

GRRF Ad-hoc Electronic Vehicle Stability Control Meeting 25th January 2005*Agenda Items 4 & 5***Proposals for Provisions for Vehicle Stability Control Systems
and Possible Test Procedures***Transmitted by the Expert from Russian Federation***A. Background**

According to the provisions set in the document EVSC04-01, the objective of utilization of Electronic Vehicle Stability Control Systems is improvement of dynamic behaviour of single vehicles and tractor-trailer combinations so as the risks of losing stability of those become noticeably lower.

There are only few circumstances causing losing stability of vehicles. Depending on driving conditions at which they occurred, utilization of Vehicle Stability Function not always helps driver to reach his driving objectives, especially if one of those is completion of a maneuver as soon as possible (a case of obstacle bypass). In such conditions it should be expected that Vehicle Stability Function be not realized, in particular in regards to braking.

The Table 1 below represents circumstances causing losing stability of vehicles and possible realization of Vehicle Stability Function.

Table 1

Vehicle type	Maneuver	Circumstance of losing stability	Description of vehicle behavior	Possible realization of Vehicle Stability Function	
				Helpful – to be welcomed	Harmful – to be avoided
Single vehicle	Turning	Vehicle drifts from the trajectory	Vehicle yaw rate is higher than expected	Application of brakes	-
Single vehicle and tractor-trailer combination	Turning	Vehicle (tractor) drifts from the trajectory	Vehicle yaw rate is lower than expected	Application of brakes	-
Single vehicle and tractor-trailer combination	Obstacle bypass (lane change)	Vehicle drifts from the trajectory	Response of vehicle yaw rate on the driver's steering input is too long in time	-	Application of brakes
Single vehicle and tractor-trailer combination	Obstacle bypass (lane change)	Vehicle drifts from the trajectory	Steering torque is too high	-	Application of brakes
Tractor-trailer combination	Turning	Trailer drifts from the trajectory	Folding angle rate of a combination is higher than expected	Application of brakes. Increase of cornering stiffness in coupling device.	-
Single vehicle and tractor-trailer combination	Turning	Vehicle (trailer) rolls over	Vehicle roll angle becomes too high	Application of brakes. Increase of suspension roll stiffness (See Note).	-

Vehicle type	Maneuver	Circumstance of losing stability	Description of vehicle behavior	Possible realization of Vehicle Stability Function	
				Helpful – to be welcomed	Harmful – to be avoided
Single vehicle and tractor-trailer combination	Obstacle bypass (lane change)	Vehicle (trailer) rolls over	Vehicle roll angle becomes too high	Increase of suspension roll stiffness (See Note).	Application of brakes. Increase of cornering stiffness in coupling device.

Note: The process of vehicle rolling over depends on suspension roll stiffness. In case of high roll stiffness wheels lift off the ground quickly. For this case additional increase of roll stiffness will not improve the situation. If the suspension roll stiffness is relatively low, roll angle of sprung mass increases at first and then wheels lift off the ground. For this case additional increase of suspension roll stiffness would be very helpful. It can be realized, for example, on air spring.

Considering data presented in the Table 1, one can realize that:

1. For such maneuvers as obstacle bypass (characterized by multiple continuous steering inputs) it would be better not use Vehicle Stability Function.

2. For such maneuvers as turning (driving on a curvature) Vehicle Stability Function can be used in accordance with the following criterions:

a) If single vehicle stability is limited by yaw rate, application of brakes has to be processed in accordance with the level of increase of vehicle yaw rate or lateral acceleration.

b) If tractor-trailer combination stability is limited by increase of folding angle rate of a combination, application of brakes has to be processed in accordance with the level of increase of folding angle rate of combination or lateral acceleration.

c) If single vehicle or trailer stability is limited by rolling over, application of brakes has to be processed in accordance rate of increase of roll angle of sprung mass at the cross sections laying through vehicle axles, or rate of change of load distribution between left and right wheel of each vehicle axle or vehicle lateral acceleration.

It would be recommended that the certain explanation of realization of Vehicle Stability Function at least in regards to above-described criterions, to be provided by the manufacturer at the time of type approval.

The Vehicle Stability Function being utilized on vehicle can be considered effective, if the following can be provided:

(1) The Vehicle Stability Function does not deteriorate vehicle behavior in response to driver's control inputs;

(2) The Vehicle Stability Function is realized depending on certain control inputs of a driver and vehicle speed as declared by the manufacturer;

(3) The Vehicle Stability Function allows reaching certain maximum level of lateral acceleration, yaw rate, folding angle rate of combination, rate of change of load distribution between left and right wheel of each vehicle axle whatever is declared by the manufacturer and confirmed at the time of assessment of vehicle performance by the Technical Service.

If the Vehicle Stability Function is not activated due to switching off or malfunction, the vehicle dynamic behavior should remain at certain acceptable level.

B. Revision of Proposals for Provisions for Vehicle Stability Control Systems (document EVSC04-01)

Note: The deleted text is crossed out; the added text is underlined.

1. The objective of use of Vehicle Stability Control Systems should be clearly mentioned in the paragraph 2.28:

2.28. “Vehicle Stability Function” means an electronic control function for a power-driven vehicle ~~which improves the dynamic stability of the vehicle~~ provided for lowering noticeably the risks of losing the dynamic stability of the vehicle that might be followed by vehicle drift from the demanded trajectory or its rolling over. “Vehicle Stability Function” shall include a directional control and may include a roll-over control as defined below: ...

2. Modify the paragraph 5.2.1.31 by including the new provisions:

5.2.1.31. Special requirements for vehicles equipped with a vehicle stability function where the installation of such equipment is mandatory.

5.2.1.31.1. Vehicle stability function shall allow reaching certain maximum level of lateral acceleration, yaw rate, folding angle rate of tractor-trailer combination, rate of change of load distribution between left and right wheel of each vehicle axle as set by the vehicle manufacturer, at which the objective of use of such function, as mentioned in the paragraph 2.28, is reached.

5.2.1.31.2. Vehicle stability function shall not deteriorate vehicle behaviour in response to the driver’s control inputs.

5.2.1.31.3. When the vehicle stability function is not activated due to switching off or malfunction, the satisfactory vehicle dynamic behavior should be demonstrated.

5.2.1.31.4. In case when the vehicle stability function activates automatic control inputs for prevention of possible losing the dynamic stability of the vehicle, the driver must be given an audible warning signal.

5.2.1.31.5. – (former 5.2.1.31.1)

5.2.1.31.6. – (former 5.2.1.31.2) To realise the functionality defined above a vehicle stability function shall include, in addition to selective braking and where appropriate automatically commanded braking, ~~at least~~ the following:

- The ability to regulate engine power output.
- The determination of vehicle behaviour from measured values of yaw rate, lateral acceleration, rate of change of load distribution between left and right wheel of each vehicle axle and wheel speeds and from the driver’s control input to the braking system, to the steering system, and to the engine.
- In addition – the ability to regulate stiffness of the suspension.
- In case of tractor-trailer combination – in addition the determination of vehicle combination behaviour from measured value of folding angle rate of combination.

The next subparagraphs of the paragraph 5.2.1.31 are renumbered consequently and currently remained unchanged until the clear assessment procedure of vehicle stability function that includes particular test procedures will be agreed.

3. Modify the paragraph 5.2.2.21 by including the new provisions:

5.2.2.21. Special requirements for a trailer equipped with a trailer roll stability function.

5.2.2.21.1. Trailer roll stability function shall allow reaching certain maximum level of lateral acceleration and rate of change of load distribution between left and right wheel of

each trailer axle as set by the trailer manufacturer, at which the objective of use of such function, as mentioned in the paragraph 2.29, is reached.

5.2.2.21.2. Trailer roll stability function shall not deteriorate behaviour of the tractor-trailer combination in response to the driver's control inputs.

5.2.1.31.3. When the trailer roll stability function is not activated due to switching off or malfunction, the satisfactory dynamic behavior of the tractor-trailer combination should be demonstrated.

5.2.2.21.4. In case when the trailer roll stability function activates automatic control inputs for prevention of possible losing the roll stability of the trailer, the driver must be given an audible warning signal.

5.2.2.21.5. – (former 5.2.2.21.1) Where a trailer is installed with a trailer roll stability function as defined in paragraph 2.29, the function shall have the ability to control individual or multiple wheel speeds by selective braking or automatically commanded braking and, in addition, may control stiffness of the suspension based on the evaluation of actual vehicle behaviour that may lead to the rolling over of the trailer.

5.2.2.21.6. – (former 5.2.2.21.2) To realise the functionality defined above a trailer roll stability function shall include, in addition to selective braking and/or automatically commanded braking, at least the following:

- The determination of trailer behaviour from measured values of lateral acceleration, rate of change of load distribution between left and right wheel of each trailer axle and wheel speeds.
- In addition – the ability to regulate stiffness of the suspension.

The next subparagraphs of the paragraph 5.2.2.21 are renumbered consequently and currently remained unchanged until the clear assessment procedure of vehicle stability function that includes particular test procedures will be agreed.

C. Proposals for Possible Test Procedures

The tests have to be performed in order to verify compliance with the provisions of the paragraphs 5.2.1.31 and 5.2.2.21.

The objectives of the tests:

A. To become assured that the vehicle stability function (trailer roll stability function) is realized effectively.

The fact that the vehicle (tractor-trailer combination) meets the criteria set by the manufacturer in regards to reaching the certain maximum level of lateral acceleration, yaw rate, folding angle rate of tractor-trailer combination, rate of change of load distribution between left and right wheel of each vehicle axle, etc. can be considered as the evidence of reaching this objective.

The typical test maneuver, taking into account the data presented in the Table 1, will be step steering input. In order to avoid possible rolling over at the time of carrying out the tests, the initial data for the tests with the step steering input (steering angle, vehicle speed) can be chosen basing on the results of the static tilting test and the tests of driving on a circle. Such an approach reduces the risk of vehicle rolling over during the tests, therefore there would be no need in using such expensive constructions as supporting wheels, etc.

B. To become assured that the vehicle stability function (trailer roll stability function) does not deteriorate vehicle behaviour in response to the driver's control inputs.

C. To become assured that the vehicle dynamic behavior is not significantly reduced when the vehicle stability function (trailer roll stability function) is deactivated.

The typical test maneuver for the both objectives B and C will be, for example, lane change maneuver. This test maneuver is considered as less dangerous in regards to rolling over as the test with the step steering input.

The description of the test procedures is presented in the Table 2.

Table 2.

Objective of the test	Test procedure	Reference concerning the test procedure	Test results and their interpretation	Notes
A	Static tilting on a test platform	ECE Regulations No. 111, Annex 3.	Tilting table angle at the time when one wheel of a vehicle lifts off the tilting table. The tangent of the tilting table angle equals to the level of vehicle lateral acceleration, when the vehicle is driven on a circle with the constant speed.	This test is intended to find out the level of the lateral acceleration, at which vehicle rolling over becomes possible.
	Driving on a circle	ISO 4138	Vehicle lateral acceleration and related steering wheel angle.	This test is intended to get the initial steering wheel angles as the input for the step steering test with avoidance of rolling over.
	Step steering input	ISO 7401	Characteristics of lateral acceleration, yaw rate, folding angle rate of tractor-trailer combination, rate of change of load distribution between left and right wheel of each vehicle axle, etc. in response to the step steering input. These characteristics have to reach their certain maximum level as set by the manufacturer	This test is intended for evaluation of the performance of the vehicle stability function (trailer roll stability function).
B	Lane change	Informal document No. GRRF-55-20	The test is intended for determination of the maximum speed of the test maneuver and the factors that limit the said speed. When the vehicle stability function (trailer roll stability function) is activated and deactivated, the maximum speed of the test maneuver has to be at the same level.	The test procedure is being used in Russia for evaluation of vehicle handling for more than 25 years.
C	Lane change (vehicle stability function or trailer roll stability function is disabled)			

The real tests partly may be substituted by computer simulation. In this case the data of correlation of results of real tests and computer simulation has to be provided.

The described above test procedures are proposed for consideration of the EVSC Informal Group. Should the Group accept the proposal, the detailed test procedures would be provided for inclusion into the amendments to the Regulations No. 13 as the separate annex.