



BSI Standards Publication

# Road vehicles — Human performance and state in the context of automated driving

---

Part 1: Common underlying concepts

## National foreword

This Published Document is the UK implementation of ISO/TR 21959-1:2020. It supersedes PD ISO/TR 21959-1:2018, which is withdrawn.

The UK participation in its preparation was entrusted to Technical Committee AUE/12, Ergonomics (Road vehicles).

A list of organizations represented on this committee can be obtained on request to its secretary.

This publication does not purport to include all the necessary provisions of a contract. Users are responsible for its correct application.

© The British Standards Institution 2020  
Published by BSI Standards Limited 2020

ISBN 978 0 539 05322 7

ICS 43.020

**Compliance with a British Standard cannot confer immunity from legal obligations.**

This Published Document was published under the authority of the Standards Policy and Strategy Committee on 31 January 2020.

### Amendments/corrigenda issued since publication

Date	Text affected
------	---------------

---

TECHNICAL  
REPORT

ISO/TR  
21959-1

Second edition  
2020-01

---

---

**Road vehicles — Human performance  
and state in the context of automated  
driving —**

Part 1:  
**Common underlying concepts**

*Véhicules routiers — État et performance humaine dans le contexte  
de la conduite automatisée —*

*Partie 1: Concepts fondamentaux*



Reference number  
ISO/TR 21959-1:2020(E)

© ISO 2020



**COPYRIGHT PROTECTED DOCUMENT**

© ISO 2020

All rights reserved. Unless otherwise specified, or required in the context of its implementation, no part of this publication may be reproduced or utilized otherwise in any form or by any means, electronic or mechanical, including photocopying, or posting on the internet or an intranet, without prior written permission. Permission can be requested from either ISO at the address below or ISO's member body in the country of the requester.

ISO copyright office  
CP 401 • Ch. de Blandonnet 8  
CH-1214 Vernier, Geneva  
Phone: +41 22 749 01 11  
Fax: +41 22 749 09 47  
Email: [copyright@iso.org](mailto:copyright@iso.org)  
Website: [www.iso.org](http://www.iso.org)

Published in Switzerland

# Contents

Page

<b>Foreword</b> .....	<b>iv</b>
<b>Introduction</b> .....	<b>v</b>
<b>1 Scope</b> .....	<b>1</b>
<b>2 Normative references</b> .....	<b>1</b>
<b>3 Terms and definitions</b> .....	<b>1</b>
<b>4 Purpose</b> .....	<b>1</b>
<b>5 Human performance in the context of automated driving</b> .....	<b>2</b>
5.1 General.....	2
5.2 Transition from manual to automated driving.....	2
5.2.1 Transition process model.....	2
5.2.2 Definition of related concepts.....	3
5.2.3 Measures for human performance in releasing control to automation.....	4
5.3 Transition from automated to manual driving.....	4
5.3.1 Transition process models.....	5
5.3.2 Definition of related concepts.....	7
5.3.3 Measures for human performance in regaining control from automation.....	8
<b>6 Human states in the context of automated driving</b> .....	<b>11</b>
6.1 General.....	11
6.2 General concepts for mental state related to automated driving.....	11
6.3 Concepts corresponding to automation related driver states.....	12
6.4 Concepts corresponding to non-driving related driver states.....	13
6.5 Driving position and posture.....	15
<b>7 Driver readiness/availability</b> .....	<b>16</b>
<b>8 Drivers' experiences and attitudes regarding driving automation system</b> .....	<b>16</b>
8.1 Prior system image.....	17
8.2 Education and training.....	18
8.3 User's understanding of driving automation system.....	18
8.3.1 User's thoughts about how driving automation system works.....	18
8.3.2 User's mental attitude to driving automation system.....	18
8.4 User's use of driving automation system.....	19
8.4.1 User's behavioural attitude while using driving automation system.....	19
8.4.2 User's interaction with driving automation system.....	19
8.4.3 User's behaviour/manner at driving automation system.....	19
<b>Bibliography</b> .....	<b>20</b>

## 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](http://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](http://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](http://www.iso.org/iso/foreword.html).

This document was prepared by Technical Committee ISO/TC 22, *Road vehicles*, Subcommittee SC 39, *Ergonomics*.

This second edition cancels and replaces the first edition (ISO/TR 21959-1:2018), which has been technically revised. The main changes compared to the previous edition are as follows:

- editorial modifications to the format of the figures;
- corrections of the references to clause numbers (Clause 7 is now Clause 8);
- corrections to redundant descriptions.

A list of all parts in the ISO 21959 series can be found on the ISO website.

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](http://www.iso.org/members.html).

## Introduction

Although automation technology is advancing at a very fast pace, the majority of automated driving levels (as defined by SAE) still require a human to fulfil specific remaining (driving related) tasks while being in automated driving mode. The basic requirements with respect to the driver strongly depend on the level of automation and are subject to human factors research all over the world. The SAE standards SAE J3016<sup>[70]</sup> <sup>[71]</sup> and SAE J3114<sup>[72]</sup> have already introduced working definitions of key concepts in this field. This document puts an emphasis on common underlying concepts of driver performance and state in the context of automated driving.

Driver performance includes driver's activities in transitions both from manual driving to automated driving and from automated to manual driving, as well as interaction behaviour while using the system. Driver state here means driver's internal conditions that may affect performance including knowledge of and attitudes toward driving automation systems.

Concepts on driver performances in transition from manual to automated driving and from automated to manual driving are described in [Clause 5](#). Concepts on driver state related to the transition are described in [Clause 6](#) and a specific concept "readiness/availability" that refers to driver state that predicts the intervention performance is described in [Clause 7](#). Concepts for driver's experiences and attitudes that may affect driver performance and state in the context of automated driving are described in [Clause 8](#).

# Road vehicles — Human performance and state in the context of automated driving —

## Part 1: Common underlying concepts

### 1 Scope

This document introduces basic common underlying concepts related to driver performance and state in the context of automated driving. The concepts in this document are applicable to all levels of automated driving functions that require a human/driver to be engaged or fallback-ready (SAE level 1, 2 and 3). It can also be used with levels that enable a driver to resume manual control of the vehicle (a compatible feature for SAE levels 1 to 5).

Common underlying concepts can be applicable for human factors assessment evaluations using driving simulators, tests on restricted roadways (e.g. test tracks) or tests on public roads. The information applies to all vehicle categories.

This document contains a mixture of information where technical consensus supports such guidance, as well as discussion of those areas where further research is required to support technical consensus. These common underlying concepts can be also useful for product descriptions and owner manuals. The contents in this document are informative, rather than normative, in nature.

### 2 Normative references

There are no normative references in this document.

### 3 Terms and definitions

No terms and definitions are listed in this document.

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/>

### 4 Purpose

The purpose of this document is to provide common underlying concepts for human performance and state for the researchers and developers of driving automation systems (more specifically SAE levels 1-5) in order to facilitate the sharing of information and knowledge as these systems are developed and deployed.

This document does not provide design principles on how a human-machine interface (HMI) for automated driving should be designed or developed. However, common concepts and measures could be used during the development phase when different HMI designs are evaluated in terms of usability, user experience and safety.

It is not intended that anything in this document restricts or provides direction regarding the technology used to create these systems, or the underlying design of these system.