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
Vehicle „dissapears“ for t≈1s
Direct sunlight

No meaningful image on monitor for t≈2s
Direct sunlight

No discomfort glare
No disturbing rain drops
Point light sources are displayed as points light sources

Smear / blooming

No discomfort glare

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Reflections on display surface

Reflection of display should be reduced

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Both solutions show advantages and disadvantages.

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

- Experienced
  - Prior Experience w/ CMS (Free Use)
  - Age Group I: 21 – 50 years (N=11)

- Non-Experienced
  - NO Prior Experience
  - Age Group I: 21 – 50 years (N=16)
  - Age Group II: ≥65 years (N=15)

Test Round

- (1) Distance-/Velocity Estimation
- (2) Parking
- (3) Highway Driving

Subjective: Acceptance; Situational Awareness; Distraction

Objective: Performance Measures; Gaze Behavior; Speed Behavior
Evaluation by „experts“ after free use

**0.1 FAHRTENPROTOKOLL - FREINUTZUNG**

**Datum:** 27.03.2014

**Vorname:** Schmidt
**Nachname:** IG CMS

Lieber Nutzer,


**Verkehrs situation**

(1) Wie empfinden Sie die Nutzung des Kamera-Monitor-Systems?

(2) Ist Ihnen etwas Besonderes aufgefallen?

(3) Gibt es einen Einfluss der Lichtverhältnisse (z.B. Tag/Nacht) oder der Witterungsverhältnisse (z.B. Regen/Wolken/Sonnenschein)?

<table>
<thead>
<tr>
<th>Verkehrssituation</th>
<th>VRN Code</th>
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<tbody>
<tr>
<td>Aus dem Stand in den fliegenden Verkehr entdecken</td>
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<td>Abbiegen nach rechts</td>
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<td>Abbiegen nach links</td>
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<td>Anfahren auf die Autobahn</td>
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<td>Fahrten Überholen auf der Autobahn</td>
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<tr>
<td>Autoabfahrt mit hoher Geschwindigkeit</td>
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<th>Fahrtenfenster</th>
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<tr>
<td>Fahrtenfenster</td>
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<td>Fahrt auf Landstraße</td>
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<td>Balkonenhäuser</td>
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<td>Molecule im unbelasteten Gebiet</td>
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<td>Rundumsicht</td>
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<td>Einparken (z.B. Quer/Parken)</td>
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<tr>
<td>Motor anlassen abstellen</td>
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<tr>
<td>aus dem Fahrzeug aussteigen</td>
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**Währe**

________________ gefahren Kilometer, davon ____ % Innertorts
________________ % 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:

– Parking (distance estimation, orienting)
– Lane change on highway (estimation of distance and velocity)
– Driving in tunnels (adaptation of brightness)
– Direct sunlight
– Position of monitor

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 \( (F(1;33) = 3.646, \text{n.s.} \ [p = .065]) \)
- No interaction between velocity and used device \( (F(2; 66) = 1.187, \text{n.s.} \ [p = .310]) \)
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)

- The further the vehicle the larger the estimated distance ($F(2;14) = 182.3, p = .000$)
- 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., $p = .207$)

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.

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Reversing / Parking

Parallelparken und parallele Annäherung an Hindernis (Randstein)

Querparken und orthogonale Annäherung an Hindernis

Position I
Position II
Position III
Position Außenspiegel
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

**Auffahren auf die Autobahn**

**Auswertung: -15s**

- **REF**
  - v=80 km/h

- **EGO**
  - v=100 km/h

**Ausscheren zum Überholen**

- **REF**
  - v=110 km/h

- **EGO**
  - v=120 km/h

**Einscheren nach Überholvorgang**

- **EGO**
  - v=130 km/h

- **REF**
  - v=120 km/h

- **Position I**
- **Position II**
- **Position III**
- **Position Außenspiegel**

Auswertung: -10s
Highway track Refrath – Overath (filtering situations)
Acceptance

*Does system acceptance change with continuous use?*

- Prior to use (Hear&Say)
- After first use
- End of study

- 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.
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?

- Position I
- Position II
- Position III
- Position ORVM

Parking
Highway Driving

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

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.
• The CMS is perceived to perform somewhat worse than 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

- Occlusion
  - KMS1
  - KMS2
  - KMS3

- Head/Eye Movements

- Reflections on Display
  - Gewöhnungsbedürftig
  - Ablenkung/Sicherheit
  - Bildqualität

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Preferred display position

Pos. 3/2
- 2
- 1

Pos. 1
- 1

Pos. 3
- 18

Pos. 2
- 18
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!