Position Paper
on
Lighting for Automated Driving Systems
CONTENT:

• Executive Summary

• Requirements on the technology move towards further automation in traffic

• Scientific proof

• Conclusions
Executive Summary

• A lighting signal for vehicles driving in automated mode is appropriate.

• For Automated driving systems (ADS), a lighting signal can contribute to enhancing the trust in interaction, and therefore also acceptance and traffic flow.

• Scientific investigations performed on behalf of Light.Sight.Safety confirm this position.

• Regulations and standards, which are both realistic and ambitious, shall be based on robust data: they shall support the improvement of road safety for all traffic participants.

• Technology neutrality shall remain a key principle.
Requirements on the technology move towards further automation in traffic

There is a common understanding that further steps in automation to unload humans from tasks by allowing more sensing can increase road safety.

However, in different countries, traffic situations and traffic infrastructure are handled differently and do not evolve at same speed.

Furthermore, the introduction of ADS technologies into new vehicles will result in a transition phase of about two decades until automated vehicles take a major role in the international car park.
Requirements on the technology move towards further automation in traffic

Projections of the future car park indicate that for the coming two decades, road safety will be characterised by mixed traffic conditions i.e. a population of both conventional, semi-automated and fully autonomous vehicles, which vulnerable road users will be exposed to.

CLEPA fully supports the UNECE approach of setting up a dedicated reporting group for autonomous vehicles (GRVA), to define priorities and handle the repercussions of the evolution towards further automation.

The outcome of the scientific investigations initiated by Light.Sight.Safety indicates that an AV marker light is a logic step forward towards further road safety improvement as lighting devices are intuitive and well-experienced in traffic.

CLEPA trusts GRVA to making use of lighting for further improvement of road safety: the decision on the type of lighting signal appropriate for ADS shall be taken as soon as possible to allow swift development and enable international harmonisation.

CLEPA endorses the work performed in the SAE J3134 working group and supports the GTB approach to harmonise the technical content also beyond UNECE.
Scientific evidence

General studies show the relation between road safety and the use of intuitive human capabilities – visual signals are common to prevent from accidents (Geneva studies)

- Vulnerable Road Users (VRUs) expect some external communication interacting with autonomous vehicles
- The majority of human sensing is guided by visual interaction
- Road users are experienced with light signals!

UNECE GRE Task Force AVSR (Autonomous Vehicles Signalling Requirements) has collected international studies with the intention to confirm that a lighting signal can support road safety due to its immediate recognition and intuitiveness.

The Signal itself needs to allow an unambiguous interpretation, which requires a common language and convention agreement.

Systematic research has been initiated by Light.Sight.Safety to support the technical solution.
**Scientific evidence**
(details on [https://wiki.unece.org/download/attachments/75532788/AVSR-03-06e.pdf?api=v2](https://wiki.unece.org/download/attachments/75532788/AVSR-03-06e.pdf?api=v2))

<table>
<thead>
<tr>
<th>Study title</th>
<th>Time</th>
<th>Outcome</th>
</tr>
</thead>
<tbody>
<tr>
<td>TUD Module1 Needs of new lighting for indicating automated state: literature study</td>
<td>2017</td>
<td>Scientific framework confirmed by former studies: <em>lighting is an appropriate tool for signalisation</em> in traffic and thus improve road safety</td>
</tr>
<tr>
<td>TUD Module2A Signaling LED-element: lighting aspects and initial experiments</td>
<td>2018</td>
<td>The vehicle can actively contribute to road safety by giving a signal to other road users <em>Specific technical parameters on visibility, recognition and color</em></td>
</tr>
<tr>
<td>TUD Module2B Signaling LED-element: color / position / intensity / location</td>
<td>2018</td>
<td>An outline framework to <em>describe size, position, brightness and color</em> for a basic ADS signal</td>
</tr>
</tbody>
</table>

---

**TU Darmstadt and Light Sight Safety**

*Module 2B: Results summary*

- Small differences between dark and light environment
- Similar results in lab and field
- No age-related differences
- Proposal for xy range:
### Scientific evidence
(details on [https://wiki.unece.org/download/attachments/75532788/AVSR-03-09e.pdf?api=v2](https://wiki.unece.org/download/attachments/75532788/AVSR-03-09e.pdf?api=v2))

<table>
<thead>
<tr>
<th>Study title</th>
<th>Time</th>
<th>Outcome</th>
</tr>
</thead>
<tbody>
<tr>
<td>THM Study 1</td>
<td>2018</td>
<td>Observers/road users do <strong>expect a communication/signal at dedicated locations of the vehicle</strong></td>
</tr>
</tbody>
</table>
Scientific evidence
(details on TBC)

<table>
<thead>
<tr>
<th>Study title</th>
<th>Time</th>
<th>Output</th>
</tr>
</thead>
<tbody>
<tr>
<td>THM Study 2 Empirical Investigation on the need of marking vehicles running in automated mode in real traffic situations</td>
<td>2019</td>
<td>The identification with a signal will give a clearly measurable safety benefit, especially in complex traffic situations</td>
</tr>
</tbody>
</table>

Results of the investigation

The comparison between vehicles marked and not marked with a visual signal confirms that:

- Observers look more than twice as long to marked as to unmarked cars
- Observers look exactly at the marking and will therefore get the information expected

The comparison of daytime and nighttime testing confirms the relevance of a visual signal
- Eye contact with the driver cannot be taken for granted at either night or day-time
- The visual signal adds safety especially to vulnerable road users
Scientific evidence
Scientific investigations other than those initiated by Light.Sight.Safety lead to similar positions: the definition of a common convention is possible.

Vision 2018 Proceedings provided by SIA, France

What kind of communication is needed for ADS?
From the basic indication to further safety enhancement

ISAL 2019 proceedings provided by TU Darmstadt

<table>
<thead>
<tr>
<th>Study title</th>
<th>Contributor</th>
<th>Output</th>
</tr>
</thead>
<tbody>
<tr>
<td>Customizable pixel signal lighting</td>
<td>Helle</td>
<td>Signallization and COMMUNICATION can be combined in ONE device!</td>
</tr>
<tr>
<td>How important is communication between automated vehicles and other road users?</td>
<td>TU Darmstadt</td>
<td>AV’s are expected to communicate. „I drive autonomous“ and „I have seen you“ are important in any situation</td>
</tr>
<tr>
<td>'I have detected you' – Perception-based Interaction Strategy for Automated Vehicles</td>
<td>Helle</td>
<td>Communication needs to be reduced to relevant use cases and addresses. There must be enough space for the coexistence of both road users (AV and HRU) in the respective situations.</td>
</tr>
<tr>
<td>Investigation and comparison of pedestrian behavior in different encounter scenarios with automated vehicles</td>
<td>TU Darmstadt</td>
<td>Observers rely on vehicle dynamics. Additional signals attract attention, reactions of observers improve. scenes with symbols provide a better recognition of the intention of the AV and a better safety feeling. Uniquely identifiable symbols are rated best.</td>
</tr>
<tr>
<td>Light-based communication of automated vehicles with other traffic participants</td>
<td>DLR</td>
<td>Using one and the same eHMI strategy in all scenarios, could help to increase the learnability and understandability of the meaning of the eHMI strategy. A pulsing light band in combination with a directed signal lamp, was rated as the preferred eHMI strategy</td>
</tr>
</tbody>
</table>
Conclusions

CLEPA supports the completion and swift implementation of rules for the interaction between vehicles and vulnerable road users in order to increase safety and trust especially in mixed traffic situations with vehicles featuring different stages of automation.

Therefore:
• The proposal for a lighting signal to address this market need is seen as the appropriate solution to realise the most effective cognitive human perception;
• Regulation and harmonisation of such lighting signals (and potential future enhanced communication signs) is strongly recommended to ensure an unambiguous interpretation for all road users, globally;
• Technology neutrality is a major principle of smart regulation: it provides a framework which stimulates innovation and pushes companies to compete for best solutions and technologies;
• From an implementation point of view, it seems worthwhile to get on the learning curve pro-actively and swiftly, as this would facilitate improving future solutions;
• Clear and strong safety benefits for consumers of the proposed ADS marking light solutions should drive early market penetration, stimulate end-user preference and create attractive economies of scale for ultimate mass market adoption.
CLEPA

CLEPA, the European Association of Automotive Suppliers based in Brussels, represents over 3,000 companies, from multi-nationals to SMEs, supplying state-of-the-art components and innovative technology for safe, smart and sustainable mobility, investing over 25 billion euros yearly in research and development. Automotive suppliers in Europe employ about five million people across the continent.
More information: www.clepa.eu

Light.Sight.Safety

Light.Sight.Safety is a coalition of lighting suppliers creating more awareness and understanding of the safety, comfort and environmental aspects of good quality automotive lighting by
• bridging the gap between the scientific community, lighting industry stakeholders and policy/rule makers;
• initiating, funding & managing scientific investigations on further road safety improvements enabled by car lighting;
• producing & communicating intelligence on lighting as a means to enhance safety for all road users.
More information: https://clepa.eu/lightsightsafety/

Imprint

Status September 2020
Image licences: CLEPA / Light.Sight.Safety
Copyright: CLEPA / Light.Sight.Safety