



EUROPEAN TECHNICAL CENTER



DEVELOPMENT OF MULTI-ATTRIBUTE
SIMULATOR FOR INTEGRATED VEHICLE
DYNAMICS AND (EXTENDED) COMFORT
EVALUATION OF AN ELECTRIC VEHICLE

HYUNDAI EUROPEAN TECHNICAL CENTER

*Riccardo Tonelli, Senior Engineer,
Vehicle Development, NVH CAE*

APPLUS IDIADA

*Javier Gutiérrez, Manager,
Virtual Vehicle Dynamics and Driving Simulator*

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2026
SMART PROTOTYPES
SUMMIT

1. The Challenge
2. The Methodology Evolution
3. POC: HMETC Case Study
4. The Path Forward



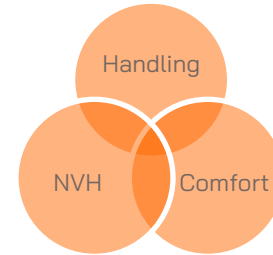
Testing and validation **budgets** decrease as investments shift towards emerging technologies.



Development **cycles** shrink to match today's fast-paced market demands



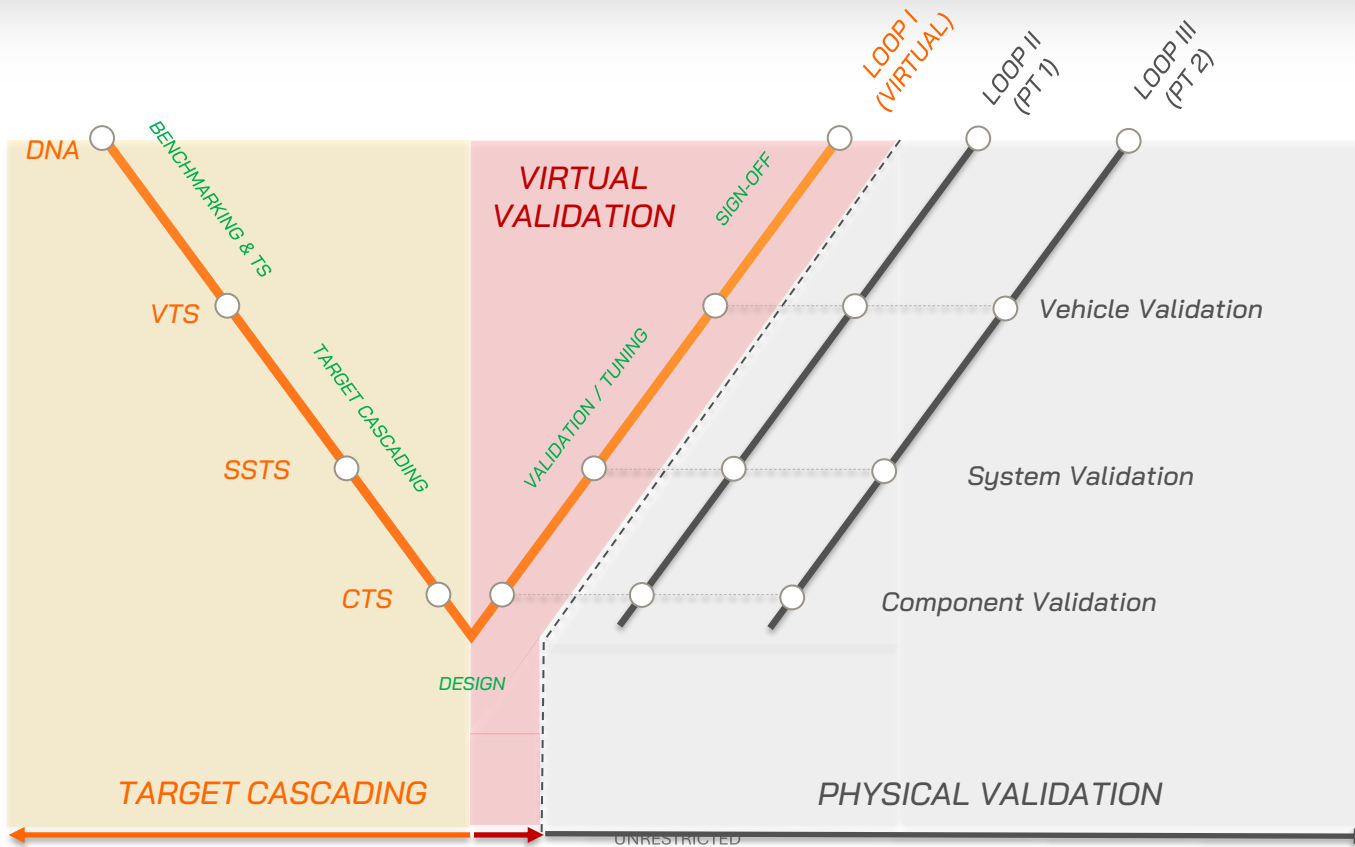
Exceptional performance is crucial to maintain industry leadership in highly competitive market



Multi-attribute Optimization is expected from early stages

THE CHALLENGE

STREAMLINED DEVELOPMENT PROCESS



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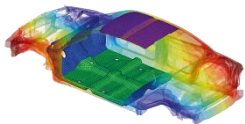
1. RT Multibody



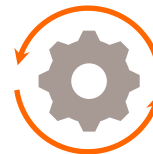
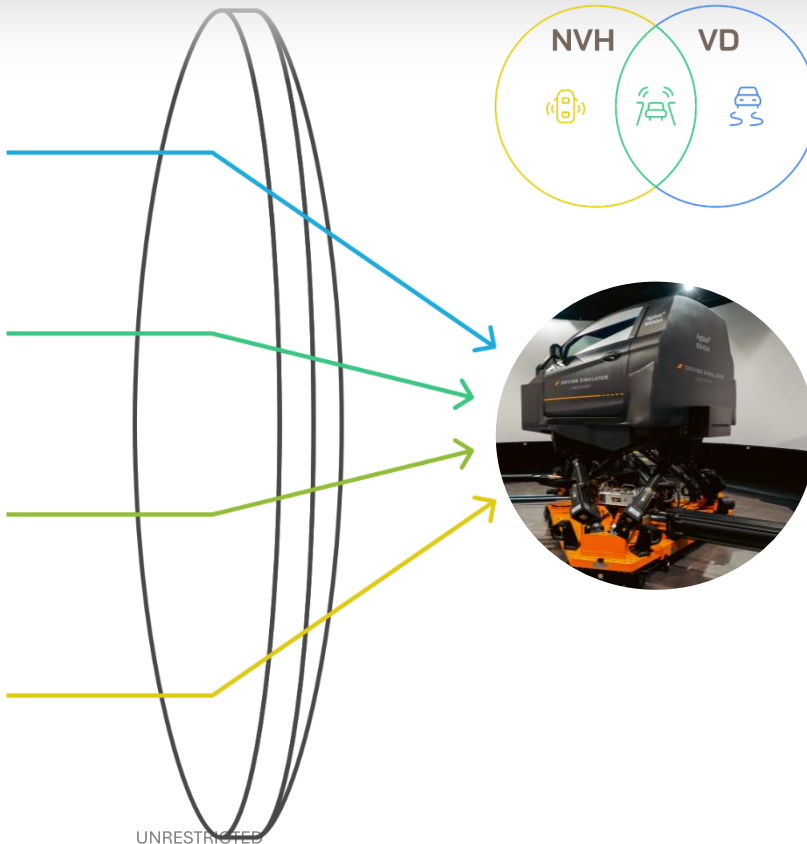
2. Hyperdock



3. NVH Simulator



4. Upgraded CCUR



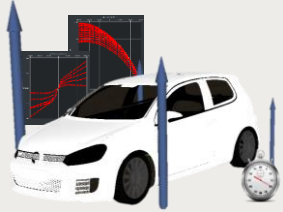
Enhanced
development
process

VEHICLE MODELS & HW

Before

Now

Parametric Vehicle Dynamics model



14 DOF
0-15 Hz



Complex Multibody model + NVH model



> 400+ DOF
0-150+ Hz



DiM250 platform + "static" cockpit



800 kg
0-35 Hz



DiM250 + lightweight cockpit + shakers package



450 kg
0-150 Hz



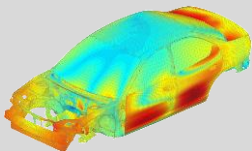
Complex MBS model



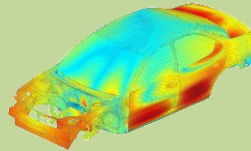
RT-Capable MBS model



Complex FEA model



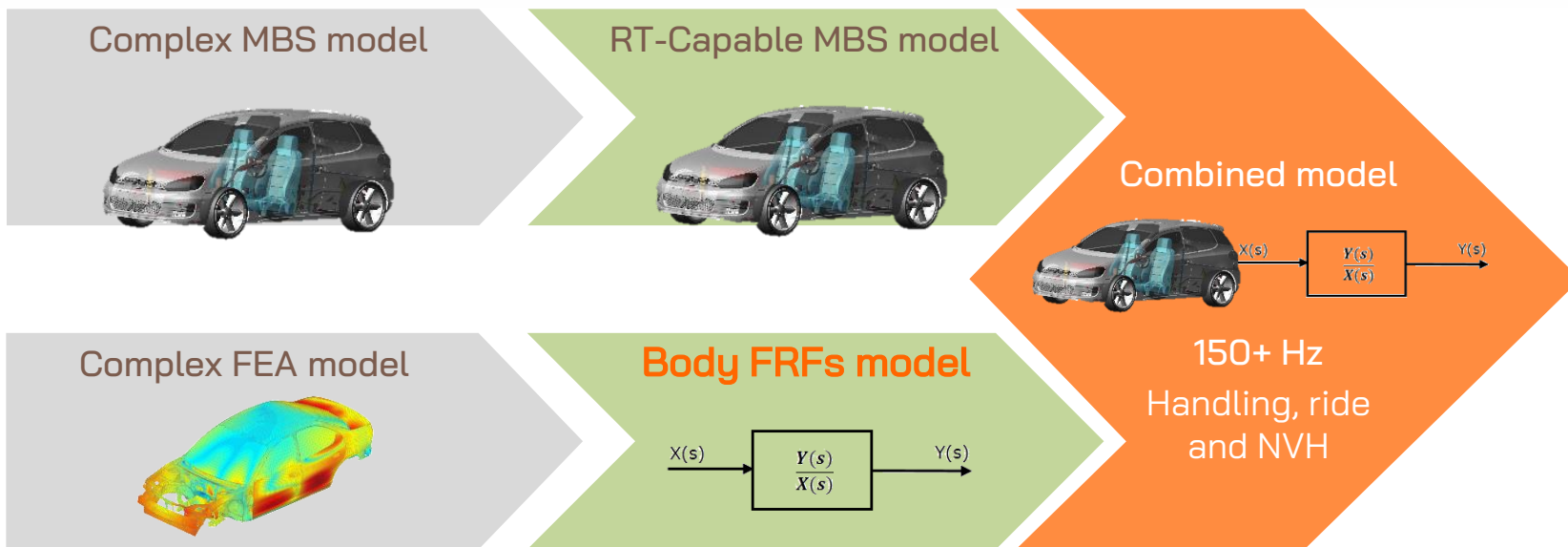
Body MNF model



✗ Not yet RT capable

✓ Correlation in all relevant directions

✓ Realistic secondary ride feel



✓ RT capable

✓ Correlation in all relevant directions

✓ Realistic secondary ride feel

Body FRFs Model



KEY GUIDELINES

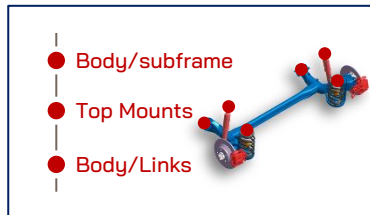
- 1) Test vs FEA vs MNF
- 2) Proper FRFs **AMPLITUDES** but **missing PHASE**
- 3) Sequential correlation: Ensure **accurate inputs**

MODAL ANALYSIS ON COMPLEX MODEL OF COMPLETE TRIMMED BODY

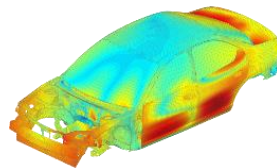
FRFs GENERATION

Inputs

Forces at suspension attachment points

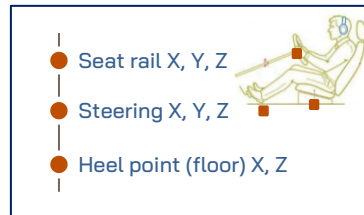


Test, FEA or MNF model
Complete trimmed body

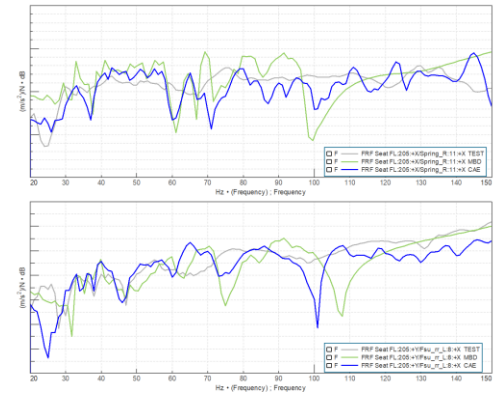


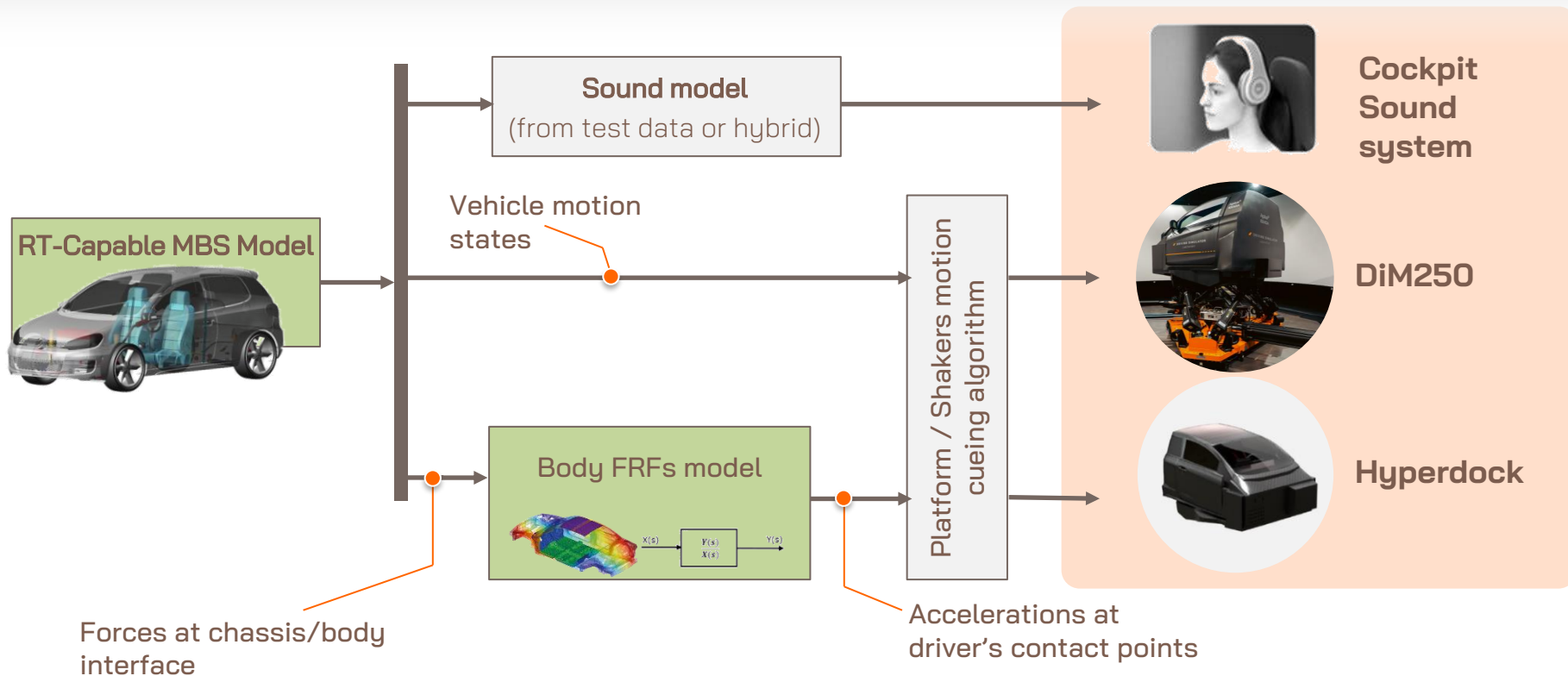
Outputs

Accelerations at driver's contact points



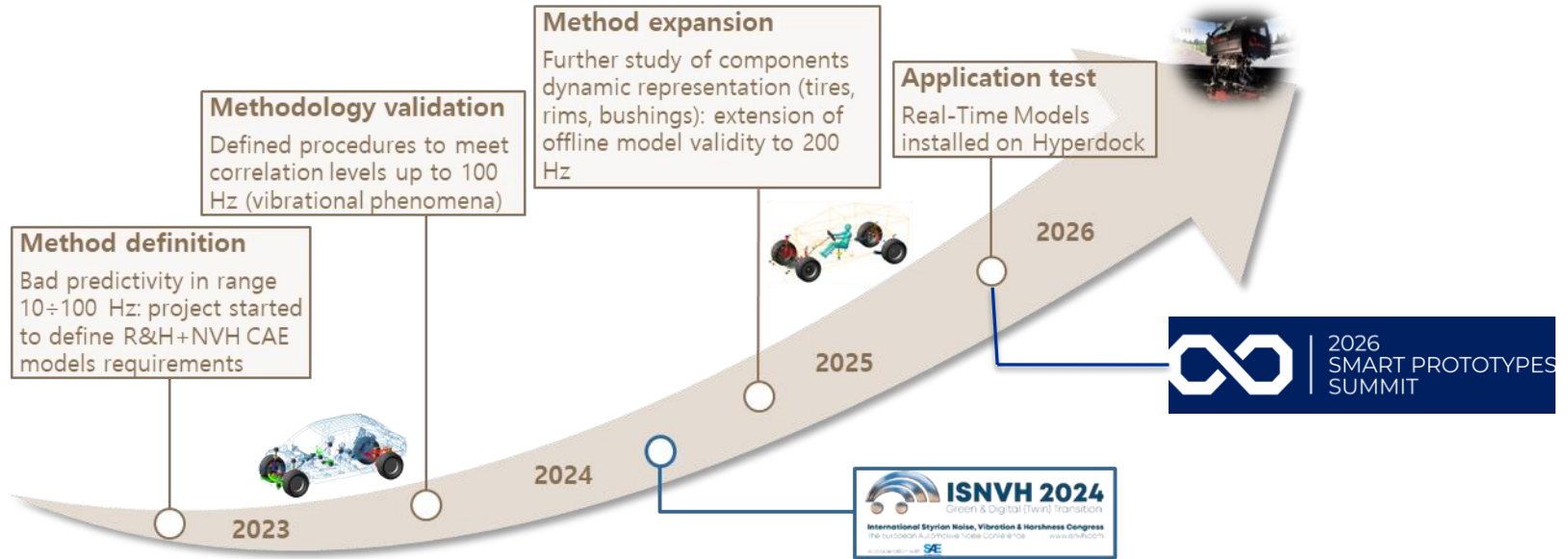
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HMETC & IDIADA collaborations during last years



OBJECTIVES

- 1) Apply new IDIADA **METHODOLOGY** for comfort and NVH
- 2) Understand the vibrational and sound capabilities of new **HW**
- 3) Validate subjective implications of different **MODELLING LEVELS**
- 4) Demonstrate **shakers influence** in comfort and NVH chassis component **subjective** tuning

RESOURCES

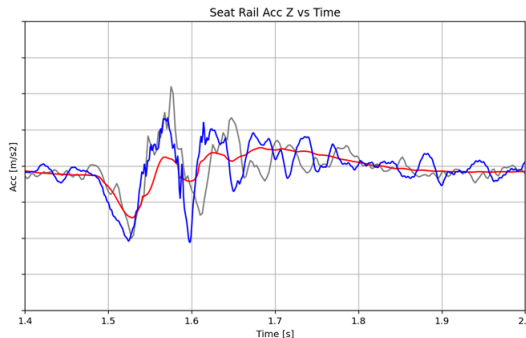
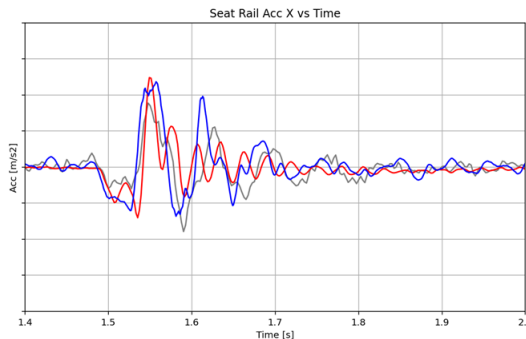
- B-SUV test vehicle from Hyundai Motor Europe
- FE and ADAMS full vehicle models
- Set of production tires, to generate physical tire models
- VD, NVH and DS teams fully integrated in the project

MAIN OPEN QUESTIONS

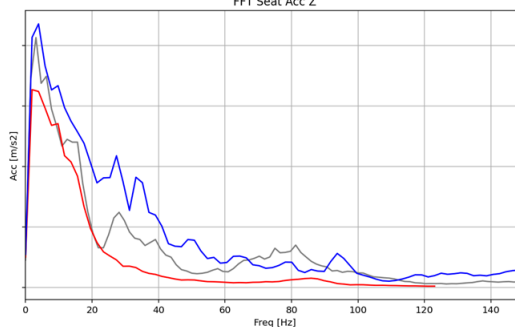
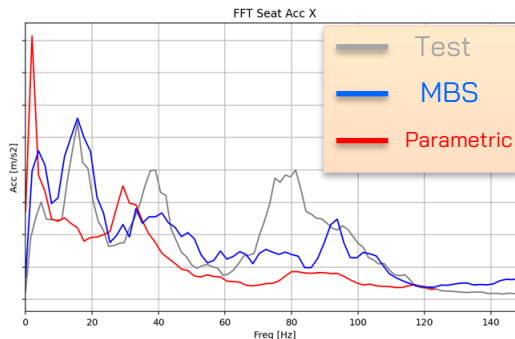
- 1) Trimmed Body representation: **MNF** vs BIW **FRFs**?
- 2) Accuracy gap & driving experience: **Replays** vs actual **online** driving?

#	Trial	VD SW	Tyre	Suspension	Body	On/Off Line
1	PARAMETRIC Models	VI-CRT	MF 5.2	LUT	Rigid	ON
2			FTIRE			

1. U-Shape – 20 km/h



2. BMR – 30 km/h



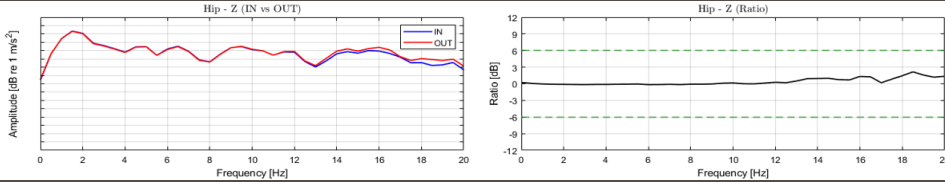
3. Conclusions

- MBD preferred
- Prediction requirements up to 150 Hz
- New CCur platform enables for higher number of DOFs.
- Model simplifications are still needed

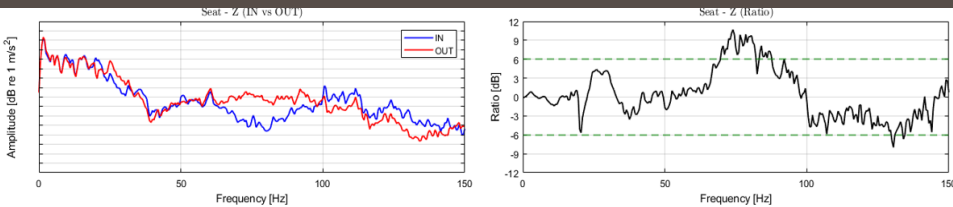
→ Need for as complex as possible flexible BIW!

HW Validation

Platform ONLY [0 - 20 Hz] ✓



Platform + Shakers [0 – 150 Hz] ✓



Key for **REPLAYs** usage!

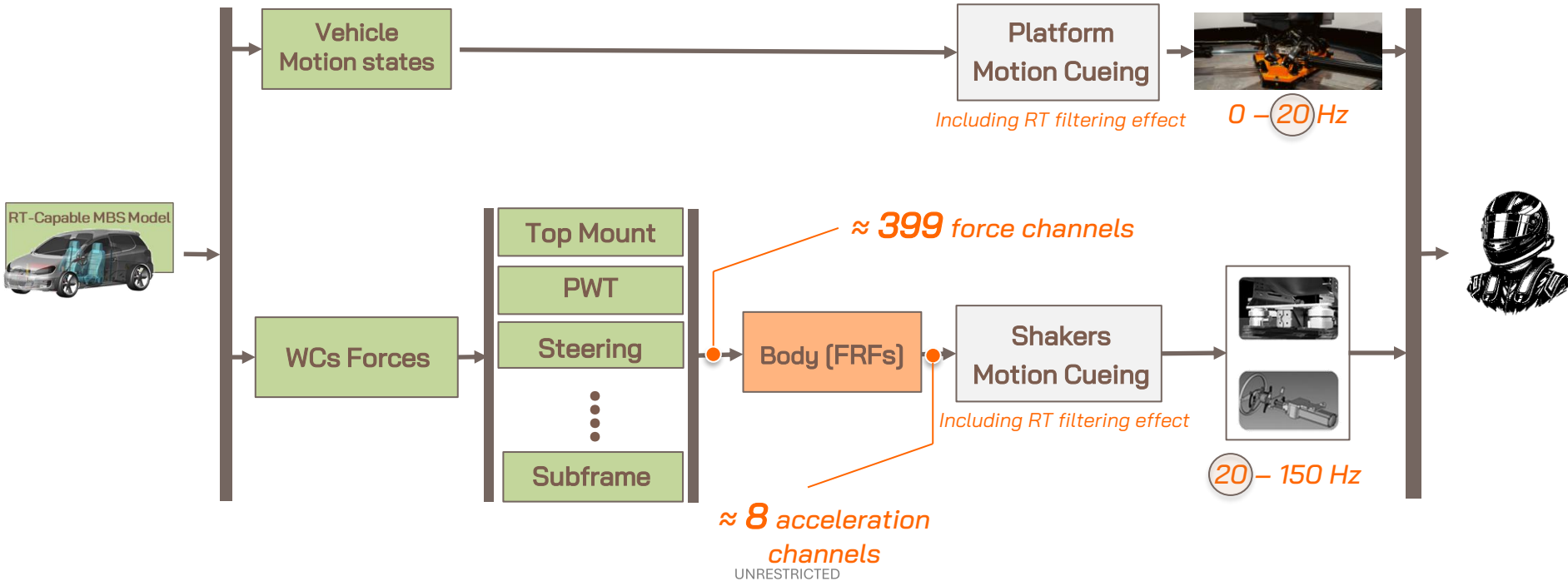
SW Integration

- 1) Vi-CRT + Shakers ✓
- 2) ADAMS/CAR RT + Shakers ✓
- 3) ADAMS/CAR RT + FRFs + Shakers ✓
- 4) Test and ADAMS/CAR RT Replays + Shakers ✓

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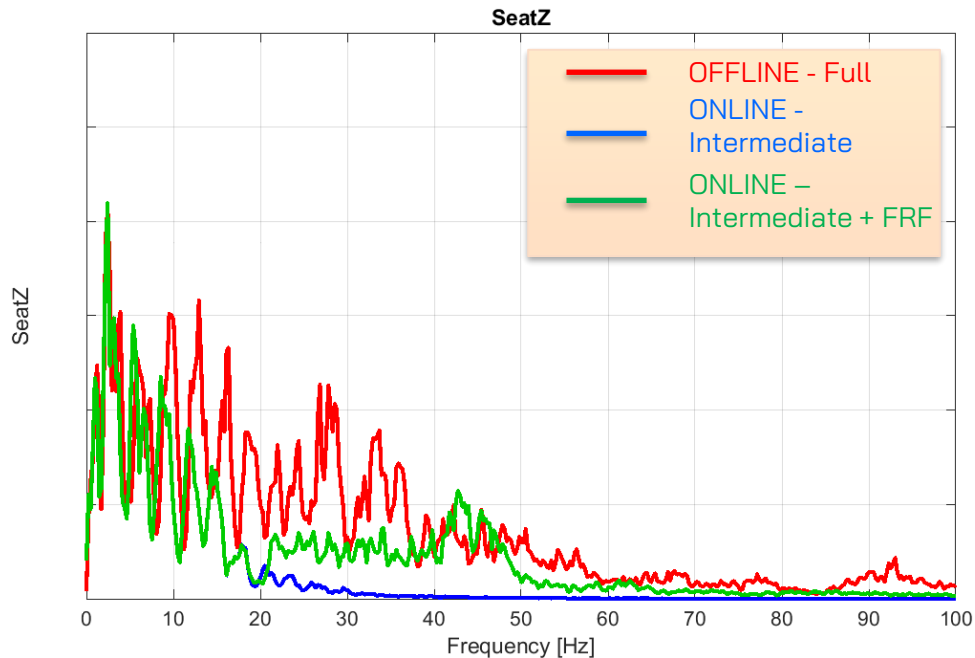
Key for **ONLINE DRIVING** usage & more!

SW Integration – FRFs WORKFLOW



SW Integration – FRFs WORKFLOW – MNF vs BIW FRFs?

BMR – 30 km/h



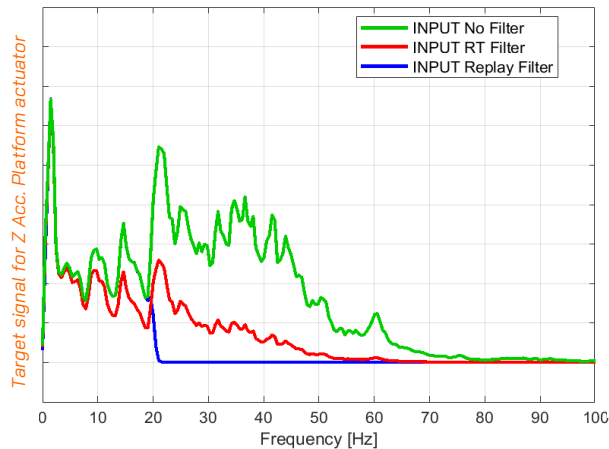
Conclusions

- 3 Gap sources: Model simplifications + Filtering + HW
- < 20 Hz: Main effect of RT Filtering - Platform
- Transition: Response VALLEY → to be tuned!
- > 20 Hz: FRF increase content above 20 Hz - Shakers

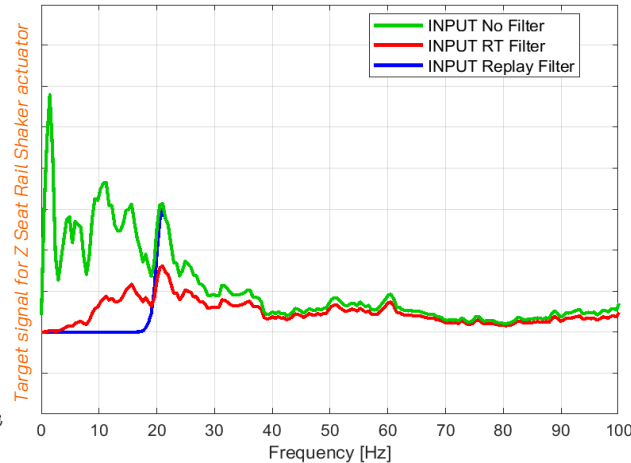
→ **CONFIRMS** FRFs is a meaningful RT Method!

SW Integration – FRFs WORKFLOW – Replays vs actual online driving (I)

1. RT FILTERING effect in motion cueing – Platform input



2. RT FILTERING effect in motion cueing – Shakers input

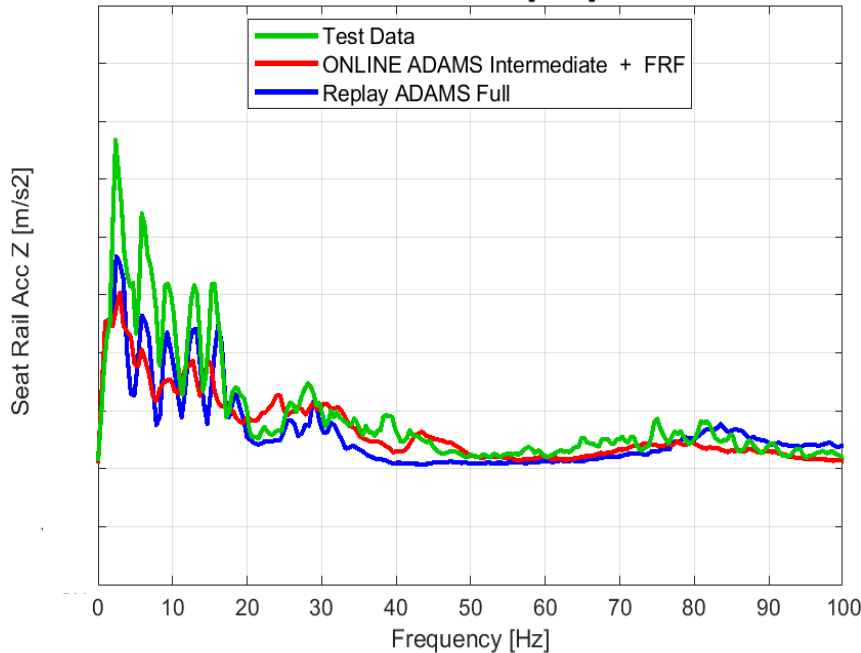


Conclusions

- 3 Gap sources: Model simplifications + Filtering + HW
 - RT Filtering Order 1: Balance delay vs filtering accuracy
- Motion Cueing filtering has a direct effect on vibration perceived!

SW Integration – FRFs WORKFLOW – Replays vs actual online driving (II)

BMR – 30 km/h - REPLAY VS ONLINE DRIVING comparison

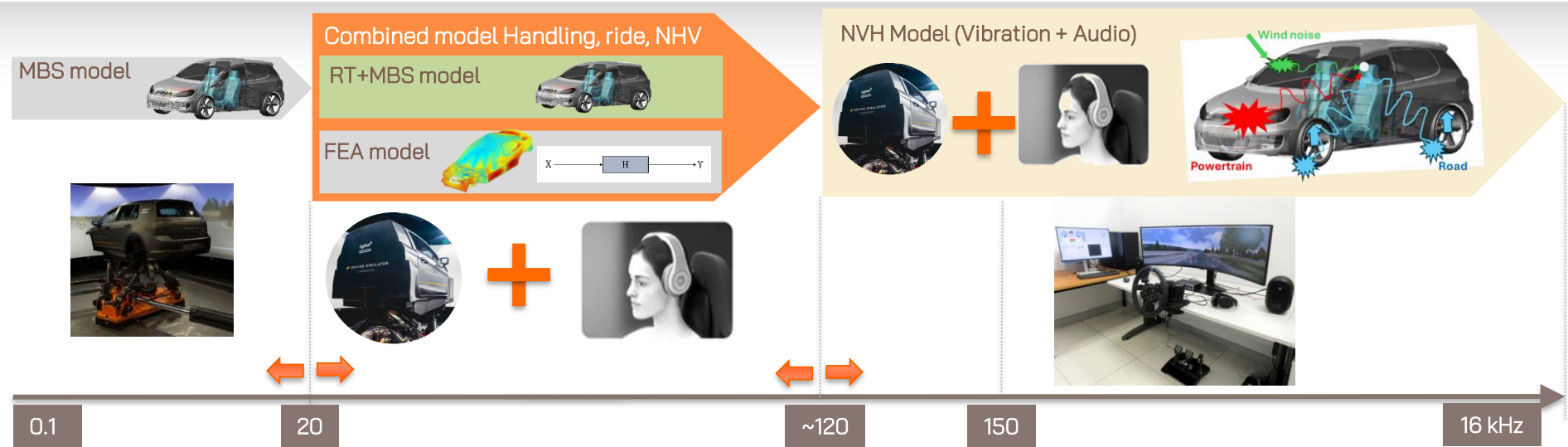


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Physical accelerometer signal on cockpit seat

Conclusions

- 3 Gap sources: Model simplifications + Filtering + HW
- **Replay vs online driving:**
 - < 20 Hz: Replay is more realistic due to more complex model
 - > 20 Hz: FRF increase content

→ Need balance between accuracy and virtual tuning flow/progress



KEY TAKEAWAYS

- NVH desktop simulator & models **fully extrapolable** to DiM250 + Hyperdock
- Experience the vehicle **full frequency** spectrum
- **Source contribution** analysis → contribution path by source
- Evaluate VD design/modification → **Impact on NVH attribute at early stages**

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1 Upgraded facility is **READY!**

2 New **HW + Modelling Methodology** allows reaching up to **150 Hz**

3 **NVH virtual development** is now possible to be heard and felt!

4 **POC with HMETC** completed!



Javier Gutiérrez
Manager
Virtual Vehicle Dynamics
& Driving Simulator

T H A N K Y O U F O R Y O U R K I N D A T T E N T I O N



www.applusidiada.com

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Applus IDIADA

Headquarters and Main Technical Centre

L'Albornar – PO Box 20

E-43710 Santa Oliva (Tarragona) Spain

T +34 977 166 000 F +34 977 166 007

e-mail: idiada@idiada.com

www.idiada.com

Applus IDIADA Belgium

T +32 2 757 27 07 (Brussels)

e-mail: idiada_belgium@idiada.com

Applus IDIADA Brazil

T +55 11 4330 9880 (São Paulo)

T +55 31 3591 6832 (Belo Horizonte)

e-mail: idiada_brasil@idiada.com

Applus IDIADA China

T +86 21 6210 0394 (Shanghai)

T +86 21 6210 0394 (Beijing)

T +86 431 8190 9680 (Changchun)

T +86 23 6756 8060 (Chongqing)

T +86 21 6210 0394 (Cixi)

T +86 20 2282 9202 (Guangzhou)

T +86 21 6210 0394 (Ningbo)

T +86 532 66019017 (Qingdao)

T +86 21 6210 0394 (Tianjin)

T +86 21 6210 0394 (Wuhu)

T +86 535 8933658 (Zhaoyuan)

e-mail: idiada_china@idiada.com

Applus IDIADA Czech Republic

T +420 493 654 811 (Hradec Králové)

T +420 778 430 095 (Brno)

T +420 482 424 243 (Liberec)

T +420 326 736 860 (Mladá Boleslav)

e-mail: info@idiada.cz

Applus IDIADA France

T +33 (0) 181 891 943 (Paris)

T +33 (0) 130 370 836 (Paris)

T +33 (0) 141 146 085 (Lyon)

e-mail: idiada_france@idiada.com

Applus IDIADA Germany

T +49 (0) 84188538-30 (Ingolstadt)

T +49 (0) 89309056-0 (Munich)

T +49 (0) 84188538-30 (Stuttgart)

T +49 (0) 5374920606-0 (Wolfsburg)

e-mail: idiada_germany@idiada.com

Applus IDIADA India

T +91 44 2275 2202 (Chennai)

T +91 124 4028 888 (New Delhi)

T +91 20 6605 6800 (Pune)

e-mail: idiada_india@idiada.com

Applus IDIADA Italy

T +39 051 0923530 (Bologna)

T +39 005 10923500 (Erbusco)

T +39 011 2640320 (Turin)

e-mail: idiada_italia@idiada.com

Applus IDIADA Japan

T +81 (0) 42 512 8982 (Tokyo)

T +81 (0) 52 588 5329 (Nagoya)

e-mail: idiada_japan@idiada.com

Applus IDIADA Malaysia

T ++60327281027 (Kuala Lumpur)

T +601 2410 7686 (Penang)

e-mail: idiada_malaysia@idiada.com

Applus IDIADA Mexico

T +52 (222) 644 1374 (Puebla)

e-mail: idiada_mexico@idiada.com

Applus IDIADA Morocco

T +212 808 625 218 / | +212 808 682 056

e-mail: idiada_morocco@idiada.com

Applus IDIADA Poland

T +48 61 6226 905 (Poznan)

e-mail: idiada_polska@idiada.com

Applus IDIADA Slovakia

T +420 778 430 098 (Košice)

e-mail: idiada_slovakia@idiada.com

Applus IDIADA South Korea

T +82 31 478 1821 (Seoul)

e-mail: idiada_korea@idiada.co.kr

Applus IDIADA Spain

T +34 977 166 000 (Santa Oliva)

T +34 928 587 447 (Las Palmas)

T +34 915 095 795 (Madrid)

T +34 950 473 256 (Mojácar)

T +34 868 912 179 (Murcia)

T +34 948 292 921 (Pamplona)

T +34 955 117 111 (Sevilla)

T +34 986 900 300 (Vigo)

e-mail: idiada@idiada.com

Applus IDIADA Sweden

T +46 (0) 31 320 1844 (Gothenburg)

T +46 731 478 202 (Stockholm)

e-mail: idiada_sweden@idiada.com

Applus IDIADA Thailand

T +66 86 7917 071 (Bangkok)

e-mail: idiada_thailand@idiada.com

Applus IDIADA Turkey

T +90 216 250 6050 (Istanbul)

e-mail: idiada_turkey@idiada.com

Applus IDIADA UK

T +44 1223 441 434 (Cambridge)

T +44 2476 328 083 (Nuneaton)

e-mail: idiada_uk@idiada.com

Applus IDIADA UAE

T +971 4 2441313 (Dubai)

e-mail: idiada_uae@idiada.com

Applus IDIADA USA

T +1 248 978 0111 (Detroit)

T +1 760 246 1672 (Los Angeles)

e-mail: idiada_USA@idiada.com

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T +84 97 724 19 86 (Hanoi)

e-mail: idiada_vietnam@idiada.com

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