

**Document EVSC05-35 as revised at 11<sup>th</sup> October 2005 Meeting**  
**(additions in red and underlined, deletions in red with double strike through)**

**As agreed at the meeting the appendix has been subsequently developed. It and associated changes are added in blue.**

## PROPOSAL SIMULATION SPECIFICATIONS

### DYNAMIC STABILITY SIMULATION

The efficiency of the directional and/or rollover stability of ~~motor~~ power-driven vehicles, ~~trailers~~ and ~~semi-trailers~~ of categories M, N and O equipped with ~~Electronic Vehicle Stability Control systems~~ a Vehicle Stability Function, ~~shall may~~ be determined by ~~a set of~~ computer simulations. In the case of any trailer, a representative towing vehicle shall be defined for the purpose of computer simulation ~~test runs~~ in agreement with the Technical Service.

#### 1. GENERAL CONDITIONS

##### 1.1. Modelling and simulation tool

The simulations shall be carried out with a validated modelling and simulation tool which is either used by or has been agreed with ~~the~~ a type approval authority or Technical Service (see paragraph 4 below) on basis of data which verifies the simulation model against a practical vehicle test.

- 1.1.1. The simulation method shall ~~take~~ into account the main factors which influence the directional and roll motion of the vehicle. The model ~~should have~~ shall include at least the following vehicle parameters in an explicit or implicit form:

##### Axle/wheel parameters

- axle/wheel geometry;
- wheel loads;
- track width;
- centre of gravity positions of unsprung masses;
- inertia (mass, Jx, Jy & Jz) of unsprung masses;
- in the case of steered wheels:
  - principal of steering;
  - steering ratio or self steering characteristics.

##### Suspension parameters

- principal of suspension;
- height of roll centre;
- suspension ~~stiffnesses of suspension~~ (vertical and roll; lateral and for/aft if significant);
- suspension ~~damping characteristics of suspension~~;
- suspension ~~kinematics of suspension~~ (if significant);
- roll stabiliser characteristic.

##### Tyre parameters

- pure cornering characteristics;
- pure braking characteristics;
- combined cornering and braking characteristics;
- relaxation length (dynamic behaviour);
- radial/vertical stiffness;

- lateral stiffness;
- dynamic tyre/road friction coefficient ranging from low (ice) to high (dry asphalt) ~~and depending of road position on an individual wheel basis.~~

Chassis/vehicle body parameters

- centre of gravity position of sprung masses;
- inertia (mass, Jx, Jy & Jz) of sprung masses;
- chassis/vehicle body (torsional) stiffness if significant.

Power train/driveline parameters if applicable

- power source characteristics (engine traction/braking torque/torque converter);
- transmission characteristics (gear ratios);
- differential gearing (gear reduction, locking characteristics).

Brake system parameters

- dynamic characteristics of the brakes.

Pay load parameters

- centre of gravity positions;
- Inertia (mass, Jx, Jy & Jz).

Other parameters/properties

- driver model with path following properties for the subjective type of simulation tests;
- steering stiffness;
- load sharing distribution between the axles of a bogie;
- in the case of a ~~fast~~ height levelling system ~~(see paragraph 1.2.2 below)~~, the properties/characteristics of the height levelling system.

The vehicle parameter values represent the loaded condition and are expressed in SI-units. The values of relevant parameters (e.g. suspension, tyres, etc.) have to be non-linear to predict correctly the directional and roll-over stability of the vehicle.

- 1.1.2. The ~~Electronic~~ Vehicle Stability ~~System~~ Function shall be added to the simulation model by means of
- a) a subsystem (software model ~~or source code~~) of the simulation tool;
  - or
  - b) the electronic control box in a hardware-in-the-loop configuration.

~~1.2. Operating components~~

~~1.2.1. In the case of differential gearings with a locking mechanism which can be disengaged, every test must be conducted with engaged and disengaged differential lock.~~

~~1.2.2. Height levelling systems shall not be included in the simulation model unless the response time of the system is less than one second.~~

2. ~~NON-POWER-DRIVEN VEHICLES~~ TRAILERS

In the case of a ~~non-powered vehicle~~ trailer, it shall be simulated using the characteristics of a representative power-driven vehicle to be agreed by the type approval authority or Technical Service in consultation with the manufacturer of the ~~non-powered vehicle~~ trailer.

3. VEHICLE LOADING CONDITION

- 3.1. The standard test condition shall be the maximum technical permissible mass of the vehicle distributed among the axles as declared by the manufacturer such that the load on each axle is proportional to the maximum permissible load for each axle. ~~In the case of tractors for semi-trailers, the load may be re-positioned approximately half way between the kingpin position resulting from the above loading conditions and the centreline of the rear axle(s).~~

~~In the case of motor vehicles, trailers and semi-trailers of categories M, N and O used for the carriage of goods, the standard type of The~~ load shall be considered to be a fixed load with properties (mass, mass distribution and maximum recommended height of the centre of gravity) specified by the manufacturer.

In the case of a tank type vehicle the normally intended load shall be considered as an equivalent fixed load.

- 3.2. Every test shall be carried out with the stability function engaged and disengaged ~~stability system~~. ~~Also, every~~ All tests shall be ~~carried out~~ repeated in the unladen condition.

#### 4. VALIDATION OF THE SIMULATION MODEL TOOL

- 4.1.1. The validity of the applied modelling and simulation tool ~~has to~~ shall be ~~proven~~ verified by means of comparisons with a practical vehicle test(s). The test(s) utilised for the validation shall result in loss of directional control (under-steer and over-steer) or roll-over control as appropriate to the functionality of the stability control system function installed on a representative vehicle. Such a test(s) may include one or more of the following:

- ~~stationary steady state~~ circular test;
- step steer input test;
- $\mu$ -split single lane change;
- double lane change;
- reversed steering test or “fish hook” test;
- asymmetrical one period sine steer or pulse steer input test;
- other recognised tests(s).

During the test(s) the following motion variables, as appropriate, shall be recorded or calculated:

- yaw velocity ~~body~~;
- lateral acceleration ~~body~~;
- roll angle ~~body~~;
- forward velocity;
- driver input;

- 4.2. The modelling and simulation tool can be regarded as valid when the simulation data is within [5%]<sup>2</sup> for the a static (stationary circular) steady state test and within [10%]<sup>2</sup> for the other a dynamic tests of the practical test data. A simulator approval report shall be produced, a model of which is defined in the appendix, and a copy attached to the vehicle approval report.

#### ~~5. TEST SIMULATION~~

~~The test simulations to establish the dynamic stability shall be:~~

- ~~directional stability~~
  - ~~$\mu$ -split single lane change;~~
  - ~~double lane change;~~
  - ~~asymmetrical one period sine steer or pulse steer input test;~~
  - ~~...~~
- ~~rollover stability~~
  - ~~stationary circular test;~~

- ~~• step steer input test;~~
- ~~• double lane change;~~
- ~~• reversed steering or “fish hook” test;~~
- ~~• ...~~

~~===== The characteristic values of the dynamic stabilities are:~~

- ~~• directional stability~~
  - ~~• maximum path deflection;~~
  - ~~• initial speed;~~
  - ~~• amplitude lateral acceleration;~~
  - ~~• amplitude yaw velocity;~~
  - ~~• ...~~
- ~~• rollover stability~~
  - ~~• initial speed;~~
  - ~~• maximum lateral acceleration;~~
  - ~~• maximum roll angle;~~
  - ~~• ...~~

## Appendix

### VEHICLE STABILITY FUNCTION SIMULATION TOOL TEST REPORT

Test Report Number: .....

#### 1. Identification

- 1.1. Name and address of the simulation tool manufacturer
- 1.2. Simulation tool identification; name/model/number (hardware and software)

#### 2. Approved use

- 2.1. Vehicle type: (e.g. truck, tractor, bus, semi-trailer, centre-axle trailer, full trailer)
- 2.2. Vehicle configuration: (e.g. 4x2, 4x4, 6x2, 6x4, 6x6)
- 2.3. Limiting factors: (e.g. mechanical suspension only)

#### 3. Verifying vehicle test(s)

- 3.1. Description of vehicle(s) including the towing vehicle in case of trailer testing:
  - 3.1.1. Vehicle(s) identification: make/model/VIN
    - 3.1.1.1 Non-standard fitments:
  - 3.1.2. Vehicle description, including axle configuration/suspension/wheels, engine and drive line, braking system(s) and vehicle stability function content (directional control/roll-over control), steering system, with name/model/number identification:
  - 3.1.3. Vehicle data used in the simulation (explicit):
- 3.2. Description of test(s) including location(s), road/test area surface conditions, temperature and date(s):
- 3.3 Results laden and unladen with the vehicle stability function switched on and off:

#### 4. Simulation results

- 4.1. Vehicle parameters and the values used in the simulation that are not taken from the actual test vehicle (implicit):
- 4.2. Results laden and unladen with the vehicle stability function switched on and off for each test conducted under paragraph 3.2. of this appendix:

#### 5. Approval

5.1. Technical Service conducting the test <sup>(1)</sup>: .....

Signed: .....

Date: .....

5.2. Approval Authority <sup>(1)</sup>: .....

Signed: .....

Date: .....

<sup>(1)</sup> To be signed by different persons if the Technical Service and the Approval Authority is the same organisation.