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Intelligent transport systems — Full speed range adaptive cruise control (FSRA) systems — Performance requirements and test procedures

Systèmes intelligents de transport — Systèmes de commande de croisière adaptatifs à la gamme entière de vitesse (FSRA) — Exigences de performance et méthodes d'essai

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Contents

Page

Foreword

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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.

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.

ISO 22179 was prepared by Technical Committee ISO/TC 204, *Intelligent transport systems*.

Introduction

The main system function of full speed range adaptive cruise control (FSRA) is to control vehicle speed adaptively to a forward vehicle by using information about:

a) distance to forward vehicles,

b) the motion of the subject (FSRA equipped) vehicle, and

c) driver commands (see Figure 1).

Based upon the information acquired, the controller (identified as “FSRA control strategy” in Figure 1) sends commands to actuators that carry out its longitudinal control strategy, and sends status information to the driver.

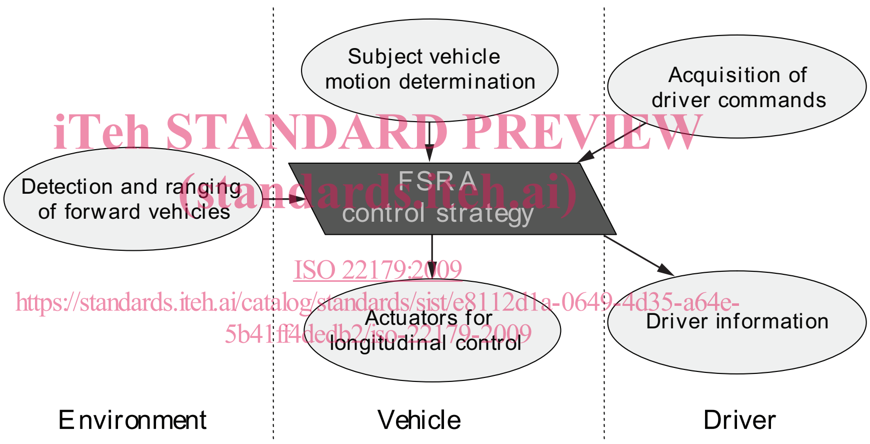


Figure 1 — Functional FSRA elements

The goal of FSRA is partial automation of longitudinal vehicle control to reduce drivers’ workload.

This International Standard may be used as a system level standard by other standards, which extend FSRA to a more detailed standard, e.g. for specific detection and ranging-sensor concepts or higher levels of functionality. Issues such as specific requirements for the detection and ranging sensor function and performance or communication links for co-operative solutions are not considered in this International Standard.

Intelligent transport systems — Full speed range adaptive cruise control (FSRA) systems — Performance requirements and test procedures

1 Scope

This International Standard 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)]}.

2 Normative references

The following referenced documents are indispensable for the application 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*

3 Terms and definitions[1)]

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

3.1
active brake control
function that causes application of the brake(s), not applied by the driver, in this case controlled by the FSRA system

3.2
adaptive cruise control
ACC
enhancement to conventional cruise control systems (see 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

1) Definitions are in accordance with the glossary of ISO/TC 204/WG 14.

EXAMPLE Brakes can be of the following types: a friction brake (where forces are generated by friction between two parts of the vehicle moving relatively to one another); an electrical brake (where forces are generated by electromagnetic action between two parts of the vehicle moving relatively but not in contact with one another); a fluid brake (where forces are generated by the action of a fluid situated between two parts of the vehicle moving relatively to one another); or an engine brake (where forces are derived from an artificial increase in the braking action of the engine, transmitted to the wheels).

NOTE Definition adapted from ECE-R 13-H, except that for the purposes of this International Standard, 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

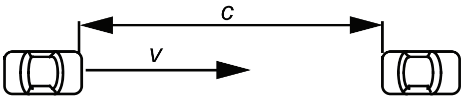
3.5
conventional cruise control
system capable of controlling the speed of a vehicle as set by the driver

3.6
forward vehicle
vehicle in front of, and moving in the same direction and travelling on the same roadway as, the subject vehicle

3.7
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

NOTE See Figure 2.



Key

c clearance

v vehicle speed

NOTE $\tau = c/v$

Figure 2 — Time gap

3.9
set speed
desired travel speed, set by either the driver or by some control system that is external to the FSRA system

NOTE The set speed is the maximum desired speed of the vehicle while under FSRA 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 FSRA system in question and related to the topic of discussion

3.12
system state
one of several stages or phases of system operation

NOTE See Figure 3.

3.12.1
FSRA off state
direct access for activation of FSRA active state (3.12.3) is disabled

3.12.2
FSRA stand-by state
state in which there is no longitudinal control by FSRA system and the system is ready for activation by the driver

3.12.3
FSRA active state
state in which the system controls speed and/or clearance

3.12.4
FSRA hold state
state in which the system is active during subject vehicle standstill

3.12.5
FSRA speed control state
state in which the system controls the speed according to the set speed

3.12.6
FSRA following control state
state in which the system controls the clearance to the target vehicle according to the selected time gap

3.13
stationary object
stationary object in front of the subject vehicle

3.14
slow moving object
object in front of the subject vehicle that is moving with less than MAX [1 m/s, 10 % of subject vehicle speed] in the direction of the centreline of the subject vehicle

3.15
target vehicle
vehicle that the subject vehicle follows

3.16
full speed range adaptive cruise control
enhancement to 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

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

LIDAR light detection and ranging

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 $a_{lateral\_max}$

v_{circle_start} vehicle speed as it enters a curve of radius R

v_{set_max} maximum selectable set speed

v_{set_min} minimum selectable set speed

$v_{stopping}$ vehicle speed of the target vehicle at the automatic "stop" capability test

$v_{vehicle\_end}$ vehicle speed at the end of a test

$v_{vehicle\_max}$ maximum vehicle speed

$v_{vehicle\_start}$ vehicle speed at the start of a test

τ time gap between vehicles

τ_{max} maximum selectable time gap

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

τ_{min} minimum selectable time gap

5 Classification

This International Standard permits FSRA systems of different curve capabilities as specified in Table 1.

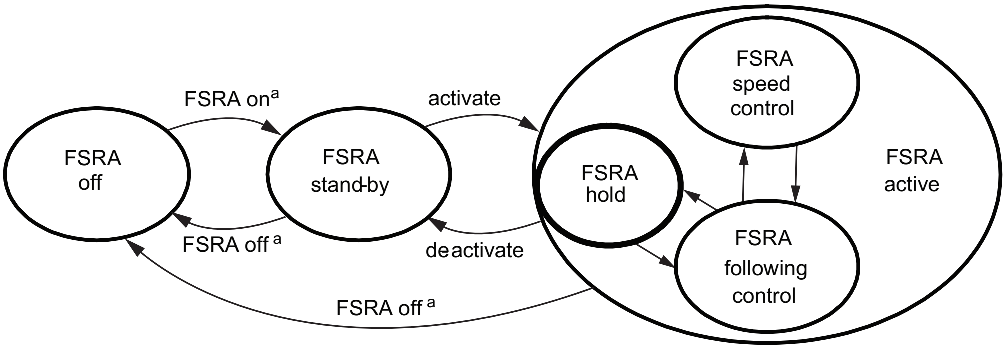
Table 1 — FSRA performance classifications

Dimensions in meters

Performance Class	Curve radius capability
I	Reserved for ACC ISO 15622, not applicable for FSRA
II	$\geqslant$ 500
III	$\geqslant$ 250
IV	$\geqslant$ 125

6 Requirements

6.1 Basic control strategy



System states are indicated by the text contained in ellipses.

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

[a] This is manual and/or automatic after self-test.

Figure 3 — FSRA states and transitions

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

a) When the FSRA 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 FSRA system.

b) The steady-state clearance may be either self adjusting by the system or adjustable by the driver (see 6.3.1).

c) If there is more than one forward vehicle the one to be followed shall be selected automatically (see 6.2.3.3).

d) The state shall change from following control to hold state within a time period not to exceed 3 s after the subject vehicle has come to a stop.

e) In the “hold” state, the automatic brake control shall be used for keeping the subject vehicle stationary.

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

The system will attempt to stop behind an already tracked and stopping vehicle within its limited deceleration capabilities. It is optional to design FSRA systems to respond to the presence of stationary or slow moving targets. If a given implementation is not intended to respond to stationary or slow moving targets, the driver shall be informed at least by a statement in the vehicle owner's manual.

6.2.3 Following capability

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 1 s.

c_{min} shall be the minimum clearance for following control mode under steady-state conditions for all speeds v (including hold state). c_{min} shall be greater than or equal to 2 m.

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

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.

As a minimum requirement, the system shall be able, starting from steady state following, to stop behind a gradually stopping vehicle which is decelerating with $a_{stopping}$ at a speed below $v_{stopping}$ (see the test procedure given in 7.3.2).

$v_{stopping}$ = 10 m/s

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

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

6.2.3.2 Detection range on straight roads (performance classes II, III and IV).

If a forward vehicle is present within the distance range d_1 to d_{max}, the FSRA 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.

$$d_{max} = \tau_{max}(v_{set\_max}) \times v_{set\_max}$$

If a forward vehicle is present within the distance range d_0 to d_1, the FSRA 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 FSRA system is not required to detect the presence of the vehicle.

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