Vehicle Model Factory

Automatic Generation of Validated Virtual Prototypes

Agenda

1 **Customer Challenge**

Modelling effort

2 **Solution**

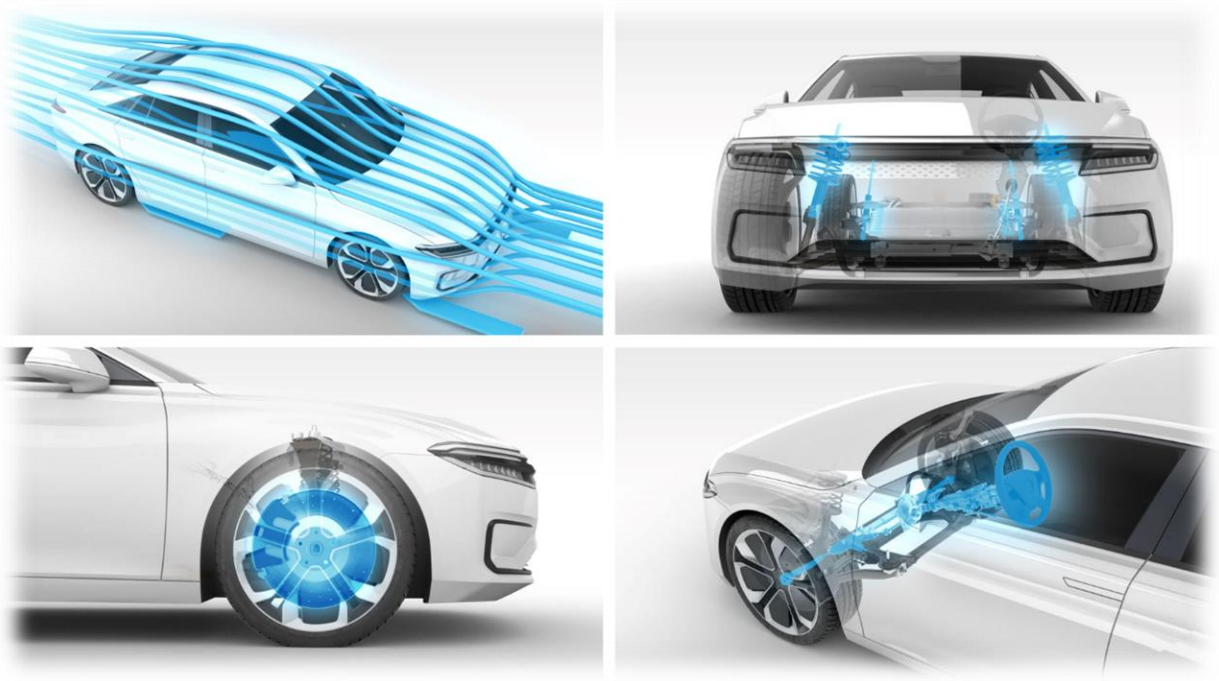
Automatic parameter identification

3 **Project Examples**

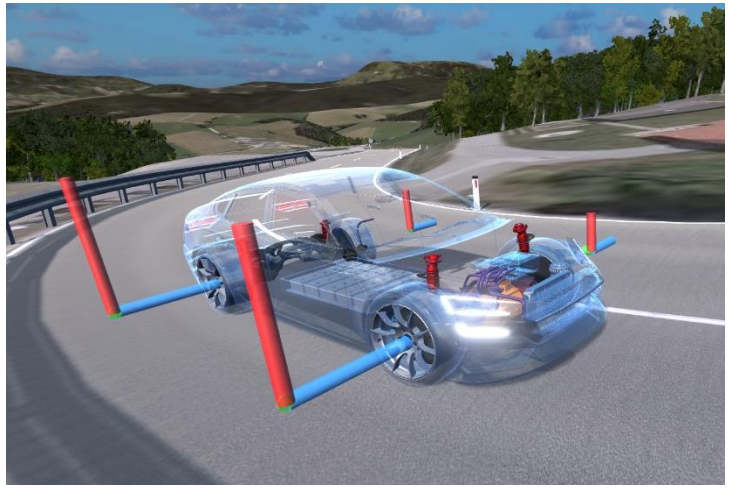
Volkswagen VW ID.3

4 **Conclusion**

Customer benefits

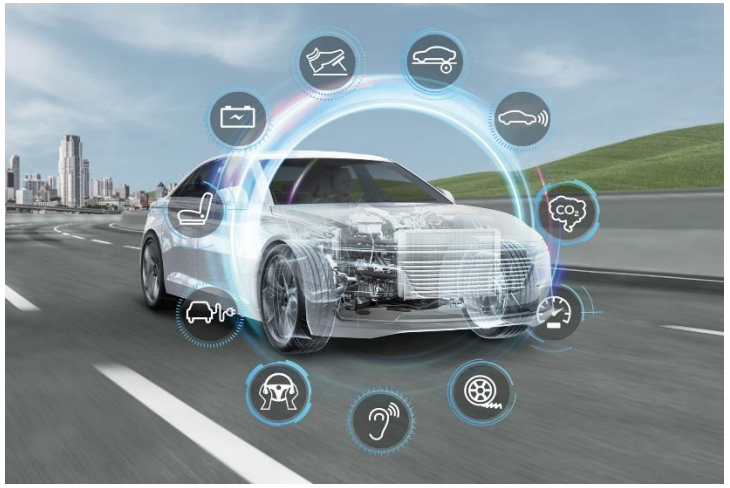


Customer Challenge



Do you spend **>50%** of your working time gathering input data, modelling or working on the correlation?

Would you prefer to **automatically** build up your simulation model based on **road measurement data**?



Do you wish to have the competitor vehicles available for **virtual benchmarking**?

Vehicle Model Factory

Solution for Automatic Vehicle Modelling and Correlation

Vehicle Measurements

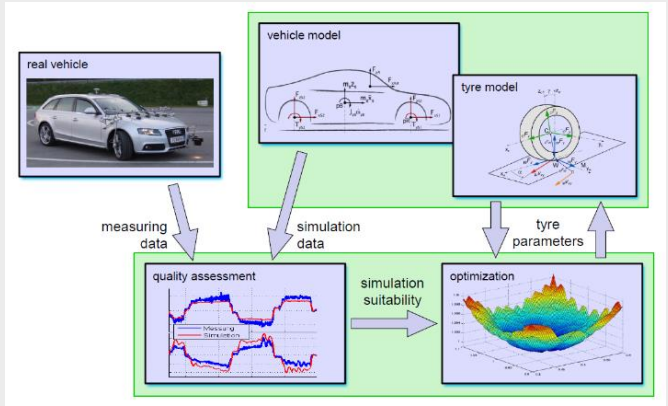
- Full load acceleration
- Part load acceleration
- Coast Down
- Tip In / Tip Out
- Constant speed
- Braking
- Const. rad. cornering
- Weave Test
- Upshift / downshift

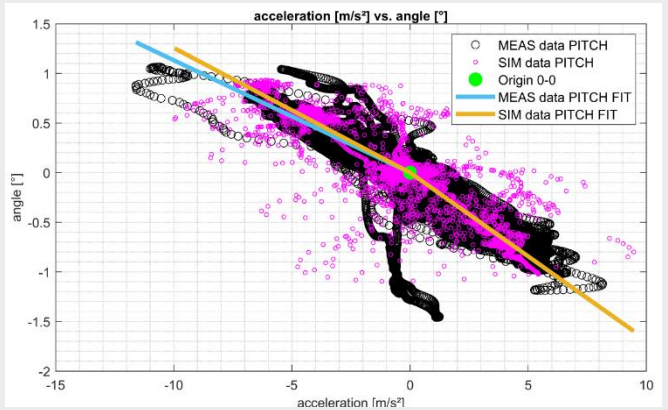
Optional:
Re-use of measurement data from AVL Vehicle Benchmark DB

Key Vehicle Parameters

- Vehicle segment / type
- Configuration: Powertrain and transmission
- Vehicle dimensions
- Tyre type and dimensions

Automatic Parameter Identification

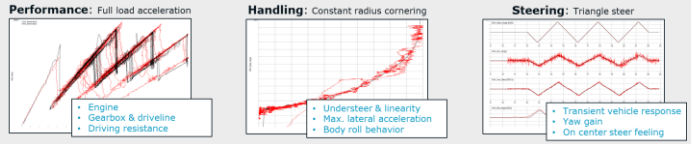




Validated Vehicle Models

Validated functional virtual prototypes for multiple applications:

Correlated with measurement data:



Simulation Environments

OFFICE HIL PTTB

Virtual Vehicle Benchmarking

Based on AVL Vehicle Data Base

292 Longitudinal dynamics **32** Longitudinal & lateral dynamics
vehicles in database

> 30
new vehicles per year

35
BEVs

> 30
PHEV/HEV

12
vehicle attributes

Latest vehicles in benchmark database


Volkswagen ID.3 1st Plus


Mercedes EQC 400 4MATIC


Peugeot 2008-e


Renault ZOE R135 z.e. 50


Mazda 3 SkyActive-X


Audi e-tron 55 quattro


Porsche Taycan Turbo-S

Automatic vehicle model generation & validation


Fuel economy


Energy Efficiency


Performance


Driveability


Vehicle Dynamics


Ride Comfort


ADAS/AD Quality

Coming soon


Renault Clio E-TECH 140


VW ID.4


Toyota Yaris 1.5 Hybrid


Tesla Model Y Performance


Polestar 2


Hyundai Ioniq 5

Solution and Use Cases
Along the Development Process


Vehicle Definition


Virtual Benchmarking

Product Vision Feasibility

AVL VSM™

Vehicle Calibration, Testing & Validation


Vehicle/PT/Chassis


Cloud-based Testing


Vehicle Function Dev.


Virtual Vehicle Concept

Concept Development

System Testing (ETB, PTTB)


Vehicle/PT/Chassis


Driving Sim. + PTTB


Component Analysis


Component Benchmark.

Component Design & Development

Component Testing (MIL, SIL, HIL)


ADAS Functions


Vehicle/PT Functions

New vehicle development:

- ✓ Vehicle modeling based on road measurements and key target parameters of **predecessor vehicle** or **competitor vehicles**
- ✓ Models of main competitor vehicles for **virtual benchmarking**
- ✓ Continuous **refinement** with key parameters from CAx data

Calibration, Testing and Validation:

- ✓ Either re-use virtual prototype from previous phase or **modeling** based on **prototype road measurements**
- ✓ **Automatic generation** of **plant model** for xCU calibration and testing in MiL/SiL/HiL/ETB/PTTB environment

Solution
Vehicle Modelling and Workflow

Manual step

Automatic step

State Of The Art

Component measurements → Perform vehicle measurements → Create vehicle model → Fill in missing data (expert knowledge) → Validate Vehicle model

4-8 weeks

Vehicle Model Factory (new vehicle measurements)

Collect key params → Perform vehicle measurements → ① → ②

① Automatic parameter identification

② Automatic model validation

2-3 weeks

Vehicle Model Factory (re-use of AVL measurements data base)

Collect key params → ① → ②

re-use of AVL measurements data base

① Automatic parameter identification

② Automatic model validation

<2 days

Vehicle Model Factory
Example: **Volkswagen ID.3**

Challenges

Spend **>50%** of working time on vehicle modelling and correlation?

Automated vehicle modelling based on **road measurement data**?

Access to **digital twins** of **target / competitor** vehicles

Vehicle Benchmark Data Base

300 vehicles

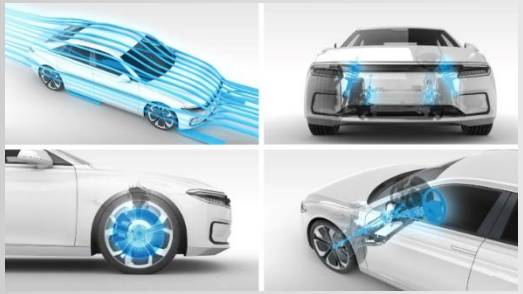
12 vehicle attributes

35 BEVs

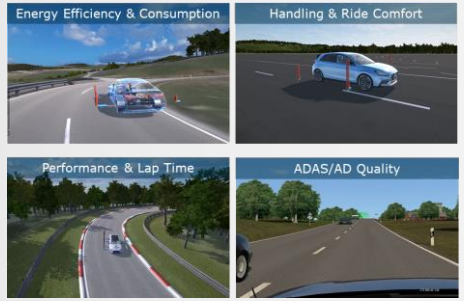
> 30 PHEVs HEVs

> 30 new cars per year

Vehicle Model Factory



Validated Vehicle Models
for multiple applications



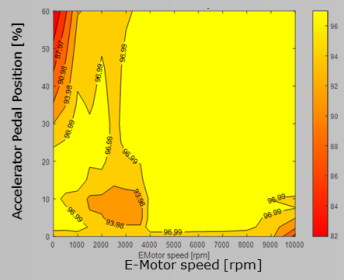
Customer Benefits

Reduce modeling effort by **up to 70%**

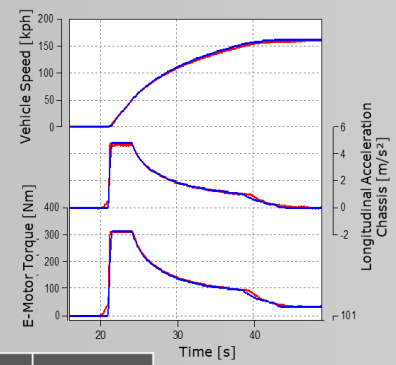
Automatic validation of virtual prototypes

>300 vehicles in benchmarking DB for virtual benchmarking

Powertrain / E-Drive Identification



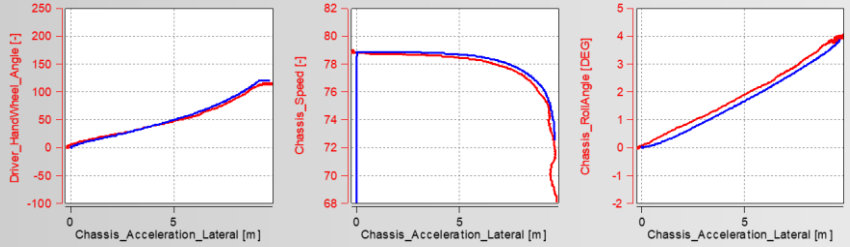
E-Drive Efficiency map



	Peak Accel. [m/s²]	0-100 kph [s]	Max. system torque [Nm]	Max. system power [kW]
Road meas.	4.78	7.9	311.0	150.2
AVL VSM™	4.82	7.8	313.5	151.1
Accuracy	**99.2%**	**98.7%**	**99.2%**	**99.4%**

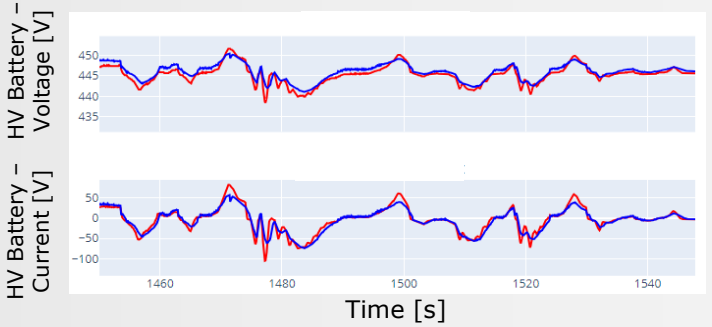
Maneuver:
Full-Load Acceleration

Suspension Identification



Slowly Increased Steer (80kph)	Max. lateral acceleration [m/s²]	Roll Angle Gradient [deg/(m/s²)]	Pitch Angle Gradient [deg/(m/s²)] *Acceleration*	*Braking*
Road measurements	9.801	0.348	8.33	8.12
AVL VSM™	9.6	0.332	8.32	8.25
Accuracy	**97.9%**	**95.4%**	**98.8%**	**98.3%**

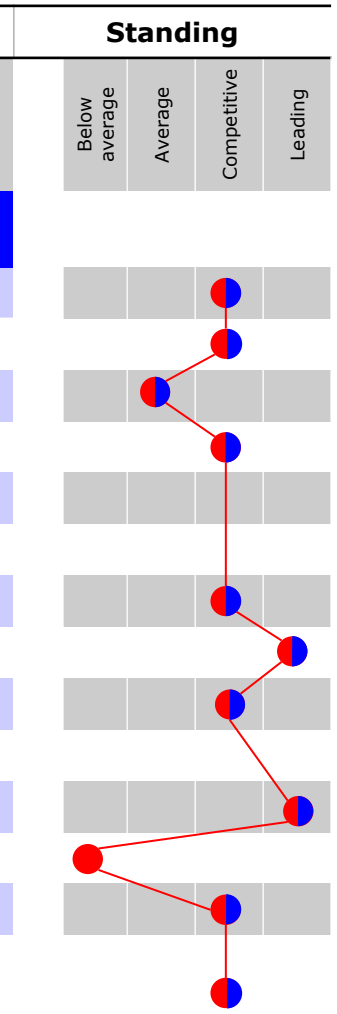
HV-Battery Identification



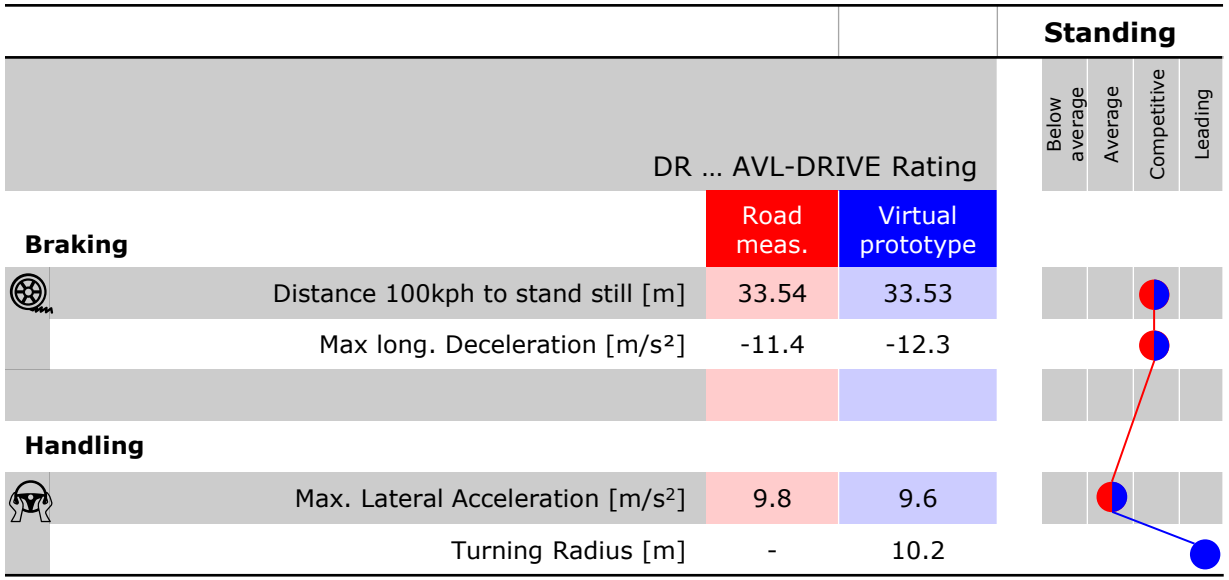
WLTC Cycle	Total Mech. Energy [kWh]	Overall E-Motor Efficiency [%]	HV Battery Consumption [kWh/100km]
Road measurements	2.808	88.7	16.535
AVL VSM™	2.790	86.1	16.502
Accuracy	**99.3 %**	**97.1 %**	**99.8 %**

Executive Summary
Correlation Quality

	DR … AVL-DRIVE™ Rating	Road meas.	Virtual prototype
Performance			
	0 to 100kph [s]	7.9	7.8
	Max long. Acceleration [m/s²]	4.8	4.8
	Top speed [kph]	160	160
	Curb weight [kg]	1779	1779
Driveability			
	Drive away – Standing start [DR]	8.0	7.9
	Acceleration – Full load [DR]	8.8	9.0
	Acceleration – Part load [DR]	7.8	7.7
Energy consumption & Range			
	WLTC [kWh/100km]	16.535	16.502
	RDE [kWh/100km]	21.3	-
	Range - Extrapolated (WLTC) [km]	344.7	345.4
	Road load: A0 [N] B0 [N/kph] C0 [N/kph²]	109.2 0.77 0.026	114.6 1.31 0.021



	DR … AVL-DRIVE Rating	Road meas.	Virtual prototype
Braking			
	Distance 100kph to stand still [m]	33.54	33.53
	Max long. Deceleration [m/s²]	-11.4	-12.3
Handling			
	Max. Lateral Acceleration [m/s²]	9.8	9.6
	Turning Radius [m]	-	10.2

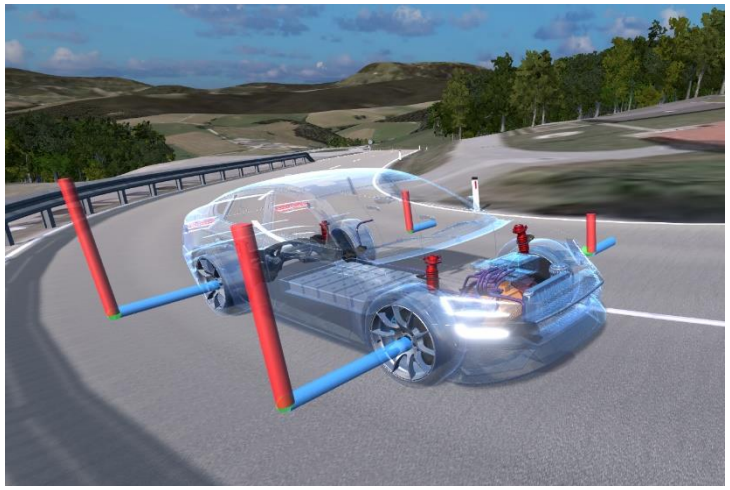


● Road measurements ● Virtual vehicle prototype

- Vehicle Benchmark Study
- Battery Benchmark Study
- E-Drive Benchmark Study

https://experience.avl.com/vehicle-benchmarking

Customer Benefits



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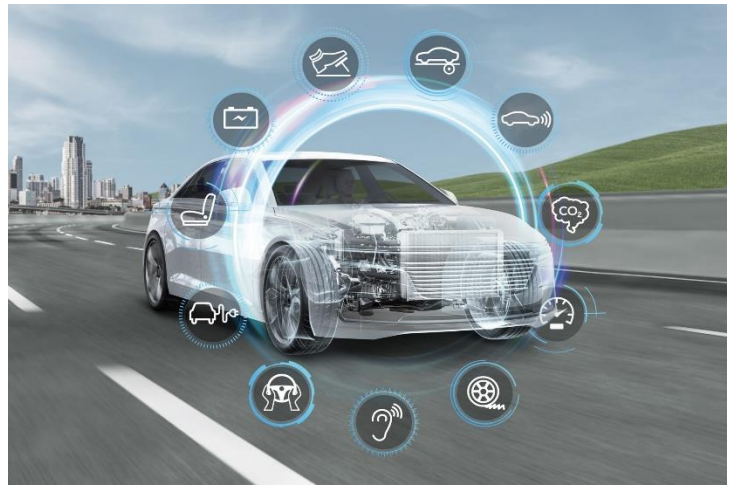
by up to **70%**

Automatic validation of
virtual prototypes



>300 vehicles
in benchmarking DB for
virtual benchmarking

Thank you

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