Road Safety Data, Collection, Transfer and Analysis

D5.3 Review of the existing evaluation procedures related to safety systems

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List of Acronyms

AAFS: Advanced Adaptive Front Light System

ABS: Antilock Braking System

ACC: Adaptive Cruise Control

ADAS: Advanced Driver Assistance Systems

AEB: Automatic Emergency Braking

AIDE: Adaptive Integrated Driver-vehicle InterfacE

AK: Alcolock Keys

APROSYS: Advanced PROtection SYStems

ASSESS: Assessment of Integrated Vehicle Safety Systems for improved vehicle safety.

ASTE: Active Safety Test Europe

AW: Anti Whiplash seat

BA: Brake Assist

BS: Blind Spot Detection

BSMS: Blind Spot Monitoring System

CA : Collision Avoidance and Emergency Braking – not pedestrian

CIB: Crash Imminent Braking

CW: Collision Warning

DDS: Drowsy Driver Detection System

DrvMon: Youth driver monitoring

EDR: Event Data Recorder

eIMPACT: Assessing the Impacts of Intelligent Vehicle Safety Systems

ERBA: Extended-Range Backing Aids

ESC: electronic stability control

ESC: Electronic Stability Control

ESoP: European Statement of Principles

ESP: Electronic Stability Program

EU: European Union

E-Value: Testing and Evaluation Methods for Active Vehicle Safety

FMVSS: Federal Motor Vehicle Safety Standards

FSRA: Full Speed Range Adaptive cruise control

FVCWS: Forward Vehicle Collision Warning Systems (FCW)

HMI: Human Machine Interaction

IC: Intersection Control

IEC: International Electrotechnical Commission

IIHS: Insurance Institute for Highway Safety

ISA: Intelligent Speed Adaptation

ISO: International Organization for Standardization

ITS: Intelligent Transport Systems

LCA: Lane Changing Assistant

LCDAS: Lane Change Decision Aid System

LDW: Lane Departure Warning

LKA: Lane Keeping Assistant

LSF: Low Speed Following

MALSO: Manoeuvring Aids for Low Speed Operation

NCAP: New Car Assessment Programme

NHTSA: National Highway Traffic Safety Administration

NV: Night Vision

PBA: redictive Assist Braking

PedPro: Airbag Pedestrian protection

PReVENT: Preventive and Active Safety Applications Integrated Project

RollD: Rollover Detection

SAE: Society of Automotive Engineers

SpdCam: Speed Cameras

TC: Technical Committee

TPMS: Tyre Pressure Monitoring and Warning

TRACE: Traffic Accident Causation in Europe

TSR: Traffic Sign Recognition

UN-ECE: United Nations - Economic Comission for Europe

UNECE: United Nations Economic Commission for Europe

VDA: German Automotive Industry Association

VRU: Vulnerable Road Users Protection

YK: Youth Key

Executive Summary

The overall objective of DaCoTA is to assist the development of knowledge-based road safety policies in European countries by continuing to develop the European Road Safety Observatory (ERSO) and providing methods to use ERSO data for policy development and implementation.

The objective of Deliverable 5.3 is the examination of existing test procedures for various technological in-vehicle safety systems. For that reason a thorough literature review was carried out to identify the most appropriate procedures that are currently used or are under development to test the various technological systems and examine if these procedures are relevant to road accident problems.

Chapter 1 describes the general goal of DaCoTA WP5 “Safety and eSafety” and the objective of Deliverable 5.3. The general terms are defined as well the difference between active and passive safety is explained and the intelligent transport systems are categorised in two different ways.

Chapter 2 describes the different organizations and bodies involved to the development of test procedures, as well methodologies for testing and evaluation of preventive safety functions that have been addressed in several research projects in Europe and US during the last years.

Chapter 3 presents several test procedures regarding active safety systems. More specifically, objective, test procedures, measurands and a summary for each individual procedure are presented.

Chapter 4 provides discussion and summary conclusions. Some experiences of carrying out this report, which will be useful for further activities in DaCoTA, are also included and more detailed information regarding ISO and SAE standards are provided in the Annex of this report.

As a next step to this deliverable and according to the work plan, the recommendation of new test procedures will be attempted, when necessary, enabling technological systems to approach as much as possible the real conditions and cover a wider part of the existing road safety problems.

1. Introduction

1.1 General goal of Dacota WP5 “Safety and eSafety”

Modern society strongly depends on mobility, and the need for transport of both people and goods is expected to grow further in the future. Cleaner, safer and more efficient transport systems are needed. Mobility and especially road transport, cause major societal problems, namely accidents, pollution, congestions etc. More than 34.000 people were killed in 2009 in road accidents in the European Union only, and the related costs are estimated to about 2% of its GDP.

The overall objective of DaCoTA is to help develop knowledge-based road safety policies in European countries by continuing to develop a European Road Safety Observatory (ERSO) and providing methods to use ERSO data for policy development and implementation.

Road safety has been increasing in motorized countries now for 30 years and this increase shows that political willingness and efficient countermeasures can actually produce positive results. The last couple of decades have seen a promising increase in eSafety systems directly linked to technological progress. These systems are complementary to traditional safety countermeasures (regulation, education, enforcement, advertising and information campaign, car crashworthiness, infrastructure improvements, etc.) ESafety systems address accident prevention (preventive safety), accident avoidance (active safety), injury mitigation (passive safety) and rescue and health care improvement.

A European Road Safety Observatory must then take the broad and extended eSafety issues into consideration by analyzing what types of safety problems are addressed by technologies, and, if and how technologies are effectively and efficiently addressing these problems.

1.2 Objectives of Task 5.4

eSafety is often regarded as having a very limited viewpoint limiting it’sconcern to only stand-alone car technologies. It is, however, actually embracing much more: road infrastructure safety, traffic also car-to-car or user-to-user communication or any kind of countermeasures linked with the availability of new technology and considerable investments and expectations have been put in all these technologies as a promising way for accident and injury prevention.

The main factors related to road accidents can be grouped in three broad categories: Road users, road infrastructure and vehicles. Regarding the vehicles, during the past decade several eSafety systems were developed, intended to assist, inform or alert the driver by addressing one or several driving tasks (e.g. a navigation system helps the driver in his search for the right direction), by amplifying driver actions (e.g. the emergency brake assist reduces the time necessary to reach ABS regulation), by correcting a problem (i.e. ESC recovers loss of control), by preparing and providing car occupant or external user protection in the case of an accident (e.g. seat belts, airbags and pre-crash systems), or even by relieving the driver of certain tasks (e.g. Intelligent Speed Adaptation systems can, to a certain extent, replace the driver for speed regulation). And of course some other systems are protecting the car occupants in combination with a stiffer and enhanced car structure (seat belts, load limiters, pretensioners, airbags, etc.). Initially, mainly passive safety systems were introduced, i.e. systems of airbags, seat belts and protective structures that increased safety for the drivers, passengers and more recently, pedestrians). Furthermore, relevant testing programs for assessment of these passive safety measures have been established.

Active safety functions such as Electronic Stability Control (ESC) and Lane Departure Warning (LDW) have also been introduced, attempting to avoid accidents through active support to the driver. Promising future improvements of road safety are expected to rely on such safety functions with the aim to prevent accidents from happening. The active safety functions are under rapid development and there is presently, and in contrast to passive safety, no generally accepted assessment program in place.

Several initiatives have identified the need for standardised testing and assessment methods over the past years. While some of them are on-going and similar, different methods have been presented recently and will be discussed.

Evaluation of the functional performance of a preventive safety system considers the technical performance of the function as well as the overall safety effects(i.e. evaluation that the function does what it was designed for). Technical performance testing aims at investigating whether a safety function meets technical requirements and specifications on what the function shall do.

The objective of this report is the examination of existing test procedures for various technological systems for vehicle safety. For that reason a literature review was carried out to identify the most appropriate procedures that are used to test the various technological systems and examine if the currently used test procedures are relevant to road accident problems.

In order to achieve the objective, initially, the general terms are defined, as well the difference between active and passive safety is explained and the intelligent transport systems are categorised in two different ways. The different actors involved to the “test procedure” are described and methodologies for test and evaluation of preventive safety functions that have been developed in several research projects in Europe and US during the last years are presented. Moreover, several test procedures for active safety are described and some more detailed information regarding ISO and SAE standards is provided in the Annex of this report.

1.3 Definitions

Intelligent Transport Systems is an umbrella term for a number of electronic, information processing, communication, and control technologies that may be combined and applied to the transport domain. ITS may refer to a single technology, an integrated system, or a network of systems.

Intelligent Transport Systems may be categorized in several ways, referring either to the physical location of the system, the timing of the effects of the system, the means by which the system enhances safety, or the transport domain to which they are applied.

One of the broadest and most common classifications regards the positioning of the system – i.e., whether system is in-vehicle, infrastructure-based or cooperative:

- **In-vehicle**: These refer to technologies based within the vehicle. These typically involve sensors, information processors and on-board units or displays that provide additional information to the user, automate or intervene with some part of the driving task, or provide warnings to the user about potential hazards.

- **Infrastructure-based**: These may serve one of two general functions: to provide drivers with additional information via roadside messages, or to better manage and control traffic flow. In both instances, various types of sensors are used to gather information from the road environment and road side signs or signals are used to influence traffic behaviour.

- **Cooperative**: Cooperative systems involve communication between vehicles and the infrastructure or between vehicles. This communication may be one way, e.g., where the vehicle receives information from the infrastructure but does not transmit information in return, or two-way where the vehicle both sends and receives information to another vehicle or infrastructure-based system.

Another popular means of categorizing ITS is to differentiate when the system takes effect (passive – active). Since the systems are fundamentally different in nature, it is helpful to trace the development of each system separately.

- **Passive safety systems** are automobile safety systems that are only deployed or effective in response to an automobile accident. These systems protect drivers and passengers from injury once a collision occurs *(7)*. Passive systems include:

  - **Seatbelts**
    Seatbelts are required to be installed by law, but lap sash seatbelts have been proven to be the most effective in the event of an accident. Look for a vehicle that provides a lap sash belt even in the middle of the back seat.

- **Front driver and passenger airbags**
  These airbags can significantly reduce life threatening head injuries, when used in conjunction with seat belts. They are designed to prevent occupants from hitting the dashboard, steering wheel or windshield.

- **Head protecting side airbags**
  Side airbags protect an occupant's head during accidents into the side of the car and can also prevent injuries in rollover accidents. They are usually installed in the roof rails above the doors and deploy downwards, covering the side windows.

- **Head restraints**
  These are extensions of the car's seats that limit head movement during a rear-impact accident, reducing the probability of neck injury. In order to be effective they must be adjusted to a height that suits you to help minimize neck and whiplash injuries in an accident.

- **Side impact bars**
  Side impact bars protect the driver by spreading the weight of the impact in front of and behind the driver.

- **Fuel pump shut-off devices**
  Most fuel-injected engines have electric fuel pumps. It is critical that these pumps shut off in the event of a collision. If a fuel pump does not shut off following a collision, the pump will continue to circulate gasoline through the fuel system, providing a constant source of fuel for any resulting fire. *(18)*

- **Active safety systems** help drivers avoid accidents. These systems function behind the scenes, monitoring the driving conditions and actively adjusting the driving dynamics of the vehicle to minimize the risk of an accident. Active systems provide a degree of protection for occupants unavailable in Passive systems and they reduce the likelihood of a situation that would require the use of Passive systems.*(7)*

  - **Anti-lock brake systems**
    Anti-lock brake systems (ABS) allows the wheels on a motor vehicle to continue interacting tractively with the road surface as directed by driver steering inputs while braking, preventing the wheels from locking up (that is, ceasing rotation) and therefore avoiding skidding.

  - **Active Front Steering**
    Active Front Steering automatically adjusts the steering input required from the driver to suit the current speed and road conditions.

  - **Adaptive Cruise Control**
    Adaptive Cruise Control serves to reduce driver workload in dense traffic. Bishop (2005) refers to ACC as a “longitudinal control co-pilot”

  - **Brake Assist**

Brake assist systems maximise the braking potential of the vehicle, reducing stopping distances.

- **Electronic Stability Control**
  Electronic Stability Control (ESC) is a system which serves to maintain control of the vehicle's trajectory when the vehicle loses optimum contact with the road surface.

- **Forward Collision Warning and Avoidance**
  Forward collision warning systems monitor the roadway ahead and provide alerts to the user when upcoming hazards are detected.

- **Lane Change Collision Warning and Avoidance**
  Lane change systems serve to monitor the vehicles lateral blind spot, detecting vehicles that are located in this space and warning the user to their presence.

- **Lane Departure Warning and Control**
  Lane departure warning systems monitor the position of the vehicle relative to lane markings and features, and provide alerts to the driver should the vehicle deviate from the lane.

- **Lane Keeping Assistance**
  Lane keeping assistance (LKA) systems actively support the driver in maintaining lane position. These systems monitor the vehicles lane position with image processing technology in the same manner as lane departure warning systems.

- **Road Departure Warning and Avoidance Systems**
  Road departure warning/avoidance systems share similarities with lane departure systems. However, road departure systems typically incorporate curve speed warnings and object collision warnings.*(11)*

The development of road vehicles during the past decade has led to vehicles with improved passive safety. Systems of airbags, seat belts and protective structures have increased safety for the drivers, passengers and lately also pedestrians. Testing programs for assessment of these passive safety measures have been established worldwide.

Active safety functions such as Electronic Stability Control (ESC) and Lane Departure Warning (LDW) have been introduced. The purpose of these technologies is to try to avoid accidents through active support to the driver. Active safety functions are currently under rapid development, and in contrast to passive safety, there is no generally accepted assessment program in place.

Several initiatives have identified the need for standardised testing and assessment methods over the past years. While some of these are currently under development and similar, alternate methods have been recently presented. It is now necessary to reach a harmonisation of the different initiatives in order to prevent different and incompatible test programs worldwide.

2. Test procedures development

2.1 Regulations

The ISO (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 specific topic for which a technical committee is established, has the right to be part of that committee. International organizations, governmental and non-governmental departments in liaison with ISO also take part in the work. The ISO collaborates closely with the International Electrotechnical Commission (IEC) on all matters of electrotechnical standardization.

International Standards are drafted in accordance with the rules given in the ISO/IEC Directives, Part 2. The main task of technical committees is to prepare International Standards. Draft International Standards adopted by the technical committees are circulated to the member bodies for voting. Publication as an International Standard requires approval by at least 75 % of the member bodies casting a vote.

Within the International Organization for Standardization there are two technical committees (TCs) with activities related to active safety systems. In TC 22 - Road Vehicles, there is a subcommittee (SC 9) responsible for standards related to vehicle dynamics and road-holding ability. Examples are standards for braking as well as lateral, yaw and roll stability. The second relevant committee is TC 204 in which one working group (WG 14) is responsible for standards related to vehicle/roadway warning and control systems. Examples include standards for FCW, ACC and LDW systems.

The SAE International (Society of Automotive Engineers) also has committees developing standards related to active safety systems. The most relevant committee is the Safety and Human Factors steering committee within the Vehicle Safety Systems group. Other relevant SAE groups and committees are: Safety Systems Component Advisory group, Truck and Bus Brake Systems committee and Highway Time Forum Steering committee.

The National Highway Traffic Safety Administration (**NHTSA**) in the US has proposed three test procedures for FCW, LDW and ESC systems which are related to US NCAP (New Car Assessment Programme) assessments. Euro NCAP has a specific test protocol for ESC systems and other active safety systems can be rewarded (Euro NCAP Advanced) by using the Beyond Euro NCAP Assessment Protocol. ESC systems are rewarded if fitted in the assessed vehicle in the Australasian NCAP (**ANCAP**). Other NCAP organizations are: Japan NCAP (**JNCAP**), China NCAP (**C-NCAP**) and Korea NCAP (**KNCAP**). *(14)*

In summary, the main responsible organisations for test procedures development worldwide are the following:

- Australian NCAP
- China NCAP
- Euro NCAP
- Japan NCAP
- Korea NCAP
- US NCAP
- United Nations - Economic Comission for Europe (UN-ECE)
- International Organisation for Standardisation (ISO)
- SAE International
- National Highway Traffic Safety Administration (NHTSA)
- US Regulations
- Insurance Institute for Highway Safety (IIHS)

2.2 Relevant Research Projects

Strategies and methodologies for testing and evaluation of preventive safety functions have been addressed in several research projects in Europe and US during the last years. This section provides a short survey of some of the work done in the field within the EU and discusses some key aspects and concepts that are of importance for the future of DaCoTA work:

2.2.1 ASTE

The ASTE study investigated the feasibility of setting up an objective test program for intelligent vehicle safety systems. The aim of the work was:

- To assess the feasibility of setting up an independent performance and conformance testing programme for Intelligent Vehicle Safety Systems;
- To define required methods and principles for verification and validation of Intelligent Vehicle Safety Systems; and
- To evaluate if a consensus of the proposed principle can be achieved with different stakeholders.

The results from the study were presented in the final report [ASTE]. The report contains a proposal on how to define performance testing and the important dimensions of testing of active safety systems that need to be considered.

A major output from ASTE is the proposal of different test strategies for doing performance testing. Two main approaches were proposed for physical testing, each taking into account traffic scenarios based on real accident statistics; the *system-based approach* and the *scenario- based approach*. These two ways of performing physical test could also be complemented with *document-based reviews*. Each strategy for physical test was concluded to have advantages and disadvantages.

- The **scenario-based approach** is defined in ASTE as development of test methods for testing the performance of a vehicle in traffic scenarios, extracted from real accident data, where the tests are independent of specific systems that the vehicle is equipped with. The first step in this approach is to categorize relevant accidents. Based on accident statistics available, assumptions are made on the most important traffic scenarios to test and the characteristics of these scenarios. The tests aim at being general and addressing the performance of the complete vehicle rather then being specifically adapted for a certain type of system. Thus, the performance is addressed with the vehicle as a "black-box", where several different systems could contribute separately or in combination.

- The **system-based approach** is defined in ASTE as development of test methods, adapted to certain systems or system cluster, starting from the systems and the technology they are based on. Based on the system descriptions relevant traffic scenarios are searched among the accident statistics available, *where the current systems are assumed to have an impact*. Assumptions are thus made in what traffic scenarios these systems are useful. For each system that is considered, a number of relevant traffic scenarios will be suggested for testing the performance of the vehicle equipped with the safety function. For both approaches, real world accident data is of great importance for deriving relevant traffic scenarios for testing a vehicle equipped with a safety function. The main difference is the way of categorizing the accident data and the way of considering the systems installed in the vehicle. Traffic scenarios can be either general; not addressing a certain system in particular (*scenario-based approach*) or being specified for a certain system (*system-based approach*).

In the ASTE study, the scenario based approach was proposed for a future performance testing program. A high-level test methodology starting from analysis of accident data was proposed. Examples of test cases were provided, that accounted for the important dimensions of a test scenario, attributes of driver state, as well as vehicle and environment parameters.(2)

2.2.2 PReVAL

The PReVAL project was undertaken as a subproject of the PReVENT Integrated Project (IP) of the 6th Framework Programme and aimed at assessing the safety impact of the functions developed within PReVENT and also to develop a general framework for evaluation and assessment of preventive safety functions. A best practice in evaluation was defined based on experience from within PReVENT and other projects such as AIDE and APROSYS.

For human factors evaluation, the following dimensions were addressed:

- Time frame of test: short term testing versus long term;
- Intended effects and unintended effects;

- Level of intervention of the function and on what actionlevel the system supports the driver.

A concept introduced in PReVAL was situational control referring to the degree of control that a driver-vehicle system has in specific traffic situations. With this concept, the purpose of a preventive safety system can be understood as an attempt to increase situational control. In validation, where both technical performance and human factors performance are important parts, the aim is to collect data to quantify the system effects, and to see whether situational control has been changed.(20)

2.2.3 AIDE

AIDE project concerns methods for assessment of IVIS and assessment of integrated HMIs for different IVIS applications. However, the project also addresses methods applicable for ADAS evaluation. In the project methods for evaluating human factor related issues like acceptance, usability and workload are suggested, which is applicable for evaluation of both IVIS and ADAS.

The European Statement of Principles (ESoP) handle in-vehicle information and communication systems intended for use by the driver while the vehicle is in motion e.g. navigation systems, telephones and traffic information. They are not specifically intended to apply to Advanced Driver Assistance Systems (ADAS) such as adaptive cruise control and collision mitigation systems. Even if ADAS require additional considerations in terms of Human Machine Interaction, in comparison to in-vehicle information systems, these principles might provide an important basis when developing corresponding methods for ADAS.(16)

2.2.4 APROSYS

2.2.4.1 APROSYS Pre-crash System Test Methodology

In order to achieve the next significant step in traffic safety, new technologies must be introduced into the car. Two novel technologies have been applied for the first time in an automotive application:

- A side-impact detection system using stereo video and radar sensors;.
- A Shape-Memory-Alloy based structural actuator.

As a technological showcase, these technologies have been combined in an integrated side-impact protection system. The system was derived from accident statistics, as was the test programme. The latter has proved finally the effectiveness of the two technologies.

2.2.4.2 Assessment methods for a side pre-crash protection system

Within APROSYS SP1.3, an evaluation methodology for advanced safety systems is currently being developed. This generic method is suitable to assess the complete safety system. The system specific test conditions and assessment criteria are defined using relevant accident and traffic scenarios. The essential evaluation of the technical performance, which is the main part of the method, is split in three steps of pre-crash performance, crash performance and driver-in-the-loop performance.(17)

2.2.5 E-Value

E-Value will address the real function of ICT-based safety systems and their capability to perform the function through two courses of action: defining and quantifying the function output to be achieved by the safety system and developing the testing and evaluation methods for the ICT-based safety systems.

The safety systems within the eVALUE scope are classified into four clusters: longitudinal, lateral and yaw/stability. The fourth cluster remains open for upcoming systems. Based on market availability and penetration rate, the consortium decided to focus on eight preventive or mitigating safety systems: ACC, FCW and CM by braking (in the longitudinal assistance domain), BSD, LDW and LKA (in the lateral assistance domain), and finally ABS and ESC(in the yaw/stability assistance domain). Following the description of current test and evaluation methods, sensor technologies, system function output and ECUs globally applicable to ICT based safety systems, the report covers these technologies and components for the eight selected systems in detail.*(19,6)*

2.2.6 ASSESS

The overall purpose of the ASSESS project is to develop a relevant and standardised set of test and assessment methods and associated tools for integrated vehicle safety systems with the focus on currently “on the market” pre-crash sensing systems. The information and methodology developed hereby can then be used for a wider range of integrated vehicle safety systems, encompassing assessment of driver behaviour, pre-crash performance and crash performance.

The first step in the project was to define casualty relevant accident scenarios so that the test scenarios will be developed based on accident types which currently result in the greatest injury outcome, measured by a combination of casualty severity and casualty frequency. Therefore, the first task in Work Package 1 was to examine how relevant scenarios had been developed by previous projects and to obtain and analyse European accident data to define preliminary accident scenarios which could then be taken by Work Packages

3 (Driver behavioural evaluation) and 4 (Pre-crash evaluation) as the initial accident types on which to base further analysis.

The review of previous projects provided a large overview of activities concerning the research in terms of integrated safety. The most promising assessment method for ASSESS is probably close to the approaches defined by APROSYS and PReVAL. Unfortunately, only some of the previous projects performed relevant accident analysis. ASSESS could only benefit from the work that was done within eIMPACT, TRACE, and eVALUE and could use aspects of this data for an overview for accidents on an EU level. In general, pre crash sensing systems may combine a wide range of functionalities (e.g. whether brake assist , driver warning , and/or restraint activation are included or not). Activities in ASSESS will be based on two currently “on the market” systems that include various functionalities. In avoiding restriction to the systems considered and their specific functionalities, the principle of accident analysis was that it considered the accidents and casualties independent of the detailed specifications of safety systems considered in ASSESS. The analysis therefore aimed to define the preliminary accident scenarios based on frontal real world accident problems, not the accidents which could be addressed by a particular safety system.

Analysis was completed for a range of accident databases, including those which were nationally representative (STATS19 and STRADA) and in-depth sources which provided more detailed parameters to characterise the accident type (GIDAS and OTS). A common analysis method was developed in order to compare the data from these different sources. While this was not a complete success, the majority of the data was aligned in such a way as to allow a comparison between these databases.

The results from the analyses were also ranked by valuations reflecting the cost assigned to fatal, serious and slight accidents/casualties. This enabled the “total casualty outcome” of the accidents to be assessed, thereby adjusting for accident types which occur less frequently but result in greater number of more severely injured casualties (and vice versa).

After a comparison between the data sources, the ranking of the preliminary accident scenarios from the analysis were:

Rank Accident type

- Type 1a: Driving accident - single vehicle
- Type 6: Accidents in longitudinal traffic (6a and 6b included)
- Type 2&3: Accidents with turning vehicle(s) or crossing paths in junction
- Type 4: Accidents involving pedestrians

The analysis has confirmed that the systems selected within ASSESS are relevant with respect to the current casualty problems, with Type 6 and Type 2&3 accidents being relevant to the ASSESS pre-crash systems. Further analysis in Task 1.2 will define the accident parameters at a more detailed level.*(1)*

2.2.7 CIB

The purpose of the CIB project is to develop and validate performance requirements and objective test procedures for CIB systems and to assess the harm reduction potential of various system configurations with differing performance capabilities. CIB systems with adjustable characteristics will be integrated into test vehicles in order to develop minimum performance requirements and further characterize the vehicle system performance sensitivity to the pre-crash sensor specifications. These results will be augmented with the final tests exercised on a limited number of system configurations. Data obtained during testing will be used to develop preliminary estimates of potential benefits of these prototype systems. In addition, this project will use the restraints performance data and results from the NHTSA-sponsored project titled “Objective Tests for Advanced Restraint Systems” to estimate the injury distribution for the occupants. The Advanced Restraint Systems project is being conducted concurrently with the CIB project by the CAMP Advanced Restraints Systems Consortium under Project Order 0003 of the NHTSA cooperative agreement discussed above.

The CIB project consists of ten tasks. Task 1 involves the project management activities needed to oversee the project. This task will run throughout the project. Tasks 2-5 feature the work needed to identify both the pre-crash events that lead to severe injuries and the near-term technologies that could potentially be used to address the selected crash events. Task 6 involves building three Performance Improvement Prototype (PIP) vehicles that can support the data collection needed to establish comprehensive test procedures in this project. It is anticipated that these test vehicles will feature an array of multiple sensors that can detect combinations of pre-crash events, brake controllers with adjustable parameters and system controls capable of supporting multiple configurations. The actual testing activities in the project are contained in Tasks 7-9. Work in these tasks will focus on defining and subsequently performing functional and operational tests that will emulate the selected pre-crash events, assess levels of CIB system performance and identify potential unintended consequences. *(5)*

2.2.8 ADAC

German motoring club, ADAC, also a member of Euro NCAP, presented in 2011 results of a test series that investigated advanced emergency braking systems (AEBS). The ADAC AEBS test assessed the AEBS capability to reduce impact speed as well as when and how effectively the driver is alerted to an imminent collision in six current family and executive car models. According to ADAC, preventing a collision because of timely warning is always better than an autonomous emergency braking with unforeseeable consequences. As another important factor for enhanced driver safety, the ADAC has identified system reliability. They conclude that most drivers will not accept false alarms even if they are no injury risk; unlike accidental emergency braking, which may be fatal. Their test also assessed the probability of false alarms or unnecessary emergency braking. *(15)*

2.2.9 AEB

An international group of insurer funded research centres is called RCAR (the Research Council for Automobile Repairs). Some RCAR members have formed a focus group, the so-called AEB group, with the aim of defining a set of test procedures that can be used by consumer test organisations such as Euro NCAP, IIHS and Thatcham. Thatcham is leading this group that also claims to be supported by a vehicle manufacturer and a tier 1 component supplier.
The AEB group states it plans to base its test procedures on real crash scenarios taking into account both frequency and severity. Therefore, they will use data sources that include insurance and national statistics as well as in-depth accident investigation. Test devices and tests able to represent these real world scenarios will be developed by the AEB group. They will publish their tests and shared them with other working parties which was done for instance with the vFSS initiative. *(22)*

2.3 Conclusion

While the PReVAL project addressed how to evaluate different systems, ASTE addressed the potential and feasibility of a future performance testing program, where harmonization of test methods and systems is concluded to be an important first step.*(21)*

The focus of the AIDE project was on methods for evaluating IVIS, but these methods could also be used in evaluation of preventive safety functions (acceptance, workload and usability). As well, in Aprosys, in order to achieve the next significant step in traffic safety, two novel technologies have been applied for the first time in an automotive application. *(16)*

E-Value addressed the real function of ICT-based safety systems and their capability to perform the function through two courses of action: defining and quantifying the function output to be achieved by the safety system and developing the testing and evaluation methods for the ICT-based safety systems. Moreover, the overall purpose of the ASSESS project was to develop a relevant and standardised set of test and assessment methods and associated tools for integrated vehicle safety systems with the focus on currently “on the market” pre-crash sensing systems.(6)

In addition, the purpose of the CIB project was to develop and validate performance requirements and objective test procedures for systems and to assess the harm reduction potential of various system configurations with differing performance capabilities. *(20)*

3. Test Procedures

This section presents the current state-of-the-art testing and evaluation of active safety systems procedures. The first part (3.1) introduces individual test procedures and the second part (3.2) presents specific characteristics of specific ISO, SAE and NHTSA test procedures.

3.1 Individual Test Procedures

3.1.1 Obstacle Avoidance Test

In its original form, the VDA obstacle avoidance test – also known as moose or elk test – had been introduced in order to demonstrate the tipping stability of vehicles. However, the test conditions allowed the driver many degrees of freedom during the performance of the tests, which meant that due to the driver's influence the test did not produce any objective and reproducible results.

The VDA revised the obstacle avoidance test, and the course – measuring a total length of 61 m – is strictly specified. The time measurement begins in the entry lane and ends prior to leaving the exit lane. At the same time, the accelerator pedal is released in the entry lane so that the vehicle moves through the course in power-off (deceleration) mode. This corresponds to the typical behaviour of drivers.

During the test, no traffic cones may be hit. Otherwise, the test is not valid. The entry speed is increased incrementally. The tests are driven with and without ESP (electronic stability program). In the case of the test vehicle, the maximum entry speed that could be driven was approximately 70 km/h.

The relevant metrics for the VDA obstacle avoidance test are:

- Vehicle longitudinal and transversal speed
- Steering wheel angle and torque
- 3-axial wheel forces and moments
- Toe and camber angle as well as 3-axial wheel travel
- Vehicle attitude angle
- Slip angle
- Pitch, roll, yaw and attitude angle
- Longitudinal, transversal and yaw acceleration

The yaw angle in Picture 1 that is present already when the vehicle enters the first lane can be explained by the special configuration of the pre-marked VDA obstacle avoidance test: the acceleration path has an angle of approximately 10° to the direction of the entry lane so that the steering correction, which naturally manifests itself as a roll angle, must be performed immediately before entering the lane.

During the first directional change, the transversal acceleration is still almost in phase with the steering angle. Later, a significant phase lag of transversal acceleration and roll angle occurs. Also, the delayed build-up of the vehicle's attitude angle is notable, which can be explained by the inertia of the vehicle mass.

According to the VDA, the obstacle avoidance test can only produce limited conclusions about the tipping stability of vehicles. Typically, the so-called “fishhook test“ is performed, where the criterion of tipping is met when two wheels have tipped up simultaneously by at least 50 mm.*(3)*

Picture 1: Vehicle manoeuvres: VDA obstacle avoidance test

3.1.2 Steady-state Circular Test

The steady-state circular test is an open-loop test, driven according to the methods of constant radius, constant steering wheel turning angle or constant speed. The tests are performed with constant transverse accelerations in standardized steps all the way up to the driving dynamics limits. During the steady-state test phase, the steering wheel turning angle and the accelerator pedal position must be kept constant over a period of time, which is specified as well. The signal courses (including, among others, the steering angle, attitude angle, roll angle, and toe and camber angle) are typically plotted via the transversal acceleration.

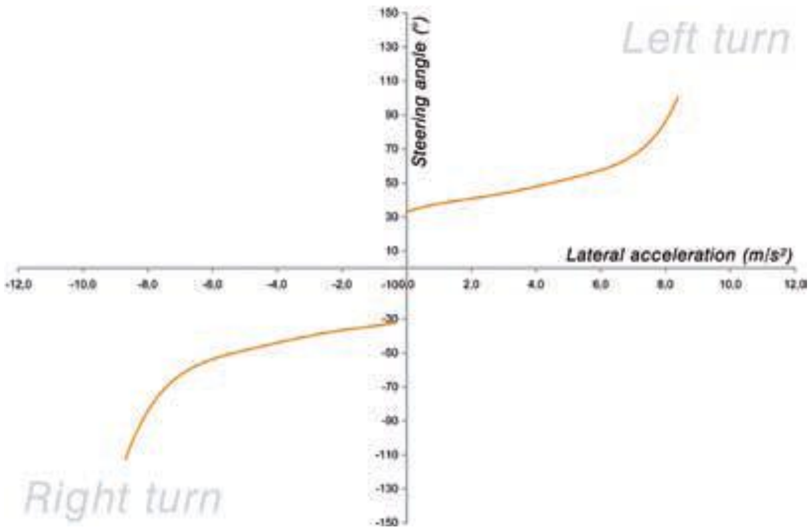


Figure 1: Steering wheel turning angle δH= f(aquer)

In Figure 1 the steering wheel angle requirement is presented over the transversal acceleration. The course of the steering wheel turning angle over the increasing transversal acceleration is an important evaluation criterion for the self-steering behaviour of the vehicle. Its increase is an indication of under-steer. For reasons of vehicle stability and the subjective perception of safety of the vehicle occupants, developers normally strive to achieve an under-steering to neutral self-steering behaviour. When the limit range of driving dynamics is reached, this is indicated by a heavily increasing steering angle requirement.

This is typically accompanied by a heavy decrease of steering wheel torque. According to Heissing/Ersoy, the self-steering gradient greater than zero characterizes under-steering behaviour and a value of zero is a neutral behaviour of the vehicle. Over-steering behaviour is practically non-existent due to modern vehicle development. However, it is certainly a question of vehicle set-up philosophy to what extent the gradient of yaw speed and steering angle approaches the critical speed, and the vehicle responds most sensitively to steering inputs in the process. In this context, descriptive terms like “driving pleasure” or “good-natured handling” can be encountered.*(4)*

3.1.3 Braking from Steady-State Circular Motion

Objective of the Driving Manoeuvre

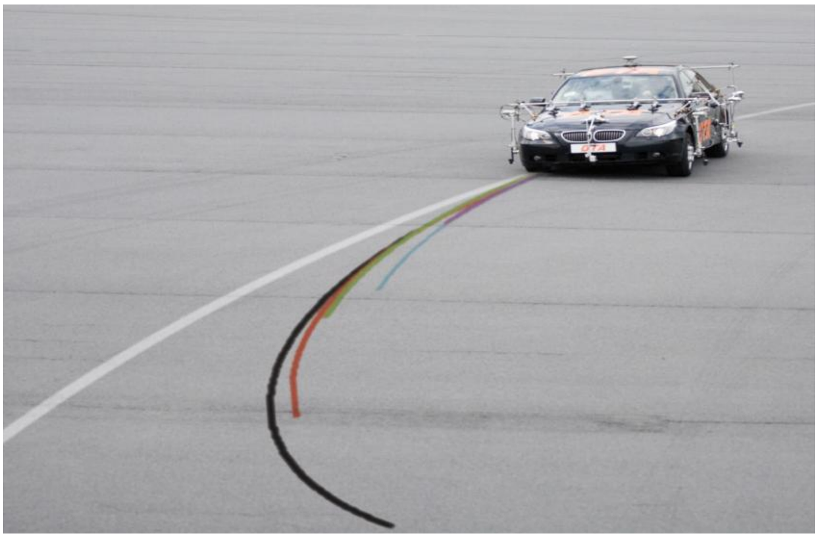
According to ISO 7975 this open-loop test serves the main objective of determining the effect of braking on the directional behaviour of a vehicle whose steady-state circular motion is only interfered with by the response of the brake. Similar to the situation that occurs during load alteration, the vehicle tends to turn toward the inside of the corner, which forces the driver to perform quick steering corrections. The float angle measured during this driving manoeuvre provides conclusions about driving stability and controllability of the vehicle.

Test Procedures

The vehicle is driven on a circle with a radius of 100 m at constant lateral acceleration. In the example shown here, lateral acceleration is 7 m/s². The steering wheel angle and accelerator pedal position must be kept constant in the test. The braking manoeuvres are driven with longitudinal decelerations of 2 to 6 m/s² in steps of 1 m/s² counter-clockwise and clockwise, in third gear. At the beginning of the manoeuvre the driver has to lift the accelerator pedal as fast as possible and immediately apply the brakes. The time span until the longitudinal deceleration of 0.5 m/s² is exceeded has to be less than 0.4 seconds. At the time of t=0, a pressure of 90 % of its mean value must be achieved. According to the analytical routine developed by TÜV, the values for the established measurands from the time of 0.9 s up to the end point of 1.1 s after initiating the actuation of the brake are averaged and stored per braking event. The values of the measurands for the steady-state range, the analysis time frame as well as the maximum values are read out, and the various characteristic values determined from them. The deviations from the original cornering radius and the maximum float angles per longitudinal deceleration step are of particular interest.

Measurands

- Steering wheel angle
- Brake pressure in brake master cylinder (alternatively brake pedal force or travel)
- Lateral acceleration
- Longitudinal acceleration
- Longitudinal speed
- Yaw speed
- Braking distance
- Roll angle
- Pitch angle
- Float angle
- Lateral speed
- Lateral deviation of the vehicle’s center of gravity from the initial radius



Picture 2: Braking from Steady-State Circular Motion

Summary

According to Heissing/Ersoy, in braking events up to mean decelerations, a maximum yaw moment occurs when the longitudinal forces in the tire contact patch change due to shifting wheel loads. The higher wheel loads lead to a reduced slip angle at the front axle and an increased slip angle at the rear axle. This causes the instantaneous center of rotation vis-à-vis the position in the un-braked state to significantly shift forward and closer to the vehicle, thus resulting in a smaller cornering radius.

At maximum deceleration, the effect is determined by the locking sequence of the wheels and thus by brake force distribution. However, when ABS is used this differentiation is no longer relevant.

The evaluation of vehicle response primarily refers to the lateral deviation from the previously maintained reference direction and the dimension of the float angle, and thus yaw stability.(*4)*

3.1.4 VDA Lane Change

Objective of the Driving Manoeuvre

Originally, this manoeuvre was named “elk test” and designed to provide a criterion to prove the tilt stability of a vehicle. However, the driving track was too wide, which meant that there was excessive driver influence leading to results that were not adequately comparable. After a revision of the test manoeuvre by a commission of Germany’s automotive industry association VDA, a new cone-lined lane with a length of 61 m was defined in conjunction with the introduction of ISO 3888-2. Objective characteristics cannot be derived from the VDA lane change test either, as only the dimensions of the driving track, which the driver has to pass as quickly as possible in the closed-loop test procedure (test of the total system including the driver), are specified. Consequently, the test also serves as a benchmark for evaluating the test vehicle’s handling capabilities. Good handling meets the following criteria:

• Spontaneous and appropriate response of the vehicle to the driver’s steering input
• Power-saving and precise directional control
• Precise and quick vehicle feedback after steering input

Test Procedures

The track offset from the entry lane to the lane-change track and from the lane-change track to the exit is 1 m and the longitudinal distance to the lane change when changing to the lane-change track is 13.5 m and 12.5 m, respectively, when changing to the exit lane. The lane-change track’s width equates to the vehicle’s width plus 1 m, the exit lane has a minimum width of 3 m. Time measurement by means of a light barrier starts 2 m after entering the entry lane and ends 2 m before leaving the exit lane. At the same time the measurement starts the driver lifts the foot off the accelerator pedal, and the vehicle is thus in deceleration mode. This procedure attempts to model a real-world situation based on the assumption that most drivers would release the accelerator pedal in a critical situation. The drive-in speed is increased step by step, and none of the cones may be touched during the lane change test. The tests are typically performed with ESP (electronic stability program) to avoid sudden overreactions of the vehicle (swerving). During the test, significant movement parameters such as speed, lateral acceleration and steering wheel angle are measured and comparable evaluation criteria like maximum steering angle speed or maximum float angle are derived afterwards.

Measurands

- Vehicle longitudinal speed
- Vehicle lateral speed
- Steering wheel angle
- Steering wheel torque
- Wheel forces Fx , Fy , Fz
- Wheel moments Mx , My , Mz
- Wheel speed FL, FR, RL, RR
- Trail angle and camber angle , wheel movement in x, y and z direction
- Vehicle float angle (levelled and related to vehicle and road surface)
- Slip angle at vehicle wheel FL, FR, RL, RR
- Pitch angle, roll angle and yaw angle (levelled and related to vehicle and road surface)
- Longitudinal, lateral and yaw acceleration (levelled and related to vehicle)

Summary

This test is suitable for demonstrating how precisely, fast and spontaneously the vehicle responds to the driver's steering angle inputs. The highest possible entry speed was measured at just under 70 km/h for the DTA measurement vehicle.

The revision of the elk test resulting in the VDA lane change test allows only limited statements to be made about the vehicle's tilt stability. Typically, the so-called fish-hook test is used for this purpose. In this test, the tilt criterion must be met by the simultaneous lifting of two wheels by a minimum of 50 mm.*(13)*

3.1.5 Steady-State Circular Test

Objective of the Driving Manoeuvre

This vehicle dynamics test serves to obtain data to determine the steady-state behaviour of vehicles. The test is focused on data acquisition of the steering wheel angle as well as the roll and float angle as a function of lateral acceleration in order to enable statements to be made about self-steering behaviour as well as comfort evaluation.

Test Procedures

The steady-state circular test is an open-loop test in which either the circular track radius, the steering wheel angle or the vehicle's speed must be constant. The example shown here involves clockwise and counter-clockwise circular tests with a constant radius of 100 m, with increasing vehicle speed. The tests are driven in second or third gear and lateral accelerations up to the vehicle's driving dynamics limit are set at the typical steps of 1 m/s². During the steady-state trial phase, the steering wheel angle and throttle must be kept constant. In each lateral acceleration step, the steady-state conditions must be maintained over the measuring period of three seconds and performed three times to demonstrate repeatability and to obtain the average values. The measurands (steering angle, roll angle, and others) are plotted over the lateral acceleration. It is recommended to record tire temperatures whenever high levels of lateral acceleration prevail during longer trial periods as well. Otherwise, the tires must cool down between the individual tests to ensure comparable conditions. Alternatively, the steady-state circular test can be performed in such a way that,with continuous data logging, the constant circular radius of 100 m is driven at a slowly increasing speed so that lateral acceleration of ≤0.1 m/s²/s increases (quasi-steady-state circular test).

Measurands

- Steering wheel angle
- Yaw speed
- Steering wheel torque
- Float angle
- Lateral acceleration
- Trail angle
- Longitudinal acceleration
- Slip angle
- Lateral speed
- Wheel forces and wheel moments
- Longitudinal speed
- Tire temperature

Picture 3: Steady-State Circular Test

Summary

The steering angle characteristic over the course of the lateral acceleration is an important evaluation criterion for a vehicle's self-steering behaviour. Its increase in conjunction with increasing lateral acceleration proves the presence of under-steering effects. For reasons of vehicle stability and the safety perception of the driver, under-steering to neutral self-steering characteristics are desirable. The signal curves of the float and roll angles characterize the parameters comfort and safety.

The steady-state circular test is one of the standard tests used to validate tire models. The following wheel-related measurands (depending on lateral acceleration) are logged for this purpose: wheel camber angle, slip angle, longitudinal and lateral speed, wheel load, self-aligning and camber torque as well as drive torque. To transform the wheel-related mapping values into the onboard coordinates system, additional measurands are required: longitudinal, lateral and yaw speed, pitch and roll angles as well as wheel travel. The DTA is able to provide all of the measurement equipment required for data acquisition of the measurands described above as a package solution. *(8)*

3.1.6 Step Steering Input

Objective of the Driving Manoeuvre

According to ISO 7401 this test serves the main objective of describing the transverse dynamic behaviour of a vehicle. It defines characteristic values and functions required for both the time range and the frequency range. Key criteria in the time range include, among others:

- Time shift between steering wheel angle, lateral acceleration and yaw speed
- Gain factor of yaw speed
- Lateral acceleration related to steering wheel angle
- Yaw speed related to steering speed

Test Procedures

From straight-line driving at a constant speed of approximately 80 km/h the steering wheel is moved as fast as possible to the angle position that will result in a lateral acceleration of 4 m/s² as the vehicle now begins to corner. This angle position was previously measured during steady-state circular motion. To facilitate the requisite steering precision for the driver, a limit stop may be used, however, actuation by a steering robot is preferable in order to ensure the repeatability of the tests. On the DTA test vehicle, an actuation speed for the steering wheel angle was fixed at 500 °/s by a steering robot. To determine the aforementioned characteristic values and functions, three tests in counter-clockwise and three in clockwise direction are analyzed. The lowest deviations between the individual tests are a measure for the quality of performing the test.

Measurands

According to ISO 7491 the following "**mandatory measurands**" must be logged:

- Steering wheel angle

• Lateral acceleration
• Yaw speed
• Steady-state float angle
• Longitudinal speed

In addition, logging of the following “**optional measurands**” is recommended:
• Lateral speed or unsteady float angle
• Roll angle
• Steering wheel torque
• Forces and moments acting on the wheels
• Slip angle on the wheels

Summary

The vehicle’s response to sudden step steering input enables statements to be made about the speed of response, vehicle stability under the existing conditions as well as for the precision of the steering system. In case of a major phase delay between steering wheel input and yaw speed the vehicle can be perceived as inert and possessing poor cornering ability.

If during the change from the unsteady to the steady-state phase of the step steering input, yaw speed and lateral acceleration exhibit large amplitudes and long transient periods, then vehicle stability may be jeopardized. The gain factor, the quotient of yaw speed and the steering wheel angle, is a measure of how much steering angle the driver needs in order to generate a certain yaw response. A precise steering system is characterized by a large gain factor.*(9)*

3.1.7 Straight line Braking

Objective of the Driving Manoeuvre

The vehicle dynamics test, “straight-line braking according to DIN 70028 and beyond,” is used to evaluate actual braking deceleration and vehicle stability while performing the test. The required brake pressure can either be adjusted by the driver using a decelerometer or a braking machine can assume this task in a way that is exactly repeatable. The driver can either provide steering wheel inputs for directional control (closed loop) or he registers the vehicle movements in the open-loop procedures of “free control“ (letting go the steering wheel) or “fixed control” (fixed holding of the steering wheel).

The objective of this vehicle dynamics test is to demonstrate a design of the braking system which is suitable for the particular vehicle by combining good levels of comfort (responsiveness, operating force, etc.) with the shortest possible stopping distances. This aspect is given above-average consideration in overall vehicle evaluations by auto magazine consumer tests, such as the AMS (auto motor und sport) test in Germany. According to statutory requirements, it must be assured that up to a vehicle deceleration of 0.8 g and above the front wheels always lock before the rear wheels because locking rear wheels result in the vehicle’s instability.

The road conditions for the tests should be standardized: dry or wet conditions or surfaces with a low friction coefficient. The longitudinal inclination of the road should be ≤ 1 % and ≥ 0.2 % in the transverse direction. The adhesion coefficient of the tyres/road should be μ ≥ 0.9. For ABS developments, vehicle stability is evaluated with different friction coefficients of the driving lanes on the vehicle sides (μsplit) or in case of changes of the road friction coefficient in transverse direction to the direction of travel (μjump). The braking system must be iteratively designed for optimum use of road/tire adhesion.

Test Procedures

When performing the deceleration measurement, a quick build-up of brake pressure must be observed. 90 percent of the desired brake pressure must be achieved after less than 0.4 s. To ensure the repeatability of the test as well as the comparability of results, the road friction coefficient must have been determined and the required base temperature of the brakes at the beginning of the braking manoeuvre defined. The duration of braking and the braking distance are defined as starting with the achievement of 5 % of the maximum brake pressure until the vehicle has come to a complete halt. The example shown here presents an ABS-controlled hard stop from a speed of 100 km/h until the vehicle comes to a complete halt.

Measurands

According to DIN 70028 the following “**mandatory measurands**” must be logged:

- Vehicle speed
- Time when braking begins
- Braking distance over the defined measurement duration
- Brake pedal force (or brake pressure in brake master cylinder)

In addition, logging of the following “**optional measurands**” is recommended:

- Wheel forces and moments
- Slip angle of the front wheels
- Float angle, float angle speed
- Trail angle of the front wheels
- Yaw angle, yaw angle speed, yaw angle acceleration
- Steering wheel angle

Summary

Characteristic parameters for the **deceleration ability** of a vehicle include, for example:

• Braking distance as a function of initial speed or
• Average deceleration as a function of brake pressure.

To evaluate **vehicle stability** and **directional stability**, the following characteristics are examined:

• Lateral deviation across the braking distance

• Yaw speed across the duration of braking (average deceleration). *(10)*

3.1.8 Sine with dwell steer input (FMVSS 126, Global Technical Regulation No. 8)

Objective of the Driving Manoeuvre

This manoeuvre establishes the presence of an electronic stability control (ESC) system and requires both the vehicle's stability as well as its responsiveness to be adequate.

Test procedures

FMVSS 126 / GTR 8 first define a number of initial checks to make sure the requirements with respect to controls and certain conditioning tests for tires and brakes are also required.

The test itself then consists of

- A series of "Slowly Increasing Steer Tests" to determine which average steering wheel angle is required for a lateral acceleration of 0.3 g. That steering wheel angle is called "A" and is used to define and evaluate the subsequent tests.

- Two series of "Sine with Dwell" tests, i.e., a sinusoidal steering pattern of 0.7 Hz frequency with a .5 s delay beginning at the second peak. The sine amplitude "δ" is increased for each test by an increment of 0.5•A until the final run. The final run in a series is reached when "δ" exceeds 270°. In case "δ" exceeds 300°, the final run is done at 300°. In each test run the initial speed is 80 km/h and a steering robot is used to ensure that the steering pattern is in line with the requirements.

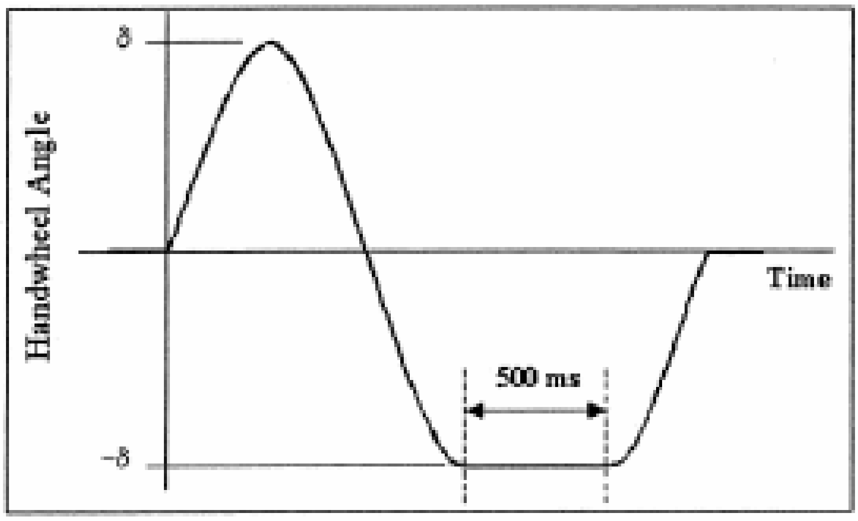


Figure 2: Sine with dwell steering input

In order to pass, the test the vehicle has to meet three criteria:

For evaluating responsiveness the lateral displacement is evaluated 1.07 s after the start of the steer input. For vehicles with a gross weight of up to 3500 kg the displacement must be at least 1.83 m (6 ft), for heavier vehicles the threshold is 1.52 m (5 ft).

For evaluating stability, the yaw rate is evaluated at 1.0 s and 1.75 s after the end of the steer input (figure 4) . At 1.0 s the yaw rate must not exceed 35% of the peak yaw rate. At 1.75 s the yaw rate must be at or below 20% of the peak yaw rate

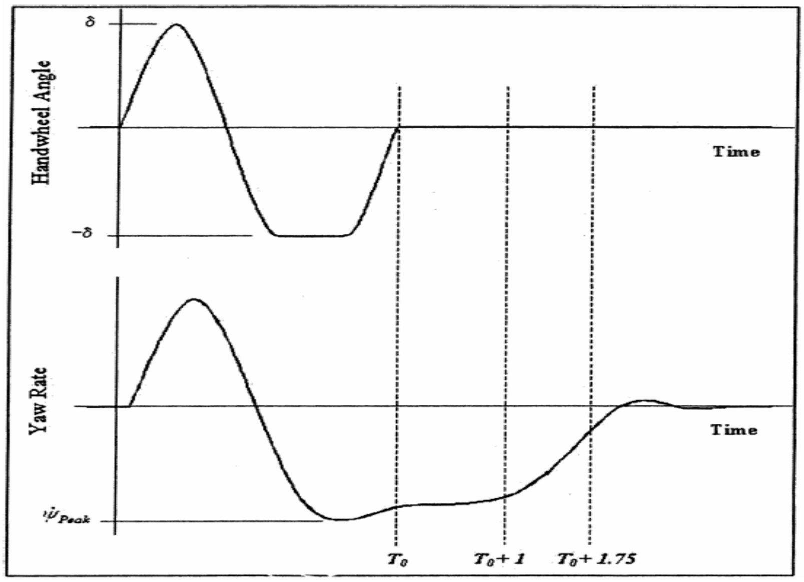


Figure 3: Sample time history of steering wheel angle and yaw velocity

Measurands

Key parameters to be logged are time, velocity, roll height, lateral, longitudinal and vertical accelerations, roll, yaw and pitch rates, and steering wheel angle. To ensure proper testing conditions some other parameters, e.g., ambient temperature, vehicle weight, tire pressure etc. need to be measured as well. However, there parameters are not used for evaluation.

Summary

Initiated by the US National Highway Safety Administration, a test procedure for Electronic Stability Control Systems has been developed and adopted as GTR 8. The underlying manoeuvre was chosen. The intention of this test is merely to identify the presence of an ESC, so according to NHTSA the test manoeuvre was selected (over a number of other alternatives) because it was deemed to be severe, repeatable, reproducible and capable to address both lateral stability and responsiveness. It was however not supposed to represent any real-world driving situation such as obstacle avoidance. *(12)*

3.2 ISO, SAE and NHTSA Test Procedures

3.2.1 ISO 15622:2002

ISO 15622:2002 [15622] contains seven parts: scope, normative references, symbols, classification, requirements, and performance evaluation test methods.

ISO 15622:2002 classifies ACC systems into four different types and four different performance classes with respect to curve radius capability (table 1).

Type	Manual clutch operation	Active brake control
1a	yes	no
1b	no	no
2a	yes	yes
2b	no	yes

Performance class	Curve radius capability
I	no capability claimed
II	≥500 m
III	≥250 m
IV	≥125 m

Table 1: ACC system types and performance classifications

The requirements are grouped into the following six categories:

- Basic control strategy, requirements on e.g. ACC system states and at what velocities the ACC function can be engaged.
- Functionality, requirements on e.g. clearance capabilities, following capability, target discrimination, and curve capability (performance classes II - IV).
- Basic driver interface and intervention capabilities, requirements on e.g. operation elements and system reactions, display elements, and symbols.
- Operational limits, requirements on e.g. minimum set speed as well as maximum deceleration and acceleration rates.
- Activation of brake lights, requirements on illumination of brake lights for type 2 ACC systems, i.e. systems with automatic braking.
- Failure reactions, requirements on how the system shall react upon the failure of a subsystem (engine, gearbox, sensor, ACC controller).

The performance evaluation tests shall be conducted with specified environmental conditions: test track surface material (flat dry asphalt or concrete), temperature (20 ± 20 °C), and horizontal visibility (> 1 km). Test targets are also specified. For LIDAR-based ACC systems, the test targets are specified using a coefficient value for a diffuse reflector. For the RADAR based ACC systems on the other hand, the targets are specified using the radar cross section (RCS).

Three (two for performance class I) different performance evaluation tests shall be performed:

- *Detection range test*, the goal of this test is to find out if a test target can be detected between minimum and maximum detection range. The maximum detection range is calculated from maximum selectable set speed and maximal selectable time gap at maximum selectable set speed. The minimum detection range is selected as the maximum of 2 m/s or 25% of minimum speed at which automatic acceleration is allowed. There is also a boundary between the maximum and minimum detection ranges below which is enough to only detect vehicles (no ranging is necessary). This boundary is calculated from the minimum speed at which automatic acceleration is allowed and minimum selectable time gap at minimum speed at which automatic acceleration is allowed.

- *Target discrimination test*, the goal of this test is to find out if the subject vehicle under ACC control can follow a target vehicle while passing an identical (to the target vehicle) forward vehicle in an adjacent lane. The test starts by having the target and forward vehicle travelling along side each other with the subject vehicle in steady state time gap control mode behind. Then the target car accelerates and pulls away after which the subject vehicle shall follow.

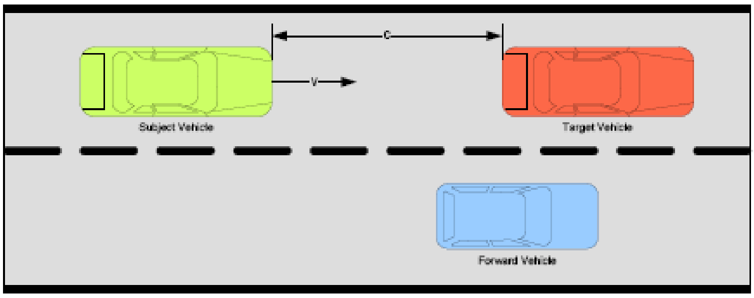


Figure 4: Target discrimination test (clearance, *c*, vehicle velocity, *v*).

- *Curve capability test*, the goal of this test is to find out if the subject vehicle can detect and decelerate when the target vehicle slows down in a constant radius curve. The ACC of the subject vehicle shall be in time gap mode and the deceleration shall start before the time gap becomes shorter than 2/3 of the maximum selectable time gap.

3.2.2 ISO 17361:2007

ISO 17361:2007 [17361] contains five parts: scope, normative references, terms and definitions, specifications and requirements, and test method. The standard also contains one annex on national road markings.

ISO 17362:2007 classifies LDWSs into two types with respect to vehicle speed and curve radius capabilities (table 2).

Parameter	Class	
	I	II
Radius of curvature	≥500 m	≥250 m
Vehicle speed	≥20 m/s	≥17 m/s

Table 2: LDWS Classification types

The requirements are grouped into the following three categories:

- Basic requirements, requirements on basic functionality, i.e. monitor system status, detect lateral position, warn driver, and so forth.
- Operational requirements, requirements on e.g. the location of earliest and latest warning lines.
- *Human interface requirements*, requirements on warning presentation and system status indication.

The tests shall be conducted with specified environmental conditions: test track surface material (flat dry asphalt or concrete), temperature (10 ± 30 °C), lane markings (visibility), and horizontal visibility (> 1 km). Test vehicle conditions are also specified. Three different tests shall be performed:

- *Warning generation test*, the goal of this test is to find out if warnings are generated curves according to curve classification. Tests shall be conducted in different curves, in different departure directions, and at different rates of departure (Table 3). The warnings shall be issued somewhere within the earliest and latest warning lines.

Rate of de-parture	Right curve		Left curve	
	Left departure	Right departure	Left departure	Right departure
0 to 0.4 m/s	one trial	one trial	one trial	one trial
0.4 m/s to 0.8 m/s	one trial	one trial	one trial	one trial

Table 3: Warning generation tests

- *Repeatability test*, the goal of this test is to find out if warnings are issued within a warning zone of 30 cm on a segment of straight road for four consecutive trails. Different departure directions and rates of departure shall be tested (Table 5). (V1 and V2 shall be selected by the manufacturer.)

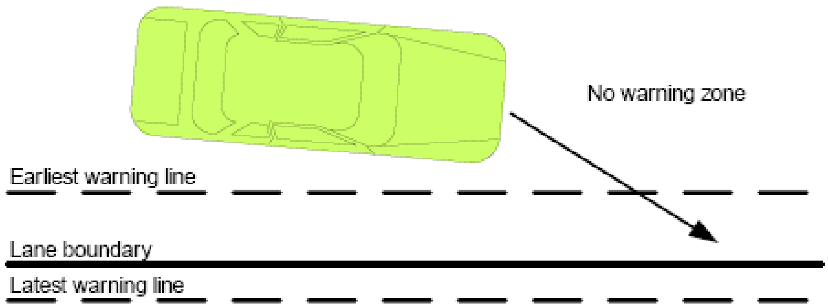


Figure 5: Warning line definitions

- *False alarm test*, the goal of this test is to find out if the system produces no warnings while driving within the no warning zone for a straight course total distance of 1000 m.

Rate of departure m/s	Departure direction	
	Left	Right
0.1 < (V1±0.05) < 0.3	four trials	four trials
0.6 < (V2±0.05) < 0.8	four trials	four trials

Table 5: Repeatability tests

3.2.3 ISO/DIS 17387

The Lane Change Decision Aid System (LCDAS) is intended to warn the driver of the subject vehicle against a potential collision with target vehicles moving in the same direction during a lane change manoeuvre. The LCDAS operates as a supplement to the interior and exterior rear-view mirrors of the vehicle but does not eliminate the need for driving mirrors.

The LCDAS shall detect vehicles to the rear and sides of the subject vehicle within the coverage zone (refer to Figure XX). By indicating the desire to make a lane change, the subject vehicle driver causes the LCDAS to evaluate the situation. The LCDAS delivers a warning if a lane change is not recommended.

The LCDAS is not intended to support aggressive driving and hence the absence of a warning signal does not guarantee a safe lane change manoeuvre. The system does not provide automatic action to prevent a possible collision. The responsibility for the safe operation of the vehicle remains with the driver.

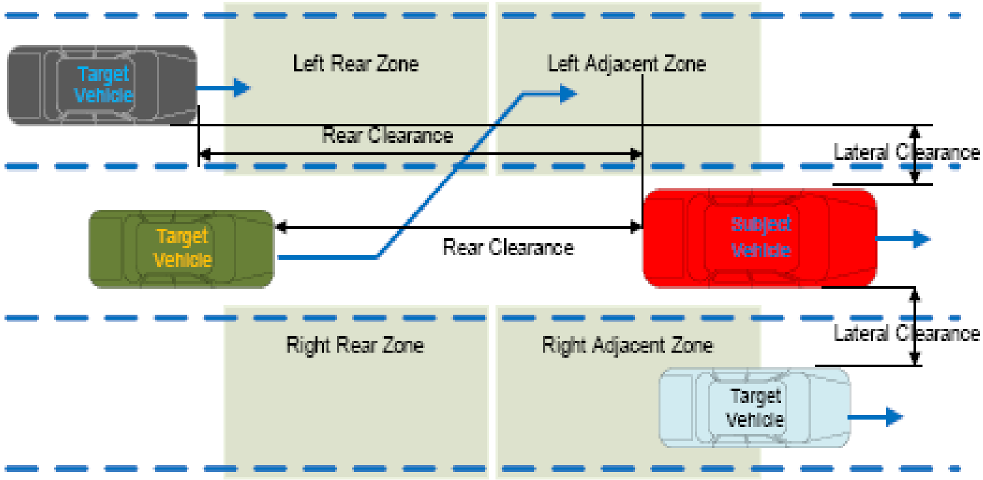


Figure 6: LCDAS Concept

Classification

The standard specifies system requirements and test methods for LCDAS. LCDAS are classified by minimum required coverage in Type I Systems, Type II Systems, Type III Systems (refer to Table 6).

Type	Left	Right	Left Rear	Right Rear	Function
I	X	X			Blind Spot
II			X	X	Closing
III	X	X	X	X	Lane

Table 6: Coverage Zone Classification

LCDAS of Type II and III are classified by the maximum target vehicle closing speed and the minimum roadway radius of curvature as shown in Table 7.

Type	Maximum target vehicle	Minimum Roadway Radius
A	10 m/s	125 m
B	15 m/s	250 m
C	20 m/s	500 m

Table 7: Target Vehicle Speed Classification

Functional requirements

LCDAS shall at minimum operate according to the state diagram of Figure 7:

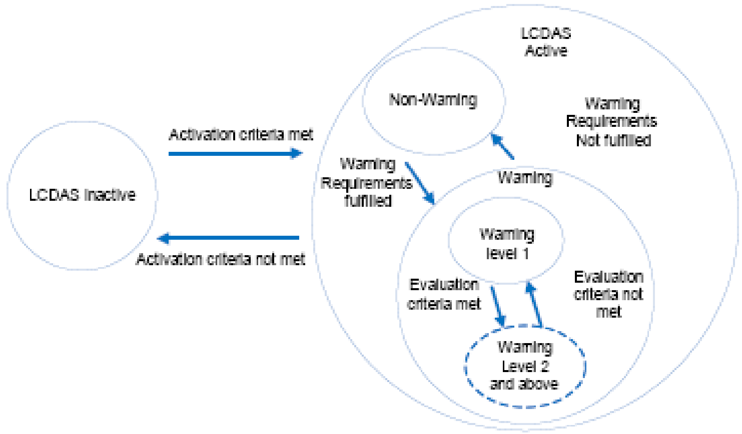


Figure 7: LCDAS state diagram

System performance

The LCDAS shall fulfil:

Minimum Detectable Target Vehicle

Requirements for the Blind Spot warning Function
- Left Side Blind Spot Warning Requirements
- Right Side Blind Spot Warning Requirements
- Optional Blind Spot Warning Suppression

Requirements for the Closing Vehicle Warning Function
- Left side closing vehicle warning requirements
- Right side closing vehicle warning requirements
- Optional dual side closing vehicle warning

Requirements for the Lane Change Warning Function
- System response time
- User interface
- LCDAS inactive indication
- LCDAS active indication
- LCDAS warning indication
- LCDAS failure indication
- Operation with trailers
- Self-test requirements

The standard also specifies test requirements. These requirements include environmental conditions, blind spot warning test requirements and lane change warning test requirements.

3.2.4 ISO 15623:2002

Transport information and control systems – Forward Vehicle Collision Warning Systems (FVCWS) – Performance requirements and test procedures.

ISO 15623:2002 specifies performance requirements and test procedures for systems capable of:

- Warning the vehicle driver for short inter-vehicle distance
- Closing speed which may result in a rear-end collision with other vehicles or including motorcycles, ahead of the subject vehicle while it is operating at ordinary speed.

ISO 15623:2002 is applicable to operations on roads with curve radii over 125 m.

Functional FVCWS elements

The functional elements of the FVCWS interact with each other together in realising the sequence of operating states and warnings issued during a specific operation. The functional elements belong to three domains, namely: the environment, the vehicle and the driver. To each domain is associated one or more functional elements as described in (Table 8).

Domain	Functional FVCWS elements	Comments
Environment	Detection and ranging of obstacle vehicles	*Obstacle vehicles* are vehicles moving or stationary that are considered as potential hazards that can be detected by this system
Vehicle	1) Subject vehicle motion determination 2) FVCWS warning strategy	
Driver	1) Driver preferences 2) Warning	1) Chosen level of sensitivity, style of driving 2) *Preliminary collision warning* is the information that the system gives to the driver indicating the presence of a forward obstacle vehicle. The *collision warning* is issued in the advanced stages of a dangerous situation to warn the driver of the need to perform emergency braking, lane changing or other manoeuvres in order to avoid a collision

Table 8: FVCWS system elements

Basic consideration of collision warning

Collision Warning uses the same sensor information as ACC. It estimates the time necessary to avoid a collision, taking the driver's reaction time into consideration. If the driver doesn't appear to react when a collision risk has been determined, Collision Warning emits an audible and visual warning to draw immediate attention. The driver can often choose different levels of sensitivity, according to the style of driving.

The *specifications and requirements* addressed in the standard concern the following:

1) Warnings
   a) Monitoring distance and relative speed between obstacle vehicle and subject vehicle
   b) Judging the timing of collision
   c) Preliminary collision warning and collision warning
   d) Fault indicator

2) System classification

Class	Horizontal curve radius capability
I	Curve radius ≥ 500 m
II	Curve radius ≥ 250 m
III	Curve radius ≥ 125 m

Table 9: System classification

3) Obstacle vehicle detection area and performance
   a) Obstacle vehicle detection area
   b) Warning distance accuracy
   c) Target discrimination ability

4) User safety requirements
   a) Optical radar
   b) Radio wave radar

5) Human interface requirements
   a) Warning output specification
   b) Interface with other warnings
   c) Operational status display

6) Awareness of system limitations

The *evaluation test methods for measuring detection performance* include:

1) Test target specification
   a) Optical radar
   b) Radio wave radar

2) Environmental conditions

3) Test method for detection zone

4) Test method for warning distance accuracy

5) Test method for target discrimination ability
   a) Longitudinal discrimination
   b) Lateral discrimination
   c) Overhead discrimination

3.2.5 ISO 7401:2003

Test execution

The manoeuvre should be performed as follows:

- more then 2 seconds of initial straight line at constant velocity at 100 km/h in fourth gear (if not differently specified)
- step steer input (SWA_nom) with steering wheel angle gradient higher than 300 deg/s and then steering wheel value SWA_nom kept fixed for at least 5 seconds
- final offset on straight at constant speed or with vehicle stopped (duration > 2 seconds)

The manoeuvre can be performed either maintaining a fixed gas pedal position during the steering wheel actuation or dropping the gas pedal 1 second before the start of the steering wheel actuation.

Suitable steering wheel amplitudes could be defined as follows:

- definition of the reference steering wheel angle (SWA_ref), i.e. the steering wheel angle required for 85 % of the maximum lateral acceleration value in a slowly increasing steer manoeuvre at a vehicle speed of 100 km/h (steering wheel gradient = 30-60 deg/s, fixed gas pedal position)
- use of steering wheel angle amplitudes SWA_nom = L x SWA_ref with L = 1, 1.1, 1.2, … 2.

Data evaluation

The parameters evaluated in this manoeuvre are related to yaw rate, sideslip angle and sideslip rate. They are:

- First peak
- Difference between second and first peak
- Time of the first peak
- Time lag between first and second peak
- RMS value after 1sec from the beginning of the steering wheel input
- RMS value after 2.5sec from the beginning of the steering wheel input

3.2.6 ISO 21994:2007

Test execution

In this case where there is uniform adherence level on left and right wheels, the manoeuvre should be performed as follows:

- 2 seconds of initial straight line at constant velocity (100 km/h if not otherwise specified)
- Step brake pedal input (panic stop) with clutch pedal down until vehicle stops with steering wheel angle fixed at 0 degrees
- Final offset (duration > 2 seconds)

In the case of a different adherence level (high - low) between the left and right wheels, the manoeuvre should be performed as follows:

- 2 seconds of initial offset straight line at constant velocity (100 km/h if not otherwise specified)
- Step brake pedal input (panic stop) with clutch pedal down until vehicle stops
- Steering wheel correction by driver is allowed in order to keep one side of the vehicle with the two wheels on low adherence
- Final offset (duration > 2 seconds)

Data evaluation

The parameters evaluated in this manoeuvre are:

- Stopping distances according to ISO 21994
- Peaks, mean values and jerk of longitudinal deceleration
- Yaw rate and steering wheel variations in the case of mu-split
- Analysis of pressure and slip on each corner

3.2.7 ISO 7975:2006

Test execution

In this case, the manoeuvre requires an initial steady-state part on constant radius with constant vehicle speed. The manoeuvre should be performed as follows:

- Initial offset straight line at constant velocity (duration > 2 seconds)
- Drive the vehicle on a constant radius of 100 m reaching a steady-state lateral acceleration of 0.5 g (about 80 km/h)
- Step brake pedal inputs from a longitudinal deceleration of 0.4g to the limit (panic stop) with clutch pedal down. Steering wheel angle must be kept fixed in the initial steady-state position

- Final offset in straight line condition or with stopped vehicle (duration > 2 seconds)

Data evaluation

The parameters evaluated in this manoeuvre are:

- Stopping distances according to ISO 21994
- Peaks, mean values and jerk of longitudinal deceleration
- Yaw rate and steering wheel variations
- Analysis of pressures and slips on each corner

3.2.8 SAE J2400

FCW systems are onboard systems intended to provide alerts to assist drivers in avoiding striking the rear end of another moving or stationary motorised vehicle.

The report describes elements for a FWC operator interface as well as requirements and test methods for systems capable of warning drivers of rear-end collisions.

The information gathered in the report concerns original equipment and aftermarket FCW systems for passenger vehicles including cars, light trucks and vans. The report does not apply to heavy trucks nor addresses integration issues associated with Adaptive Cruise Control (ACC). Consequently, aspects considered in he report may be inappropriate for an ACC system integrated with a FCW system.

The report contains a requirement set-up for *operating characteristics* and for the occurrence of accident alerts, as follows:

1) System and Information Display Characteristics (16 parameters)

2) Requirements for the occurrence of Accident Alerts
   a) Geometric characteristics of the alert zone
   b) Longitudinal conditions for alerts
   c) Computing alert timing requirements (6 steps are used)

Performance evaluation test methods to verify compliance with J2400 are addressed as follows.

3) Testing criteria and assumptions
   a) A Pass/Fail criteria
   b) Accident alert timeliness
   c) In-path nuisance alerts
   d) Out-of-path nuisance alerts

4) Test procedure descriptions

12 test scenarios where the speed and acceleration of the subject vehicle (SV) and lead vehicle (LV) or target vehicle, are presented in Figure 8.

The FCW-equipped vehicle is called the “subject vehicle” while the “lead vehicle” represents the potential collision threat. VSV and VLV denote the initial speeds of the SV and the LV as shown in Figure 8 aSV and aLV denote the acceleration of the SV and the LV respectively.

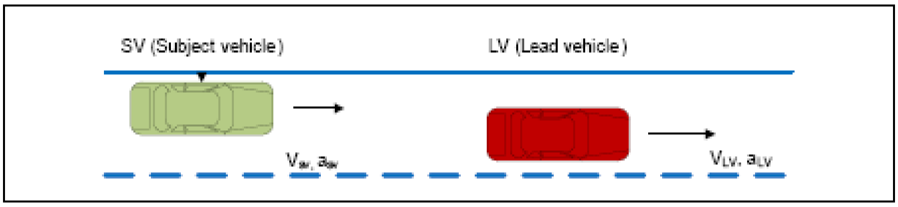


Figure 8: Rear instantaneous observed alert onset

A schematic for combining alert timing rules and alert zone requirements is presented in Figure 9.

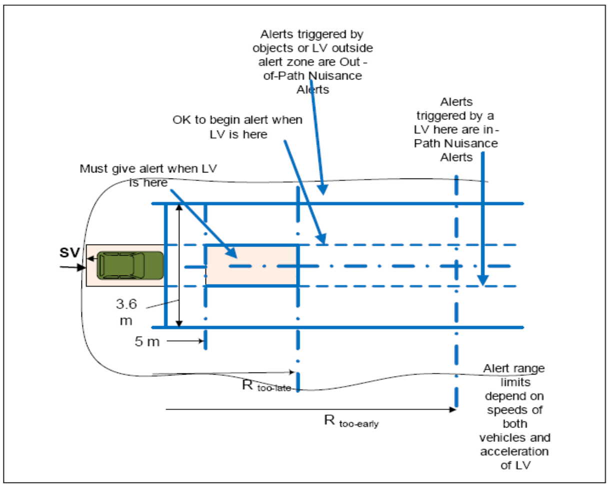


Figure 9: Combining alert timing rules and alert zone requirements

Parameters for test 1 – test 11 and coefficient for weighing out-of-path nuisance tests are also listed.

#	FCW system test	Crash alert test	Out-of-path Nuisance Alert test	Number of trials
1	SV at 100 kph approaches stopped vehicle	*		5
2	SV 70 kph behind principal other LV. Changing lanes to reveal stopped LV	*		5
3	SV (nominally at 60 kph) approaches 10 kph. Principal other LV	*		5
4	SV at 100 kph approaches a motorcycle that is following a truck at 35 kph	*		5
5	SV at 50 kph approaches a 30 kph principal other LV	*		5
6	SV tailgating a principal other LV at 100 kph – principal other LV brakes mildly	*		5
7	SV at 100 kph principal other LV braking moderately hard from same initial speed	*		5
8	SV (nominally at 100 kph) passes principal other LV travelling at 40 kph in adjacent lane, in curve		*	10
9	SV 100 kph passes between trucks travelling at 35 kph in adjacent lanes		*	10
10	SV passes roadside signs along straightaways and curves		*	10
11	SV at 100 kph approaches overpass		*	10

Table 10: Summary of object test scenarios

3.2.9 SAE J2399

SAE J2399 [J2399] contains four parts: scope, references, definitions, and requirements as well as two appendices. One of the appendices contains the ACC system characterization procedure. There is no classification of ACC systems in SAE J2399.

The requirements are grouped into the following five categories:

- *Sensor capability*, requirements on the response capability of the sensor.
- *Operational characteristics*, requirements on e.g. minimum and maximum set speed as well as time gap settings. There are also requirements on the illumination of stop lights.
- *Operating state transitions*, requirements on ACC system states and via what means the ACC can be disengaged.
- *Displays*, requirements on indicators, signals, warnings, and alerts.
- *Performance evaluation test methods*, requirements for a minimum available time gap test and a maximal available time gap test.

The goals of the performance evaluation tests are to find out if the ACC system fulfils its maximal and minimal time gap throughout the ACC velocity range. The subject vehicle shall be travelling in speed mode until it closes in, when the time gap mode shall be automatically activated. The forward vehicle shall be travelling at three different speeds: 97 km/h, 16 km/h above the minimum ACC operating speed, and 16 km/h below the maximum ACC operating speed.

Considering maximum set and operating speed, SAE J2399 refers to ISO 15622:2002 for compliance test procedure.

3.2.10 FMVSS 126

The US National Highway Traffic Safety Administration (NHTSA) has published the Federal Motor Vehicle Safety Standard (FMVSS) No. 126, on Electronic Stability Control Systems, in April 2007. This document requires new passenger cars, multipurpose passenger vehicles, trucks, and buses with a gross vehicle weight rating of 4,536 kg (10,000 pounds) or less, to be equipped with an ESC system that meets the requirements of the standard. Vehicles must be equipped with an ESC system which fulfils the definition of an ESC system.

An ESC system must be capable of applying brake torques individually to all four wheels, and have a control algorithm utilizing this capability. The control algorithm has to be operational during all phases of driving including acceleration, coasting and deceleration, except when the driver has disabled the ESC. The ESC system must also be capable of detecting and warning of system malfunctions.

Test execution

Each manoeuvre should be performed as follows:

- initial straight line at constant velocity at 80 km/h (duration > 2 seconds)
- dropped gas pedal on straight line (duration 1 second)
- steering wheel actuation with dropped gas pedal (see Figure 10 below)
- final straight line at constant velocity or with vehicle stopped (duration > 2 seconds)

The complete test procedure requires:

- definition of the reference steering wheel angle SWA_ref, i.e. the steering wheel angle needed to reach a lateral acceleration of 0.3g in a slowly increasing steer manoeuvre at a constant vehicle speed of 80 km/h

- steering wheel actuation with the following features:
  - steering wheel angle amplitude = L x SWA_ref with L = 1.5, 2.5, 3.5, 4.5, 5.5, 6.5
  - highest steering wheel angle amplitude = 270 degrees or 6.5 x SWA_ref whichever is greater
  - frequency of actuation = 0.7 Hz
  - dwell duration after 1.07 seconds (Dt_dwell) = 0.5 seconds

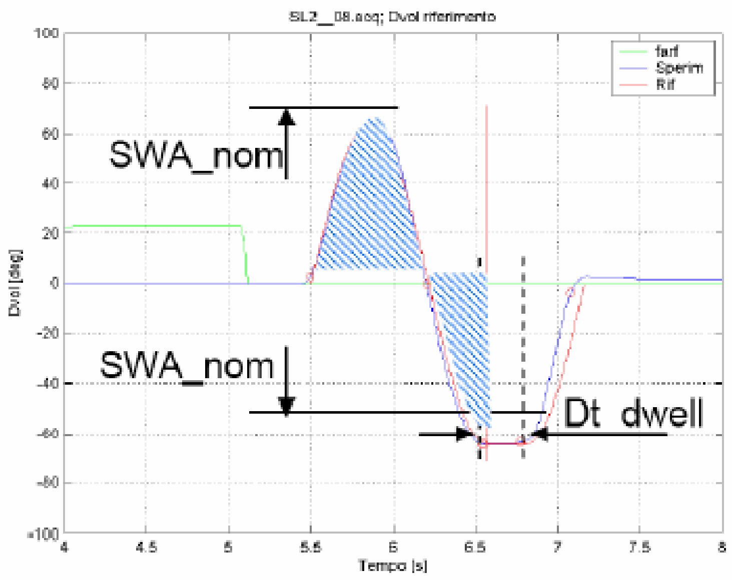


Figure 10: Sine with dwell

Data Evaluation

The main parameters to be evaluated, following indications of NHTSA, are:

- yaw rate at 1 second after steering wheel input has finished (Stability Metric)
- lateral displacement at 1.07 seconds after steering wheel input has started (Responsiveness Metric)

Other useful parameters are:

- peak values of lateral acceleration
- peak values of yaw rate
- peak values of sideslip angle

The test will verify the requirements for lateral stability and responsiveness performance. The lateral stability is verified by yaw rate thresholds. The yaw rate measured one second after completion of a 0.7 Hz ``sine with dwell steering input" manoeuvre must not exceed 35 percent of the first peak value of yaw rate recorded after the steering wheel angle changes sign (between first and second peaks) during the same test run, and the yaw rate measured 1.75 seconds after completion of the same manoeuvre must not exceed 20 percent of the first peak value of yaw rate recorded after the steering wheel angle changes sign (between first and second peaks).

The responsiveness of the vehicle is verified by the lateral displacement. The lateral displacement of the vehicle centre of gravity with respect to its initial straight path must be at least 1.83 m (6 feet) for vehicles with a GVWR of 3,500 kg (7,716 lb) or less, and 1.52 m (5 feet) for vehicles with a GVWR greater than 3,500 kg (7,716 lb) when computed 1.07 seconds after the Beginning of Steer (BOS) at specified commanded steering wheel angles.

The “Sine with dwell” test uses a steering robot maintaining a reasonable level to produce a single 0.7Hz sine wave with a half second steering angle hold between the third and fourth quarter cycles. The test is performed at 80 km/h (50 mph) with no throttle application and on dry ground. The test focuses on over-steer mitigation because it is believed to prevent more accidents than under-steer mitigation.

3.2.11 NHTSA DOT HS 810 757

The U.S. Department of Transportation is working together with industry to accelerate the deployment of ICT-based safety systems under the Integrated Vehicle-Based Safety System (IVBSS) programme. The IVBSS initiative will build and field test prototypes of safety systems. This will require objective test procedures to verify that the IVBSS prototypes meet their performance specifications and are safe for use by ordinary drivers.

There is a report [810757] recommending a basic set of accident imminent test scenarios for integrated vehicle-based safety systems designed to warn the driver of an impending rear-end, lane change, or run-off-road accident. The scenarios are selected based on the U.S. 2000-2003 General Estimates System (GES) accident databases.

Four dominant scenarios account for 97% of light-vehicle rear-end accidents and 95% of heavy truckrear-end accidents. These four scenarios are recommended as base test scenarios for the rear-end accident warning function:

1. Subject vehicle changes lanes and encounters a stopped lead vehicle ahead in daylight, clear weather, on straight and level road.
2. Subject vehicle is moving at constant speed and encounters a lead vehicle moving at slower constant speed in daylight, clear weather, on straight and level road
3. Subject vehicle is following a lead vehicle at constant speed and then lead vehicle suddenly decelerates in daylight, clear weather, on straight and level road
4. Subject vehicle is moving at constant speed and encounters a stopped lead vehicle in daylight, clear weather, on straight and level road

Four dominant scenarios account for 65% of light-vehicle lane change accidents and 76% of heavy truck lane change crashes. These four scenarios are recommended as base test scenarios for the lane change crash warning function:

1. Subject vehicle changes lanes to the right and encroaches on an adjacent vehicle in daylight, clear weather, on straight and level road.
2. Subject vehicle passes to the left and encroaches on an adjacent vehicle in daylight, clear weather, on straight and level road.

3. Light vehicle turns left at 20-40 mph (heavy truck turns right at 15-35 mph) and encroaches on an adjacent vehicle going straight in daylight, clear weather, on straight and level road. (refer to Figure 11
4. Subject vehicle drifts right (light vehicle at 35-60 mph and heavy truck at 35-55 mph) and encroaches on an adjacent vehicle in daylight, clear weather, on straight and level road.

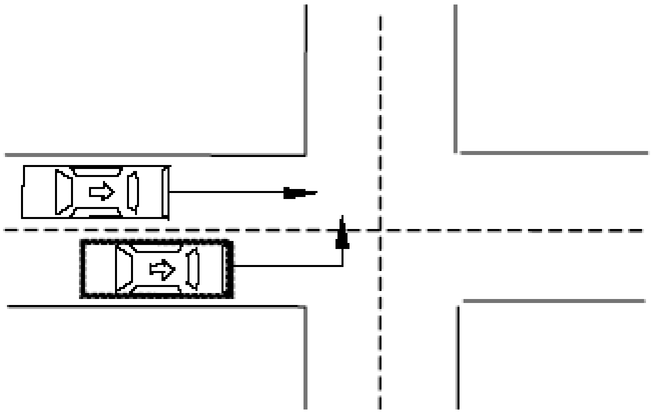


Figure 11: Definition scenario where vehicle turns left and encroaches on adjacent vehicle [810757]

Five dominant scenarios account for 63% of light-vehicle lane change crashes and 83% of heavy truck run-off road crashes. These five scenarios are recommended as base test scenarios for the run-off road countermeasures:

1. Subject vehicle is going straight and departs road edge to the right in daylight or darkness, clear weather, on straight and level road.
2. Subject vehicle is going straight and departs road edge to the left in daylight or darkness, clear weather, on straight and level road
3. Subject vehicle is negotiating a curve and departs road edge to the right in daylight or darkness, clear weather, on sloped road.
4. Subject vehicle is negotiating a curve and loses control in daylight, clear or adverse weather, on sloped road.
5. Subject vehicle is turning left at an intersection and departs road edge to the right in daylight, clear weather, on straight and level road.

Situations can occur, when threats are combinations of the previously presented crash imminent test scenarios for rear-end, lane change, and run-off-road crashes. These five scenarios evaluate the capability of the integrated system to issue crash alerts in near simultaneous threat events:

1. Subject vehicle is moving at constant speed and encounters a lead vehicle moving at lower constant speed; subject vehicle then attempts to pass to the left adjacent lane occupied by another vehicle.
2. Subject vehicle is moving at constant speed and encounters a stopped lead vehicle; subject vehicle then attempts to change lanes to the right adjacent lane occupied by another vehicle.

3. Subject vehicle drifts and is about to unintentionally depart to the right adjacent lane occupied by another vehicle.
4. Subject vehicle drifts and is about to unintentionally depart to the left adjacent lane occupied by another vehicle.
5. Subject vehicle is following a lead vehicle at a constant speed on a straight road, both driving too fast for the upcoming curve; and then lead vehicle suddenly decelerates.

The first annual report of IVBSS [810842] gives a suggestion for verification test procedures. These procedures are scenario-based and fall into two broad categories: closed-course test track and on-road tests.

There are twelve rear-end crash threat scenarios. One of the test scenarios is intended to verify the appropriateness of an FCW when a vehicle approaches, from behind, a slower moving vehicle in the centre of the same lane. In this test, the vehicles are travelling at a constant speed with a speed differential between them of at least 8.9 m/s (20 mph). (refer to Figure 12).

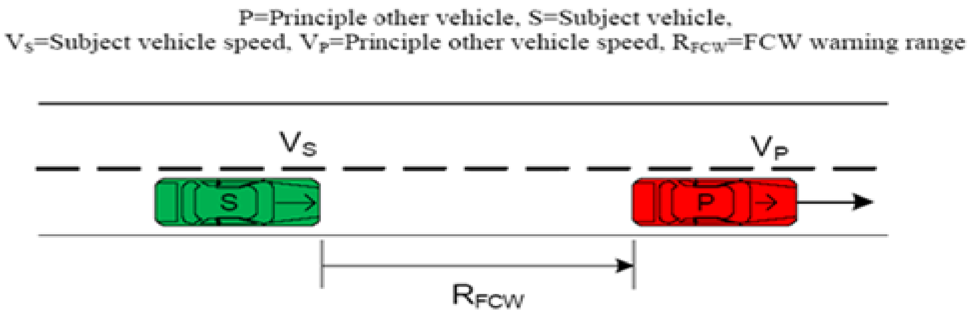


Figure 12: Rear-end crash scenario1 [810842]

There are: nine lane change threat scenarios, seven road departure crash threat scenarios, three multiple-threat scenarios, and eight no-warn threat scenarios. The no-warn tests are designed to verify that the system does not issue warnings that the driver might perceive as false or nuisance alarms.

The IVBSS first annual report [810842] also lists tests for human factors. These test include:

- Auditory warning selection
- Time course for various test conditions
- Shared warnings
- System time or Accuracy Trade-off
- Co-Occurring Warnings (20)

4. Conclusions

The objective of this report is the examination of existing test procedures for various technological in-vehicle safety systems. As a baseline, the technologies and components currently used in ICT based safety systems as well as existing testing and evaluation methods have been collected and analysed and an overview of the different systems that are currently available or under development, with aim to increase vehicle safety has been given.

While test methods for validation of ICT-based safety systems with drivers in the loop are not widely applied, there are certain methods for testing specific systems, mainly given by means of standards. Additionally, some research projects have already been carried out in the field of eSafety systems testing and evaluation. Their focus was mainly on strategies and methodologies for testing active safety systems.

Through testing procedures, a significant amount of data is recorded. These data have to be processed and interpreted in an efficient way. The measured data can then be used to calculate safety performance indicators describing the performance of the safety function. Post-processing of measured data should be automatable and representative in a clear format and results should be understandable by different recipients. While experts are able to interpret precise measurements, end customers should be provided with abstracted values, e.g. by means of a rating.

The evaluation of a safety system for regulatory consideration is not completed after a value is determined and a decision is made whether to presently consider the system or to defer its consideration indefinitely. An evaluation that indicates present consideration requires full attention and further concrete steps. Such steps could involve educating consumers on the merits of a safety system, incentivizing automobile manufacturers to make the system readily available or further analyzing the system.

As a next step to this deliverable and according to the work plan, the recommendation of new test procedures will be attempted, when necessary, enabling technological systems to approach as much as possible the real conditions and cover a wider part of the existing road safety problems.

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6. Annex

6.1 ISO Standards

ISO 3888-1:1999 Passenger cars -- Test track for a severe lane-change manoeuvre -- Part 1: Double lane-change

This part of ISO 3888 specifies the dimensions of the test track for a closed-loop method to subjectively determine a double lane-change which is one part of the vehicle dynamics and road-holding ability of passenger cars. It is applicable to passenger cars as defines in ISO 3888. It is also applicable to light commercial vehicles up to a gross vehicle mass of 3,5 tonnes.

ISO 3888-2:2002 Passenger cars -- Test track for a severe lane-change manoeuvre -- Part 2: Obstacle avoidance

ISO 3888-2:2011 defines the dimensions of the test track for a closed-loop, severe lane-change manoeuvre test for subjectively determining the obstacle avoidance performance of a vehicle, one specific part of vehicle dynamics and road-holding ability. It is applicable to passenger cars as defined in ISO 3833. It is also applicable to light commercial vehicles up to a gross vehicle mass of 3,5 tonnes.

ISO 4138:2004 Passenger cars -- Steady-state circular driving behaviour -- Open-loop test methods

ISO 4138:2004 specifies open-loop test methods for determining the steady-state circular driving behaviour of passenger cars as defined in ISO 3833 and light trucks.

ISO 6597:2005 Road vehicles -- Hydraulic braking systems, including those with electronic control functions, for motor vehicles -- Test procedures

ISO 6597:2005 specifies the method of testing the hydraulic braking systems of vehicles of categories M and N which are built to comply with ECE-R 13/09, including supplements 1 to 7.

Hydraulic braking systems include vacuum-assisted and power hydraulic-assisted braking systems as well as full power hydraulic braking systems.

ISO 7401:2003 Road vehicles -- Lateral transient response test methods -- Open-loop test methods

ISO 7401:2003 specifies open-loop test methods for determining the transient response behaviour of road vehicles. It is applicable to passenger cars, as defined in ISO 3833, and to light trucks.

ISO 7975:2006 Passenger cars -- Braking in a turn -- Open-loop test method

ISO 7975:2006 specifies an open-loop test procedure to examine the effect of braking on course holding and directional behaviour of a vehicle. Specifically, the procedure determines how the steady-state circular response of a vehicle is altered by a braking action only. ISO 7975:2006 applies to passenger cars as defined in ISO 3833 and to light trucks.

The open-loop manoeuvre specified in this test procedure is not representative of real driving conditions but is useful to obtain measures of vehicle braking behaviour resulting from control inputs under closely controlled test conditions.

ISO/TR 8725:1988 Road vehicles -- Transient open-loop response test method with one period of sinusoidal input

This Technical Report specifies a method for determining transient response behaviour at approximately constant speed. It is not fully representative of real driving conditions but similar to lane change manoeuvres in real traffic. It also applies to passenger cars as defined in ISO 3833. In a simplified form this test method is also specified in ISO 7401 together with alternative and complementary procedures.

ISO/TR 8726:1988 Road vehicles -- Transient open-loop response test method with pseudo-random steering input

This Technical Report specifies a method for determining transient response behaviour at approximately constant speed. The quasi-open-loop manoeuvre used in this method is not representative of real driving conditions but is useful in obtaining measures of vehicle transient behaviour in terms that will enable the response to any deterministic input to be calculated. This applies to passenger cars as defined in ISO 3833. In a simplified form, this test method is also specified in ISO 7401 together with alternative and complementary procedures.

ISO 9815:2010 Road vehicles -- Passenger-car and trailer combinations -- Lateral stability test

ISO 9815:2010 specifies a lateral stability test for passenger-car and trailer combinations. It is applicable to passenger cars in accordance with ISO 3833, and also to light trucks, and their trailer combinations.

The lateral stability test determines the damping characteristic of the yaw oscillation of such towing-vehicle–trailer combinations excited by a defined steering impulse. The combination is initially driven in a steady-state, straight-ahead driving condition. Oscillation of the vehicle is then initiated by the application of a single impulse of steering, followed by a period in which steering is held fixed and the oscillation of the combination is allowed to damp out. Testing is conducted at several constant speeds. Where non-periodic instability is of interest, a steady-state circular test is specified.

ISO 9816:2006 Passenger cars -- Power-off reaction of a vehicle in a turn -- Open-loop test method

ISO 9816:2006 specifies open-loop test methods to determine the reactions of a vehicle in a turn to a sudden drop in motive power resulting from release of the accelerator pedal. It applies to passenger cars as defined in ISO 3833.

The open-loop manoeuvre specified in this test method is not representative of real driving conditions, but is useful to obtain measures of a vehicle's power-off behaviour resulting from specific types of control inputs under closely controlled test conditions.

ISO 11012:2009 Heavy commercial vehicles and buses -- Open-loop test methods for the quantification of on-centre handling -- Weave test and transition test

ISO 11012:2009 describes two open-loop test methods for determining on-centre handling characteristics of a vehicle in response to specific types of steering input under closely controlled test conditions:

- the weave test, and
- the transition test.

ISO 11012:2009 applies to heavy vehicles, i.e. commercial vehicles, commercial vehicle combinations, buses and articulated buses as defined in ISO 3833 (trucks and trailers with maximum weight above 3,5 tonnes and buses and articulated buses with maximum weight above 5 tonnes, in accordance with ECE and EC vehicle classification, categories M3, N2, N3, O3 and O4).

ISO 11026:2010 Heavy commercial vehicles and buses -- Test method for roll stability -- Closing-curve test

ISO 11026:2010 specifies an open-loop test method for determining the roll stability of a vehicle negotiating a curve on dry surface.

It applies to heavy vehicles, that is commercial vehicles, commercial vehicle combinations, buses and articulated buses as defined in ISO 3833 (trucks and trailers with maximum weight above 3,5 tonnes and buses and articulated buses with maximum weight above 5 tonnes, according to ECE and EC vehicle classification, categories M3, N2, N3, O3 and O4).

The method is intended for vehicles equipped with electronic roll stability control systems.

ISO 12021:2010 Road vehicles -- Sensitivity to lateral wind -- Open-loop test method using wind generator input

ISO 12021:2011 specifies an open-loop test method to determine the sensitivity to lateral wind of a vehicle by means of a wind generator. It applies to passenger cars as defined in ISO 3833, passenger car-trailer combinations and light trucks. Its applicability to motorcycles is yet to be investigated.

The test conditions specified in this test method are not representative of real driving conditions but are useful to obtain measures of vehicle dynamic response to lateral wind.

ISO 13674-1:2010 Road vehicles -- Test method for the quantification of on-centre handling -- Part 1: Weave test

ISO 13674-1:2010 specifies a test schedule that addresses a particular aspect of the on-centre handling characteristics of a vehicle: the weave test. It is applicable to passenger cars in accordance with ISO 3833, and to light trucks.

ISO 13674-2:2006 Road vehicles -- Test method for the quantification of on-centre handling -- Part 2: Transition test

ISO 13674-2:2006 specifies a test schedule that addresses the transition test, a particular aspect of the on-centre handling characteristics of a vehicle. It is applicable to passenger cars in accordance with ISO 3833, and to light trucks.

ISO 14792:2003 Road vehicles -- Heavy commercial vehicles and buses -- Steady-state circular tests

ISO 14792:2003 specifies tests for determining the steady-state directional control response of heavy vehicles, one of the factors composing vehicle dynamics and road-holding properties. It is applicable to heavy vehicles -- i.e. commercial vehicles, combinations, buses and articulated buses as defined in ISO 3833 -- covered by Categories M3, N2, N3, O3, and O4 of UNECE (United Nations Economic Commission for Europe) and EC vehicle regulations. These categories pertain to trucks and trailers with a maximum mass above 3,5 tonnes and to buses and articulated buses with a maximum mass above 5 tonnes.

ISO 14793:2011 Road vehicles -- Heavy commercial vehicles and buses -- Lateral transient response test methods

ISO 14793:2011 specifies test methods for determining the transient response behaviour of heavy commercial vehicles, heavy commercial vehicle combinations, buses and articulated buses, as defined in ISO 3833 for trucks and trailers above 3,5 tonnes and buses above 5 tonnes maximum weight, and in UNECE (United Nations Economic Commission for Europe) and EC vehicle classification, categories M3, N2, N3, O3 and O4.

ISO 14794:2011 Heavy commercial vehicles and buses -- Braking in a turn -- Open-loop test methods

ISO 14794:2011 specifies open-loop test methods for determining the effect of braking on the course-holding and directional behaviour of heavy vehicles or heavy vehicle combinations when braking is accomplished using

- the service-brake system, or
- the retarder or engine brake only.

ISO 14794:2011 is applicable to heavy vehicles, i.e. commercial vehicles, commercial vehicle combinations, buses and articulated buses as defined in ISO 3833, covered by Categories M3, N2, N3, O3 and O4 of UNECE (United Nations Economic Commission for Europe) and EC vehicle regulations. These categories pertain to trucks and trailers with a maximum mass above 3,5 tonnes and to buses and articulated buses with a maximum mass above 5 tonnes.

ISO 15037-1:2006 Road vehicles -- Vehicle dynamics test methods -- Part 1: General conditions for passenger cars

ISO 15037-1:2006 specifies the general conditions that apply when vehicle dynamics properties are determined according to ISO test methods.

In particular, it specifies general conditions for:

- variables

- measuring equipment and data processing
- environment (test track and wind velocity),
- test vehicle preparation (tuning and loading),
- initial driving, and
- test reports (general data and test conditions).

ISO 15037-1:2006 is applicable to passenger cars as defined in ISO 3833 and light trucks.

ISO 15037-2:2002 Road vehicles -- Vehicle dynamics test methods -- Part 2: General conditions for heavy vehicles and buses

ISO 15037-2:2002 specifies the general conditions that apply when vehicle dynamics properties are determined according to ISO test methods carried out on heavy vehicles. These are commercial vehicles, combinations, buses and articulated buses, as defined in ISO 3833 for trucks and trailers above 3,5 tonnes and buses above 5 tonnes maximum weight, and in UNECE (United Nations Economic Commission for Europe) and EC vehicle classification, categories M3, N2, N3, O3 and O4.

ISO 16234:2006 Heavy commercial vehicles and buses -- Straight-ahead braking on surfaces with split coefficient of friction -- Open-loop test method

ISO 16234:2006 describes an open-loop test method for determining vehicle reactions during a straight-line braking manoeuvre on a surface having a split coefficient of friction.

It applies to heavy vehicles, i.e. commercial vehicles, commercial vehicle combinations, buses and articulated buses as defined in ISO 3833 (trucks and trailers with maximum weight above 3,5 tonnes and buses and articulated buses with maximum weight above 5 tonnes, according to ECE and EC vehicle classification, categories M3, N2, N3, O3 and O4).

The method is limited to vehicles in which at least the first unit is equipped with an anti-lock braking system. It is valid for braking with service-brake systems only or in combination with retarders and/or engine brakes.

ISO 16333:2011 Heavy commercial vehicles and buses -- Steady-state rollover threshold -- Tilt-table test method.

ISO 16333:2011 specifies a tilt-table test method for estimating the steady-state rollover threshold of a heavy commercial vehicle or bus, i.e. the maximum lateral acceleration that the test vehicle could sustain in steady-state turning without rolling over.

ISO 16333:2011 is applicable to complete roll units/combinations of roll-coupled vehicle units, e.g. single-unit vehicles, tractor semitrailer combinations, articulated buses, full trailers, B-train combinations, of commercial vehicles, commercial vehicle combinations, buses or articulated buses as defined in ISO 3833, and under Categories M3, N2, N3, O3 and O4 of ECE and EC vehicle regulations (trucks and trailers with maximum weights above 3,5 tonnes and buses and articulated buses with maximum weights above 5 tonnes. ISO 16333:2011 does not cover transient, vibratory or dynamic rollover situations, nor does it consider the influences of dynamic stability control systems. Furthermore, the quality of the estimate of the steady-state rollover threshold provided by the test method decreases as the tilt angle required to produce rollover increases. Even so, the results for heavy vehicles with high rollover thresholds can be used for comparing their relative steady-state roll stability.

ISO/AWI 16552 Heavy commercial vehicles and buses -- Stopping distance in straight-line braking with ABS -- Open loop and closed loop test methods

Currently under development

ISO 17288-1:2011 Passenger cars -- Free-steer behaviour -- Part 1: Steering-release open-loop test method

ISO 17288-1:2011 specifies an open-loop test method for determining the free control stability of a passenger car as defined in ISO 3833, by measurement of the transient behaviour following steering release, starting from a steady-state cornering status.

ISO 17288-2:2011 Passenger cars -- Free-steer behaviour -- Part 2: Steering-pulse open-loop test method

ISO 17288-2:2011 specifies a procedure for determining the free control stability of a passenger car as defined in ISO 3833, by measurement of the transient behaviour following steering pulse input, starting from a straight-ahead, steady-state status.

ISO/TS 20119:2002 Road vehicles -- Test method for the quantification of on-centre handling -- Determination of dispersion metrics for straight-line driving

ISO/TS 20119:2002 specifies a test schedule that addresses certain aspects of the on-centre handling characteristics of a vehicle, *on-centre handling* being used to describe the steering "feel" and precision of the vehicle during nominally straight-line driving and in negotiating large-radius bends at high speeds but low lateral accelerations. It is applicable to passenger cars in accordance with ISO 3833, and to light trucks.

ISO 21994:2007 Passenger cars -- Stopping distance at straight-line braking with ABS -- Open-loop test method
ISO 21944:2007 specifies an open-loop test method to determine the stopping distance of a vehicle during a straight-line braking manoeuvre, with the Anti-lock Braking System (ABS) fully engaged. It applies to passenger cars as defined in ISO 3833 and light trucks.

ISO 21944:2007 specifies a reference method and is especially designed to ensure high repeatability.

ISO/AWI 11270 Lane keeping assist systems

Currently under development

ISO 15622:2010 Intelligent transport systems -- Adaptive Cruise Control systems -- Performance requirements and test procedures

ISO 15622:2010 contains the basic control strategy, minimum functionality requirements, basic driver interface elements, minimum requirements for diagnostics and reaction to failure, and performance test procedures for Adaptive Cruise Control (ACC) systems. Adaptive Cruise Control is fundamentally intended to provide longitudinal control of equipped vehicles while travelling on highways (roads where non-motorized vehicles and pedestrians are prohibited) under free-flowing traffic conditions. ACC can be augmented with other capabilities, such as forward obstacle warning.

ISO 15623:2002 Transport information and control systems -- Forward vehicle collision warning systems -- Performance requirements and test procedures

ISO 15623:2002 specifies performance requirements and test procedures for systems capable of warning the driver of short inter-vehicle distance and closing speed which may cause a rear-end collision with other vehicles, including motor cycles, ahead of the subject vehicle while it is operating at ordinary speed.

ISO 15623:2002 is applicable to operations on roads with curve radii over 125 m as well as higher radius curves.

ISO 17361:2007 Intelligent transport systems -- Lane departure warning systems -- Performance requirements and test procedures

ISO 17361:2007 specifies the definition of the system, classification, functions, Human-Machine Interface (HMI) and test methods for lane departure warning systems. These are in-vehicle systems that can warn the driver of a lane departure on highways and highway-like roads. The subject system, which may utilize optical, electromagnetic, GPS or other sensor technologies, issues a warning consistent with the visible lane markings. The issuance of warnings at roadway sections having temporary or irregular lane markings (such as roadwork zones) is not within the scope of ISO

17361:2007. ISO 17361:2007 applies to passenger cars, commercial vehicles and buses. The system will not take any automatic action to prevent possible lane departures. Responsibility for the safe operation of the vehicle remains with the driver.

ISO 17386:2010 Transport information and control systems -- Manoeuvring Aids for Low Speed Operation (MALSO) -- Performance requirements and test procedures

ISO 17386:2010 addresses light-duty vehicles, e.g. passenger cars, pick-up trucks, light vans and sport utility vehicles (motorcycles excluded) equipped with MALSO (Manoeuvring Aids for Low Speed Operation) systems. It specifies minimum functionality requirements which the driver can generally expect of the device, i.e., detection of and information on the presence of relevant obstacles within a defined (short) detection range. It defines minimum requirements for failure indication as well as performance test procedures. It includes rules for the general information strategy but does not restrict the kind of information or display system.

ISO 17387:2008 Intelligent transport systems -- Lane change decision aid systems (LCDAS) -- Performance requirements and test procedures

ISO 17387:2008 specifies system requirements and test methods for Lane Change Decision Aid Systems (LCDAS). LCDAS are fundamentally intended to warn the driver of the subject vehicle against potential collisions with vehicles to the side and/or to the rear of the subject vehicle, and moving in the same direction as the subject vehicle during lane change manoeuvres. This standardization addresses LCDAS for use on forward moving cars, vans and straight trucks in highway situations.

ISO 22178:2009 Intelligent transport systems -- Low speed following (LSF) systems -- Performance requirements and test procedures

ISO 22178:2009 contains the basic control strategy, minimum functionality requirements, basic driver-interface elements, minimum requirements for diagnostics and reaction to failure, and performance test procedures for Low Speed Following (LSF) systems.

An LSF system is primarily intended to reduce the driver's workload of repeatedly operating the accelerator and the brake pedal under congested traffic in order to keep a proper following distance behind the target vehicle for a relatively long period on roadways where there are no objects like pedestrians and bicyclists who might interrupt motorized traffic flow. An LSF system provides automatic car-following at lower speed by use of a driver interface mechanism and a speed adjustment system. The LSF system does not normally provide speed regulator control.

ISO 22179:2009 Intelligent transport systems -- Full speed range adaptive cruise control (FSRA) systems -- Performance requirements and test procedures

ISO 22179:2009 contains the basic control strategy, minimum functionality requirements, basic driver interface elements, minimum requirements for diagnostics and reaction to failure, and performance test procedures for full speed range adaptive cruise control (FSRA) systems. FSRA is fundamentally intended to provide longitudinal control of equipped vehicles while travelling on highways (roads where non-motorized vehicles and pedestrians are prohibited) under free-flowing and congested traffic conditions. FSRA provides support within the speed domain of standstill up to the designed maximum speed of the system. The system will attempt to stop behind an already tracked vehicle within its limited deceleration capabilities and will be able to start again after the driver has input a request to the system to resume the journey from standstill. The system is not required to react to stationary or slow moving objects {in accordance with ISO 15622 [adaptive cruise control (ACC)]}.

ISO/AWI 22839 Intelligent Transport System -- Forward Vehicle Collision Mitigation Systems - Operation, Performance, and Verification Requirements

Currently under development

ISO 22840:2010 Intelligent transport systems -- Devices to aid reverse manoeuvres -- Extended-range backing aid systems (ERBA)

ISO 22840:2010 for Extended-Range Backing Aids (ERBA) addresses light-duty vehicles [e.g. passenger cars, pick-up trucks, light vans and sport utility vehicles (motorcycles excluded)] equipped with such ERBA systems. ISO 22840:2010 establishes minimum functionality requirements that the driver can expect of the system, such as the detection of and information on the presence of relevant obstacles within a defined detection range. ISO 22840:2010 also sets minimum requirements for failure indication as well as performance test procedures. ISO 22840:2010 includes rules for the general information strategy but does not restrict the kind of information or display system.

ERBA systems are intended to provide reversing aid functionality over an extended area located aft of the subject vehicle. ERBA systems are not intended for short-range detection of obstacles located immediately behind the vehicle. If a short-range detection system is needed, either in lieu of or in addition to an ERBA system, reference can be made to ISO 17386.

ISO 22840:2010 does not include reversing aids and obstacle-detection devices for use on heavy commercial vehicles. Requirements for those systems are defined in ISO/TR 12155. ISO 22840:2010 does not include visibility-enhancement systems, such as video-camera aids that do not have distance ranging and warning capabilities.

ERBA systems use object-detection devices (sensors) for detection and ranging in order to provide the driver with information based on the distance to obstacles. The sensing technology is not addressed. However, technology does affect the performance test procedures defined in ISO 22840:2010. The test objects are defined based on systems using ultrasonic and radar sensors, which are the most commonly used detection technology for long-range applications at the time of publication of ISO 22840:2010.

ERBA systems are intended to supplement the interior and exterior rear view mirrors, not eliminate the requirement for such mirrors. Automatic actions (e.g. applying brakes to prevent a collision between the subject vehicle and the obstacle) are not addressed in ISO 22840:2010. Responsibility for the safe operation of the vehicle remains with the driver.

ERBA systems calculate a dynamic estimate of collision danger (e.g. perhaps using a time-to-collision algorithm) and warn the driver that immediate attention is required in order to avoid colliding with the detected obstacle. A dynamic warning is necessary for the higher vehicle speeds that occur in backing events where the relative closing velocities between the vehicle and the obstacle are greater as compared to low-speed situations, such as parking. The purpose of this dynamic warning is to deliver a more urgent warning to the driver in order for the driver to take timely action. Distance indications are optional, but if so included, it is recommended that reference be made to ISO 15008 for requirements.

ISO/NP TR 26682 Crash and Emergency Notification Reference Architecture

Currently under development

6.2 SAE International Standards

J2399_200312 Adaptive Cruise Control (ACC) Operating Characteristics and User Interface

This SAE Standard focuses on specifying the minimum requirements for ACC system operating characteristics and elements of the user interface. This document applies to original equipment and aftermarket ACC systems for passenger vehicles (including motorcycles). This document does not apply to commercial vehicles. Future revisions of this document should consider enhanced versions of ACC, as well as the integration of ACC with Forward Collision Warning (FCW).

J2400_200308 Human Factors in Forward Collision Warning Systems: Operating Characteristics and User Interface Requirements

This SAE Information Report describes elements for a FCW operator interface, as well as requirements and test methods for systems capable of warning drivers of rear-end collisions. This Information Report applies to original equipment and aftermarket FCW systems for passenger vehicles including cars, light trucks, and vans. This report does not apply to heavy trucks. Furthermore, this document does not address integration issues associated with adaptive cruise control (ACC), and consequently, aspects of the document could be inappropriate for an ACC system integrated with a FCW system.

J2536_200401 Anti-Lock Brake System (ABS) Road Test Evaluation Procedure for Trucks, Truck-Tractors and Buses

Test procedure for Anti-Lock brake system (ABS/Anti-Lock) performance for trucks, truck-tractors and buses over 4536 kg (10 000 lb).

J2802_201001 Blind Spot Monitoring System (BSMS): Operating Characteristics and User Interface

This document specifies the minimum recommendations for Blind Spot Monitoring System (BSMS) operational characteristics and elements of the user interface. A visual BSMS indicator is recommended. BSMS detects and conveys to the driver via a visual indicator the presence of a target (e.g., a vehicle), adjacent to the subject vehicle in the “traditional” Adjacent Blind Spot Zone (ABSZ). The BSMS is not intended to replace the need for interior and exterior rear-view mirrors or to reduce mirror size. BSMS is only intended as a supplement to these mirrors and will not take any automatic vehicle control action to prevent possible collisions. While the BSMS will assist drivers in detecting the presence of vehicles in their ABSZ, the absence of a visual indicator will not guarantee that the driver can safely make a lane change manoeuvre (e.g., vehicles may be approaching rapidly outside the ABSZ area). This document applies to original equipment and aftermarket BSMS systems for passenger vehicles. This document does not apply to installing a BSMS on either motorcycles or commercial vehicles. Finally, this document does not address Lane Change Warning systems, which monitor areas substantially farther back than the side blind spot areas monitored by the BSMS (See ISO FDIS 17387).

J2808_200708 Road/Lane Departure Warning Systems: Information for the Human Interface

This document specifies the minimum recommendations for Blind Spot Monitoring System (BSMS) operational characteristics and elements of the user interface. A visual BSMS indicator is recommended. BSMS detects and conveys to the driver via a visual indicator the presence of a target (e.g., a vehicle), adjacent to the subject vehicle in the "traditional" Adjacent Blind Spot Zone (ABSZ). The BSMS is not intended to replace the need for interior and exterior rear-view mirrors or to reduce mirror size. BSMS is only intended as a supplement to these mirrors and will not take any automatic vehicle control action to prevent possible collisions. While the BSMS will assist drivers in detecting the presence of vehicles in their ABSZ, the absence of a visual indicator will not guarantee that the driver can safely make a lane change manoeuvre (e.g., vehicles may be approaching rapidly outside the ABSZ area). This document applies to original equipment and aftermarket BSMS systems for passenger vehicles. This document does not apply to installing a BSMS on either motorcycles or commercial vehicles. Finally, this document does not address Lane Change Warning systems, which monitor areas substantially farther back than the side blind spot areas monitored by the BSMS (See ISO FDIS 17387).

J2830_200807 Process for Comprehension Testing of In-Vehicle Icons
This document describes a process for testing the comprehension of symbols or icons. Although the process may be used to test any symbols or icons, it has been developed specifically for testing ITS active safety symbols or icons (e.g., collision avoidance), or other symbols or icons that reflect some in-vehicle ITS message or function (e.g., navigation, motorist services, infotainment). Within the process, well-defined criteria are used to identify the extent to which the perceived meaning matches the intended meaning for a representative sample of drivers. Though the process described below reflects a paper-and-pencil approach to conducting the testing, electronic means (i.e., conducted using a computer) can be used as well. The data or results from this process are analyzed to assess the drivers comprehension of the symbol or icon. These data will be used to provide guidance in the design of in-vehicle symbols or icons.

J2909_201005 Light Vehicle Dry Stopping Distance

This document establishes best practices to measure vehicle stopping distance on dry asphalt in a straight path of travel intended for the purpose of publishing stopping distance by manufacturers and media organizations. It is recommended that the test method within be adopted for all vehicles less than 10 000 lb.