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University of Applied Sciences

HYUNDAI
MOTOR GROUP
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Ride Comfort Simulation in IPG CarMaker

Development of a test procedure to support vehicle testing by real-time capable virtual methods

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Project Introduction

Objectives:

Setting up a simulation of a ride comfort test procedure in CarMaker

Studying the validity of the CarMaker simulation using real road measurements as reference

Project Introduction

Ride comfort test procedure:

- Low damping
- Medium damping
- High damping

- Smooth road (SR)
- Badly maintained road (BMR)

- 50 km/h
- 70 km/h
- 90 km/h

Test config.	Road type	Speed in km/h	Damper setting
1	BMR	50	Low
2	BMR	70	Low
3	BMR	90	Low
4	BMR	50	Medium
5	BMR	70	Medium
6	BMR	90	Medium
7	SR	50	Low
8	SR	70	Low
9	SR	90	Low
10	SR	50	Medium
11	SR	70	Medium
12	SR	90	Medium
13	SR	50	High
14	SR	70	High
15	SR	90	High

Project Introduction

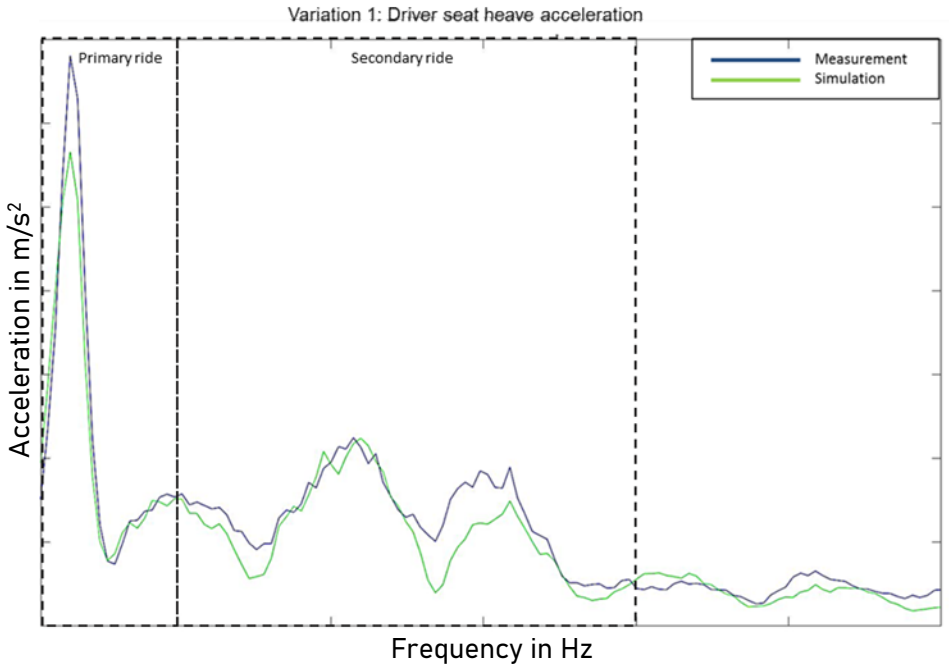
Approach:

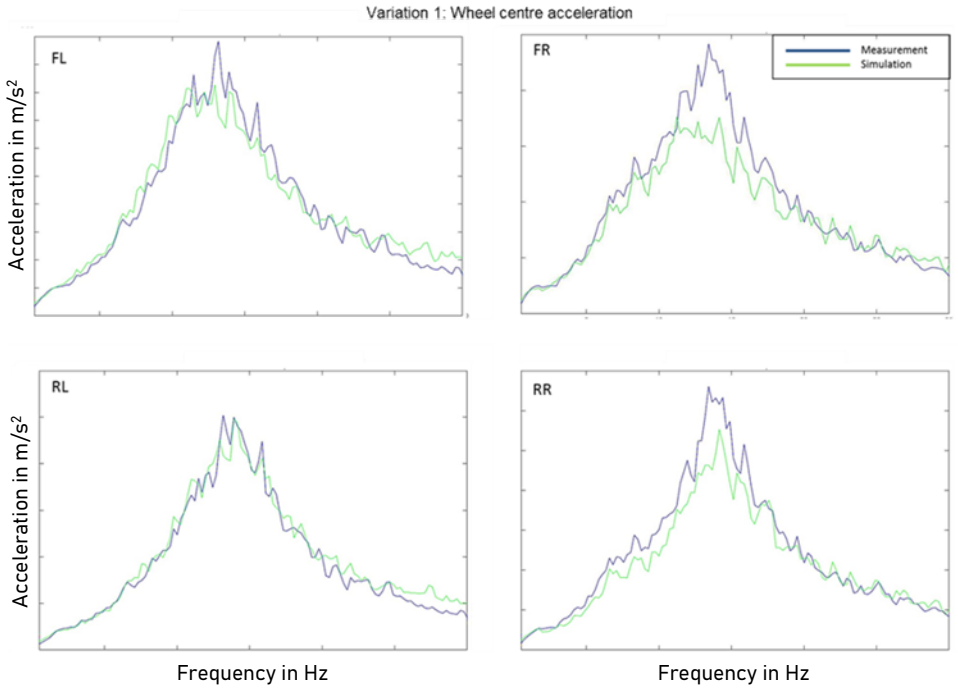
Parametrization in CarMaker

Mass	• Weight measurement • Data sheet of vehicle parts • CAD files	→	• Accurate weight distribution across all 4 wheels • Partition in sprung and unsprung mass
Engine mounting	• Hydraulic engine mount • Static and dynamic measurements of the mount	→	• Hydromount model in CarMaker 8 and onwards • Amplitude and frequency dependent mount model
Suspension	• Spring, Stabilizer and Buffer: Default CarMaker models • Damper: Mxdamper, advanced damper model		
Tire	• RealTime Tire model		
Road	• Scan data of the test roads in CRG format	→	• Integration in road model using Scenario Editor

Initial Comparison

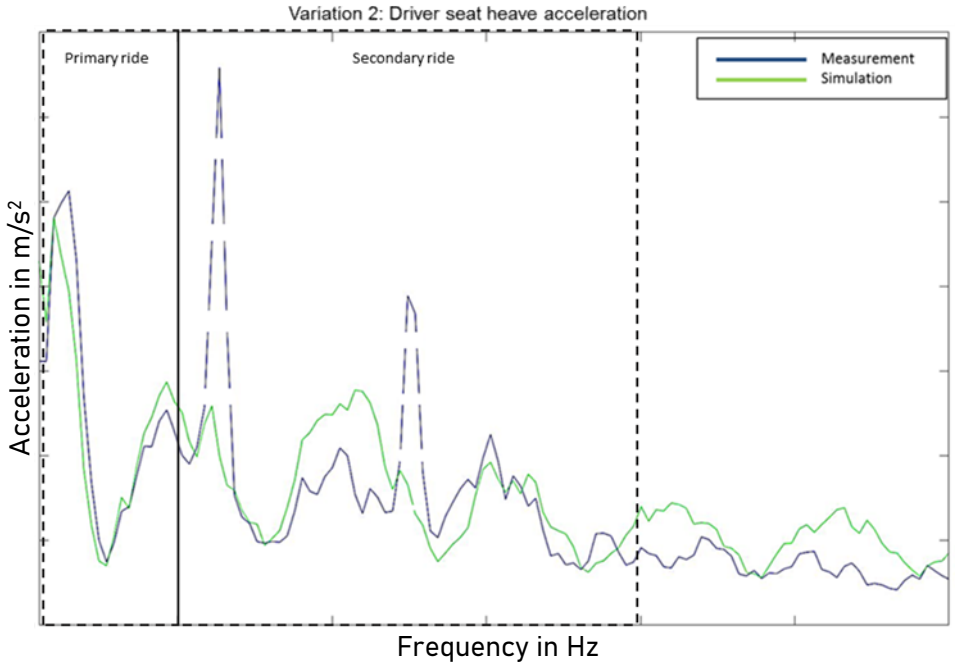
Test configuration 1: Low damping, 50km/h, badly maintained road (BMR)

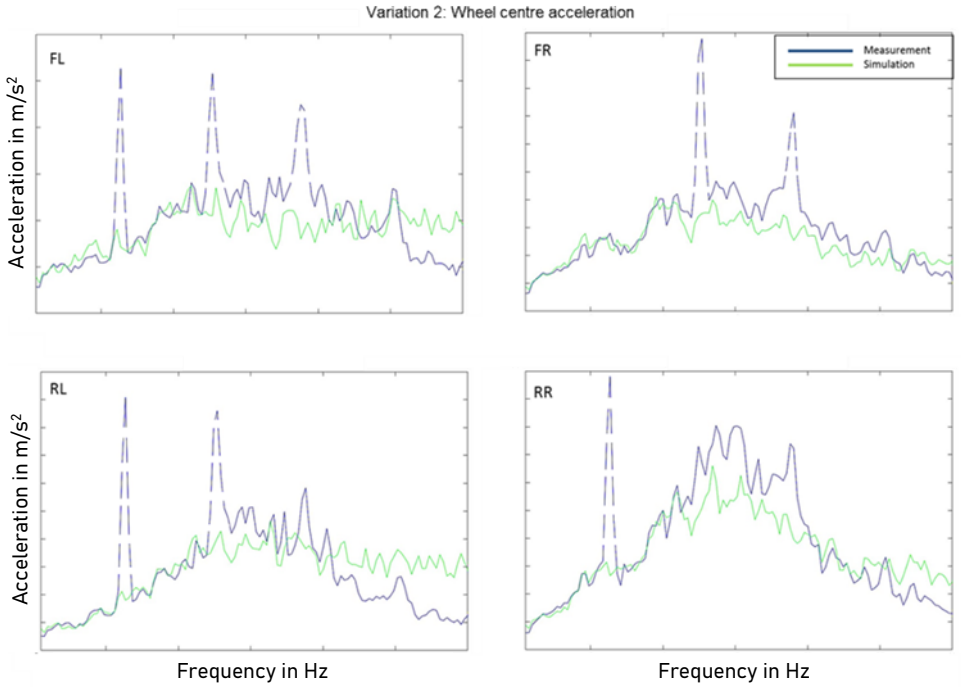




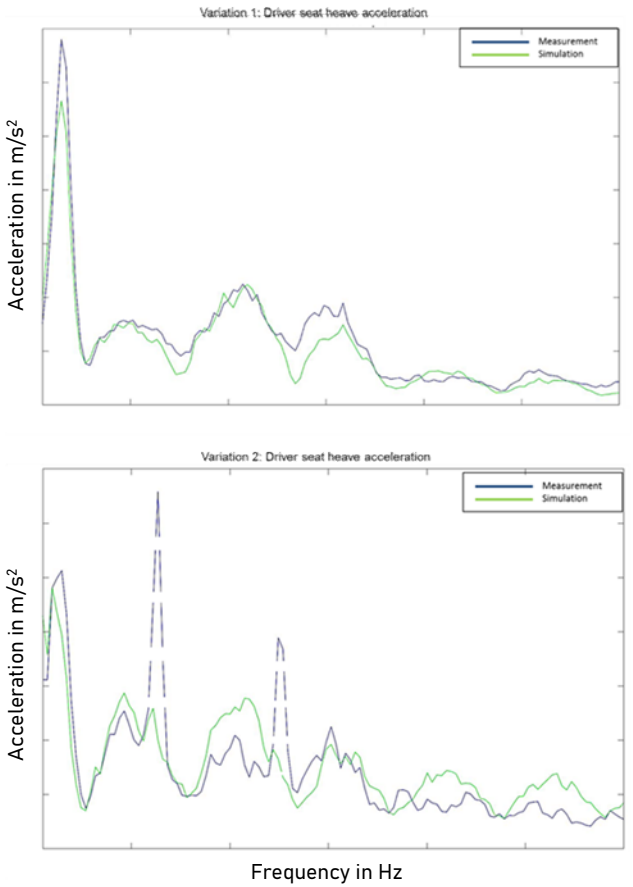
Initial Comparison

Test configuration 2: Low damping, 50km/h, smooth road (SR)



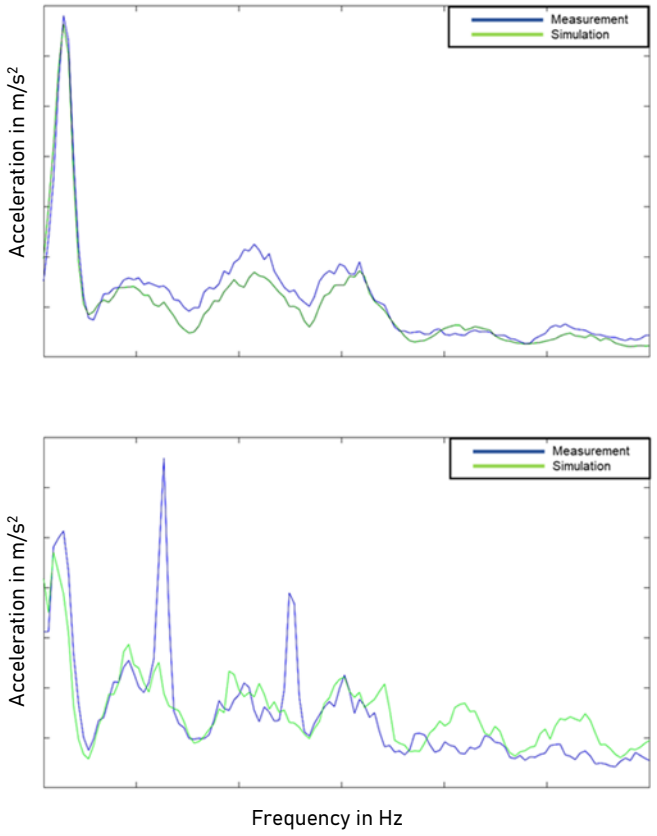


Parameter Optimization



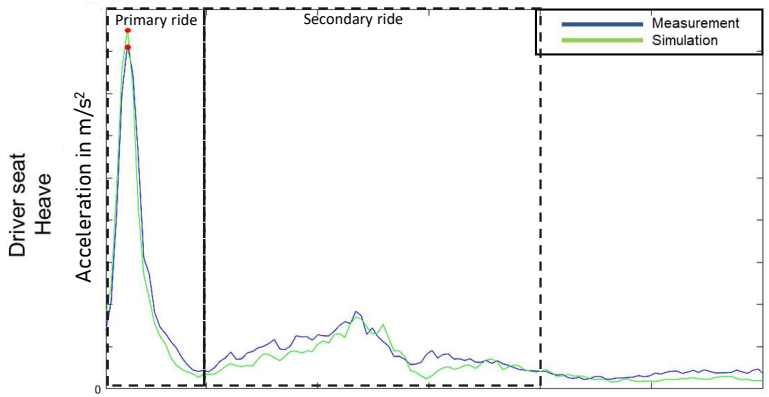
Optimized parameters

- Vehicle position on virtual road
- Tire stiffness
- Hydromount amplification factor
- Mxdamper amplification factor

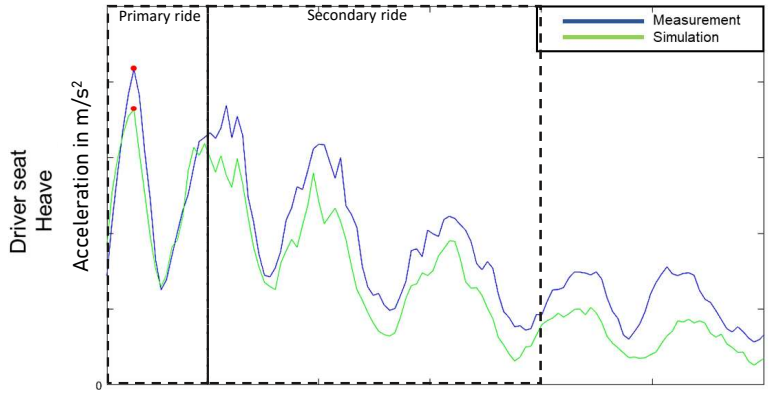


Validation

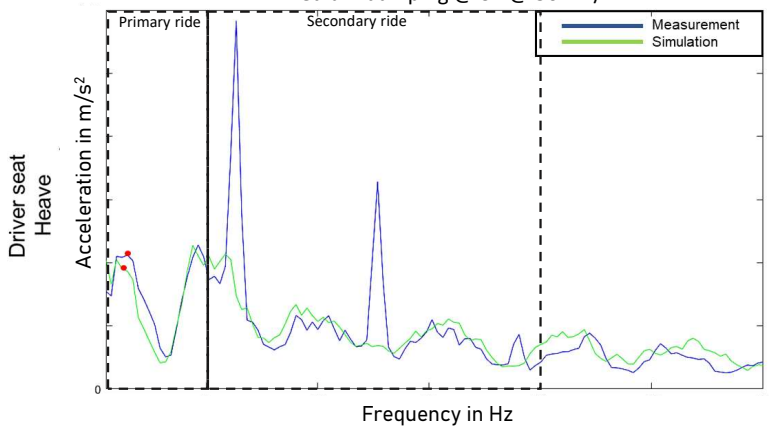
Low damping @ BMR @ 90 km/h



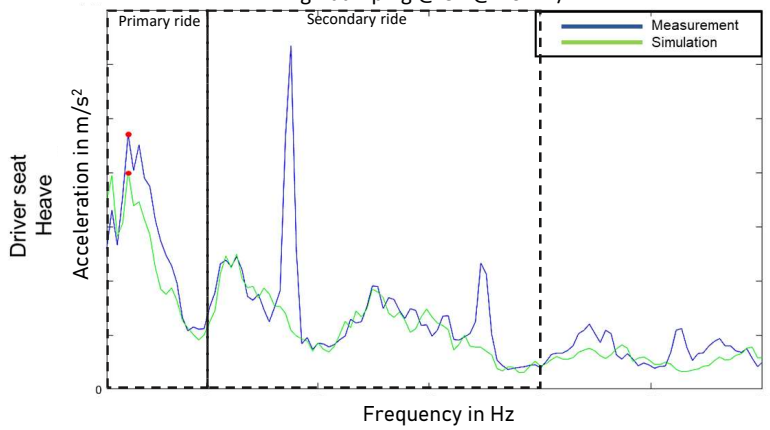
Medium damping @ BMR @ 50 km/h



Medium damping @ SR @ 50 km/h



High damping @ SR @ 70 km/h



Validation

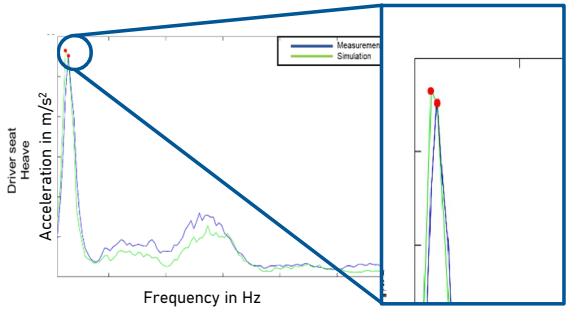
Validation in primary ride

- Accuracy of the body resonance's peak
- Normalized error in peak frequency

$$E_f = \frac{f_{peak,m} - f_{peak,s}}{f_{peak,m}}$$

- Normalized error in peak amplitude

$$E_A = \frac{A_{peak,m} - A_{peak,s}}{A_{peak,m}}$$



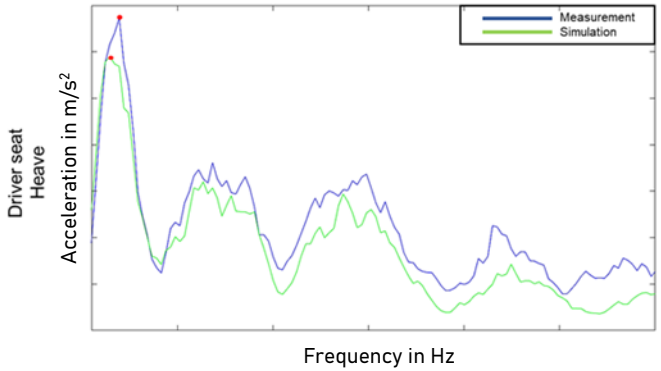
Validation in secondary ride

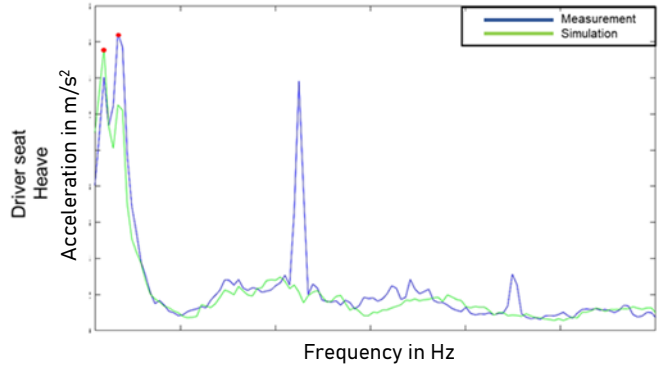
- Multiple components involved
- Subjective approach
- Detailed observation

Validation

Validation in primary ride

Test configurations			Frequency error, E_f	Amplitude error, E_A
Road	Damper setting	Velocity in km/h		
BMR	Low	70	0.17	-0.03
		90	0	-0.05
	Medium	50	0	0.13
		70	0.25	0.12
		90	0.14	0.09
SR	Low	70	0	0.18
		90	0.43	0.05
	Medium	50	0.17	0.10
		70	0	0.12
		90	0	0.15
	High	50	0.17	0.11
		70	0	0.15
		90	0	-0.09





Validation

Test configuration			Comments on secondary ride behaviour of the simulated vehicle
Road type	Damper setting	Velocity in km/h	
BMR	Low	70	+ Can portray the correct ride comfort behaviour from 5 to 10 Hz - Lack of acceleration amplitude from 5 to 16 Hz - Frequency shift in wobbling mass natural frequency region
		90	+ Able to portray the correct ride comfort behaviour from 5 to 15 Hz - Lack of acceleration amplitude from 5 to 18 Hz - Highest error at 15 Hz
	Medium	50	+ Can portray the correct behaviour from 5 to 20 Hz - Lack of acceleration amplitude from 5 to 20 Hz
		70	+ Can portray the correct behaviour from 5 to 20 Hz - Lack of acceleration amplitude from 5 to 20 Hz
		90	+ Can portray the correct behaviour from 5 to 15 Hz - Incorrect behaviour from 15 to 20 Hz; possible frequency shift - Lack of acceleration amplitude from 5 to 20 Hz - Highest error at 15 Hz
SR	Low	70	+ Simulation fits the measurement well in terms of frequency and acceleration amplitude from 5 to 12 Hz - Peak at 13 Hz region not portrayed correctly
		90	+ Simulation fits the measurement well in terms of frequency and acceleration amplitude from 5 to 14 Hz - Incorrect behaviour from 15 Hz onwards
	Medium	50	+ Simulation fits the measurement well in terms of frequency and acceleration amplitude from 5 to 18 Hz
		70	+ Simulation fits the measurement well in terms of frequency and acceleration amplitude from 5 to 13 Hz - Lack of acceleration amplitude at 13 to 15 Hz
		90	+ Simulation fits the measurement well in terms of frequency and acceleration amplitude from 10 to 13 Hz - Peak at 8 Hz not portrayed correctly - Incorrect behaviour from 15 Hz onwards
	High	50	+ Simulation fits the measurement well in terms of frequency and acceleration amplitude from 5 to 20 Hz
		70	+ Simulation fits the measurement well in terms of frequency and acceleration amplitude from 5 to 20 Hz
		90	+ Good correlation from 5 to 8 Hz - High acceleration amplitude from 8 to 11 Hz - Inaccurate behaviour from 15 to 20 Hz

Validation in secondary ride

Positive observations:

- Generally correct representation of ride comfort behaviour in terms of frequency up to 18 Hz

Negative observations:

- Poor simulation at 90 km/h on BMR and SR
- On BMR, slightly lower acceleration amplitude for all test configurations

Conclusion & Outlook

Conclusion

- Up to 80% accuracy in primary ride
- In secondary ride, good correlation for simulation on smooth road for tests below 90 km/h
- In secondary ride, good correlation in terms of frequency with lack of acceleration amplitude on badly maintained road for tests below 90 km/h

Outlook

- More complex tire model such as Ftire and MF Swift
- Measurement on the exact component installed in the test vehicle instead of identical component during data collection
- Use of synthetic road excitation

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THANK YOU

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