Human factor guidelines for the design of safe in-car traffic information services

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Preface

In 2014, the first version of the “Human factor guidelines for the design of safe in-car traffic information services” was a fact. In the years following, this guideline has proven to be helpful to both policymakers and service providers. It aided designers from flagship projects for smart mobility in The Netherlands (e.g. C-ITS Corridor and Practical Trial Amsterdam) to develop safe in-car traffic information services.

It all started with the 'ITS Plan the Netherlands 2013-2017' and the ambition of the Dutch programme Connecting Mobility to put the valuation of human factors of ITS-applications on the agenda. The goal: making the technical applications more effective and safe. The development of this guideline for the safe design of in-car information services – commissioned by the Ministry of Infrastructure and the Environment - was a first step in achieving this. In recent years, smart mobility has taken a huge flight. To further the cause of smart mobility in The Netherlands, the Smart Mobility Round Tables have been established in 2015. The Round Tables are a community with participants from the industry, governments, knowledge institutes and interest groups. Together they create solutions and share developments to enable the next step in smart mobility. One of these Round Tables is the Smart Mobility Round Table Human Behaviour, which soon adopted the guideline and became its ambassador (see www.ditcm.eu/hb for more information on this Round Table).

The guideline that lies before you is an update of the first edition of 2014. It has been produced in commission of the Smart Mobility Round Table Human Behaviour and has been written by TNO, SWOV, University of Groningen, and Connecting Mobility, in cooperation with DITCM. The guideline gives practical support to:

1) Designers, to develop safe in-car traffic information services
2) Authorities who commission the development of traffic information services, in specifying tenders and checking project proposals.

The guideline is aimed at in-car traffic information services as we strongly believe that messages from applications not directly relevant for the driving task – such as social media apps – are distracting and will disadvantage road safety. Hence, they should not be used while driving. Currently there are some initiatives from insurance companies, the Ministry and telecom providers to minimise the use of traffic-unrelated information in traffic. By introducing a “driving mode” or “bicycling mode”, they either disable social media messages from coming through or award road users for not using their smartphone in traffic. By taking away traffic-unrelated distraction they are improving road safety.

Although this guideline is not a formal regulation and is voluntary in use, several Dutch organisations – including industry, national and local governments and knowledge institutes who are organised in the Tactical Board of the Smart Mobility Round Tables – have expressed their commitment to use the guideline in their projects and products. The guideline is meant as a base for parties that want to deliver good services in respect to the shared collective aim of road safety. It is a living document that will be updated from time to time based on experience with new technologies and new research.

Together we can improve road safety by designing safer in-car traffic information services.

Ilse Harms
Chair of the Smart Mobility Round Table Human Behaviour

1. Introduction

The trend is that traffic-related information services will be presented more by individual means in vehicles ('in-car') and less by collective means on the road side (next or above roads). Due to this trend, more and also different types of parties will provide traffic information services to the road user via in-car systems and mobile devices.

It is of key importance that in-car traffic service providers take the abilities and capabilities of the driver into account when developing these services. This is because the effect of the services will largely be depending on how road users respond to the information, and therefore also on how these systems are designed and how they interact with the driver. The goal of the guideline as described in this report is to support in-car traffic service providers with taking the abilities and capabilities of the driver into account. The guideline is based on existing literature, European standards (such as ESoP and SAE), expert opinions and consultations with relevant public and private organisations, both at the beginning of this project as well as at the stage of the concept guideline.

The underlying principle of the guideline is the objective that the information service does not give rise to potentially hazardous driving behaviour. All criteria pursue this objective, which means that the criteria are interdependent. That is, a bad performance on one criterion may be detrimental to the performance on other criteria and the overall service. With that, it is not only important to design for safe use by the driver using the service, but also to take the behaviour of other (non-equipped) road users into account. An advise or warning may seem in the best interest to the driver, but it may undermine traffic safety due to the (absent) reactions of other road users. It is important to realise that a traffic information service will operate in the complex and dynamic traffic environment.

The guideline is developed for services that support the driver in his or her driving task, and distinguishes safety-related warnings and non-safety related information (such as navigation advice and driver behaviour feedback apps). The guideline is not written for apps that provide entertainment or commercials, since it is the believe that, in general and at the moment, such systems are not reconcilable with a safe performance of the driving task. Though, knowing that advertisement cannot be outlawed, it is important to understand the basic principles of this guideline to minimise the safety risks that distraction by such messages may cause. For instance, these messages should only be given when driver’s workload is low and should have the lowest priority (in comparison to information related to the driving task). Furthermore, this guideline elaborates on standard devices, currently available. New developments, such as head-up displays or head-mounted displays, will bring new design possibilities, which are not all covered by the current criteria.

Report outline

The guideline is divided in two sections. The first section is on human factor criteria, describing aspects of the interaction with the driver such that the service is not seriously distracting nor raising driver's workload to an unacceptable level. This guideline elaborates the criteria and provides some examples per criterion to illustrate their application in practise. Topics that will be covered are related to driver workload, timing of a message, information priority, distraction, validity, recognisability, acceptance, physical interaction and possible side effects.

The second section is on ergonomic criteria, focussing on issues such as legibility and audibility of the information. These criteria are more or less self-explaining and do not require additional information. Therefore examples will not be provided in the second section.

Helpdesk

In addition to the human factor guidelines, a helpdesk has been created for private and public organisations who struggle with human factor questions in relation to in-car information services. See the website of the Smart Mobility Round Table Human Behaviour, www.ditcm.eu/hb, for more information on the Human Behaviour Helpdesk (in Dutch: vraagbaak) or send an email to behaviour@ditcm.eu.

2. Human Factor Criteria

The 10 human factor criteria are summarised below, stating per criterion the main rules of thumb. This list provides an overview of the main points of attention which an in-car information service should meet. The following sections of this chapter elaborate on the human factor criteria in more detail, providing background information on the origin of the rules of thumb and practical examples.

Additional workload

Limit additional workload.

- Information can be presented best when the workload of the primary task is low (tedious for some, to a long, time), e.g. driving on a quiet road with low traffic density and activity for a long time.
- In complex situations, depending on the complexity of the infrastructure, the traffic density and the speed that is being driven, information provided to the driver should be minimised; less urgent messages should be postponed.

Timely presentation

Information should be presented on time, not too late or too early.

- Information should be presented preferably about 36 seconds before the point of action or 200 m before the first road sign.
- Information should be presented minimally 9 seconds before the point of action.
- Information which is always of (high) relevance to the driving task can be displayed best continuously at a fixed position on the screen.

Priority by context and urgency

Information is prioritised by importance to the driver in relation to the context and urgency.

- Safety related warnings have priority over non-safety related information.
- Information that requires behavioural change has priority over information that does not.
- Information that is related to the manoeuvre or control level of the driving task has priority over information related to the navigation level of the driving task (see Annex 1for the explanations on the three levels of the driving task).

Visual attraction

Visual distraction away from the driving task should be avoided.

- □ Information should not lead to glances that exceed 2 seconds eyes off the road.
- □ Emotional content should be avoided.
- □ The display does not present more than 4 separate types of information units simultaneously in relation to an event, next to the continuously shown navigation information.

Auditory attraction

Auditory distraction away from the driving task should be avoided.

- □ Safety related warnings should always be combined with an auditory attention cue.
- □ A ‘neutral’ auditory sound should be used when warning for hazardous situations rather than emotion-laden sounds.

Ambiguity, validity and reliability

Information presented is non-ambiguous, valid and reliable.

- □ Information presented should not be interpretable in multiple ways.
- □ The occurrence of false alarms and misses should be minimised, to ensure reliable information.
- □ The content of the information should be relevant and in line with the traffic scenario at that moment in time to be valid.

Recognisability and consistency

Information should be recognisable and consistent with legal traffic signs and signals and local road side information.

- □ In-car information is in accordance with local road side information, discrepancies between different information resources should not occur.
- □ The traffic information service should use the formal national signs and signals of the local country (no modifications).
- □ Text and sound are preferably displayed in the driver’s preferred language.

Credibility, acceptance and compliance

Information is credible and aims for high acceptance and compliance.

- □ Dynamic information provision such as a sudden speed limit change or closing of a traffic lane should be accompanied by an argument.
- □ Information should make sense in the situation, not conflicting with perceived feasibility.

Physical interaction

Physical interaction with the driver should be minimised.

- □ The information service should not require any manual control input from the driver while driving.
- □ Upon request of the driver, it should always be possible to turn off the application, to adjust the brightness of the screen and tune the volume. Furthermore, operating buttons should require minimal visual guidance.
- □ The display should always be fixed to the car with a holder, preferably in 10 to 20 cm reach of the hand.

Negative side effects

The information service minimises negative side effects.

- □ An advice should not lead to higher speeds, and particularly avoid large speed differences between different drivers (maximum 20km/h differences in operating speed).
- □ City centres, school areas and other safety critical areas should be avoided (if it is not the final destination).

Additional workload

Limit additional workload

The driving task is a task that may be quite loading for a human being. Additional workload, for instance by processing a visual, auditory or tactile message, may add considerably to the varying workload of driving the car safely from A to B. In scientific terms it concerns a secondary task in addition to the primary task of safely driving the car. Provided that the primary task has priority over the secondary task at all times, the time for processing the message, including execution should be kept as short as possible and low-demanding to prevent overload.

For the amount of workload of the primary task, the complexity of the situation is very important (the complexity of the situation is also important for the criterion ‘Timing of a message’). The complexity of the situation depends amongst other things on the complexity of the infrastructure, the traffic density and the speed that is being driven. With increasing speed, task load of driving and the amount of information that needs to be processed within a given time frame increases accordingly. As a result the corresponding spare capacity for a secondary task decreases. And vice versa of course, which might even lead to favourable effects of a secondary task in case of a long tedious primary task, e.g. driving on a quiet road with low traffic density for a long time.

Services should be confined to information providing messages, being more or less task-relevant. Actions such as gaming, using social media, skyping, using Whats-app etc. are fundamentally incompatible with manual driving.

Finally, driving skill, primarily coinciding with age, increases considerably in the course of time with a coinciding decrease in required capacity for the primary task, which leaves more capacity for the secondary task. However, irrespective of driving skill, high workload of the secondary task should always be avoided. Also, the improvement in skill is not a linear one. It is assumed to improve to a certain relatively stable level, until aging starts to interfere with capacity synthesis, for each individual at a different age. At a certain point in time after this change, capacity for processing primary and secondary tasks decreases, up to a point in time when messages should preferably be adapted for the aging driver, to enable adequate processing and allow safe driving.

Example 1. Adjustable settings

Some car manufacturers today lead the way by designing and developing driving aid devices to provide information in such a way that their target groups (e.g. solvent, often elderly drivers) are offered more tuning adaptations such as bigger letter type, more time to process the messages, navigation based on arrows only etc. So, the settings of a service provider can be standard initially, should be adaptable in principle. An example is a navigation system that tells the driver where to turn (e.g. at the corner with the bakery) instead of when to turn (in 600 meters) (e.g. GrannyNav).

Example 2. Workload related settings

Some apps or services have a ‘Driving mode’ that can be switched on before starting the car. This means that while driving, specific items or actions cannot be performed while driving. A more advanced option would be that in the vicinity of complicated road networks (large junctions), less information is provided, or information is provided in a more simple way with less details.

Timely presentation

Information should be presented on time

Route guidance has a long history, from indicator stones along the roads in the Roman Empire to modern digital navigation systems. Timing has always been an important item along this stairway towards flawless travelling. TomTom starts 2km before a required action (and when referring to a distance they refer to the end of an exit), while Rijkswaterstaat starts 1200 m before, referring to the start of an exit or in case of a weaving area to the end of the weaving area. The Rijkswaterstaat distances are tuned to the standard cruise speed at 120 km/h and are 36 seconds when converted to time. Information regarding route choices should be provided at least 200 m before the first route guidance sign (allowing time for reading the normal road guidance signs).

Position and timing is based on an optimum across the highway user, allowing sufficient time to read and process all the information and to make a decision and act; this is requiring about 36 seconds as a starting point for a navigation message. It leaves sufficient time to change traffic lane(s) in time at high traffic density. Note that providing a message rather late may lead to dangerous driving behaviour by drivers who still try to follow up on the advice but do not succeed (or succeed by performing risky behaviour). It is advised to provide a message at least 9 seconds before the start of the off ramp. On the other hand, providing information too early may be perceived as a false alarm by drivers and lead to confusion, which undermines the acceptance (see also criteria on valid and reliable information and acceptance). Besides, when providing road side information in-car, it is strongly advised to match the timing (see also criterion on consistency and recognisability).

In contrast to route guidance messages, the time range of safety related warnings varies more, depending on the content of the message. Preferably the message is also given at 36 seconds before the relevant event, although often the exact location might not be known. Depending on the accuracy of knowing the exact location, it might be wise to enlarge the time slot. As opposed to navigation messages, safety related warnings that alert the driver (and provide an advice on the control level of the driving task, see Annex 1) should always been given since they require less time to be processed and executed.

Other information is continuously relevant to display, such as the maximum speed at that road section. However, in case of high priority (safety) messages, it is wise to give them priority at certain moments (see criterion about priority).

Also relevant for the timing of a message is the location and traffic situation, i.e. the point in time of the start of message presentation in relation to sharp curves, high traffic densities or even the presentation of two simultaneous messages (priority determined which message should be provided first). This presupposes a lot of information about the direct environment, but in a modern car this information can be made available (e.g. via extended maps). In complicated situations, e.g. a blind bend or high traffic density, workload for safe driving may easily increase (see also criterion about workload) up to a point that messages should not be given unless very urgent. However, route guidance information should always be provided, but it may be provided earlier if the driver is approaching a complicated situation or workload is expected to be high. Less urgent messages should be postponed.

Example 1. Stranded lorry
Urgent message: suppose the driver approaches a stranded lorry, situated just after a blind bend in dense traffic, the message “leave the right traffic lane / stranded lorry ahead” is provided further ahead than in case of a normal lane change advice. If there is a delay in the information provision, it is given even while entering the curve; all other messages are suppressed.

Example 2. A too late navigation message
Advising the driver to take the exit while he is already passing it, may lead to dangerous driving behaviour by the driver who still might try to take the off ramp. The information is preferably provided 200 m before the first route guidance sign of 1200 m.

Example 3. Wrong way driver
It is hard to accurately predict the location of a wrong way driver, since this information is often based on limited reports of other road users and changes rapidly. A safety related warning is therefore provided to all road users in a wide range (e.g. 30 km area circular around the location), who (may) come across the wrong way driver.

Priority by context and urgency

Information is prioritised by importance to the driver in relation to the context and urgency

The most urgent information should always have priority over less important information. Priority is defined by:

- Relation to behavioural change. Information that relates to behavioural changes (such as speed adjustments or lane changes) gets priority over information not directly related to driving behaviour (such as delay due to traffic jams).
- Relation to the strategic, manoeuvre, control level of the driving task (see Annex 1) and urgency. Generally speaking, information with respect to the manoeuvre/control level (e.g. lane changes) gets priority over information with respect to the strategic driving task (e.g. route changes) and information at the control level (e.g. braking) gets priority over route information or lane changes.
- Relation to safety. Safety related warnings and advises have priority over general information with respect to the manoeuvre/control level.

The service should only present one message at a time and not too soon after one another (see criterion on visual distraction), since this is detrimental for drivers' comprehensibility and increases distraction and workload (see criteria related to distraction and workload). In addition, presenting information that is not related to the driving task is therefore highly discouraged as well. This type of information should be presented while being stationary (e.g. at gas station or after having parked).

Safety warnings should only be presented if the scenario requires a behavioural change of the driver or if raising alertness is needed directly. The following lists indicate the priority of safety warnings and non-safety related information. Please note that the priority of a warning also depends on how close one is to the actual hazard. This means that distance to the hazard has priority over the hazard in itself. Exception here is wrong-way driver since the exact location of the hazard cannot be determined, so this always has the highest priority.

Safety related warnings[1]

a) Wrong way driver
b) Unprotected accident area
c) Animal, people, obstacles, debris on the road
d) Slippery road
e) Unmanaged blockage of a road
f) Reduced visibility
g) Exceptional weather conditions
h) Short-term road works
i) Unexpected end of cue
j) Protected accident area

Non-safety related information

a) Navigation
b) General traffic information
c) Feedback and advice on traffic flow (e.g. speed and lane advice to pass a traffic light at green) or eco-friendly driving (to reduce fuel consumption)
d) Fuel advice (e.g. advising the most favourable gas station on the route to full up, etc.)

Example 1. Slippery road

A safety warning is suddenly activated, such as a slippery road ahead. This slippery road warning temporary mutes the route navigation messages (sound) as long as a driver is not required to take action. If a driver is required to take action, the two warnings should be played after one another: "In 600m, take the exit on the left, warning, slippery road". The symbol for slippery road can remain to be displayed on the screen as long as this message is valid.

Example 2. Traffic delay

If information, in addition to the navigation screen, about a traffic delay is presented in the navigation screen, these messages should disappear if a safety related warning is activated. The safety message has priority and in order to avoid too many messages on one screen non-safety related information should disappear, see also the criterion on visual distraction.

[1] Warnings a) to h) are described in the European regulation No886/2013. Warnings i) and j) are added since they are also used in practice.

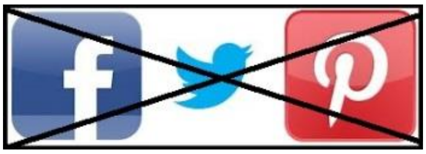
Visual attention

Visual distraction away from the driving task should be avoided

Visual information should not lead to a situation in which a driver takes his eyes off the road too long. The information or advice should not lead to glances that exceed 2 seconds eyes off the road. Driving with the eyes off the road for more than 2 seconds has been shown to lead to increased crash risk and hazardous situations.

Therefore, messages should not contain animations, moving images or alternating messages. Presenting animations or alternating (text) messages will attract attention from drivers and distract them from the driver's task. Drivers are curious to see what will come next and will continue looking at the screen to see the next part of the animation or message. As a result drivers may take their eyes off the road for too long and driving performance may decrease.
Also emotional content should be avoided. From research on distraction by commercial billboards along the road it is known that drivers react slower to traffic signs, brake harder and look longer away from the road, when the message has emotional content. Especially negatively emotional content, such as showing the consequences of an accident, is highly distracting. As a result drivers pay less attention to the relevant aspects of the road environment. Positive emotional content, such as romantic pictures, is distracting as well, though to a lesser extent. Based on guidelines for billboards it is also advised that messages should not change more frequently than every 6 seconds.
The display should not present more than 4 separate types of information units simultaneously in relation to an event, next to the continuously shown navigation information. Other information, not relevant to this event, should be suppressed. Too many different types of information cannot be read and processed within a few seconds, and will be distracting to drivers. Upon request of the driver, messages can also be spoken out loud to minimize visual distraction.
Commercial messages should be avoided while in driving mode.

Example 1. Social media



Distracting messages that are continuously provided by other (non-traffic information) applications and not directly relevant for the driving task, should be switched off while driving. This should preferably be done automatically, if a device is mounted and/or put in driver-mode ('safe'). For instance, social media messages and applications are often not designed for safe usage while driving. While driving, these messages should be blocked by the traffic information service or a safe user mode should be activated (e.g. messages are spoken out loud).

Example 2. Road work warnings

Information, additional to the navigation screen, should not contain more than 4 information units. A safety warning on road works may therefore contain a speed sign, road works warning sign, an indication of the road layout and distance.

Auditory attention

Auditory distraction away from the driving task should be avoided

In case of hazardous situations and safety warnings directly relevant for the driving task, visual information should always be combined with an auditory attention cue.

A ‘neutral’ auditory sound should be used when warning for hazardous situations rather than emotion-laden sounds (such as exclamations). Drivers receiving auditory (spoken) route guidance, show better lane keeping behaviour and report less workload compared to visual route guidance.
A neutral alert sound preceding a risky situation leads to a reduction of the speed without affecting lateral position, and may help drivers to look at relevant areas of their visual field. It is important to make sure that there is no confusion among the various signals in the vehicle’s auditory repertoire. In addition, sounds associated with acute alarms such as sirens used by emergency services (police, ambulance, fire brigade) are not neutral and should not be used, nor should too loud sounds be presented since they may cause dangerous driving behaviour. Other loud sounds that could cause startle reactions, such as traffic horns and honking sounds should also be avoided. Semantic urgent warning signs (such as word: Danger) at a moderate noise level (70 dB) and less urgent signals (such as the word: Pay attention) at higher volume (85 dB) were found to be effective in reducing the risk of a (simulator) accident.

Example 1. Mute sound warnings of non-driving related apps
Some apps that inform and/or provide warnings on incoming email or weather alarms combine these messages with auditory sounds. This mode should be switched off during driving since auditory warning sounds should only be used in hazardous situations.

Example 2. Continuously changing information
A sound relating to continuously changing information, as expected traffic delay and current speed limit, is highly distracting and interferes with the important warnings. These messages should not be used in combination with auditory cues.

Ambiguity, validity and reliability

Information presented is non-ambiguous, valid and reliable

Information that is ambiguously formulated or presented and could be understood in multiple ways, leads to confusion by the driver and/or unwanted or unsafe driving behaviour. Clear and unambiguous information is therefore essential for traffic safety. In case the message contains a (safety) advice, the message should clearly communicate what is going on, why an advice is given and what (behaviour) is expected from the driver. Only when there is no time for additional information, the safety warning should only present what is expected from the driver, without an explanation.

High reliability is crucial for acceptability and road safety. It is therefore important that there are no false alarms (a message when there is no issue, e.g. traffic queue warning system provides a warning for congestion under free driving conditions) and no misses (no message when there is an issue, e.g. road works warning system does not report a roadwork zone). False alarms and misses decrease trust and the willingness to comply and lead to de-activation of the system. Furthermore, all the information provided should be valid. That is, the content of the message should be relevant and in line with the traffic scenario at that moment in time. In case speed limits and other roadway traffic signs are shown in-car, the limit or sign should only appear at the moment where the limit or traffic sign is actually valid. So, it should not be active before or after the road section at which it applies. It is strongly recommended to assess the reliability and validity of the system in advance before the system launching. Note, reliability is a point of interest for the service providers as well as the government; the latter is responsible for providing correct and timely information in the first place (see Nationaal Wegen Bestand).

Example 1. Signs may be ambiguous in their context

Indicating a traffic jam sign with a speed limit might mean that this speed limit is due to a traffic jam ahead, or that this speed limit tries to prevent the occurrence of a traffic jam. The message does not clearly communicate what's going on and

why the advice is given. Using the same traffic jam sign in both scenarios may undermine the credibility of the advice. In this case, it is advised to use the formal traffic jam sign to indicate and warn for an existing traffic jam ahead.

Example 2. Validity of a message

If a lane or motorway exit is blocked, an advice to follow this lane or take this exit is not valid. The information service should advice a different lane or exit and provide an alternative route in case this is necessary. In addition, when this information is not relevant to the driver because he takes an off ramp earlier, this information should not be provided at all.

Example 3. Avoid exceptions and clarifications that may lead to more confusion

This sign tries to communicate a complex message, containing two specifications about the speed limit. First of all, the message is complicated in itself and secondly, the speed limit outside this range is implicit (not explicitly mentioned). It's not clear what the speed limit is during other circumstances, this could be 100km/h or 130km/h. It is not clear to drivers what is expected of them. In addition, the two specifications might be interpreted in multiple ways. This leads to confusion and larger variations in speed, which is adverse to traffic safety. Due to these comprehensibility problems, these road signs are no longer used. In-vehicle systems should always provide the speed limit that is valid at that specific moment in time at that specific location.

Recognisability and consistency

Information should be recognisable and consistent with legal traffic signs and signals and local road side information

Not only should the information itself be easy to understand, it is also important that in-car information is in accordance with local road side information. Discrepancy between roadside information and in-car information may lead to confusion and might be perceived by the driver as incorrect, undermining the perceived reliability of the service.

High consistency is especially important when the information concerns legal traffic signs and signals. It may have a detrimental effect on traffic safety if drivers are advised incorrectly with respect to legal limits and traffic regulations.

In The Netherlands, the traffic information service should use the formal Dutch national signs and signals if applicable (see I&M booklet). Although a foreign driver may encounter signs that are not used in his/her home country, providing the local signs in-car is to be advised. The chance of errors increases when local signs need to be translated into signs and symbols of the driver's home country. Text messages may be displayed in the driver's preferred language.

In addition, no new signs or signals should be "invented". Only if current traffic signs and signals are not applicable, a new sign may be introduced after proper testing for the self-explaining character in user tests.

Example 1. Signs when driving in The Netherlands

A foreign driver is provided with a Dutch warning sign in The Netherlands, though the explaining text is in his own language. A driver can set his/her own language preferences in the settings.

Example 2. Consistency with road side speed limits

A service providing a speed *advice* below the speed limit is correct (and not conflicting with road side information), while providing a lower speed *limit* is not correct. In addition, matrix signs should preferably be displayed similar to those that are presented above the road, to ensure consistency between in-car and road side information (i.e. as a speed limit sign with red border and not as an advisory speed).

Example 3. Displaying routes in-car

Ordinary routes should be displayed in blue and detour signs as a result of road works should be displayed with a yellow background shield (as they are also used along the road). Not the other way around.

Example 4. Speed limit

Displaying a speed limit should be in accordance with the general symbol for speed limits. The image to the right shows an undesirable modified version. By modifying the symbol, the sign becomes more difficult to interpret and affects the legibility. Is it 50 km/h over 1000m or during the upcoming 1000m? Also, the red border is smaller and the font for the 50 is also different than the 50 used on traffic signs. If one wants to display this kind of additional information (e.g. “in 1000 m” or “during 1000 m”) one should place this next to or below the symbol.

Credibility, acceptance and compliance

Information is credible and aims for high acceptance and compliance

Whether a message in a certain situation is accepted by the driver depends on how the message is perceived given that situation. If the driver completely agrees with, or endorses the underlying principle or reason behind the message, compliance follows more or less automatically. However, compliance is not a direct consequence of acceptance and credibility, though good acceptance and high credibility certainly help. If a message is not credible but the inherent measure is visibly enforced (by the police), acceptance will be low, but compliance is highly likely.

To create or enhance acceptance of messages and advice, solid arguments should be given why this specific behaviour should be adapted if it deviates from normal bans and orders. For normal bans and orders (such as an overtaking ban in a curve or a speed limit at the entrance of a village) no extra explanation or argument is needed. However, dynamic information provision such as a sudden speed limit change or closing off a traffic lane should be accompanied by an argument.

The credibility of the underlying argumentation is related to or even conditional to complete acceptance of messages and advices. Especially at seemingly inconsistent or illogical bans or orders, the specific order or ban should make sense in the situation, not conflicting with perceived feasibility. The driver should have a feeling of feasibility of the ordered behaviour, it must be practicable. Incredible messages with respect to a certain ordered behaviour will quickly lead to an interpretation of false alarm, if not properly argued.

Pure information provision, for example “For Dam Square, turn right in 600m”, should not be argued, acceptance is superfluous.

Example 1. Compliance

Advising to keep right without an explanation will result in a lower compliance. If the reason isn’t made clear, drivers are not inclined to follow up on the advice. When explaining why a traffic lane is closed, for instance due to road works, drivers will understand the importance of the advice.

Example 2. Credibility

Suppose the speed limit is decreased, but no explanation is given, the credibility will be nil and compliance is quickly gone. This is disastrous for that specific spot and the effect could easily spread out. When this speed limit is accompanied by an explanation such as “urban area”, acceptance and compliance by drivers will be higher. Also, when presenting a speed limit with the explanation ‘smog’ on a clear day, credibility is also affected and compliance will be low, although the advice is correct (note, smog is not always clearly visible and noticed by drivers).

Physical interaction

Physical interaction with the driver should be minimised

The information service should not require any manual control input from the driver while driving. This means that there may be manual interaction with the system on the initiative of the driver, but the system should be able to function properly without the driver's response. Physical interaction while driving results in reduced attention to the road, which potentially results in a decrease in driving performance. This is due to physical as well as visual and cognitive distraction. Therefore it is important that default settings are consistent with drivers' needs and preferences.

However, upon request of the driver, it should be possible to turn off the application, to adjust the brightness of the screen and tune the volume. These may be adjusted by the driver with a simple interface, but preferably brightness and volume are adjusted automatically to the changing surroundings (like darkness in tunnels). Preferably, a driver should only operate a simple button in case the system desires input by the driver, for instance a 'yes' or 'no' button. Though, with the remark that the corresponding message is easy to comprehend and the whole exercise does not lead to more than 2 seconds eyes off the road (see criterion on visual distraction).

If the display is not located within reach of the driver, hazardous situations might arise if the driver wants to control the system. Hence, put controls within easy reach. Reach envelopes for drivers are specified in SAE Standard Driver Hand Control Reach (SAE J287). Other relevant information appears in SAE J1138. Research on driver reach preferences shows that preferred ranges are 4 to 8 in (10 to 20 cm) less than maximum envelopes in the standards and recommended practices.

For safety reasons, the display should always be fixed to the car by means of a holder. Recommended is to place the display beneath the highest point of the dashboard (see picture), to ensure that the display is not blocking the view of the driver.

Example 1. No input necessary
Service asks the driver whether he wants to take a shorter alternative, with a yes/no button. Preferred: no input is necessary; driver sees the options and chooses by following the directions he prefers.

Example 2. Extensive menu
Service gives the driver the opportunity to mark an incident or police surveillance, though the option menu is too extensive with long and uninterruptible sequences of manual-visual interactions to indicate the type and location of the incident. If this input cannot be simplified, this should not be a feature of the service at all.

Example 3. On/off button
A system should have a clear on/off button at a fixed spot.

Negative side effects

The service minimises negative side effects

One should be aware of the possible consequences of the information and advices, such as consequences for safety, traffic flow or the environment. The advice should not have substantial negative side effects on any of these traffic related outcomes.

With regard to safety, it should be avoided that the advice will lead to higher speeds, and particularly avoid large speed differences within one driver or between different drivers (e.g. users and non-users of the service). In general, higher driving speeds lead to higher collision speeds and thus generally to more severe injuries. Higher driving speeds also provide less time to process information and to act on it, and the braking distance is longer. Therefore the possibility of avoiding a collision is smaller. In short: high driving speeds lead to a higher crash rate, also with a greater likelihood of a more severe outcome.

In addition, roads with a large speed variance are less safe. The advice should therefore not give rise to behaviour inducing large and sudden speed differences, such as harsh braking. The slower or faster a car drives compared with most of the vehicles on that road, the higher the risk of being involved in a crash. Particularly cars that drive faster than average on that road have a higher crash rate. On rural roads and highways with speed limits of 80 – 130 km/h it is the general understanding that particularly large speed deviations of 20 km/h or more as compared to the general driven speed should be avoided at all times.

The information or advice should not lead to large detours away from highways to less safe roads. Driving more kilometres will lead to more crashes and unwanted environmental effects. Moreover, not all roads are equally safe. Highways are the safest roads. In the Netherlands, most fatalities occur in crashes on urban and rural roads with speed limits below 90 km/h. Generally speaking, the number of fatalities per distance travelled by motor vehicles on motorways and trunk roads has been shown to be around four times lower than on roads with a speed limit of 80 km/h. In addition, city centres, school areas and other safety critical areas should be avoided (if it is not the final destination).

Example 1. Avoid abrupt behaviour

Do not warn for speed checks at the very last moment (< 100 m or 3 seconds) because this can cause abrupt braking reactions (see also criterion on timing).

Example 2. Encourage smooth driving

An application that encourages drivers to accelerate in order to get the green light just in time would lead to undesired behaviour from both a safety as well as an environmental perspective. On the other hand, a good example would be informing the driver about green lights coming up with an advice to choose a smooth and even driving speed that will lead to drive through the green traffic lights. Such smooth driving behaviour can be beneficial for safety, environment and traffic flow.

Example 3. Erroneous information

Erroneous information regarding the current speed limit – either too low or too high – can result in large speed differences on the road between those who rely on the advice provided by the application compared to those using the signs along the road.

3. Ergonomic criteria

Brightness and contrast of the system are adjustable to ambient lighting conditions. In addition, contrast ratio is between 3:1 and 10:1

When the brightness and contrast of the system are not adaptable to the ambient light conditions (day/night), this could result in blinding and/or difficulty to read the message. It is desirable that brightness and contrast are automatically adjusted to match the ambient. In addition, contrast is easily adjustable by the driver while driving, with a very simple gesture (preferably turning knob on side of display). A contrast ratio of 5:1 is preferred.

Font type, size and spacing should be easily legible from the driver's seating position (taking into account different age groups)

The font should be simple and clear to facilitate easy reading. Font size should be determined by the distance between the eyes and the screen, and a minimum visual angle of 15° (preferably 24°). Possible crowding effects should be taken into account. This may occur due to words and symbols that are located too close together. As a result visual clutter may occur. The human factors literature shows that differences among modern font types have less impact on legibility (readability) than physical characteristics such as size or contrast. Nevertheless, plain font types (such as Geneva and Helvetica) are more legible than ornate ones (such as London). Where in-vehicle displays are compared with external displays (e.g. highway signs), it is desirable that the font types be similar.

Use words of maximum 10 letters and no more than 2 lines of 4 to 5 words per message, confining reading to 2x2 seconds maximum

Long messages may result in too much distraction, since drivers keep their eye off the road for too long. See also criterion on visual distraction in the previous chapter.

The auditory volume level of the system should be adaptable, but never higher than 115 dB

The volume of the system should be loud enough to overcome background noise, though not too loud to be a cause for driver distraction or startle the driver. Pitch (increase) may emphasize a message, but only to be used temporarily. Research claims maximum volume levels of 95 dB-115 dB. It is desirable that the volume level is automatically adjusted according to the background noise. Volume level should be easily adjustable while driving with a very simple interface, preferably one touch on a touch screen or by means of a knob on the side of the display. In addition, it is preferred that the volume level is about 15 dB above ambient noise.

Colour use should be in line with drivers' expectations and general colour use in traffic. For colour blind people use redundant colour coding or colour combinations that are visible for them
Colour use is closely related to comprehensibility. In order to facilitate quick recognition of the signs provided, they should be designed according to the standard colour coding of road signs. It is desirable that no more than 5 colours are used in the design (incl. black and white). For colour blind people extra design rules should be observed. In the Netherlands, about 1 out of every 12 men and 1 out of every 200 women has a colour deficiency. The vast majority has a congenital type of red-green colour blindness. To provide for colour blind people, use redundant colour coding, i.e., support the colour coding with additional information of a different type (e.g. shape, position, size, text, sound) which is directly linked to the colour. For example, the red traffic light is always on top. Furthermore, use an orange-red colour instead of red as an alarm signal and a bluish-green colour instead of green as "safe situation" signal. Part of the colour blind people (protanopes) perceive a red colour as black, therefore they are unable to see red coloured objects on a black background. The use of an orange-red colour overcomes this.

Information presented should make use of abbreviations as little as possible
Abbreviations often take more time to be comprehended by the driver and can be quickly misunderstood when the explaining context is minimal. Commonly known abbreviations that can be used are km/h, m, min and s.

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5. Annex

Annex 1 The three-level model of the driving task

Level	Explanation
Strategic	Finding the way through a road network (navigation) including, modifying modal choice, route choice and exposure (e.g. frequency and/or length of travel).
Manoeuvre	Changing lanes, keeping the vehicle on the lanes, including modifying speed choice.
Control	Maintaining speed, headway and distance to other vehicles.