A Comprehensive Methodology for Optimizing Suspension Systems in Complex Ride Comfort and Lateral Dynamics Applications

VI-Grade Zero Prototypes Summit 2025

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in cooperation with

HYUNDAI MOTOR GROUP
EUROPEAN TECHNICAL CENTER

Applus+ IDIADA

European R&D

HYUNDAI

KIA

GENESIS

GENESIS

Hyundai Motor Europe Technical Center GmbH

Rüsselsheim a.M.

Nürburgring Test Center

Meuspath

WHO WE ARE & WHAT WE DO

IDIADA is an engineering partner to the automotive industry providing complete solutions for product development projects worldwide

OUR ASSETS

3.356
PROFESSIONALS

FIRST CLASS
STATE-OF-THE-ART
TESTING FACILITIES

24 COUNTRIES
60 LOCAL OFFICES

CONSTANT
INNOVATION
IN NEW SERVICES
AND TECHNOLOGIES

COMPLETE SOLUTIONS FOR AUTOMOTIVE ENGINEERING

PROJECT MANAGEMENT

KNOW-HOW IN ALL VEHICLE FUNCTIONALITIES

ENGINEERING, TESTING & HOMOLOGATION

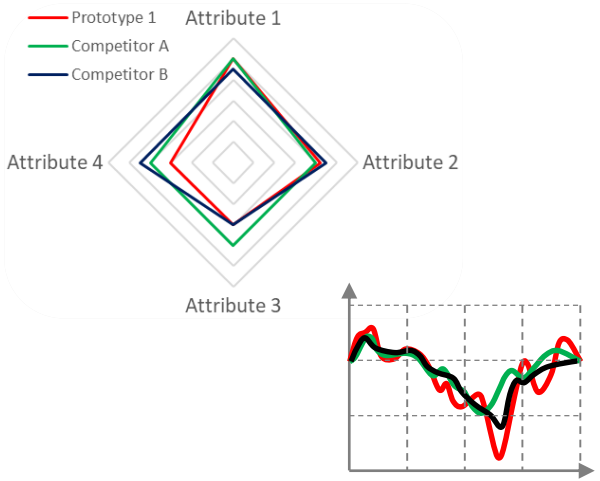
CONTENTS

1. INTRODUCTION

Understanding a new performance area

HYUNDAI MOTOR GROUP
EUROPEAN TECHNICAL CENTER

2. DEVELOPMENT PROCESS



Virtual optimisation and driving simulator

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EUROPEAN TECHNICAL CENTER

3. TECHNICAL CHALLENGES

Overcoming the technical challenges

Applus IDIADA

4. CONCLUSION

Zero prototypes as a result

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INTRODUCTION

Ride Comfort **Handling**

No focus on <u>combined scenarios</u>

How can we ensure top class performance?

Which process should we follow?
What technical challenges will we face?

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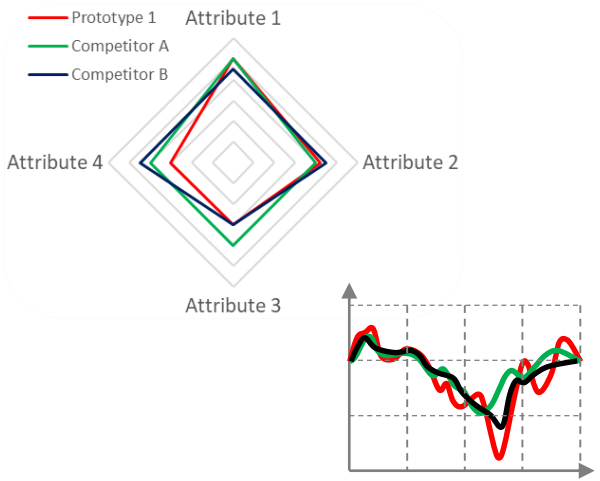

Virtual optimisation and driving simulator

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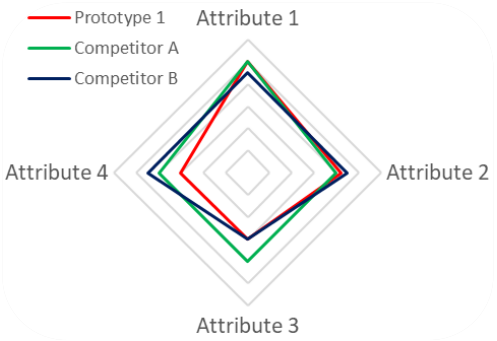
Development Process Testing-Based

Subjective Evaluation

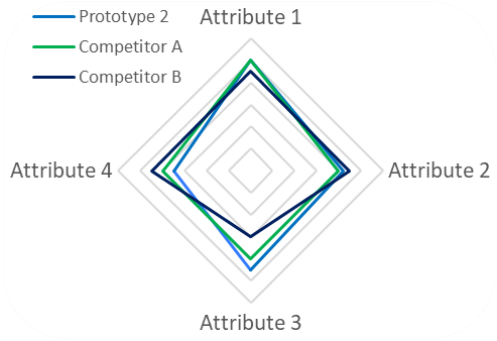


Weak Points

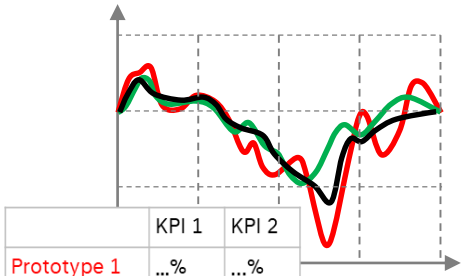
1. Time and cost efficiency

2. Relies on engineer experience, not possible to explore full design scenarios

Subjective Confirmation



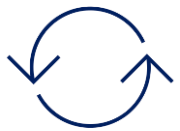
Objective Measurements



	KPI 1	KPI 2
Prototype 1	...%	...%
Competitor A	√	√
Competitor B	...%	√

Road Tuning

Trial Error Approach



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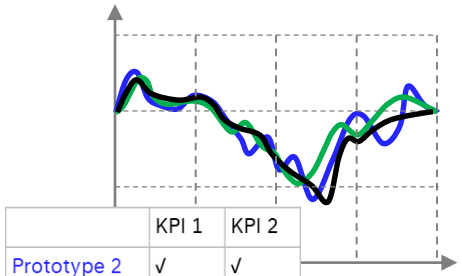
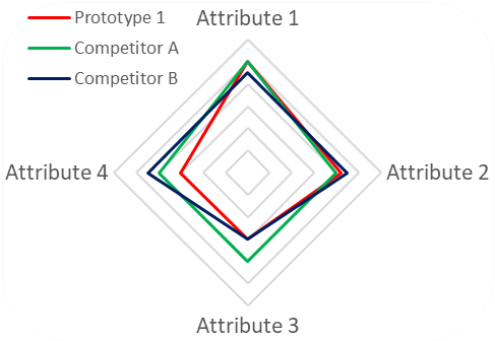


	KPI 1	KPI 2
Prototype 2	√	√
Competitor A	√	√
Competitor B	...%	√

DEVELOPMENT PROCESS SIMULATION-BASED

Subjective Evaluation



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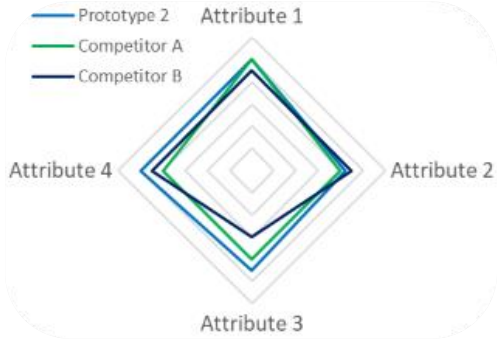
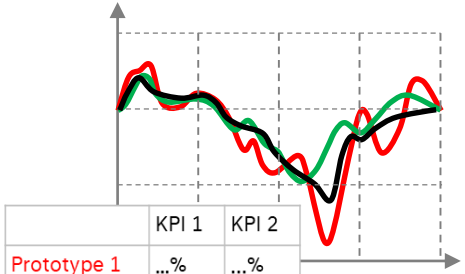


Objective Measurements

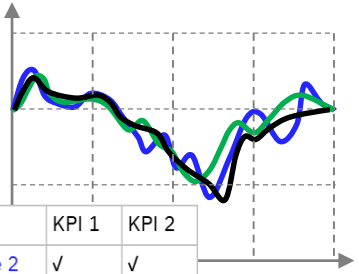


	KPI 1	KPI 2
Prototype 1	...%	...%
Competitor A	√	√
Competitor B	...%	√

Virtual Optimisation

MBD Simulation + DiL

Objective Measurements



	KPI 1	KPI 2
Prototype 2	√	√
Competitor A	√	√
Competitor B	...%	√

Development Process Simulation-Based

Virtual Optimisation

MBD Simulation + DiL

Technical Challenges

How to accurately represent **ride** comfort events coupled with **transient lateral dynamics**?

Reproducible in Driving Simulator?

Robust methodology to assess and optimise the performance area

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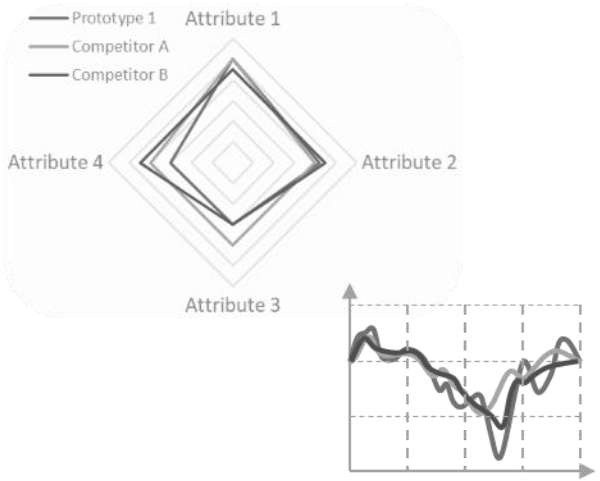

Virtual optimisation and driving simulator

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3. TECHNICAL CHALLENGES

Overcoming the technical challenges

Applus IDIADA

4. CONCLUSION

Zero prototypes as a result

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Overcoming The Technical Challenges

Creation of a Digital Twin

Understanding Performance

Proposal of solutions

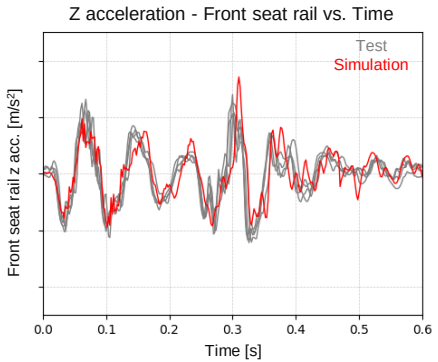
Accurate representation of **ride** coupled with **transient lateral dynamics**

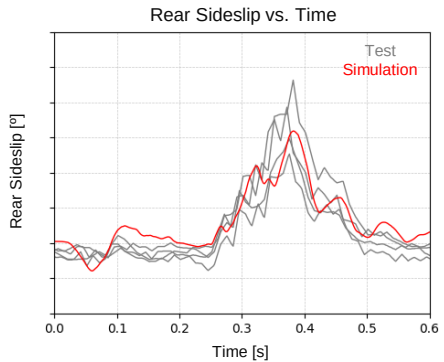
Adams Car

Accurate component modelling
At both quasi-static (K&C) and dynamic level.

Physical Tire model
For comfort applications, with accurate side force transient behaviour.

Flexible bodies
Flexible bodies for suspension and chassis parts.

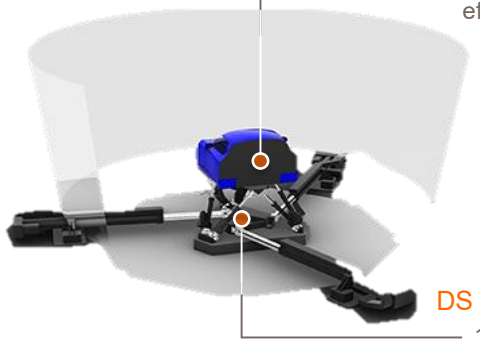




Need for a **multibody model** in **Driving Simulator**

VI-GRADE

Adams Replay
High fidelity, robust and time effective.



DS Cueing
1 to 1, up to 30 Hz

Subjective evaluation for confirmation of performance

Overcoming The Technical Challenges

Creation of a Digital Twin

Understanding Performance

Proposal of solutions

Engineering analysis through a virtual model

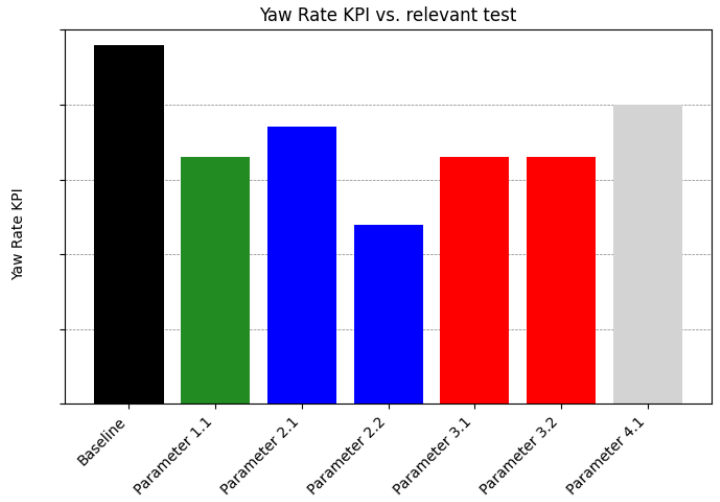
Simulation model to understand the performance area.

Confirmation of main contributors through sensitivity analysis

1 *Contributor 1*

2 *Contributor 2*

3 *Contributor 3*



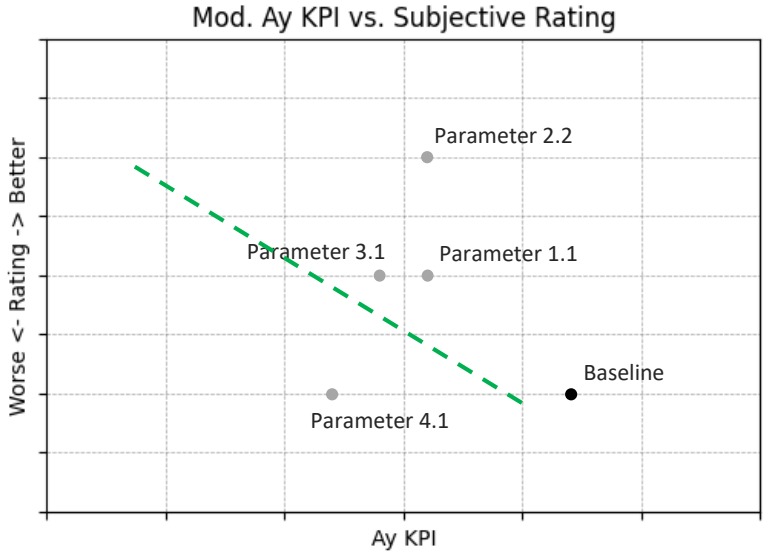
KPI robustness through Driving Simulator

- KPIs derived from objective-subjective analysis.
- Few vehicles are tested.

Are KPIs robust indicators of performance?

Yaw Rate KPI

Ay KPI



Overcoming The Technical Challenges

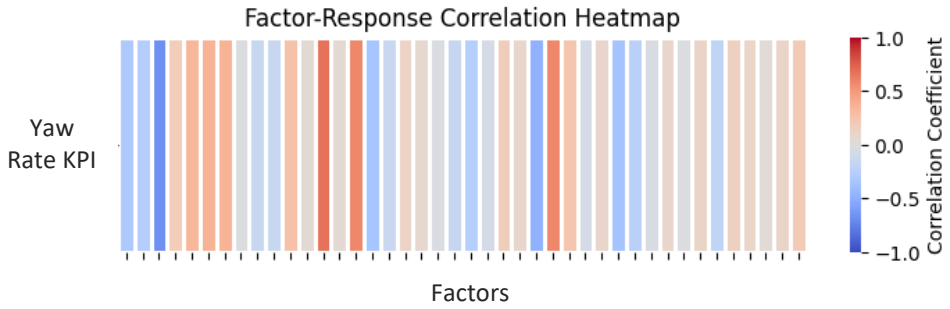
Creation of a Digital Twin

Understanding Performance

Proposal of solutions

Design of Proposals

- Sensitivity Study – Based on Analysis
- DoE – Extensive exploration



+500 Simulated Configurations

Key Contributors Identified

5 Feasible Proposals
Considering Full R&H Attributes

Final Selection in Driving Simulator

VI-GRADE CAR Adams Real Time

✓ Accurate for ride scenarios

✓ Full R&H evaluation with only one model

Optimal Configuration

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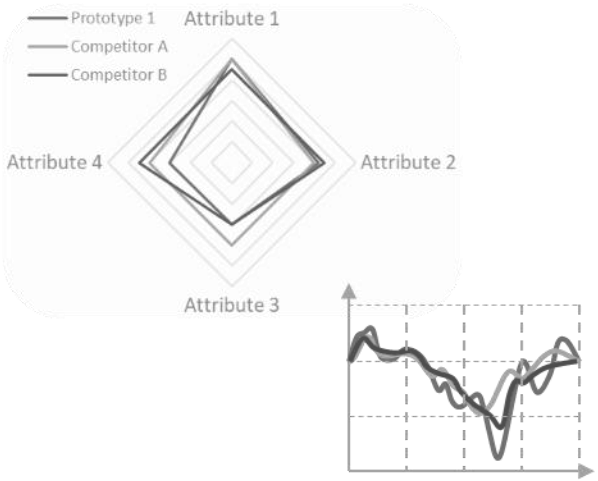

Virtual optimisation and driving simulator

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Zero prototypes as a result

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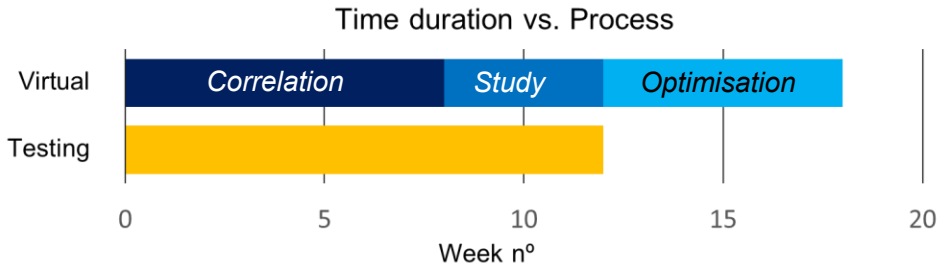
Which process should we follow?
What technical challenges will we face?

From pure road testing to virtual optimisation and road confirmation

TIME AND COST EFFICIENT



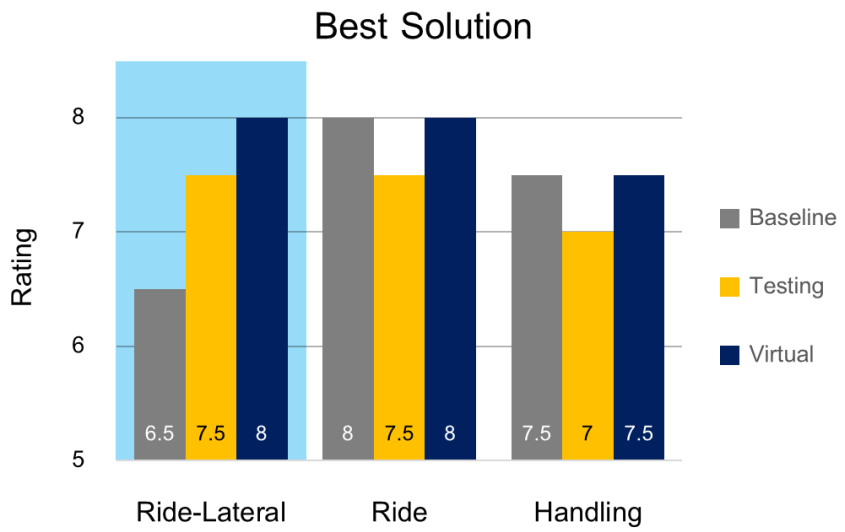
COMPLETE DESIGN EXPLORATION

ROBUST KPI & METHODOLOGY FOR FUTURE DEVELOPEMENTS

0 PARTS PRODUCED

ZERO PROTOTYPES

OPTIMAL SOLUTION



Thank You!

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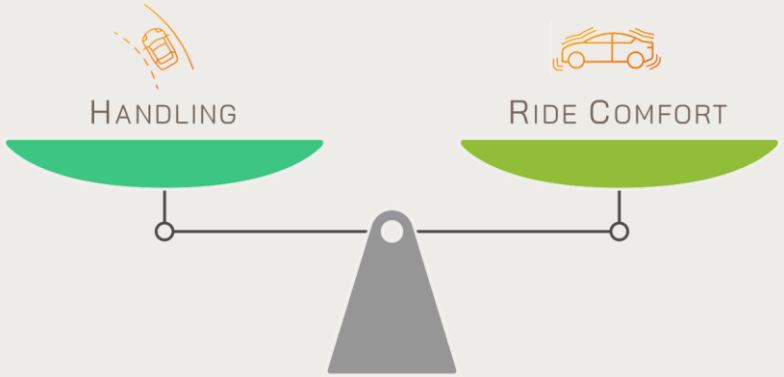
Updates on IDIADA's Driving Simulator Lab

New **Hyperdock** cockpit on IDIADA's DiM250 simulator

Motivation

1



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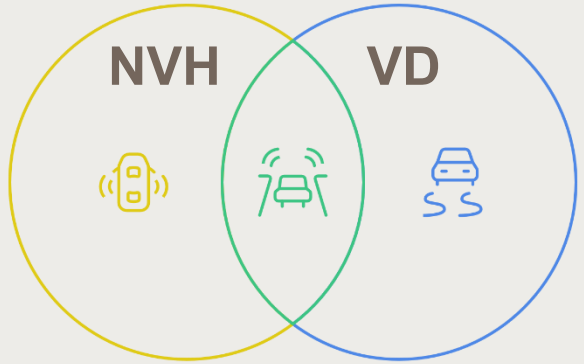
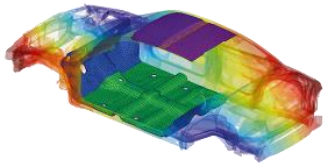


→ Available in **Q4 2025**

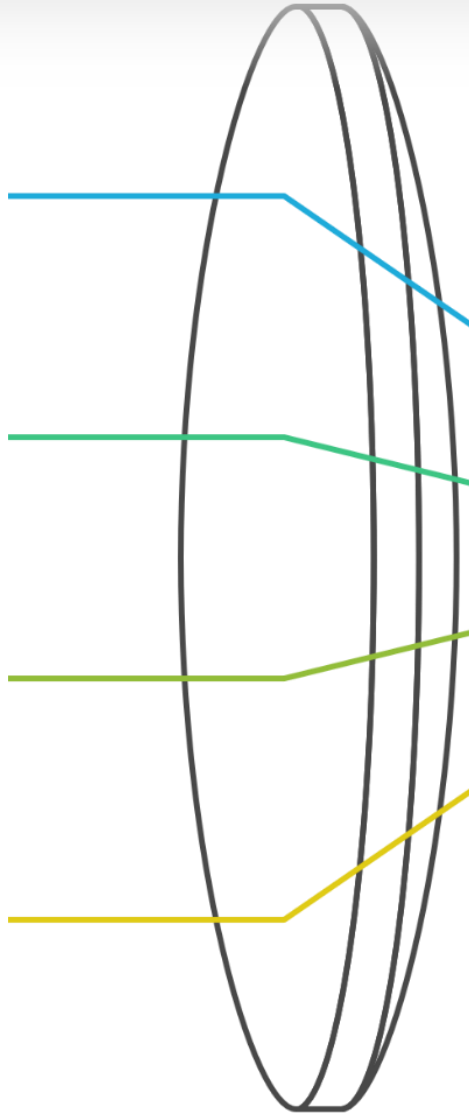
1. RT Multibody

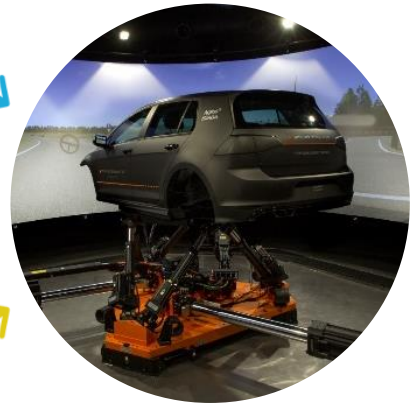
2. Hyperdock

3. NVH Simulator



4. Upgraded CCUR





Enhanced development process

Integration in IDIADA's Driving Simulator

Sound model
(from test data or hybrid)

Cockpit Sound system

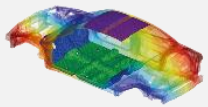
Vehicle motion states

RT Multibody

Motion cueing algorithm

DiM250

Body TF model
(from virtual data)



$$X(s) \rightarrow \frac{Y(s)}{X(s)} \rightarrow Y(s)$$

Hyperdock

Accelerations at chassis/body interface

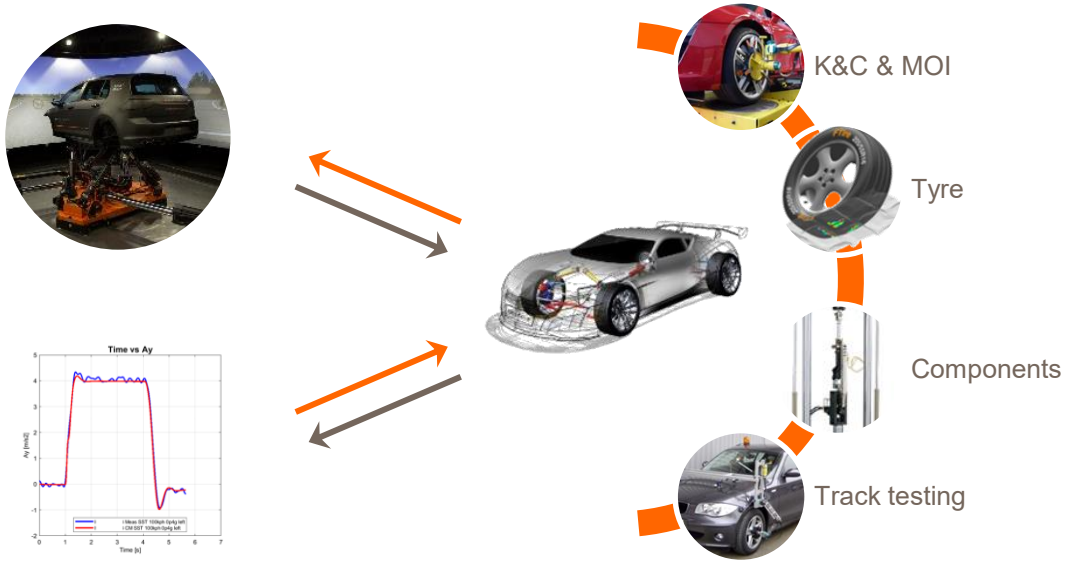
Accelerations at driver's contact points

New K&C test rig

- 2 axles
- Integrated COG/MOI measurement

→ Key element for **true digital twin** generation (available end of 2025)

Digital Twin Factory



On-demand vehicle model generation

Models and data from IDIADA's database

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THANK YOU FOR YOUR KIND ATTENTION

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