Development Platform for Safe and Efficient Drive

Generic Vehicle Model - Final Release

Deliverable n.	D2.3.3 – Generic Vehicle Model - Final Release Deliverable nature is "others" [1]		
Sub Project	SP2	ADAS Development Platform	
Workpackage	WP2.3	Vehicle Modelling	
Task n.	T2.3.2	Definition and development of a generic vehicle model	
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File name	Deserve_D233_GenericVehicleModel_FinalRelease_v05.doc		
Status	Final		
Distribution	Restricted (RE)		
Issue date	08/09/2014	Creation date	25/08/2014
Project start and duration	1st of September, 2012 – 36 months		

1 Deliverables that are of a nature other than written "reports", such as "prototypes", "demonstrators" or "others", should also be accompanied by a short report, so that the European Commission has a record of their existence [1]

REVISION AND HISTORY CHART

VER.	DATE	AUTHOR	REASON
0.1	16.10.2013	N. Pallaro (CRF)	Template
0.2	25.08.2014	I. Camuffo (CRF)	Executive summary
0.3	04.09.2014	Dr. Lars Krüger (Daimler)	Peer review DAIMLER
0.4	05.09.2014	J. Perez (INRIA)	Peer review INRIA
0.5	08.09.2014	I. Camuffo (CRF)	Final version for ARTEMIS submission

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ABBREVIATION	DESCRIPTION
ADAS	Advanced Driver Assistance Systems
ASM	Automotive Simulation Models (dSPACE)
C.o.G.	Centre of gravity
CRF	Centro Ricerche Fiat
ISO	International Organization for Standardization
MBD	Multibody

EXECUTIVE SUMMARY

The purpose of **D233 deliverable – final release** (work package 2.3, task 2.3.2) is to build up and validate the simulation model of the reference vehicle selected for this task (front wheel drive L0-segment car), using the commercial tool ASM from dSPACE.

For ADAS development purpose the vehicle dynamics simulation tool should be based at least on **14 degrees of freedom vehicle model.** In the last years, the development level of vehicle simulation softwares based on 14 degrees of freedom models has reached a good level either for performance aspects, either for use flexibility. There are many suppliers in the sector providing tools for simulation of passenger cars and multi-axes vehicles. A preliminary benchmark activity has been performed on some commercially available tools, evaluating the fidelity of simulation results by a comparison with a reference Multibody vehicle model, which are the standard for vehicle dynamics simulation. The ASM simulation tool has been then selected to build the generic vehicle model for the DESERVE Project [2].

The following main subsystems are included in the vehicle dynamics model:

- Body and Wheels
- Suspensions
- Steering
- Tires

Body and Wheels are basically modelled as rigid bodies defined by their geometric and inertial properties [3][4]. Input data related to the full vehicle (body + wheels) are summarized in the table below.

Table 1 - Geometric and inertial input data

Input data	Value
Total Mass	1341 kg
C.o.G. longitudinal position (from front axle)	1.1 m
C.o.G. height (from ground)	0.63 m
Total roll moment of inertia	750 kgm^2
Total pitch moment of inertia	1710 kgm^2
Total yaw moment of inertia	1820 kgm^2
Wheelbase	2.61 m
Total track (average front-rear)	1.51 m

Primary suspensions are modelled through the characteristic curves that describe:

- the internal forces due to primary stiffness (springs, bumpstops, reboundstops, antiroll bars) and damping (shock absorbers);
- the location and orientation of the wheel plane with respect to the car body, i.e. wheel centre position [X and Y displacements] and wheel carrier orientation [toe, camber and caster angles] as a function of steering rod displacement, suspension jounce and contact forces and moments.

The necessary characteristic curves have been obtained from virtual bench tests, performed using detailed Multibody models of front suspension + steering and rear suspension.

Examples of suspension characteristic curves, which have been loaded in ASM, are shown in the figure below.

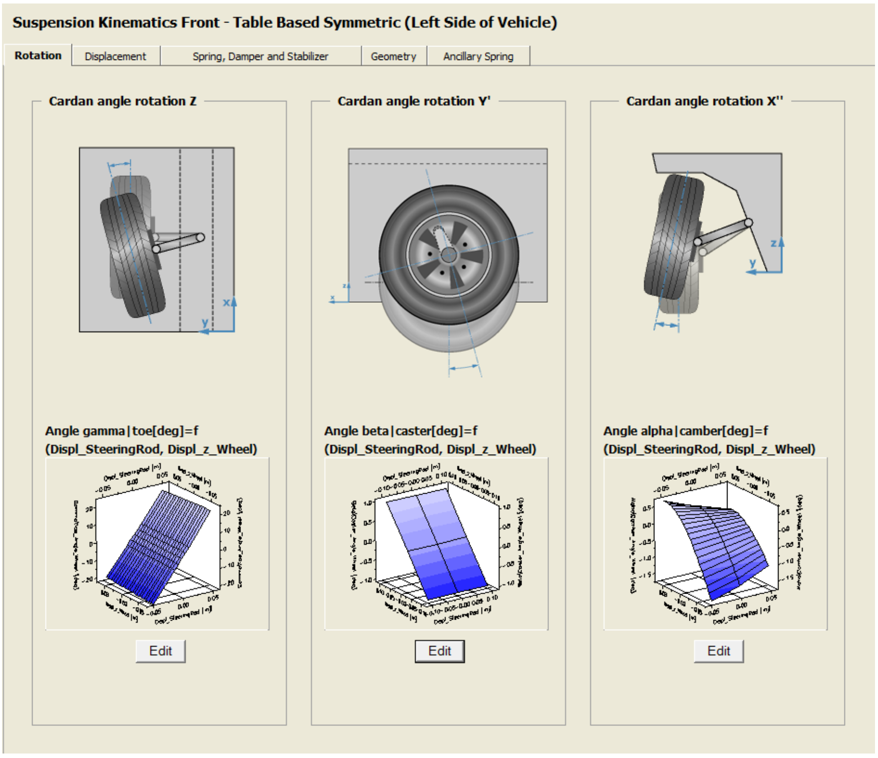

Figure 1 - Suspension kinematic curves: wheel carrier rotations

The steering is modelled as a 1 degree of freedom dynamic model defined by the parameters shown in the figure below.

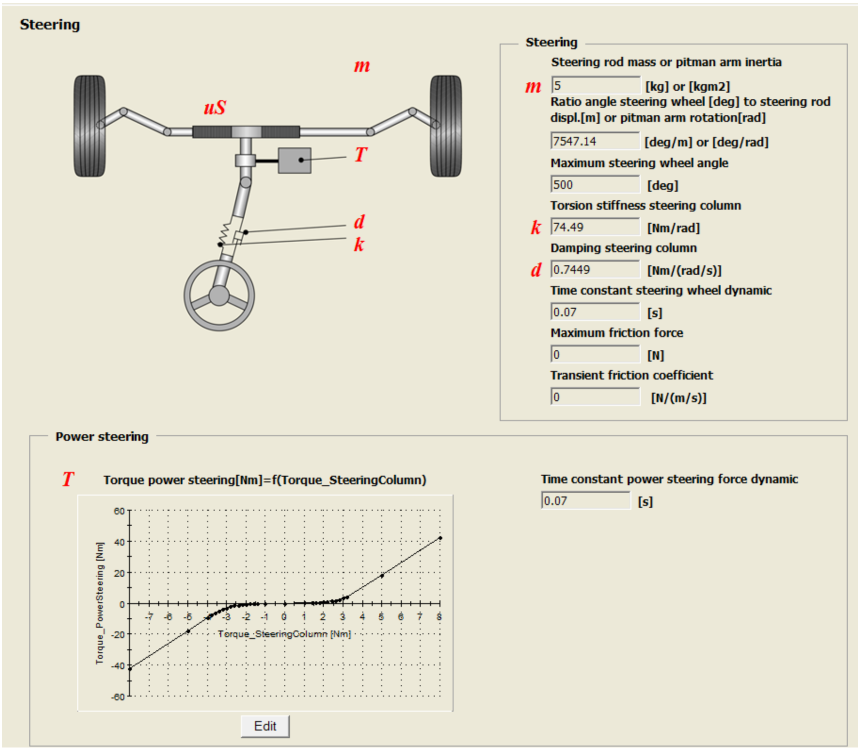

Figure 2 - Steering model input data

Vertical, lateral and longitudinal contact forces and moments between tire and road have been described using the Pacejka Magic Formula [5]. For the selected reference vehicle reasonable coefficients for a tire size 205/55 R16 have been retrieved from a tire supplier.

A handling characterization has been performed experimentally in order to collect reference data for vehicle model validation in steady-state and transient conditions.

The following ISO standard manoeuvres have been considered:

- Slow ramp steer at constant vehicle speed;
- Step steers at constant vehicle speed and at increasing levels of steering wheel angle;
- Sweep steer at constant vehicle speed and at one level of steering wheel angle;
- Straight-line limit brakes from different initial vehicle speeds.

The following signals have been measured:

- Steering wheel angle;
- C.o.G lateral and longitudinal accelerations;
- Yaw rate;
- C.o.G. sideslip angle;
- Body roll and pitch angles;
- Vehicle speed.

In the first phase of the validation process, the collected experimental data have been used to validate a detailed Multibody model of the reference vehicle, considering that the Multibody simulation environment is the Company standard for vehicle dynamics simulation.

An example of the correlation level reached between the reference Multibody model (blue curve) and the experimental data (red curve) in the case of a sweep steer manoeuvre is shown in the following figure.

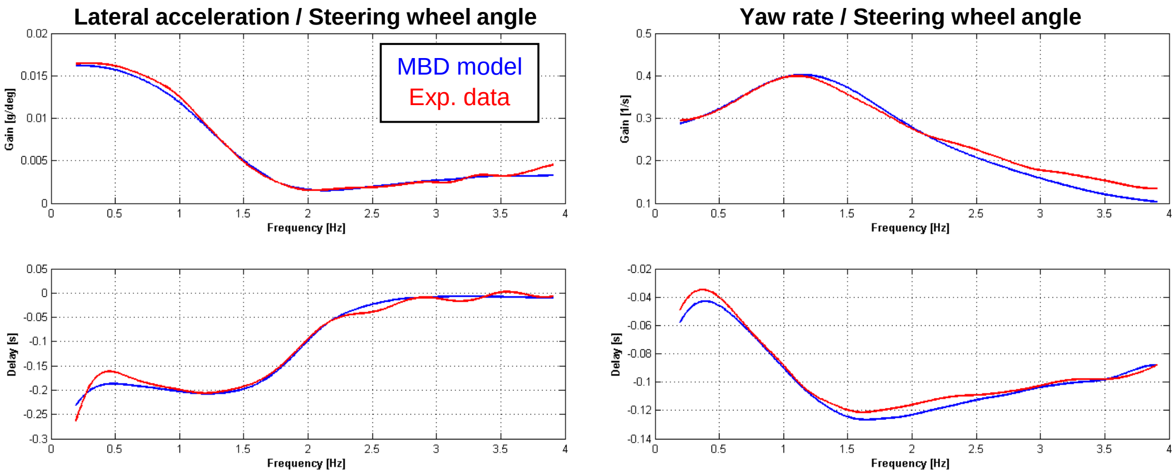

Figure 3 - Multibody vehicle model validation: handling frequency responses

In the second phase the outputs of the validated Multibody model have been used as reference to assess the accuracy of simulation results obtained from ASM model, coherently with the approach followed for the benchmark of commercially available simulation tools based on models with 14 degrees of freedom.

An example of a comparison between the outputs of the two models in the case of a slow ramp steer manoeuvre is shown in the following figure: the AMS model (blue curve) shows reasonable results in comparison to the reference Multibody model (red curve) validated with respect to the experimental data.

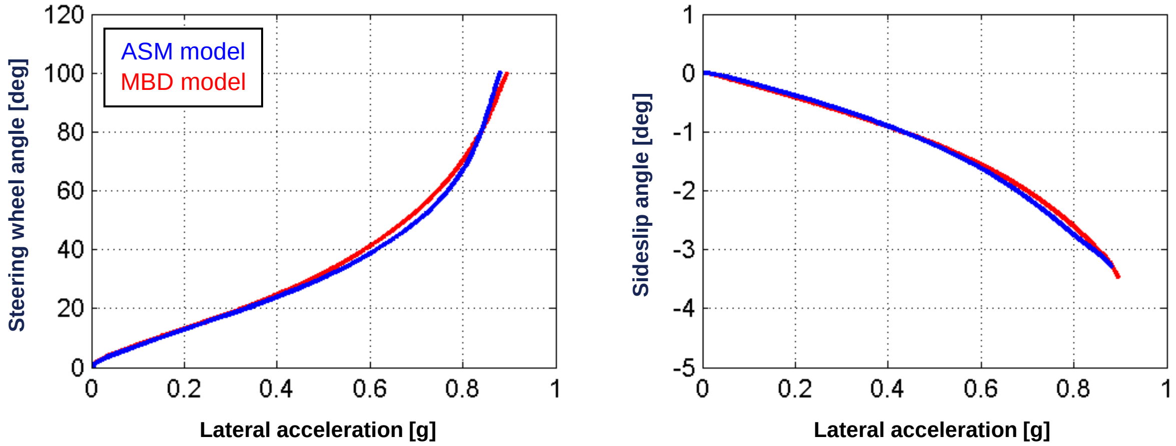

Figure 4 - ASM vehicle model validation: handling steady-state behaviour

It can be concluded that the objectives of D233 deliverable were achieved with the performed activities that have been summarised in this report. In particular the main results are:

- an ASM model of the reference vehicle has been build and is now available for following project tasks;
- the accuracy of that model has been proved to be satisfying in comparison to a reference Multibody model, previously validated with respect to experimental data.

REFERENCES

[1] Guidance Notes on Project Reporting – European Commission seventh frame work programme, Version 10/11/2008 - page 12

[2] D231 Existing vehicle models

[3] G. Genta, Meccanica dell'Autoveicolo, Levrotto & Bella

[4] Gillespie, Fundamental of vehicle dynamics, SAE, 1992

[5] J. C. Dixon, Tires, suspension and handling, 2nd ed., Arnold, 1996

[6] D232 Generic Vehicle Model - First Release