AVL List GmbH (Headquarters)

Frontloaded e-AWD development with automated system optimization

EAWD19 - Electrification and All-wheel Drive Congress

Graz / Spielberg May 9. – 10. 5. 2019

Joachim ECKER

Patrick TEUFELBERGER

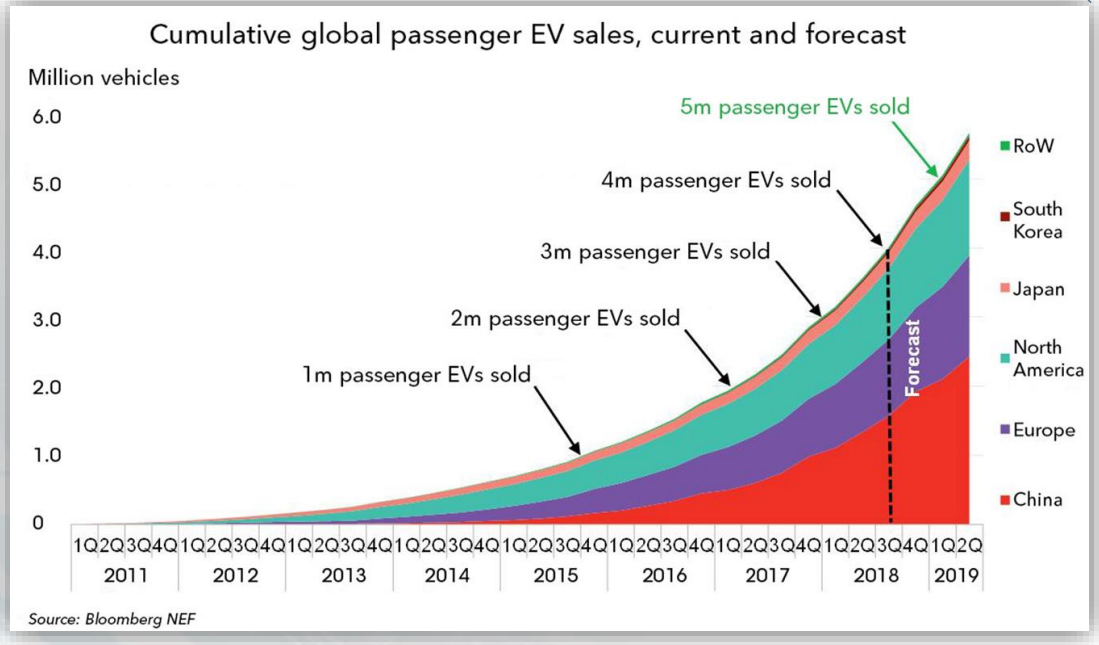
Christof DANNER

Mario OSWALD

Manfred KOGLER

Market Situation & Challenge

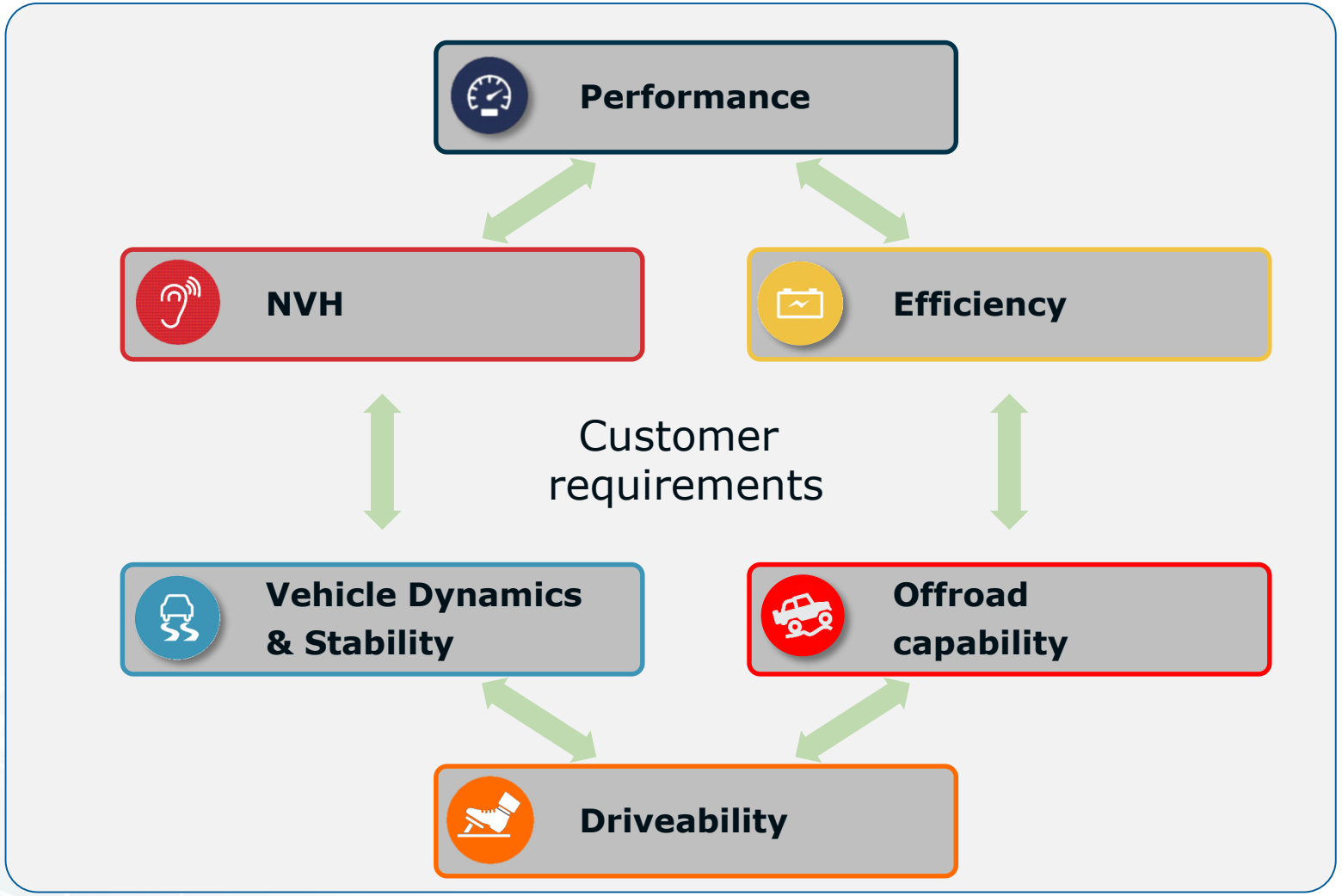
Electric vehicles worldwide sales



Source:
https://about.bnef.com/blog/cumulative-global-ev-sales-hit-4-million/
https://www.best-selling-cars.com/global/2018-full-year-international-worldwide-car-sales-and-global-market-analysis/

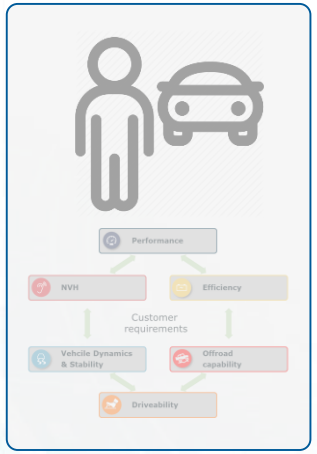
1. Customer demands on electric vehicle

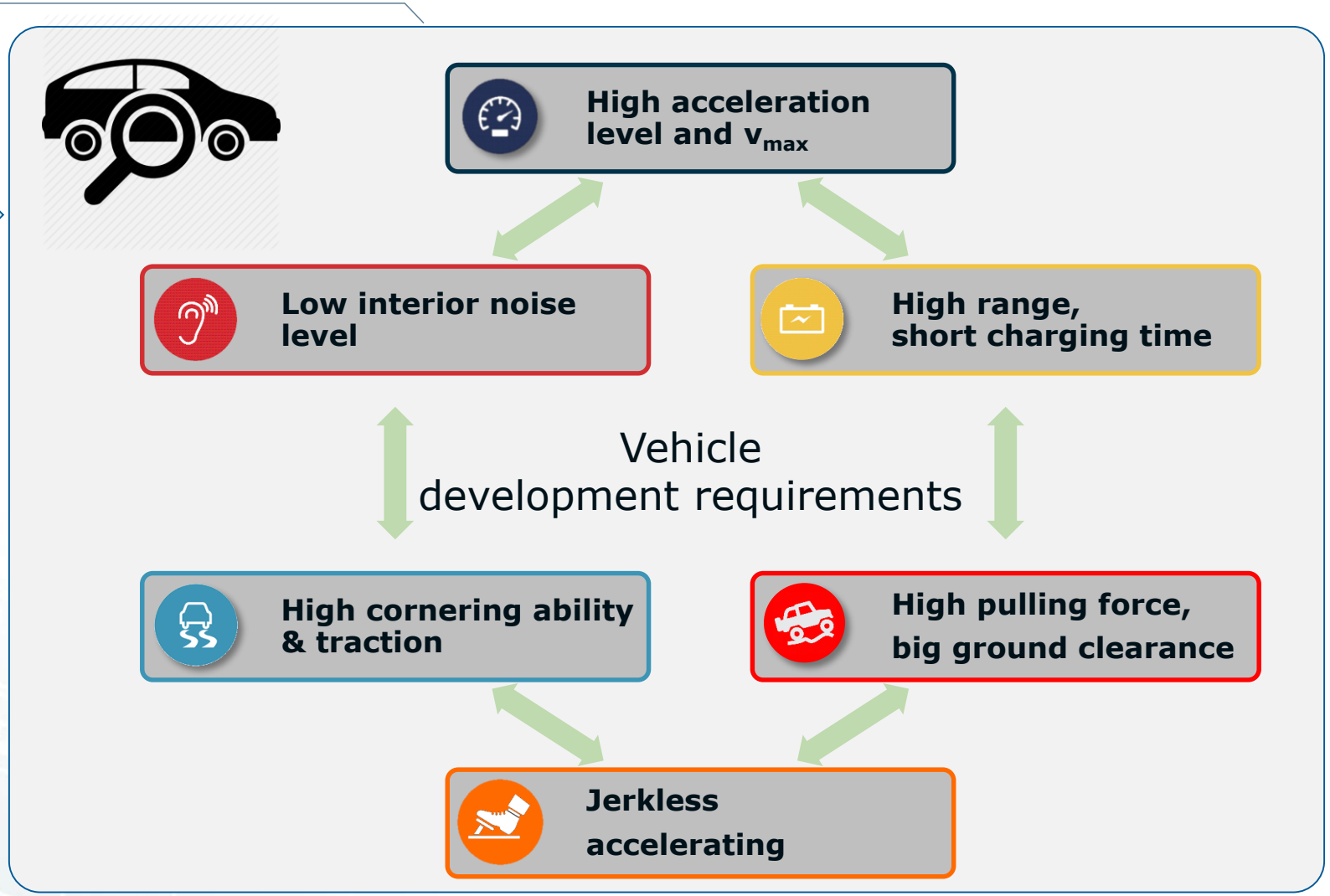
Which are the main electrification related vehicle attributes



2. Electric vehicle development requirements

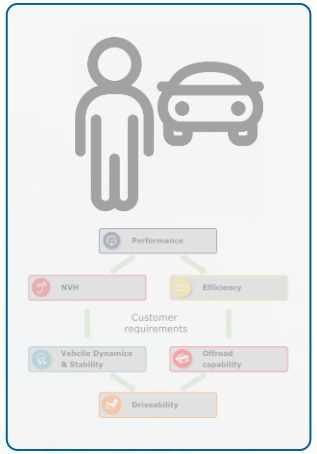
The customer defines the main requirements



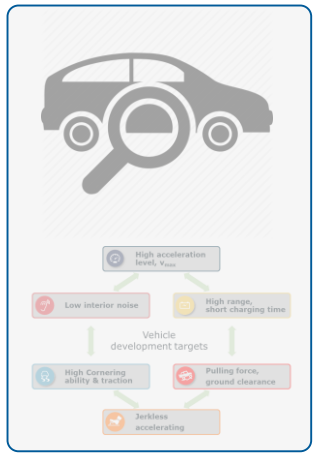


3. Electric Vehicle Specification

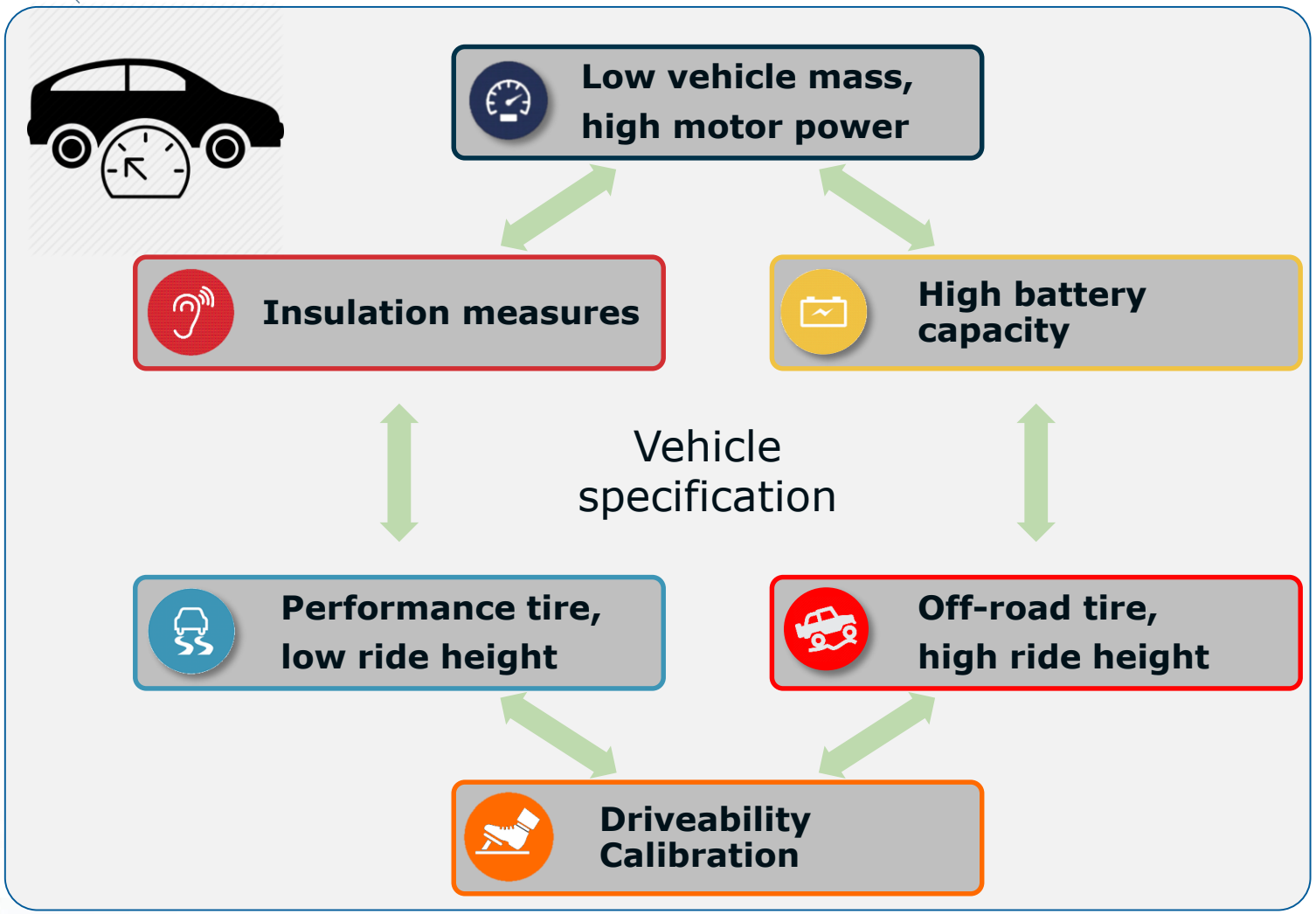
The vehicle requirements set the vehicle specifications



Customer's demands

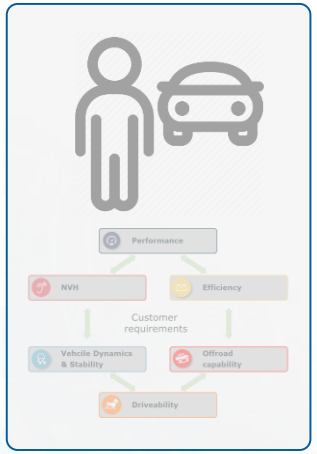


Vehicle requirements

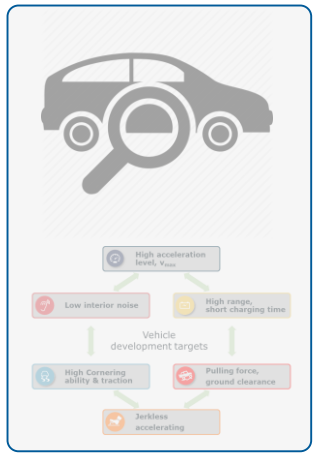


4. Powertrain System Requirements

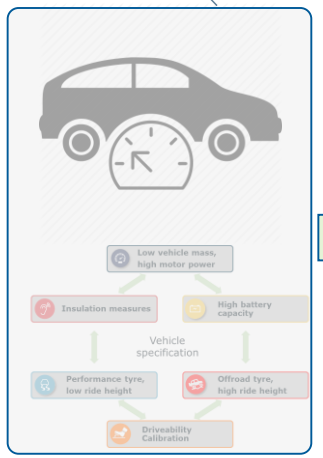
The vehicle specification set the powertrain requirements



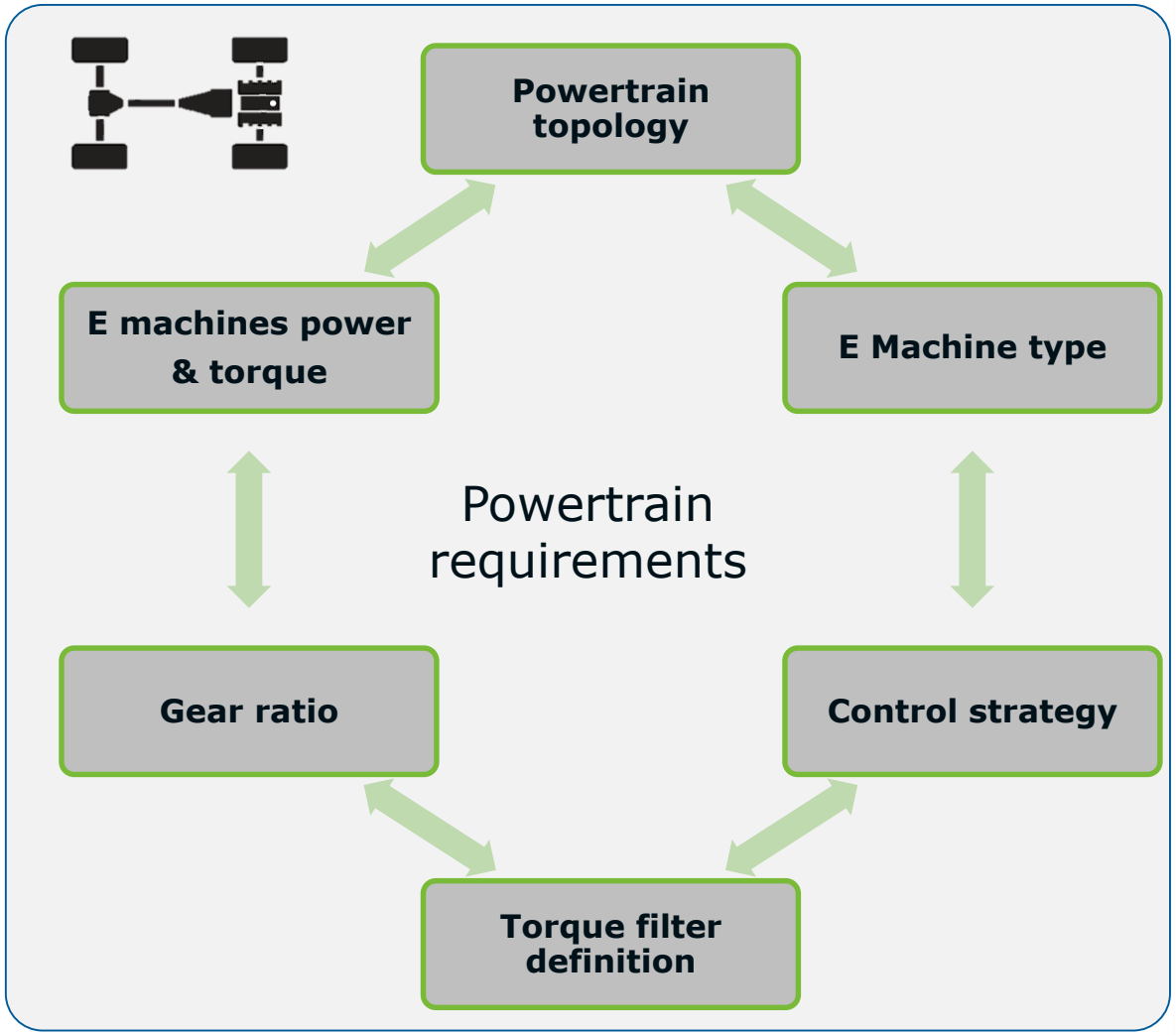
Customer's demands



Vehicle requirements



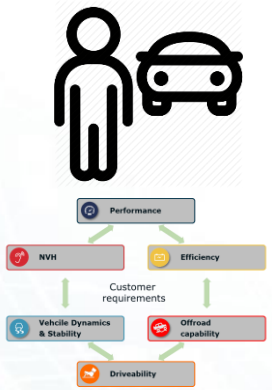
Vehicle specification

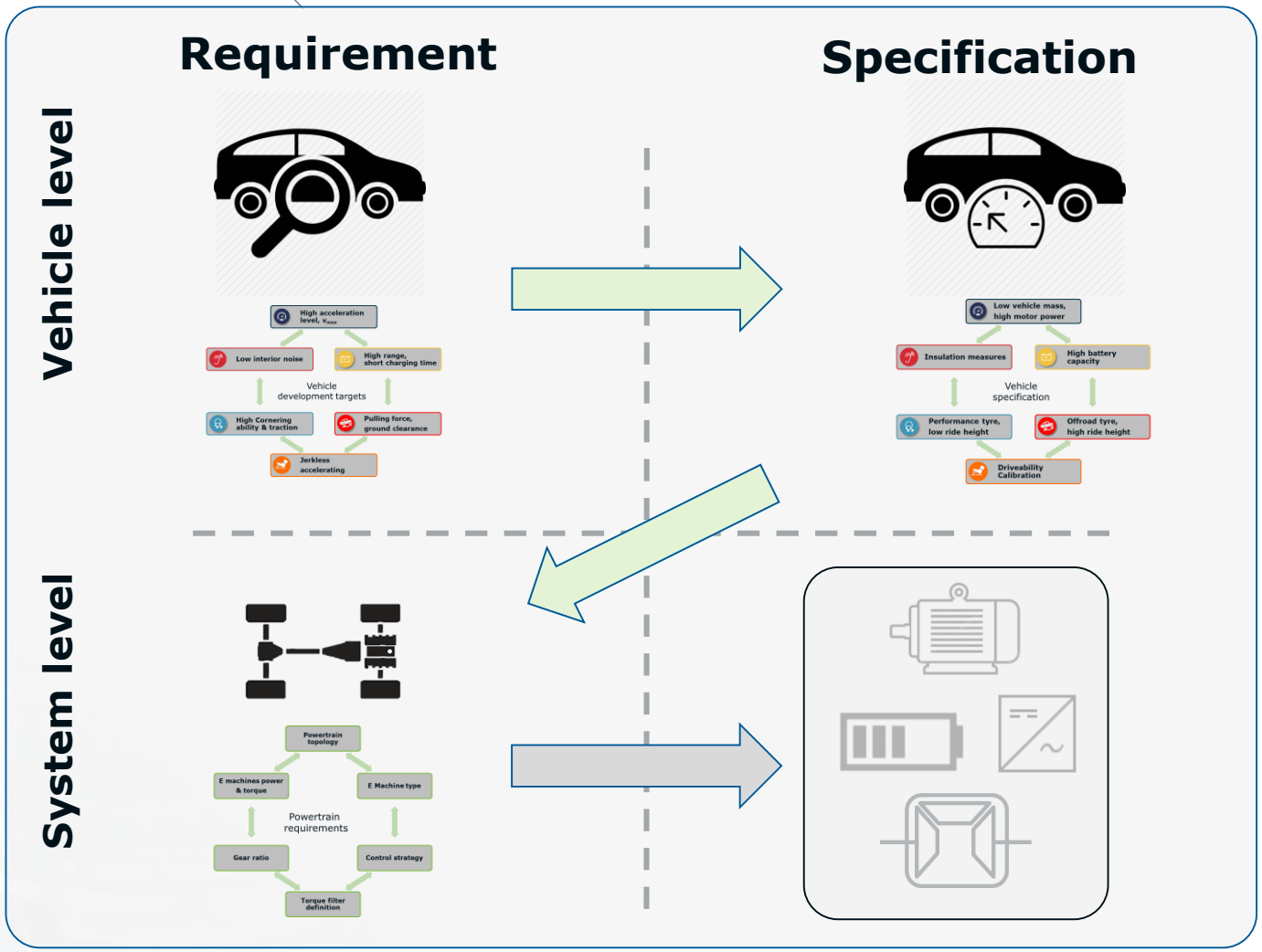


4. Powertrain System requirements

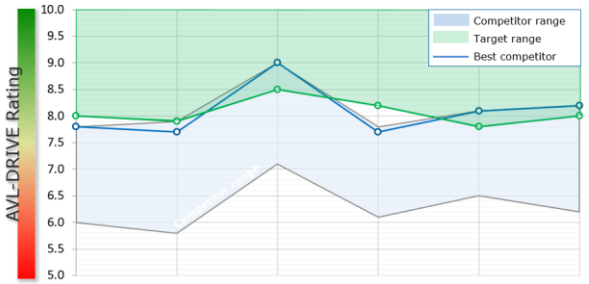
Goal of frontloaded development is to gain powertrain requirements

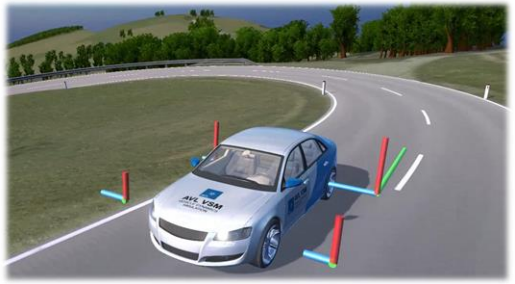
Customer

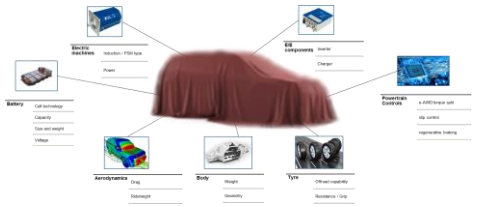


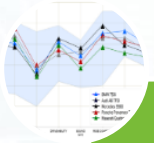


Virtual Concept Definition
Process









Benchmarking

Target Setting

Simulation

Improvements

Benchmarking:

- Competitive analysis
- Highlights & weaknesses
- Deep dive

Vehicles:

- Tesla Model X
- Jaguar I Pace

Target Setting

Translating customers vision into technical requirements:

- Performance
- Efficiency
- Handling
- AWD / Off-road
- Driveability

→ Definition of E-AWD vehicle attributes

Vehicle Simulation

- Vehicle simulation and virtual calibration

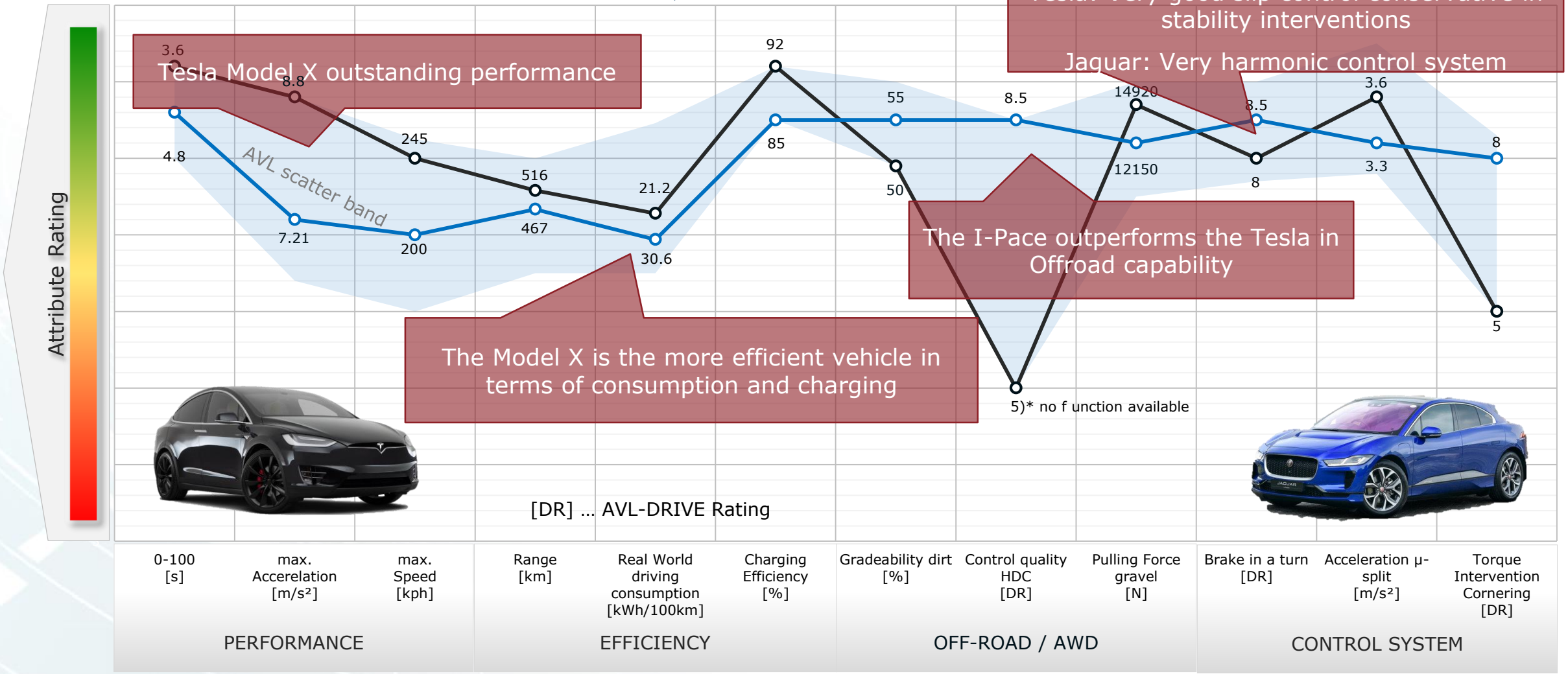
- Simultaneous vehicle attribute assessment

Improvements

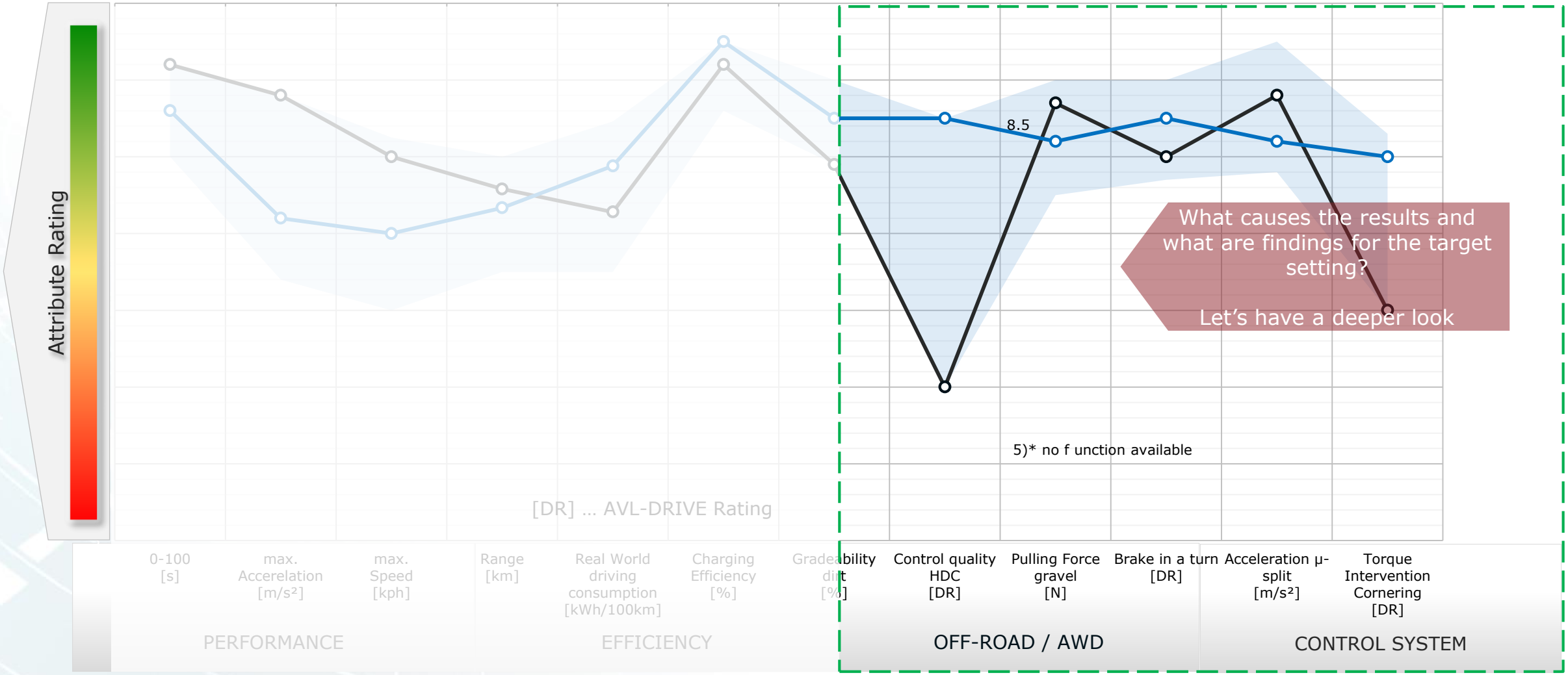
- Long. torque split
- Torque vectoring
- Slip control
- Regenerative braking
- Efficiency strategy

<u>Output:</u>
E-AWD Powertrain according customer's demands

Benchmarking on Vehicle level



Benchmarking
Offroad / AWD

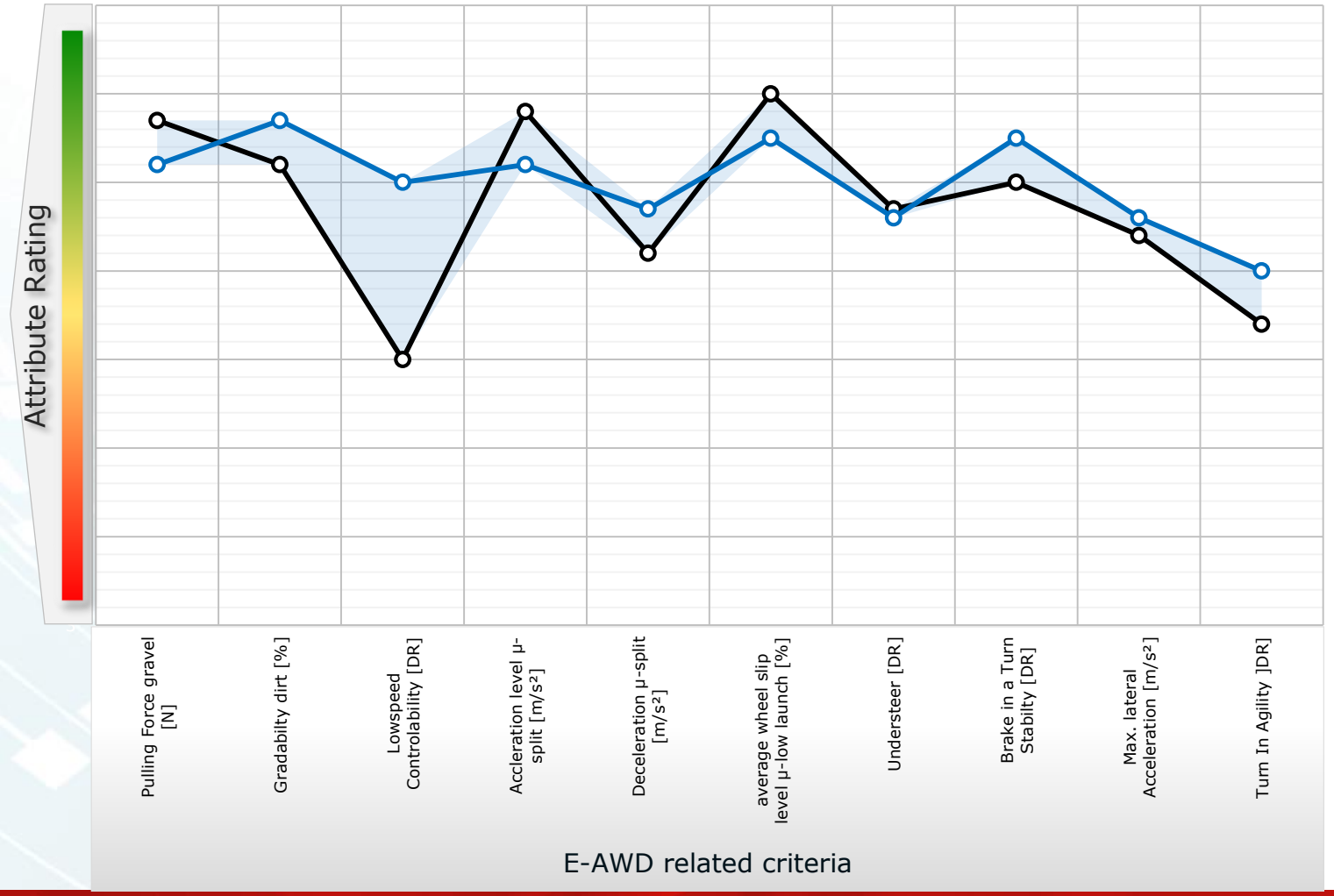


What causes the results and what are findings for the target setting?

Let's have a deeper look

E-AWD related vehicle criteria

Benchmark Vehicles Overview



Model X

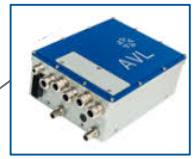
- Excellent performance level
- Very good wheel slip control
- Limited off-road capability
- Inert on-road agility
- Very restrictive cornering stability control

I pace

- Very balanced over all attributes
- Good total control system characteristic
- Satisfying off-road capability (HDC, Hill hold)
- Good on road handling balance

What are the right system elements?

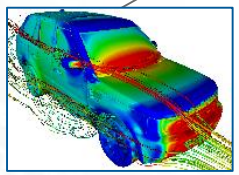
Electric machines
- Induction / PSM type
- Power



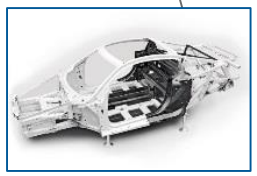
E/E components
- Inverter
- Charger

Battery
- Cell technology
- Capacity
- Size and weight
- Voltage

Powertrain Controls
- E-AWD torque split
- Slip control
- Regenerative braking
- Operation strategy



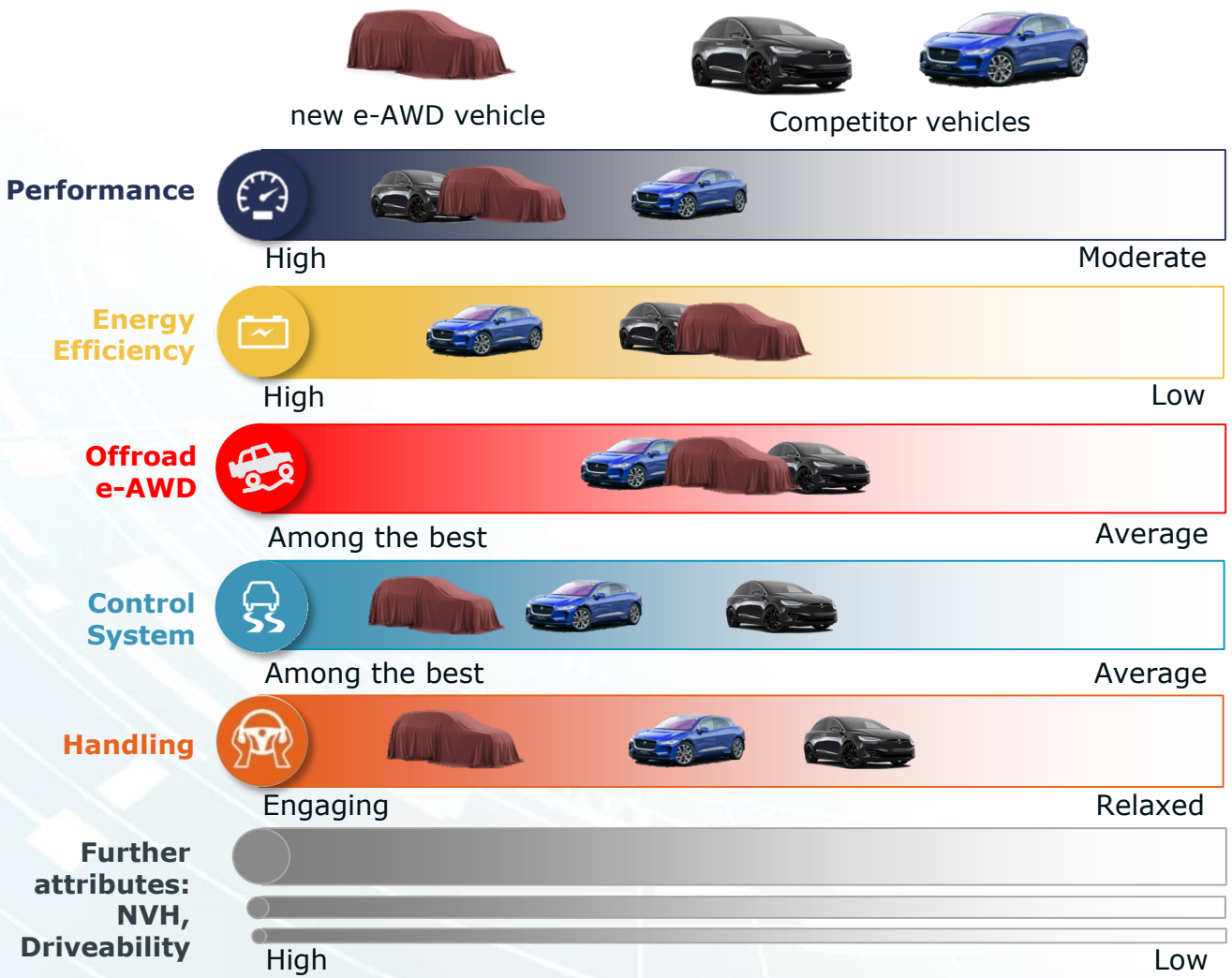
Aerodynamics
- Drag
- Rideheight

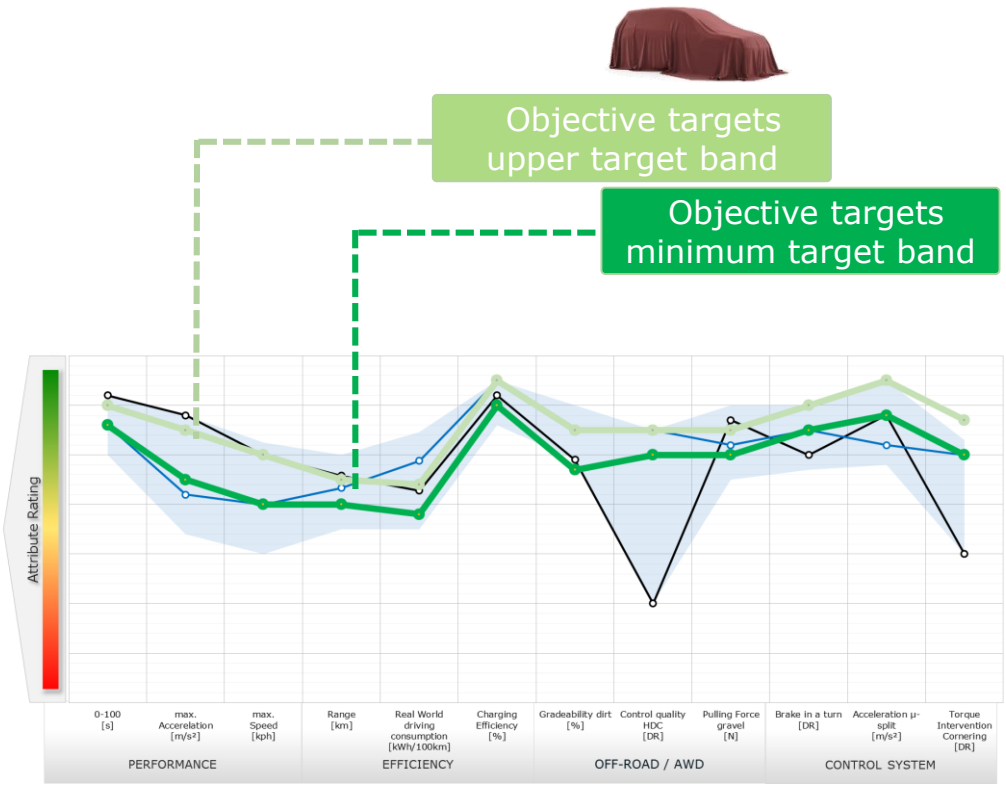


Body
- Weight
- Geometry

Tyre
- Off-road capability
- Resistance / Grip

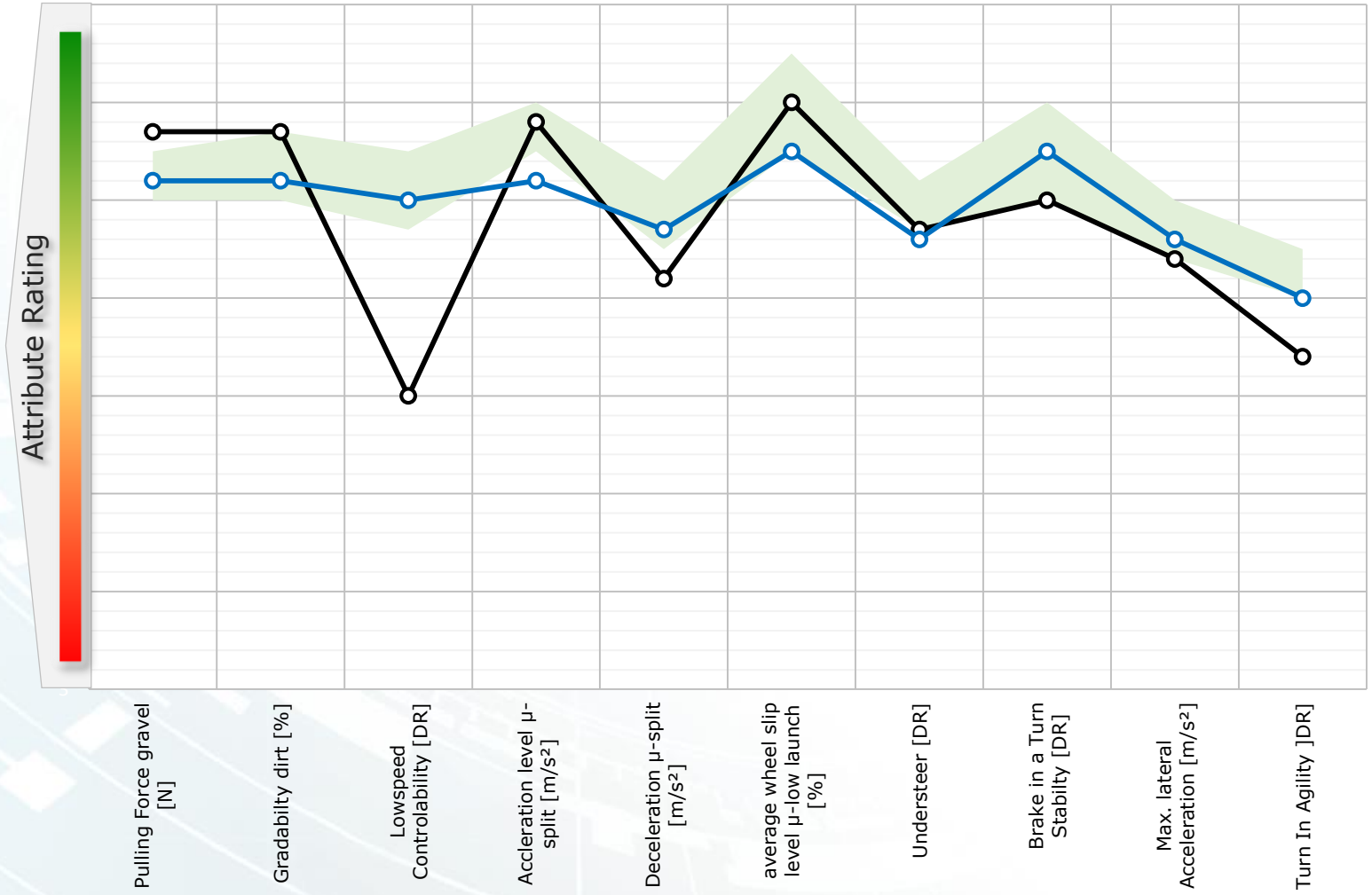
Vehicle positioning





Translating customers vision into technical requirements down to a very detailed level

Target Setting
E-AWD related vehicle criteria



- **Off-road capability:**
  - Acceptable allover off-road capability
  - Good low speed controllability
  - Very good µ-split acceleration level
- **Performance**
  - Performance level close to Model X
  - Very good overall traction
- **Handling**
  - Low understeer
  - Good oversteer stability
  - Acceptable turning agilty

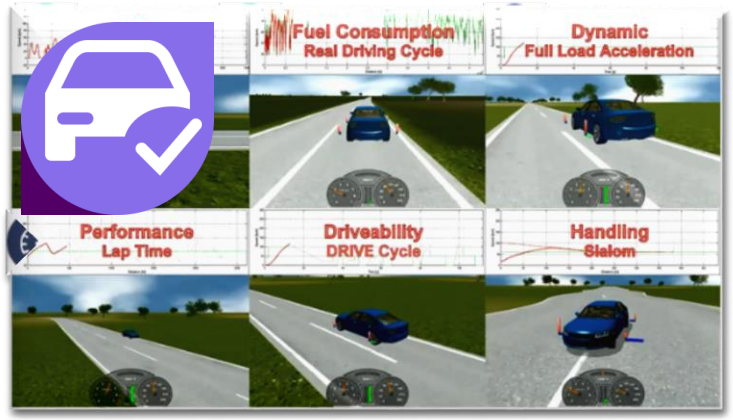
Set Up of Virtual Calibration Toolchain

Automatized Optimization Toolchain

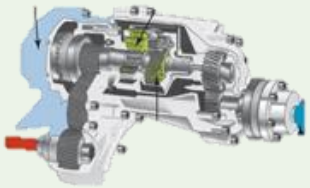
AVL Cameo:
DOE approach
calibration parameter variation

AVL VSM:
Vehicle dynamic simulation +
e-AWD controller model embedded

AVL-DRIVE™:
Objective evaluation of
driving attributes

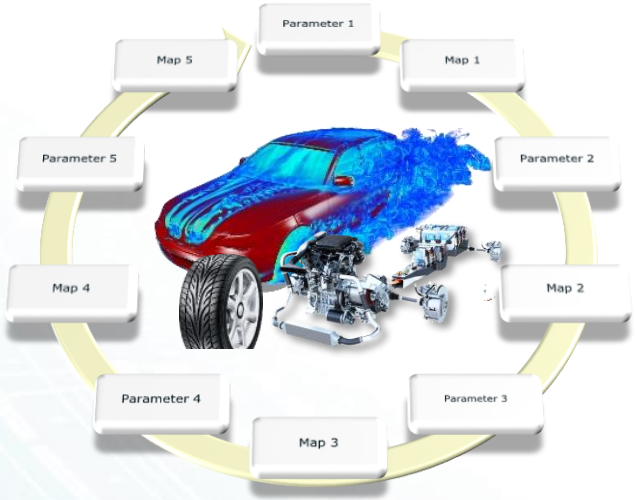


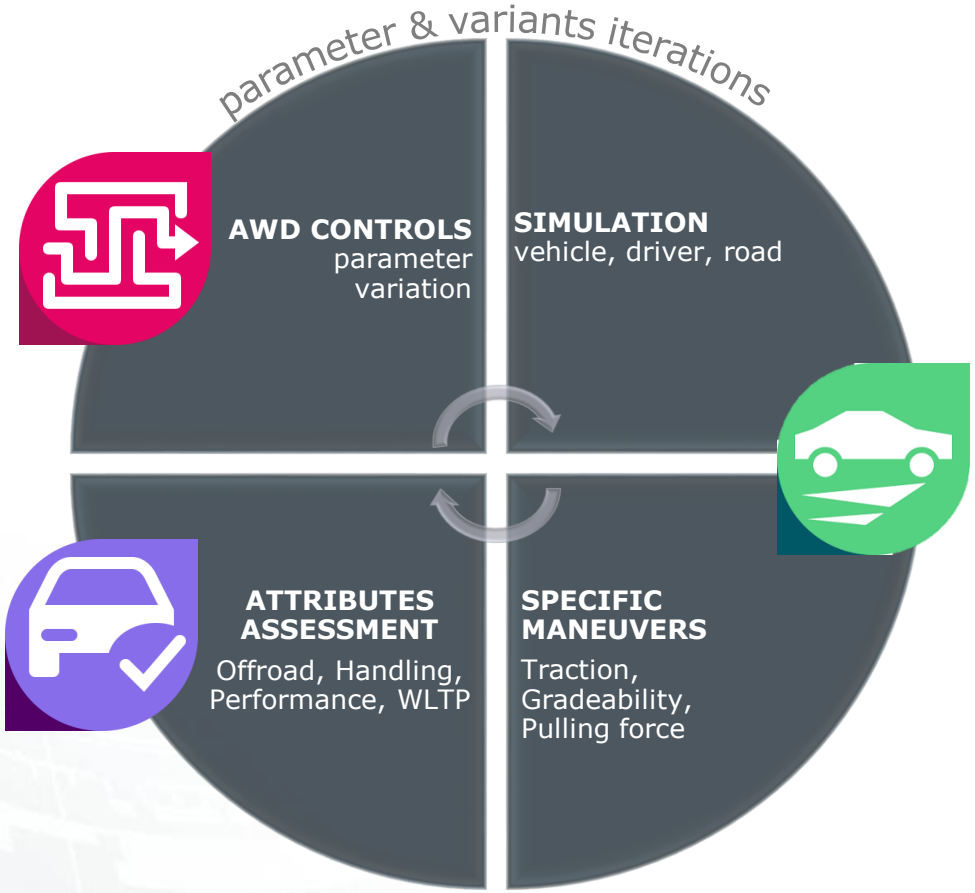
E-AWD Functions Definition

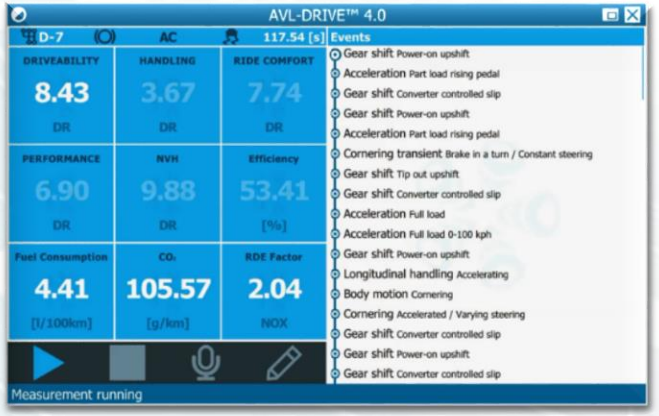
E-AWD Functions			
Function	**Torque split**	**Slip Control**	**Torque vectoring**
Mechanical equivalent	Center Differential 	E-LSD (electronic-limited slip differential)	TV-Differential 
Description	Torque split between front and rear axle to maximize traction and vehicle dynamics	Axle / wheel selective torque reduction in case of the spinning wheels	Torque split between left and right side to generate a yaw moment

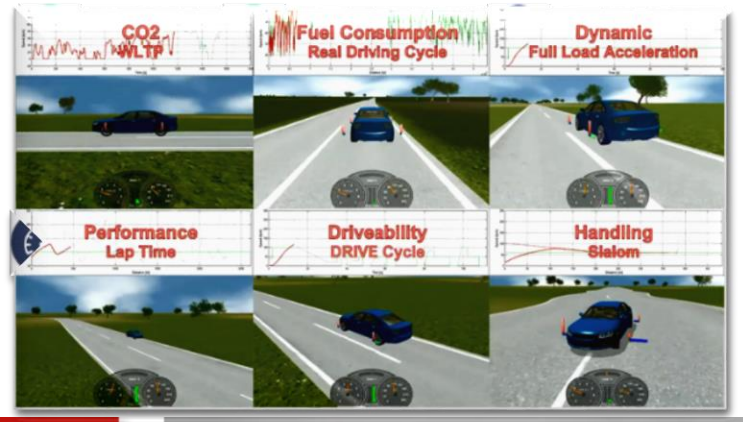
Virtual Calibration and Optimization

Optimization





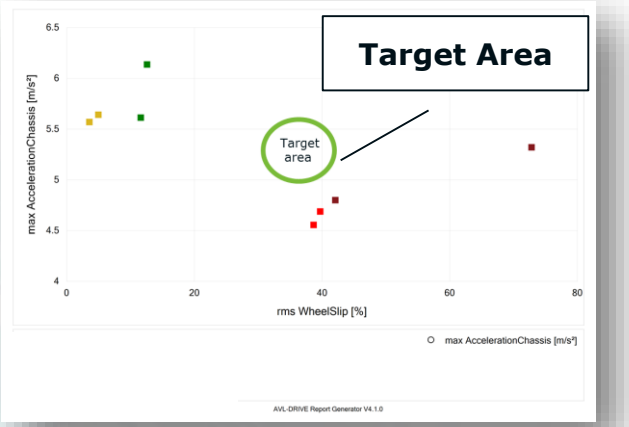




Capability of vehicle dynamic calibration

Methodology for DOE optimization of AWD to achieve targets

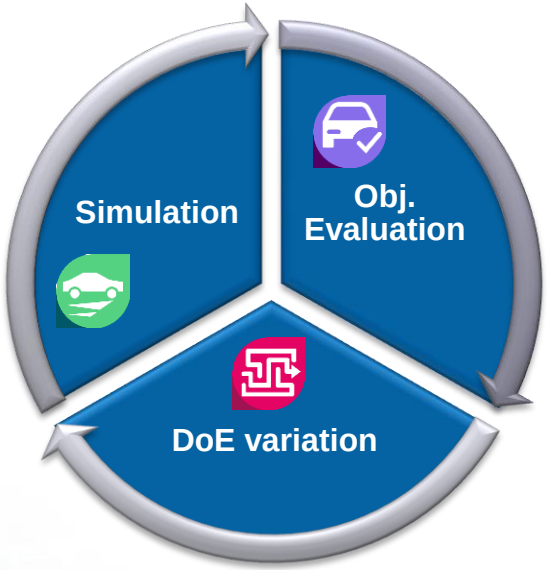
Benchmarking & competitor analysis



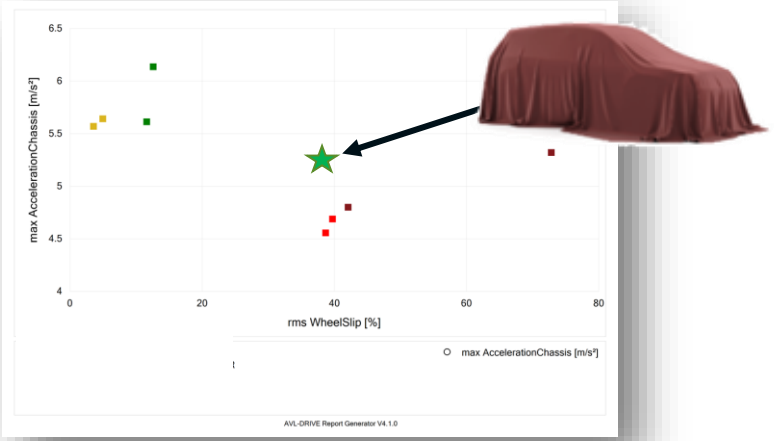
Target definition by KPIs

18% gradient µ-split	
KPI	Target value
max. long acc.	> n [m/s²]
wheel slip level	n-nn [%]
….	

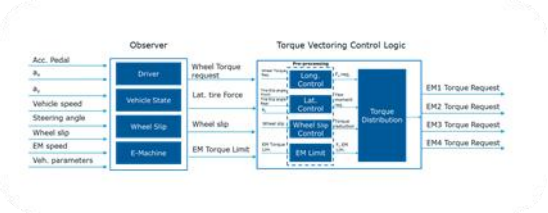
DoE-based calibration closed- loop optimization



Optimized AWD characteristic



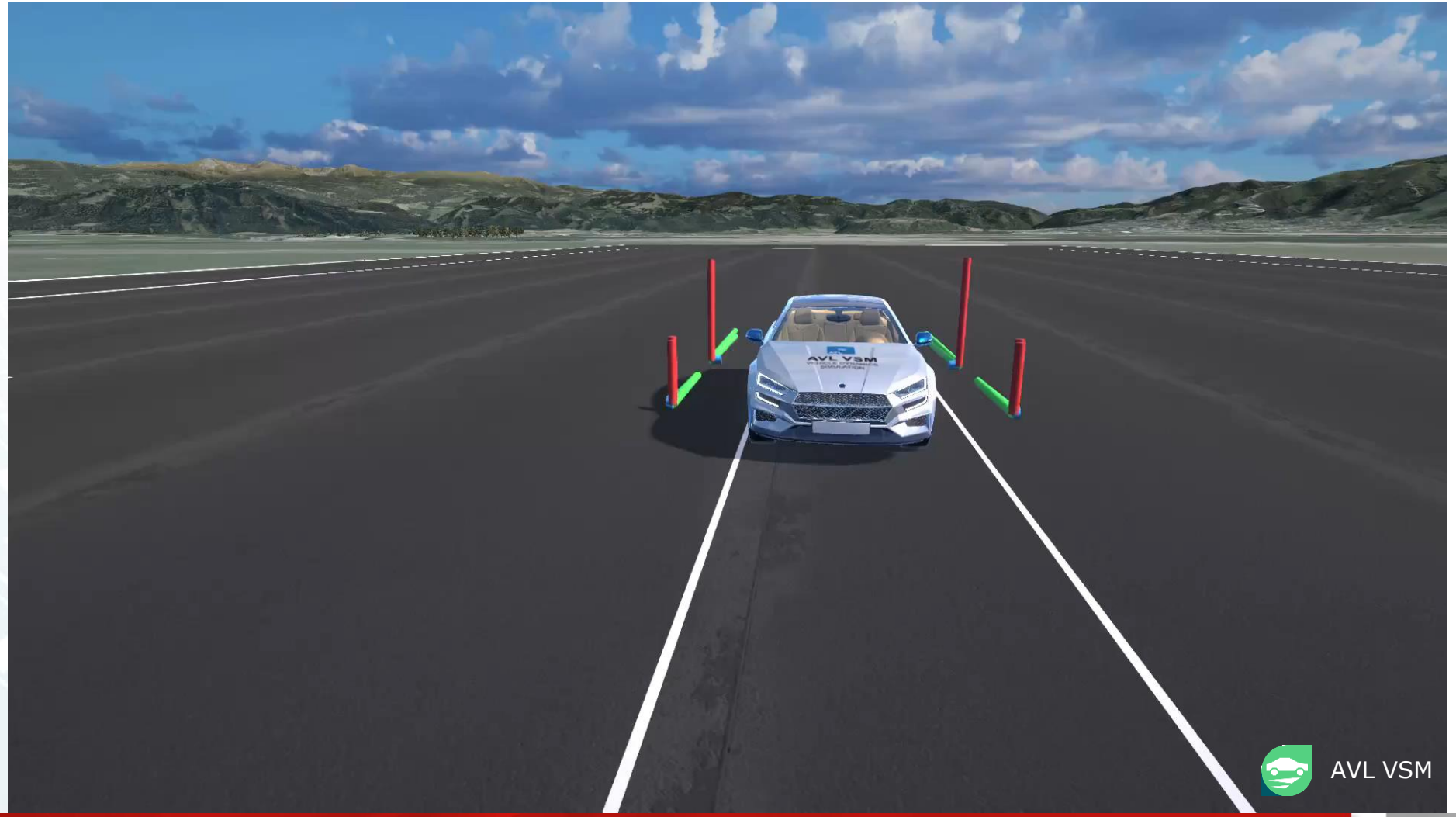
Optimized AWD function parameter-set



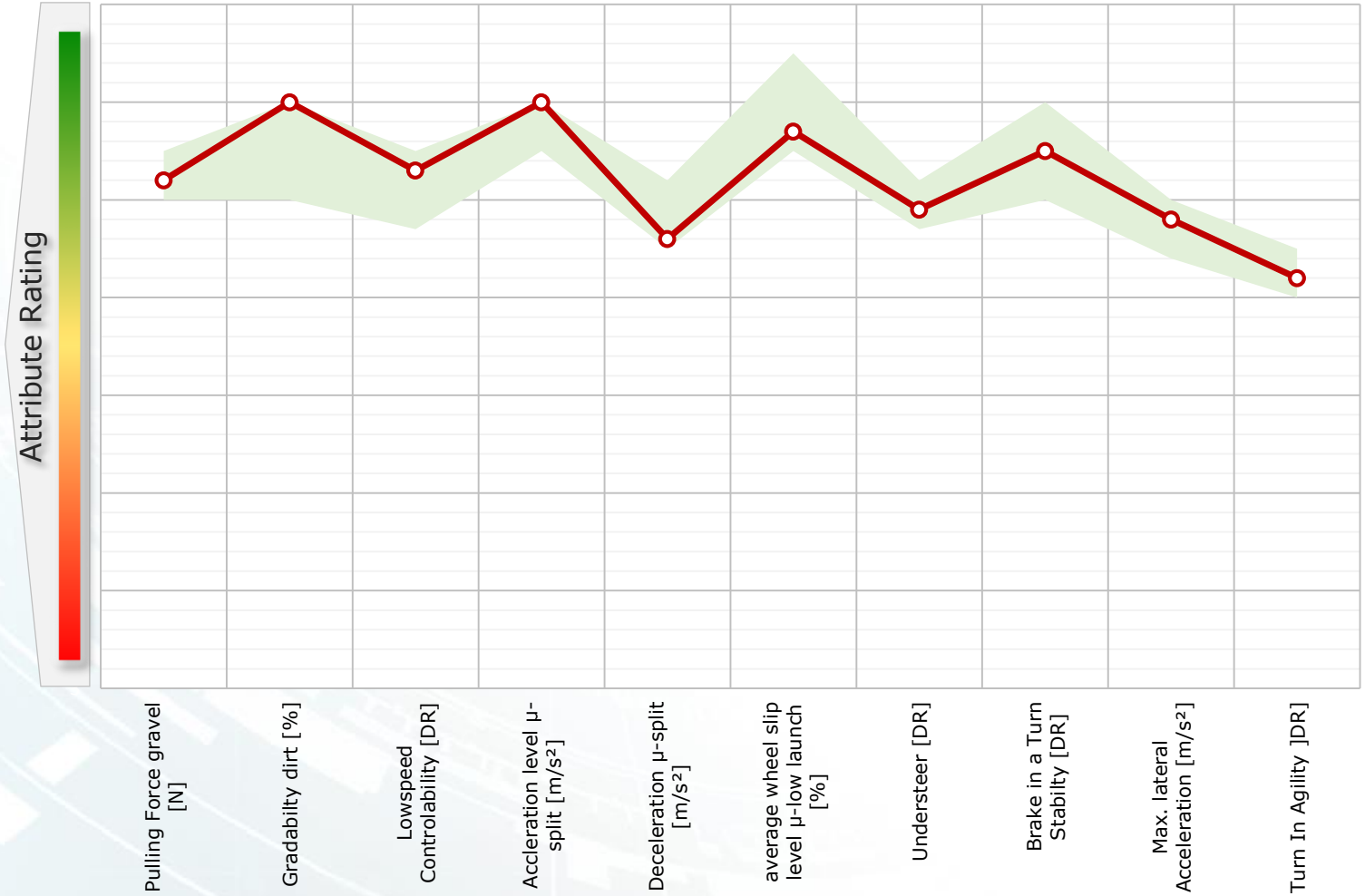
Optimization Result Video e-AWD

Optimization Result Video

Torque Vectoring – ISO T2 Lane Change



Results of automated optimization
E-AWD related vehicle criteria



Optimized results:

- Target band could be met for all criteria
- Very good on road handling due to torque vectoring
- Good Performance due to low vehicle weight

Optimization Result Video

Nürburgring Nordschleife

Thank You

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