Modeling of a Real Vehicle in MBSVT and Validation Efforts using Experimental Data

Jose L. Bueno-Lopez[1], Sebastien Corner[2] and Corina Sandu[3]

[1] *Computational Mechanics Group, INSIA, Universidad Politcnica de Madrid, joseluis.bueno.lopez@upm.es*
[2] *Advanced Vehicle Dynamics Laboratory & Computational Sciences Laboratory, Virginia Tech, scorner@vt.edu*
[3] *Advanced Vehicle Dynamics Laboratory, Virginia Tech, csandu@vt.edu*

This paper presents the development of a multibody system model for a real vehicle using the MBSVT (Multibody Systems at Virginia Tech) software. The vehicle considered is a Daily 35C15 Iveco van owned by INSIA (University Institute of Automobile Research, Spain). The paper also discusses efforts made toward the validation of this model by comparing the measurements obtained experimentally while performing simple maneuvers with the corresponding simulation results. This process is the first phase of a collaborative effort between the researchers at the Universidad Politécnica de Madrid and Virginia Tech. The next phase includes a sensitivity analysis followed by the optimization of the vehicle suspension design [1].

The topology diagram of the Iveco van multibody system used to simulate the vehicle in MBSVT is shown in Fig. 1. The model has 29 rigid bodies joined by 36 kinematic joints plus 5 extra primitive constraints: 16 revolute joints, 12 spherical joints, 8 universal joints, 1 translational joint, 4 constraints to avoid the rotation of the tie rods in the steering system and the rear stabilizer bar, and a rheonomic constraint to control the steering rack. As Euler's parameters have been used for the orientation of the rigid bodies, the total number of coordinates of the multibody model is 203, and the total number of constraints is 187. Therefore, the model has 16 degrees of freedom (DOF): 6 for the rigid motion of the chassis, 4 for the rotation of the wheels, 1 per front suspension and 2 per rear suspension. The steering is not a real DOF as it is driven kinematically.

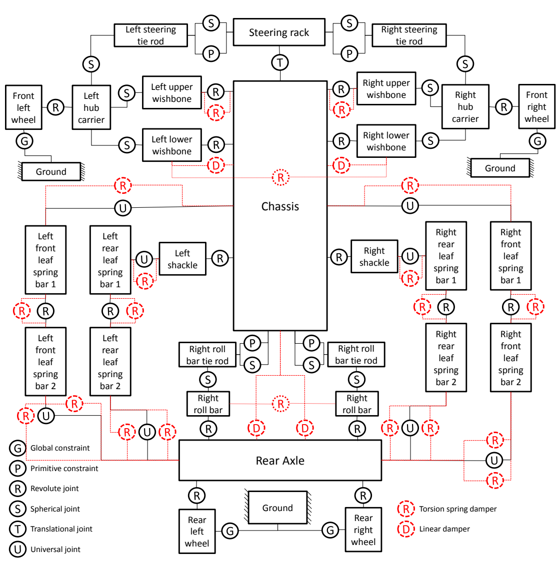
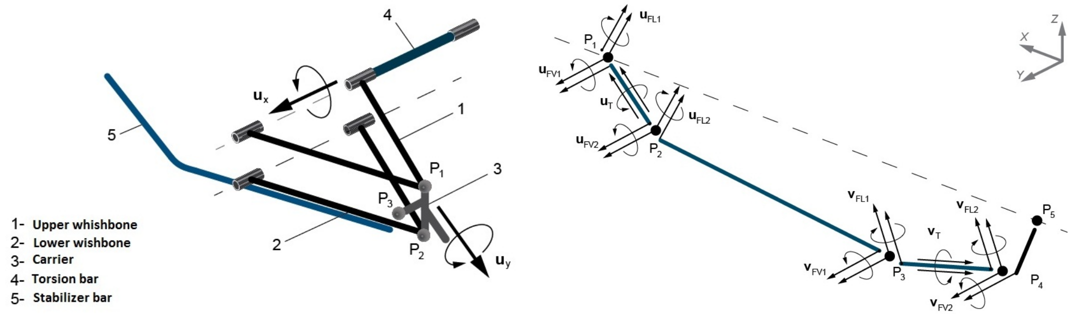


Fig. 1: Topology diagram of the Iveco van

The front suspension consists of an upper and a lower wishbone, a carrier, and a torsion and stabilizer bar, while the rear suspension is a rigid axle with leaf springs and stabilizer bar.

Schematic diagrams of the left front and rear suspension systems are shown in Fig. 2. The forward direction of the vehicle is given by the x axis. The modeling of both suspension systems is presented in [2] and [3] and was already used in [4] with another multibody formulation [5].

Experimental road tests of simple maneuvers have been done at INSIA. The information of the vehicle was acquired through the CAN-BUS port and both a GPS system and an Inertial Measurement Unit (IMU) were mounted in the vehicle. The IMU integrates the measurements provided by triaxial accelerometer, rate gyro, and magnetometer into a Kalman filter to estimate the attitude and heading. The estimation may be improved by the GPS data [6]. Fig. 3 shows the vertical acceleration recorded by the IMU (mounted as close as possible to the Center of Gravity (COG) of the vehicle) while driving over five rows of bumps. The same figure shows a preliminary simulation where the vehicle model passes over five rows of bumps with a constant velocity. It can be seen that the order of magnitude is similar for the simulation results and the experimental data; once the velocity of the simulated vehicle will correspond to the experimental velocity, the correlation of the results is expected to be improved. An error analysis will also be provided.



(a) Front left suspension (b) Rear suspension leaf spring model

Fig. 2: Front and rear suspensions schematics

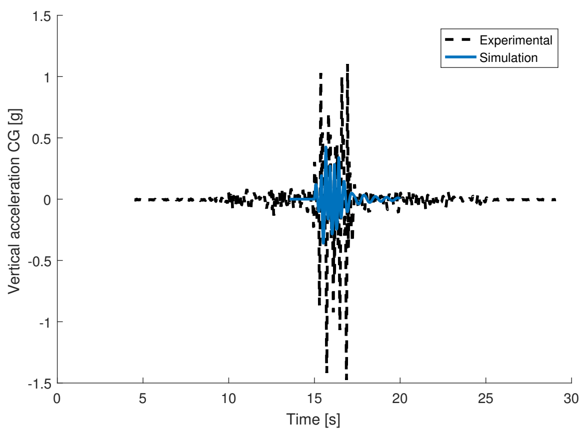


Fig. 3: Vertical acceleration of the COG while passing over bumps

The maneuvers that have been done are a constant radius turn, a double lane change maneuver, slalom, and driving over bumps. The trajectory and the velocity of the model are enforced using the data measured during the tests. The accelerations of the COG, the displacement of the suspension systems, and the roll, pitch ,and yaw angles of the simulation are compared with the test data.

The presentation will focus on the vehicle model development, a detailed comparison between the simulated and the experimental data, and an error analysis. A discussion on the steps made towards the sensitivity analysis and the design optimization of the vehicle will also be included.

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