# Revised fluid internal HMI concept

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|---|---|---|---|
| 0.1 | 2023-12-14 | Sandra Trösterer (VIF) | First structure |
| 0.2 | 2024-01-19 | Sandra Trösterer, Caitlin Velasquez (VIF) | First complete draft |
| 1.0 | 2024-02-16 | Sandra Trösterer, Paolo Pretto (VIF) | Final draft |
| 2.0 | 2024-02-26 | Paolo Pretto (VIF) | Revised final version |

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# 1. Executive Summary

This deliverable contains the descriptions of the revised internal fluid Human-Machine Interface (iHMI) concepts for regular (attentive and distracted) drivers and older drivers. The purpose of the different versions of the iHMI is to inform, warn, and instruct the respective driver category about pedestrians who are about to cross the road. Therefore, the different needs of the two driver categories – regular (also distracted), and older drivers – were considered when designing the iHMI.

The initial concepts (as described in D2.1 "Initial fluid iHMI concept description") were implemented as prototypes to be investigated in exploratory simulator studies with participant samples of the respective driver group. This deliverable depicts the revised iHMI concepts, which are the outcome of a two-step iteration process:

First, the initial prototypes were iterated and adapted in several pretests, thereby mostly focusing on simplification (e.g., by removing superfluous or obtrusive information), adequate time-to-collision (TTC) values (i.e., when a certain warning is shown), and fine-tuning of individual HMI components (e.g., size and position of head-up display icons) (section 3).

Second, the iterated prototypes were investigated in two exploratory simulator studies with 10 drivers under the age of 50 in attentive and distracted state ("regular drivers"), and 5 drivers over the age of 70 ("older drivers"). The age range of both groups was selected to ensure adequate differences in driver's needs related to aging factors. During the studies, driving data and subjective impressions about the HMIs were collected to explore the safety, usability and effectiveness of the proposed designs. The results are presented in D2.3 "Initial simulator studies results" (see section 4 for a summary).

Some of the initial HMI concepts were therefore improved based on participant feedback. The resulting revised concepts of the iHMI for regular (attentive and distracted) drivers ("regular iHMI") and for older drivers ("older iHMI") are described in this deliverable (section 0). The descriptions account for the level of escalation of the message that is provided to the driver, ranging from simple information (L0, L1), to warning (L2), alert (L3) and emergency (L4).

These HMI concepts will be further investigated in upcoming evaluation studies in WP5 (Validation Methods & Standardisation Recommendations).

**Keywords:** internal HMI, distracted driver, older driver, fluid interactions, pedestrian crossing, pedestrian safety

# 2. Objectives

The main objective of this deliverable is to describe the revised versions of the internal fluid human-machine interface (iHMI) concepts. Initially, the iHMI concepts were iteratively designed to fulfil the needs of two driver categories: regular (under the age of 50), including driver in attentive and distracted states, and older (over the age of 70), as described in D2.1. Two studies in driving simulator environment were carried out to test the selected versions of the respective iHMIs: “regular iHMi” for regular (attentive and distracted) drivers and “older iHMI” for older drivers. Results are reported in D2.3. Hence, the revised version of the iHMIs was produced considering the results of the preliminary studies and the participants’ feedback, as reported here.

This deliverable addresses the HEIDI Objective 1 "Develop and demonstrate fluid, cooperative HMI solutions", Objective 2 "Develop technical innovation modules for mutual awareness between road users and drivers", and Objective 3 "Develop suitable validation methods for assessing fluid, cooperative HMI solutions".

In relation to Objective 1, this deliverable provides a complete description of all messages that are provided to the driver via the iHMI, considering the driver’s state (attentive/distracted) and the driver’s choice to adhere or not to the recommended or expected action. The revised iHMI design is described to highlight the innovative fluid features of the displayed messages. Also, the revised iHMI version has been designed to improve usability, safety, and effectiveness of the system, facilitating the recognition of pedestrians’ intentions also by drivers who are not in the best state (i.e., distracted) or conditions (older) to respond promptly to approaching dangerous situations. The iHMI logics and messages incorporate real-time data from driver’s observed state and actions, as well as information about pedestrians’ position and motion, therefore addressing Objective 2. The user-centred, iterative evaluation process of the iHMI concept design, together with the acquisition and analysis of subjective and objective data within the preliminary studies, enabled the development of sensitive and valid assessment methods that will be used in WP5, WP6 and WP7 validation studies (Objective 3).

# 3. Iterative design process

The concept of fluid interaction enables human-machine interfaces to adapt to user's state and conditions, integrating data from driver monitoring, vehicle sensors, and connected infrastructure. The adaptation consists in providing information the is needed by the specific user type in a specific situation, in a way that minimizes distraction and workload and maximizes understanding, acceptance and safe (re)actions, not only for the driver, but also for other (vulnerable) road users. In other words, only the information that is needed is provided when and where necessary. These goals are achieved by analyzing the road situation, selecting the proper information to be provided to the different stakeholders, and shaping the messages to ensure the most efficient communication. Properties of the messages that are considered include the timing, the sensory modality, the location and amount of information to be displayed. The timing led to the creation of messages in escalating sequence, where the urgency of the message content increases at every step ("Level of escalation" L0-L4, Figure 5-2). Each step is triggered only if the situation becomes more safety critical and the driver does not react as expected or recommended. The saliency of related signals is increased accordingly, targeting multiple sensory modality (e.g., visual, auditory) with the purpose of increasing situational awareness and oversight, and eliciting prompt and proper reactions as the criticality of the situation increases. The logics controlling the escalation sequence is based on vehicle state, driver's state, and surrounding (road) conditions and/or users. The location where the information is displayed adapts to the driver's gaze direction, effectively counteracting visually distracting non-driving-related activities, like, e.g., attending the infotainment screen or the roadside. Finally, both the design of the displayed message (visual and auditory) and the escalation sequence adapt to the user's conditions, enabling also older users, or users with reduced sensory/cognitive/motor abilities, to respond safely to critical situations.

Therefore, the iterative design process of the iHMI, as depicted in Figure 5-2, was dictated by the principles described above, which resulted in qualitative and quantitative differences for the combinations of iHMI messages, interactive situations, and target users. Indeed, Figure 5-2 indicates that the fluidity of the iHMI can be read both horizontally and vertically. Different columns show the fluid adaptation of the iHMI messages to different user states (attentive and distracted) and age-related conditions (below the age 50 and above the age of 70). For example, it can be noted that in the scalation level "L2: Warning", a distracted regular driver receives an additional spatial sound indication to be informed about the location of the approaching pedestrian, as compared to the attentive regular driver. Also, an older driver can hear an explicit voice message recommending an action "*Attention: slow down, pedestrian on right side*" and see an enhanced icon on the Head-Up-Display, highlighting the pedestrian's contour and position. These differences are constructed to fit the specific needs and limitation of the three driver's types, as described in D1.1 “Description of user needs”.

# 4. Summary of results from exploratory studies

This section is an excerpt of deliverable D2.3 "Initial simulator studies results", which describes two small-scale exploratory studies that were executed in a driving simulator to evaluate the first versions of the iHMI. The main results of those studies are summarized to provide the reader with the rationale for the revision of the iHMI design (section 0). Subjective and objective data were collected from 15 participants, including regular (sometimes distracted) and older drivers. Questionnaires and interviews were used to evaluate the usability of the interface, while the analysis of the motion of the simulated vehicle allowed to assess the impact of the interfaces on driving behavior. The first exploratory study was focused on the evaluation of regular drivers (age 20 – 50) in both attentive and distracted states, while the second exploratory study was dedicated to older drivers (age 70+).

In study 1 – regular and distracted drivers – the fundamental principles of the fluid iHMI designed for regular drivers "*Regular iHMI*" were tested, and its effects were compared to "*no iHMI*" and to a selected version of the iHMI designed for older drivers, which uses LED strips to highlight pedestrians in specific situations "*Older iHMI LED*".

In study 2 – Older drivers – two versions of the fluid iHMI that account for specific needs and age-related limitations in older drivers were tested. In general, both versions present more information earlier to the drivers in various forms, including voice messages supporting the HUD (Head-Up-Display) icons and recommendations for the driver. These recommendations are given a step earlier in comparison to the *regular iHMI* design and the design escalates more quickly in urgency with regards to the messages to the driver. "*Older iHMI*" and "*Older iHMI LED*" differ in the presence of an LED strip in the latter, which is used to further highlight pedestrians' positions and changes thereof. The design of the *Older iHMI* instead relies purely on voice messages and HUD icons to convey the relevant information.

The main usability results (safety, comfort and effectiveness) and differences in driving behavior are summarized below for the respective studies.

## 4.1 Study 1 – Regular drivers

Main results from the subjective measures indicate that both iHMI versions (regular iHMI and older iHMI LED) were rated positively with regards to usability and perceived safety, with a preference for the regular iHMI version, considered as more acceptable due to less obtrusive audio messages. The design of self-explanatory HUD icons, as well as the presence of LED warnings were rated positively in both versions. Notably, the (subtle) changes in the messages directed to regular vs. distracted drivers went mostly unnoticed. On the negative side, it was often requested to shorten the duration of the displayed icons, reduce the brightness of the LED, and remove the voice prompts from the older iHMI LED version, all perceived as rather distracting. All participants indicated that they could imagine using a version of the iHMI in a real car, as it helped increasing driving safety and protecting pedestrians via earlier detection. However, concerns were raised as to the reliability of such a system in detecting the actual pedestrian intention and to overreliance on the system, inducing unsafe driving behavior.

Main results from the objective measures indicate that the adoption of iHMI may help driver reducing their approaching speed, facilitating faster braking reactions and at a farther distance in case of crossing pedestrians. Moreover, it seems that iHMi would help maintaining a better lateral control of the vehicle.

In general, it can be concluded that subjective and objective results are in line indicating that both iHMI versions lead to safer driving behavior compared to baseline and are adequately warning the driver on time about approaching pedestrians.

## 4.2 Study 2 – Older drivers

Main results from the subjective measures are less distinct than in study 1. This is most likely due to the lower number of participants and simulated events. However, several contradictions also appeared between self-assessed questionnaires and the results of interviews. Both versions of the iHMI for older drivers (with/without LED aid) were rated positively with regards to usability and perceived safety. The LED version seemed to be preferred by older drivers for perceived safety and especially for acceptance.

In general, the LEDs were positively perceived and referred to. However, it was also mentioned that they could be irritating and confusing during night. Notably, a similar consideration was also recorded in study 1. Contrary to study 1, though, the clearly noticeable voice prompts were experienced positively. Nevertheless, it appears unclear whether a participant would be willing to use such a system in a real car. On the one hand, it is perceived as helpful and safe; on the other hand, it is viewed with scepticism. Older drivers generally prefer to rely on their own skills rather than to adopt new technologies. Finally, it seems that LED are not a strong enough feature to really make the HMI more usable, while voice prompts may suffice.

Main results from the objective measures may indicate that older participants drove more slowly and braked earlier when using the Older iHMI LED version compared to the Older iHMI version without LEDs. These results add to a generally more cautious driving behavior measured with older participants, as compared to the study with regular drivers.

In general, the same preliminary conclusions can be drawn as for study 1. The iHMI is perceived by older drivers as facilitating safe driving behavior and adequately warning the driver in time of approaching pedestrians.

Overall, all three HMI versions seemed to be effective in warning and informing the respective drivers about incoming pedestrians. The older iHMI LED was not liked by regular drivers because of obtrusive voice messages, while older drivers seemed to be satisfied with it. Therefore, it is advisable to keep the differentiation in the iHMI design targeting different driving populations.

# 5. Revised iHMI concepts

The HEIDI iHMIs aim at increasing the safety of interaction between crossing pedestrians and vehicles. Therefore, the iHMIs inform, warn, and alert the driver according to the respective level of escalation (L0-L4, see Figure 5-2), i.e., at a certain time to collision (TTC). At the highest level of escalation (L4), the vehicle activates automatic emergency braking (AEB). This type of advanced driver assistance system (ADAS) is already available in many vehicles and is beyond the scope of interactive situations such as those considered in this project. Note that for escalation levels L2 and L3 the reaction of the drivers is considered, i.e., the next-level warning or alert will only be triggered if the drivers do not slow down or brake sufficiently at the current alert level. If they react promptly and adequately, however, no further action of the HMI is necessary, and the drivers will not receive any further warnings. This adaptiveness ensures that the driver only receives information when it is needed and in a timely manner, thus, increasing safety as drivers can react in time and promoting acceptance since the frequency of warnings is kept to a minimum.

Furthermore, the presented iHMIs are composed in a multimodal manner, addressing the visual and auditory perception channel of the driver depending on the respective driver needs and state. The hardware components are depicted in Figure 5-1.

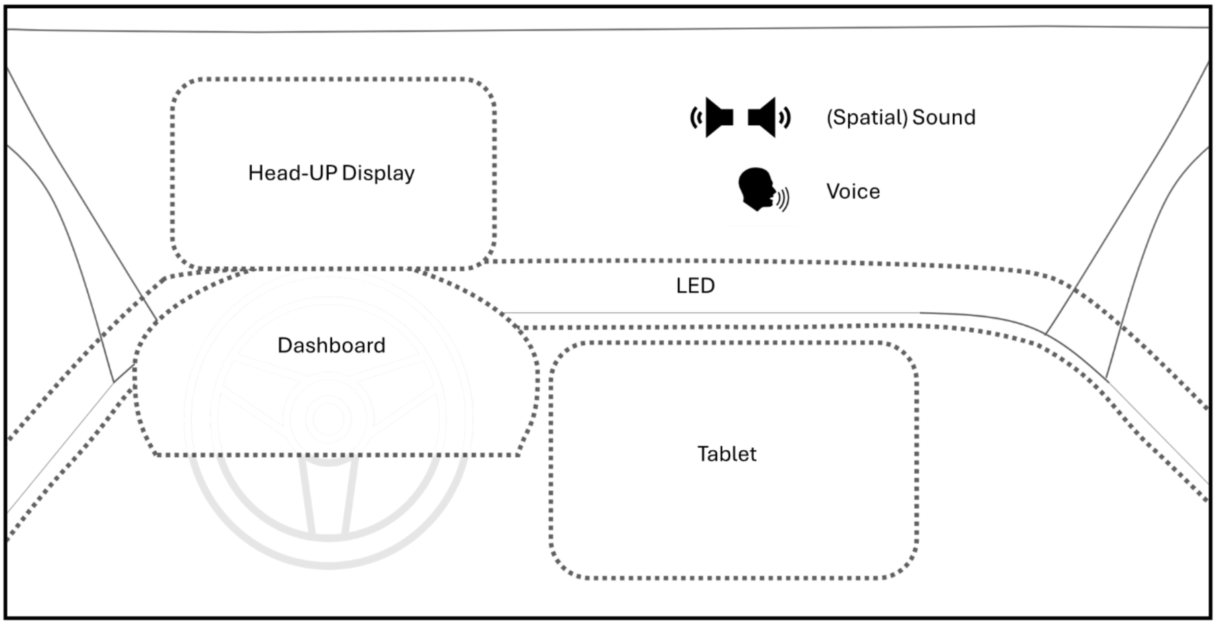


Figure 5-1: HMI components for visual and auditory information.

The iHMI for regular drivers provides information to the driver via head-up display (HUD) icons, sound, and light-emitting diodes (LEDs) on an LED strip mounted at the bottom of the windshield. An eye-tracking system captures drivers' eye-movement data in real-time to determine whether the driver is attentive or visually distracted (e.g., by performing a side task). If a distracted state is detected, the HMI uses additional modalities to inform and warn the driver (see Figure 5-2) and the L3 alert is given at an earlier point in time. A detailed description of the regular iHMI for attentive and distracted driver state is provided in section 5.1. The iHMI for older drivers provides information via HUD icons, sound, and speech messages. A detailed description is provided in section 5.2.

Note that in the Older iHMI the behavior recommendation is provided already at L2 stage, i.e. with a TTC of 8 seconds.  Also, note than on the highest escalation L4, both iHMIs use an HUD icon, LEDs, and voice to convey the alert message.

| | Regular iHMI – if driver is attentive: | Regular iHMI – if driver is distracted: | Older iHMI |
|---|---|---|---|
| L0: System Failure (unable to detect pedestrian) | Pedestrian detection deactivated + **sound** | Pedestrian detection deactivated + **sound** | Pedestrian detection unavailable + **sound** and **voice** |
| L1: Inform (approaching crosswalk) | TTC = 10s | TTC = 10s + **sound** | TTC = 10s + **sound** |
| L2: Warning (location of detected pedestrian) | TTC = 8s + **LED** | TTC = 8s + **LED** and **spatial sound** | TTC = 8s + **sound** and **voice** |
| L3: Alert (behavior recommendation) | TTC = 5s STOP + **LED** and **sound** | TTC = 6s STOP + **LED** and **sound** and **tablet** | TTC = 4s STOP + **voice** |
| L4: Emergency (automatic braking) | TTC = 2s NOTHALT + **LED** and **voice** | | TTC = 2s NOTHALT + **LED** and **voice** |

Figure 5-2: Overview of the iHMI concepts for regular (left) and older drivers (right).

## 5.1 iHMI for regular (attentive and distracted) drivers

In the following, the iHMI concept for regular drivers is described in detail for each alert level as depicted in Figure 5-2. First, it is outlined how the HMI works if the driver is attentive (section 5.1.1), and then how it works if a distracted state of the driver is detected (section 5.1.2). For the detection of a distracted state, the iHMI uses real-time eye-movement data captured by an eye-tracking system and the AttenD algorithm (Kircher & Ahlström, [1] ) is applied (see D2.2 "Driver monitoring and behavior prediction system" for more details).

L0: Generally, in case the pedestrian detection system should not work, drivers are informed as depicted in Figure 5-3, independently of their state. A sound indicates the malfunction of the system and the message "*Pedestrian detection not available*" is shown in the dashboard.

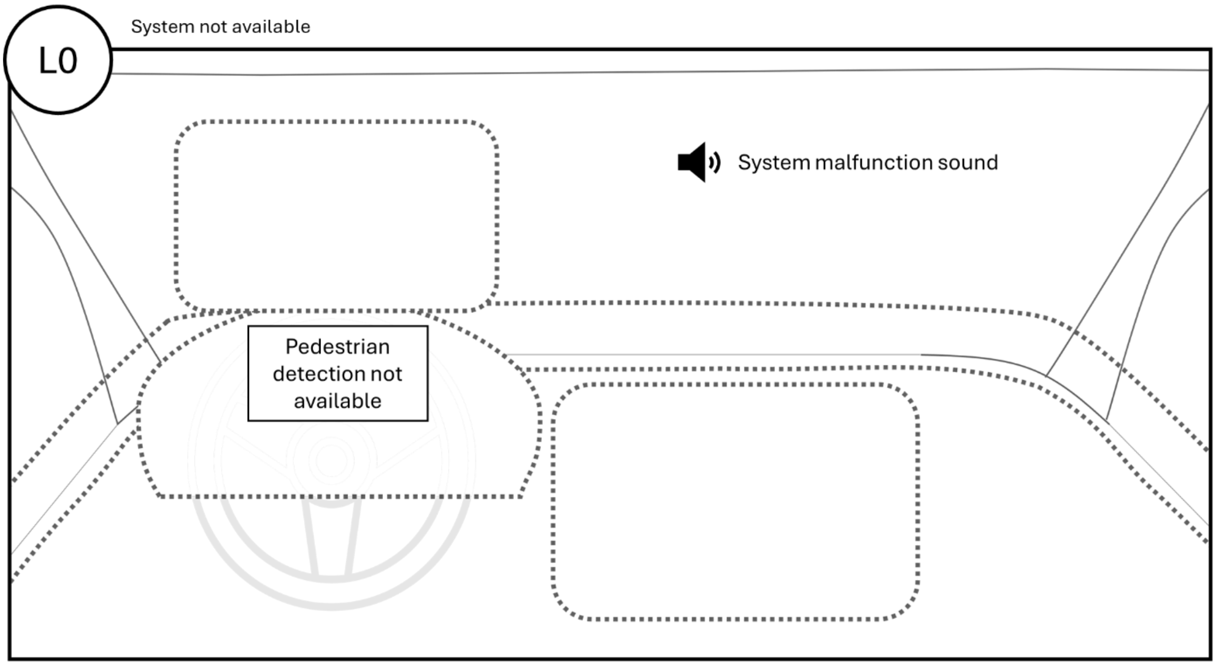


Figure 5-3: Regular iHMI: System not available (unable to detect pedestrian).

### 5.1.1 Driver in attentive state

L1: If drivers are in attentive state and are approaching a crosswalk, they are informed about the crosswalk by an icon shown in the head-up display at TTC=10s (Figure 5-4). This allows drivers to anticipate the upcoming crosswalk and potentially crossing pedestrians.

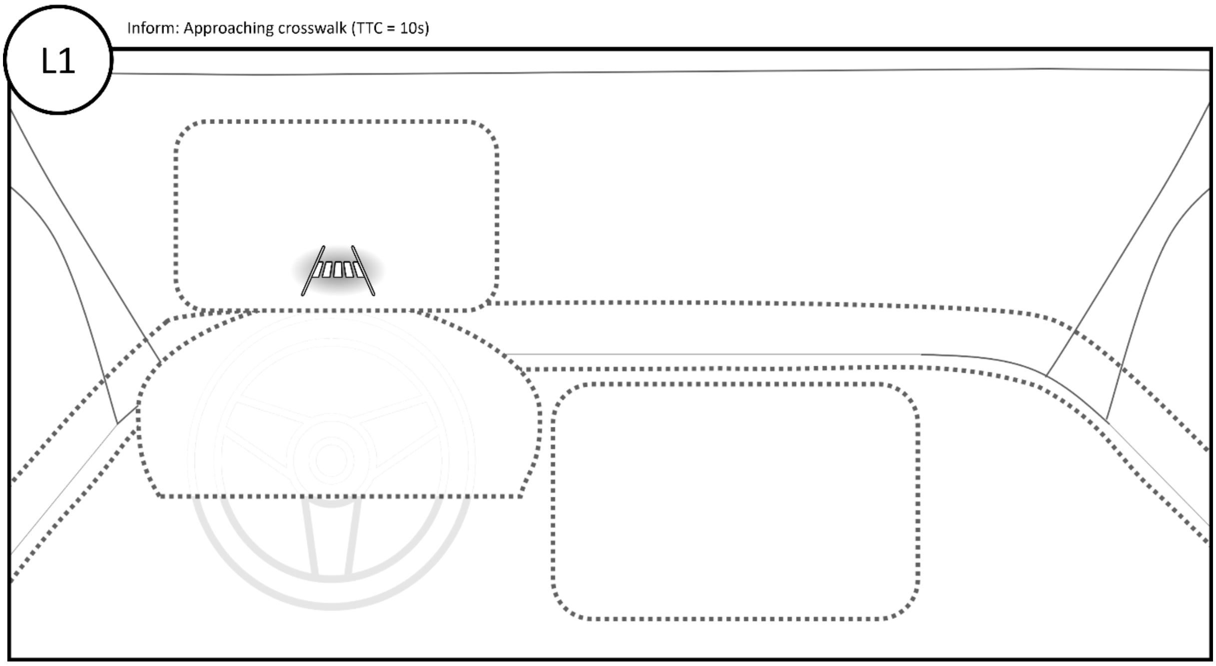


Figure 5-4: Regular iHMI – attentive driver: Inform (approaching crosswalk).

L2: If a pedestrian who is about to cross is detected nearby the crosswalk, the icon in the HUD changes and indicates the pedestrian position (left or right of the crosswalk). LED lights are indicating the position and distance to the pedestrian. The position is indicated by a matching horizontal position of the LED light, while distance is indicated by the width of the LED light, i.e., the closer the driver gets to the pedestrian, the broader the LED light becomes. Figure 5-6 gives an example of a warning of a pedestrian on the right side of the crosswalk. The warning is provided at TTC=8s.

Note that the iHMI also covers the case where a pedestrian is about to cross without a crosswalk present. In that case, the driver does not get the L1 alert since no crosswalk is detected, but the L2 warning is issued directly with an adapted HUD icon (see Figure 5-5) and the LEDs indicating the pedestrian position.

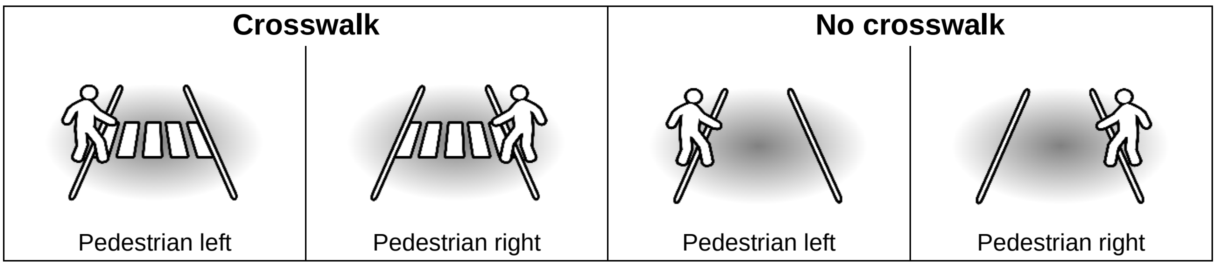


Figure 5-5: Regular iHMI: HUD icons to indicate pedestrian position with/without crosswalk.

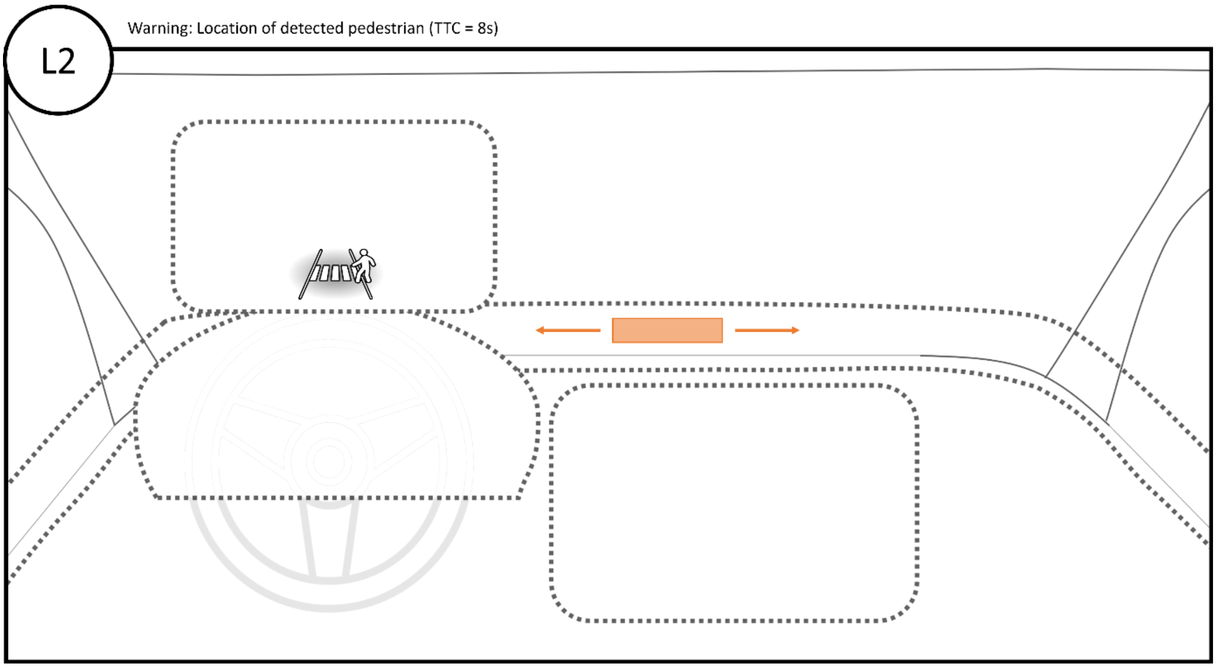


Figure 5-6: Regular iHMI – attentive driver: Warning (location of detected pedestrian).

When drivers are provided with this warning, they may react by braking or slowing down. Here, one central aim in HEIDI is to correctly assess the driver's reaction and intention by considering driving and gazing behaviour. Note that an according algorithm is currently under development (D2.2 “Driver monitoring and behavior prediction system”). In the exploratory simulator studies, it was considered an appropriate reaction when the drivers decreased their speed to below 30 km/h. In case the driver reacts appropriately by slowing down or stopping to let the pedestrian pass, no further action by the iHMI is required and the icon and LEDs disappear.

L3: However, if the driver does not show such a reaction, an escalated alert is provided. At TTC=5s, a warning sound is issued, and drivers are displayed with the behavioural recommendation to stop, which is indicated by a “*stop*” message above the HUD icon. Note that at this point, the LEDs indicating the pedestrian position are increased in their width (Figure 5-7).

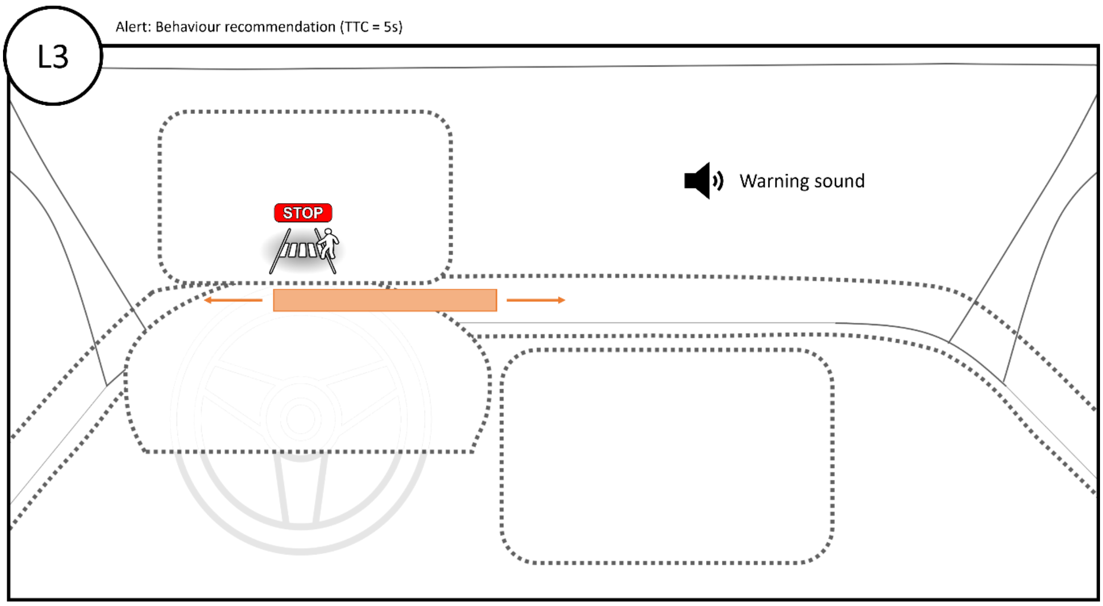


Figure 5-7: Regular iHMI – attentive driver: Alert (behaviour recommendation).

If drivers are reacting appropriately at this point by stopping, the iHMI indications disappear, however, if drivers still do not show any reaction, the highest escalation level is triggered:

L4: If drivers do not react, an emergency stop is performed by the vehicle at TTC=2s, i.e., the car brakes automatically to a full stop. This action is indicated by the iHMI by showing a corresponding icon in the HUD, an audio message “*Emergency stop*” and the LEDs turning red over the full length of the windshield (Figure 5-8). Note that the highest escalation level is the same for drivers in attentive or distracted state.

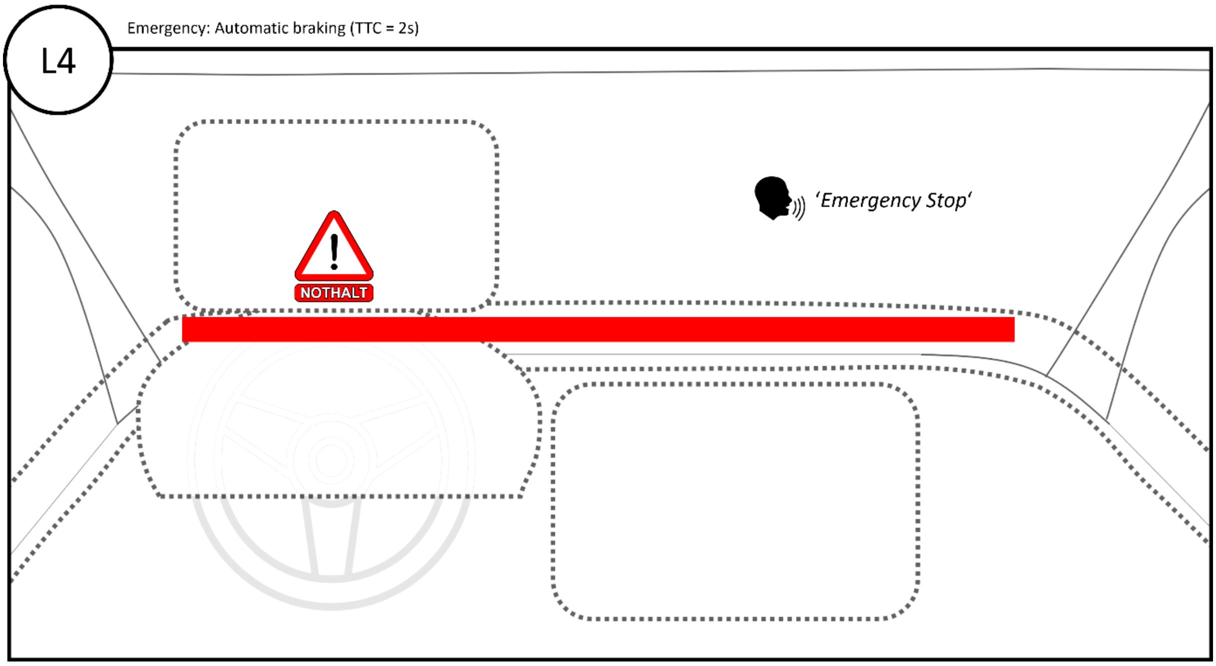


Figure 5-8: Regular iHMI: Emergency (automatic braking).

### 5.1.2 Driver in distracted state

If a driver is visually distracted by, e.g., performing a side task such as texting while driving, the iHMI adapts to this distracted state by providing additional auditory cues, an adapted TTC for L3 alerts, and by showing visual information where it can be perceived by the distracted driver. Thereby, the iHMI follows the same escalation levels as for the attentive driver.

L1: If a distracted driver approaches a crosswalk this is indicated by an icon in the HUD (same as for attentive state) at TTC=10s, however, it is accompanied by a subtle sound. This allows a visually distracted driver to become aware of the crosswalk, even if they are not looking at the road in this moment (Figure 5-9).

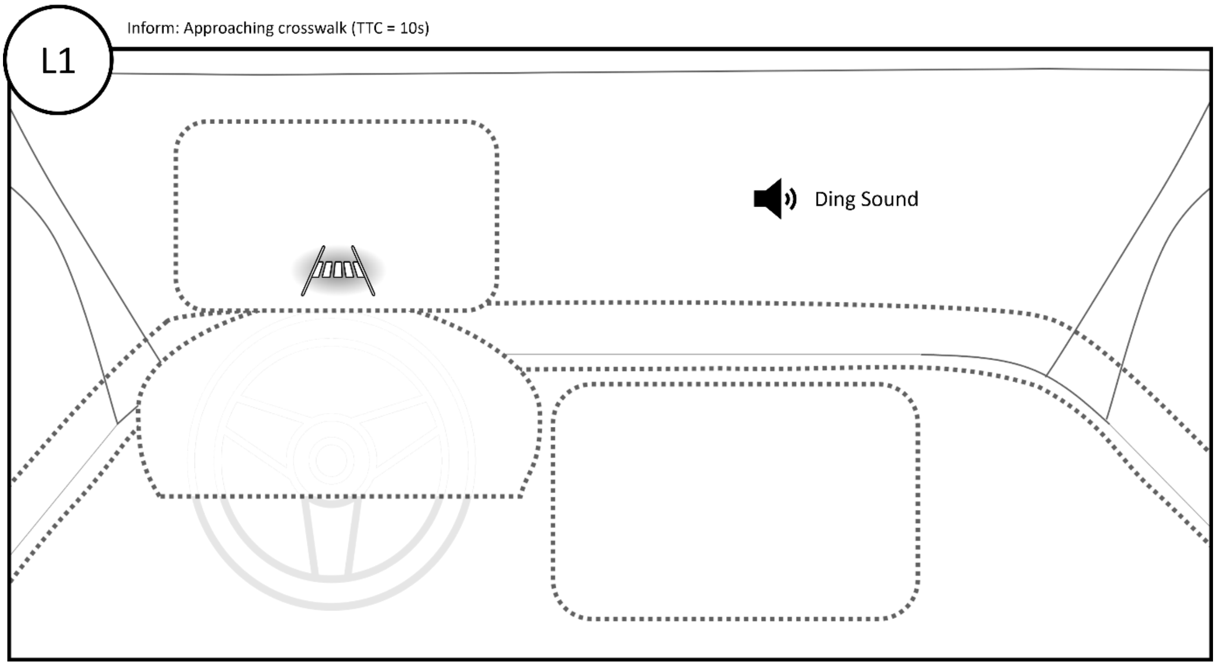


Figure 5-9: Regular iHMI – distracted driver: Inform (approaching crosswalk).

L2: If a pedestrian who is about to cross is detected, this is indicated by a corresponding HUD icon and the LEDs indicating the pedestrian position at TTC=8s. In addition, spatial sound indicates the pedestrian position (Figure 5-10), i.e., if the pedestrian is on the right side, also the sound will come from the right side, allowing drivers to perceive where the pedestrian is coming from, even if they are currently not looking at the road.

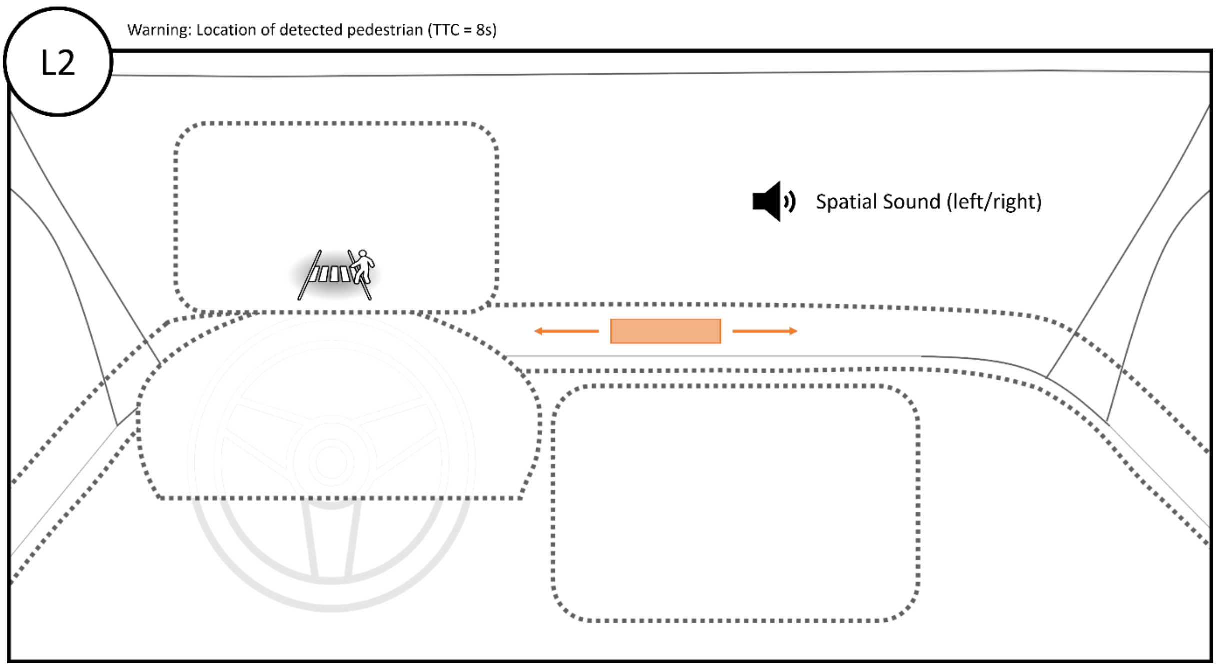


Figure 5-10: Regular iHMI – distracted driver: Warning (location of detected pedestrian).

If the driver reacts at this point and brakes or slows down adequately, no further action of the iHMI is required and the hints disappear. However, if drivers do not react, the next escalation level is triggered.

L3: Considering that the driver is distracted and will also need time to focus on the driving task again, the L3 alert is provided at TTC=6s (in contrast to 5s for attentive state) to give the driver one second more time to react. As is the case with the attentive state (Figure 5-7), a stop message is displayed above the HUD icon, a warning sound is issued, and the LEDs further indicate the current position and distance to the pedestrian. However, for distracted drivers, the icon and stop message are also shown on the tablet in use for the side task (Figure 5-11). This means that the behavioural recommendation to stop is shown where the driver is most likely currently looking at, allowing them to immediately perceive the information. In the current design, showing the icon also automatically interrupts the possibility to continue with the side task as it is shown in full-screen and the icon only disappears if the driver reacts appropriately. Note that eye-tracking data could provide the information where the driver is currently looking at in real time, and the shown information could basically “float” with the gaze of the driver, i.e., could be shown either on the HUD or the tablet depending on where the driver is currently looking at. However, this also requires highly reliable and accurate eye-tracking data.

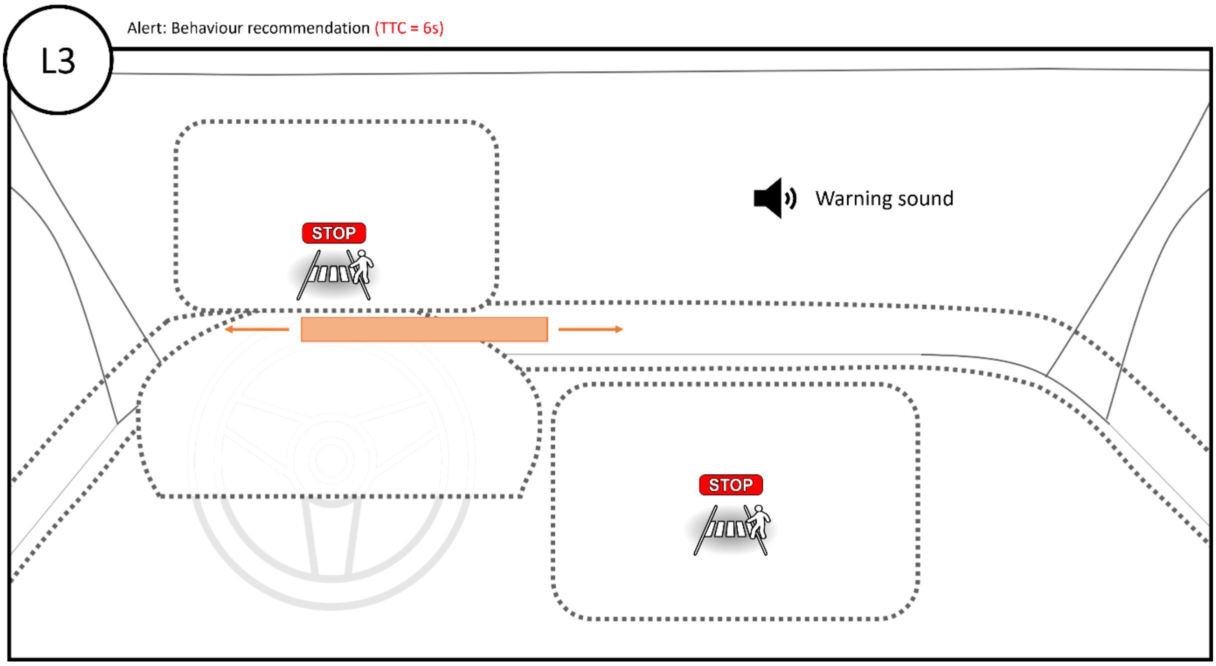


Figure 5-11: Regular iHMI – distracted driver: Alert (behaviour recommendation).

Both features (earlier TTC, stop indicated on tablet) allow the driver to react appropriately and in time.

L4: If, however, the driver still does not react, the vehicle would automatically brake to a full stop at TTC=2s with corresponding indications by the iHMI (Figure 5-8). As outlined before, the vehicle behaviour and iHMI indications are the same as for attentive drivers at this point.

Figure 5-12 provides an overview of the implemented regular iHMI for drivers in distracted state for the simulator setup. Note that LED brightness and width will be further adapted for the upcoming studies, as this was perceived as too bright and broad by several participants in the exploratory study.

L1: An upcoming cross-walk is indicated by an icon in the HUD and is accompanied by a sound.

L2: If a pedestrian who is about to cross is detected, this is indicated by an icon and the LEDs show the pedestrian position. Furthermore, spatial sound indicates the position.


L3: At a TTC=6s, the icon changes (shows stop) and is displayed on the tablet used for the side task. This is accompanied by a warning sound.

L4: If the driver still does not react at TTC=2s, the system is designed to trigger an emergency stop. The LEDs change to red, an emergency stop icon is shown and a voice message is given (“*Emergency stop*”).

Figure 5-12: Different layouts of the regular iHMI when the driver is distracted.

## 5.2 iHMI for older drivers

In the following, the iHMI concept for older drivers is described in detail for each alert level as depicted in Figure 5-2.

L0: In general, if the pedestrian detection system should not work, drivers receive the alert as depicted in Figure 5-13. In that case, the message "*Pedestrian detection not available*" is shown in the dashboard, accompanied by the voice message "*Warning, pedestrian detection not available*". The voice message is preceded by a pre-emptive notice sound.

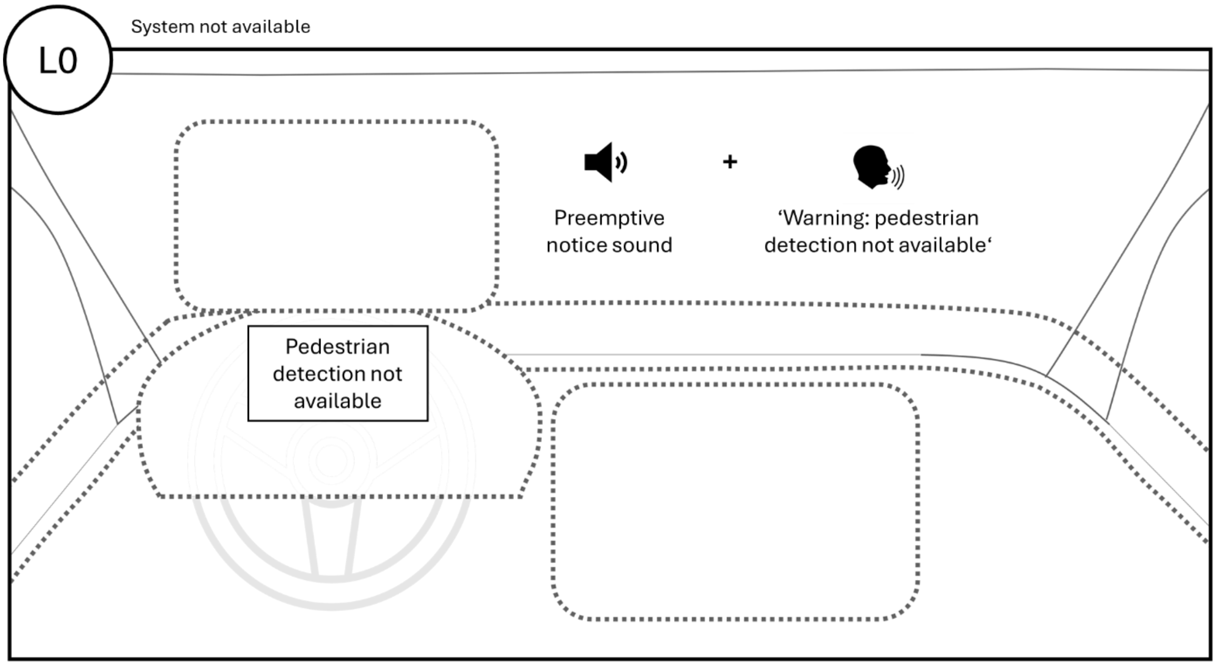


Figure 5-13: Older iHMI: System not available (unable to detect pedestrian).

L1: If the driver approaches a crosswalk, this is indicated by a corresponding HUD icon and an additional sound at TTC=10s (Figure 5-14). This allows drivers to anticipate the upcoming crosswalk and potentially crossing pedestrians.

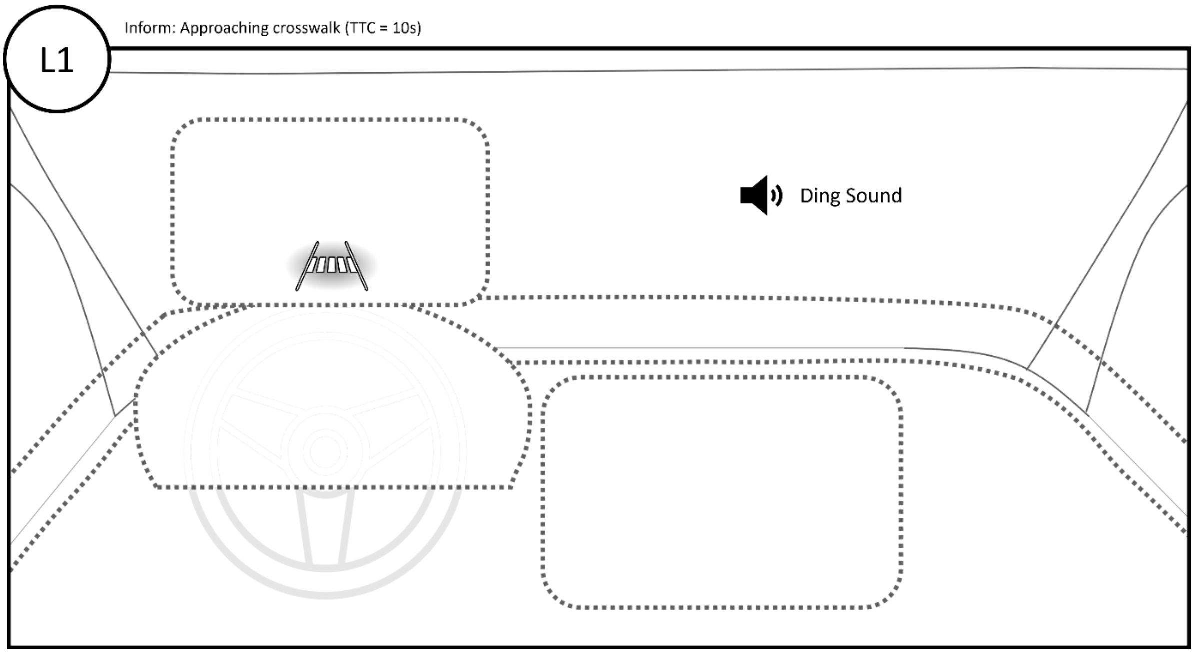


Figure 5-14: Older iHMI: Inform (approaching crosswalk).

L2: If a pedestrian who is about to cross is detected, this is indicated by a HUD icon and a voice message (with pre-emptive notice sound) at TTC=8s: “*Attention: slow down, pedestrian on right side*” (in case the pedestrian is on the right side, Figure 5-15). Hence, in contrast to the iHMI for regular drivers, older drivers already receive a recommendation of what to do at this point to account for eventual slower reaction times and allowing them to react early enough and with enough time available. Also note that the HUD icon is designed slightly different compared to the regular iHMI, more prominently highlighting the pedestrian position with a red frame. Like the regular iHMI, the older iHMI is also designed for cases where pedestrians want to cross a road without crosswalk present. In such case no L1 information is provided, but drivers will receive a L2 warning with an adapted HUD icon (see Figure 5-16) and the corresponding voice message.

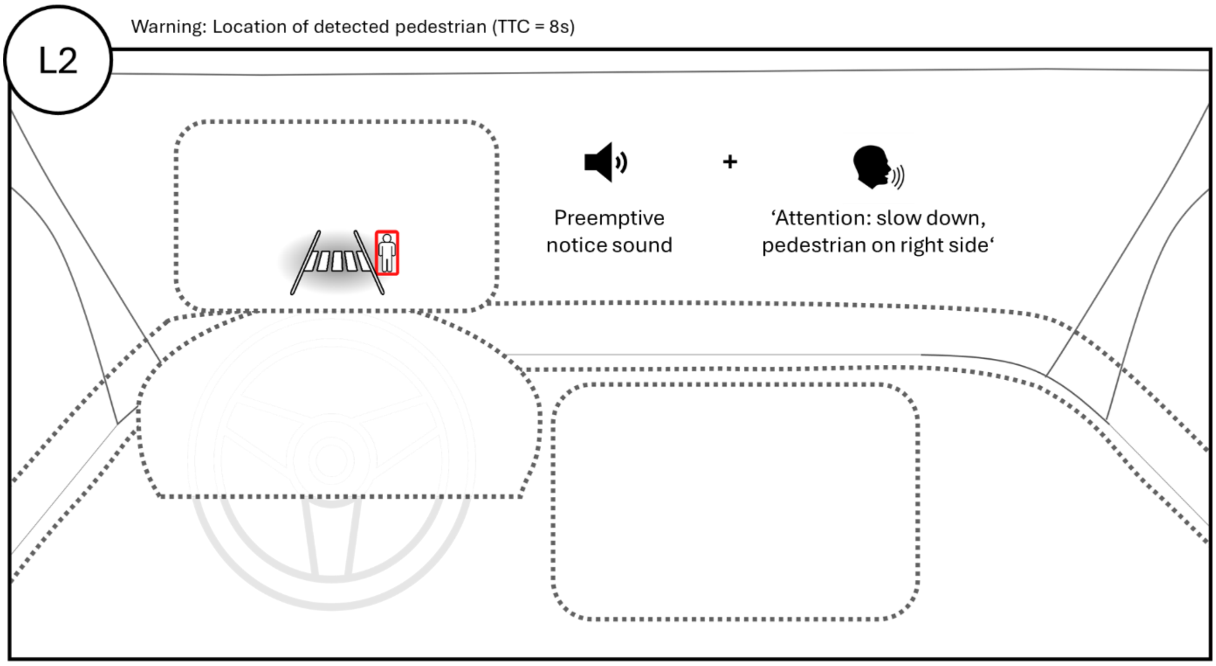


Figure 5-15: Older iHMI: Warning (location of detected pedestrian).

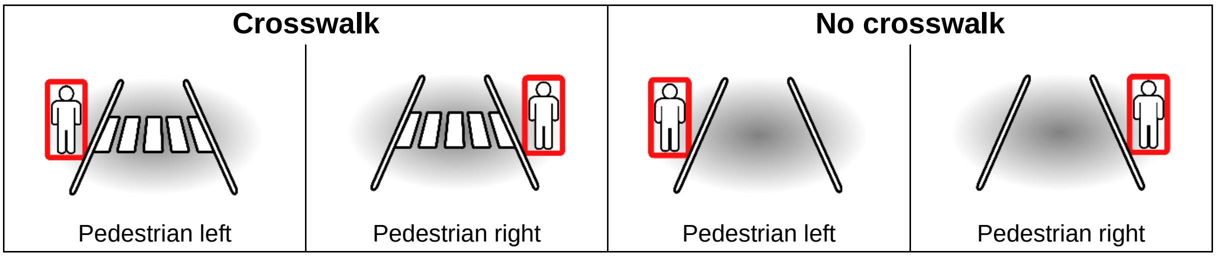


Figure 5-16: Older iHMI: HUD icons to indicate pedestrian position with/without crosswalk.

As outlined, the iHMI for older drivers already gives them advice to slow down at an earlier point in time. If they react accordingly, the HMI hints disappear.

L3: However, if drivers do not react, they receive another alert to stop at TTC=4s. A “*Stop*” message is shown in the HUD, accompanied by an immediate voice message (i.e., without pre-emptive sound): “*Danger – stop immediately*”. The iHMI provides this instruction in a very concise and straightforward manner to avoid confusion about what to do (Figure 5-17).

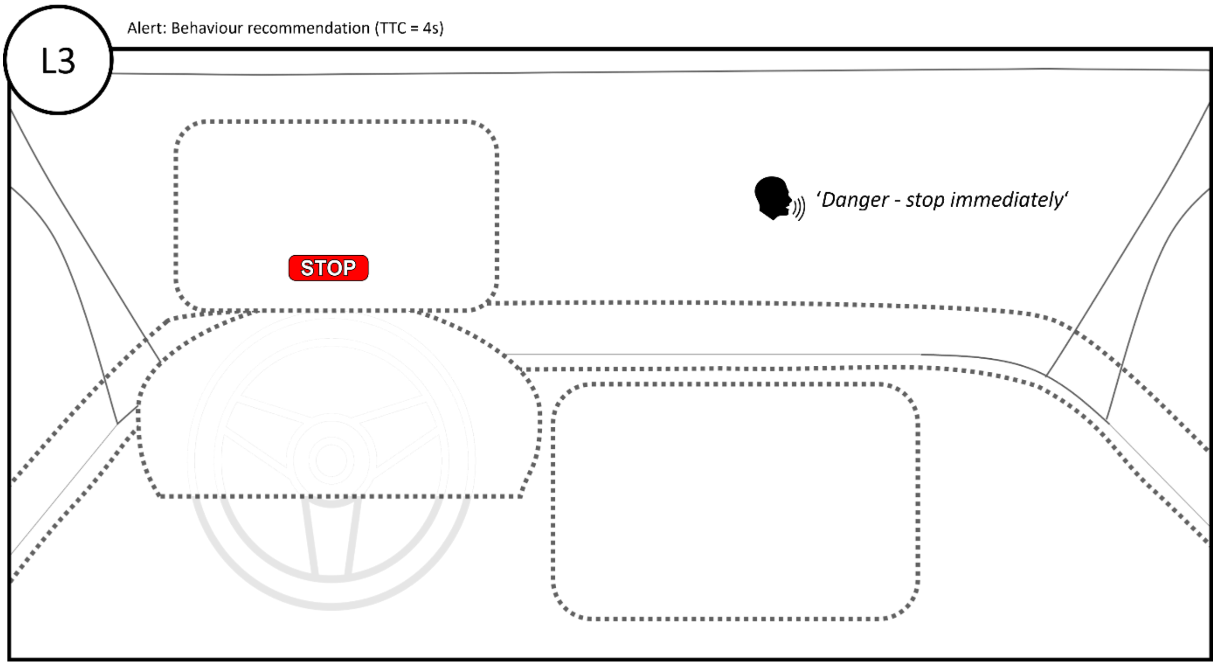


Figure 5-17: Older iHMI: Alert (behaviour recommendation).

L4: However, in case drivers should still not react, the vehicle is automatically braking to a full stop at TTC=2s. This is indicated by a corresponding icon in the HUD, red LED lights, and an "*Emergency stop*" voice message (Figure 5-18) like it is done for regular drivers.

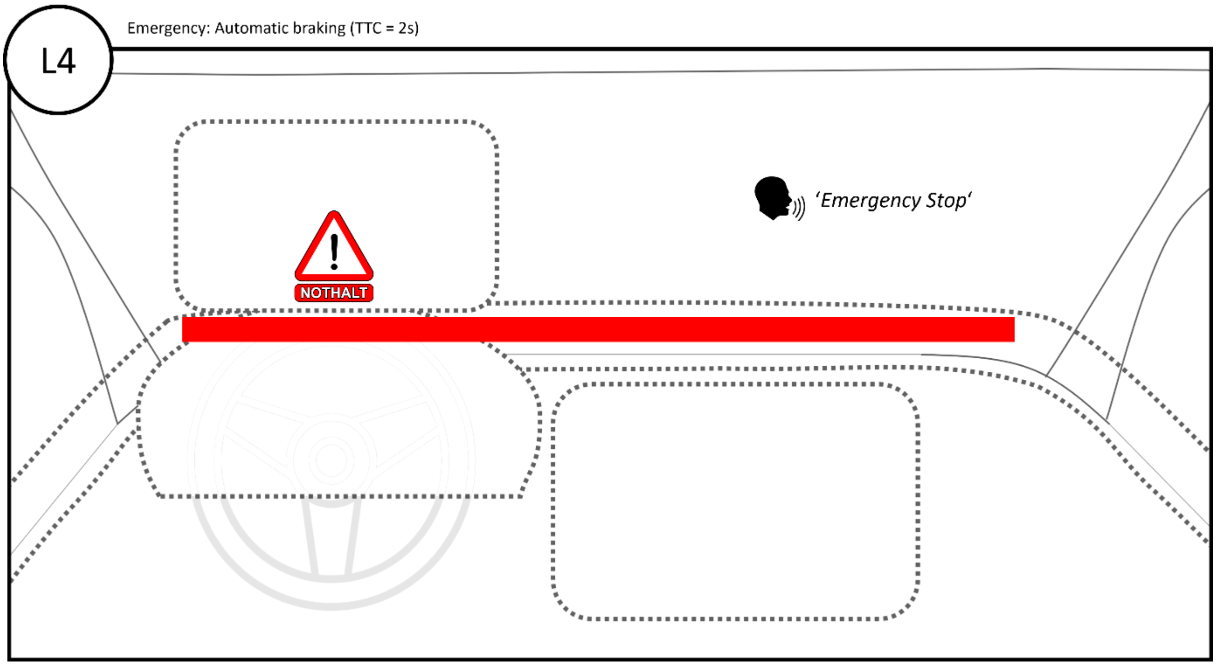


Figure 5-18: Older iHMI: Emergency (automatic braking).

# 6. Conclusions

This deliverable describes the two revised iHMI concepts for regular (attentive and distracted) and older drivers. These concepts are the outcome of an iterative process of design and testing.

The initial iHMI concepts as described in D2.1 “Initial fluid iHMI concept description” have been implemented as initial prototypes to be tested in a simulator environment. The prototypes were then iterated and adjusted several times based on pretests and the iterated versions investigated in two exploratory simulator studies with participant samples of the respective driver group. Based on the results of these studies (as depicted in D2.3 “Initial simulator studies results”) the concepts were selected and further revised.

The novelty of these concepts is that they consider the respective user needs, while the provided warnings are adjusted and escalated depending on the monitored driver state and reaction. The iHMIs provide a fluid interaction, where the driver gets information in time, only when it is needed, and with fitting modalities.

As a next step, the current concepts will be further evaluated to investigate the changes on a broader level with more study participants, and to answer remaining research questions as to whether the regular iHMI version can be adopted by older drivers. Also, the exploratory studies provided valuable insights on how to improve the methodology to investigate such fluid HMIs. This will also be taken into consideration for the planned evaluation studies in WP5, WP6 and WP7.

# 7. Abbreviations

| Term | Definition |
|---|---|
| ADAS | Advanced Driver Assistance System |
| AEB | Automatic Emergency Brake |
| HEIDI | Holistic and adaptivE Interface Design for human-technology Interactions |
| HMI | Human-Machine Interface |
| HUD | Head-Up Display |
| iHMI | internal Human-Machine Interface |
| L0, L1, L2, L3, L4 | Level of Escalation (0-4) |
| LEDs | Light-Emitting Diodes |
| PU | Public |
| R | Document, Report |
| TTC | Time To Collision |
| WP | Work Package |

# 8. References

[1] Kircher, K., & Ahlström, C. (2017). The Driver Distraction Detection Algorithm AttenD. In M. A. Regan, J. D. Lee, & T. W. Victor, Driver Distraction and Inattention (1. Aufl., S. 327–348). CRC Press. https://doi.org/10.1201/9781315578156-23.