User Roles Definitions for Vehicles with Automated Driving Systems

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Background

The automation of the driving task is progressing. However it will still take a long time before a vehicle can perform the full driving task under all conditions. Moreover, certain aspects of the driving task may be automated, while other aspects still need to be executed by the driver. For example, the longitudinal and lateral control of the vehicle may be fully automated, while the vehicle may still need assistance with overtaking or may not even be capable of executing a lane change.

Consequently, a binary split of the driving task (the vehicle performs the full driving task or the driver performs the full driving task) is not adequate to describe the variety of user roles. The role depends on the level of automation and more precisely it depends on which aspects of the driving task are automated.

In addition, the execution of Dynamic Driving Task (DDT; see SAE J3016) by an ADS also depends on the Operational Design Domain (ODD) of that ADS. So for an ADS the DDT and ODD are intertwined, which also leads to a broad spectrum of automation possibilities. As indicated above, an ADS can be capable of full lateral and longitudinal control and capable of Object, Event Detection and Recognition (OEDR), but not able to perform tactical manoeuvres such as lane changes. From a technical perspective such an ADS can be considered as fully executing the DDT within its ODD ('in lane driving'). However, from a user's perspective the ADS can actually not perform the full DDT (because it cannot execute lane changes which are tactical manoeuvres).

The previous examples show that for defining functional requirements for automated vehicles it is highly relevant to approach the automated vehicle also from a user's perspective and to define what role a user needs to fulfil while travelling in a vehicle capable of automated driving. In the end for a safe use of the automated vehicle, the vehicle needs to interact with the user, for example, about roles and responsibilities, about operational mode, and transfer of control. It is then vital that the user knows and understands the role the vehicle will fulfil and the counterpart role that the user need to fulfil. And these roles depend on which aspects of the driving task are automated.

This document will define the different roles a user can or needs to fulfil when using a vehicle equipped with an ADS and which need to be considered for Functional Requirements for Automated Vehicles (FRAV). A user is defined as the human being who is directly involved in using the vehicle with an ADS. The 'use' can be active (involvement in the execution of the driving task) or passive (e.g., a passenger

of a vehicle under full automation). The scope of this document is limited to this type of user.[1] An automated vehicle is a vehicle equipped with an ADS. It can but does not necessarily mean a 'fully' automated vehicle.

It is important to realise that the role of a user of an automated vehicle can change during a single drive. For example, a user can first be a manual driver, then enable assistance systems (become an assisted driver), then enable automation and thus become a "user in charge" and so on. This shift in roles has an impact on the interaction processes between vehicle and user and is therefore highly relevant for the design of automated vehicles. Consequently it is also necessary to include user roles with ADAS or no assistance as well. However, it may be the case requirements are not needed for every role. At the same time, they need to be acknowledged to ensure that specific shifts in roles and the nature of the roles themselves are addressed by the interaction processes.

Where applicable existing relevant standards that provide definitions will be used or referred to.

FRAV Approach
The approach has started with determining the underlying dimensions of the user roles. And from there define the user roles. In a later phase (after May 9th) the needs of different users to execute their roles will be considered. In a final step, the needs are to be projected on to high-level requirements for automated vehicles. The objective of these requirements is to support an accepted, user-friendly, and efficient interaction between the user and ADS to ensure the safety of the user and of other road users.

To ensure that all possible user roles are included, the various dimensions underlying the different roles a user of an automated vehicle can perform have been specified.

Dimensions to differentiate users roles
Four dimensions were distinguished to differentiate the user roles:
1) Number of vehicles (#)
2) Driving Task Level (DTL)
3) Operation Mode (OM)
4) Locus of operation (LoO)

Explanation of 1) Number of vehicles (#V)
The user role can pertain to a single vehicle, a platoon of vehicles or a fleet of vehicles.

Explanation of 2) Driving Task Level (DTL)
The driving task consists of three levels (Michon, 1985):
- Strategic level (e.g., route choice)
- Tactical level (e.g., decision to overtake)
- Operational level (e.g., braking, steering)

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[1] Without this definition or limitation a fleet owner, for example, also has a user role. Although a fleet owner may definitely have responsibilities for a correct use of the ADS in the vehicle s/he is not directly involved with using the ADS. The role of, for example, fleet owners in the use of ADS will need to be defined elsewhere.

Michon (1985) indicated that the Strategic level included the route and mode choice a driver must make before undertaking a trip and during a trip. However, at this level actions like engaging an ADS are here included (e.g., a user of a fully automated vehicle still needs to indicate, e.g., where to go to and to switch the system on).

The user role can relate to all three levels of the driving task or only to a specific level of the driving task. Since by definition the entire driving task consists of all three levels, it follows that if the user is, for example, involved in only one level, then the other levels are automated.

Moreover, given that there is a hierarchy between the levels, a user cannot act on the Operational level while the Tactical and Strategic levels are automated. From this follows Table 1.

Table 1: Permutations of Driving Task Level

DTL executed by ADS	DTL (partly) executed by User
None	Operational, Tactical and Strategic
Operational	Tactical and Strategic
Operational and Tactical	Strategic
Operational, Tactical and Strategic	Strategic

The table is actually quite simplified. In the table it is assumed that, if the tactical level is automated, the ADS is capable of performing all relevant manoeuvres. However, the tactical level is difficult to automate since this is the driving task level where the driver decides to overtake, when to turn left before an oncoming vehicle, etc. At this level, it may very well be the case that ADS and the user both have a share in deciding when to initiate an action.

Moreover, the DTLs are subdivided into perception, decisions and actions. At the moment, these subdivisions are not addressed. However, it reasonable to assume that in certain cases an ADS may need the assistance of the driver in perceiving the environment to ensure that it is safe to overtake.

When a user performs the driving task at all three levels, s/he is fully and directly involved; when, for example, the operational level is fully automated then the user performs the driving task partially; and when the user does not have to be involved in the driving task on a continuous basis, the driver is temporarily not involved, but can still remain a potential driver.

The DTL is related to the OM. The combination of these two dimensions shows who is the (main) responsible for what in the execution of the driving task, the ADS or the user.

Explanation of 3) Operation Mode (OM)

There are different ways in which the driving task can be executed which depends on the type of vehicle:

- Control of the vehicle
- Assisted control
- Available
- None

The OM is related to the DTL. The combination of these two dimensions shows who is the (main) actor responsible for what in the execution of the driving task, the ADS or the user.

To differentiate between (1) a role where a user still has control / assisted control at the tactical or/and operational level of the driving task and (2) when the user has no such control, we propose the use 'driver' for (1) and 'user' for (2).

Explanation of 4) Locus of operation (LoO)

The user can be in different loci of operation when using the ADS:

- In the driver seat
- In a passenger seat
- Outside the vehicle with vehicle in sight (ViS)
- Outside the vehicle not in sight (VniS)
- In a control room

Overview of the user dimensions

Combining the different levels of the four dimensions leads to different user roles. However, it is not the case that all possible combinations of all individual levels lead to the different user roles.
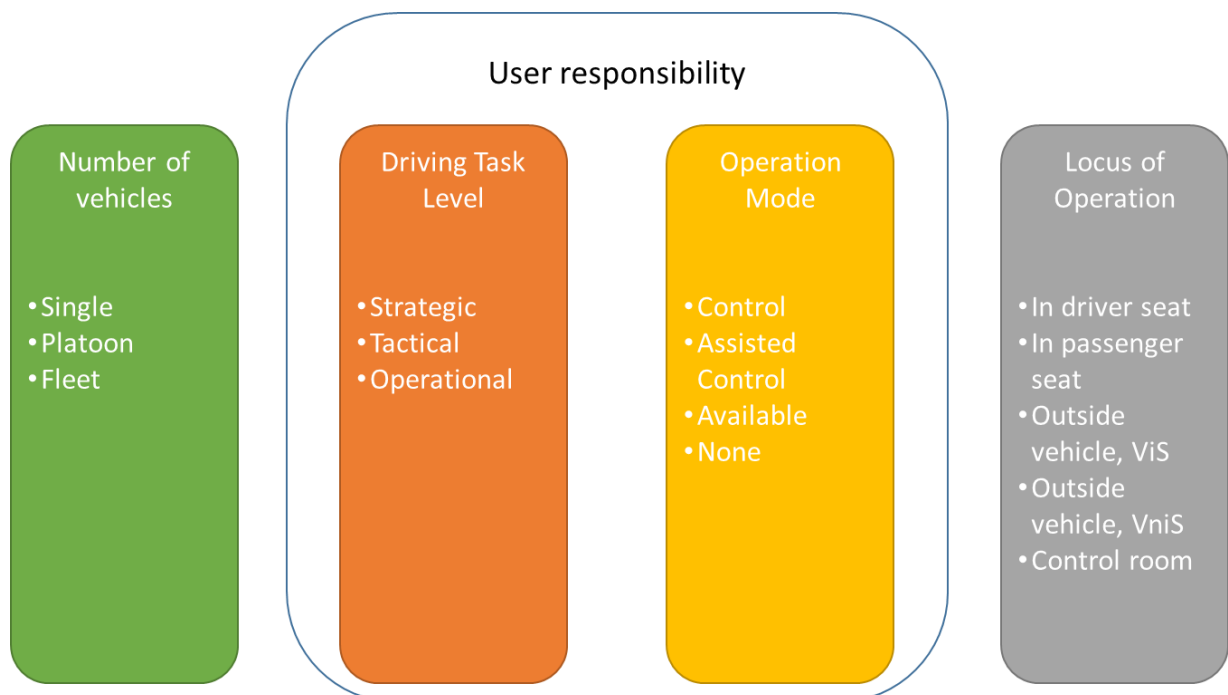
Figure 1 – The different levels of the four dimensions undelying the possible user roles

Note: As stated earlier the role for a single individual may change during a single trip.

In Figure 1 'User responsibility' does not mean user liability. With user responsibility is meant for which level of the DTL the user is responsible in what way. It is important to realise that what the driver is not responsible for is done by the ADS (see also Table 1).

User Roles: Names and descriptions

As stated not all combinations of each dimension and each level result in a specific role. The total number of possible combinations are 960. For the single vehicle, the exercise of going systematically through all 320 individual combinations has been carried out (e.g., {Strategic [control], Tactical [control], Operational [control], in driver seat}, {Strategic [control], Tactical [control], Operational [control], in passenger seat}, ... {Strategic [assisted control], Tactical [control], Operational [control], in driver seat}, ... {Strategic [none], Tactical [none], Operational [none], control room}.)

The different roles of users of a single vehicle with ADS are presented in Table 2.

Table 2: User roles for single automated vehicles

#	User Role name	Description	Example user	Example ADS	Example ADAS	SAE defined role
			User roles for single automated vehicles			
1	**Conventional Driver**	User performs unassisted the operational and tactical level. Level of strategic control may differ between users.	car drivers (full strategic control); taxi, long haul bus drivers, and truck drivers (shared strategic control); city bus drivers (no strategic control)	No ADS feature	No ADAS	Conventional driver
2	**Operational Assisted Driver**	User is only assisted with the longitudinal and lateral control (operational level).	car drivers (full strategic control); taxi, long haul bus drivers, and truck drivers (shared strategic control); city bus drivers (no strategic control)	No ADS feature	ACC	Conventional driver
3	**Tactical Assisted Driver**	User is assisted with manoeuvres (tactical level) and the longitudinal and lateral control.	car drivers (full strategic control); taxi, long haul bus drivers, and truck drivers (shared strategic control); city bus drivers (no strategic control)	No ADS feature	ACC, LKS, BLIS	Conventional driver
4	**Fallback-ready Driver**	User decides and executes manoeuvres. The ADS performs the longitudinal and lateral control but the user has to be available.	car drivers (full strategic control); taxi, long haul bus drivers, and truck drivers (shared strategic control); city bus drivers (no strategic control)	ALKS without lane change	No ADAS	In-vehicle fallback-ready user
5	**Fallback-ready Assisted Driver**	User is assisted with manoeuvres. The ADS performs the longitudinal and lateral control but the user has to be available.	car drivers (full strategic control); taxi, long haul bus drivers, and truck drivers (shared strategic control); city bus drivers (no strategic control)	ALKS without lane change	ACSF category C or D	In-vehicle fallback-ready user
6	**Fallback-ready User**	User has to be available for controlling the vehicle. The ADS	car drivers (full strategic control); taxi, long haul bus drivers, and truck	ALKS with lane change	No ADAS	In-vehicle fallback-ready user

		performs the tactical and operational task.	drivers (shared strategic control); city bus drivers (no strategic control)			
7	**Limited Automation Driver**	User has to perform manoeuvres if wished or needed. The longitudinal and lateral control is fully automated and the user doesn't have to be available.	car drivers (full strategic control); taxi, long haul bus drivers, and truck drivers (shared strategic control); city bus drivers (no strategic control)	ALKS+ without lane change	No ADAS	-
8	**Tactical Assisted Limited Automation Driver**	User is assisted with manoeuvres if wished or needed. The longitudinal and lateral control is fully automated and the user doesn't have to be available.	car drivers (full strategic control); taxi, long haul bus drivers, and truck drivers (shared strategic control); city bus drivers (no strategic control)	ALKS+ without lane change	ACSF category C or D	-
9	**ADS available user**	User is available for manoeuvres and has no involvement in the lateral and longitudinal control.	car drivers (full strategic control); taxi, long haul bus drivers, and truck drivers (shared strategic control); city bus drivers (no strategic control)	ALKS+ with lane change ACSF cat E	No ADAS	In-vehicle fallback-ready user
10	**ADS user**	User activates the ADS and if necessary indicates directions.	car drivers (full strategic control); taxi, long haul bus drivers, and truck drivers (shared strategic control); city bus drivers (no strategic control)	ALKS+ with lane change	No ADAS	Passenger
11	**Proximity remote user**	User is outside the vehicle with the vehicle in sight and operates through a device the ADS. User monitors environment for safety.	car drivers	Parking system with app	No ADAS	Remote driver

12	**Distant Remote User**	User engages and/or instructs the ADS to perform a specific task.	car drivers	Valet parking system	No ADAS	Remote driver
13	**Safety Steward**	User has to start the system and indicate the route it has to follow. User also has to manage the pod in difficult traffic situations	Shuttle pod assistant	Shuttle pod	No ADAS	In-vehicle fallback-ready user

The specifications of the roles of users of a fleet of vehicles or as part of a platoon will follow later.

Annex 1 SAE user definitions

3.31 [HUMAN] USER

A general term referencing the human role in driving automation.

NOTE 1: The following five terms (1 - driver, 2 - passenger, 3 - DDT fallback-ready user, 4 - driverless operation dispatcher, and 5 - remote assistant) describe categories of (human) users.

NOTE 2: These human categories define roles that do not overlap and may be performed in varying sequences during a given trip.

3.31.1 [HUMAN] DRIVER

A user who performs in real time part or all of the DDT and/or DDT fallback for a particular vehicle.

NOTE: This definition of "driver" does not include a robotic test device designed to exercise steering, braking, and acceleration during certain dynamic test maneuvers.

3.31.1.1 [CONVENTIONAL] DRIVER / IN-VEHICLE DRIVER

A driver who manually exercises in-vehicle braking, accelerating, steering, and transmission gear selection input devices in order to operate a vehicle.

NOTE 1: An in-vehicle driver is seated in what is normally referred to as "the driver's seat" in automotive contexts, which is a unique seating position that makes in-vehicle input devices (steering wheel, brake and accelerator pedals, gear shift) accessible to a (human) driver.

NOTE 2: "Conventional driver" is an acceptable synonym for in-vehicle driver.

NOTE 3: In a conventional or dual-mode vehicle equipped with a driving automation system, an in-vehicle driver, who may be a passenger or a fallback-ready user during ADS engagement, may assume or resume performance of part or all of the DDT from the driving automation system during a given trip.

3.31.1.2 REMOTE DRIVER

A driver who is not seated in a position to manually exercise in-vehicle braking, accelerating, steering, and transmission gear selection input devices (if any), but is able to operate the vehicle.

NOTE 1: A remote driver may include a user who is within the vehicle, within line-of-sight of the vehicle, or beyond line-of-sight of the vehicle.

NOTE 2: A remote driver is not the same as a driverless operation dispatcher (see 3.32.4), although a driverless operation dispatcher may become a remote driver if s/he has the means to operate the vehicle remotely.

NOTE 3: A remote driver does not include a person who merely creates driving-relevant conditions that are sensed by, or communicated to, the ADS (e.g., a police officer who announces over a loudspeaker that a particular stop sign should be ignored; another driver who flashes his/her head lamps to encourage overtaking, or a pedestrian using a dedicated short range communication (DSRC) system to announce his/her presence).

EXAMPLE 1: A Level 2 automated parking feature allows the remote driver to exit the vehicle near an intended parking space and to cause the vehicle to move into the parking space automatically by pressing and holding a special button on the key fob, while s/he is monitoring the driving environment to ensure that no one and nothing enters the vehicle pathway during the parking maneuver. If, during the maneuver, a dog enters the pathway of the vehicle, the remote driver releases the button on the key fob in order to cause the vehicle to stop automatically. (Note that the remote driver in this Level 2 example completes the OEDR subtask of the DDT during the parking maneuver.)

EXAMPLE 2: Identical situation to Example 1, except that the remote driver is sitting in the back seat, rather than standing outside the vehicle.

EXAMPLE 3: A Level 4 closed campus delivery vehicle that has experienced a DDT performance-relevant system failure, which forced it to resort to a minimal risk condition by parking on the side of a campus roadway, is returned to its designated marshalling yard by a remote driver who is able to operate the vehicle using wireless means.

3.31.2 PASSENGER

A user in a vehicle who has no role in the operation of that vehicle.

EXAMPLE 1: The person seated in the driver's seat of a vehicle equipped with a Level 4 ADS feature designed to automate high-speed vehicle operation on access-controlled freeways is a passenger while this Level 4 feature is engaged. This same person, however, is a driver before engaging this Level 4 ADS feature and again after disengaging the feature in order to exit the controlled access freeway.

EXAMPLE 2: The in-vehicle users of an ADS-DV shuttle on a university campus are passengers.

EXAMPLE 3: The in-vehicle users of a Level 5 ADS-equipped dual-mode vehicle are passengers whenever the Level 5 ADS is engaged.

3.31.3 [DDT] FALLBACK-READY USER

The user of a vehicle equipped with an engaged Level 3 ADS feature who is properly qualified and able to operate the vehicle and is receptive to ADS-issued requests to intervene and to evident DDT performance-relevant system failures in the vehicle compelling him or her to perform the DDT fallback.

NOTE 1: DDT performance by a Level 3 ADS assumes that a fallback-ready user is available to perform the DDT as required. There is no such assumption at Levels 4 and 5.

NOTE 2: A DDT fallback-ready user who transitions to performing part or all of the DDT becomes a driver (in-vehicle or remote).

3.31.3.1 IN-VEHICLE FALLBACK-READY USER

A fallback-ready user of a conventional vehicle with an engaged Level 3 ADS feature who is seated in the driver's seat.

EXAMPLE: A Level 3 ADS sub-trip feature designed to perform the DDT in congested traffic on certain freeways encounters emergency responders who are rerouting traffic to the exit due to a serious crash; the ADS issues a request to intervene. The in-vehicle fallback-ready user becomes a driver and performs the fallback by manually operating the vehicle.

3.31.3.2 REMOTE FALLBACK-READY USER

A fallback-ready user of a Level 3 ADS-equipped vehicle in driverless operation who is not in the driver's seat.

EXAMPLE: A Level 3 ADS-DV encounters a crash scene for which emergency personnel are re-routing traffic; the ADS issues a request to intervene. The remote fallback-ready user becomes a remote driver and performs the fallback by remotely operating the vehicle.

3.31.4 DRIVERLESS OPERATION DISPATCHER

A user(s) who dispatches an ADS-equipped vehicle(s) in driverless operation.

NOTE: A dispacher(s) may also perform other fleet operations functions.

3.31.5 REMOTE ASSISTANT
A human(s) who provides remote assistance to an ADS-equipped vehicle in driverless operation.
NOTE: A remote assistant(s) may also perform other fleet operations functions.

Text taken from SAE J3016 April 2021. Colours are added to emphasize the different groups distinguished by the SAE.

Annex 2

What "user definitions" do we need to support user-interaction/HMI requirements?

	Character	**Description**
1	**User**	General term for human roles associated with driving automation. Note:The role of the user can be transformed under certain conditions.
2	**Driver**	For a specific vehicle, users who perform part or all of the dynamic driving tasks and/or take over in real time.
3	**Conventional driver**	A driver sitting in a driver's seat who controls the vehicle by manually operating the vehicle's brake, acceleration, steering and shift controls.
4	**Remote driver**	The vehicle can be operated in real time without the driver in the driving seat , remote driver can manually and directly operate the vehicle brake, acceleration, steering and shift control devices. Note: The remote driver may be a user within the vehicle, within the field of vision or outside the field of vision of the vehicle.
5	**Passenger**	In the vehicle, but the user does not undertake any dynamic driving tasks
6	**DDT fallback-ready user**	When the level 3 driving automation system works, the user can identify the take-over request issued by the driving automation system and the obvious vehicle failure related to the dynamic driving task, and performs the dynamic driving task take-over. Note 1: The term applies to level 3 driving automation functions. Level 4 and level 5 do not have this role. DDT fallback-ready user can be inside or outside the vehicle. Note 2: DDT fallback-ready user become drivers when performing part or all of the dynamic driving tasks.
7	**Dispatcher**	Under the condition of no driver operation, the dispatcher realizes the vehicle scheduling service by activating the driving automation system, but does not perform the dynamic driving task. Note: It can be scheduled only when the vehicles equipped with level 4 and level 5 driving automation and ODD cover the entire journey. If the route is not planned by the driving automation system, the dispatcher needs to specify the destination.