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## 5.11 Interactions between ADS users and the ADS

### Introduction

This section provides safety-related recommendations to support user interactions with automated driving systems (ADS). It is noted that the recommendations vary depending on user role, system design and tasks to be performed by the user during the use of the vehicle with ADS.

“Human-Machine Interaction and Operator Information” were identified as key areas to address within Functional Requirements for Automated Vehicles (FRAV).

The recommendations in this document focus mainly on safe interaction needs for three specific roles the human being may be required to perform when utilising an ADS: 1) passengers (in the driver seat), 2) fallback user, and 3) driver, also noting that these roles may change depending on the ADS design while using ADS. This document also provides general recommendations relevant to the safe design of controls, displays, information, and warnings for ADS activation, deactivation, and usage.

These recommendations are informed by prior UNECE regulations that support safe user interactions with advanced driver assistance systems (ADAS).

Human interaction with automation has had a troubled history so, in order not to repeat the mistakes of technology-driven automation, it is necessary to develop recommendations based on human factors, which is an established multidisciplinary science that applies knowledge of human abilities and limitations to the design and evaluation of technology for improved safety and usability.

To avoid hazardous automation mode confusion due to a lack of clarity about human and ADS responsibilities, or varying capabilities and ODD between ADS, it is essential to provide users with the appropriate information, in a suitable format, related to their current role and status of the ADS.

While these recommendations are focused on human-centred design to achieve minimum levels of safety, it is recognized that following them will also help to improve ADS usability and user experience.

Given the challenges of developing a common set of safety recommendations for diverse ADS capabilities, vehicle types, and user roles, this document endeavours to prioritise minimum safety needs for higher-risk applications (i.e., ADS vehicles that can also be driven manually).

The recommendations in this document are designed to establish a minimum that manufacturers are expected to consider in order to avoid compromising safety.

It should also be noted that it is a novel challenge for a regulatory body to develop safety recommendations for vehicle systems that perform the entire driving task rather than a more traditional focus on limited functions for specific vehicle classes where a driver is always available to intervene.

ADS present further challenges to regulators because they require new regulatory concepts, tools, and methodologies to assess and monitor the admitted vehicles in addition to those historically used for previous vehicle technologies and systems.

Accordingly, while the recommendations herein are attempting to be objectively verifiable, further work may be needed to refine the requirements into more readily verifiable specifications for ADS as understanding and experience increase.

While this document recognizes the importance of innovation to the development of ADS by providing flexible recommendations to accommodate progress, there are some limits because innovation can never be prioritised over safety.

Where manufacturers do not follow specific recommendations herein, they will be expected to provide evidence that such designs will not compromise safety.

These recommendations provide direction for potential future regulations and support the industry by explaining the expected outcome, while allowing for flexibility in design.

### 5.11.1 The ADS shall interact safely with the user

A **high-level commonality in the interaction processes and interface** between the vehicle and a user for all brands and models will help drivers to develop and apply a mental model<sup>1</sup> of how their responsibilities relate to the level of automation and of how to interact with the systems. It will also help to reduce the risk of user confusion (e.g., mode confusion) when changing between vehicles with ADS from different manufacturers. Such commonality cannot be defined now, but it is vital to establish it as a goal of future design.

### 5.11.2 ADS system designs that anticipate a user to perform the DDT

#### 5.11.2.1 General requirements

5.11.2.1.1 These recommendations deal with the following user roles: driver, fall-back user (when applicable), passenger (in the driver seat)

5.11.2.1.2 The interaction should be simplified:

- (a) When activating the ADS all features are activated
- (b) The number of response options for critical events should be limited
- (c) An activated ADS is completely responsible for the DDT
- (d) A driver performing the DDT is completely responsible for the DDT
- (e) If an engaged feature reach the end of its ODD a transition of control will be initiated.

5.11.2.1.3 The ADS HMI shall provide information and signals clearly noticeable under all operating conditions, multimodal, simple and understandable.

5.11.2.1.4 The vehicle shall indicate its ADS capabilities in terms of their automated [features] and their ODD.

5.11.2.1.5 The ADS shall inform the user on the current conditions (dependent on the activated or deactivated state):

- (a) ADS status information.
- (b) The availability of automated features (ADS).

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<sup>1</sup> A mental model is an explanation of someone's thought process about how something works in the real world.

- (c) Responsibilities for the user.
- (d) Permitted NDRA or not-permitted NDRA.
- (f) "Standard" safety related information.
  - (i) e.g., range, speed, seat-belts, a.o.
- (g) Any failure of the ADS.

5.11.2.1.6 The ADS shall inform the user in time on the upcoming events:

- (a) Upcoming actions or change in roles.
- (b) Estimated time until transition of control in nominal conditions (when applicable).

5.11.2.1.7 The ADS shall ensure that safety related information is prioritised and presented in a clear and unambiguous manner. Indicators, tell-tales and warnings not related to the operation of ADS (feature) may be disabled, de-activated inhibited or by other means be made un-available to support user (vehicle mode) understanding.

5.11.2.1.8 The ADS shall be designed to prevent misuse and errors in operation by the user.

5.11.2.1.9 The controls dedicated to the ADS shall be clearly distinguishable from other controls to accommodate the appropriate interactions.

5.11.2.1.10 The ADS shall be designed to prevent inadvertent activation or deactivation.

- (a) The vehicle controls should be disabled, suppressed, de-activated, inhibited or by other means made un-available, as needed to limit errors in operation, misuse and reduce ambiguous states of vehicle control.
- (b) Indicators, tell-tales and warnings not related to the operation of the ADS should be disabled, de-activated inhibited or by other means be made un-available to support user vehicle mode understanding.

5.11.2.1.11 The ADS shall provide prompt feedback when the user attempts to enable unavailable features.

5.11.2.1.12 The ADS shall have a Driver Monitoring System to support correct engagement of the [fallback] user.

5.11.2.1.13 The HMI of an ADS shall be consistent with the entire vehicle HMI.

5.11.2.1.14 The vehicle and ADS HMI need to take into account potential impairments of users (such as colour blindness, impaired hearing) which do not require specific hardware adaptations of the vehicle.

## 5.11.2.2 Activation

5.11.2.2.1 The ADS shall ensure safe ADS activation.

5.11.2.2.2 The ADS shall inform the user that preconditions for activation are met.

5.11.2.2.3 The activation shall follow a **common sequence** of actions and states.

5.11.2.2.4 The ADS shall provide confirmation that the system is activated.

## 5.11.2.3 Transition of Control

5.11.2.3.1 A transition of control in nominal situations should be indicated in timely manner to support that the fallback user may re-engage to the driving task as appropriate.

5.11.2.3.2 The Transition of control process shall follow a common sequence of actions and states.

5.11.2.3.3 Transition of control shall return control of the DDT to the driver without any continuous control assistance (temporarily intervening safety systems such as ESC will remain activated).

5.11.2.3.4 The ADS shall

- (a) continuously verify whether the fallback user is available for the Transition of Control and
- (b) adapt the Transition of Control process, including the time budget where feasible, to the state of the fallback user and/or to the ADS. (and suggest a minimum time budget)
- (c) provide a warning when the user is not available when required.

5.11.2.3.5 The ADS shall verify that the fallback user is in stable control of the vehicle to complete the Transition of Control process.

5.11.2.3.6 During transition, the ADS shall remain active until the Transition of control has been completed or the ADS reaches a minimal risk condition.

5.11.2.3.7 The ADS shall provide clear, specific feedback of the completion of the transition of control.

5.11.2.3.8 After the transition of control the ADS shall have no control at all over the vehicle and shall only indicate relevant status information.

#### 5.11.2.4. Deactivation (Take-over)

5.11.2.4.1 The ADS shall be designed to ensure a safe user-initiated takeover process. .

5.11.2.4.2 The ADS shall allow the user to initiate a take-over process

5.11.2.4.3 The take-over process shall follow a **common sequence** of actions and states

5.11.2.4.4 The ADS shall momentarily delay deactivation of driving control when immediate human resumption of control could compromise safety

5.11.2.4.5 The ADS shall verify that the user is in stable control of the vehicle to complete the user-initiated takeover of control process.

5.11.2.4.6 The ADS shall provide clear, specific feedback of the completion of a user initiated take over.

5.11.2.4.7 The user initiated take over shall return control of the DDT to the driver without any continuous control assistance.

5.11.2.4.8 The ADS shall provide clear, specific feedback of the completion of the deactivation of the ADS.

5.11.2.4.9 Upon ADS deactivation, the vehicle controls, indicators, warnings and tell-tales shall be restored to an activated state.

#### 5.11.2.5 Documentation

Explanatory: The documentation, tools and/or instructions that are provided by the ADS manufacturer / vehicle manufacturer on the ADS will ensure that the user of an ADS can develop a general mental model of how the system functions, its capabilities, the user responsibilities and a more specific mental model of how to interact with the systems. A correct mental model is necessary for correct usage and expectations of the ADS. This section is phrased in a generic way. The complexity of the mental model for the user that is necessary for correct interaction depends highly on the involvement of the user in the driving task.

5.11.2.5.1 The ADS shall be supported by documentation and tools to facilitate user understanding of the functionality and operation of the system.

5.11.2.5.2 The owner's manual should contain at least:

- (a) An operational description of the ADS capabilities and limitations (the information should also refer to specific scenarios and/or ODD).
- (b) A description of the roles and responsibility of driver/user and ADS when an ADS (feature) is on/off .
- (c) A description on the permitted transitions of roles and the procedure for those transitions.
- (d) A general overview of NDRA allowed when an ADS is active.

(below requirement might be at another section of the document)

5.11.2.5.3 The ADS manufacturer / vehicle manufacturer (as appropriate) shall provide documentation available for audit on:

- (a) The details of their user-centred design process
- (b) Its intended educational approach for theoretical and practical training

### 5.11.3 ADS system designs that do not anticipate a user to perform the DDT (e.g. shuttle, robotaxi)

5.11.12 The following recommendations apply to ADS vehicles with a system design that does not anticipate a user to perform the in the vehicle.

5.11.12.1 The user in the vehicle is a **passenger (in a passenger seat)**.

5.11.12.2 The ADS vehicle shall provide safety-related information to the passengers.

(e.g., emergency stop instructions(MRM), communication to remote operator for assistance)

5.11.12.3 ADS features may control the operation of closures, if available, as relevant to occupant safety, or to restrict or enable access to compartments. Controls related to closures may be disabled by the ADS feature whilst the vehicle is in motion.

5.11.12.4 The ADS vehicle shall provide users with means to request a minimal risk manoeuvre to stop the ADS vehicle.

- (a) MRM request shall be accessible to the users
- (b) The MRM request shall automatically alert the **remote operator**

### 5.11.4 ADS system designs for the transport of goods only

Systems designed for the transport of goods only will not have a user in the vehicle and have no need of in-vehicle user-vehicle interaction.

This section does not cover external human machine interaction (f.ex. for intervention of humans that are near the automated vehicle and should see a need for an emergency stop).

### 5.11.5 Remote operation of ADS vehicles

To be determined.