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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

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Foreword

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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.

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, 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.

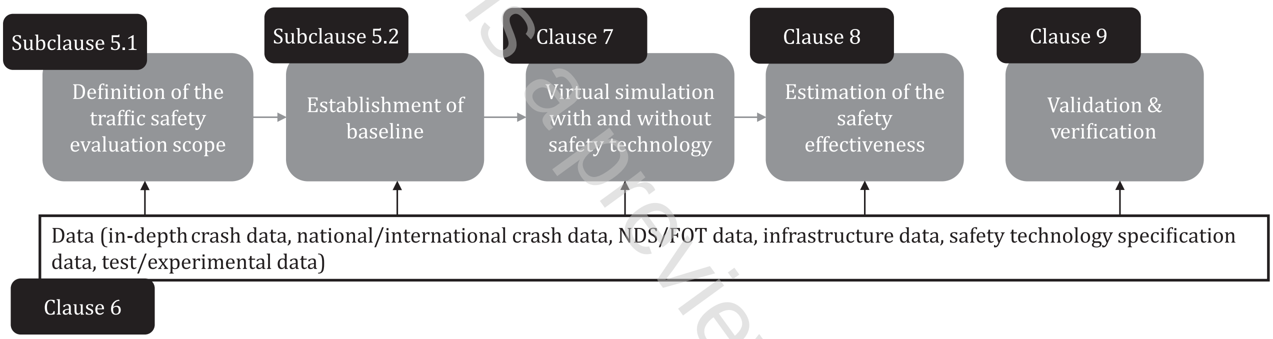

Figure 1 — Overview of the process of prospective assessment of traffic safety for vehicle-integrated safety technologies by means of virtual simulation and the structure of this document

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/.

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].