Applus IDIADA

YOUR DEVELOPMENT PARTNER

VI-grade User Conference 2020

Advanced Ride Comfort Development on the Driving Simulator

May, 2020

Advanced Ride Comfort on the Driving Simulator

Applus IDIADA

Agenda:

IDIADA Overview

- IDIADA Driving Simulators
- IDIADA Virtual Proving Ground

Advanced Ride Comfort Development on the Driving Simulator

- Ride & Comfort Evaluation with Parametric models
- Replay of Pre-recorded data from Multibody Offline Simulation
- Multibody RealTime Simulation for High Fidelity evaluations

IDIADA Overview

IDIADA Driving Simulator lab

VI-grade **DiM250** & **Compact**

IDIADA **Proving Ground**

The best setting for Driving Simulator development projects

IDIADA Overview

IDIADA Driving Simulators

Proving ground

Turn-key model build and validation

Active systems integration

Chassis testing (K&C, Full vehicle, etc)

ADAS testing & development

CAV scenarios generation

XiL support

Human Factor

Real Time simulation

IDIADA Virtual Proving Ground

Integration of Physical & Virtual Proving Ground

- Immediate correlation with reality
  - Fast learning process for drivers
  - Validation of models and cueing parameters
  - *“Does it feel like the real vehicle?”*
- “Hybrid” scenarios
  - Combination of physical and virtual testing
- Logistic of testing and engineering teams

IDIADA Overview

IDIADA Virtual Proving Ground

General Road (Track #0)

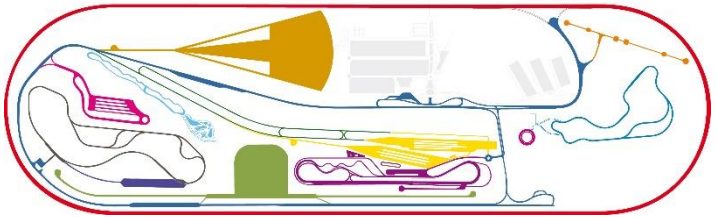
Dry Handling (Track #5)

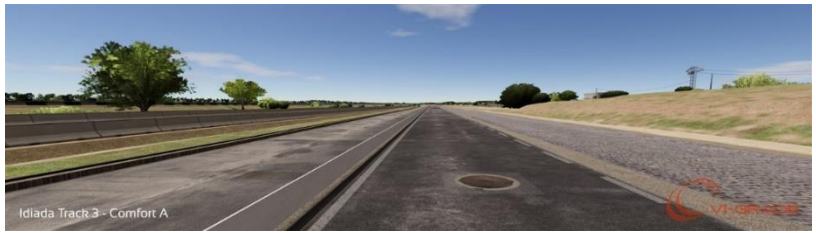
Ride comfort A (Track #3)

Ride comfort B (Track #7)

IDIADA Ride (Tracks #3 & #7)

La Juncosa





www.vi-grade.com/en/solutions/graphic_scenarios/

Leading Edge Applications for Ride & Comfort Evaluation

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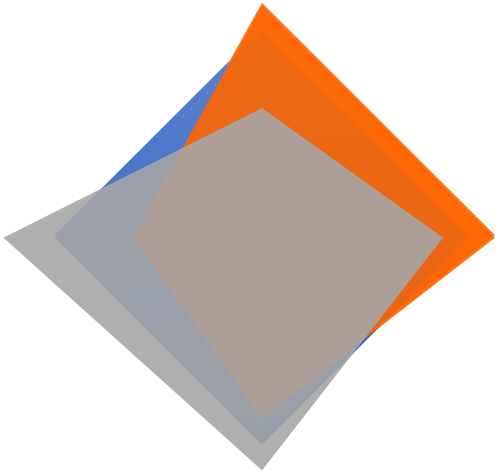
The essence of vehicle dynamics

Advanced Ride Comfort on the Driving Simulator

The essence of vehicle dynamics

Steering

Comfort



Handling

Stability

Advanced Ride Comfort on the Driving Simulator

What is required to develop ride comfort on a driving simulator?

Motion Platform

Need for Accurate motion in all relevant directions and in wide range of frequency

Tyre model

Need for realistic interaction with road surface (enveloping and frequency resp)

Vehicle model

Need for validated model in ride comfort scenarios

Digital road model

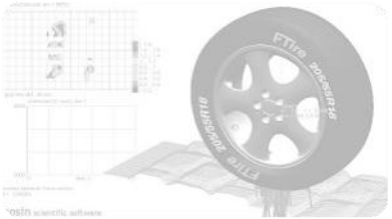
Need for accurate model of existing road inputs (reference)

Advanced Ride Comfort on the Driving Simulator

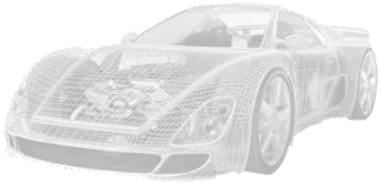
What is required to develop ride comfort on a driving simulator?

Motion Platform

Tyre model



Vehicle model



Digital road model

→ Requirements related with the motion platform

Advanced Ride Comfort on the Driving Simulator

Motion platform validation: methodology

Pre-Recorded Data

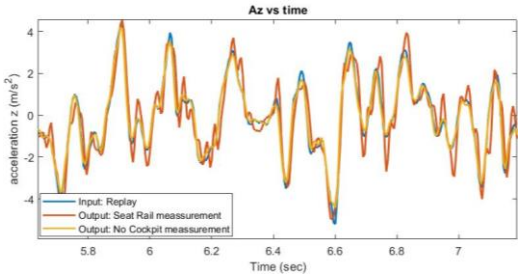
Motion Cueing

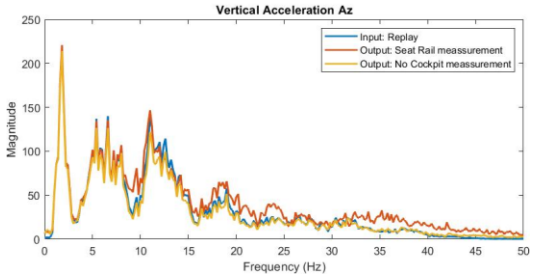
Simulator with Intrumentation

Specific replay procedure

Measured Motions

Results Comparison





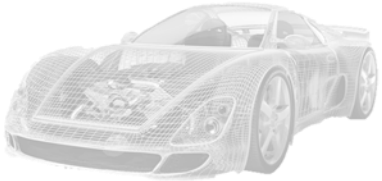
Advanced Ride Comfort on the Driving Simulator

What is required to develop ride comfort on a driving simulator

Motion Platform

Tyre model

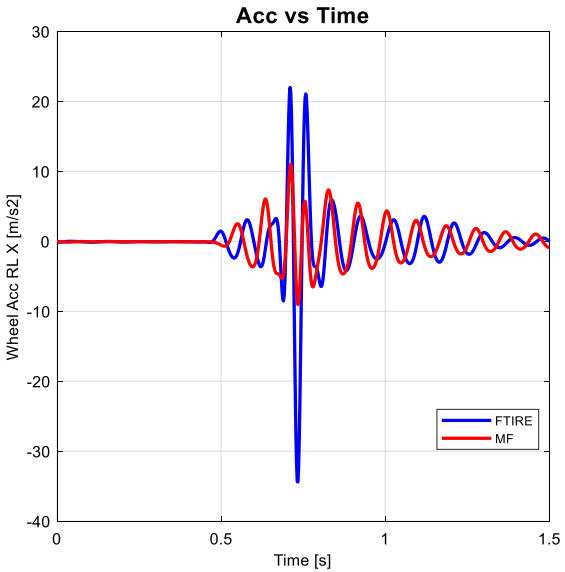
Vehicle model

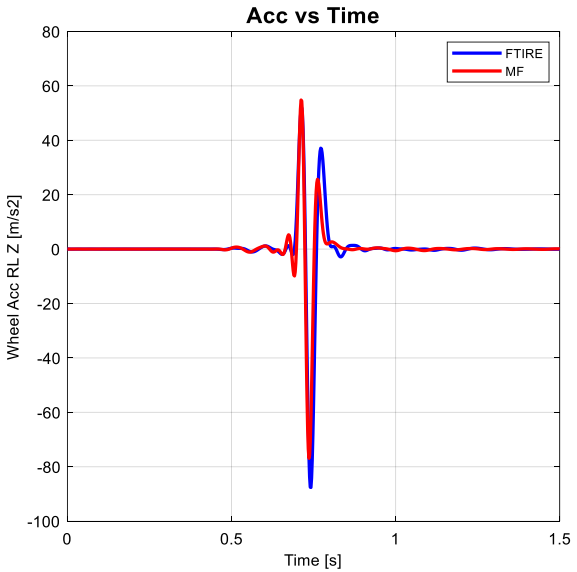


Digital road model

→ Requirements related with the tyre model

MF-Tyre Vs FTire (positive step)





- Better correlation with reality in longitudinal accelerations
- Some difference also in vertical dynamics
- Physical tyre model is the preferred choice for ride comfort evaluation

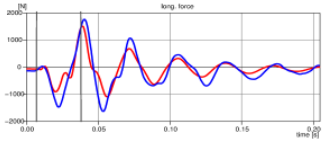
Advanced Ride Comfort on the Driving Simulator

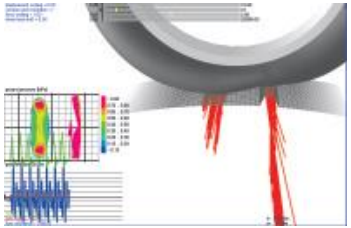
Tyre modelling and validation at IDIADA (MF-Tyre and FTire)

Measurement

Validation for DS use
(stability, RT capability, …)

Model fitting



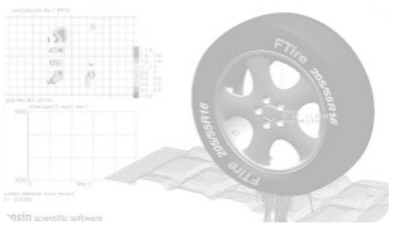


Advanced Ride Comfort on the Driving Simulator

What is required to develop ride comfort on a driving simulator

Motion Platform

Tyre model

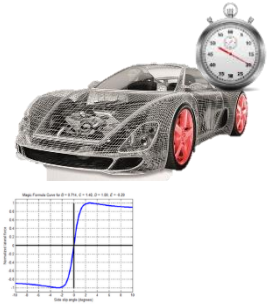


Vehicle model

Digital road model

→ Vehicle model options

Vehicle modelling strategies



Vehicle model
→ Parametric

Tyre model
→ Magic Formula

Solver
→ On-line

Vehicle model
→ Parametric

Tyre model
→ FTire

Solver
→ On-line

Vehicle model
→ Full-MBS

Tyre model
→ FTire

Solver
→ Off-line

Vehicle model
→ RealTime MBS

Tyre model
→ FTire

Solver
→ On-line

Advanced Ride Comfort on the Driving Simulator

Vehicle modelling strategies

Vehicle model
→ Parametric

Tyre model
→ FTire

Solver
→ On-line

Ride Comfort evaluation with parametric models

- ✓ *Easier to integrate and less computing demanding*
- ✓ *Integration of a physical tyre model such as **FTire** improves significantly the subjective perception*
- ✓ *Vi-CarRealTime offers the possibility to partially close the gap with additional modelling features (longitudinal DOF, engine suspension)*
- ✓ *Possibility to run set-up changes live for some components*

- ✘ *Lower fidelity in comparison with a Full MBS model, especially in longitudinal dynamics and high-frequency domain*
- ✘ *Set-up changes difficult for some parameters (e.g. bushings require model export)*

Vehicle modelling strategies

Vehicle model
→ Parametric

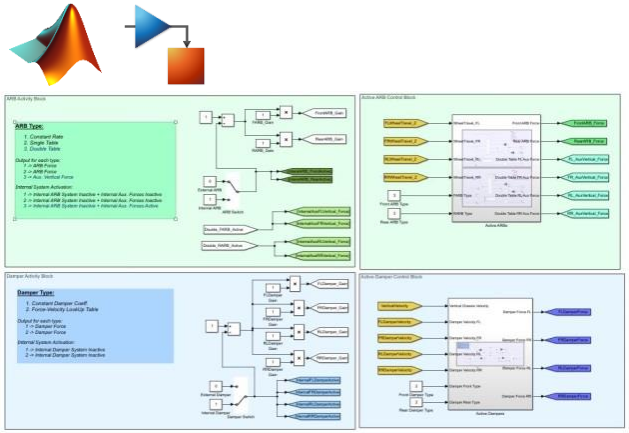
Tyre model
→ FTire

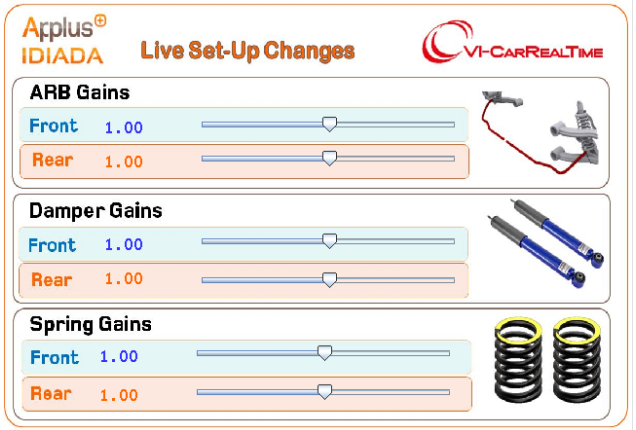
Solver
→ On-line

Implementation of scaling factors through Simulink for main tuning parameters.

→ Facilitate subjective evaluation

→ Speed-up decision making





Vehicle modelling strategies

Vehicle model
→ Full-MBS

Tyre model
→ FTire

Solver
→ Off-line

Replay of pre-recorded data from Multibody Offline Simulation

- ✓ *Highest Fidelity from Complex Multibody Model (including flexible bodies)*
- ✘ *Post and Pre-processing of data required*
- ✘ *Long time to run set-up changes*
- ✘ *No possibility to "drive" the simulator*

Advanced Ride Comfort on the Driving Simulator

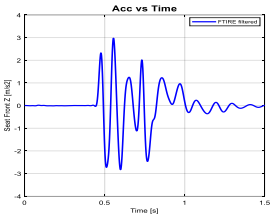
Vehicle modelling strategies

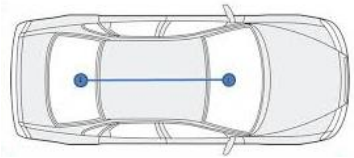
Vehicle model
→ Full-MBS

Tyre model
→ FTire

Solver
→ Off-line

Pre-Recorded Data





Simulator

Data from Virtual Sensor (no differentiation / integration)

→

Specific Motion Cueing settings (as close as possible to 1:1)

→

Target on platform to be the same reference point (no transformations)

Vehicle modelling strategies

Vehicle model
→ RealTime MBS

Tyre model
→ FTire

Solver
→ On-line

Multibody RealTime simulation for High Fidelity driving evaluations

- ✓ *High Fidelity from Multibody Model RealTime (DoF reduction)*
- ✓ *Set-up changes can be done quickly at component level for any component*
- ✓ *Possibility to run set-up changes live*
- ✓ *Allows to drive the simulator (ride and handling on the same model)*

- ✘ *Requires RT capable MBS model*
- ✘ *Requires extra computing power*

…Is it possible?

Advanced Ride Comfort on the Driving Simulator

Multibody RealTime simulation for High Fidelity driving evaluations

Objective - Implementation of a technology demonstrator

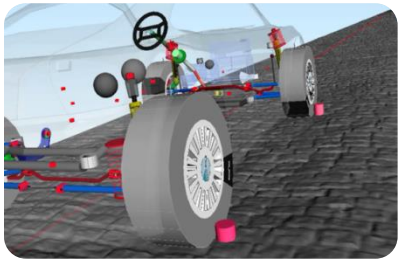
VI-grade DiM250

VI-GRADE

FTire

cosin scientific software

Multi-Body model



SIM PACK

IDIADA PG

VI-GRADE

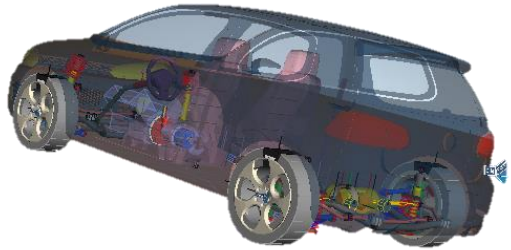
Advanced Ride Comfort on the Driving Simulator

Multibody RealTime simulation for High Fidelity driving evaluations

Step 1 - Integration of Simpack model on RealTime machine to work with VI-Grade environment system.

concurrent REAL-TIME

SIMULATION WORKBENCH



SIM PACK

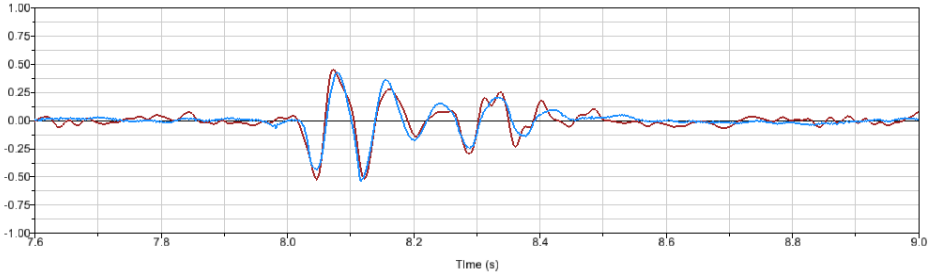
VI-GRADE DiM 250

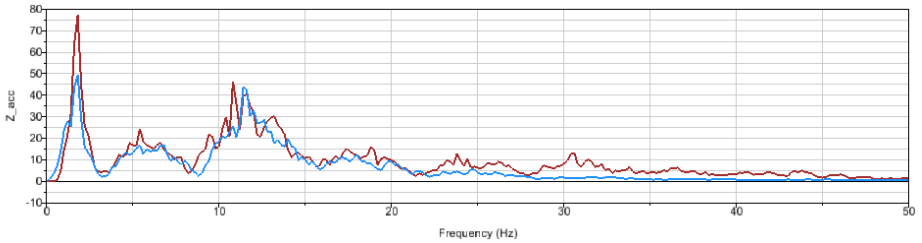
Advanced Ride Comfort on the Driving Simulator

Multibody RealTime simulation for High Fidelity driving evaluations

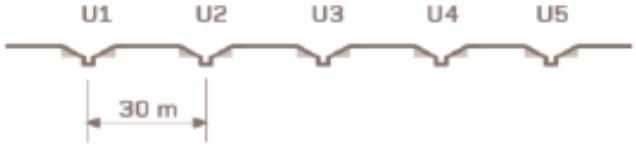
Step 2 – Real Time model validation running on DiM250.

Measurement Simulation





U-shape impacts

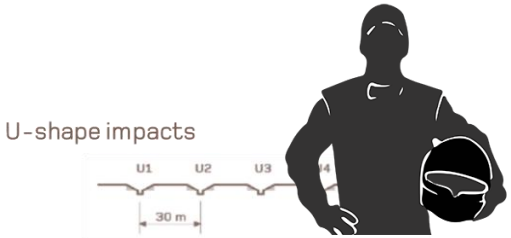


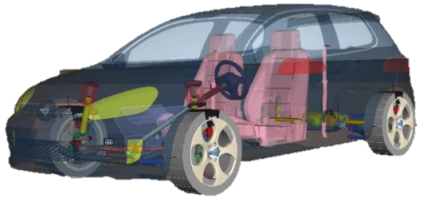
Badly Maintained Road

Advanced Ride Comfort on the Driving Simulator

Multibody RealTime simulation for High Fidelity driving evaluations

Step 3 – Subjective back to back comparison in IDIADA proving ground





Advanced Ride Comfort on the Driving Simulator

Multibody RealTime simulation for High Fidelity driving evaluations

Simpack RT model is valid for ride comfort evaluation:

- Acceleration Z is well correlated up to 25 Hz
- Acceleration X is correlated well up to 20 Hz (Expected due to lack of Flex. bodies)
- Pitch Acceleration is well correlated up to 20 Hz

Subjective against real vehicle:

- Very accurate and realistic feeling for Primary and Secondary Ride
- Appreciation of Impacts and After-shake

Advanced Ride Comfort on the Driving Simulator

Conclusions

IDIADA has worked on a complete and unique set of solutions for ride comfort development on their VI-grade DiM250 simulator.

Motion Platform

DiM250 provides best-in-class motion fidelity for primary and secondary ride.

Tyre model

Experience in generation, integration and validation of physical models (FTire)

Vehicle model

Wide variety of solutions, including full scale MBS

Digital road model

Synergy of digital and physical tracks provides reliable reference for advanced ride validation

Next steps

- Extend MBS RT simulation to further SW packages (MSC ADAMS RT)
- Consider further tyre models (depending on market request)
- Improve cockpit attachment for longitudinal dynamics

Thank you very much for your attention

Q&A

Applus IDIADA

YOUR DEVELOPMENT PARTNER

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