PD ISO/TR 21934-1:2021



BSI Standards Publication

Road vehicles — Prospective safety performance assessment of pre-crash technology by virtual simulation

Part 1: State-of-the-art and general method overview

bsi.

National foreword

This Published Document is the UK implementation of ISO/TR 21934-1:2021.

The UK participation in its preparation was entrusted to Technical Committee AUE/7, Automobile occupant restraint systems.

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

Contractual and legal considerations

This publication has been prepared in good faith, however no representation, warranty, assurance or undertaking (express or implied) is or will be made, and no responsibility or liability is or will be accepted by BSI in relation to the adequacy, accuracy, completeness or reasonableness of this publication. All and any such responsibility and liability is expressly disclaimed to the full extent permitted by the law.

This publication is provided as is, and is to be used at the recipient's own risk.

The recipient is advised to consider seeking professional guidance with respect to its use of this publication.

This publication is not intended to constitute a contract. Users are responsible for its correct application.

This publication is not to be regarded as a British Standard.

© The British Standards Institution 2021
Published by BSI Standards Limited 2021

ISBN 978 0 539 02479 1

ICS 43.020

Compliance with a Published Document cannot confer immunity from legal obligations.

This Published Document was published under the authority of the Standards Policy and Strategy Committee on 30 June 2021.

Amendments/corrigenda issued since publication

Date	Text affected

PD ISO/TR 21934-1:2021

TECHNICAL REPORT

ISO/TR 21934-1

First edition
2021-06

Road vehicles — Prospective safety performance assessment of pre-crash technology by virtual simulation —

Part 1: State-of-the-art and general method overview

Véhicules routiers — Evaluation prospective de la performance sécuritaire des systèmes de pré-accident par simulation numérique —

Partie 1: Etat de l'art et aperçu des méthodes générales

Reference number
ISO/TR 21934-1:2021(E)

© ISO 2021



COPYRIGHT PROTECTED DOCUMENT

© ISO 2021

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
Email: copyright@iso.org
Website: www.iso.org

Published in Switzerland

Contents

Page

Foreword ... **iv**
Introduction ... **v**
1 Scope ... **1**
2 Normative references ... **1**
3 Terms and definitions ... **1**
4 Symbols and abbreviated terms ... **3**
4.1 Symbols ... 3
4.2 Abbreviated terms ... 3
5 Evaluation objective and baseline of assessment ... **4**
5.1 Definition of the evaluation objective ... 4
5.2 Establishment of baseline ... 6
6 Input data ... **7**
6.1 General ... 7
6.2 Active safety technology related data ... 8
6.3 Accident data ... 9
6.4 Data from naturalistic driving studies and field operation test ... 10
6.5 Infrastructure and traffic data ... 11
6.6 Data from tests in controlled environments ... 11
7 Implementation of virtual simulation ... **11**
7.1 General ... 11
7.2 Simulation framework ... 11
7.3 Simulation tool ... 12
7.4 Simulation models ... 12
7.4.1 Vehicle model ... 12
7.4.2 Safety technology model ... 13
7.4.3 Environment model ... 14
7.4.4 Traffic situation model ... 14
7.4.5 Traffic model ... 15
7.4.6 Driver model ... 16
7.4.7 Collision model ... 16
7.5 Simulation control ... 17
8 Estimating safety technology safety performance ... **18**
9 Validation and verification ... **20**
10 Practical experience ... **23**
10.1 General ... 23
10.2 Establishment of baseline ... 23
10.3 Simulation framework ... 24
10.4 Comparative study of different simulation tools ... 24
10.5 Estimating the safety performance ... 25
10.6 Validation and verification ... 25
11 Conclusions and limitations ... **25**
12 Outlook ... **27**
12.1 General ... 27
12.2 Automated driving ... 27
12.3 V2X technologies ... 28
Annex A (informative) **List of tools** ... **30**
Annex B (informative) **Input and output of simulation models** ... **31**
Bibliography ... **36**

© ISO 2021 – All rights reserved

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 22 *Road vehicles*, Subcommittee SC 36 *Safety and impact testing*.

A list of all parts in the ISO 21934 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.

© ISO 2021 – All rights reserved

Introduction

Different Active Safety and Advanced Driver Assistance Systems (ADAS), in the following both referred to as active safety technology, have been developed and introduced into the market. The question that goes along with the development and introduction is, what impact these technologies have on road traffic and more specifically, to what extent these technologies prevent crashes and injuries. Such questions are of relevance for different stakeholders, such as vehicle manufacturers and suppliers, road authorities, research organisations and academia, politics, insurance companies as well as consumer organisations.[1]

The answers to these questions are derived from assessment of such technologies in terms of road traffic safety. Different assessment methodologies have been developed in the past and are being used today.[2] In general, the utilized methodologies can be divided in two types of assessment. The first type determines the technology's safety effect after its market introduction. Typically, in this assessment type accident statistics are analysed in order to determine the difference between the accident situation with the technology compared to a control group without the technology.[1] These methods are called retrospective assessment methods. A precondition for these methods is that the technology under assessment has reached a sufficient penetration rate in the market and that sufficient accident cases with and without the technology are recorded for a comparison. The penetration rate does not necessarily need to be related to the whole vehicle fleet, but can also be related to a certain vehicle subgroup or class.[3]–[5] On the other hand, there are methods that predict the technology's effect on traffic in relation to traffic safety before its market introduction.[6][7] These methods are called prospective methods using different approaches and tools.

This document focuses on the **prospective assessment** of traffic safety for **vehicle-integrated technologies acting in the pre-crash phase** by means of **virtual simulation**.

The safety performance of a technology is determined by means of comparing data from the baseline and treatment simulations based on a certain metric. The baseline for the assessment is the situation without the vehicle-integrate technology under assessment present. The virtual simulation with the technology is called treatment simulation.

The described assessment is limited to "vehicle-integrated" technology and does not consider technologies operating off-board. The virtual simulation method per se is not limited to a certain vehicle type. Although the main focus is often on passenger cars, the method is also applicable to motorised two-wheelers as well as heavy goods vehicles. Furthermore, the assessment approach discussed in this document focuses rather on accident avoidance and the technology's contribution to the mitigation of the consequences. Safety technologies that act in the in-crash or the post-crash phase are not explicitly addressed by the method, although the output from prospective assessments of crash avoidance technologies can be considered as an important input to determine the consequences. The extension of the method to technologies, such as automated driving and V2X based technologies, are discussed in the outlook at the end of this document.

In general, the assessment of active safety technologies requires the consideration of interaction with surrounding traffic as well as the host vehicle driver. These interactions increase the complexity of the assessment due to the high number of resulting variables. Consequently, for a comprehensive assessment, the technology's safety performance is analysed in a high number of test scenarios, in order to cover all relevant circumstances that affect the critical situation and crashes. The virtual simulation approach allows for running large numbers of test scenarios while offering a promising combination of safety performance, flexibility, reproducibility, and experimental control. The need for using virtual simulations in the prospective assessment of safety technologies is generally recognized. However, standardized terminology and processes of methodological aspects to perform such assessments are not available to date, which makes results hardly comparable.[1] For this reason, automotive industry,

© ISO 2021 – All rights reserved

research institutes, and academia joined in the P.E.A.R.S.[1)] (**P**rospective **E**ffectiveness **A**ssessment for **R**oad **S**afety) initiative with the objective to develop a comprehensible, reliable, transparent, and accepted methodology for quantitative assessment of crash avoidance technology by virtual simulation. [1]

This document aims to provide an overview on the state-of-the-art in the prospective assessment of road safety for vehicle-integrated (active) safety technologies by means of virtual simulation, see Figure 1.

After the introductive Clauses 1 to 4, the general method for a prospective assessment study is described in Clause 5, where special attention is given to the definition of the traffic safety evaluation scope and the establishment of the baseline. Clause 6 describes various data that can be used as input for different tasks within the assessment procedure. Then a general virtual simulation framework and various simulation models needed for conducting the simulation are presented in Clause 7, followed by a description of the approaches to quantify the derived safety effect in Clause 8. A description of validation and verification aspects as well as an overview on tools are given in Clause 9. Clause 10 of the document provides a practical example of a comparative study of different simulation tools and discusses the lessons learned. Clause 11 provides conclusions as well as describes limitations for the state-of-the-art methods. Clause 12 provides an outlook towards the prospective safety performance assessment for automated driving as well as the follow up to the current document.

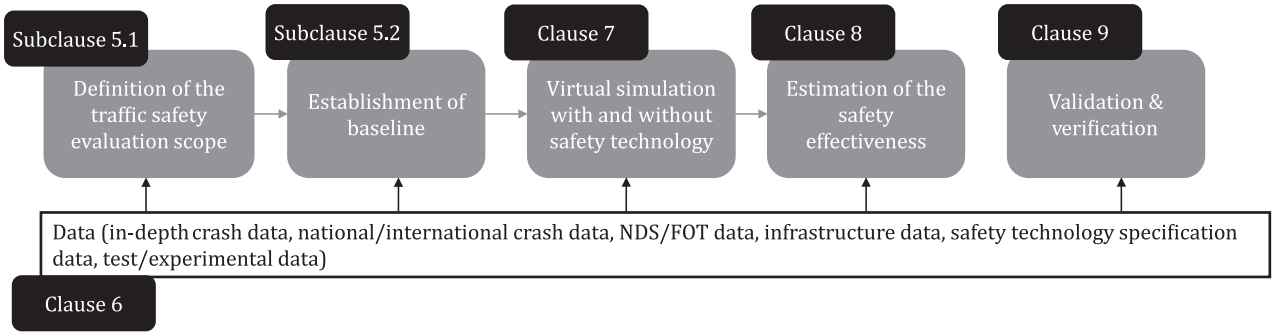


Figure 1 — Overview of the process of prospective assessment of traffic safety for vehicle-integrated safety technologies by means of virtual simulation and the structure of this document

1) P.E.A.R.S. is an open consortium (established in 2012) in which engineers and researchers from the automotive industry, research institutes and academia join with the objective to develop a comprehensible, reliable, transparent and accepted methodology for quantitative assessment of crash avoidance technology by virtual simulation. Partners of P.E.A.R.S. are (status Sep. 2020): Automotive Safety Technologies, AZT Automotive, BMW Group, Federal Highway Research Institute (BASt), Chalmers University of Technology, Continental, Denso, Fraunhofer IVI, Generali, RWTH Aachen University (ika), LAB, Swiss Re, TH Ingolstadt, Technical University Dresden, Technical University Graz, TNO, Toyota, Technical University Dresden, TÜV Süd, University Leeds, UTAC CERAM, Virtual Vehicle, Volkswagen, Volvo Cars, VUFO, ZF. More information at https://pearsinitiative.com/.

© ISO 2021 – All rights reserved

TECHNICAL REPORT **ISO/TR 21934-1:2021(E)**

Road vehicles — Prospective safety performance assessment of pre-crash technology by virtual simulation —

Part 1: State-of-the-art and general method overview

1 Scope

This document describes the state-of-the-art of prospective methods for assessing the safety performance of vehicle-integrated active safety technologies by virtual simulation. The document describes how prospective assessment of vehicle-integrated technologies provides a prediction on how advanced vehicle safety technology will perform on the roads in real traffic. The focus is on the assessment of the technology as whole and not of single components of the technology (e.g. sensors).

The described assessment approach is limited to "vehicle-integrated" technology and does not consider technologies operating off-board. The virtual simulation method per se is not limited to a certain vehicle type. The assessment approach discussed in this document focuses accident avoidance and the technology's contribution to the mitigation of the consequences. Safety technologies that act in the in-crash or the post-crash phase are not explicitly addressed by the method, although the output from prospective assessments of crash avoidance technologies can be considered as an important input to determine the overall consequences of a crash.

The method is intended as an overall reference for safety performance assessment studies of pre-crash technologies by virtual simulation. The method can be applied at all stages of technology development and in assessment after the market introduction, in which a wide range of stakeholders (manufactures, insurer, governmental organisation, consumer rating organisation) could apply the method.

2 Normative references

The following documents, in whole or in part, are normatively referenced in this document and are indispensable for its application. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

ISO 12353-1, *Road vehicles — Traffic accident analysis — Part 1: Vocabulary*

3 Terms and definitions

For the purposes of this document, the terms and definitions given in ISO 12353-1 and the following 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 https://www.electropedia.org/

3.1
levels of automation
levels that primarily identify how the "dynamic driving task" is divided between human and machine

Note 1 to entry: See Reference [8].

© ISO 2021 – All rights reserved