallelparken und parallele Annäherung an Hindernis (Randstein)



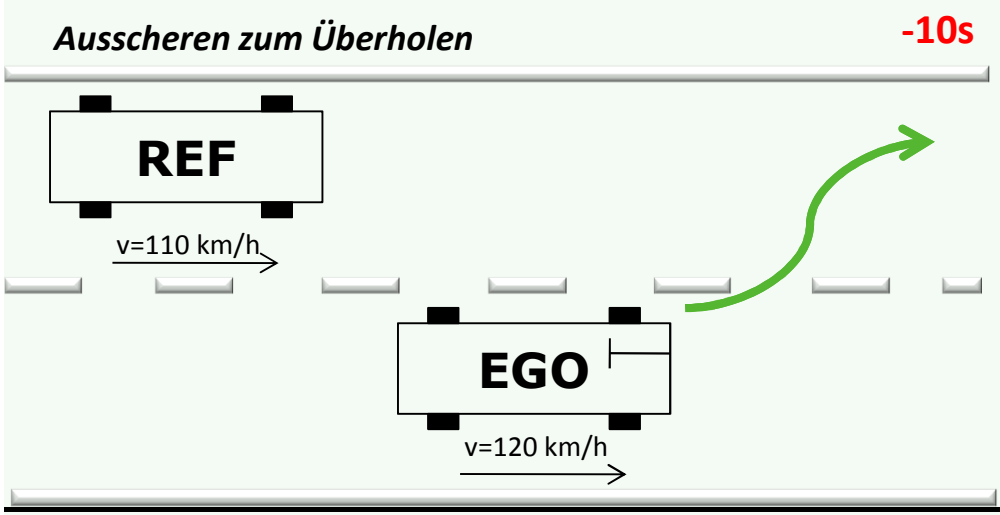
Querparken und orthogonale Annäherung an Hindernis

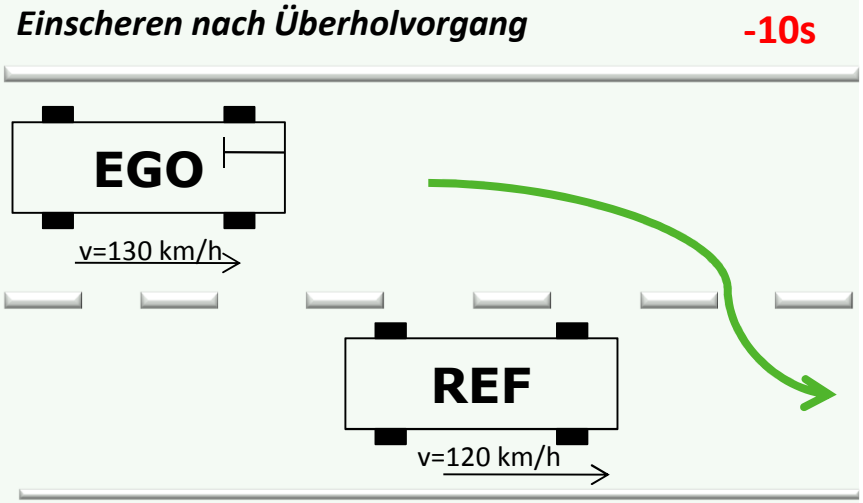


Parking

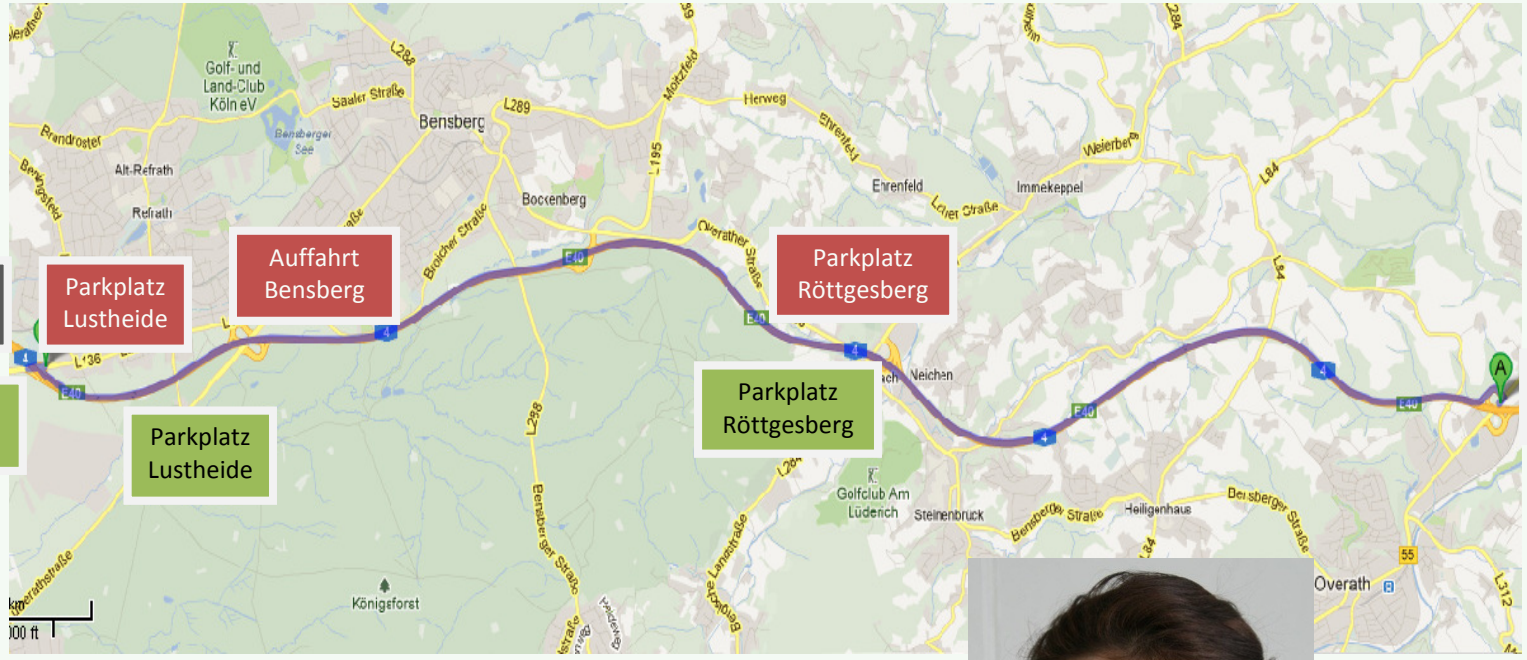
- There was no significant influence of the used system on the number of reversals and the subjective judgement neither for parallel nor for orthogonal parking
- There is a tendency that especially elderly drivers tend to need more reversals when using display position 1 (lowest position). This is also reflected in the general judgement.

Highway driving



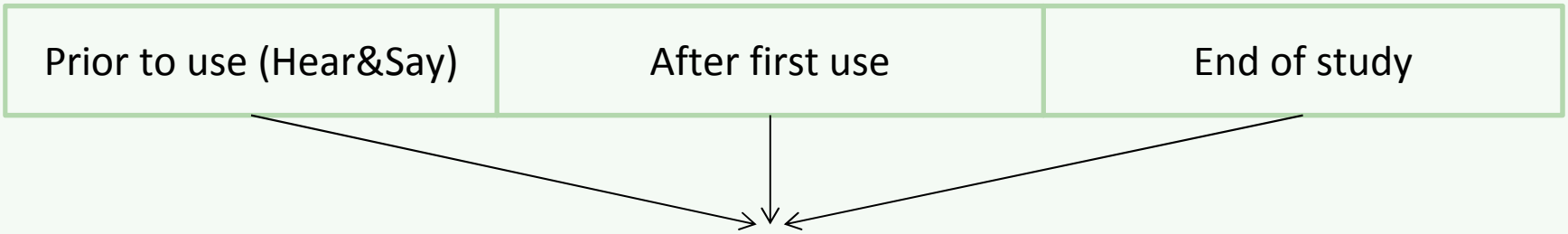


Highway track Refrath – Overath (filtering situations)



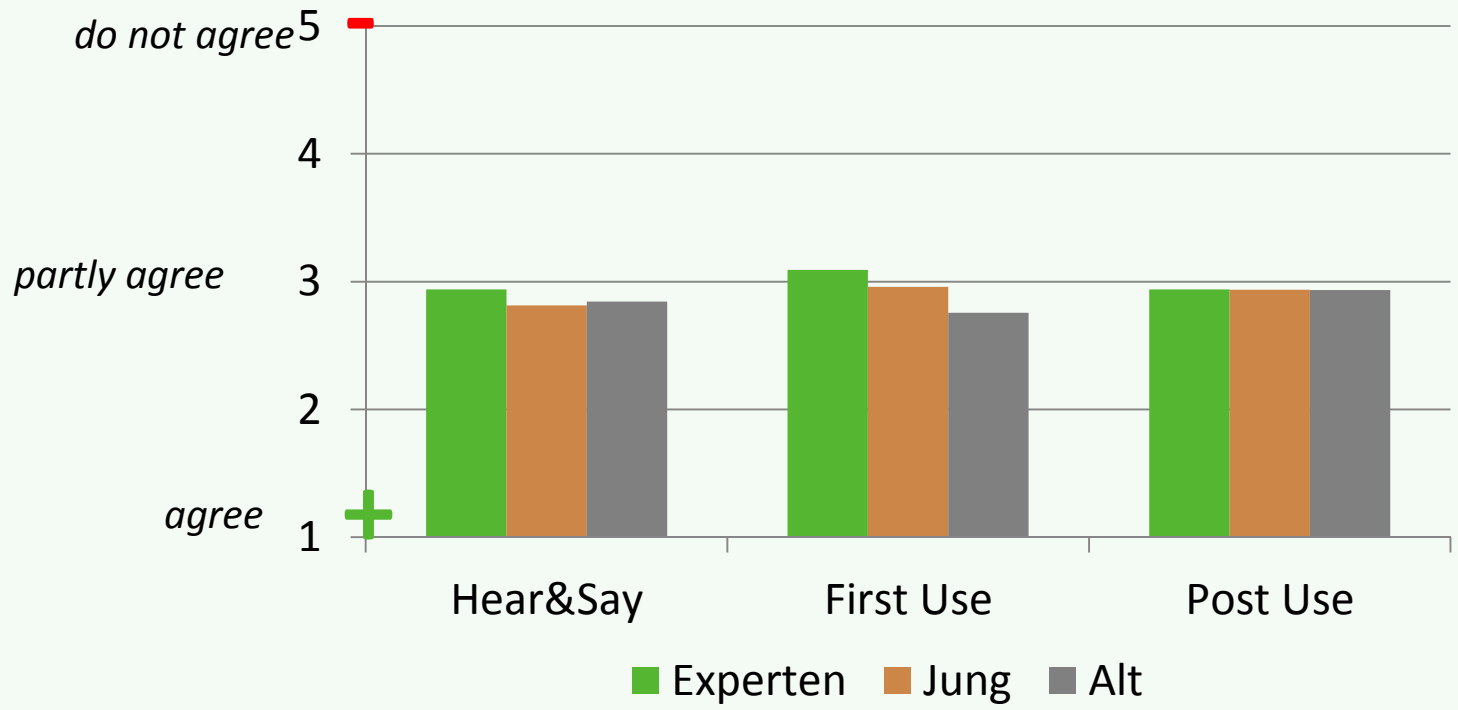
Acceptance

Does system acceptance change with continuous use?



a. The system is helpful.
b. I would like to own the system in my own car.
c. I have a positive attitude towards the replacement of outside rear view mirrors by CMS.

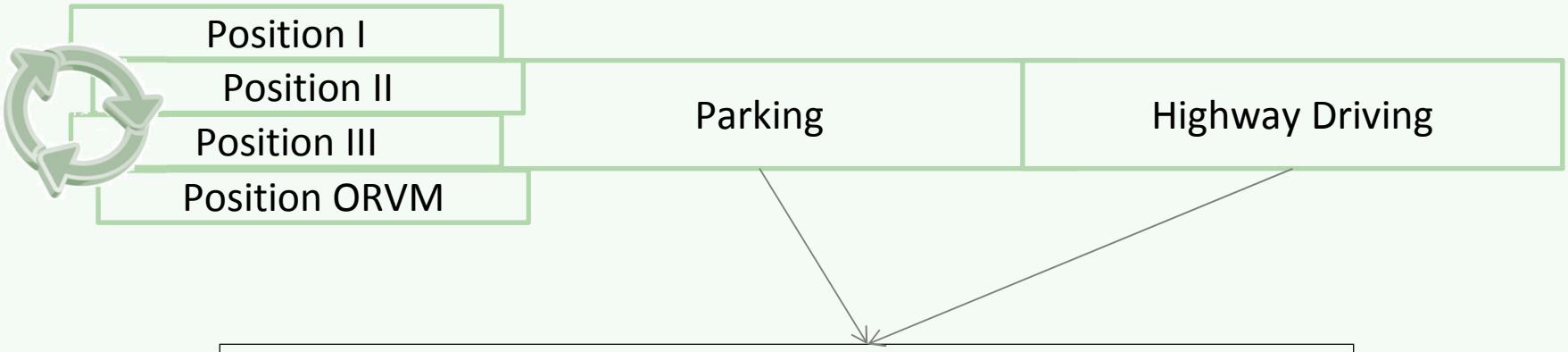
Acceptance



- The system shows a moderate acceptance which does not change significantly with increasing experience. (HE Erfahrung, $F(2,38) = .330$, $p = .721$)
- No difference between the three groups („experts“, young, elderly)

Situation awareness

Is it possible to form an adequate situation awareness by using the CMS?

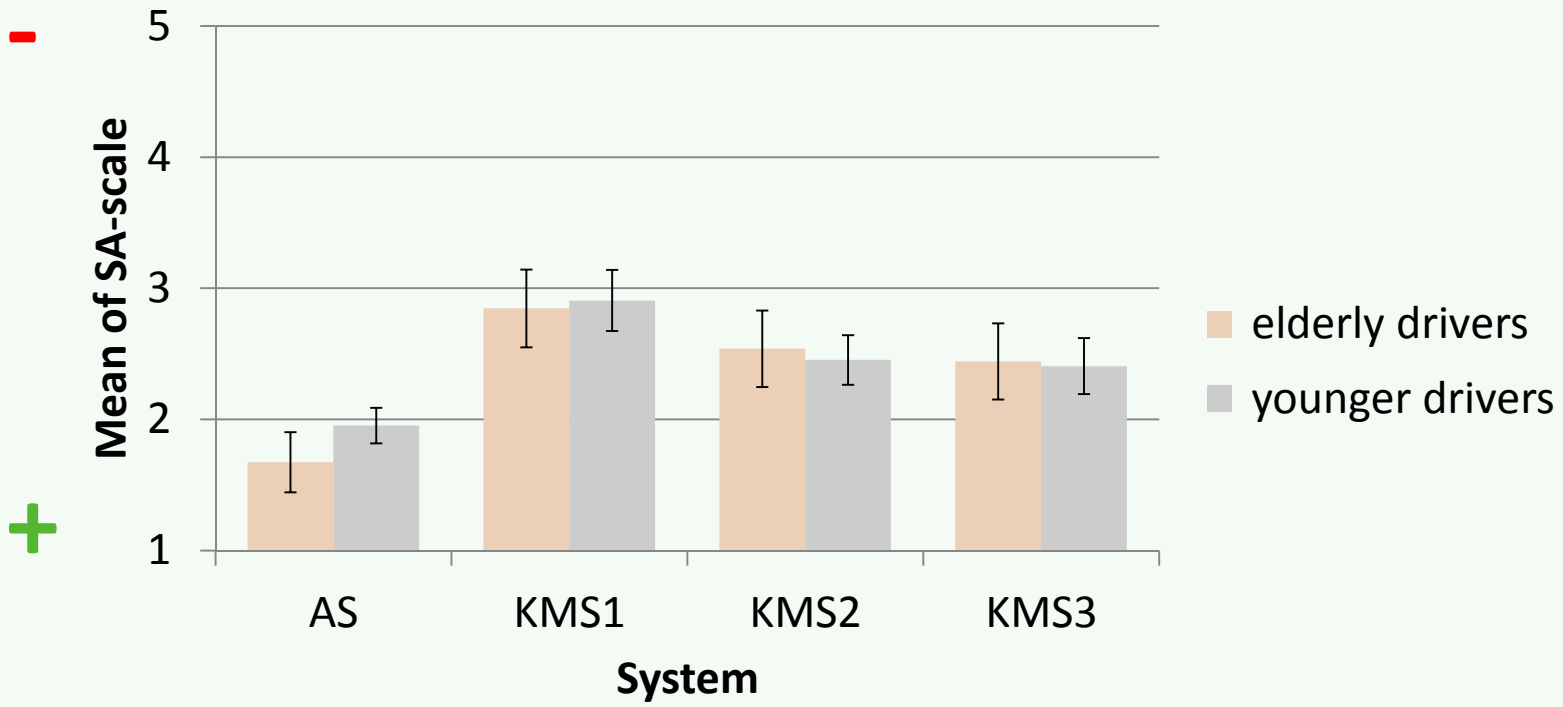


a. The systems supports me ideally for the estimation of distances to obstacles in the surrounding of my vehice.

b. The monitor shows all relevant information that I need in order to perform the driving task adequately.

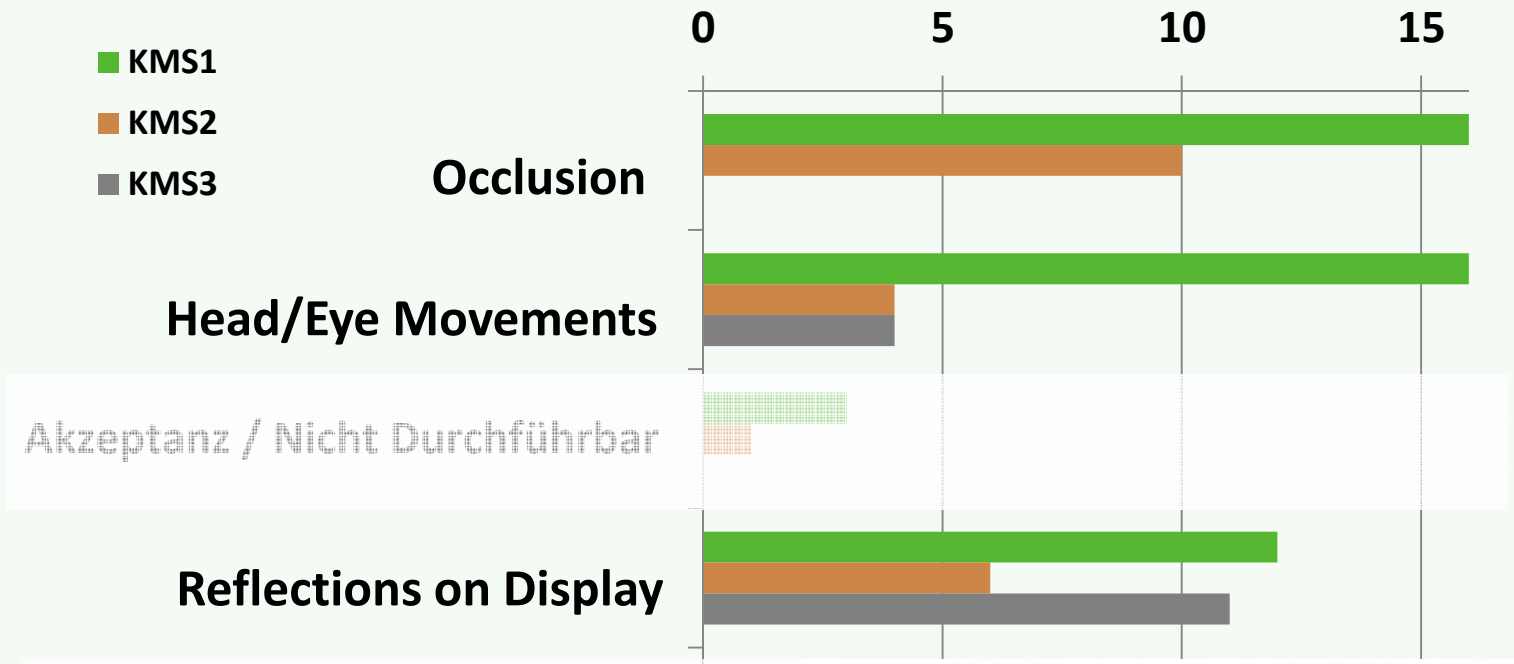
c. The system supports me ideally during maneuvering.

Situation awareness

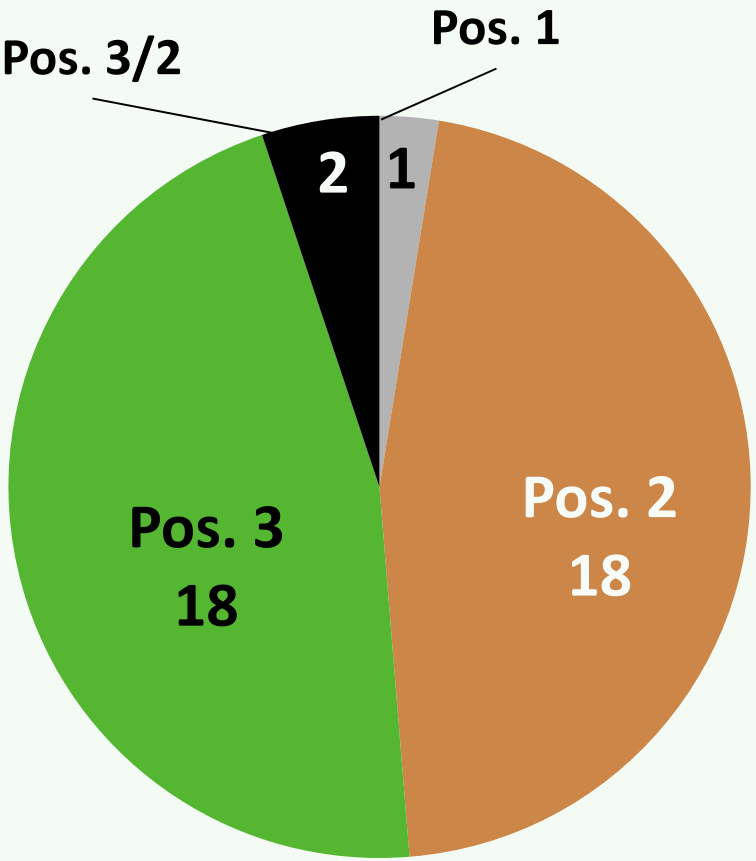


- The CMS is perceived to perform somewhat worse that the outside rearview mirror (AS) [HE System (F (3;81) = 12,516, p = .000)], especially for position 1
- No age-effect

Comments on display position



Preferred display position



Next steps

- Finalisation of analysis
- Study on influence of visual abilities on use of CMS (e.g. hyperopia)
- Study on the use of CMS in heavy goods vehicles (technical and HMI)
- Support of discussion in IG CMS
- Final report expected in summer 2014 (will be translated into English language)

Thank you for your attention!

Bundesanstalt für Straßenwesen

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