

## Working Document

- GRRF agreed amendment text (GRRF-69-06-Rev1, AMEVSC-05-01e) highlighted in green
- Text amendment for consideration in red
- 6<sup>th</sup> meeting text in blue (orange text proposed as an alternative to the preceding text subsequent to the official closure of the meeting)
- 7<sup>th</sup> meeting: yellow highlight

## Annex 21 - Appendix 2

## DYNAMIC STABILITY SIMULATION TOOL AND ITS VALIDATION

## 1. SPECIFICATION OF THE SIMULATION TOOL

- 1.1. The simulation method shall take into account the main factors which influence the directional and roll motion of the vehicle. ~~A typical~~ The simulation ~~mathematical vehicle~~ model ~~may shall~~ include the following ~~vehicle~~ parameters as applicable ~~in an explicit or implicit??~~ form <sup>1</sup>:

- ~~(a) Axle/wheel~~
- ~~(b) Suspension~~
- ~~(c) Tyre~~
- ~~(d) Chassis/vehicle body~~
- ~~(e) Power train/driveline, if applicable~~
- ~~(f) Brake system~~
- ~~(g) Payload~~
- (a) Vehicle category;
- (b) Character of the vehicle;
- (c) Vehicle configuration(s) (e.g. 4x2, 6x2, etc., identifying ~~including~~ axle functionality (e.g. free running, driven, lifted, steered) and position);
- (d) Additional steering axles (e.g. forced steering, self-steering);
- (e) Steering ratio;
- (f) Drive axles (effect on wheel speed sensing and vehicle speed) ~~number and position~~);
- (g) Lift axles (detection/control and wheelbase change effect when lifted);
- (h) Engine management (communication, control and response);
- (i) Gearbox type (e.g. manual, automated manual, semi-automatic, automatic);
- (j) Drive train options (e.g. retarder);
- (k) Differential type (e.g. standard or self-locking);
- (l) Differential lock(s) (driver selected);
- (m) Brake system type (e.g. air over hydraulic, full air);
- (n) Brake type (e.g. disc, drum (single wedge, twin wedge, S-cam));
- (o) Anti-lock braking configuration;

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- (p) Wheelbase;
- (q) Tyre type (e.g. structure, category of use, size);
- (r) Track width;
- (s) Suspension type (e.g. air, mechanical, rubber);
- (t) Centre of gravity height;
- (u) Lateral acceleration sensor position;
- (v) Yaw rate sensor position;
- (w) Loading.

Footnote <sup>1</sup>: Parameters not covered shall be a limitation on the use of the simulator

1.1.1. The Technical Service conducting the validation shall be provided with an information document covering at least the points in paragraph 1.1. above.

1.2. The Vehicle Stability Function shall be added to the ~~simulation vehicle~~ simulation model by means of:

- a) a subsystem (software model) of the simulation tool as software-in-the-loop ~~of the simulation tool~~,
- or
- b) ~~the an actual~~ electronic control ~~box~~ unit in a hardware-in-the-loop configuration.

1.3. In the case of a trailer, the simulation shall be carried out with the trailer coupled to a representative towing vehicle.

1.4 Vehicle loading condition

1.4.1. The simulator shall be able to take into account the laden and unladen conditions.

1.4.2. The load shall be considered to be a fixed load with given properties (mass, mass distribution and ~~maximum recommended~~ height of the centre of gravity) ~~specified by the manufacturer. In conflict with preceding paragraph??~~

## 2. VALIDATION OF THE SIMULATION TOOL

2.1. The validity of the applied modelling and ~~the~~ simulation tool shall be verified by means of comparisons with a practical vehicle test(s). The test(s) utilised for the validation shall be those which, without control action, would result in loss of directional control (under-steer and over-steer) ~~and/or~~ roll-over control as appropriate to the functionality of the stability control function installed on a ~~representative~~ vehicle.

During the test(s) the following motion variables, as appropriate, shall be recorded or calculated in accordance with ISO 15037 Part 1:~~2005 2006: General conditions for passenger cars~~ or Part 2:2002: ~~General conditions for heavy vehicles and buses~~ (depending on the vehicle category):

- (a) yaw velocity;
- (b) lateral acceleration;
- (c) wheel load or wheel lift;

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- (d) forward velocity;
- (e) driver input.

~~Lift axle—change in wheelbase—detection and control??~~  
~~Engine and retarder control??~~

- 2.2. The objective is to show that the simulated vehicle behaviour and operation of the vehicle stability function is comparable with that seen in practical vehicle tests.

~~The ability of the simulator to be used with intermediate values of the parameters shall be shown by conducting simulations with changed parameters. This shall only be applicable to parameters that are not significant in the dynamic behaviour of the vehicle and operation of the vehicle stability function.~~

The ability of the simulator to be used with parameters that have not been validated by a practical vehicle test shall be shown by conducting simulations with varied parameter values. The results of these simulations shall be checked to be logical and similar compared to the results of the known practical vehicle tests.

- 2.3. The simulator shall be deemed to be validated when its output is comparable to the practical test results produced by a given the same vehicle type during the selected manoeuvre(s) selected from those defined with Paragraph 2.1.3. or 2.2.3. of Annex 21, as appropriate.

**The simulator shall only be used with regard to features for which a comparison has been made between real vehicle tests and simulator results. The comparisons shall be carried-out in the laden and unladen condition to show the different conditions of load can be adapted to and to confirm the extreme parameters to be simulated, e.g.:**

- **vehicle with shortest wheelbase and highest centre of gravity;**
- **vehicle with longest wheelbase and highest centre of gravity.**

In the case of the steady state circular test the under-steer gradient shall be the means of making the comparison.

In the case of a dynamic manoeuvre, the relationship of activation and sequence of the vehicle stability function in the simulation and in the practical vehicle test shall be the means of making the comparison.

- 2.4. The physical parameters that are different between the reference vehicle and simulated vehicle configurations shall be modified accordingly in the simulation. ????????????
- 2.5. A simulator test report shall be produced, a model of which is defined in Appendix 3 of this Annex, and a copy attached to the vehicle approval report.