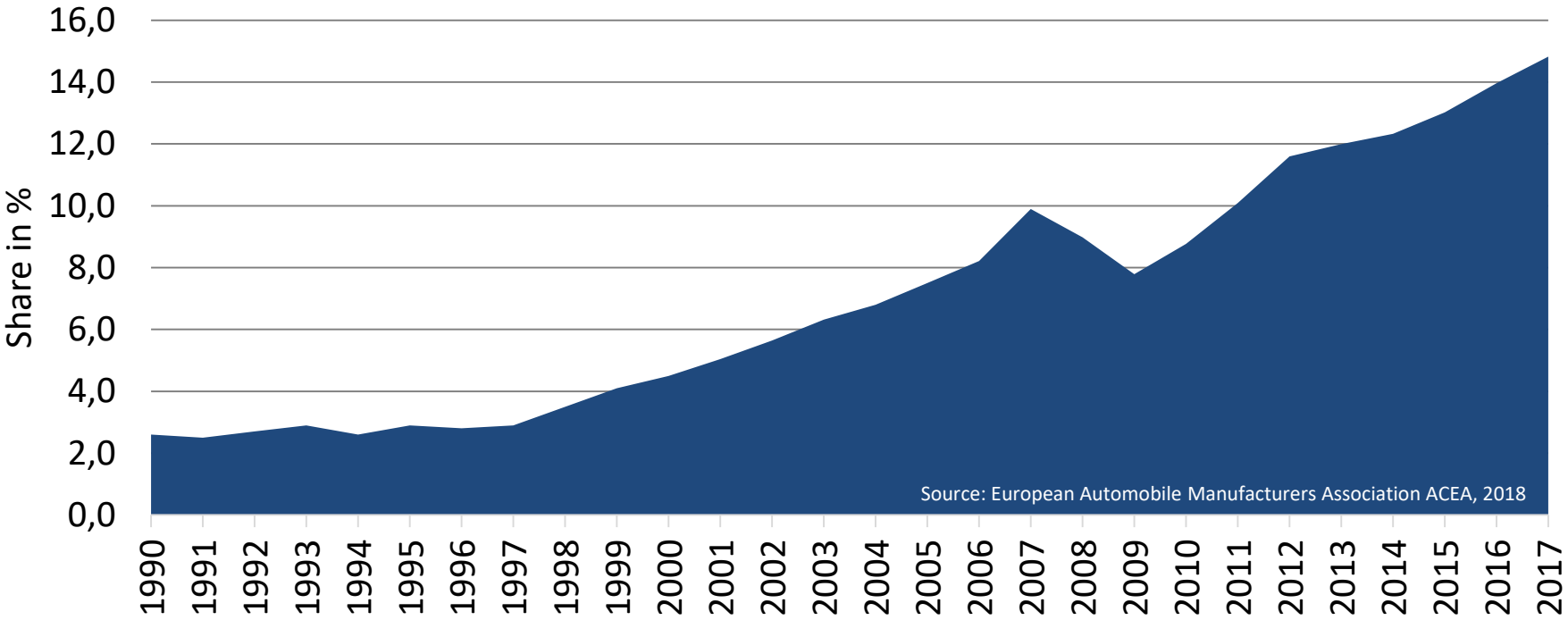
Institute of Automotive Technology
Department of Mechanical Engineering
Technical University of Munich

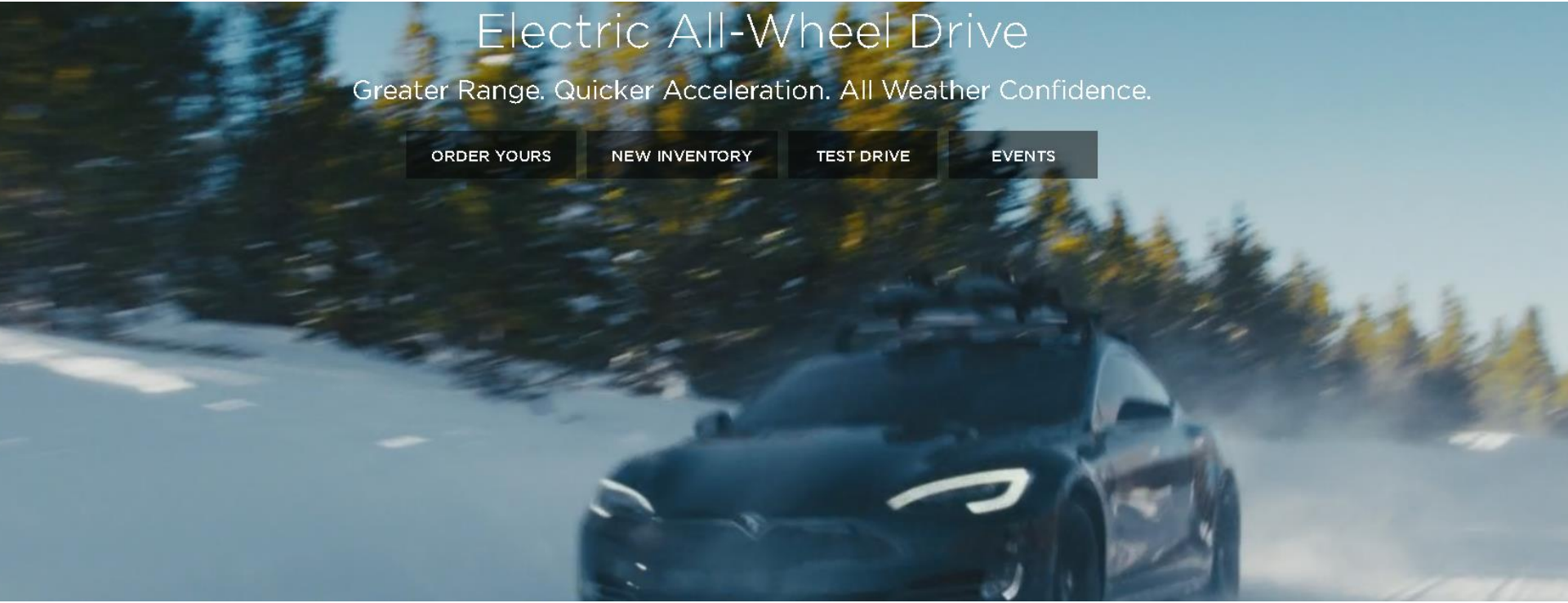
Comparison of Electric Powertrain-Topologies for AWD-Vehicles

An Approach for Design and Optimization

AWD-share in new registrations (Europe)



Improved efficiency



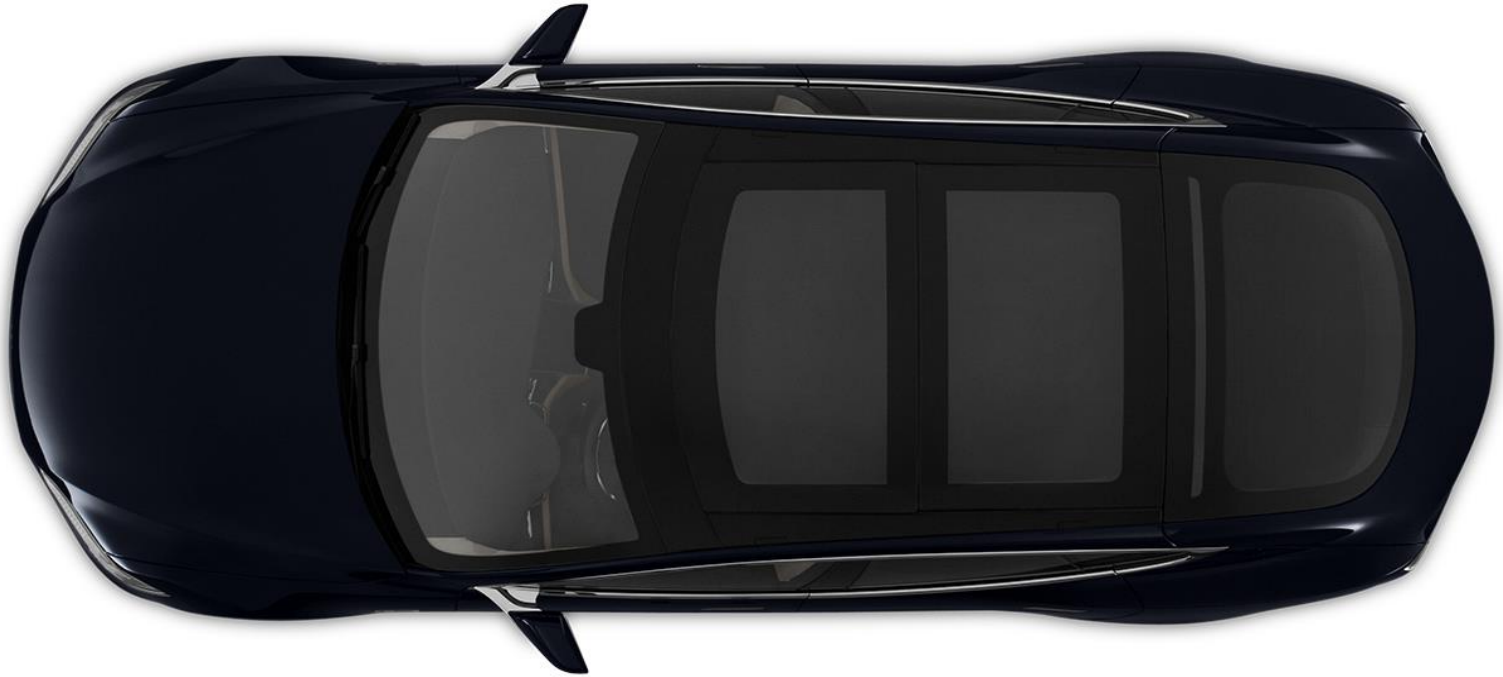
Images: Tesla

Dissolving the AWD trade-off

	properties	consumption	costs
ICEV	+	−	−
BEV	+	How? +	−

Images: woxikon.de, kostengünstiger.de, diegoldenenase.de, Itespresso.de

Basic idea



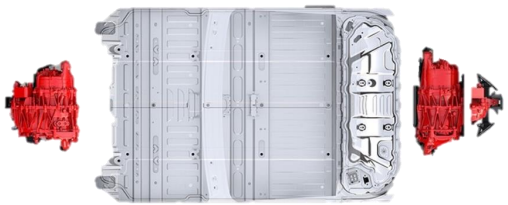
Images: Tesla

Powertrain

Electric Drive

Transmission

Battery



Powertrain

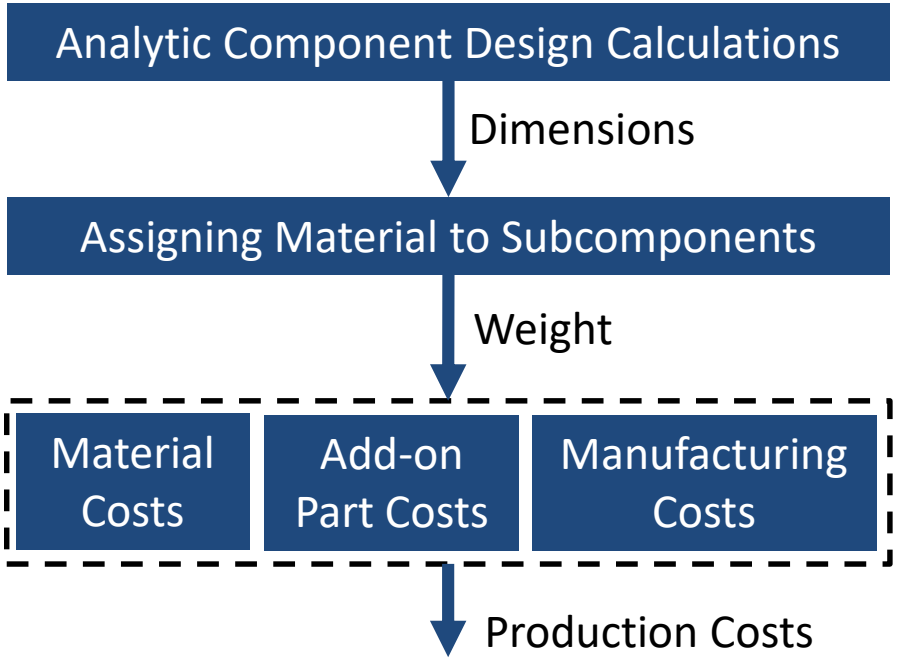
Images: Tesla

Powertrain: Electric Drive

Electric Drive

Variables:

Type (PSM or IM)
max. Speed
nom. Torque



Powertrain: Transmission

- two stages
- parallel configuration only
- different final drives

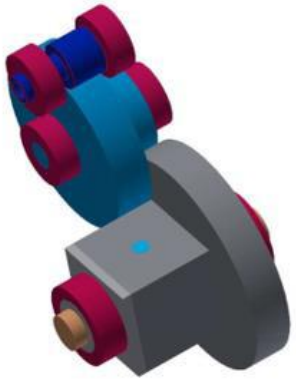
Transmission

Variables:

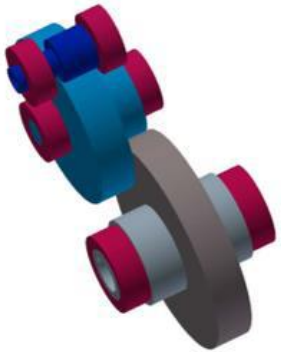
gears (1 or 2)

1st gear ratio

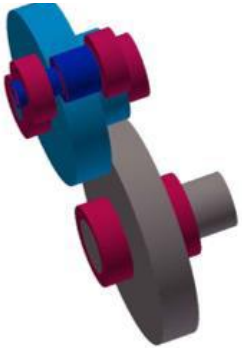
1st to 2nd gear ratio



Differential

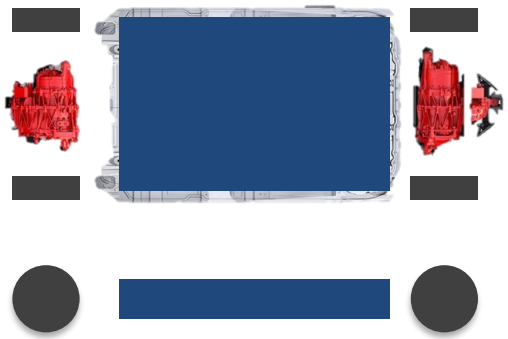


Torque-Vectoring



Wheel-Individual

Powertrain: Battery



Battery

- 18650-Cells
- 400 km fixed Range (WLTP)
- Iterative weight calculation
- variable length and position

Images: Tesla

Powertrain: Battery

Battery

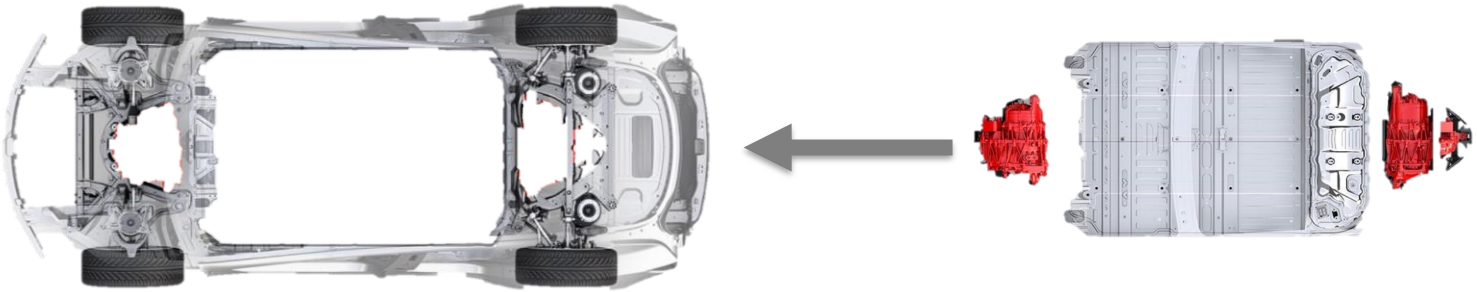
- 18650-Cells
- 400 km fixed Range (WLTP)
- Iterative weight calculation
- variable length and position

Images: Tesla

Design-Variables per axle

Topology	Wheel-individual Drive	Central drive open differential	Central drive Torque-Vectoring	
Choice of Components	1- or 2-speed Transmission	PSM or IM electric motor		
Design / Scaling of Components	1st gear	1st to 2nd gear	torque	speed

Glider

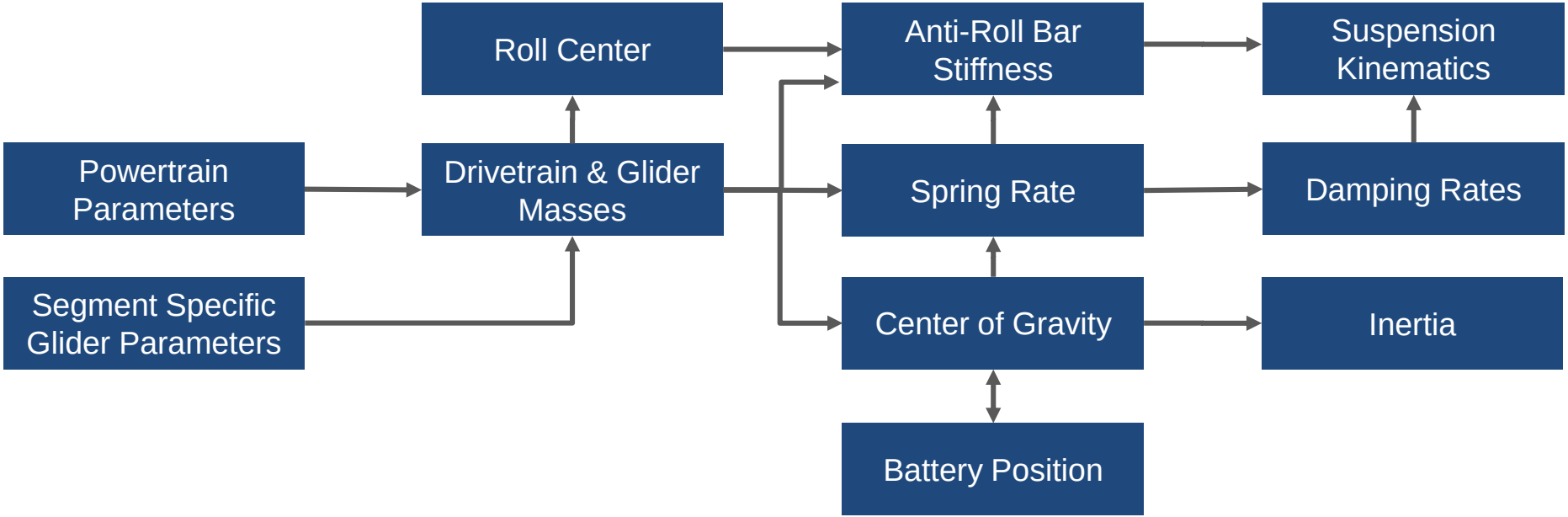


Glider

Powertrain

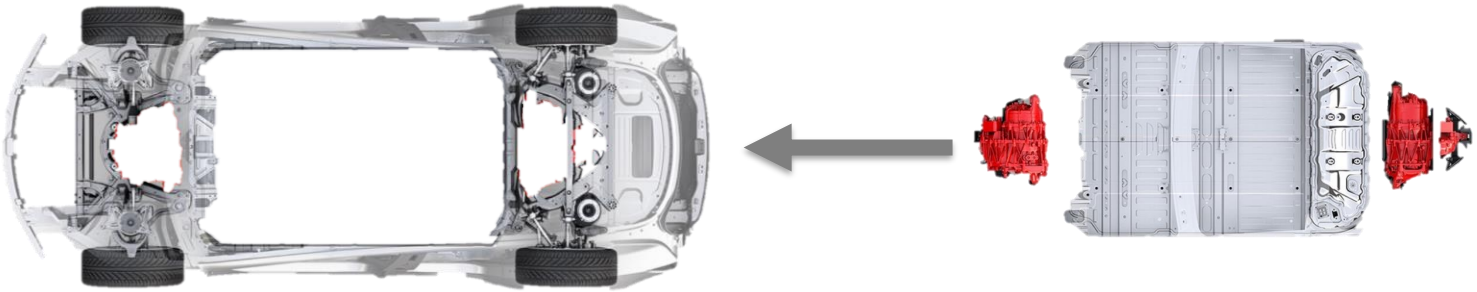
Images: Tesla

Glider: Parameter-Adaption



Images: Tesla

Glider

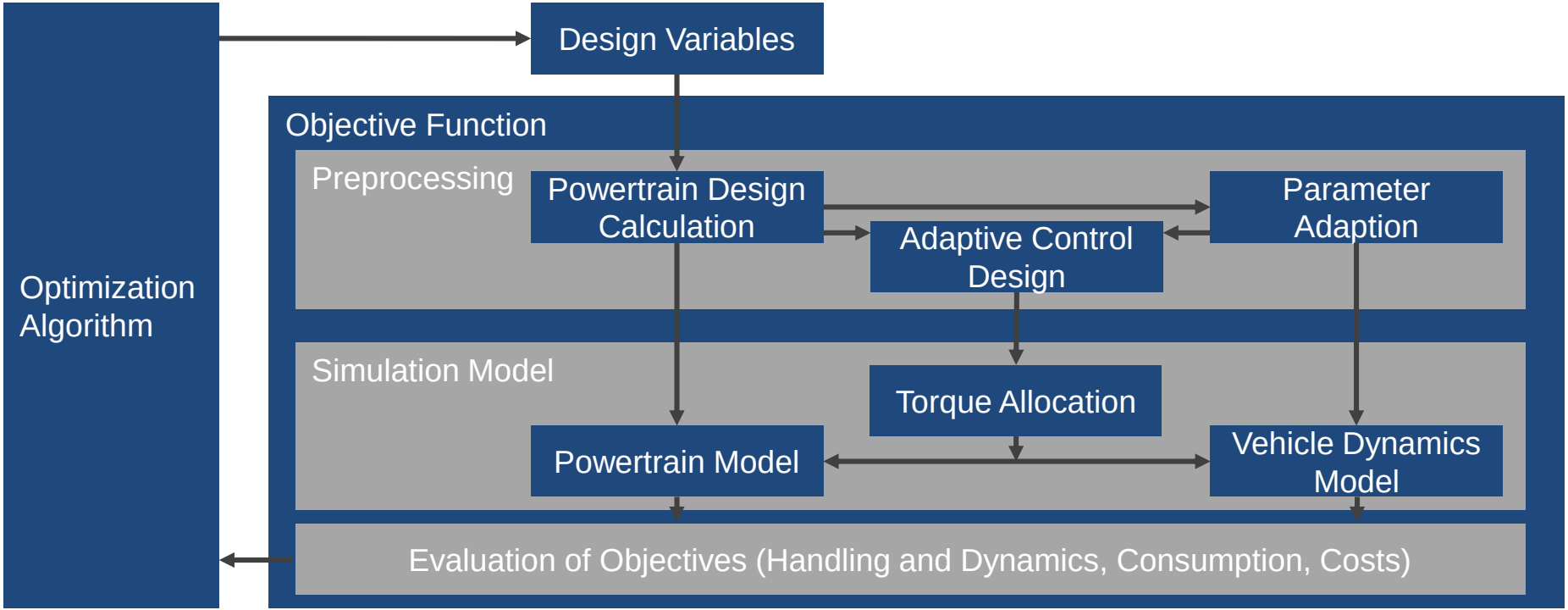


Glider

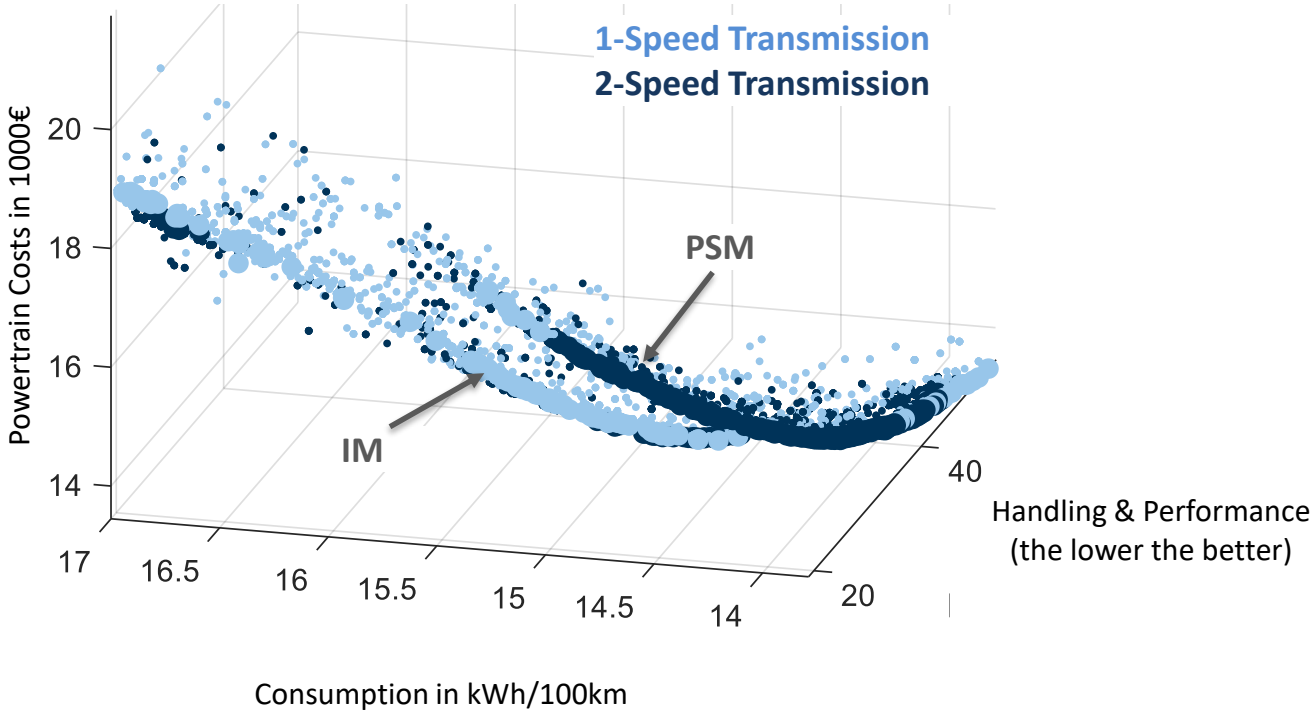
Powertrain

Images: Tesla

Optimization

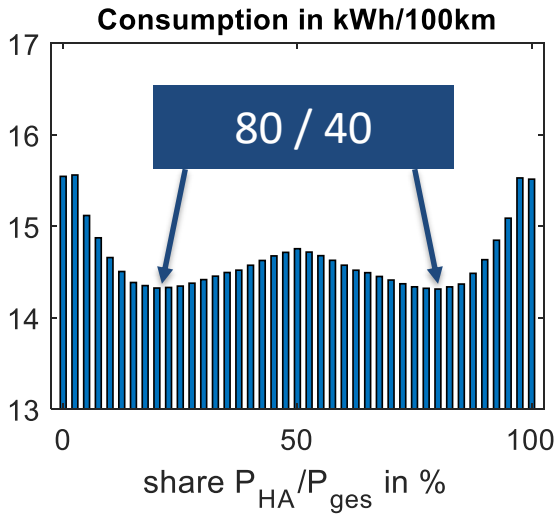


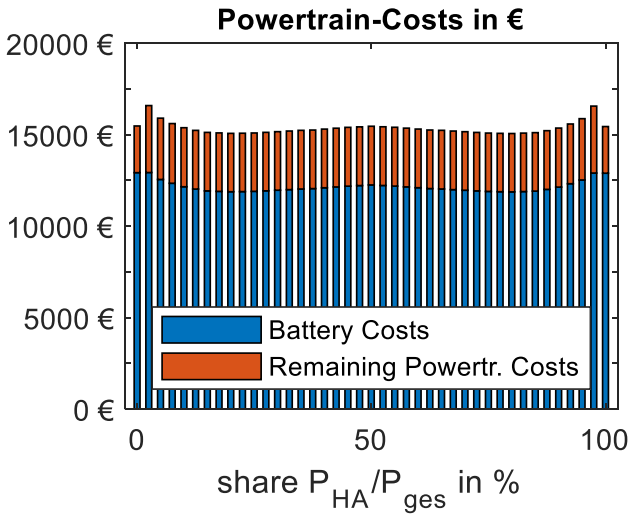
Overall Results

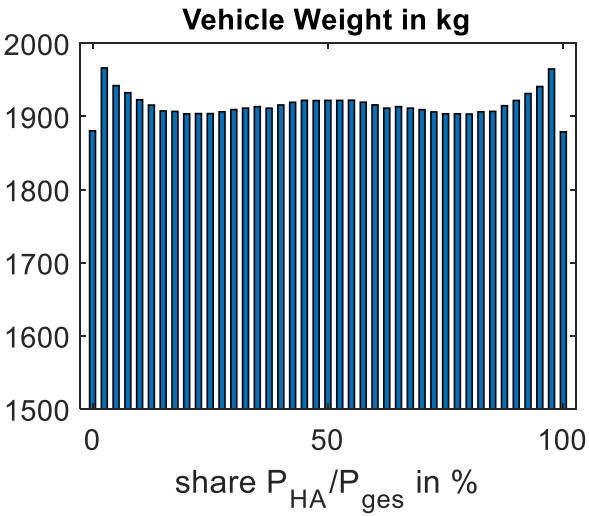


Variation of installed nominal Power

Optimal Distribution







Results

Topology

- FWD or RWD remain lightest option
- 2-motored AWD with large drive-unit in the rear and small one in the front is the cheapest AWD
- Torque-Vectoring is way more cost effective and lighter than wheel individual drive-units

Results

Motors

- Large ASM or PSM in the rear for acceleration
  - ASM cheaper but less efficient
  - PSM is more efficient than ASM
  - PSM cost savings do not pay off in the chosen case

- Small PSM in the front for efficient handling of continuous load

Results

Transmission

- 2 speed transmission equally qualified
- Additional weight is compensated by acceleration and efficiency
- Additional efforts for development and rise in complexity is neglected → SIMPLIFICATION!

Discussion and Summary

Small differences between Motor-Types and Transmission-Types
→ No “easy” answer
→ “it depends”

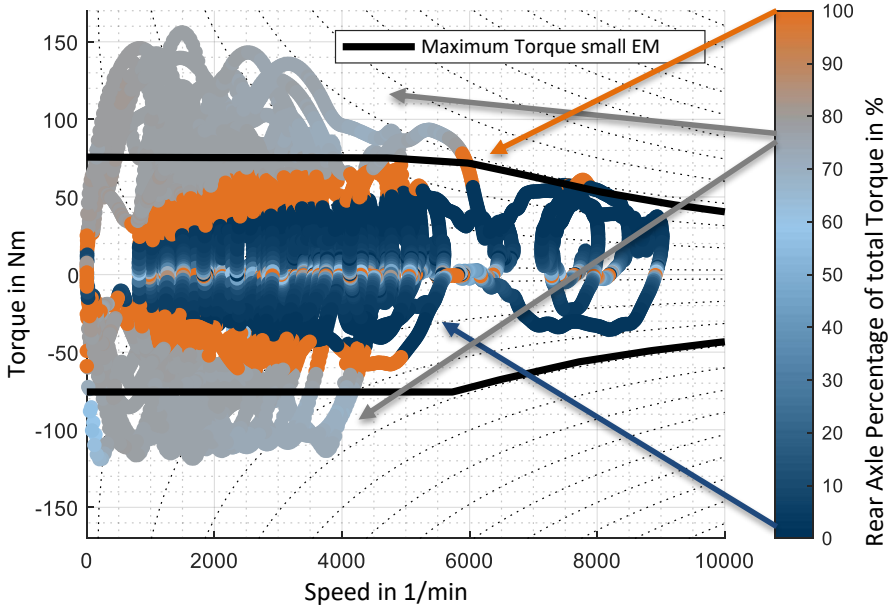
Electric AWD enable improved Handling, Performance AND Efficiency
→ Dissolve the trade-off
→ Large motor rear and small in the front is ideal for both:
Dynamics and Efficiency

Comparison of Electric Powertrain-Topologies for AWD-Vehicles

THANKS FOR YOUR ATTENTION!

Why?

Load Points



Efficiency Map