Ride comfort development and improvement at the dynamic simulator

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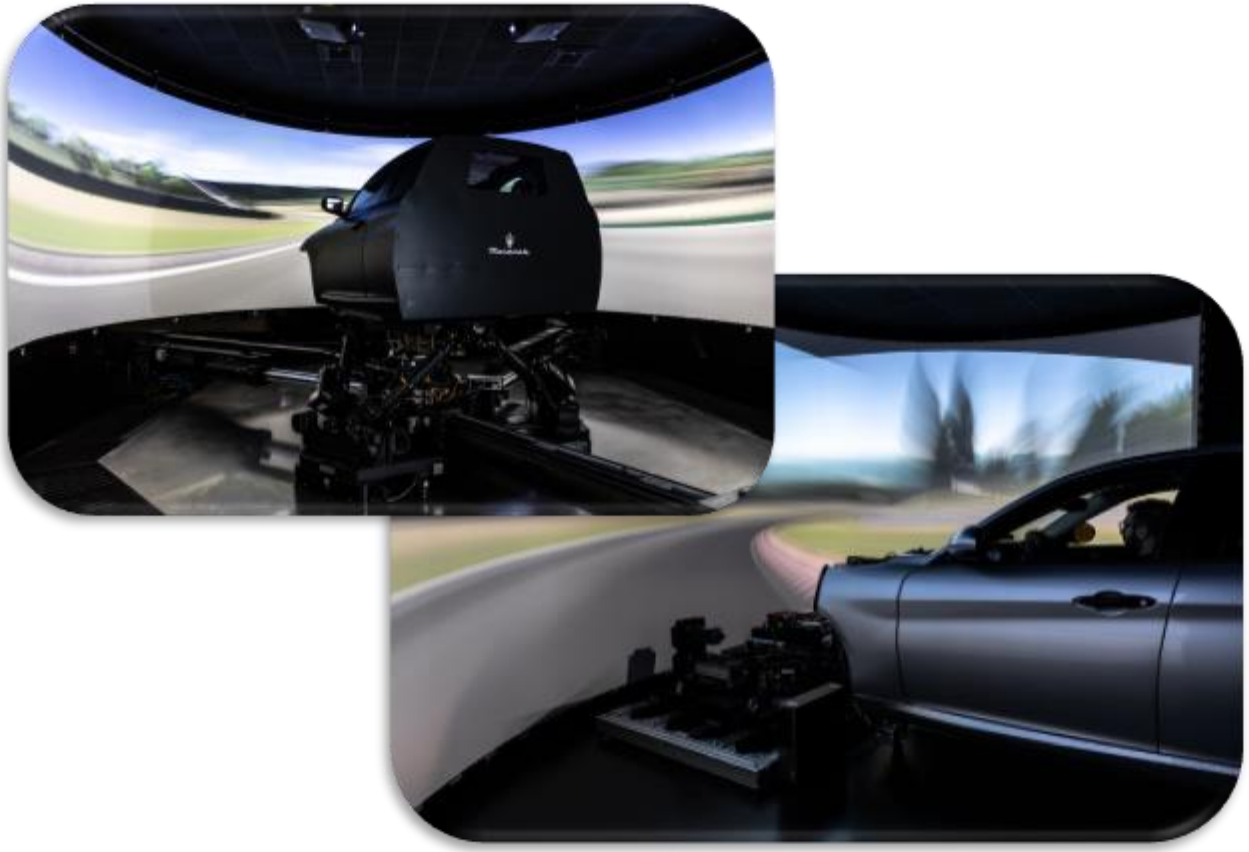
VI-Grade Simulators in Stellantis

Simulator plan and development



Program setup

- K&C
- Primary Ride
- Tire assessment
- Steering Ratio

VD Virtual Development

- HW tuning
- Active controls tuning
- Tire development
- HIL Brake/steering

Multi-functional approach

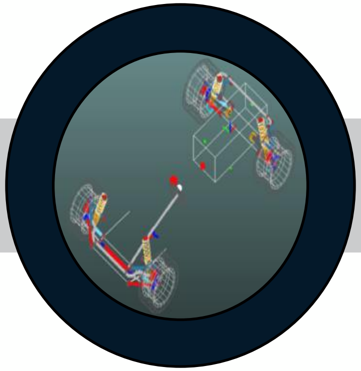
- Laptime
- PWT Thermal behavior
- Aerothermal assessment

Comfort at simulator: why? - Work flow

Starting from experimental data, model correlation has been performed in order to align simulator objective and subjective results.

Standard procedure for COMFORT assessment on driving simulator was created in order to perform subjective comfort session in advance to testing

Experimental tests



Multibody Model Validation

CRT Model validation

Simulator tests

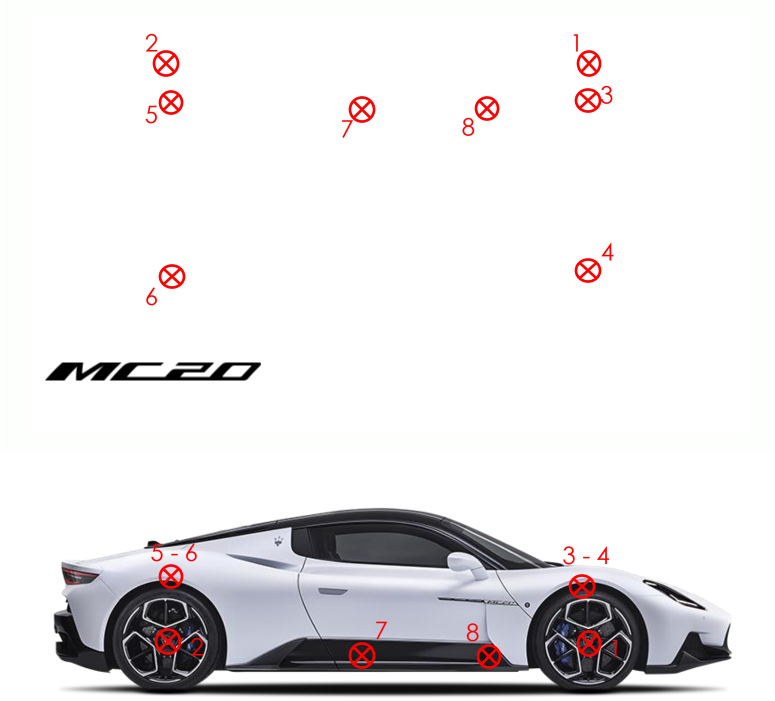
Subjective comfort session in advance to testing

Objective Evaluation of Vehicle Ride Comfort

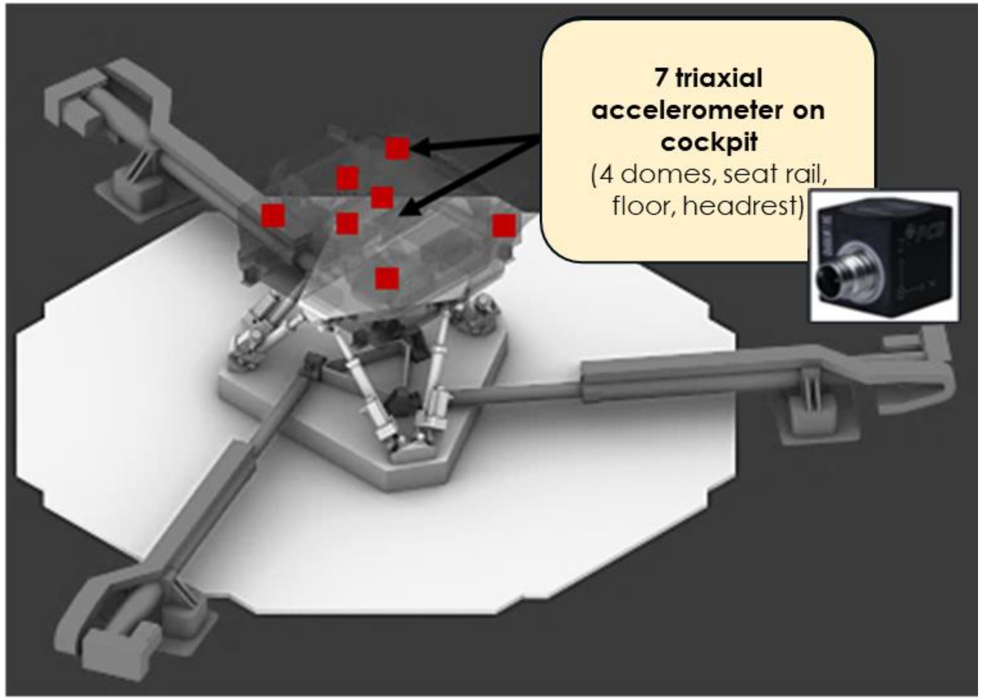
Global Stellantis Harmonized Standard Sensor have been replicated on CRT model and on Driving Simulator.

7 tri-axial accelerometer have been installed on Cockpit.

<u>Sensor's list</u>:
1. Front Left Hub
2. Rear Left Hub
3. Front Left Dome
4. Front Right Dome
5. Rear Left Dome
6. Rear Right Dome
7. Seat Rail
8. Floor



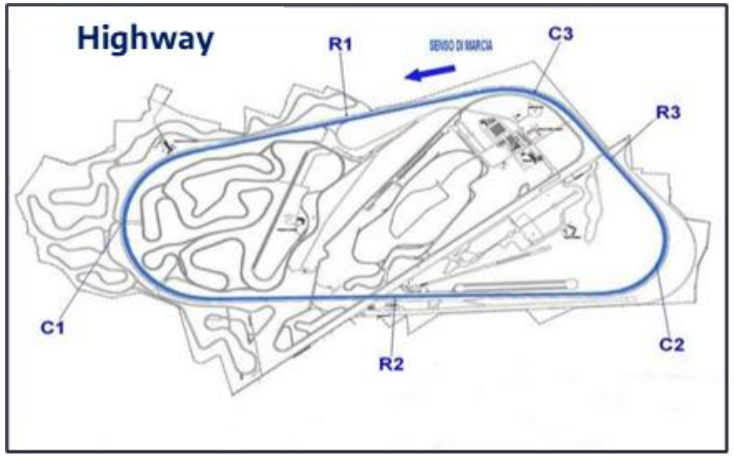
Experimental configuration

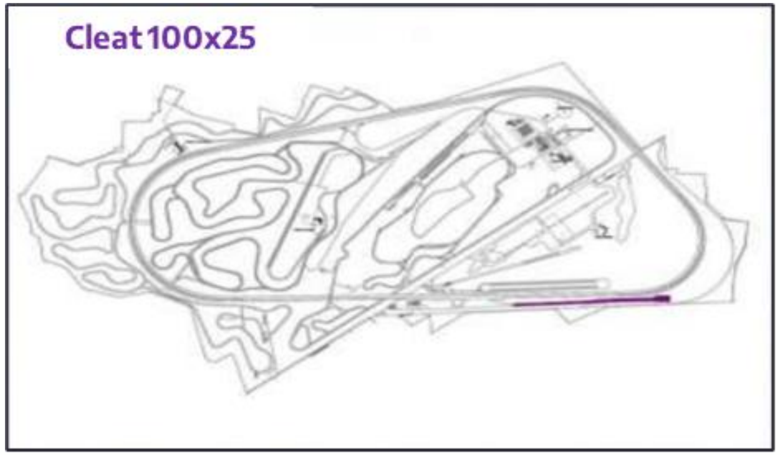


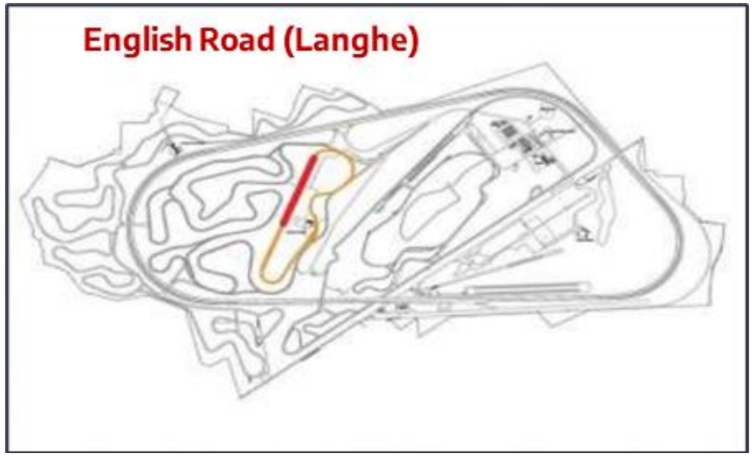
DrivSim Cockpit configuration

Objective Evaluation of Vehicle Ride Comfort

Correlation on following track (available also on Driving Simulator Scenarios) have been performed:







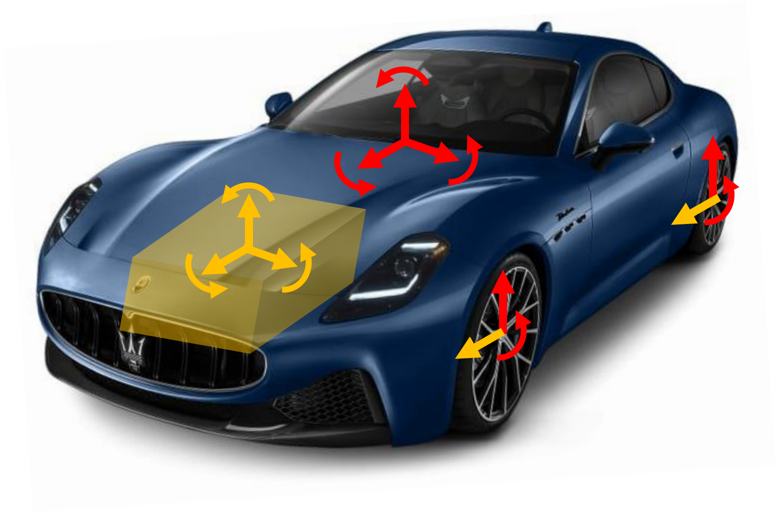
Real Time Model Upgrade and Implementation

Real Time Model for **Handling**

State of Art: CRT model with 14 dofs is used for handling assessment with high correlation on body movement and acceleration:

- Vehicle body (6 dofs)
- Wheels (2x4=8 dofs)

Real Time Model for **Ride Comfort**



In order to increase correlation on ride comfort, 10 dofs have been added on the model:

- Longitudinal dofs on wheel center (+4 dofs)
- Engine mass and suspension (+6 dofs)

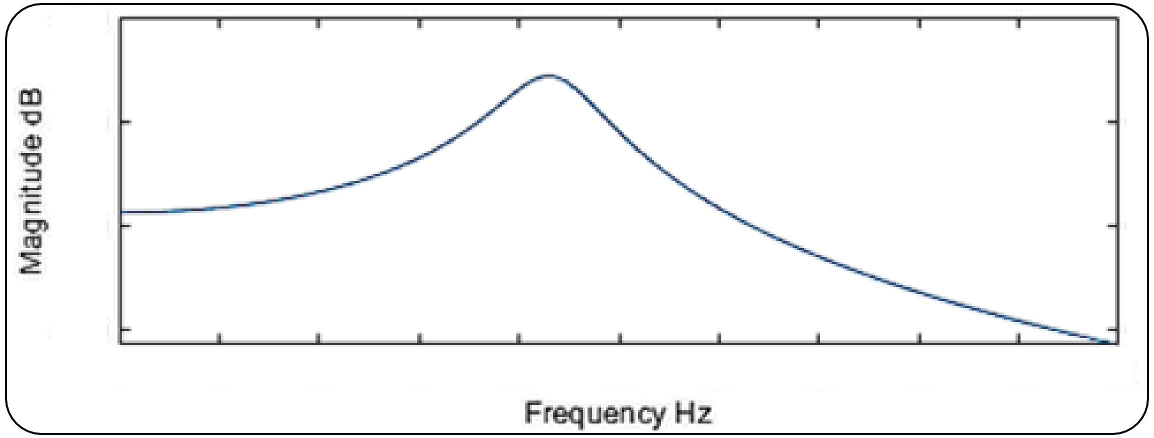
Correlation was done using CDTire Real Time model on both Multibody and CarRealTime

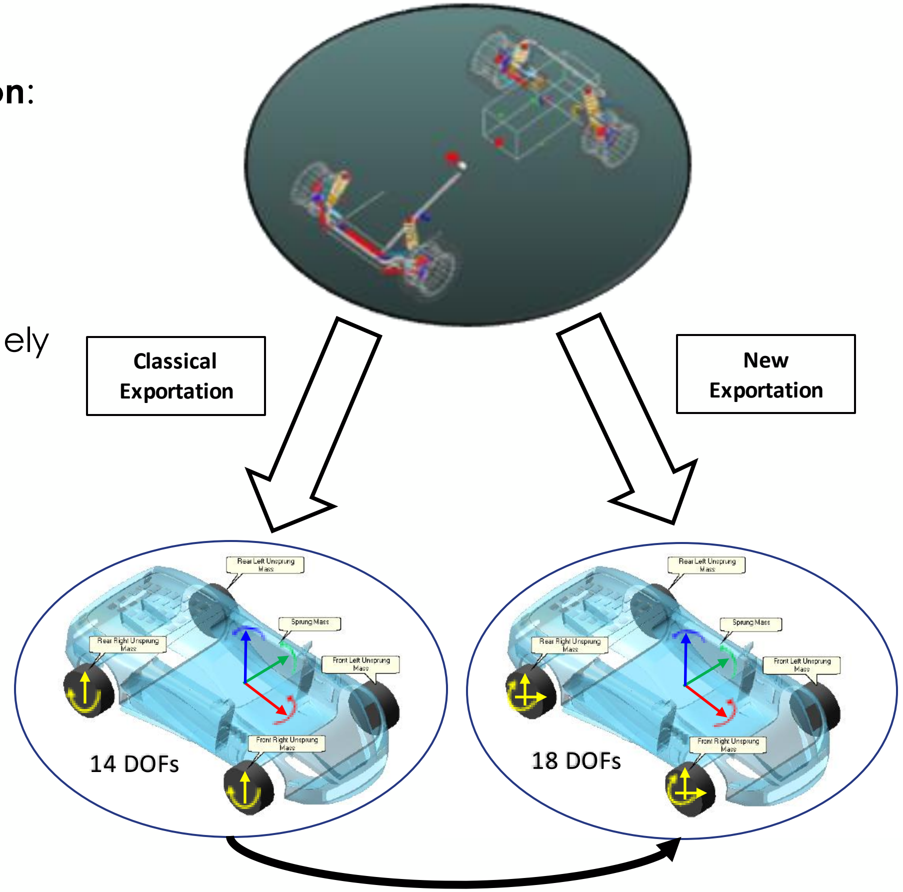
STEP1: Susp. Longitudinal DOFs Model Implementation

Multibody to CRT export procedure for additional **longitudinal DOFs on Suspension**:

A successful exportation depends on the choice of the initial parameters:

- **Frequency range up to 150 Hz**
- **Force Amplitude** must be representative of the tests to perform;
- Numerator and Denominator **order have been initially set to 0 and 2** respectively





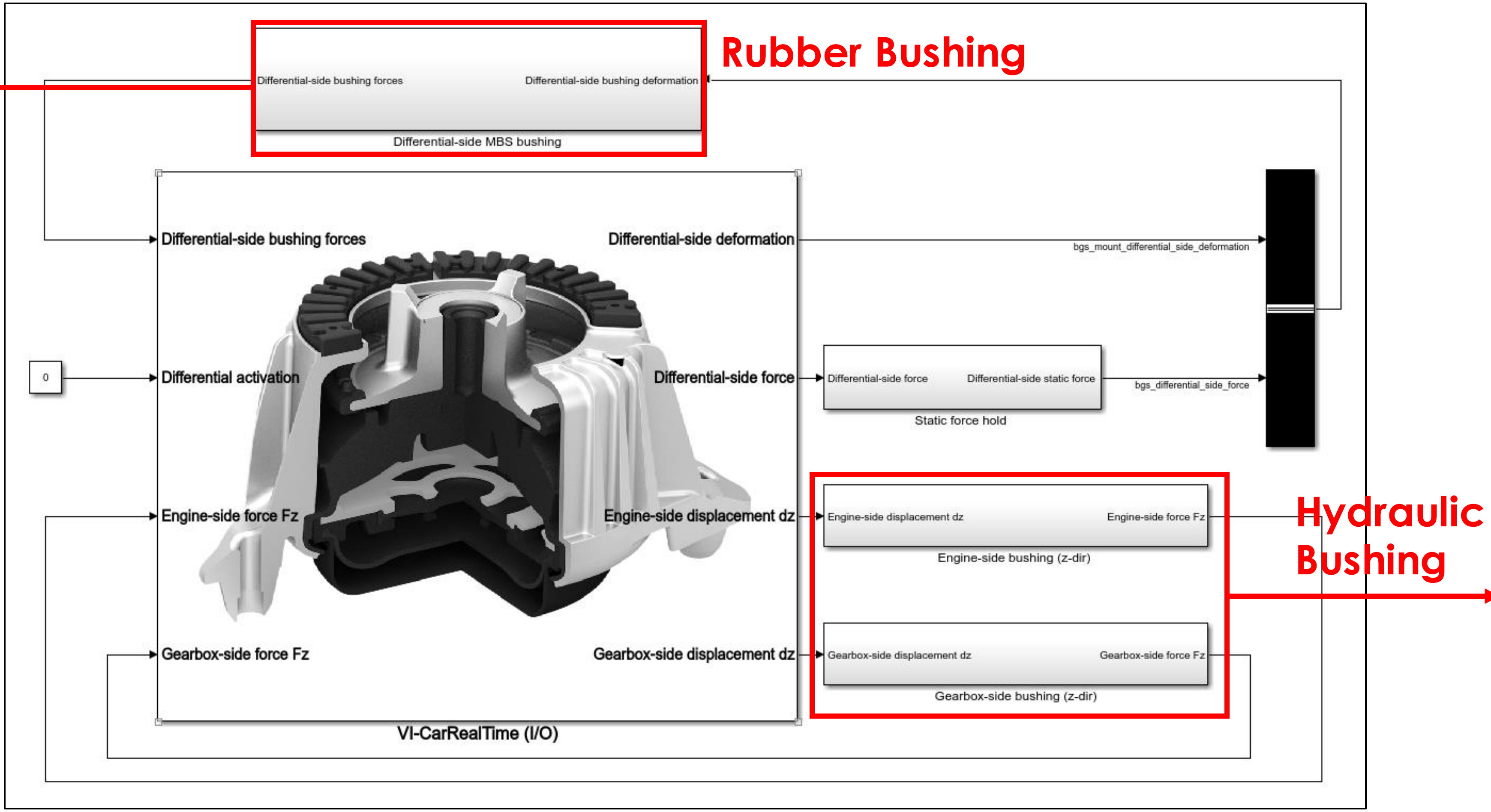
The additional DOFs are defined through the use of a ***Transfer Function***

STEP2: Engine Suspension Model Implementation

In addition, a cosimulation with Simulink has been setted to enhance the engine suspension behavior:

- Rubber bushing with specific behavior, same as multibody model
- Hydraulic bushing in order to add just one direction frequency response

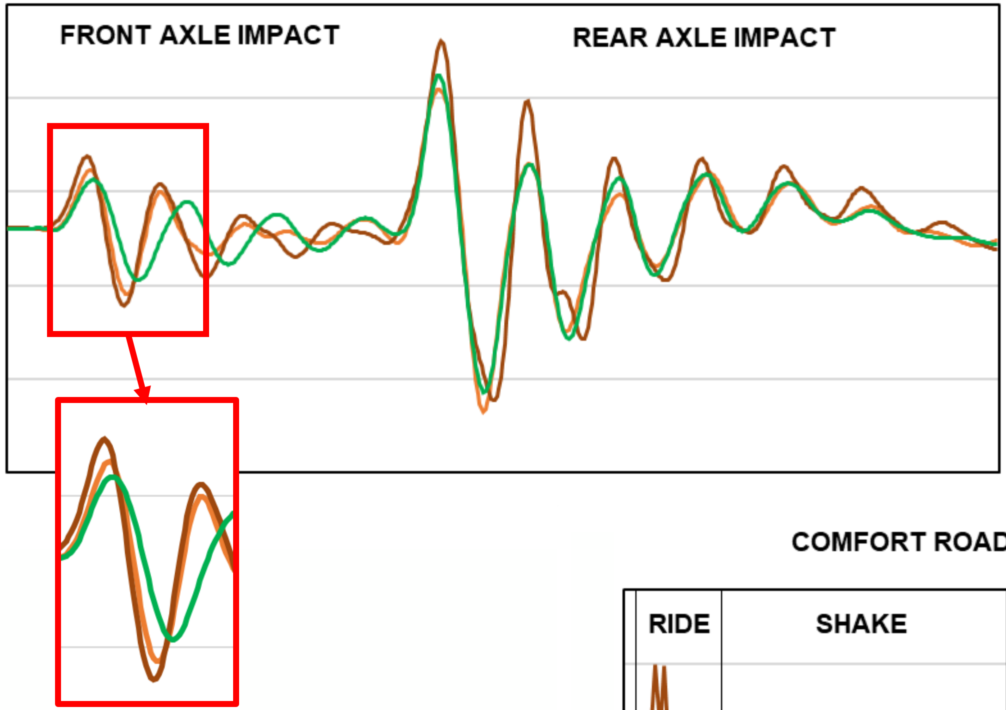
Adding dynamic stiffening while keeping the same working point of the normal characteristics



Adding z-dir. transfer function to the elastic characteristic built in VI-CRT

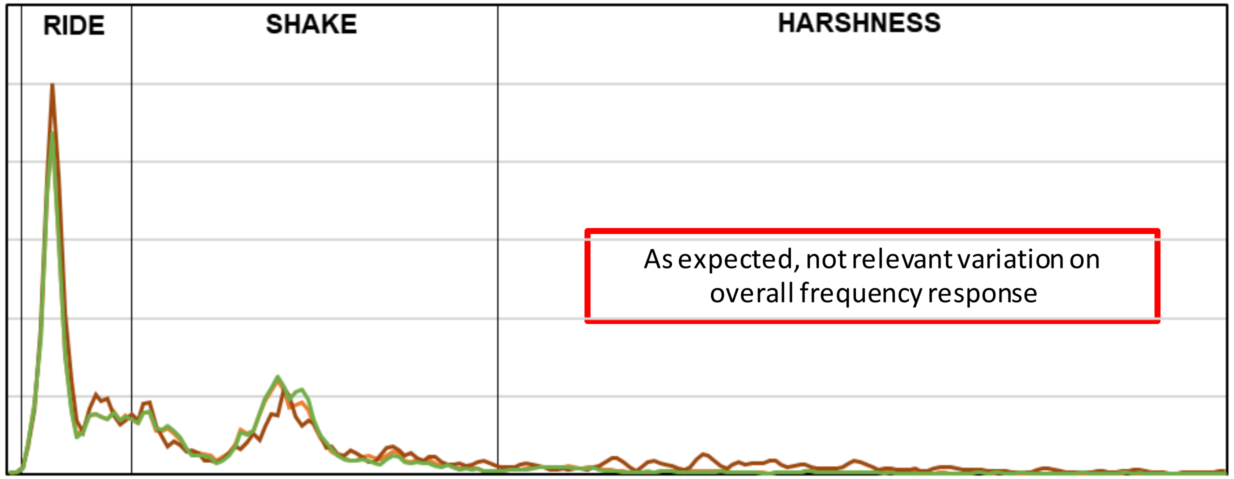
Multibody vs CRT – Z direction

IMPULSIVE TEST: SEAT RAIL Z-DIR (ZZG)

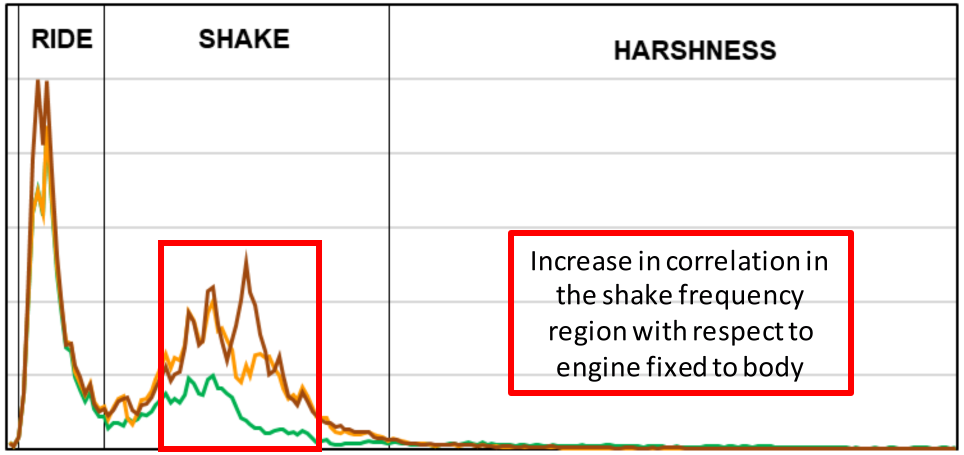


Increase in correlation for the front axle impact range and dissipation frequency

COMFORT ROAD: SEAT RAIL Z-DIR (ZZG)



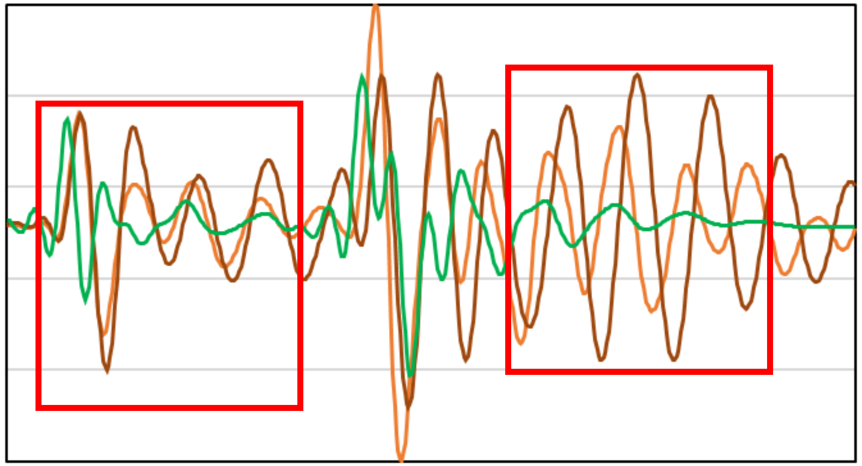
COMFORT ROAD: ENGINE HEAD Z-DIR (ZTM)



Multibody
CRT base
CRT w/ X-dof and Eng. Susp.

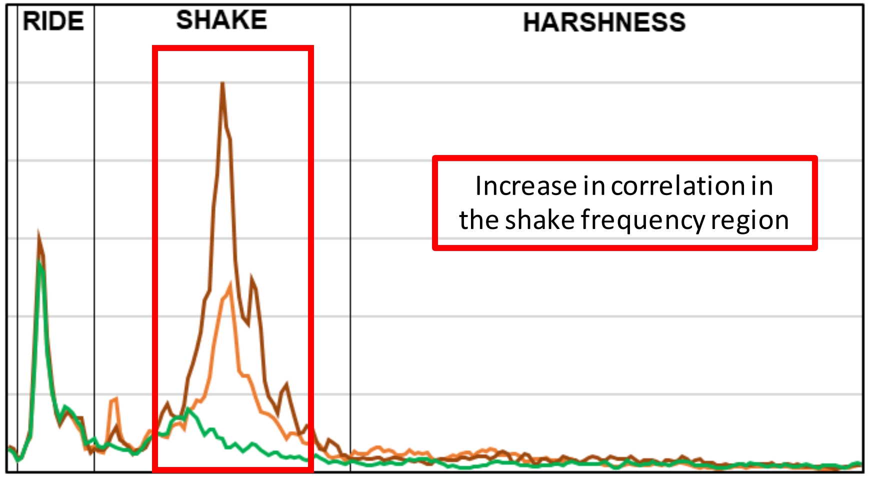
Multibody vs CRT – X direction

IMPULSIVE TEST: SEAT RAIL X-DIR (XXG)

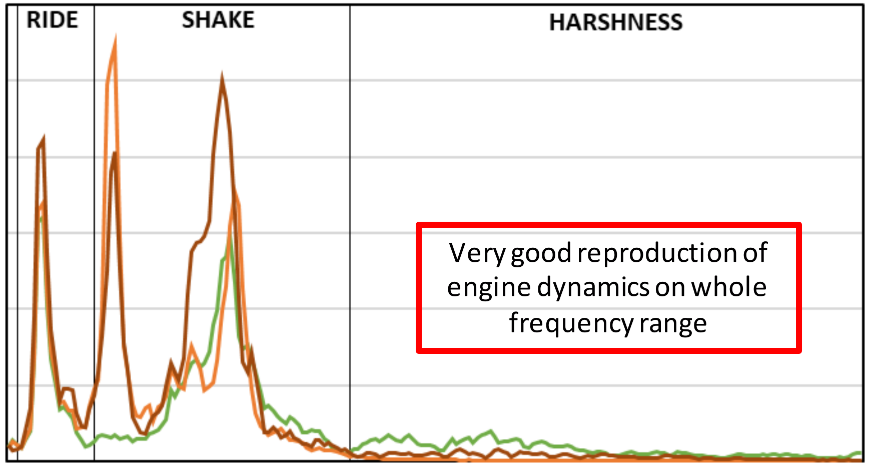


Higher correlation on obstacle envelope and higher correlation of both axle dissipation behavior

COMFORT ROAD: SEAT RAIL X-DIR (XXG)

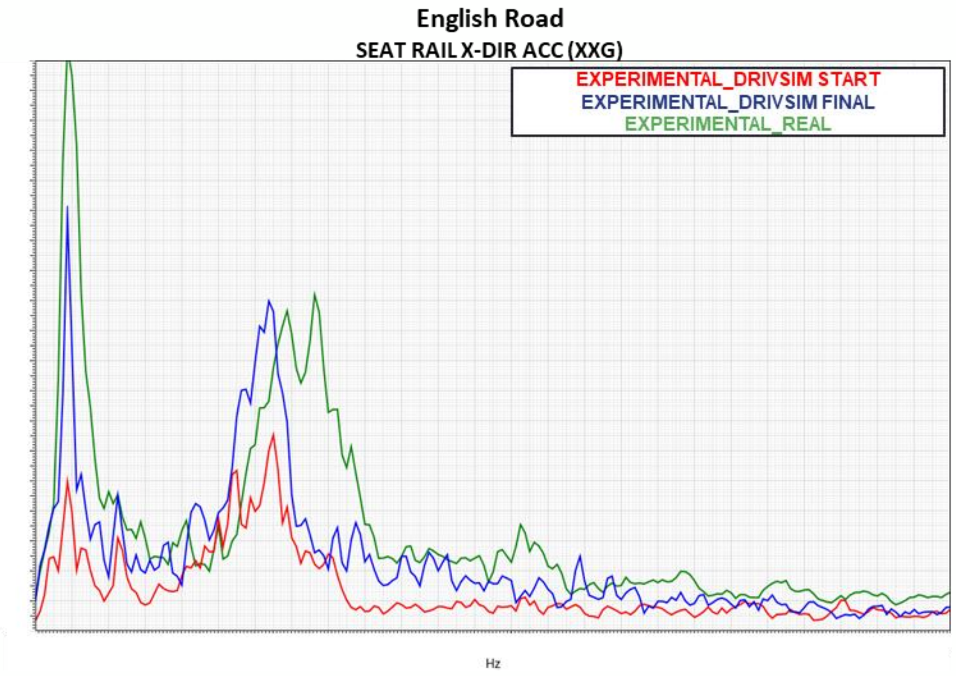


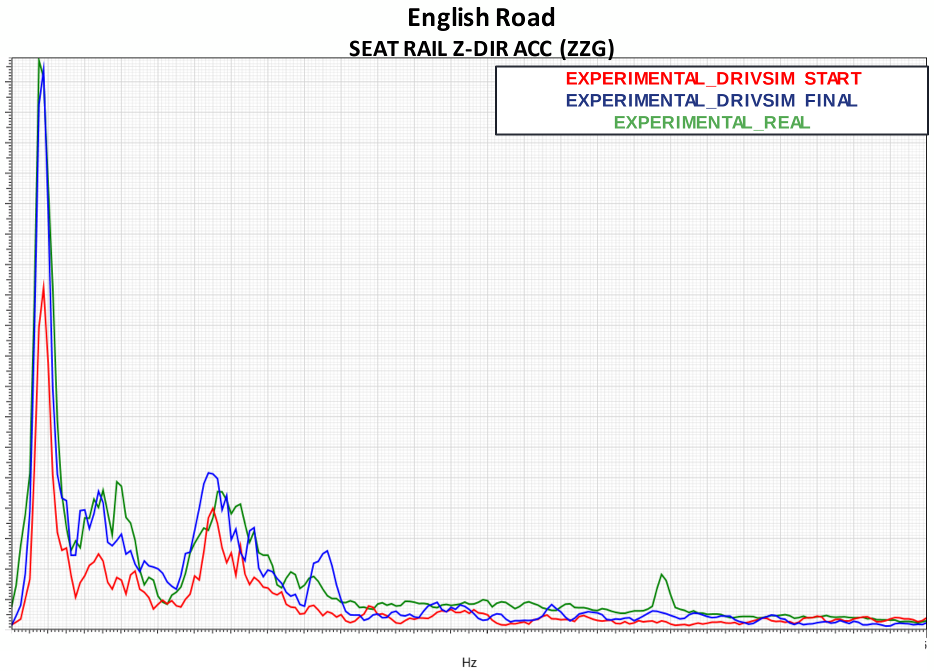
COMFORT ROAD: ENGINE HEAD X-DIR (XTM)



Multibody
CRT base
CRT w/ X-dof and Eng. Susp.

Cueing calibration

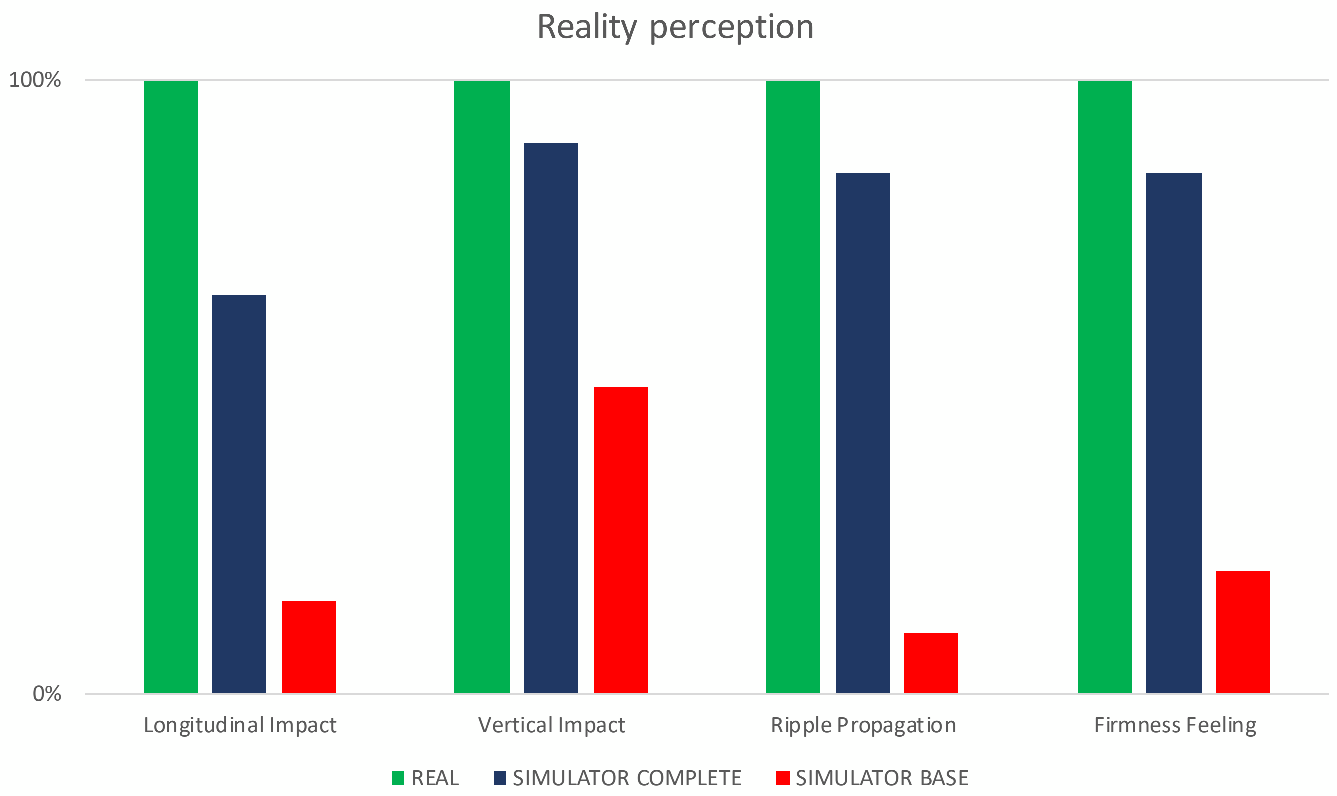




Parameter	Handling setup	Comfort setup
Long. Acc. Gain	ref.	x1.96
Long. Acc. Non Linear Gain	ref.	x5
Pitch velocity gain	ref.	x2
Roll velocity gain	ref.	x1.5
Vert. Acc. Gain	ref.	x1.96
Vert. Acc. HF	ref.	x2

«1-1 oriented» cueing

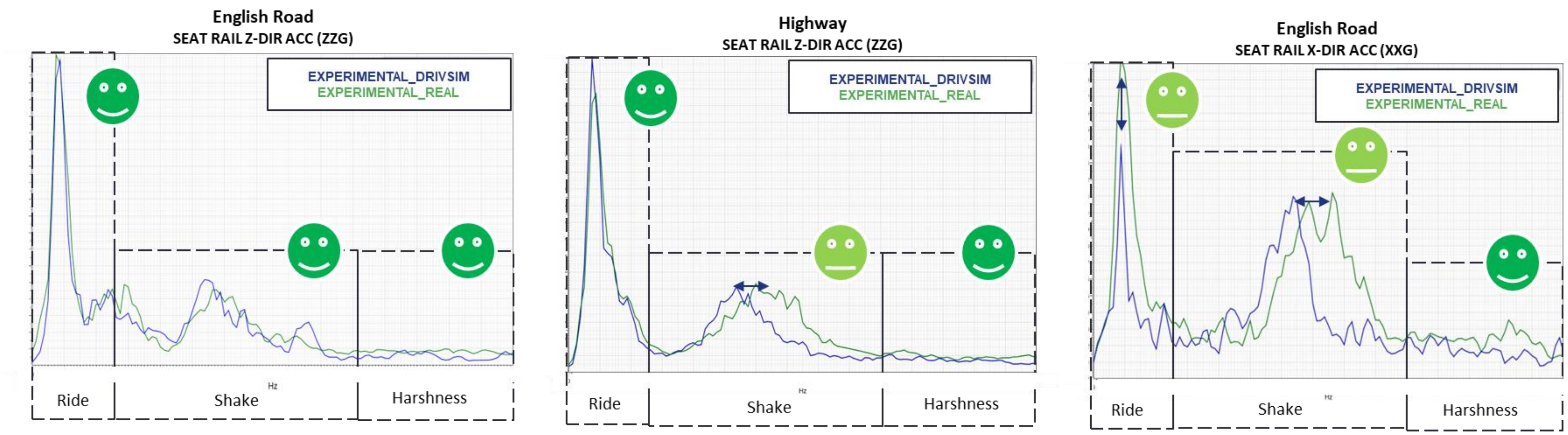
Subjective evaluation



The driving session with the test driver has highlighted that the difference between the base and the complete model is perceptible and coherent with the offline simulation:

- higher impact of the complete model both in vertical and longitudinal direction
- dissipation of the front and rear axle is higher in the complete model

Conclusion and next step



Frequency range has been divided in 3 macro areas: Ride (0-5 Hz), Shake (5-20 Hz), Harshness (20-30 Hz). Graphs shown correlation in English road and Highway in these macro areas.

- Simulator motion cueing setup + advanced real time model can reproduce very well vertical acceleration in all the range
- Longitudinal acceleration are well reproduced in terms of:
  - peaks frequency for ride, not well reproduced in amplitude;
  - amplitude in shake, small shift in frequency domain.

Thank you for the attention!