
**Intelligent transport systems —
Truck platooning systems (TPS)
— Functional and operational
requirements**

*Systèmes de transport intelligents — Systèmes de convois de camions
(TPS) — Exigences fonctionnelles et opérationnelles*

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Foreword

ISO (the International Organization for Standardization) is a worldwide federation of national standards bodies (ISO member bodies). The work of preparing International Standards is normally carried out through ISO technical committees. Each member body interested in a subject for which a technical committee has been established has the right to be represented on that committee. International organizations, governmental and non-governmental, in liaison with ISO, also take part in the work. ISO collaborates closely with the International Electrotechnical Commission (IEC) on all matters of electrotechnical standardization.

The procedures used to develop this document and those intended for its further maintenance are described in the ISO/IEC Directives, Part 1. In particular, the different approval criteria needed for the different types of ISO documents should be noted. This document was drafted in accordance with the editorial rules of the ISO/IEC Directives, Part 2 (see www.iso.org/directives).

Attention is drawn to the possibility that some of the elements of this document may be the subject of patent rights. ISO shall not be held responsible for identifying any or all such patent rights. Details of any patent rights identified during the development of the document will be in the Introduction and/or on the ISO list of patent declarations received (see www.iso.org/patents).

Any trade name used in this document is information given for the convenience of users and does not constitute an endorsement.

For an explanation of the voluntary nature of standards, the meaning of ISO specific terms and expressions related to conformity assessment, as well as information about ISO's adherence to the World Trade Organization (WTO) principles in the Technical Barriers to Trade (TBT), see www.iso.org/iso/foreword.html.

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

A truck platoon is a vehicle string in which multiple vehicles are driving under coordinated longitudinal and possible lateral control.

Truck platooning is beneficial for the transportation industry because it can improve the operational efficiency of motorway transportation, improve safety and reduce the energy consumption of truck operation, as well as improving drivers' working environment and reducing workload. In addition, truck platooning improves the road capacity and efficiency for overall traffic.

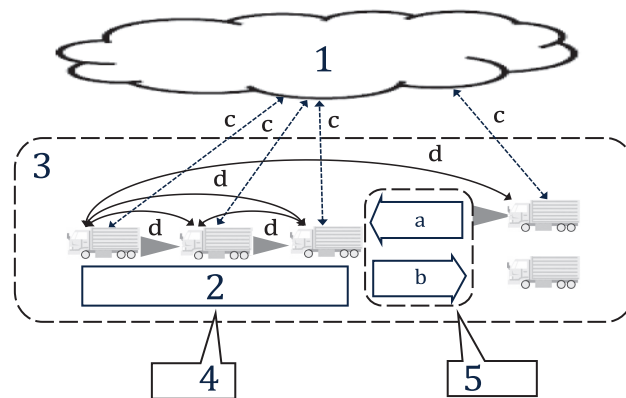
The truck platooning system consists of a platooning control system and optionally a back office (BO) as shown in [Figure 1](#). Information from the back office can be helpful and effective for planning platoon operations.

The platooning control system controls the processes by which vehicles join or leave the platoon and the manoeuvring of the platoon under coordinated longitudinal vehicle control strategies such as cooperative adaptive cruise control (CACC). Each vehicle has vehicle-to-vehicle (V2V) over-the-air communication to exchange information with the other vehicles in the platoon and recognizes its participation in a platoon. Each vehicle controls its own motions in a platoon based on the data obtained from sensors such as radar, lidar and camera, and the data received from the over-the-air communication.

The truck platooning system may include a back office infrastructure system to support the platooning control system. BO functions can include platooning demand matching, and platooning formation and operation management. Platooning demand matching covers forming requests, matching requests, route management and charge/payment of platoon from operators such as shippers and fleet operators. Platooning formation and operation management may issue notifications about the acceptance/refusal of platooning requests, truck sequence in platoon, route selection/permission/recommendation, and geographical limitations on the platooning.

The platooning operational control function controls changes in the membership of platoon; the platooning manoeuvre control function controls interactions within the platoon.

This document provides the common base needed for platooning system development. It also supports market introduction of the platooning system and assists in accelerating the deployment of truck platooning.



Key

- | | | | |
|---|---------------------------------------|---|--|
| 1 | back office | a | Join. |
| 2 | platoon (steady state) | b | Leave. |
| 3 | platooning control system | c | Vehicle to infrastructure (V2I) communication. |
| 4 | platooning manoeuvre control function | d | Vehicle to vehicle (V2V) communication. |
| 5 | platooning operation control function | | |

Figure 1 — Overall architecture of the truck platooning system (TPS)

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Intelligent transport systems — Truck platooning systems (TPS) — Functional and operational requirements

1 Scope

This document defines the terms and definitions related to truck platooning systems (TPS), and the mode transitions in the platooning control system (PCS). The PCS is comprised of two main functions: the platooning operation control function (POCF) and the platooning manoeuvre control function (PMCF).

This document specifies:

- POCF and PMCF governing how vehicles join and leave platoons;
- PMCF governing longitudinal and lateral control of each vehicle;

NOTE PMCF makes reference to current International Standards, such as ISO 20035, ISO 11270 and ISO 21717, where appropriate.

- functional evaluation test methods for POCF and PMCF.

This document also describes:

- the data to be communicated for POCF and PMCF in vehicle to vehicle (V2V) messages and optionally in vehicle to infrastructure (V2I) messages, including local roadside and broader network and cloud;
- strategies for forming platoons, such as ad-hoc or planned formation, and types of truck platooning systems, such as top-down management and peer-to-peer.

This document covers:

- platooning of heavy goods vehicles of multiple brands and fleets, operated by on-board drivers. Light trucks, buses and passenger cars are excluded;
- level 1 and 2 driving automation systems, which provide driver support and operate under the continuous supervision of the drivers.

The functions and operations of the back office (BO) are out of scope of this document.

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 21202, *Intelligent transport systems — Partially automated lane change systems (PALS) — Functional/operational requirements and test procedures*

3 Terms and definitions

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

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

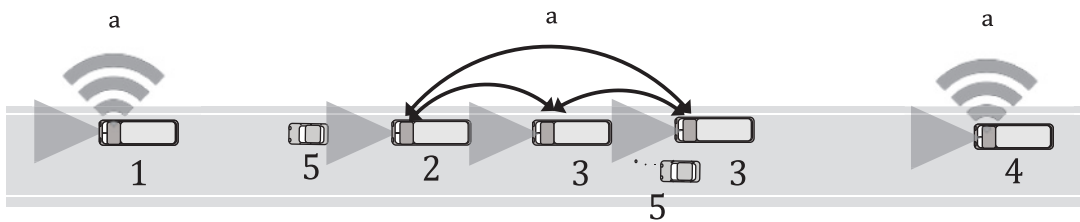
- ISO Online browsing platform: available at <https://www.iso.org/obp>

— IEC Electropedia: available at <https://www.electropedia.org/>

3.1 platoon
vehicle formation with a common platoon ID and sequence of participants

3.2 platooning
operation of a platoon in which multiple vehicles are driving under coordinated longitudinal control and possibly lateral control

Note 1 to entry: Each vehicle uses forward-vehicle detection by on-board sensors and vehicle to vehicle (V2V) over-the-air communication to exchange information needed to execute the coordinated longitudinal control with the other vehicles in the platoon (see [Figure 2](#)).



Key

- Key**
- a Vehicle to vehicle (V2V) communication.
 - 1 potential leading vehicle (PLV)
 - 2 leading vehicle (LV)
 - 3 following vehicle (FV)
 - 4 potential following vehicle (PFV)
 - 5 other vehicle (OV)

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Figure 2 — Platooning formation

3.3 leading vehicle
first vehicle in a platoon

3.4 following vehicle
vehicle operating in a platoon behind the leading vehicle and connected using vehicle to vehicle communication

3.5 other vehicle
vehicle that does not participate in the platoon but can potentially affect platoon operations, by performing emergency braking or a cut-in manoeuvre, for example

3.6 potential leading vehicle
vehicle that is not currently in a platoon but is in a position enabling it to potentially become the leading vehicle in the future or a former leading vehicle after leaving the platoon

3.7 potential following vehicle
vehicle that is not currently in a platoon but is in a position enabling it to potentially become the following vehicle in the future or a former following vehicle after leaving the platoon

3.8**join**

transition by which one or more vehicle(s) become(s) member(s) of a platoon

3.9**leave**

transition by which one or more vehicle(s) separate(s) from its current platoon

3.10**platooning control system**

system for operating the platooning operation control function and the platooning manoeuvre control function in a platoon, including the potential leading vehicle and potential following vehicle

3.11**platooning operation control function**

function to manage the transitions of vehicles in and out of platoon membership

3.12**platoon management message**

vehicle to vehicle communication or vehicle to infrastructure communication message that transmits information relevant to the platooning operation control function

3.13**platooning manoeuvre control function**

function to manage the continuous operations of platoon vehicles, including responses to situations such as cut-in and cut-out

3.14**platoon control message**

vehicle to vehicle communication message that transmits information relevant to the platooning manoeuvre control function

3.15**vehicle to infrastructure communication**

communication between vehicle and devices such as a roadside unit of infrastructure or mobile phone base station, but excluding vehicles

3.16**back office**

infrastructure system to support platoon operation, such as platoon planning and demand matching to start the platoon, and route management and the charge/payment process from the operators, such as shippers and fleet operators

3.17**time gap**

time needed to travel a distance equal to the clearance gap between the rear surface of the preceding vehicle and the forward surface of the following vehicle at the current vehicle speed

Note 1 to entry: This value is calculated as c/v , where v is the vehicle speed of the following vehicle and c is the clearance between the head of the following vehicle and the tail of the leading vehicle.

3.18**heavy goods vehicle**

truck with a gross combination mass (GCM) over 3 500 kg, which is considered as a vehicle according to categories N2 and N3 of WP.29 TRANS/WP.29/78/Rev.6

Note 1 to entry: See Reference [14].

4 Symbols and abbreviated terms

4.1 Abbreviated terms

| | |
|------|---|
| ACC | adaptive cruise control |
| BO | back office |
| CC | cruise control |
| CACC | cooperative adaptive cruise control |
| FV | following vehicle |
| GCM | gross combination mass |
| LKAS | lane keeping assistance systems |
| LV | leading vehicle |
| OV | other vehicle |
| PADS | partially automated in-lane driving systems |
| PALS | partially automated lane change systems |
| PCM | platoon control message |
| PCS | platooning control system |
| PFV | potential following vehicle |
| PLV | potential leading vehicle |
| PMCF | platooning manoeuvre control function |
| PMM | platoon management message |
| POCF | platooning operation control function |
| V2I | vehicle to infrastructure/infrastructure to vehicle |
| V2V | vehicle to vehicle |

5 Types of truck platooning systems

5.1 Top-down-managed platooning

The top-down managed platooning type is managed by the LV via V2V communication or optionally is managed by the BO via V2I communication to optimize platoon operations and recommend vehicle sequence, platooning speed, time gap, etc.

5.1.1 LV-managed platooning

The LV-managed platooning type is managed by the LV. The LV or its driver selects the speed and maximum number of vehicles in the platoon. The LV or its driver may inform the FV drivers about the recommended minimum time gap for FVs.

POCF such as "join" and "leave" may be triggered by FV drivers. Final permission to join is provided by the LV.

5.1.2 BO- and LV-managed platooning

The BO and LV perform the platoon management. Under management by the BO, the LV or its driver selects the speed and number of vehicles in the platoon. The LV or its driver may inform the FV drivers about the recommended minimum time gap for FVs and may make lane changing decisions under the management by the BO.

POCF such as "join" and "leave" may be triggered by FV drivers. Final permission to join is provided by the LV based on BO planning. The LV or BO may provide instructions for the "leave" operation.

5.2 Peer-to-peer platooning

Peer-to-peer platooning management operates based on peer-to-peer relationships among all of the vehicles in a platoon. All vehicles have equal status and none of them are governing other vehicles. All FVs individually control their speed (and optionally steering) to follow the LV or preceding FV and all drivers may choose their preferred gap settings.

6 Types of truck platoon formation

6.1 Overview

When a platoon is formed, different locations and types of formation are applied based on one of the strategies described in the following subclauses.

Platoon formation is the process in which it is determined if vehicles may become part of a platoon.

Platoon formation is the coordination of candidate vehicles which form the platoon in a defined structure.

Platoon formation may be done on the motorway during driving or at the staging area before entering the motorway.

Platoon formation may be done on an ad-hoc basis (that is, not planned) or planned in advance.

Platoon formation is completed to become a cruising operation after the join manoeuvre.

6.2 Formation on the motorway

6.2.1 General

In case of formation on the motorway, V2V and optionally V2I are used to search for other candidate vehicles.

6.2.2 Ad-hoc platoon formation on the motorway

Any vehicle or platoon which is capable of platooning searches for other similarly capable vehicles or platoons via V2V communications, and starts the join operation to form a new platoon. Optionally, V2I communications may be used to identify the availability of other eligible vehicles to join the ad-hoc platoon within the available effective communication range. The communication range covers the same motorway as well as the access ramps and at the interchanges.

6.2.3 Planned platoon formation on the motorway

In case of planned formation on the motorway, the BO coordinates potential platooning participants via V2I communication and manages speeds and routes to the meeting point of vehicles.

Platoon candidates (PLV and PFV) communicate with each other via V2V communications and join the platoon on the motorway.

Platoon candidates can receive instructions from the BO via V2I communications for platoon formation to allow the start of the "join" procedure with the platoon.

6.3 Formation at the staging area

6.3.1 Ad-hoc platoon formation at the staging area

Any vehicle or platoon which is capable of platooning searches for other similarly capable vehicles or platoons via V2V and optionally V2I communications within the available communication range and an ad-hoc platoon "join" operation is started at the staging area before entering the motorway. Each vehicle may start in sequence of platoon when they enter the motorway, or may move to the staging area in advance and park in sequence of platoon before entering motorway.

6.3.2 Planned platoon formation at the staging area

In case of planned formation at the staging area, the BO coordinates potential platooning participants via V2I communication.

Platoon candidates can receive instructions from the BO for platoon formation to allow the start of the "join" procedure with the platoon at the staging area.

Platoon candidates communicate via V2V communications and the "join" operation is implemented at the staging area.

Platoon formation may be achieved and completed at the staging area before initiating the drive. Vehicles can configure the sequence in platoon at the staging area based on the instructions from the BO.

7 Operation state diagram

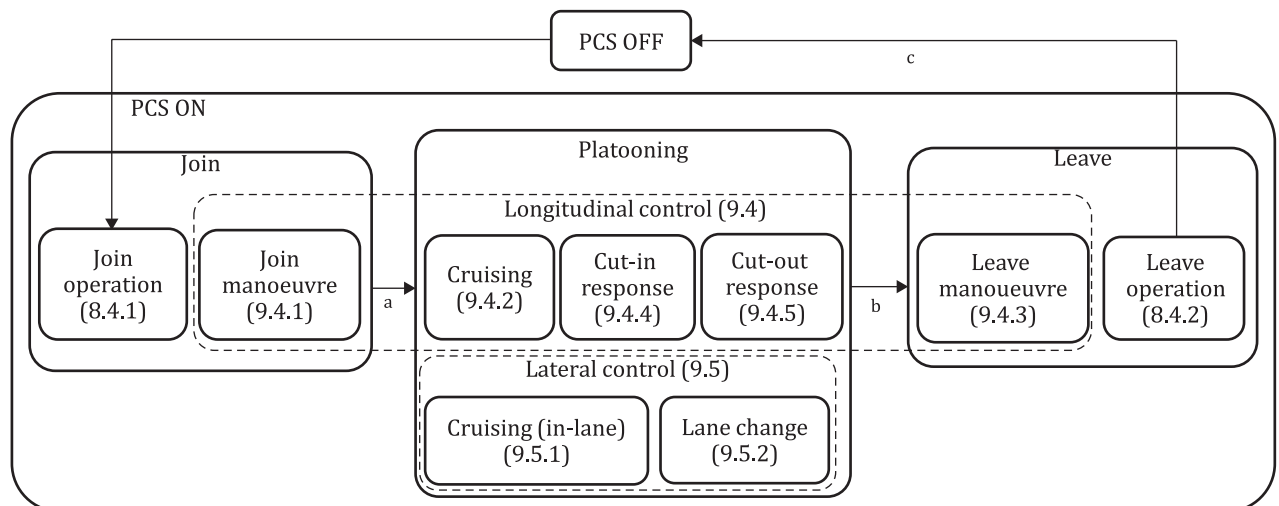
7.1 General

The truck platooning system is under operation when the PCS turns on (PCS ON). When the vehicle turns on the PCS, the "join" operation can be implemented as a POCF. After the "join" manoeuvre is completed, the platooning state is implemented and continues under various manoeuvre controls. When the "leave" notification is transmitted, the "leave" operation is implemented and the vehicle leaves the platoon and turns off the PCS (PCS OFF).

7.2 Operation state diagram of platooning operations

A state diagram of platooning operations is shown in [Figure 3](#).

POCF and PMCF operations are described in [Clauses 8](#) and [9](#).



- a Join complete.
- b Leave notification.
- c Leave complete.

Figure 3 — Operation state diagram

8 Platooning operation control function (POCF)

8.1 General

In the PCS, there are two modes of transition: "join" and "leave". Both transition modes are operated by the POCF which controls the change in membership status of the platoon.

8.2 Join

In the platooning operation, a platoon ID is provided for a new platoon and a sequential number of participant vehicles are confirmed to be a platoon. Joins may be achieved between any combination of individual vehicles and platoons in the leading and following positions. The join transition can be made within a lane during driving or at a staging area, such as a parking site.

Normally, the PLV becomes LV and the PFV becomes FV in a platoon. In some situations, V2V communication and/or V2I communication with BO may adjust the sequence of PLV and PFV to make a suitable platoon during this transition.

Use case examples of "join" transitions are shown in [Annex A](#).

The typical operation flow of "join" transitions is shown in [Figure 4](#).