International Standard

ISO 23793-1

First edition
2024-07

Intelligent transport systems — Minimal risk manoeuvre (MRM) for automated driving —

Part 1: Framework, straight-stop and in-lane stop

Systèmes de transport intelligents — Manœuvre à risque minimal pour la conduite automatisée (MRM) —

Partie 1: Cadre général, arrêt en ligne droite et arrêt dans la voie

Reference number
ISO 23793-1:2024(en)

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Published in Switzerland

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Foreword

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

A list of all parts in the ISO 23793 series can be found on the ISO website.

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Introduction

A minimal risk manoeuvre (MRM) is the fallback function of an automated driving system (ADS) used to achieve a minimal risk condition (MRC) which is a stable, stopped state (see ISO/SAE PAS 22736).

In a scenario where the dynamic driving task is being performed by the ISO/SAE Level 3-5 ADS, an event which prevents the ADS from continuing the dynamic driving task can occur. Examples of such events include:

a) for ISO/SAE Level 3-5 ADS, the failure of the ADS, automated driving component(s) or other vehicle component(s);

b) for ISO/SAE Level 3 or 4 ADS, the risk that the ADS exits its operational design domain (ODD);

c) for ISO/SAE Level 3 ADS, the failure of the fallback ready user (FRU) or passenger to take over the dynamic driving task when the ADS issues a request to intervene.

In response, the ADS initiates an MRM function to provide enhanced safety for all passengers and other road users. The MRM function selects the most appropriate MRM type to reduce the risk (taking into account the subject vehicle state and traffic conditions) and eventually stops the vehicle through vehicle control. In addition to longitudinal control, lateral control can be added for certain MRM types.

The MRM is not a system, but rather a functionality within an ADS. "MRM" and "failure mitigation strategy" appear similar in that both functions stop the vehicle in response to an adverse event for ADS operating at Level 3 to 5 automation. However, they differ in that the MRM is a function of an ADS, whereas failure mitigation strategy is a vehicle function designed to automatically bring a vehicle to a stop when it has been incapacitated.

"MRM" and "object and event detection and response" (OEDR) based collision mitigation and avoidance systems such as a "forward vehicle collision mitigation system" (FVCMS) sometimes behave similarly, as they try to minimize the collision risk. However, they also differ in their purposes: collision mitigation and avoidance systems consider impacts with external objects during normal operations, whereas an MRM tries to stop the vehicle in order to limit risk under abnormal conditions (such as ADS system failures or violations of ODD conditions) by decelerating the vehicle. OEDR-based collision mitigation and avoidance will be executed independently of and in parallel to MRM.

This document can be used to define the MRM function of ADSs such as motorway chauffeur systems (MCS) (ISO/TS 23792-1) or low speed automated driving (LSAD) systems (ISO 22737).

Intelligent transport systems — Minimal risk manoeuvre (MRM) for automated driving —

Part 1:
Framework, straight-stop and in-lane stop

1 Scope

This document addresses the minimum requirements for minimal risk manoeuvres (MRM), which are the response of an ADS to perform automated fallback to reach a minimal risk condition (MRC).

This document specifies the classification framework for MRMs. The classification framework establishes the concept of MRM operation, classification of different MRM types, and basic principles of the decision-making process to decide which MRM type can be performed based on the situation.

This document also specifies the minimum requirements of the control strategy and test procedures for the two simplest types of MRM: straight stop for type 1 and in-lane stop for type 2.

The scope of the MRM described in this document covers minimum requirements for ADS performance during MRM action, from initiation to termination, aimed at achieving an MRC. MRM action-specific safety requirements for robust system design, such as those specified in ISO 26262 and ISO 21448, are not within the scope of this document.

The MRM described in this document are intended to be used on light-duty vehicles equipped with Level 3-5 ADS.

The scope does not include methods for detecting ADS failures and the decision-making process to initiate an MRM. This is because there are numerous cases that can initiate MRMs, and there is no general agreement on classification of those cases in the industry.

2 Normative references

There are no normative references in this document.

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
minimal risk manoeuvre
MRM
manoeuvre by an automated driving system while performing the DDT fallback to attain the minimal risk condition

3.2
minimal risk condition
MRC
stable, stopped condition to which a user or an automated driving system may bring a vehicle after performing the dynamic driving task fallback in order to reduce the risk of a crash when a given trip cannot or should not be continued

[SOURCE: ISO/SAE PAS 22736:2021, 3.16, modified — Notes to entry and Examples have been removed.]

3.3
subject vehicle
SV
vehicle equipped with an automated driving system that is capable of performing minimal risk manoeuvres

3.4
standstill management
function that is implemented in actions taken to maintain the vehicle in minimal risk condition

3.5
lane boundary
borderline of the lane that is determined by a visible lane marking, and in the absence of a visible lane marking, by incidental detectable road features or other means such as localization relative to a digital map, magnetic markers, crash barriers, etc.

3.6
road shoulder
part of the road installed at the edge of the road, outside the lane boundary, to enable an emergency vehicle to bypass traffic congestion or to provide a place for a vehicle that encounters a problem to get out of the active traffic

3.7
acceleration control
control that generates positive acceleration using vehicle functions such as powertrain control

3.8
deceleration control
control that generates negative acceleration using vehicle functions such as brake

3.9
failure mitigation strategy
vehicle function [not an automated driving (ADS) function] designed to automatically bring an ADS-equipped vehicle to a controlled stop in path following either:

1) prolonged failure of the fallback-ready user of a Level 3 ADS feature to perform the fallback after the ADS has issued a request to intervene; or

2) occurrence of a system failure or external event so catastrophic that it incapacitates the ADS, which can no longer perform vehicle motion control in order to perform the fallback and achieve a minimal risk condition

[SOURCE: ISO/SAE PAS 22736:2021, 3.11]

3.10
collision mitigation and avoidance system
vehicle system that senses and monitors conditions inside and outside the vehicle for the purpose of identifying perceived present and potential dangers to the vehicle, occupants and/or other road users, and that automatically intervenes to help avoid or mitigate potential collisions via active control of the vehicle subsystems (brakes, throttle, suspension, etc.)

4 Abbreviated terms

ADS	automated driving system
CAN	control area network
DDT	dynamic driving task
ECU	electronic control unit
FRU	fallback-ready user
HMI	human-machine interface
MRC	minimal risk condition
MRM	minimal risk manoeuvre
ODD	operational design domain
OEDR	object and event detection and response
SV	subject vehicle
V2X	vehicle to everything

5 Function framework

5.1 MRM description

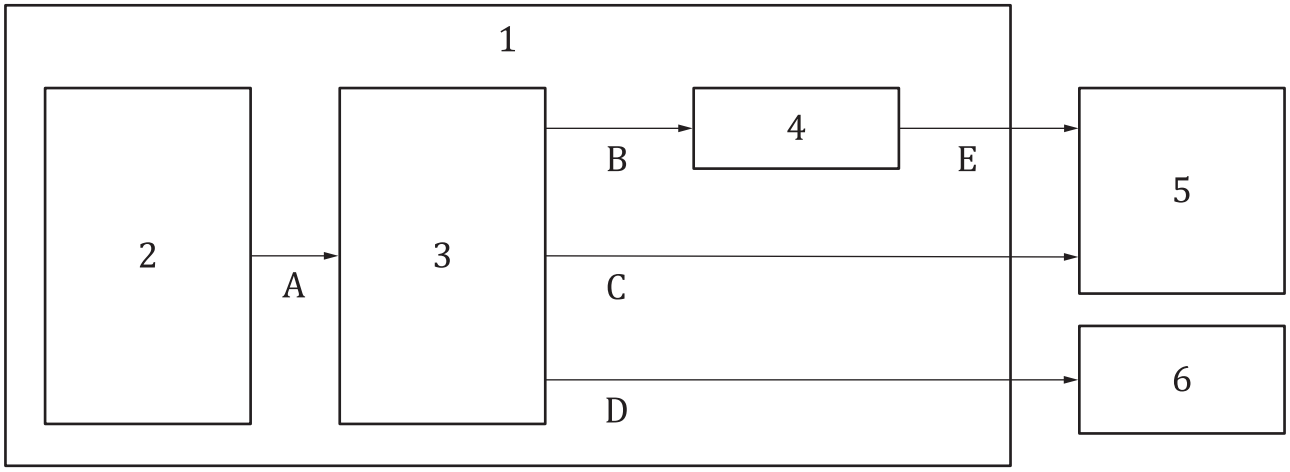
The MRM is a fallback action by ADS which entails stopping as the last countermeasure of an ADS in response to various risky situations such as failures and ODD constraint violations. Therefore, MRM is performed only when an ADS is not able to continue performing the DDT, and once an MRM starts, the ADS cannot automatically return to a normal state. MRM is not triggered in situations when ADS performance of the DDT can be maintained. Maintaining the DDT includes temporary stops (e.g. due to changes in environmental conditions) under the condition of remaining within the prescribed ODD.

The MRM is a function that aims to stop the SV in the safest achievable way, not to stop the SV as quickly as possible. Therefore, it is not a sudden hard braking control, but rather a longitudinal/lateral control according to the situation, which continuously seeks ways to minimize risks. The MRM is designed to minimize traffic hazards, but it can violate traffic regulations while performing the MRM to minimize the risk (e.g. stop in-lane).

5.2 State diagram

5.2.1 General

Figure 1 shows an example of an MRM state diagram to help illustrate the feature. Specific states of the MRM and transition conditions can be different for each ADS.



Key

1	ADS active	A	transition to MRM
2	ADS normal operation	B	transition to MRC
3	ADS MRM operation	C	transition to sustained standstill management
4	minimal risk condition	D	transition to manual driving
5	sustained standstill management	E	transition to sustained standstill management
6	manual driving		

Figure 1 — State diagram

5.2.2 ADS active (1)

5.2.2.1 ADS normal operation (2)

In the ADS normal operation state, the ADS performs the DDT as the system is intended to operate.

In the ADS normal operation state, the ADS determines whether an MRM is required. If it is determined that an MRM is required, the ADS transitions to MRM operation (A).

5.2.2.2 MRM operation (3)

In the MRM operation state, the ADS controls the SV to reach the MRC state.

In the MRM operation state:

— the ADS makes a decision on MRM type;

— the ADS controls the SV to execute the MRM;

— if a human user is on board, the ADS provides status information about the MRM;

— when the ADS is operated in the presence of other traffic, it displays an external indication that an MRM is occurring.

In the transition from the MRM operation to an MRC (B):

— the SV speed is zero (V_{SV} = 0 km/h) and the ADS activates standstill management, which is the ADS functionality.

In the transition from the MRM operation to sustained standstill management (C):

— the SV activates the failure mitigation strategy, either: