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Intelligent transport systems — Partially automated lane change systems (PALS) — Functional / operational requirements and test procedures

Systèmes de transport intelligents — Systèmes de changement de voie partiellement automatisés (PALS) — Exigences fonctionnelles et opérationnelles et procédures d'essai

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Foreword

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This document was prepared by Technical Committee ISO/TC 204, *Intelligent transport systems*.

Any feedback or questions on this document should be directed to the user's national standards body. A complete listing of these bodies can be found at www.iso.org/members.html.

Introduction

In general, driving assist systems and automated driving systems equipped in a vehicle reduce the burden of the drivers and contribute to safe driving. For a lane change operation, there are many drivers who are not good at performing a lane change. To support such drivers, Partially Automated Lane Change Systems (PALS) execute an automatic lane change manoeuvre following the request of the driver and under the supervision of the driver, on a road with visible lane markings, where non-motorized vehicles and pedestrians are prohibited.

PALS acquire information not only on the position of the vehicle within the lane, but also on adjacent lanes and obstacles in the vicinity of the subject vehicle (SV). PALS evaluate whether or not a lane change to an adjacent lane is possible and send commands to the actuators which control lateral movement of the vehicle to perform a lane change. This document specifies how PALS support drivers for a lane change and describes PALS' operations.

Intelligent transport systems — Partially automated lane change systems (PALS) — Functional / operational requirements and test procedures

1 Scope

This document contains the basic control strategy, minimum functionality requirements, basic driver interface elements, minimum requirements for reaction to failure, and performance test procedures for PALS.

PALS perform part or all of lane change tasks under the driver's initiation and supervision. PALS are intended to function on roads with visible lane markings, where non-motorized vehicles and pedestrians are prohibited (e.g. access controlled highway), and to perform a lane change into a lane with traffic moving in the same direction. Support on sections of roadway with temporary or irregular lane markings (such as roadwork zones) is not within the scope of this document.

This document does not describe functionalities based on combinations with longitudinal control systems such as those standardized in ISO 22839 (FVCMS) or ISO 15622 (ACC).

The driver always assumes responsibility for this system and the driver's decisions and operations take priority at all times.

Use of PALS is intended for light-duty and heavy-duty vehicles (heavy trucks and buses).

This document does not address any functional or performance requirements for detection sensors, nor any communication links for co-operative solutions.

2 Normative references

The following documents are referred to in the text in such a way that some or all of their content constitutes requirements of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

ISO 15037-1, *Road vehicles — Vehicle dynamics test methods — Part 1: General conditions for passenger cars*

ISO 15037-2, *Road vehicles — Vehicle dynamics test methods — Part 2: General conditions for heavy vehicles and buses*

ISO 17387, *Intelligent transport systems — Lane change decision aid systems (LCDAS) — Performance requirements and test procedures*

3 Terms and definitions

For the purposes of this document, the following terms and definitions apply.

ISO and IEC maintain terminological databases for use in standardization at the following addresses:

— ISO Online browsing platform: available at https://www.iso.org/obp

— IEC Electropedia: available at http://www.electropedia.org/

3.1
subject vehicle
SV
vehicle equipped with the system in question and related to the topic of discussion

3.2
PALS state
one of several stages or phases of the system operation flow

Note 1 to entry: See Figure 1.

3.3
PALS off state
PALS state when the system is switched off

3.4
PALS stand-by state
PALS state when the system is switched on, but the activation criteria are not all met

3.5
PALS active state
PALS state when the system is switched on and the activation criteria are met

3.6
lane
one of the longitudinal strips into which a roadway is divided by *lane markings* (3.7)

3.7
lane marking
delineators, markings, or Botts' dots intentionally placed on the borderline of the *lane* (3.6)

3.8
lane change manoeuvre
lateral movement which the system automatically executes to change *lanes* (3.6) from its initial lane to an adjacent lane

3.9
lane change function
function of the system which includes both gap-searching and *lane change manoeuvre* (3.8)

3.10
time gap
value calculated from vehicle speed, v, and clearance, c, by the Formula: $t_{gap} = c/v$

Note 1 to entry: see Figure 1

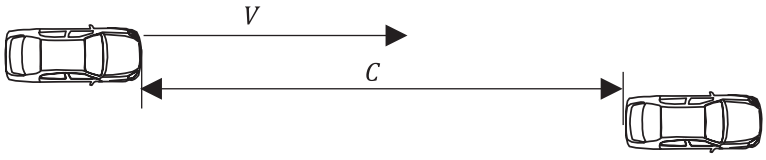

Figure 1 — Time gap

3.11
time to collision
TTC
estimated time that it would take a target vehicle to collide with the SV if the SV were in the target vehicle's path and the target vehicle's current closing speed remains constant

3.12
overtaking speed
difference between the SV's speed and the target vehicle's speed when the SV is overtaking the target vehicle

Note 1 to entry: A positive overtaking speed indicates that the SV is moving faster than the target vehicle.

3.13
gap searching
system function to search for sufficient gap between the SV and the other vehicle(s) in the adjacent target lane

4 Symbols and abbreviated terms

4.1 Symbols

See Table 1.

Table 1 — Symbols

Symbol	Definition
$A_{PALS,l,max}$	Maximum lateral acceleration which is allowed to be induced by a lane change manoeuvre
$J_{PALS,l,max}$	Maximum lateral jerk which is allowed to be induced by a lane change manoeuvre
V_{max}	Maximum SV speed which PALS is required to function
V_{min}	Minimum SV speed which PALS is required to function
V_{sv}	Velocity of SV
V_{rv}	Velocity of the rearward vehicle
V_{fv}	Velocity of the forward vehicle
D_r	Distance between the front edge of the rearward vehicle and the rear edge of the SV
D_f	Distance between the rear edge of the forward vehicle and the forward edge of the SV. The distance is equivalent to $V_{sv} \times T_f$.
T_f	Time gap between the forward vehicle and the SV
$T_{col,r}$	TTC between the rearward vehicle and the SV
$T_{I,S}$	Time from the initiation of the lane change function to the start of the lane change manoeuvre itself, in a free gap available condition

4.2 Abbreviated term

ACC Adaptive cruise control

HMI Human-machine interface

LCDAS Lane Change Decision Aid Systems

SV Subject vehicle

TTC Time to collision

5 Classification

5.1 General

PALS are classified into two types by different tasks split between system and driver as shown in 5.1.1, and 5.1.2, and by a modified sequence of operations. In both types, the lane change manoeuvre is initiated and supervised by the driver and is terminated when the SV is brought totally inside the target lane.

In Type I systems, the driver intends to promptly change the lane as the driver evaluates the target lane to be free and the PALS receive a driver command to perform the lane change manoeuvre. The system performs the lane change unless it detects an adjacent vehicle that obstructs the lane change.

In Type II systems, the driver intends to change the lane as soon as a sufficient gap in the target lane becomes available. The driver authorizes the system to search for a sufficient gap and then to perform a lane change manoeuvre.

In both types, a lane change manoeuvre is only started when no hazardous obstacle is detected in the relevant range for Type I or Type II, respectively (see 5.1.1 and 5.1.2).

For both types, the point in time when the SV leaves the current lane is specified as the point in time when the preceding wheel of the SV crosses the inner edge of the lane marking.

Type I and II systems can be offered separately, or as a combined system with both types in one system.

Both types may be combined with a longitudinal control system such as ISO 15622 (ACC) to maintain an appropriate time gap behind a forward vehicle.

5.1.1 Type I systems

Type I systems perform a lane change corresponding to the driver's initiation by controlling the lateral manoeuvre of the vehicle when there is no obstacle detected at least in the blind spot area. Means to detect the blind spot area shall conform to the requirements of LCDAS Type I specified in ISO 17387.

The following actions shall be performed.

a) The driver monitors the target lane and initiates a lane change manoeuvre (e.g. by indicator or specific HMI) if he or she believes that there is no hazardous obstacle in the target lane.

b) The system monitors the traffic situation at least in the blind spot area, (see ISO 17387:2008, LCDAS Type I) and if there is no interfering vehicle, the requested lane change manoeuvre can be executed. The system performs the lane change unless it detects an adjacent vehicle that obstructs the lane change. If a vehicle is detected in the adjacent lane, the PALS lane change function is cancelled and an additional driver initiation may be applied to start the lane change manoeuvre at a later time.

c) The turn signal shall be activated no later than at the beginning of the lane change manoeuvre. The SV should not leave the current lane earlier than 3 s and shall not leave earlier than 1 s after activation of the turn signal.

d) The driver shall be informed when the lane change manoeuvre starts.

e) The system performs a lane change manoeuvre when the necessary activation conditions have been met.

5.1.2 Type II systems

If the driver initiates a lane change, Type II systems search the gap in the adjacent lane at least in the blind spot and closing range and automatically perform the lane change. Means to detect the blind spot and closing range shall conform to the requirements of LCDAS Type III C specified in ISO 17387.

The following actions shall be performed:

a) The driver initiates the PALS lane change function (e.g. by indicator or specific HMI).

   Optionally, Type II systems may propose a lane change first without the driver's initiation of a lane change, e.g. when a slower vehicle is detected ahead or when an exit or junction in the routing is being approached. In this optional case, the system requires driver confirmation before the lane change manoeuvre is initiated, e.g. by switch or by steering wheel input.

b) The system continuously monitors the traffic situation and determines whether there is a sufficient gap which allows the lane change manoeuvre to be executed (gap searching). This should include detecting whether the target lane for the lane change is still available for the lane change manoeuvre (e.g. lane still exists, or lane markings and road signs still allow lane change).

c) The system informs the driver by an appropriate HMI that a sufficient gap exists, and the lane change manoeuvre can be started.

d) If a sufficient gap is not detected for longer than 10 s after the driver's lane change initiation request, an additional driver confirmation is necessary to continue gap searching. However, if the same vehicle has been obstructing the lane change since the driver initiated the lane change, gap searching may continue without additional confirmation. It is up to the manufacturer to determine how the gap searching is terminated if the driver doesn't confirm after a certain time period.

e) The turn signal shall be activated no later than at the beginning of the lane change manoeuvre. The SV should not leave the current lane earlier than 3 s and shall not leave earlier than 1 s after activation of the turn signal.

f) The driver shall be informed when the lane change manoeuvre starts and is expected to monitor that there is no hazardous obstacle in the target lane.

g) The system performs the lane change manoeuvre.

6 Requirements

6.1 General

PALS do not perform automated driving and only provide a lane change manoeuvre under the driver's initiation and supervision.

When the driver overrides the system, PALS shall allow the driver to take control. In that case, the lane change manoeuvre by the system shall be terminated.

In the following subclauses, the minimum requirements of functionalities and state transitions which PALS provide are specified.

6.2 Functionality

PALS shall have the means to detect visible lane markings and detect other vehicles and obstacles in the vicinity of the SV.

PALS shall have the means to move the SV in a lateral direction in order to perform a lane change manoeuvre.

PALS may have the capability of conducting longitudinal control relative to a vehicle in the adjacent lane. In this case, the functionality should be executed according to other control systems, such as ISO 21717 (PADS).