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Intelligent transport systems — Forward vehicle collision warning systems — Performance requirements and test procedures

Systèmes intelligents de transport — Systèmes d'avertissement de collision frontale du véhicule — Exigences de performance et modes opératoires

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Foreword

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The committee responsible for this document is ISO/TC 204, *Intelligent transport systems*.

This second edition cancels and replaces the first edition (15623:2002), which has been technically revised.

Introduction

The main system function of a forward vehicle collision warning system (FVCWS) is to warn the driver when the subject vehicle encounters the situation of a forward vehicle in the subject vehicle's trajectory becoming a potential hazard. This is done by using information such as: (1) the range to forward vehicles, (2) the relative velocity of the forward vehicles with respect to subject vehicle and (3) whether a forward vehicle is in the subject vehicle trajectory. Based upon the information acquired, the controller identified as "FVCWS target selection and warning strategy" in Figure 1 produces the warning to the driver.

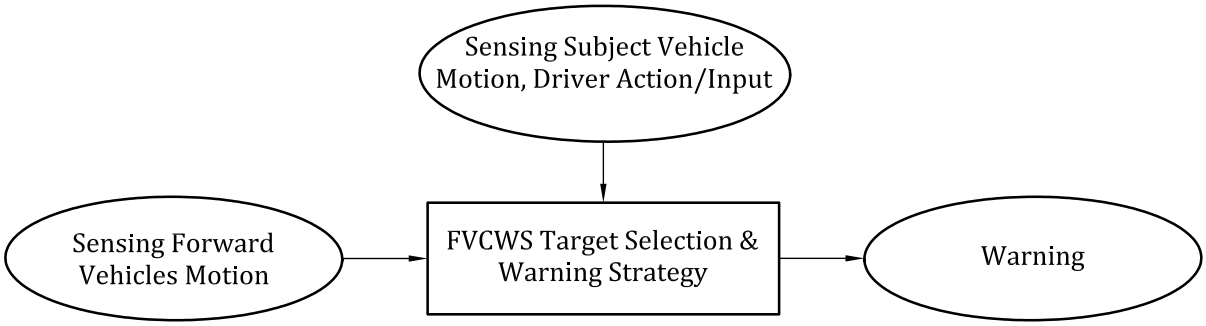


Figure 1 — Functional forward vehicle collision warning system's elements

Automobile manufacturers and component suppliers throughout the world have been vigorously pursuing the development and commercialisation of these FVCWS systems. Systems of this type have already been introduced on to the market in some countries. Thus the standardization efforts began in 1994 amongst interested countries. This International Standard is composed to address only the basic performance requirements and test procedures for the FVCWS type systems. This International Standard may be used as a basis by other standards for systems which have more features and may extend beyond this International Standard.

Intelligent transport systems — Forward vehicle collision warning systems — Performance requirements and test procedures

1 Scope

This International Standard specifies performance requirements and test procedures for systems capable of warning the driver of a potential rear-end collision with other vehicles ahead of the subject vehicle while it is operating at ordinary speed. The FVCWS operate in specified subject vehicle speed range, road curvature range and target vehicle types. This International Standard covers operations on roads with curve radii over 125 m, and motor vehicle including cars, trucks, buses, and motorcycles. Responsibility for the safe operation of the vehicle remains with the driver.

2 Normative references

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

IEC 825-1:1993, *Safety of laser products — Part 1: Equipment classification, requirements and user's guide* (includes update of 1994)

3 Terms and definitions

For the purpose of this document, the following terms and definitions apply.

3.1
collision warning
information that the system gives to the driver indicating the need for urgent action to avoid or reduce the severity of a potential rear end collision with another forward vehicle

Note 1 to entry: This 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 emergency manoeuvres in order to avoid a collision.

3.2
reflection coefficient of test target
RCTT
optical radar reflectivity of the target, which is defined as the radiated intensity towards the receiver (Iref - W/sr) measured at target level, immediately after the reflection; divided by the intensity of irradiation received from the transmitter (Et - W/m^2) measured at target level, immediately before the reflection

Note 1 to entry: The units for RCTT value are in m^2/sr (see Annex C).

3.3
forward vehicle
vehicle in front of and moving in the same direction and travelling on the same roadway as the subject vehicle

3.4
forward vehicle collision warning system
FVCWS
system capable of warning the driver of a potential collision with another forward vehicle in the forward path of the subject vehicle

3.5
obstacle vehicles
vehicles, both moving and stationary, considered potential hazards that can be detected by this system

EXAMPLE Motor vehicles only, that is cars, trucks, buses, and motorcycles.

3.6
preliminary collision warning
information that the system gives to the driver in the early stages of a potentially dangerous situation that may result in a rear end collision.

Note 1 to entry: The system may provide this warning prior to the collision warning.

3.7
radar cross section
RCS
measure of the reflective strength of a radar target measured in square meters, and defined as 4π times the ratio of the power per unit solid angle scattered in a specified direction to the power per unit area in a radio wave incident on the scatterer from a specified direction

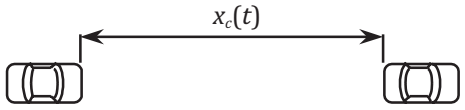
3.8
visibility
distance which the illuminance of a non-diffusive beam of white light with the colour temperature of 2700 K is decreased to 5 % of its original light source illuminance

3.9
adaptive Cruise Control
ACC
enhancement to conventional cruise control systems which allows the subject vehicle to follow a forward vehicle at an appropriate distance by controlling the engine and/or power train and optionally the brake

Note 1 to entry: See ISO 15622.

3.10
adjacent lane
lane of travel sharing one lane boundary with the lane in which the subject vehicle is traveling and having the same direction of travel as the subject vehicle lane

3.11
clearance
$x_c(t)$
distance $x_c(t)$ from the target vehicle trailing surface to the subject vehicle leading surface



3.12
cut-in vehicle
forward adjacent vehicle that has a lateral component of motion towards the path of the subject vehicle

3.13
jerk
third derivative with respect to time of the position of an object; equivalently the rate of change of the acceleration of an object; considered a measure of harshness of vehicle motion

3.14
minimum velocity
V_{min})
minimum subject vehicle (SV) speed for which the FVCWS must be capable of initiating a warning

3.15
rear-end collision
forward vehicle collision in which the front of the subject vehicle strikes the rear of the forward vehicle

3.16
relative velocity
$v_r(t)$
difference between the longitudinal velocities of the subject vehicle (SV) and the target vehicle (TV), $v_r(t)$, given by the equation; equivalently the rate of change with respect to time of the distance between the two vehicles. A positive value of relative velocity indicates that the target vehicle is moving faster than the subject vehicle, and that the distance between them is increasing with time

$$v_r(t) = v_{TV}(t) - v_{SV}(t)$$

3.17
required deceleration
A_{req}
minimum deceleration that, if constant, would enable the subject vehicle to match the velocity of the target vehicle without contacting the target vehicle and thus prevent a collision:

$$A_{req}(t) = A_{TV} + \frac{(V_r(t))^2}{2*(x_c(t) - x_r(t))}$$

Note 1 to entry: $x_r(t)$ is the amount of reduction in the clearance distance due to reaction time.

3.18
subject vehicle
SV
vehicle equipped with FVCWS as defined herein

3.19
target vehicle
TV
forward vehicle that is closest in the forward path of the subject vehicle; forward vehicle that the FVCWS operates on

3.20
time to collision
TTC
estimated time that it will take a subject vehicle to collide with the target vehicle assuming the current relative speed remains constant, as given in the following equation:

$$TTC = -\frac{x_c(t)}{v_r(t)}$$

3.21
enhanced time to collision
ETTC
time that it will take a subject vehicle to collide with the target vehicle assuming the relative acceleration between the subject vehicle (SV) and target vehicle (TV) remains constant, as given in the following equation:

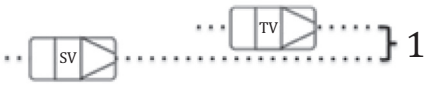
$$ETTC = \frac{\left[-(v_{TV} - v_{SV}) - \sqrt{(v_{TV} - v_{SV})^2 - 2*(a_{TV} - a_{SV})*x_c}\right]}{(a_{TV} - a_{SV})}$$

3.22
warning braking
action in which FVCWS respond to detection of a possible rear-end collision by automatically applying the brake for a short period of time to provide a warning to the driver

3.23
FVCWS warning modalities
means used to convey the different type of FVCWS warnings to the driver.

EXAMPLE Visual, auditory, and/or haptic cues.

3.24
lateral offset
lateral distance between the longitudinal centerlines of a subject vehicle (SV) and a target vehicle (TV), measured as a percentage of the width of the SV, such that if the centers of the two vehicles are aligned, the value is zero



4 Symbols and abbreviated terms

$a_{lateral\_max}$	maximum allowed lateral acceleration in curves
a_{min}	minimum deceleration of the subject vehicle's emergency braking
d_0	minimum detectable distance without distance measuring capability
d_1	minimum detectable distance with distance measuring capability
d_2	minimum detection distance for a cut-in vehicle
d_{max}	maximum detectable distance
h	upper detection height from ground
h_1	lower detection height from ground
RCTT	reflection coefficient for test target for infrared reflector
T_{max}	maximum driver's brake reaction time after the warning
T_{min}	minimum driver's brake reaction time after the warning
Tresp	driver brake reaction time
Tb	braking system response time
RCS	radar cross section
V_{circle_start}	speed of the test vehicles at the start of the test
V_{max}	maximum vehicle speed at which the system is capable of operating
V_{min}	minimum vehicle speed at which the system is capable of operating
V_{rel_max}	maximum relative vehicle speed at which the system is capable of operating
W_L	lane width
W_V	subject vehicle width

5 Specifications and requirements

5.1 System functionality

The purpose of the FVCWS is to provide warnings that will assist drivers in avoiding or reducing the severity of rear end crashes. These warnings should be provided in time to help drivers avoid most common rear end crashes by applying the brakes only. The timing of the alerts should be selected such that they strive to provide alerts early enough to help the driver avoid the crash or mitigate the harm caused by the crash without introducing other alerts perceived as nuisance or false. FVCWS provide warning only and do not perform vehicle control to mitigate the crash.

FVCWS may operate differently when the subject vehicle is applying an automatic braking commanded by other system in the vehicle such as full speed range ACC. In this situation, the FVCWS could take into account the capability of the automatic braking system. The fact that the vehicle is under sustained automatic braking may affect the warning criteria and warning modality.

5.2 Necessary functions

Vehicles equipped with FVCWS shall be equipped to fulfil the following functions.

— Detect the presence of forward vehicles,

— Determine measure or measures for relative position and position dynamic of the detected forward vehicles with respect to the subject vehicle,

— Determine the subject vehicle velocity,

— Estimate the path of the subject vehicle (Class II and III),

— Provide driver warnings in accordance with the FVCWS function and requirements.

5.3 Operating model

Figure 2 shows the state transition diagram for the FVCWS.

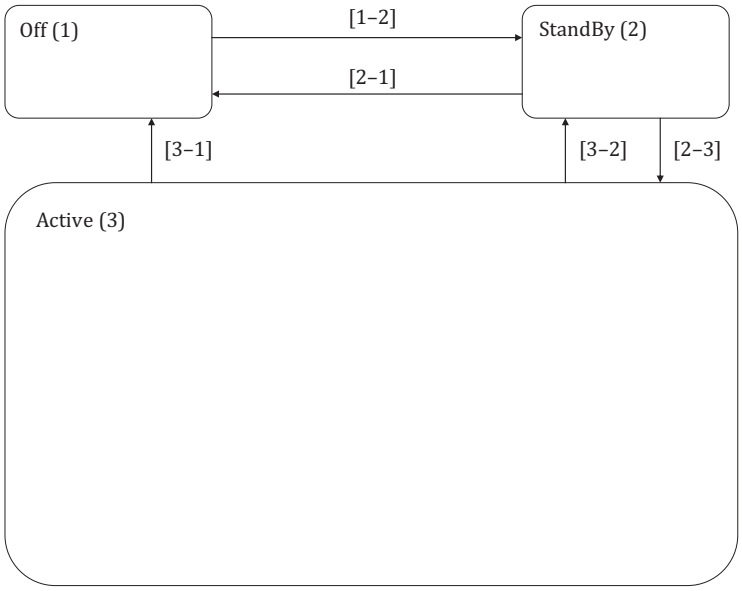


Figure 2 — FVCWS State Transition Diagram

Key

[1-2] engine running, or engine running and on switch (if on switch exists)

[2-1] ignition off or off switch or fault condition

[3-1] ignition off or off switch or fault condition

[2-3] V_{min} < = speed < = V_{max} and gear is not in reverse or park positions

[3-2] (V_{min} > speed) or (speed > V_{max}) or gear is in reverse or park positions

5.3.1 State functional descriptions

The FVCWS state descriptions address the functional contents of FVCWS, identifying what functions are performed in each state. Descriptions that correspond to a functional requirement are presented in bold text.

5.3.1.1 FVCWS off (1)

No warning is performed in the FVCWS off state. It is optional to provide a driver-selected means of placing FVCWS in this state, other than the Ignition key (for example: on/off Switch). **Upon turning the ignition to the off position, the FVCWS transitions to the FVCWS off state. Whenever the Self-Test function determines that the FVCWS is not able to deliver adequate performance, a fault condition is set and FVCWS transitions to the FVCWS off state.**

5.3.1.2 FVCWS standby (2)

No warning is performed in the FVCWS standby state. **In this state, FVCWS monitors the vehicle speed and the gear position. If the vehicle speed comes within the FVCWS operating range and the gear select is in forward position (all gear positions except reverse and park), the system transitions from the standby state to the active state. FVCWS enters the FVCWS standby state from the FVCWS off state if the ignition cycle has been completed and the engine is running, or if the engine is running and the optional on/off switch is the "on" position. FVCWS enters this state from the active state if the conditions for activating are not met: if the vehicle speed value is outside the FVCWS operation range (hysteresis delta is added), reverse gear is selected, or park is selected.**

5.3.1.3 FVCWS active (3)

The warning is performed in this state whenever the warning conditions are met. **FVCWS enters this state if gear select is in any forward position and the vehicle speed value is in the FVCWS operation range.**

5.3.2 Operational limits

The value of V_{min} shall be at most 11,2 m/s. The value of V_{max} shall be at least the minimum of 27,8 m/s and the maximum vehicle operating speed. The value for V_{rel_min} shall be at most 4,2 m/s. The value of V_{rel_max} shall be at least 20 m/s.

5.4 Warning functionality

Forward vehicle collision warning systems shall provide warnings for moving (including "has been detected as moving by the sensor and now stopped") obstacle vehicles. Providing warnings for stationary obstacle vehicles (has never been detected moving at an absolute speed above 4,2 m/s) is optional. The FVCWS warning is provided in accordance with the following functions.

5.4.1 Monitoring distance and relative speed between obstacle vehicle and subject vehicle

A forward obstacle vehicle is sensed by obstacle detecting devices such as optical (laser) radar, radio wave radar, or image processing systems.

