Finalised recommendations for legislation proposal and standardisation

Deliverable Number	D7.3
Deliverable Type	R – Document, Report
Dissemination Level	PU (Public)
Author(s)	Robert Leute (MAR)
Document Version & Status	V2.0 | Final

Project Acronym	HEIDI
Project Title	Holistic and adaptivE Interface Design for human-technology Interactions
Grant Agreement Number	101069538
Project Coordinator	Virtual Vehicle Research GmbH
Project Website	https://heidi-project.eu/

HEIDI has received funding from the European Union's Horizon Europe research and innovation programme under Grant Agreement No. 101069538.

Author(s)

Name	Organisation	Name	Organisation
Robert Leute	MAR		

Reviewers

Name	Organisation	Date
Miguel Angel Sotelo	UAH	2025-08-18
Paolo Pretto	VIF	2025-08-20

Change History

Version	Date	Name/Organisation	Description
0.1	2025-07-30	R. Leute / MAR	Document created
0.2	2025-08-18	R. Leute / MAR	Input from MAR experts
1.0	2025-08-18	R. Leute / MAR	Ready for Review
2.0	2025-08-21	R. Leute / MAR	Input from Reviewers, creation of final version

Table of Contents

List of Figures

List of Tables

1. Executive Summary

Communication of vehicles with other road users, especially vulnerable road users (VRUs) has great potential to benefit traffic safety and improve traffic flow.

However, the deployment of eHMIs needs amendments to existing regulations in order to fulfil their potential.

Therefore, this deliverable presents recommendations how to add these additional communication functions into the regulation and create the framework for eHMIs to exist in. It is based on the research done during the HEIDI project and builds on the preliminary recommendations already presented. Indeed, over the course of the HEIDI project, the efficacy of external human machine interfaces (eHMIs) was demonstrated. Studies done both with virtual reality and real-world prototypes integrated into a test vehicle were conducted.

In this document, an outlook is also provided to highlight the path where HEIDI's work can support the non-governmental organizations (NGOs) tasked with regulation proposals which will be needed to take over the mantle and make eHMIs for vehicle to VRU communication a reality in the future.

Keywords: external HMI, traffic conditions, regulations

2. Objectives

HMI systems developed during the HEIDI project present significant legal and regulatory challenges that need to be addressed alongside the related ethical questions (see D5.1 “Ethical guidelines and procedures”). For this reason, we will compile a catalogue of recommendations and guidelines for the implementation of test protocols leading to the standardisation of these systems. These activities are supported by the results from D7.1 “Report on Evaluation Tests” and D7.2 “HMI Rating”. In addition, this deliverable is a revision of the preliminary recommendations for standardisation presented in D5.4 “Initial recommendations for Legal Framework and Standardisation”.

Specifically, we will make recommendations for and address the following topics:

- Mounting / Placement of an eHMI on a *road* vehicle.
- Optical parameters allowing for appropriate visibility while avoiding glare & discomfort.
- Use-cases and situations where eHMIs shall be utilized.
- Messages which shall be conveyed by eHMIs.
- Requirements on Symbols & Patterns to be used for messages.
- Systematic requirements.

These aspects have already been discussed in D3.1 “Concept - Pedestrian-Car HMI” and D5.4. This deliverable may be understood as the evolution of a growing understanding of eHMIs over the course of the HEIDI project.

Establishing appropriate parameters, in which HMIs can be safely and legally used is key to ensure the benefits and technological opportunities.

3. Motivation

The HEIDI project has identified a significant opportunity for improvement in current automotive standards related to external vehicle lighting. With the advancement of adaptive and autonomous driving technologies, the need for intuitive and communicative interfaces between vehicles and external road users has become increasingly important.

Existing regulations do not adequately address the needs of modern traffic environments, where explicit, dynamic communication between vehicles and pedestrians or other road users will become increasingly essential for safety.

The following functions will bring real benefit and make changes to existing regulation necessary.

Adaptive Communication: External HMIs can display a range of signals, from simple warnings to complex interactions, e.g. indicating pedestrian recognition and intent to yield.

Enhanced Safety: By adapting to environmental conditions and pedestrian characteristics (e.g. distracted or impaired pedestrians), vehicles can convey clearer messages, reducing accidents.

Technological Feasibility: Advancements in display technologies allow for flexible matrix lighting solutions integrated into vehicle exteriors without compromising design or cost-efficiency. However, any regulation should be “open to new technologies” to allow set makers and OEMs to incorporate technologies best suited to their requirements.

Supporting Automation: As vehicles become more autonomous, the ability to communicate intent non-verbally will bridge the gap left by the absence of a human driver.

Safety: Reduction in pedestrian-vehicle accidents through clearer communication.

Clarity: Standardizing eHMI functions will eliminate confusion and improve road safety, facilitating potential learning obligations of road users

Acceptance and Trust: Encouraging wider acceptance of autonomous vehicles by providing clear and understandable communication of vehicle actions to all road users but especially for vulnerable traffic participants.

In conclusion, updating current regulations to include provisions for external HMIs will not only enhance road safety but also pave the way for seamless integration of future automotive technologies. This initiative aligns with the EU's Vision Zero strategy to eliminate road fatalities and serious injuries.

4. Recommendation for eHMI regulation

External HMIs will presumably fall under the umbrella of external lighting of vehicles which is highly regulated for use on public roads. Some use cases of the proposed eHMI might allow homologation under existing regulations, other use cases will require amendments to existing regulation. In the following both the existing framework, as well as proposed changes and amendments are presented.

This report is focussing on UNECE (United Nations Economic Commission for Europe) regulations R48 [1] (including annexes & amends [2][3]), R148 [4] (including annexes & amends[5]-[9]) and R149 [10] (including annexes & amends [11]-[17]). There are multiple further regulations for light functions like Fog Lamp, reverse light, etc., which are not expected to be of interest regarding eHMI applications. However, there will be references to regulation regarding system logic like UNECE R13 [18].

Table 4-1: UNECE Regulations regarding vehicle lighting

Regulation	Title	Comment	Ref
48	Uniform provisions concerning the approval of vehicles with regard to the installation of lighting and light-signalling devices	Main regulation	[1]
148	Uniform provisions concerning the approval of light-signalling devices (lamps) for power-driven vehicles and their trailers	Specific regulation, signalling devices (DRL, TI, etc.)	[4]
149	Uniform provisions concerning the approval of road-illumination devices (lamps) and systems for power-driven vehicles	Specific regulation, illumination devices (LB, HB, etc.)	[10]

4.1 Placement of eHMI

Regulation R48 chapter 6 contains regulations regarding position and orientation of allowed lighting units. Figure 4–1 is taken from R48 in chapter 6. It is important to note that all lighting functions in the front are required to be mounted below the windshield, specifically, main functions are required to be lower than 1200 mm above ground, signal functions may be positioned up to 1500 mm above ground. Additionally, light functions are always assigned to one side, with most functions having symmetric implementations left and right.

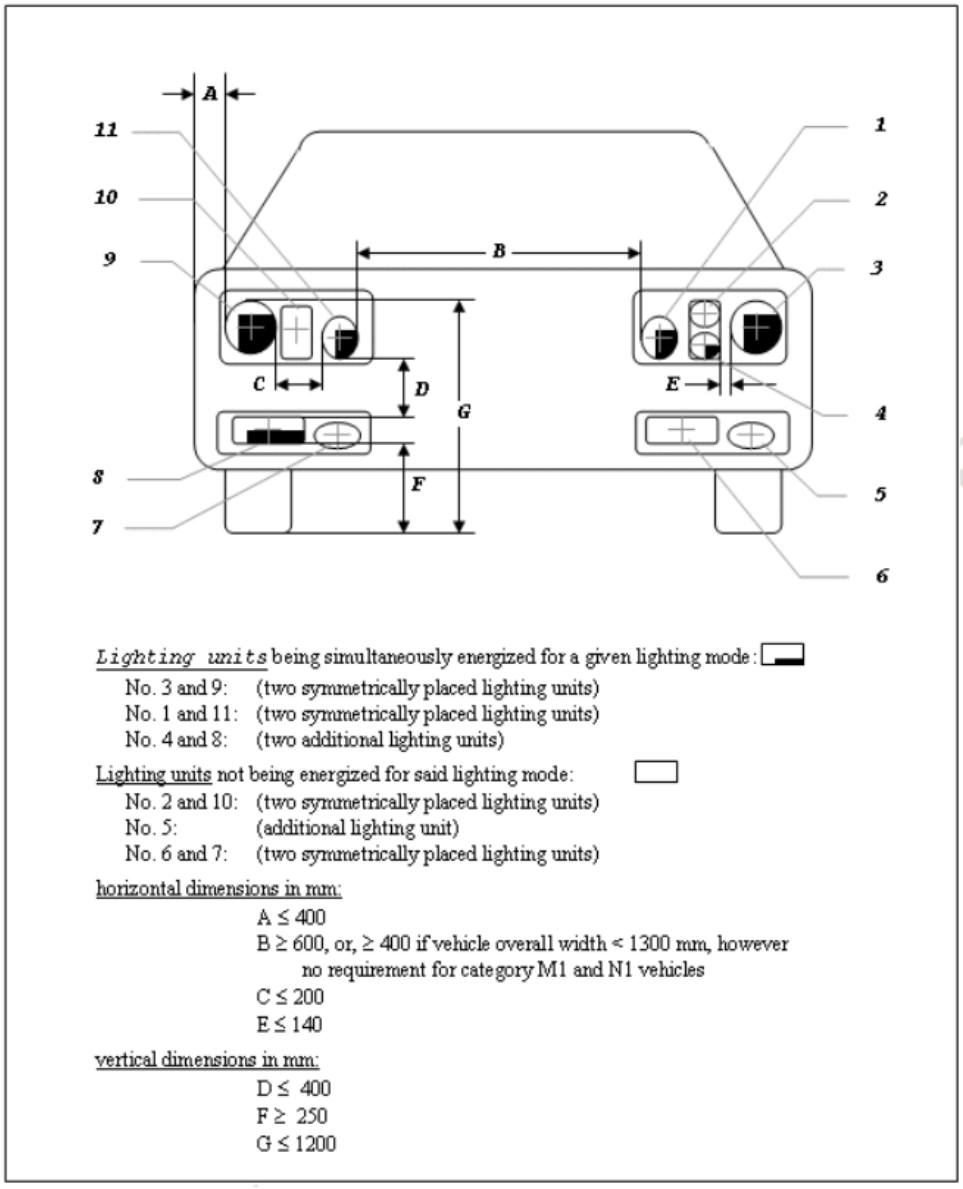


Figure 4–1: Placement of lighting units according to and taken from [1]

We recommend the following requirement for the placement of eHMI.

- Above ground, no less than 350 mm.
- Below windshield, not higher than 1500 mm above ground, see R48 6.5.4.2.1.
- Inside of position lamps (light functions indicating the width of the vehicle).
- No requirement on minimal / maximal distance to other light functions beyond requirement above to allow central placement.
- Either single eHMI display or segmented, e.g. two per vehicle and one per side.
- No dimensional requirement on the eHMI itself, rather requirement on the symbols/patterns displayed, see section 4.4.

4.2 Optical requirements of eHMI

In the following we will make recommendations for the optical characteristics of the eHMIs. We will address multiple aspects.

- Visibility, i.e. viewing angles.

- Recognizability, glare and discomfort, i.e. brightness requirements, including dynamic brightness.
- Colour, main colour and additional colours to allow adaptive messaging.

4.2.1 Visibility - Readability

Regulation R148 [4] contains requirements on all signal functions which are currently allowed under UNECE standards. Figure 4–2 shows the definition of viewing angles whereas [4] contains the requirements per function.

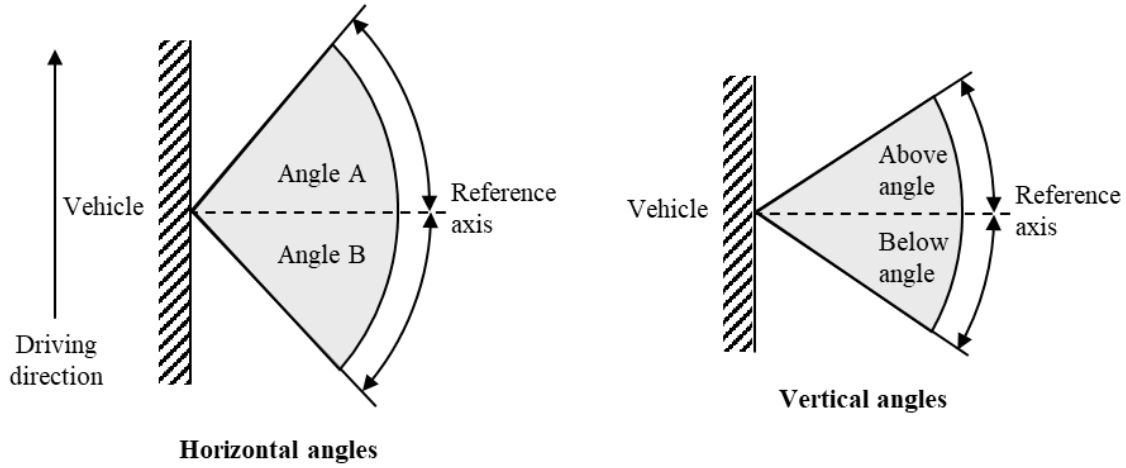


Figure 4–2: Angles of geometric visibility, horizontal and vertical [4].

Note for Table 4-2, the smaller values in brackets are for lamps mounted lower than 750 mm above ground.

Table 4-2: Visibility angles for front signal functions

Lamp	Minimum horizontal angles (inboard / outboard)	Minimum vertical angles (above / below)
Front direction indicator	45°/80° (20°/80°)	15°/15° (15°/5°)
Front/rear position pair	20°/80°	15°/10° (15°/5°)
Daytime running lamps	20°/20°	10°/5°

Any eHMI device to be homologated under existing regulation, i.e. Position Light or Direction Indicator / TI, needs to fulfil these requirements.

Experience with the real-world prototype, presented in D6.1 “iHMI & eHMI prototype” corroborates these requirements with slight adaptation for a higher vertical visibility, especially for short distances.

Therefore, our recommendations for requirements for visibility for eHMI are as follows:

- Horizontal visibility minimum 45 degrees to each side.
- In case of an eHMI comprising of multiple segments, at least one instance of a message pattern must always be visible from 45 degrees horizontally of either side.
- Vertical visibility of 15 degree downward (5 degrees in case of a mounting height below 750 mm).
- Vertical visibility of 45 degrees upward.

- In case of an eHMI comprising of multiple segments, at least one instance of a message pattern must always be visible from 45 degrees upwards.

4.2.2 Brightness

Regarding brightness for an eHMI multiple aspects have to be considered.

- Good visibility under most conditions.
- No glare to other road users under most conditions.
- Support understanding of communication.

Regarding the first two aspects, visibility and glare, we recommend the following.

- Brightness of the eHMI shall be adaptive to surrounding conditions.
- In bright daylight, i.e. outside illumination > 25,000lx, the minimum brightness shall be >9000 cd/m^2.
- In reduced illumination (clouded, dusk/dawn, etc.) with outside illumination > 7000 lx, the minimum brightness shall be >3000 cd/m^2.
- During nighttime, with outside illumination < 7000 lx, the brightness of the eHMI shall be between 700 cd/m2 and 1500 cd/m^2.
- Further adaptation with regards to
    - Fog
    - Snowfall
    - Rain
    - Spray
    - Dust clouds
    - Contamination of the light emitting surface

This follows examples from UNECE R48, sections 2.93 and 5.26.

In addition to this generally adaptive brightness with regards to outside conditions, we recommend allowing adaptation of brightness to support communications, especially regarding situations requiring an urgent reaction, e.g. imminent collision or emergency breaking.

Following the example of UNECE R48, section 6.23, we propose the following:

- In cases of urgency, the eHMI shall be allowed to flash its message with a frequency of 4 Hz ± 1.0 Hz.

4.2.2.1 Brightness measurements

In order to measure the brightness of the eHMI, we recommend a procedure to allow calculation of brightness based on an illuminance measurement, which is standard for signalling functions.

- a pre-defined pattern of no less than 100 cm^2 shall be displayed.
- either 50% of the area being completely illuminated, e.g. checkerboard pattern.
- or the complete area shall be illuminated with a 50% dimming.
- Illuminance is measured at 5 m distance under certain angles, see Table 4-3.
- Brightness is calculated based on illuminance and illuminated surface.

The table below shows the angles for measurement of illuminance. Values are given as relative with 100 relating to 100 percent of the respective values defined in 4.2.2.

Table 4-3: Recommended measurement points, vert. & horiz. angles, rel. illuminance

h/v	0°	-5 °/+5 °	-10 °/+10 °	-20 °/+20 °	-30 °/+30 °	-45 °/+45 °
30 °						20
20 °						
15 °				30		
10 °		40	40			
5 °	60	60	60			
0 °	100	100	80	40		
-5 °	60	60	40		20	20

4.2.3 Colour

A major topic in regulation 48 concerns visibility requirements for signals. Specifically, the choice of colour when designing an eHMI to the front is considered in Chapter 5.10 of [1], see also the annex, which clearly eliminates the colour red as option for eHMI messaging.

In general, colour is an important feature to enable clear understanding of the message. Therefore, we recommend the following:

- The eHMI is required to display patterns and messages in white.
- The colour white is defined in UNECE R48, section 2.1.1. with well-defined boundaries, as given in Table 4-4 and Table 4-5.
- The use of cyan shall be optional in case of vehicles of ADAS automation level 3 with autonomous features active. This shall be used together or instead of a cyan ADAS indicator.
- The use of further colours, if not prohibited by other regulations, e.g. red, shall be optional, together with flashing in case of situations of high urgency, e.g. emergency breaking or to prevent imminent collision.

Table 4-4: CIE White boundaries for Illuminance

name	description	formula
W12	green boundary	y = 0.150 + 0.640 x
W23	yellowish green boundary	y = 0.440
W34	yellow boundary	x = 0.500
W45	reddish purple boundary	y = 0.382
W56	purple boundary	y = 0.050 + 0.750 x
W61	blue boundary	x = 0.310

Table 4-5: CIE White intersection points

	x	y
W1	0.310	0.348
W2	0.453	0.440
W3	0.500	0.440
W4	0.500	0.382
W5	0.443	0.382
W6	0.310	0.283

We recommend for the measurement of colour the same test pattern as used for measurement of brightness.

4.3 Messages to be communicated

In D1.1 “Description of user needs” specific user needs were identified and together with other research [19][20], fundamental objectives for the eHMI are identified:

- Driving mode information. It informs other road users that additional sensing and control functions beyond the ego-driver are active and can influence the behaviour of the vehicle. This function can be signalled with cyan lamps.
- Information about perception, i.e. communicate to other road users that they have been detected. This is the replacement for eye-contact.
- Information about current status and intention. Support other road users to correctly evaluate speed, change of speed, change of direction.

The tasks above can in future iterations be supported by an additional functionality:

- Initiate Cooperation. For optimal safety and optimized traffic flow, a truly holistic approach will consider all road users affected by a situation. An osmotic layer uses information from all participants in order to reach an optimal conclusion. A vehicle will then not only communicate its own intention but also a solution for the situation.

However, this deliverable will focus on the first three, and especially on the second and third, i.e., information about perception and information about current status and intention.

We therefore identified the need for each eHMI to communicate the following messages:

- VRU with intention to cross/interact has been detected.
- Vehicle is slowing down.
- Vehicle is moving at constant velocity / accelerating.

In case of an ego-driver being in control of the vehicle, the messages can only be about the current status of the vehicle. In case of a fully autonomous vehicle, the messages, esp. “slowing down” can also be about intent.

These messages are currently very reduced and leave any decision on how to interact with the vehicle to the intended recipients themselves. Currently, we recommend no messages which direct instructions on how to behave to VRUs.

In the future further messages might be recommended for collaborative HMI solutions.

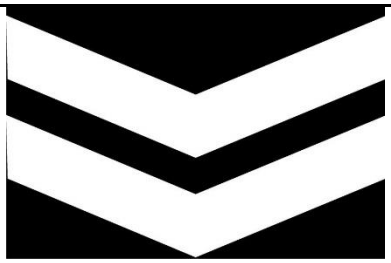
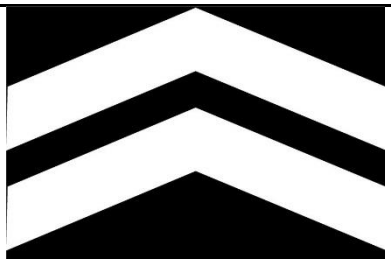
4.4 Patterns to be displayed

For each message, clear symbols/patterns are to be displayed. We have the following requirements:

- Simplicity, it must be possible to show these symbols on a wide variety of technical solutions for eHMIs.
- Clarity, the symbols themselves must be easily recognizable.
- Widespread appeal, the symbols shall not have cultural annotations, e.g. no hand signatures, text, or similar.

Therefore, we recommend the use of the following symbols (Table 4-6):

Table 4-6: Patterns to be displayed by eHMI.

Symbol Name	Symbol Image	Symbol Meaning	Additional info
Eye		VRU detected, “I see you”	Shall consist of at least one oblong outline
Chevrons downward		Vehicle slowing down	Dynamic, i.e. sequential illumination or animated movement.
Chevrons upward		Vehicle moving at speed/accelerates	Dynamic i.e. sequential illumination or animated movement

The symbols can be reinforced by dynamic appearance, as described in sections 4.2.2 and 4.2.3:

- Flashing “eye” symbol to draw attention.
- Dynamic appearance, animation of “chevrons upward” and “chevrons downward”, e.g. subsequent flashing of individual chevrons to indicate movement, or animated chevrons moving along indicated direction.
- Colour change to indicate urgency, e.g. if distance between moving vehicle and VRU is below a certain threshold.

4.4.1 Requirements on pattern display

While we recommend no size requirement for the eHMIs themselves, we recommend a size requirement by the symbols themselves. Depending on the technical solution used, the size of the eHMI will follow from that.

Regarding size and usage of patterns, we recommend the following:

- The apparent surface (see UNECE R 48 2.10.4) of each symbol displayed shall be no less than 100 cm^2.
- The apparent surface for each surface shall not exceed 800 cm^2.

- More than one pattern can be displayed at the same time, i.e. eye symbol and chevrons, if the requirement above is met.
- Conflicting patterns must NOT be visible at the same time, e.g. chevrons downward and upward.
- Patterns can be shown alternating, e.g. eye symbol and chevrons alternating. Each pattern shall be shown for at least 0.4 s.
- In case of segmented animation, at least three chevrons shall be shown in sequence.
- Timing requirements for animated or segmented lighting shall be defined at a later stage.

5. Recommendation for Vehicle / System requirements

As described, this deliverable focuses on recommendations for regulations and standardization regarding eHMIs. Nevertheless, effective use of eHMIs for vehicle to VRU communication requires the following capabilities of the vehicle:

- Sensing capabilities in line with ADAS level 2 or higher.
- Capability to reliably detect VRUs at distances of 30 m when adjacent to road in case of a straight road.
- Capability to calculate time to collision and similar metrics to evaluate risk of interaction with VRUs.
- At the time of type approval, compliance with this requirement shall be confirmed by the vehicle manufacturer.

5.1 Limitations on use of eHMI

As a new and specific light function for interactions, we recommend restricting the use of the eHMI function as follows:

- The function – NOT individual patterns – shall be switched on by the user of the vehicle. This might happen as part of activating an assistance function, autopilot, etc.
- Communication via eHMI shall only be active at speeds below 55 km/h.
- Communication via eHMI shall only be active in case of a VRU detected within 50 m distance.
- In case of an error detected, the function shall be switched off. Fail State is OFF.

6. Conclusion

This deliverable presents recommendations for standardization and regulation of external HMIs for use in traffic to communicate between vehicles and others, especially vulnerable road users.

The recommendations aim to accommodate the clear benefits as well as drawbacks of an additional light function and are meant as starting point for a Standardization / Regulation process as performed by responsible and qualified parties like GTB and GRE.

Therefore, they are not to be understood as complete and or final. Especially on the topic of pattern selection for communication we foresee a strong necessity for further work and discussions.

Accordingly, the research within the HEIDI project, especially the results of studies 10 & 12, will be part of wider communication activities. The whole process will presumably take place over many years with many partners from industry and regulating bodies involved. Further scientific activities can be expected, too.

7. Abbreviations

Term	Definition
ADB	Adaptive driving beam. High beam distribution which can be altered to prevent glare to other road users by creating “tunnels” of low intensity.
AFS	Adaptive Front-lighting System. Light distributions are optimized according to driving situations (speed, curves, traffic …)
BEV	Battery electric vehicle. Electric vehicle exclusively powered by rechargeable battery packs with no secondary source of propulsion.
cHMI	Cooperative HMI
DAP	Driver Assistance Projection
DRL	Daytime Running Light,
eHMI	External HMI
GRE	Working Party on Lighting and Light-Signalling (GRE) is the subsidiary body of the World Forum for Harmonization of Vehicle Regulations (WP29)
GTB	The International Automotive Lighting and Light Signalling Expert Group. A Non-Governmental Organization established in 1952, and in special consultative status with ECOSOC, the UN Economic and Social Council, since 2014.
HB	High beam (main beam, driving beam, full beam). Light distribution for road illumination with bright centre when no other road users are present.
HEIDI	Holistic and adaptivE Interface Design for human-technology Interactions
HMI	Human Machine Interface
iHMI	Internal HMI
KBA	Kraftfahrt-Bundesamt, German Federal Agency in charge of road transportation
LB	Low beam, (dipped beam, passing beam, meeting beam). Light distribution for road illumination in the presence of other road users.
LED	Light Emitting Diode
NGO	non-governmental organization
PCB	Printed Circuit Board
POS	Position Light
PU	Public
PWM	Pulse Width Modulation
R	Document, Report
RID	Road illuminating devices
SNCH	Société Nationale de Certification et d’Homologation. A type approval authority in accordance with European Community (EC) automobile directives and United Nations Economic Community for Europe (ECE) regulations based in Luxembourg

TI	Turn Indicator (direction indicator)
UNECE	United Nations Economic Commission for Europe
VRU	Vulnerable Road User
WP	Work Package

8. References

[1] UNECE R48 https://unece.org/transport/vehicle-regulations-wp29/standards/addenda-1958-agreement-regulations-41-60 forthcoming

[2] UNECE Ref 48 amend 1 https://unece.org/transport/documents/2023/02/standards/un-regulation-no-48-rev14-amend1

[3] UNECE Ref 48 amend 2 https://unece.org/transport/documents/2023/06/standards/un-regulation-no-48-rev14-amend2

[4] UNECE R148 https://unece.org/transport/documents/2021/05/standards/un-regulation-no-148-light-signalling-devices-lsd

[5] UNECE R148 amend 1 https://unece.org/transport/documents/2021/05/standards/un-regulation-no-148-amend1

[6] UNECE R148 amend 2 https://unece.org/transport/documents/2021/04/standards/un-regulation-no-148-amend2

[7] UNECE R148 amend 3 https://unece.org/transport/documents/2021/12/standards/un-regulation-no148-amend-3

[8] UNECE R148 amend 4 https://unece.org/transport/documents/2022/11/standards/un-regulation-no-148-amend4

[9] UNECE R148 amend 5 https://unece.org/transport/documents/2023/03/standards/un-regulation-no-148-amend-5

[10] UNECE R149 Road Illuminating devices (RID) https://unece.org/transport/documents/2021/05/standards/un-regulation-no-149-road-illumination-devices-rid

[11] UNECE R149 amend 1 https://unece.org/transport/documents/2021/05/standards/un-regulation-no-149-amend1

[12] UNECE R149 amend 2 https://unece.org/transport/documents/2021/04/standards/un-regulation-no-149-amend2

[13] UNECE R149 amend 3 https://unece.org/transport/documents/2021/12/standards/un-regulation-no149-amend3

[14] UNECE R149 amend 4 https://unece.org/transport/documents/2022/09/standards/un-regulation-no-149-amend4

[15] UNECE R149 amend 5 https://unece.org/transport/documents/2022/11/standards/un-regulation-no-149-amend5

[16] UNECE R149 amend 6 https://unece.org/transport/documents/2023/02/standards/un-regulation-no-149-amend6

[17] UNECE R149 amend 7 https://unece.org/transport/documents/2023/06/standards/un-regulation-no-149-amend7-1

[18] UNECE R13 Revision 9 https://unece.org/transport/documents/2023/10/working-documents/regulation-no-13-revision-9

[19] K. Bengler, M. Rettenmaier, N. Fritz, A. Feierle: From HMI to HMIs: Towards an HMI Framework for Automated Driving, Information Special Issue “Automotive User Interfaces and Interactions in Automated Driving” (11(2):61), 2020.

[20] A. Schieben, M. Wilbrink, C. Kettwich et al.: Designing the interaction of automated vehicles with other traffic participants: design considerations based on human needs and expectations, Cogn Tech Work 21, (pp. 69–85), 2019.

A - Annex

Following are excerpts from UNECE regulations which are relevant to the content of this deliverable.

Colour Red

UNECE R48

5.10. Provisions regarding light which could give rise to confusion:

5.10.1. Red light emitted by a lamp fitted on the rear of the vehicle (as defined in paragraph 2.1.5.) shall not be visible from the front of the vehicle.

5.10.2. White light emitted by a lamp fitted on the front of the vehicle (as defined in paragraph 2.1.5.) shall not be visible from the rear of the vehicle.

5.10.3. No account shall be taken of lighting devices fitted for the interior lighting of the vehicle.

5.10.4. To verify paragraphs 5.10.1. and 5.10.2.:

5.10.4.1. For the visibility of red light towards the front of a vehicle, with the exception of a red rearmost side marker lamp, **there shall be no direct visibility of the apparent surface of a red lamp** if viewed by an observer moving within Zone 1 in a transverse plane situated 25 m in front of the vehicle (see Annex 4);

5.10.4.2. For the visibility of white light towards the rear of a vehicle, with the exception of reversing lamps and white side conspicuity markings, there shall be no direct visibility of the apparent surface of a white lamp if viewed by an observer moving within Zone 2 in a transverse plane situated 25 m behind the vehicle (see Annex 4);

5.10.4.3. In case of doubt, the requirement above shall be deemed fulfilled if the luminous intensity of the red light emitted to the front and/or the white light emitted to the rear, as verified during type approval of the lamps, is less than 0.25 cd per lamp taking into account the influence of the vehicle body if applicable.

Changing Light Patterns

R48 5.9.2 [1] allows changing the photometric characteristics of signal functions (i.e., DRL / POS). In principle, multiple different symbols can be homologated as signatures which are all allowed to be used.

However, the current regulation and its interpretation by authorities is very restrictive on when to allow a change between signatures.

Options are:

- Change of ambient light conditions (tunnel, nightfall, …)
- Change of lighting mode (switching of main functions LB/HB)
- Vehicle at standstill (choose new personalization)

While those use cases are not well suited for the use cases envisioned for vehicle to VRU communication, it is already very positive that there is precedent to homologate multiple distinct signatures for matrix signal lights.

ADB

UNECE R48 Automatic Switching ADB

6.1.7.2. The control of the main-beam headlamps may be automatic regarding their switching ON and OFF, the control signals being produced by a sensor system which is capable of detecting and reacting to each of the following inputs:

(a) Ambient lighting conditions;

(b) The light emitted by the front lighting devices and front light-signalling devices of oncoming vehicles;

(c) The light emitted by the rear light-signalling devices of preceding vehicles.

Additional sensor functions to improve performance are allowed.

6.1.7.3. It shall always be possible to switch the main-beam headlamps ON and OFF manually and to manually deactivate the automatic control of the main-beam headlamps.

Moreover, the switching OFF of the main-beam headlamps and the deactivation of their automatic control shall be by means of a simple and immediate manual operation; the use of sub-menus is not allowed.

6.1.9.3. Automatic switching ON and OFF of the main-beam headlamps:

6.1.9.3.1. The sensor system used to control the automatic switching ON and OFF of the main-beam headlamps, as described in paragraph 6.1.7.2., shall comply with the following requirements:

6.1.9.3.1.1. The boundaries of the minimum fields in which the sensor is able to detect light emitted from other vehicles defined in paragraph 6.1.7.2. above are defined by the angles indicated below.

6.1.9.3.1.1.1. Horizontal angles: 15° to the left and 15° to the right.

Vertical angles:

Upward angle	5°		
Mounting height of the sensor (centre of sensor aperture above the ground)	Less than 2 m	Between 1.5 m and 2.5 m	Greater than 2.0 m
Downward angle	2°	2° to 5°	5°

These angles are measured from the centre of the sensor aperture relative to a horizontal straight line through its centre and parallel to the longitudinal median plane of the vehicle.

6.1.9.3.1.2. The sensor system shall be able to detect on a straight level road:

(a) An oncoming power driven vehicle at a distance extending to at least 400 m;

(b) A preceding power driven vehicle or a vehicle-trailers combination at a distance extending to at least 100 m;

(c) An oncoming bicycle at a distance extending to at least 75 m, its illumination represented by a white lamp with a luminous intensity of 150 cd with a light emitting area of 10 cm^2 ± 3 cm^2 and a height above a ground of 0.8 m.

To verify compliance with (a) and (b) above, the oncoming and preceding power driven vehicle (or vehicle-trailer combination) shall have position lamps (if applicable) and dipped-beam headlamps switched ON.

6.1.9.3.2. The transition from main-beam to dipped-beam and vice versa according to the conditions indicated in paragraph 6.1.7.2. above may be performed automatically and shall not cause discomfort, distraction or glare.

6.1.9.3.3. The overall performance of the automatic control shall be verified by:

6.1.9.3.3.1. means of simulation or other means of verification accepted by the Type Approval Authority, as provided by the applicant.

6.1.9.3.3.2. a test drive according to paragraph 1 in Annex 12. The performance of the automatic control shall be documented and checked against the applicant’s description. Any obvious malfunctioning shall be contested (e. g. excessive angular movement or flicker).

6.1.9.3.4. The control of the main-beam headlamps may be such that the main-beam headlamps are switched ON automatically only when:

(a) no vehicles, as mentioned in paragraph 6.1.7.2. above, are detected within the fields and distances according to paragraphs 6.1.9.3.1.1. and 6.1.9.3.1.2.;

And

(b) the detected ambient lighting levels are as prescribed in paragraph 6.1.9.3.5. below.

6.1.9.3.5. In the case where main-beam headlamps are switched ON automatically, they shall be switched OFF automatically when oncoming or preceding vehicles, as mentioned in paragraph 6.1.7.2. above, are detected within the fields and distances according to paragraphs 6.1.9.3.1.1. and 6.1.9.3.1.2.

Moreover, they shall be switched OFF automatically when the illuminance produced by ambient lighting conditions exceeds 7000 lx.

Compliance with this requirement shall be demonstrated by the applicant, using simulation or other means of verification accepted by the Type Approval Authority. If necessary the illuminance shall be measured on a horizontal surface, with a cosine corrected sensor on the same height as the mounting position of the sensor on the vehicle. This may be demonstrated by the manufacturer by sufficient documentation or by other means accepted by the Type Approval Authority.

Stop Light

UNECE R48 Variable Intensity

2.9.3. "Variable intensity control" means the device which automatically controls rear light signalling devices producing variable luminous intensities to assure the unvarying perception of their signals. The variable intensity control is part of the lamp, or part of the vehicle, or split between the said lamp and the vehicle.

2.10.4. The "apparent surface" for a defined direction of observation means, at the request of the manufacturer or his duly accredited representative, the orthogonal projection of: Either the boundary of the illuminating surface projected on the exterior surface of the lens; Or the light-emitting surface; Only in the case of a light-signalling device producing variable luminous

intensities, its apparent surface that may be variable as specified in paragraph 2.9.3. shall be considered under all conditions permitted by the variable intensity control, if applicable.

5.26. Rear direction indicator lamps of category 2b, rear position lamps of category R2 and stop lamps of category S2 with variable luminous intensity control, which respond simultaneously to one or more of the conditions listed in paragraphs 5.26.1. and 5.26.2., are allowed, provided that:

(a) The intensity of the all lamps mentioned above, when combined, grouped or reciprocally incorporated, vary all together in the same manner and in a similar proportion.

(b) In the entire intensity range, the specific prescribed ratio between the luminous intensities of two lamps, if applicable, shall be maintained throughout variation transitions.

5.26.1. Environmental conditions Increase and decrease of the luminous intensity, in the limits prescribed in the pertinent UN Regulations, is allowed in relation to the following conditions:

(a) Ambient lighting,

(b) Fog,

(c) Snowfall,

(d) Rain,

(e) Spray,

(f) Dust clouds,

(g) Contamination of the light emitting surface.

5.26.2. Traffic conditions Independent from environmental conditions mentioned under 5.26.1. a decrease of the luminous intensity, in the limits prescribed in the pertinent UN Regulations, is allowed as long as the vehicle speed is equal or less than 20 km/h or the distance to the following vehicle is equal or less than 20 m. However as long as the vehicle speed is equal or less than 50 km/h the intensity decrease already activated may remain active.

5.26.3. Stop lamps of category S4 and rear fog lamps of category F2 may produce variable luminous intensity, based on the conditions listed in paragraphs 5.26.1. and 5.26.2., independently from the other lamps.

5.26.4. No sharp variation of intensity shall be observed during transition. It may be possible for the driver to set the functions above to static luminous intensities.

UNECE R13 Braking Logic

5.2.1.31. When a vehicle is equipped with the means to indicate emergency braking, activation and de-activation of the emergency braking signal shall only be generated by the application of the service braking system when the following conditions are fulfilled: [footnote 10, 10 At the time of type approval, compliance with this requirement shall be confirmed by the vehicle manufacturer.]

5.2.1.31.1. The signal shall not be activated when the vehicle deceleration is below the values defined in the following table but it may be generated at any deceleration at or above those values, the actual value being defined by the vehicle manufacturer: The signal shall not be activated below N1 6 m/s2 M2, M3, N2 and N3 4 m/s2 The signal shall be de-activated for all vehicles at the latest when the deceleration has fallen below 2.5 m/s2 .

5.2.1.31.2. The following conditions may also be used: (a) The signal may be generated from a prediction of the vehicle deceleration resulting from the braking demand respecting the activation and de-activation thresholds defined in paragraph 5.2.1.31.1 above; or (b) The signal may be activated when the service braking system is applied at a speed above 50 km/h and when the antilock system is fully cycling (as defined in paragraph 2. of Annex 13). The signal shall be de-activated when the antilock system is no longer fully cycling.

UNECE R 48 Emergency Brake Signal

6.23. EMERGENCY STOP SIGNAL

6.23.1. Presence Mandatory on motor vehicles. Optional on trailers. The emergency stop signal shall be given by the simultaneous operation of all the stop or direction-indicator lamps fitted as described in paragraph 6.23.7.

6.23.2. Number As specified in paragraph 6.5.2. or 6.7.2.

6.23.3. Arrangement As specified in paragraph 6.5.3. or 6.7.3.

6.23.4. Position As specified in paragraph 6.5.4. or 6.7.4.

6.23.5. Geometric visibility As specified in paragraph 6.5.5. or 6.7.5.

6.23.6. Orientation As specified in paragraph 6.5.6. or 6.7.6.

6.23.7. Electrical connections

6.23.7.1. All the lamps of the emergency stop signal shall flash in phase at a frequency of 4.0 ± 1.0 Hz.

6.23.7.1.1. However, if any of the lamps of the emergency stop signal to the rear of the vehicle use filament light sources the frequency shall be 4.0 +0.0/-1.0 Hz.

6.23.7.2. The emergency stop signal shall operate independently of other lamps.

6.23.7.3. The emergency stop signal shall be switched ON and OFF automatically.

6.23.7.3.1. The emergency stop signal shall be switched ON only when the vehicle speed is above 50 km/h and the braking system is providing the emergency braking logic signal defined in Regulations Nos. 13 and 13-H.

6.23.7.3.2. The emergency stop signal shall be automatically switched OFF if the emergency braking logic signal as defined in Regulations Nos. 13 and 13-H is no longer provided or if the hazard warning signal is activated.