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**Intelligent Transportation Systems - Full speed range
adaptive cruise control systems - Performance
requirements and test procedures**

智能运输系统 全速自适应巡航控制系统 性能要求和测试规程

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Intelligent Transportation Systems - Full speed range adaptive cruise control systems - Performance requirements and test procedures

1 Scope

This Standard specifies the basic control strategy, minimum functional requirements, basic interaction methods, minimum requirements for diagnosis and response to faults, and system performance test methods for full speed range adaptive cruise control system (hereinafter referred to as FSRA) of the vehicle.

The FSRA system is suitable for unobstructed and congested road conditions on expressways (that is, roads that prohibit non-motorized vehicles and pedestrians from passing). It provides longitudinal control for subject vehicle in driving. The working speed range is from zero to the highest speed limit that can be set by the system. The system can park the subject vehicle behind the tracked forward vehicle with the deceleration capability within its limit. And it can start again after the driver inputs the command to the system to continue driving. The system does not respond to stationary or low-speed moving targets (consistent with the adaptive cruise control system standard in GB/T 20608-2006).

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.

GB/T 20608-2006, *Intelligent transportation systems - Adaptive cruise control systems - Performance requirements and test procedures*

JTG B01-2003, *Technical Standard of Highway Engineering*

ISO 15623:2013, *Transport information and control systems - Forward vehicle collision warning systems - Performance requirements and test procedures*

ISO 22179:2009, *Intelligent transport systems - Full speed range adaptive*

3.6 forward vehicle

the vehicle that is located in front of the road where the subject vehicle is traveling and is traveling in the same direction

3.7 free-flowing traffic

including start-stop and emergency braking conditions, smooth flow and heavy traffic

3.8 time headway, THW

use time to represent the distance between two vehicles traveling on the same path, and calculate by dividing the distance between the two vehicles by the speed of the subject vehicle

3.9 set speed

the desired driving speed set by the driver or by other control systems other than the FSRA system

NOTE: This speed is the highest expected speed of the vehicle under the control of the FSRA system.

3.10 steady state

the state of the vehicle in which the relevant parameters do not change with time and distance

3.11 subject vehicle

the vehicle that is equipped with the full speed range adaptive cruise control system defined in this Standard

3.12 system state

a certain stage or state of the system's work

1) FSRA off

No direct action can trigger the FSRA system.

2) FSRA stand-by

The FSRA system does not participate in the longitudinal control of the vehicle, but it can be triggered by the driver to enter the working state at any time.

3) FSRA active

- 5) In the hold state, the automatic parking control will be used to keep the subject vehicle stationary (to take over the electronic braking function of the ESP).

5.2 Functions

5.2.1 Control mode

The switching between the distance control state and the speed control state shall be automatically completed by the system.

5.2.2 Stationary or slow moving targets

The system attempts to stop the subject vehicle behind the target vehicle within its deceleration capacity. Whether the system responds to stationary or slow moving targets, this Standard does not make mandatory design requirements. If the system does not respond to stationary or slow moving targets, it shall be declared in the vehicle's user manual.

5.2.3 Vehicle following ability

When the vehicle is running in a steady state, the minimum clearance between vehicles shall be set to $\text{MAX}(c_{\min}, \tau_{\min} \times v)$. When operating under transient conditions, the clearance can be temporarily lower than the minimum clearance. At this time, the system shall have the function of automatic adjustment to adjust the clearance to the desired value.

When the vehicle speed is higher than 8m/s, the setting range of headway is: $1.5\text{s} \leq \tau \leq 2.2\text{s}$. [GB/T 20608-2006, definition 5.2.2].

Minimum requirement: When the target vehicle starts to stop with deceleration as a_{stopping} and driving speed as v_{stopping} , the system can control the subject vehicle to stop behind the target vehicle.

Where, $c_{\min}$ is the minimum steady state headway when the system is operating in the following control mode within the full speed range (including the hold state), and $c_{\min} \geq 2\text{m}$;

$\tau_{\min}$ is the minimum steady-state time headway available for selection, which can be used for FSRA control in the full speed range, $\tau_{\min} \geq 1\text{s}$;

v is the speed of the subject vehicle;

τ is the time headway;

$a_{\text{stopping}} = 2.5\text{m/s}^2$;

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

When the driver and the FSRA system both have engine power control (throttle input) requests, whichever is greater shall prevail. This will enable the driver to always give priority to engine power control over the FSRA system. If the driver's braking demand is higher than that of the FSRA system, the automatic braking force of the FSRA system shall be released immediately. There shall be no significant response delay for the driver to control the accelerator pedal.

The locking time of the wheels in the automatic braking state shall not exceed the allowable value of ABS. The FSRA system does not interfere with the ABS system.

The wheel slip time caused by the engine power control effect of the FSRA system shall not exceed the allowable value of the traction control system. The FSRA system does not interfere with the traction control system.

The FSRA system can appropriately adjust the time headway to adapt to changes in the driving environment (such as inclement weather). But the adjusted time headway shall not be lower than the driver's set-value.

If the FSRA system allows the driver to select the desired time headway, one of the following methods shall be adopted:

- a) If the FSRA system still stores the last selected headway value after shutting down, then when the system is activated again, the time headway value shall be displayed to the driver;
- b) If the FSRA system does not store the recently-selected time headway value after shutting down, then the time headway shall be set to the default value ($\geq 1.5\text{s}$).

If the vehicle is equipped with both the FSRA system and the conventional cruise control system, there shall not be automatic switching between the two.

The system can be activated by the driver at any time, even if the vehicle is stationary or the driver is stepping on the brake pedal.

5.3.2 Display

- a) Provide the driver with the most basic feedback information, including FSRA system state and set speed, and they can be combined together to show the output. For example, the set speed information is displayed only when the FSRA system is activated, and the display shall not affect driving behavior;
- b) If the FSRA system fails to work normally, the driver shall be notified in time. The prompt symbol shall comply with the regulations (see 0);
- c) If the FSRA system is automatically deactivated, the driver shall be notified

in time. The prompt symbol shall comply with the regulations (see 0);

- d) If the vehicle is equipped with both the FSRA system and the conventional cruise control system, the driver shall be notified of the system that is currently working;
- e) If the forward vehicle is locked as the target vehicle, the prompt message "Detection Vehicle" shall be used to indicate that the FSRA system is detecting the vehicle in front.

5.3.3 Symbols

If symbols are used to identify the function and failure state of the FSRA system, it shall comply with the requirements of ISO 2575.

5.4 Operational restrictions

To ensure comfort, when the vehicle speed is lower than 5m/s, no sudden braking force release is allowed, such as the releases caused by:

- a) The target vehicle is lost;
- b) System failure (not the failure of the brake itself) causes the system to automatically deactivate;

The lowest set speed should be: $v_{set_min} \geq 7\text{m/s}$.

When the vehicle speed is higher than 20m/s, the average deceleration of the FSRA system shall not be greater than 3.0m/s^2 (it is averaged according to the sampled value with a length of 2s), [GB/T 20608-2006, definition 5.4]. When the vehicle speed is lower than 5m/s, the average deceleration of the FSRA system shall not be greater than 4.1m/s^2 (average the sampled value with a length of 2s).

When the vehicle speed is higher than 20m/s, the average rate of change of the deceleration of the FSRA system shall not be greater than 2.5m/s^3 (it is averaged according to the sampled value with a length of 1s), [GB/T 20608-2006, definition 5.4]. When the vehicle speed is lower than 5m/s, the average rate of change of the deceleration of the FSRA system shall not be greater than 3m/s^3 (average the sampled value with a length of 2s).

When the vehicle speed is higher than 20m/s, the average acceleration of the FSRA system shall not be greater than 2m/s^2 (average according to the sampled value with a length of 2s), [GB/T 20608-2006, definition 5.4]. When the vehicle speed is lower than 5m/s, the average acceleration of the FSRA system shall not be greater than 3.1m/s^2 (average the sampled value with a length of 2s).

The minimum reflection cross section of test targets A and B is 20cm^2 .

- Test target A is a diffuse reflector with $\text{CTT} = 2\text{m}^2/\text{sr} \pm 10\%$ (see Annex A);
- Test target B is a diffuse reflector, and its $\text{CTT} = 1\text{m}^2/\text{sr} \pm 10\%$.

NOTE: The test target is defined by the parameters of the reflector.

Target A shall represent at least 95% of vehicles driving on highways.

Target B represents the reflectivity of a vehicle with a dirty surface and no retro-reflector.

6.2.2 Millimeter wave radar

The test target is defined by the scattering cross section RCS of the radar signal. The frequency range is $20\text{GHz} \sim 95\text{GHz}$.

- The RCS of test target A shall be 10m^2 ;
- The RCS of test target B shall be 3m^2 .

For obviously different frequency ranges, RCS shall be redetermined and defined (see Annex A).

6.3 Automatic stopping ability test

6.3.1 Test target vehicle

Install the test target A as described in 0 at the rear of the target vehicle. The remaining uncovered surfaces are hidden according to the following principles: After removing test target A, make the radar cross section RCS at the rear of the vehicle not greater than 2m^2 or make its reflectivity not greater than 20% of the test target.

6.3.2 Initial conditions

The driving speed of the target vehicle is V_{stopping} ;

The width range of the target vehicle is: $1.4\text{m} \sim 2.2\text{m}$;

The subject vehicle runs in the following control mode and follows the target vehicle steadily;

In the whole test process, the expected headway value is τ_{min} ;

The lateral deviation between the longitudinal centerline of the subject vehicle and the longitudinal centerline of the target vehicle is less than 0.5m (see Figure 6).

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