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Intelligent transport systems — Vehicle-to-vehicle intersection collision warning systems (VVICW) — Performance requirements and test procedures

Systèmes de transport intelligents — Systèmes d'alerte de collision aux intersections de véhicule-à-véhicule (VVICW) — Exigences de performance et procédures d'essai

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Foreword

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The procedures used to develop this document and those intended for its further maintenance are described in the ISO/IEC Directives, Part 1. In particular, the different approval criteria needed for the different types of ISO documents should be noted. This document was drafted in accordance with the editorial rules of the ISO/IEC Directives, Part 2 (see www.iso.org/directives).

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This document was prepared by Technical Committee ISO/TC 204, *Intelligent transport systems*.

Any feedback or questions on this document should be directed to the user's national standards body. A complete listing of these bodies can be found at www.iso.org/members.html.

Introduction

Vehicle-to-vehicle intersection collision warning systems (VVICW) warn the driver to avoid potential collisions at intersections. The VVICW warns the driver of imminent crashes with other vehicles crossing at a road junction. The system relies on relative positioning, speed and heading between vehicles determined using vehicle-to-vehicle (V2V) communication, such as dedicated short-range communication (DSRC). It is intended to be used to avoid intersection crossing crashes, the most severe crashes based on fatality counts. Due to limited field of view sensing, on-board sensor systems such as camera, lidar and radar systems cannot be used efficiently for such systems. Figure 1 illustrates the functional elements of VVICW.

The VVICW is a road level system that deals with conflict scenarios between vehicles driving on two connected road segments sharing a common intersection. VVICW positioning requirements are not demanding compared to those of red light violation warning systems, for example. A comprehensive set of intersection collision scenarios can be found in Reference [1].

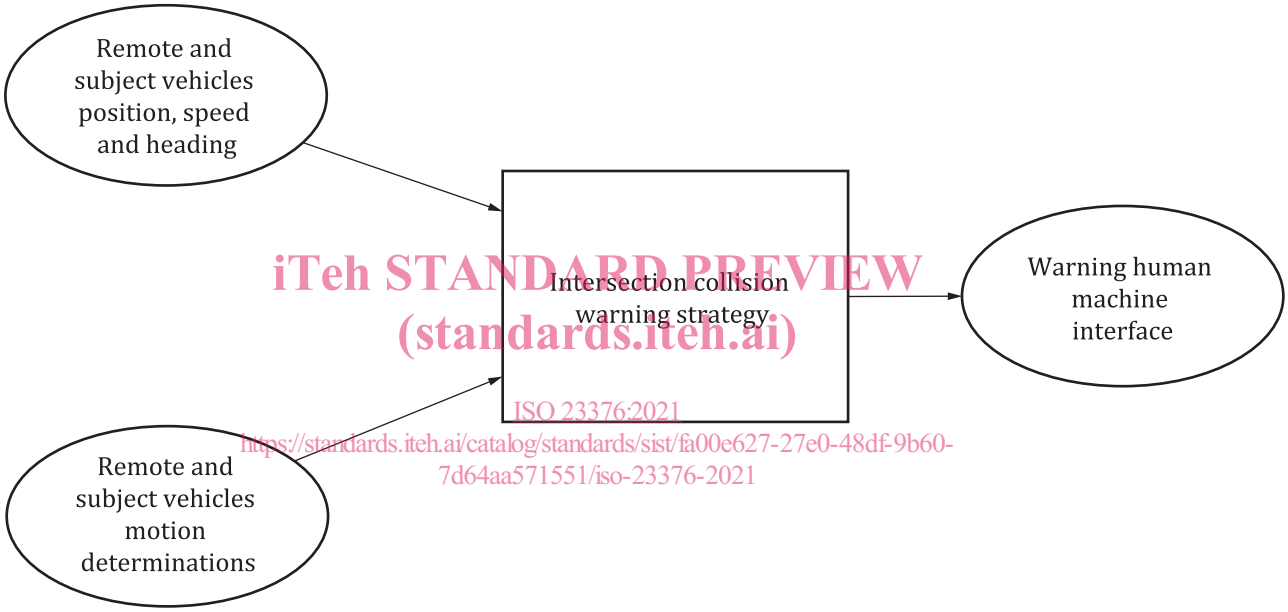


Figure 1 — Vehicle-to-vehicle intersection collision warning systems functional elements

Intelligent transport systems — Vehicle-to-vehicle intersection collision warning systems (VVICW) — Performance requirements and test procedures

1 Scope

This document specifies performance requirements and test procedures for systems capable of warning the subject vehicle driver of a potential crossing-path collision with other vehicles at intersecting road segments.

Vehicle-to-vehicle intersection collision warning systems (VVICW) rely on vehicle-to-vehicle (V2V) communications and relative positioning between the subject vehicle and crossing-path vehicles (remote vehicles). V2V data, such as position, speed and heading are used to evaluate if an intersection collision is imminent between the subject and remote vehicles. The performance requirements laid out in this document specify the warning criteria for these systems.

In addition, VVICW operate in specified subject and remote vehicle speed ranges, road intersection geometries and target vehicle types. Moreover, the requirements for the V2V data will be specified. The scope of this document includes operations on intersecting road segments (physically intersecting roads), and motor vehicles including cars, trucks, buses and motorcycles. Responsibility for the safe operation of the vehicle remains with the driver.

2 Normative references

There are no normative references in this document.

3 Terms and definitions

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

ISO and IEC maintain terminology databases for use in standardization at the following addresses:

— ISO Online browsing platform: available at https://www.iso.org/obp

— IEC Electropedia: available at https://www.electropedia.org/

3.1
subject vehicle
SV
motor vehicle equipped with a VVICW

Note 1 to entry: A subject vehicle can be also a remote vehicle for another subject vehicle.

3.2
subject vehicle speed
subject vehicle velocity in the heading direction

3.3
remote vehicle
RV
motor vehicle equipped at minimum with a V2V transmission device and localization system and that has the ability to possibly intersect the path of the subject vehicle

3.4
remote vehicle speed
longitudinal component of the remote vehicle velocity in the heading direction

3.5
intersecting road segment
physically intersecting roads that are described based on the number of road segments

Note 1 to entry: A road junction is where two or more road segments intersect.

Note 2 to entry: Roundabout, ramp/highway, street 4-way intersection and street 3-way intersection are examples of intersection road geometry.

EXAMPLE 1 A four-way intersection, or crossroads, usually involves a crossing of two streets or roads. In areas where there are rectilinear blocks and in some other cases, the crossing streets or roads are perpendicular to each other. However, two roads may cross at a different angle. In a few cases, the junction of two road segments can be offset from each other when reaching an intersection, even though both ends may be considered the same street.

EXAMPLE 2 A three-way intersection is a junction between three road segments, a T junction where two arms form one road, or a Y junction. The latter also known as a fork if approached from the stem of the Y.

3.6
time to collision
TTC
time that it takes a subject vehicle to collide with a remote vehicle assuming the relative velocity remains constant

Note 1 to entry: For the VVICW, TTC is the time needed for the subject vehicle to reach the collision point. TTC is therefore calculated using Formula (1):

$$t_c = -\frac{d_c}{v_{SV}} \quad (1)$$

where

t_c is the time to collision;

d_c is the distance of the subject vehicle from the collision point;

v_{SV} is the speed of the subject vehicle.

3.7
enhanced time to collision
ETTC
time that it takes a subject vehicle to collide with a remote vehicle assuming the relative acceleration between the subject vehicle and the remote vehicle remains constant

Note 1 to entry: For the VVICW, ETTC is the time needed for the subject vehicle to reach the collision point and not a remote vehicle. An enhanced arrival time therefore takes into consideration the acceleration of the subject vehicle. Since the collision point is fixed at any point in time, the value of zero is substituted for v_{RV} and a_{RV}. ETTC is calculated using Formula (2):

$$t_{c,e} = \frac{\left[-(v_{RV} - v_{SV}) - \sqrt{(v_{RV} - v_{SV})^2 - 2*(a_{RV} - a_{SV})*d_c}\right]}{(a_{RV} - a_{SV})} \quad (2)$$

where

$t_{c,e}$ is the enhanced time to collision;

v_{RV} is the speed of the remote vehicle;

v_{SV} is the speed of the subject vehicle;

d_c is the distance of the subject vehicle from the collision point;

a_{RV} is the acceleration of the remote vehicle;

a_{SV} is the acceleration of the subject vehicle.

3.8
required deceleration
A_{req}
minimum deceleration that, if constant, enables the subject vehicle to stop at a defined calculated distance from the current subject vehicle position

Note 1 to entry: A_{req} is calculated using Formula (3):

$$A_{req} = \frac{v_{SV}^2}{2(d_{sp} - d_r)} \quad (3)$$

where

A_{req} is the required deceleration;

v_{SV} is the speed of the subject vehicle;

d_{sp} is the current distance from stopping point;

d_r is the reaction travel distance.

4 Symbols and abbreviated terms

A_{req}	required deceleration
a_{RV}	acceleration of the remote vehicle
a_{SV}	acceleration of the subject vehicle
d_c	distance of the subject vehicle from the collision point
d_r	reaction travel distance
$d_{sl,min}$	minimum required distance measured from the stop line
d_{sp}	current distance from stopping point
DSRC	dedicated short-range communication
GNSS	global navigation satellite system

l_{RV}	length of the remote vehicle
l_{SV}	length of the subject vehicle
$T_{(1,2, etc.)}$	tolerance
t_b	braking system response time
t_c	time to collision
$t_{c,e}$	enhanced time to collision
t_{resp}	driver brake reaction time
v_{SV}	speed of the subject vehicle
v_{RV}	speed of the remote vehicle
$v_{RV,p}$	projected speed of the remote vehicle at the arrival time
v_{SVmax}	maximum subject vehicle speed for VVICW operation
v_{SVmin}	minimum subject vehicle speed for VVICW operation
$v_{SV,p}$	projected speed of the subject vehicle at the arrival time
V2V	vehicle-to-vehicle
VVICW	vehicle-to-vehicle intersection collision warning system

5 Requirements

5.1 Minimum enable conditions

Vehicles equipped with VVICW shall be capable of the following:

— determining if the V2V communication between the SV and RVs is available at the road junction;

— receiving valid V2V communication that provides the GNSS position, speed and heading of RVs approaching the road junction;

— determining GNSS position, speed and heading of the SV approaching the road junction.

5.2 Minimum required VVICW scenarios

The purpose of the VVICW is to provide the drivers of the SVs with alerts that assist them in avoiding or reducing the severity of impending collisions associated with the following scenarios:

a) Crossing scenarios (illustrated in Figure 2):

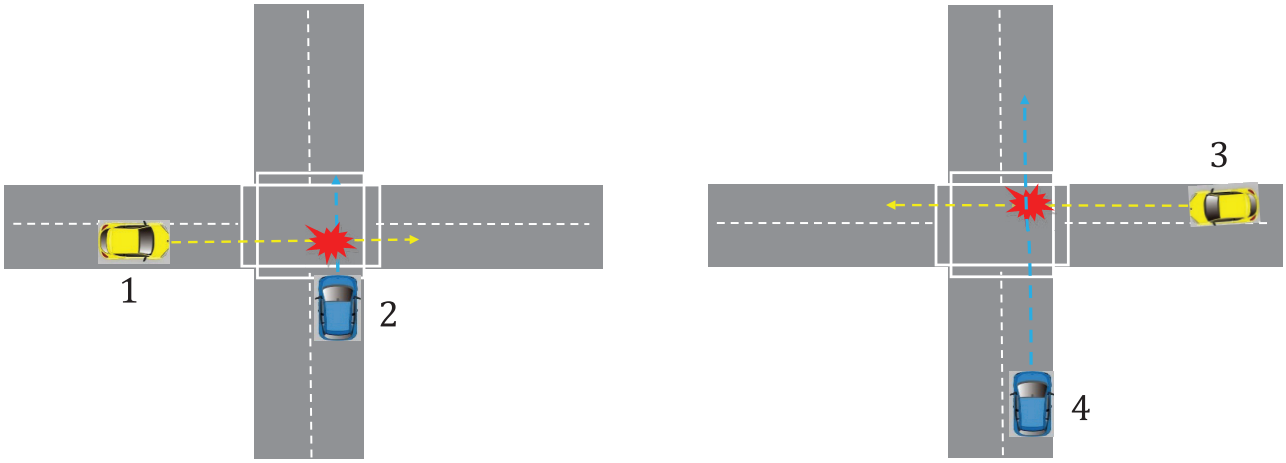
   1) cross straight through an intersection, across the path of a vehicle approaching from a lateral direction;

   2) cross straight through an intersection, after initially being stopped, across the path of a vehicle approaching from a lateral direction.

b) Oncoming scenarios (illustrated in Figure 3):

   1) turn left or right (depends on left or right driving rule) across the path of an oncoming vehicle approaching from the opposite direction;

2) turn left or right (depends on left or right driving rule), after initially being stopped, across the path of an oncoming vehicle approaching from the opposite direction.



Key

1 RV moving
2 SV initially stopped, then accelerating
3 RV moving
4 SV moving

Figure 2 — Crossing scenarios

Key

1 RV moving
2 SV initially stopped, then turning left
3 RV moving
4 SV moving

Figure 3 — Oncoming scenarios

5.3 Necessary functions

Vehicles equipped with VVICW shall be equipped to fulfil the following functions:

— receive V2V messages from RVs that provide data representing the position, speed and heading of the RV;

— monitor SV and RV dynamics, including heading, heading change, speed and acceleration;

— determine the threat potential of collision with approaching RVs and evaluate the warning criteria;

— if needed, provide alerts to the driver of an impending collision with an RV in the intersection.