
**Intelligent transport systems —
Adaptive cruise control systems —
Performance requirements and test
procedures**

*Systèmes intelligents de transports — Systèmes stabilisateurs de
vitesse adaptés — Exigences de performance et modes opératoires*

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Contents

	Page
Foreword	iv
Introduction	v
1 Scope	1
2 Normative references	1
3 Terms and definitions	1
4 Symbols and abbreviated terms	4
5 Classification	5
5.1 Type of ACC systems.....	5
6 Requirements	5
6.1 Basic control strategy.....	5
6.2 Functionality.....	6
6.2.1 Control modes.....	6
6.2.2 Stationary or slow moving targets.....	6
6.2.3 Following capability.....	6
6.2.4 “Go” transition.....	8
6.3 Basic driver interface and intervention capabilities.....	9
6.3.1 Operation elements and system reactions.....	9
6.3.2 Display elements.....	10
6.3.3 Symbols.....	10
6.4 Operational limits.....	10
6.5 Activation of brake lights.....	12
6.6 Failure reactions.....	12
7 Performance evaluation test methods	13
7.1 Environmental conditions.....	13
7.2 Test target specification.....	13
7.2.1 General.....	13
7.2.2 Infrared LIDAR.....	13
7.2.3 Millimetre wave RADAR.....	14
7.3 Automatic “Stop” capability test for FSRA-type only.....	14
7.3.1 Test target vehicle.....	14
7.3.2 Initial conditions.....	14
7.3.3 Test procedure.....	14
7.4 Target acquisition range test.....	15
7.5 Target discrimination test.....	15
7.5.1 General.....	15
7.5.2 Initial conditions.....	16
7.5.3 Test procedure.....	16
7.6 Curve capability test.....	16
7.6.1 General.....	16
7.6.2 Test field.....	17
7.6.3 Curve capability, target vehicle.....	17
7.6.4 Driving scenario.....	17
Annex A (normative) Technical information	19
Bibliography	24

Foreword

ISO (the International Organization for Standardization) is a worldwide federation of national standards bodies (ISO member bodies). The work of preparing International Standards is normally carried out through ISO technical committees. Each member body interested in a subject for which a technical committee has been established has the right to be represented on that committee. International organizations, governmental and non-governmental, in liaison with ISO, also take part in the work. ISO collaborates closely with the International Electrotechnical Commission (IEC) on all matters of electrotechnical standardization.

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

Attention is drawn to the possibility that some of the elements of this document may be the subject of patent rights. ISO shall not be held responsible for identifying any or all such patent rights. Details of any patent rights identified during the development of the document will be in the Introduction and/or on the ISO list of patent declarations received (see www.iso.org/patents).

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For an explanation on the voluntary nature of standards, the meaning of ISO specific terms and expressions related to conformity assessment, as well as information about ISO's adherence to the World Trade Organization (WTO) principles in the Technical Barriers to Trade (TBT) see the following URL: www.iso.org/iso/foreword.html.

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

This third edition of ISO 15622 cancels and replaces ISO 15622:2010 and ISO 22179:2009, which have been technically revised.

The main changes compared to the previous editions are as follows:

- the third edition of ISO 15622 is extended with the performance requirements and test procedures for full speed range adaptive cruise control systems formerly described in ISO 22179:2009 (with minor changes);
- in-vehicle devices are allowed as a possible source for the acquisition of driver commands (set-speed-advise);
- curve classification and related dependencies have been removed;
- automatic start from hold is no longer prohibited.

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

The main system function of Adaptive Cruise Control (ACC) is to control vehicle speed adaptively to a forward vehicle by using information about: (1) distance to forward vehicles, (2) the motion of the subject (ACC equipped) vehicle and (3) driver commands (see [Figure 1](#)). Based upon the information acquired, the controller (identified as “ACC control strategy” in [Figure 1](#)) sends commands to actuators for carrying out its longitudinal control strategy and it also sends status information to the driver. Optionally, the driver may choose to have the ACC use set speed advice from in-vehicle devices.

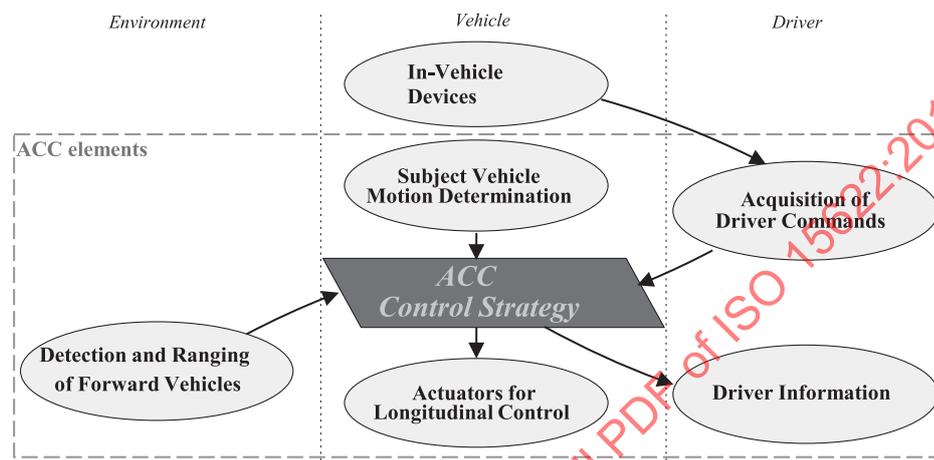


Figure 1 — Functional ACC elements

The goal of ACC is a partial automation of the longitudinal vehicle control and the reduction of the workload of the driver with the aim of supporting and relieving the driver in a convenient manner. The generic ACC system comprehends two classes: Full Speed Range ACC (FSRA) and Limited Speed Range ACC (LSRA).

This document can be used as a system level standard by other standards, which extend the ACC to a more detailed standard, e.g. for specific detection and ranging sensor concepts or higher level of functionality. Therefore, issues like specific requirements for the detection and ranging sensor function and performance or communication links for co-operative solutions will not be considered here.

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Intelligent transport systems — Adaptive cruise control systems — Performance requirements and test procedures

1 Scope

This document 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.

ACC systems are realised as either Full Speed Range Adaptive Cruise Control (FSRA) systems or Limited Speed Range Adaptive Cruise Control (LSRA) systems. LSRA systems are further distinguished into two types, requiring manual or automatic clutch. 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 and for FSRA-type systems also for congested traffic conditions. ACC can be augmented with other capabilities, such as forward obstacle warning. For FSRA-type systems 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

2 Normative references

The following documents are referred to in the text in such a way that some or all of their content constitutes requirements of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

ISO 2575, *Road vehicles — Symbols for controls, indicators and tell-tales*

UN/ECE Regulation No. 13-H. Uniform provisions concerning the approval of passenger cars with regard to braking

3 Terms and definitions

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

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

- IEC Electropedia: available at <http://www.electropedia.org/>
- ISO Online browsing platform: available at <http://www.iso.org/obp>

3.1

active brake control

function that causes application of the brake(s), not applied by the driver, in this case controlled by the ACC system

3.2

Adaptive Cruise Control

ACC

enhancement to conventional cruise control systems [see *conventional cruise control* (3.5)], which allows the subject vehicle to follow a forward vehicle at an appropriate distance by controlling the engine and/or power train and potentially the brake

**3.3
brake**

part in which the forces opposing the movement of the vehicle develop

Note 1 to entry: It can be a friction brake (when the forces are generated by friction between two parts of the vehicle moving relatively to one another); an electrical brake (when the forces are generated by electro-magnetic action between two parts of the vehicle moving relatively but not in contact with one another); a fluid brake (when the forces are generated by the action of a fluid situated between two parts of the vehicle moving relatively to one another); an engine brake (when the forces are derived from an artificial increase in the braking action, transmitted to the wheels, of the engine).

Note 2 to entry: Definition according to ECE-R 13-H, except for the purposes of this document, transmission control devices are not considered as brakes.

**3.4
clearance**

distance from the forward vehicle's trailing surface to the subject vehicle's leading surface

**3.5
conventional cruise control**

system capable of controlling the speed of a vehicle as set by the driver

**3.6
forward vehicle**

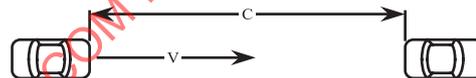
vehicle in front of and moving in the same direction and travelling on the same roadway as the *subject vehicle* (3.11)

**3.7
free-flowing traffic**

smooth-flowing and heavy traffic excluding stop and go and emergency braking situations

**3.8
time gap**

τ
time gap calculated as clearance, c , divided by vehicle speed v



Key

- c clearance
- v vehicle speed

NOTE $\tau = c/v$.

Figure 2 — Time gap

**3.9
set speed**

desired travel speed, set either by the driver or by some control system that is external to the ACC system

Note 1 to entry: The set speed is the maximum desired speed of the vehicle while under ACC control.

**3.10
steady state**

condition whereby the value of the described parameter does not change with respect to time, distance, etc.

3.11**subject vehicle**

vehicle equipped with the ACC system in question and related to the topic of discussion

3.12**system states**

one of several stages or phases of system operation

Note 1 to entry: See [Figure 3](#).

3.12.1**ACC off state**

phase in which direct access for activation of “ACC active state” is disabled

3.12.2**ACC stand-by state**

phase in which there is no longitudinal control by ACC system and the system is ready for activation by the driver

3.12.3**ACC active state**

phase in which the system controls the speed and/or clearance

3.12.4**ACC speed control state**

phase in which the system controls the speed according to the set speed

3.12.5**ACC following control sub-state**

phase in which the system controls the clearance to the target vehicle according to the selected time gap

3.12.6**FSRA hold state**

phase in which the system is active during standstill

Note 1 to entry: Applied for FSRA-type systems only.

3.13**target vehicle**

vehicle that the subject vehicle follows

3.14**stationary object**

object in front of the subject vehicle which is stationary

3.15**slow moving object**

object in front of the subject vehicle which is moving with less than MAX [1,0 m/s, 10 % of subject vehicle speed] in the direction of the centreline of the subject vehicle

3.16**Full Speed Range Adaptive Cruise Control****FSRA cruise control**

class of *adaptive cruise control systems* ([3.2](#)), which allows the subject vehicle to follow a forward vehicle at an appropriate distance by controlling the engine and/or power train and the brake down to standstill

3.17

Limited Speed Range Adaptive Cruise Control

LSRA cruise control

class of *adaptive cruise control systems* (3.2), which allows the subject vehicle to follow a forward vehicle at an appropriate distance by controlling the engine and/or power train and the brake above a certain minimum velocity

3.18

in-vehicle device

manufacturer-integrated device that provides the ACC set-speed value without active communication to external devices

4 Symbols and abbreviated terms

$a_{\text{lateral_max}}$	maximum allowed lateral acceleration in curves
a_{stopping}	longitudinal acceleration of the target vehicle at the automatic “stop” capability test
CTT	Coefficient for Test Target for infrared reflectors
c	clearance, inter vehicle distance
c_{min}	minimum clearance under steady state conditions for all speeds (including hold state)
d_0	distance, below which detection of a target vehicle is not required
d_1	distance, below which neither distance measurement nor determination of relative speed is required
d_2	distance for measurement purposes
d_{max}	maximum detection range on straight roads
R	circle radius, curve radius
R_{min}	minimum curve radius
RCS	RADAR Cross Section
v	the true subject vehicle speed over ground
v_{circle}	maximum speed on a curve for a given lateral acceleration $a_{\text{lateral_max}}$
$v_{\text{circle_start}}$	vehicle speed as it enters a curve of radius R
v_{low}	minimum operational speed
$v_{\text{set_max}}$	maximum selectable set speed
$v_{\text{set_min}}$	minimum selectable set speed
v_{stopping}	vehicle speed of the target vehicle at the automatic “stop” capability test
$v_{\text{vehicle_end}}$	vehicle speed at the end of a test
$v_{\text{vehicle_max}}$	maximum vehicle speed
$v_{\text{vehicle_start}}$	vehicle speed at the start of a test
τ	gap, time gap between vehicles

$\tau_{\max}(v)$	maximum possible steady-state time gap at a given speed v
τ_{\max}	maximum selectable time gap
τ_{\min}	minimum selectable time gap

5 Classification

5.1 Type of ACC systems

Different configurations of actuators for longitudinal control result in very different system behaviour. Therefore, based on the two different ACC classes, three types of ACC systems are addressed in this document.

Table 1 — Classification of ACC system types

Type	Manual clutch operation required	Operational speed range
FSRA	No	Full speed range
LSRA 1	Yes	Minimum operational speed v_{low}
LSRA 2	No	Minimum operational speed v_{low}

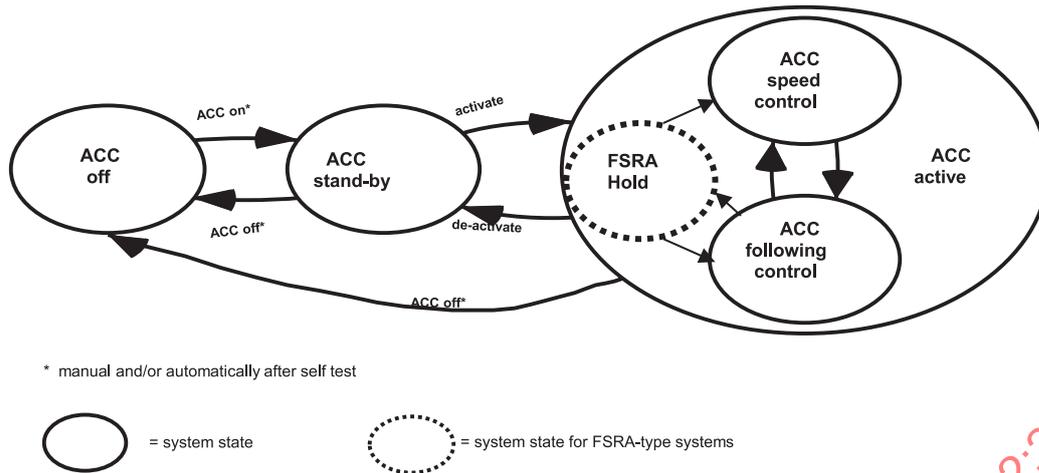
The deceleration capability of the ACC system shall be clearly stated in the vehicle owner's manual. All types incorporate active brake control. In case of active brake intervention in vehicles with a clutch pedal (type LSRA 1) the driver shall be informed clearly and early about a potential conflict between brake and engine idle control, if the clutch cannot be disengaged automatically. A practicable and unambiguous handing-over procedure shall be provided for the driver. See [6.3.1](#).

6 Requirements

6.1 Basic control strategy

ACC systems shall, as a minimum, provide the following control strategy and state transitions. The following constitutes the fundamental behaviour of ACC systems.

- When the ACC is active, the vehicle speed shall be controlled automatically either to maintain a clearance to a forward vehicle, or to maintain the set speed, whichever speed is lower. The change between these two control modes is made automatically by the ACC system.
- The steady-state clearance may be either self-adjusting by the system or adjustable by the driver (see [6.3.1](#)).
- If there is more than one forward vehicle, the one to be followed shall be selected automatically (see [6.2.3.3](#)).
- Only for FSRA-type: The state shall change from following control to hold state within a time period not to exceed 3 sec after the subject vehicle has come to a stop.
- Only for FSRA-type: In “Hold” state, automatic brake control shall be accomplished for keeping the subject vehicle stationary.
- Only for LSRA-type: The transition from “ACC stand-by” to “ACC active” shall be inhibited if the subject vehicle's speed is below a minimum operational speed, v_{low} . Additionally, if the vehicle's speed drops below v_{low} while the system is in the “ACC active” state, automatic acceleration shall be inhibited. Optionally, the ACC system may drop from “ACC active” to “ACC stand-by” (see [6.3.2](#) and [6.4](#)).



NOTE * Manual transition describes a switch to enable/disable ACC function. Automatic switch off can be forced by failure reaction.

Figure 3 — ACC states and transitions

6.2 Functionality

6.2.1 Control modes

The transition between the control modes (following controlled or speed controlled) shall be made automatically.

6.2.2 Stationary or slow moving targets

Generally, it is not a requirement that an ACC system is designed to respond to the presence of stationary or slow moving targets. If the system is designed not to respond to stationary targets the driver shall be informed at least by a statement in the vehicle owner's manual.

Systems of FSRA-type will and systems of LSRA-type may attempt to stop behind an already tracked and stopping vehicle within their limited deceleration capabilities.

6.2.3 Following capability

6.2.3.1 General

τ_{min} shall be the minimum selectable time gap for following control mode under steady-state conditions for all speeds v . τ_{min} shall be greater than or equal to 0,8 s.

At least one time gap setting τ in the range of 1,5 s to 2,2 s shall be provided for speeds higher than 8 m/s.

Under steady-state conditions the minimum clearance shall be $MAX(c_{min}, \tau_{min} * v)$.

Under transient conditions, the clearance may temporarily fall below the minimum clearance. If such a situation occurs, the system shall adjust the clearance to attain the desired clearance.

For all FSRA-type systems and those LSRA type systems which attempt to stop behind a stopping vehicle (see 6.2.2 above): As a minimum requirement the system shall be able, starting from steady state following, to stop behind a gradually stopping vehicle which is braking with the acceleration $a_{stopping}$ at a speed below $v_{stopping}$. (refer to test procedure 7.3.2).

$$v_{stopping} = 10 \text{ m/s}$$

$$a_{\text{stopping}} = -2,5 \text{ m/s}^2$$

The ACC shall have detection range, target discrimination and curve capabilities as specified below.

6.2.3.2 Detection range on straight roads

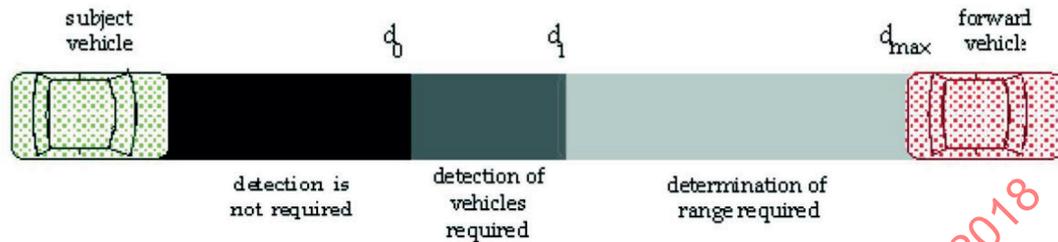


Figure 4 — Zones of detection

If a forward vehicle is present within the distance range d_1 to d_{max} , the ACC system shall measure the range between the forward and subject vehicles (see Figure 4). Within this range the forward vehicle shall be detected within a lateral area of at least the subject vehicle width.

$$d_{\text{max}} = \tau_{\text{max}}(v_{\text{set_max}}) \times v_{\text{set_max}}$$

If a forward vehicle is present within the distance range d_0 to d_1 , the ACC system shall detect the presence of the vehicle but is not required to measure the range to the vehicle nor the relative speed between the forward and subject vehicles.

$$d_1 = 4 \text{ m}$$

If a forward vehicle is present at a distance less than d_0 , the ACC system is not required to detect the presence of the vehicle.

$$d_0 = 2 \text{ m}$$

6.2.3.3 Target discrimination

If there is more than one forward vehicle on straight roads and in steady-state curves, the forward vehicle (see Figure 5) in the subject vehicle's path shall be selected for ACC control in typical ACC situations as represented by the test scenario. See 7.5.

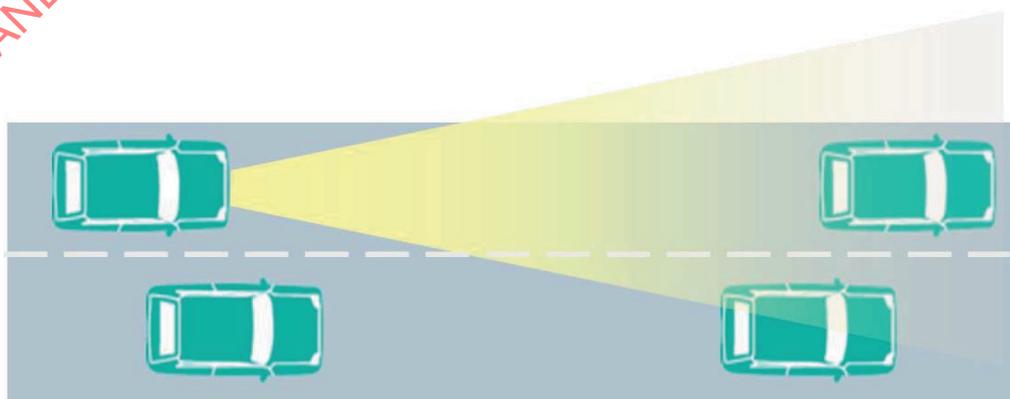


Figure 5 — Target discrimination

6.2.3.4 Curve capability

The ACC system shall enable a steady-state vehicle following with a time gap of $\tau_{\max}(v_{\text{circle}})$, on straight roads and curves with a radius down to $R_{\min} = 500$ m. Therefore the system shall be capable of following a forward vehicle with the steady-state time gap $\tau_{\max}(v_{\text{circle}})$, if the forward vehicle cruises on a constant curve radius R_{\min} with a constant speed v_{circle} given by:

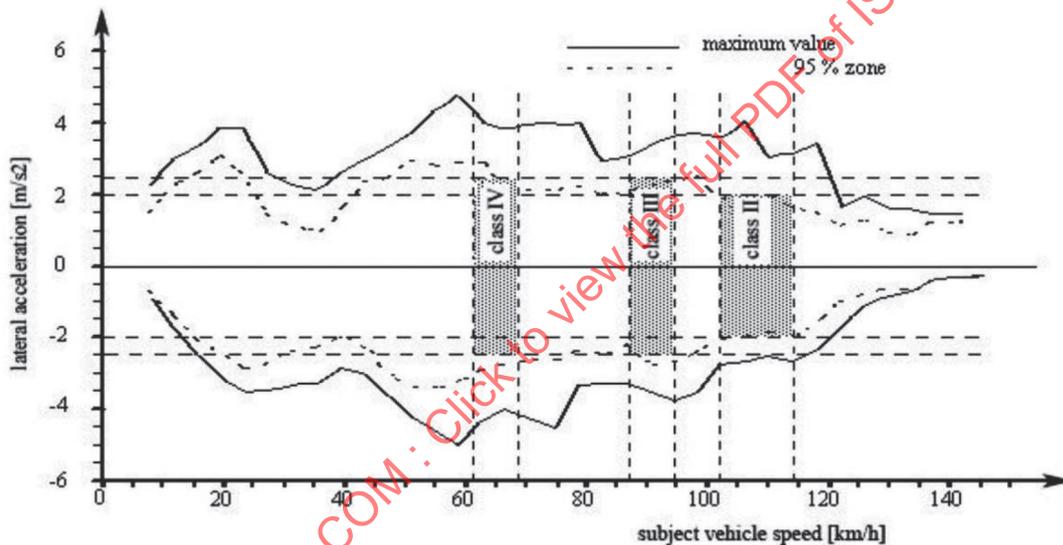
$$v_{\text{circle}} = \sqrt{a_{\text{lateral_curve}} * R_{\min}} \tag{1}$$

where

$\tau_{\max}(v)$ is the maximum possible steady-state time gap while driving with a speed v on a straight;

$a_{\text{lateral_curve}}$ is the design lateral acceleration for curves on highways.

The value for $a_{\text{lateral_curve}}$ is derived from average driver behaviour in curves (95 % drivers). See [Figure 6](#) below.



NOTE Class II to IV are not relevant for the ACC standard.

Figure 6 — Lateral acceleration of the average driver^[3]

Thus the value to use is:

$$a_{\text{lateral,curve}} = 2,0 \text{ m/s}^2$$

which leads to a steady-state speed for the curve driving of $v_{\text{circle}} = 114$ km/h.

6.2.4 “Go” transition

The transition from hold to following control or to speed control may be enabled through driver request or automatically by the ACC function.

6.3 Basic driver interface and intervention capabilities

6.3.1 Operation elements and system reactions

6.3.1.1 ACC systems shall provide a means for the driver to select a desired set speed. Optionally, the driver could be provided with means to accept a set speed that is suggested by in-vehicle devices, e.g. a traffic sign recognition system.

6.3.1.2 In the “ACC following control” and the “ACC speed control” states, braking by the driver shall deactivate ACC function at least if the driver initiated brake force demand is higher than the ACC initiated brake force. For FSRA-type only: In the “ACC Hold” state it is not mandatory that braking by the driver deactivates the ACC system (leading to ACC standby state; refer to [Figure 3](#)).

6.3.1.3 The ACC-system shall not lead to a significant transient reduction of braking response to the driver's braking input (refer to ECE-R 13-H) even when the ACC-system has been braking automatically.

6.3.1.4 The larger of the power demands from either the driver or the ACC system will be used to drive the engine power actuator (e.g. throttle actuator). This always gives the driver authority to override the ACC system engine power control.

If the power demand of the driver is greater than that of the ACC system, automatic braking shall be disengaged with an immediate brake force release. A driver intervention on the accelerator pedal shall not lead to a significant delay of response to driver's input.

6.3.1.5 Automatic brake activation shall not lead to locked wheels for periods longer than anti-lock devices (ABS) would allow. This need not require an ABS system.

6.3.1.6 Automatic power control by ACC shall not lead to excessive positive wheel slip for periods longer than traction control would allow. This need not require a traction control system.

6.3.1.7 ACC systems may automatically adjust the time gap without action by the driver in order to respond to the driving environment (e.g. poor weather). However, the adjusted time gap shall not be less than the minimum time gap selected by the driver.

6.3.1.8 If the system allows the driver to select a desired time gap, the selection method shall conform to either one of the following:

- 1) if the system retains the last selected time gap after it is switched to ACC OFF, as shown in [Figure 2](#), the time gap shall be clearly presented to the driver at least upon system activation;
- 2) if the system does not retain the last selected time gap after it is switched to ACC OFF, as shown in [Figure 2](#), the time gap shall be set to a predefined default value equal of 1,5 s or greater.

6.3.1.9 If there is a conventional cruise control function in addition to ACC there shall be no automatic switching between the ACC and conventional cruise control.

6.3.1.10 Optional: The system may be activated by the driver at standstill even when the driver is applying the brake pedal.

6.3.1.11 For LSRA 1-type only: Type LSRA 1 systems shall either temporarily suspend operation but remain in the ACC active state or switch to ACC stand-by if the driver depresses the clutch pedal. The automatic brake manoeuvre can be continued during the use of the clutch pedal. After the system releases the brakes, the system may either resume ACC control or transition to ACC stand-by in response to the driver depressing the clutch pedal.

6.3.2 Display elements

A minimum feedback information for the driver contains activation state (whether the ACC system is active or not active) and the set speed. This can be done by a combined output, e.g. displaying of set speed information only when ACC is active.

If the ACC system is not available due to a failure, the driver shall be informed. If a symbol is used to notify the driver, a standard symbol shall be employed. See ISO 2575.

If the ACC system deactivates automatically, the driver shall be informed. If a symbol is used to notify the driver, a standard symbol shall be employed.

If the vehicle is equipped with both ACC and conventional cruise control systems, the driver should be made aware of which system is operating.

A “vehicle-detected” signal, with the meaning that the active ACC system is detecting a forward vehicle, is required to be active if this forward vehicle is used for adaptation of the control.

6.3.3 Symbols

If symbols are used to identify ACC function or malfunction, standardized symbols in accordance with ISO 2575 shall be used.

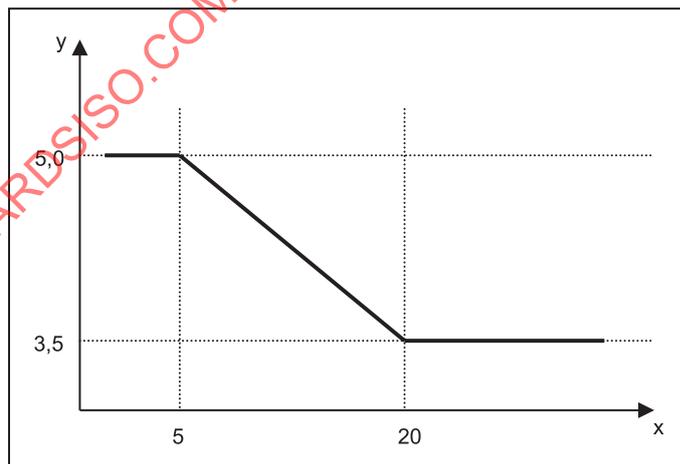
6.4 Operational limits

To promote comfort, below 5 m/s there shall not be a sudden brake force release due to a disappearing target vehicle or an automatic deactivation due to a system failure other than brake failures.

For LSRA-type only: Automatic positive acceleration of ACC requires a vehicle speed v_{low} of at least 5 m/s.

The minimum set speed shall be $v_{set_min} \geq 4,4$ m/s.

The average automatic deceleration of ACC systems shall not exceed $3,5$ m/s² (average over 2 s) when the vehicle is travelling above 20 m/s and 5 m/s² (average over 2 s) when the vehicle is travelling below 5 m/s as shown in [Figure 7](#).

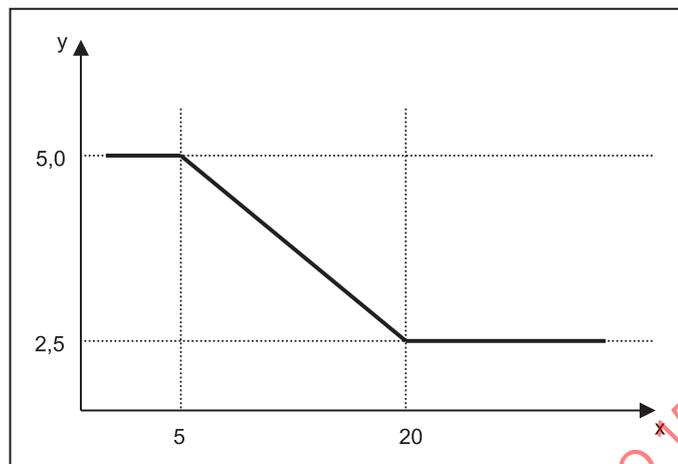


Key

- x subject vehicle speed [m/s]
- y max. deceleration [m/s²]

Figure 7 — Maximum deceleration

The average rate of change of automatic deceleration (negative jerk) shall not exceed $2,5 \text{ m/s}^3$ (average over 1 s) when the vehicle is travelling above 20 m/s and 5 m/s^3 (average over 1 s) when the vehicle is travelling below 5 m/s as shown in the [Figure 8](#).

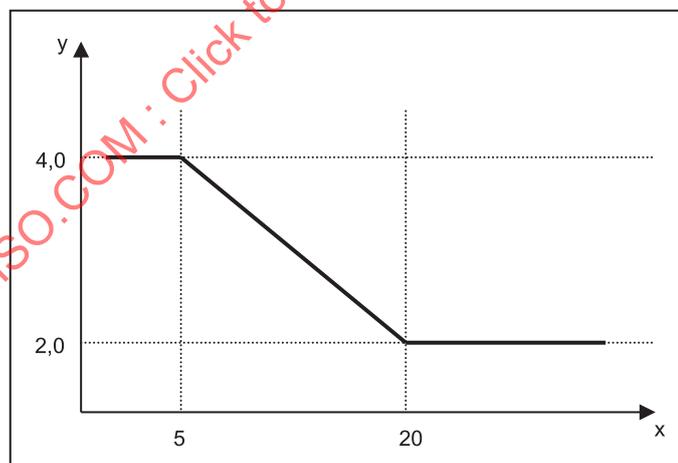


Key

- x subject vehicle speed [m/s]
y negative jerk [m/s³]

Figure 8 — Maximum negative jerk

The average automatic acceleration of ACC systems shall not exceed 2 m/s^2 (average over 2 s) when the vehicle is travelling above 20 m/s and 4 m/s^2 (average over 2 s) when the vehicle is travelling below 5 m/s as shown in [Figure 9](#).



Key

- x subject vehicle speed [m/s]
y automatic acceleration [m/s²]

Figure 9 — Maximum acceleration

If the target vehicle comes closer than d_0 and is not detected anymore, the system should initiate a controller strategy starting with the last valid braking command, until the subject vehicle is stopped or the system detects a forward vehicle within d_1 or the driver overrides the system via accelerator pedal. If a forward vehicle is detected within the distance range d_0 to d_1 and the distance cannot be determined, the system shall inhibit automatic acceleration.

6.5 Activation of brake lights

If automatic service braking is applied, the brake light shall be illuminated. When the ACC system applies other deceleration devices the system may illuminate the brake lights. The brake lights shall be illuminated within 350 ms of the ACC system initiating the service brake. To prevent irritating brake light flickering, the brake light may remain on for a reasonable time after the ACC initiated braking has ended.

6.6 Failure reactions

Table 2 shows the required reactions to failures depending on which subsystem fails. See Figure 10.

The failures described in Table 2 shall result in immediate notification to the driver (except in the case of a gearbox failure with LSRA 1-type systems). The notification shall remain active until the system is switched off.

The reactivation of the ACC system shall be prohibited until a successful self-test, initiated by either ignition off/on or ACC off/on, is accomplished.

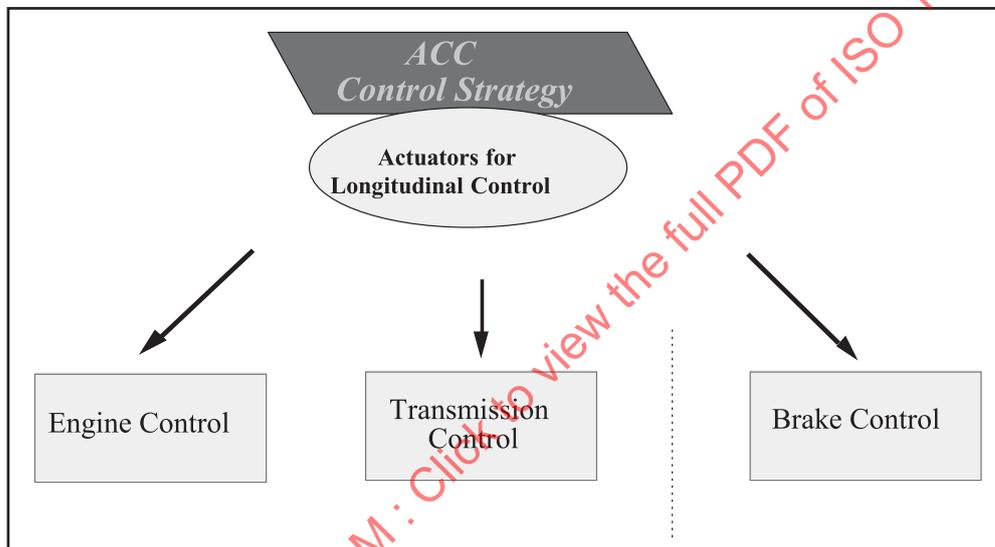


Figure 10 — Actuators for longitudinal control

Table 2 — Failure reactions for ACC systems

Failure in sub-system		Failure occurs whilst ACC is applying:	
		Brake control	Engine control
1	Engine	Should maintain braking as required at least for the actual/current braking manoeuvre.	ACC engine control shall be relinquished.
2	Brake system ¹⁾	ACC control shall be relinquished. If the brake system failure is not total during an active brake manoeuvre, the system may finish the current braking manoeuvre before the ACC control is relinquished completely.	ACC engine control shall be relinquished.
3	Detecting and ranging sensor	Should initiate a controller strategy starting with the last valid braking command. Braking shall not be released suddenly in this case The system shall be switched off immediately after driver intervention by brake or accelerator pedal or ACC off switch	ACC engine control shall be relinquished.
4	ACC controller	ACC control shall be relinquished.	ACC control shall be relinquished.
¹⁾ If a malfunction within the gear controller occurs, the brake will be able to handle the deceleration function.			

7 Performance evaluation test methods

7.1 Environmental conditions

- Test location shall be on a flat, dry asphalt or concrete surface.
- Temperature range shall be between +20 °C and +40 °C.
- Horizontal visibility range shall be greater than 1 km.

7.2 Test target specification

7.2.1 General

The test targets are specified for technologies used today. For other technologies, representative test targets shall be used.

7.2.2 Infrared LIDAR¹⁾

The infrared test target is defined by an infrared coefficient for test target CTT and the cross-section of the test target. The minimum cross-section for test targets A and B is 20 cm².

Test target A: a diffuse reflector with a CTT = 2,0 m²/sr ± 10 % (see [Annex A](#)).

Test target B: a diffuse reflector with a CTT = 1,0 m²/sr ± 10 %.

¹⁾ The test target is defined by a coefficient of a reflector:
Target A represents at least 95 % of all vehicles driving on motorways.
Target B represents the reflectivity of a dirty car without any retro reflector.

7.2.3 Millimetre wave RADAR²⁾

The radar test target is defined by a radar cross-section (RCS).

For the frequency range between 20 GHz and 95 GHz:

- test target A: the RCS for test target A shall be 10 m²;
- test target B: the RCS for test target B shall be 3 m².

For significant different frequency ranges, the RCS shall be determined and defined (see [Annex A](#)).

7.3 Automatic “Stop” capability test for FSRA-type only

The “Stop” capability test shall ensure the function of the FSRA-system in the lower speed range down to a standstill.

7.3.1 Test target vehicle

The target vehicle shall be equipped with the test target A as defined in 7.2. The test target shall be placed on the rear end of the vehicle. The remaining exposed vehicle surface shall be concealed in such a way that the rear surface, with the test target removed, represents an RCS of no greater than 2 m² or a reflectivity of no greater than 20 % of the test target.

7.3.2 Initial conditions

A target vehicle shall travel at a speed of $v_{stopping}$.

The width of the target vehicle shall be between 1,4 m and 2,0 m.

The subject vehicle cruises behind the target vehicle in a steady-state following-control mode.

The desired time gap shall be the value of τ_{min} during the whole test procedure.

The lateral displacement of the subject vehicle’s longitudinal centreline relative to the target vehicle’s longitudinal centreline shall be less than 0,5 m. (refer to [Figure 11](#)).

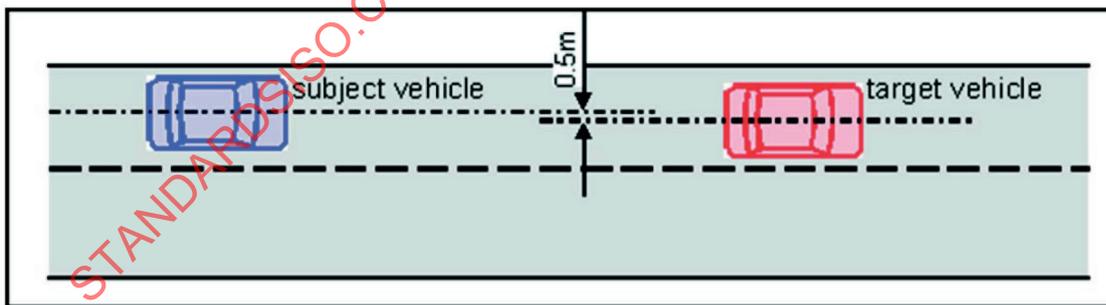


Figure 11 — Automatic stop capability test — Start conditions

7.3.3 Test procedure

The target vehicle shall brake to stop with an acceleration between $-2,0 \text{ m/s}^2$ and $-2,5 \text{ m/s}^2$.

2) The test target is defined by a Radar Cross Section (RCS) Target A at today known frequencies (60, 77, 90 GHz), represents at least 95 % of all vehicles driving on motorways. Target B is representative of a motorcycle.

The test is considered to be successfully completed when the subject vehicle is stopped by the system behind the preceding vehicle.

7.4 Target acquisition range test

Refer to [6.2.3.2](#).

Test procedure for d_0 , d_1 , d_2 and d_{\max} .

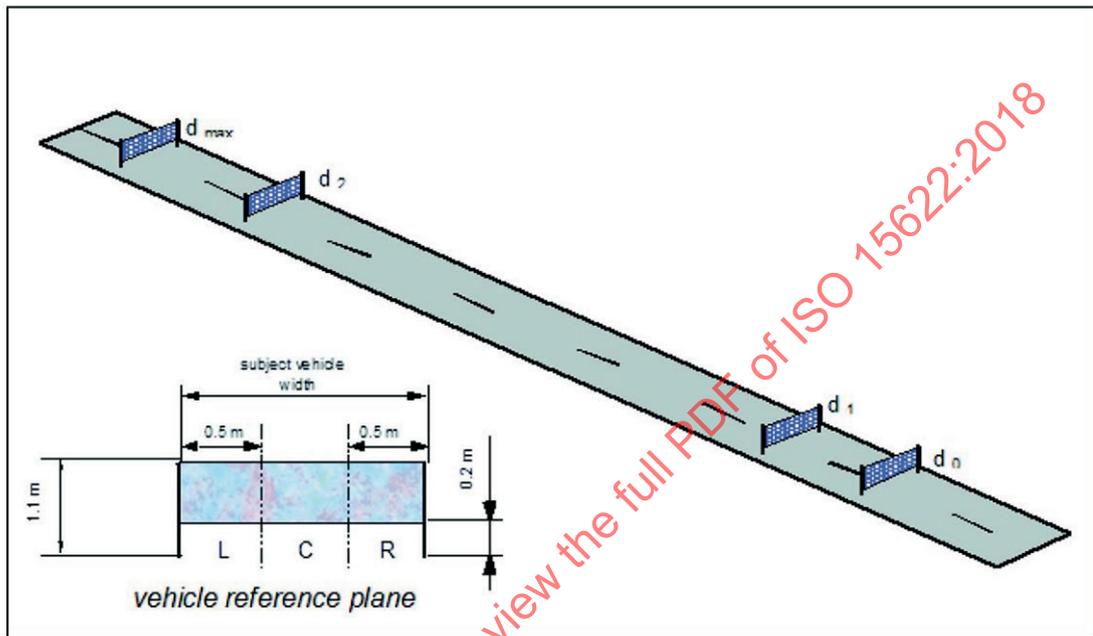


Figure 12 – Longitudinal detection zone

The vehicle reference plane corresponds to a rectangle in the height of 0,9 m by subject vehicle-width beginning at a height of 0,2 m. The detection area considers different places within the vehicle front-end plane. It is also restricted by the minimum height of passenger cars. The reference planes of d_1 , d_2 , d_{\max} are divided into 3 columns. The columns L and R have the width of 50 cm each. During testing the defined reflector shall be detected at least at one position within each column (L, C, R) of the vehicle reference plane at the position d_1 , d_2 , d_{\max} . At d_0 only one position within the whole reference plane has to be detected. Refer to [Figure 12](#).

- For the position d_{\max} , the test target A shall be used.
- For the position d_0 , d_1 and d_2 , the test target B shall be used.
- The d_2 point refers to a fixed measurement point at 75 m in front of the vehicle.
- Range testing should be done while the subject vehicle and the test target are moving. As an option, testing while the subject vehicle and the test target are stationary is permissible.

The maximum target acquisition time should not exceed 2 s after presentation of the target.

7.5 Target discrimination test

7.5.1 General

Refer to [6.2.3.3](#).

7.5.2 Initial conditions

Two forward vehicles of the same model travel alongside each other at a speed of $v_{\text{vehicle_start}}$. The spacing between the longitudinal centrelines of the forward vehicles is $3,5 \text{ m} \pm 0,25 \text{ m}$. The width of the forward vehicles shall be between 1,4 m and 2,0 m.

The subject vehicle cruises behind one of the forward vehicles in steady state following control mode. The forward vehicle that the subject vehicle follows is designated the target vehicle. The time gap = $\tau_{\text{max}}(v_{\text{vehicle_start}})$ and the set speed $> v_{\text{vehicle_end}}$. The lateral displacement of the longitudinal centreline of the subject vehicle relative to the longitudinal centreline of the target vehicle shall be less than 0,5 m. See [Figure 13](#).

$$v_{\text{vehicle_end}} = 27 \text{ m/s } (\sim 100 \text{ km/h})$$

NOTE If the vehicle is not capable of this speed, $v_{\text{vehicle_end}} = 22 \text{ m/s } (\sim 80 \text{ km/h})$ shall be used.

$$v_{\text{vehicle_start}} = v_{\text{vehicle_end}} - 3 \text{ m/s}$$

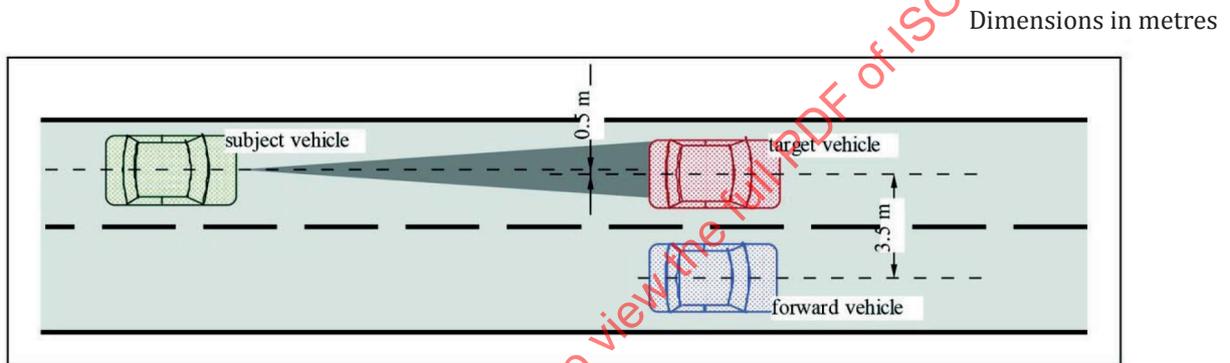


Figure 13 — Discrimination test — Start conditions

7.5.3 Test procedure

The target vehicle accelerates to $v_{\text{vehicle_end}}$. The test is successfully fulfilled if the subject vehicle passes the forward vehicle in the adjacent lane while under ACC control. See [Figure 14](#).



Figure 14 — Discrimination test — End conditions

7.6 Curve capability test

7.6.1 General

Refer to [6.2.3.4](#).

This test should take into consideration the road geometry prediction in combination with the field of view of the ACC system's sensor.

Different methods of road geometry prediction and headway sensing result in the need for a driving scenario.

7.6.2 Test field

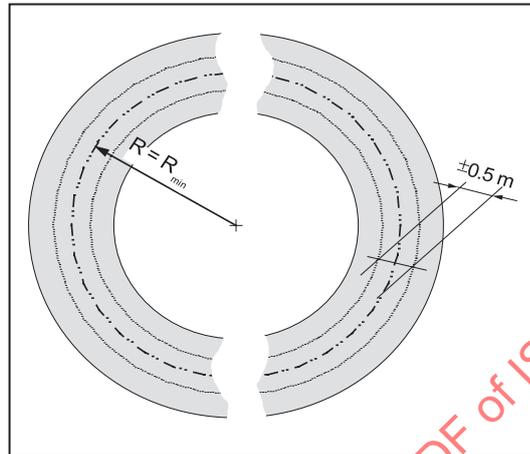


Figure 15 — Outline test track

The test track shall consist of either a circular track of constant radius or a sufficiently long segment of curve of constant radius. The radius should be within 80 % to 100 % of $R_{\min} = 500$ m. The direction of travel on the track shall be both clockwise and anti-clockwise. There is no restriction concerning lane markings, guard rails, etc. See [Figure 15](#).

7.6.3 Curve capability, target vehicle

The target vehicle shall be equipped with test target A as defined in [7.2](#). The test target shall be placed in the middle on the rear end of the vehicle at a height of $0,6 \text{ m} \pm 0,1 \text{ m}$ above ground.

The remaining exposed vehicle surface shall be concealed in such a way that the rear surface, with the test target removed, represents an RCS of no greater than 2 m^2 or a reflectivity of no greater than 20 % of the test target.

7.6.4 Driving scenario

The subject vehicle follows the target vehicle along the same path ($\pm 0,5 \text{ m}$ lateral separation as measured from the centrelines of both vehicles) in following control mode. The two cars shall conform to the test start conditions as defined in [Figure 16](#) (subject and target vehicle only) prior to the start of the test. Details of the test are shown in [Table 3](#) and in [Figure 16](#).

The speed of the target vehicle at the start of the test is given by:

$$v_{\text{circle_start}} = \min ((a_{\text{lateral_max}} * R)^{1/2}, v_{\text{vehicle_max}}) \pm 1 \text{ m/s}$$

with $a_{\text{lateral_max}} = 2,0 \text{ m/s}^2$.

At the proper time, the target vehicle decelerates and the reaction of the subject vehicle is observed. The subject vehicle shall start to decelerate due to the decreasing distance to the target vehicle before the time gap falls below $2/3 \tau_{\text{max}}$.

Table 3 — Test conditions for the curve capability test

	Test preliminary	Test start conditions	1st test manoeuvre	2nd test manoeuvre
Target vehicle				
speed	$v_{\text{circle_start}} = \text{constant}$		Decrease velocity by $3,5 \text{ m/s} \pm 0,5 \text{ m/s}$	$v_{\text{circle}} = \text{constant}$ $= v_{\text{circle_start}} - 3,5 \text{ m/s} \pm 1 \text{ m/s}$
time	minimum 10 s	time trigger 0 s	2 s	
radius	$\geq R$ as defined in 7.5.1, may vary	$R = \text{constant}$ (see 7.5.1)		
Subject vehicle				
speed	as controlled by ACC			
acceleration	$\leq 0,5 \text{ m/s}^2$		deceleration to be observed	
radius	$\geq R$ as defined in 7.5.1, may vary	$R = \text{constant}$ (see 7.5.1)		
time gap to target vehicle	$\tau_{\text{max}}(v_{\text{circle_start}}) \pm 25 \%$		as controlled by ACC, shall be observed	

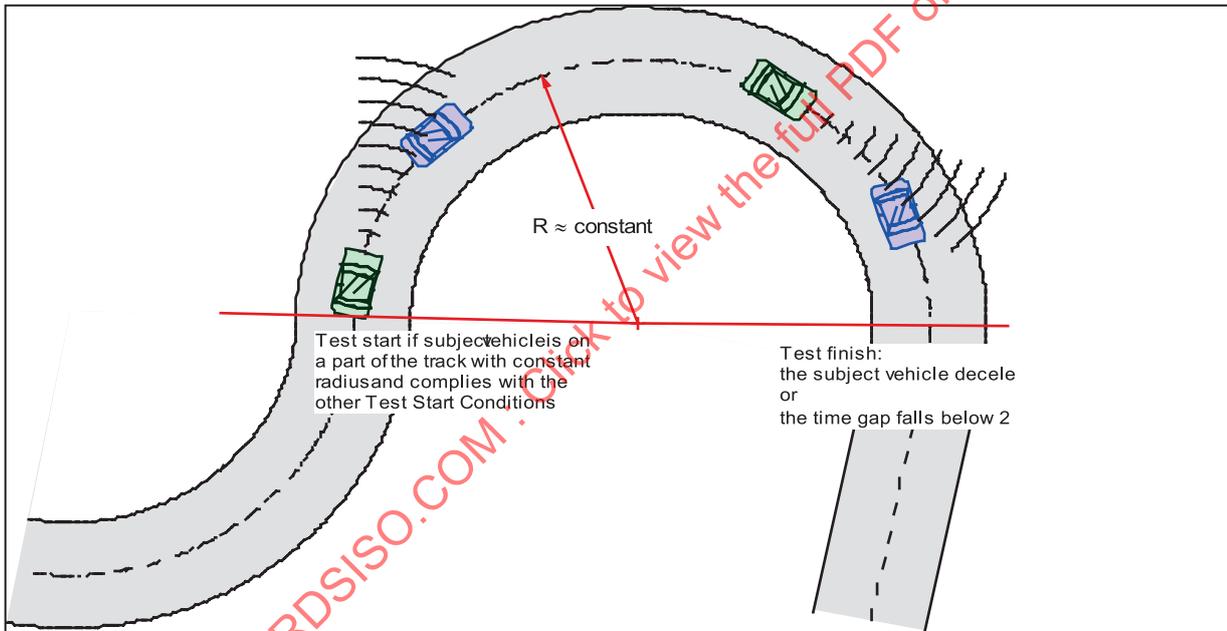


Figure 16 — Example of test track layout

Annex A (normative)

Technical information

A.1 LIDAR, coefficient of test target

A.1.1 Solid angle, Ω

The solid angle, Ω , is the ratio of the irradiated portion of the surface of light to the square of the radius of the sphere. See [Figure A.1](#).

$$\Omega = \frac{A}{d_A^2} \times \Omega_0 \quad (\text{A.1})$$

where

Ω is the solid angle, in steradians;

A is the utilized area;

d_A is the distance between source and projected area A ;

Ω_0 is the solid angle of the source, in steradians.

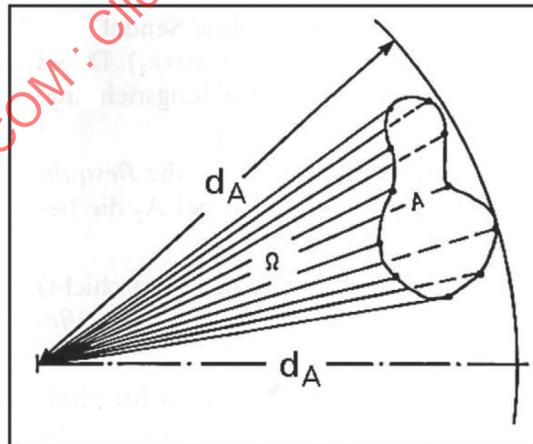


Figure A.1 — Solid angle

A.1.2 Radiated intensity, I

The radiated intensity, I , is given by the radiated power, Φ , out of a radiation source, inside a solid angle, Ω :

$$I_{\text{ref}} = \frac{d\Phi_{\text{ref}}}{d\Omega_1} \quad (\text{A.2})$$

where