DEVELOPMENT AND OPTIMIZATION OF AN ELECTRIC HYPERCAR POWERTRAIN

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IPG Apply & Innovate 2020

AGENDA

- Introduction
- Background and motivation
- Development process
- Targets
- Use case: longitudinal performance
- Use case: track performance
- Use case: range and efficiency
- Correlation and validation

WHO WE ARE

- Founded: 2009 (first employees in April 2011)
- Team today: 700+ people (400+ in R&D)
- Completed B2B projects: 30+
- Developed, produced and delivered world's fastest electric supercar
- Tier 1 supplier to 10 Global OEMs
- Total investment so far: ~€140M
- Deloitte technology fast 50: 10th place
  4 consecutive years amongst top 100
- Awarded as the best employer in Croatia
- European Business Award

2008
- Mate Rimac converts his BMW E30 into an electric race car and the idea is born

09
- Rimac Automobili is founded in Sveta Nedelja, Croatia.

10
- Mate Rimac breaks 5 Guinness and FIA World records for the fastest accelerating electric car.

11
- World Premiere of the Concept_One, world's first all-electric supercar
- 10 employees

12
- Rimac completes its first B2B project for IDIADA. First revenues.
- First OEM projects
- First profitable year

13
- First car delivered
- Intense development and testing of Rimac All Wheel Torque Vectoring System.

14
- The Concept_One becomes FIA Formula E's official Race Director car
- First production vehicle contract
- A-round completed

15
- Rimac builds Nobuhiro Monster Tajima's race car for the Pikes Peak International Hill Climb.
- 100 employees

16
- Contracts with major OEMs
- Production model of the Concept_One introduced.
- Significant expansion of facilities

17
- Joint Venture in China signed
- Dealer network expansion in three continents – North America, Europe and Asia
- 250 employees

18
- World premiere of Rimac's next generation hypercar, the C_Two
- Porsche becomes a shareholder
- 400+ employees
- further expansion of production facilities
- Opening of offices in Split and Osijek
- Launch of the Xianyang JV location

19
- Hyundai Motor Group becomes a shareholder
- 500+ employees
- Porsche increases stake in Rimac

20
- Testing and development of the C_Two continues
- More than 700 employees

OEM PROJECTS

Development of an powertrain system and electronics of Automobili Pininfarina Battista electric hypercar.

HYUNDAI MOTOR GROUP

Development of an electric version of Hyundai Motor's N brand midship sports car and a high-performance fuel cell electric vehicle.

ASTON MARTIN

Development and production of the Aston Martin Red Bull Valkyrie supercar hybrid battery system, infotainment and connectivity system

Koenigsegg

Development and manufacturing batteries and power distribution units for the Koenigsegg Regera hypercar.

CUPRA

Development of full EV system for CUPRA (SEAT) e-racer prototype

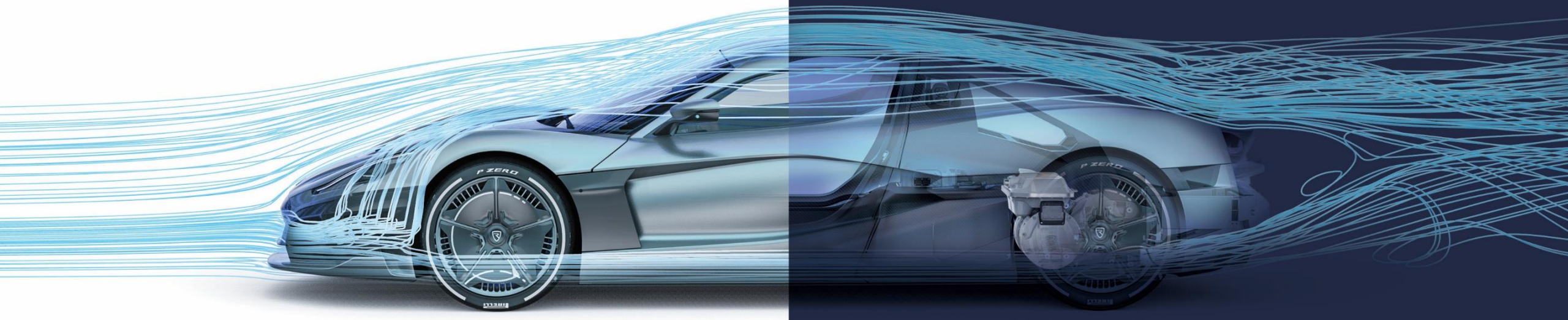
JAGUAR

Developed an electric version of the iconic Jaguar E-Type, which was used as the groom and bride car for the Meghan Markle and Prince Harry's royal wedding.

RIMAC

HYPERCARS

TECHNOLOGY



A new approach to high performance through technology and innovation

Technology developed from the ground up, driving the electric revolution

HYPERCAR | CONCEPT_ONE

RIMAC

2.5 sec
0-100km/h

14 sec
0-300km/h

1224 hp
900 kW

355 km/h
Electrically limited

1600 Nm
From 0 to 6500rpm

350 km
On a single charge

Debuted at the 2011 Frankfurt International Auto Show

HYPERCAR | C_Two

RIMAC

1.85*sec
0-100km/h

1914 hp
1400 kW

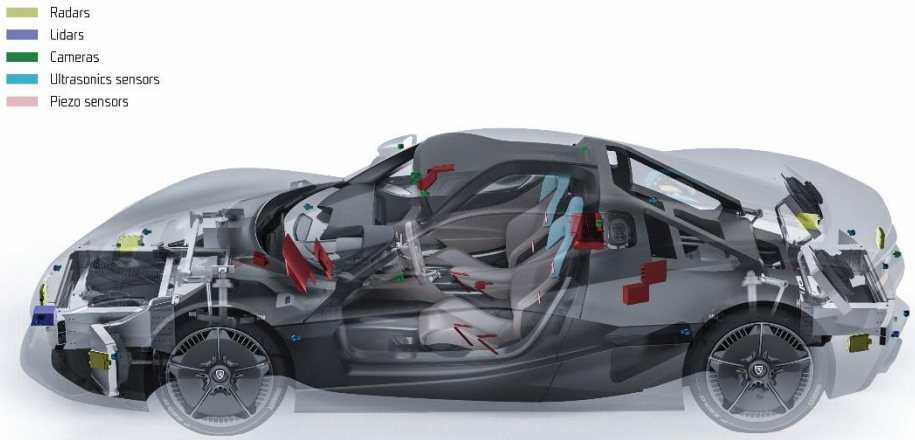
412 km/h
Electrically limited

2300 Nm
From 0 to 6500rpm

550 km
On a single charge

C_TWO

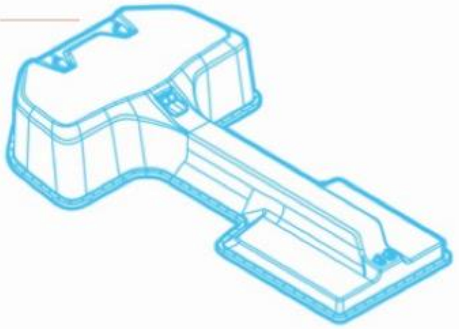
- Globally homologated
- 4 independently controlled electric motors power each wheel
- Rimac all-wheel torque vectoring
- Full carbon fibre monocoque with structurally integrated battery pack
- Active Aerodynamics
- Autonomous driving capabilities
- Driving Coach



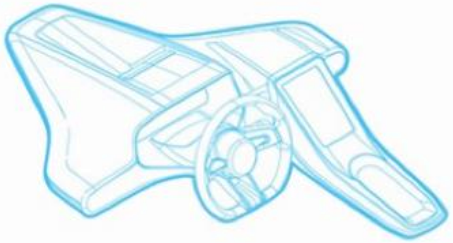

RIMAC
TECHNOLOGY

OUR SERVICES

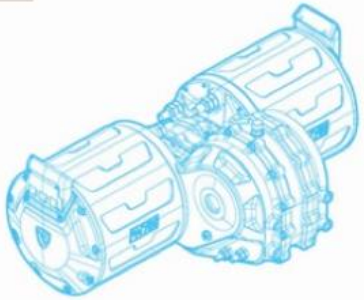
BATTERY PACKS



INFOTAINMENT

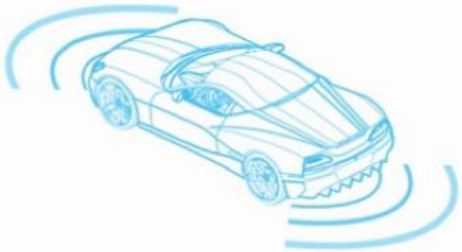


DRIVETRAIN

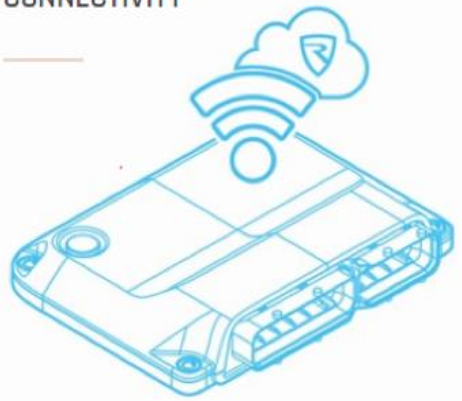


ELECTRONICS

ADAS

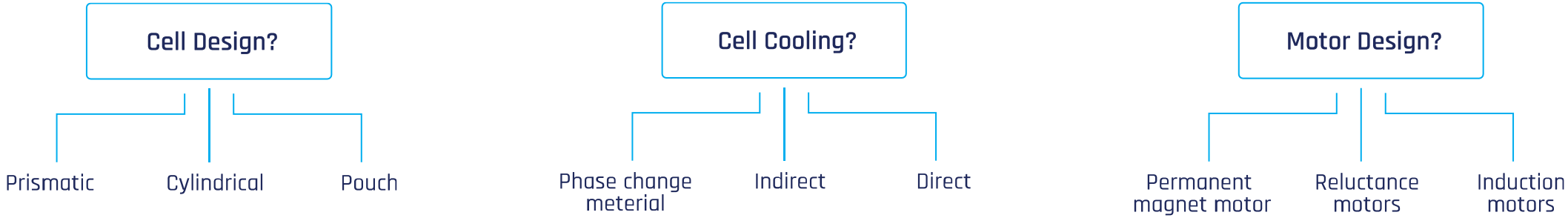


CONNECTIVITY



BACKGROUND & MOTIVATION

- Hypercar EV segment
  - Low volume
  - Less cost conscious
  - Incorporates latest and most advanced EV technology
- Electric vehicles (EV) are undergoing exponential growth and development
  - Electric motors
  - Inverters
  - Battery Cells
  - Battery pack design and cooling
  - Architecture

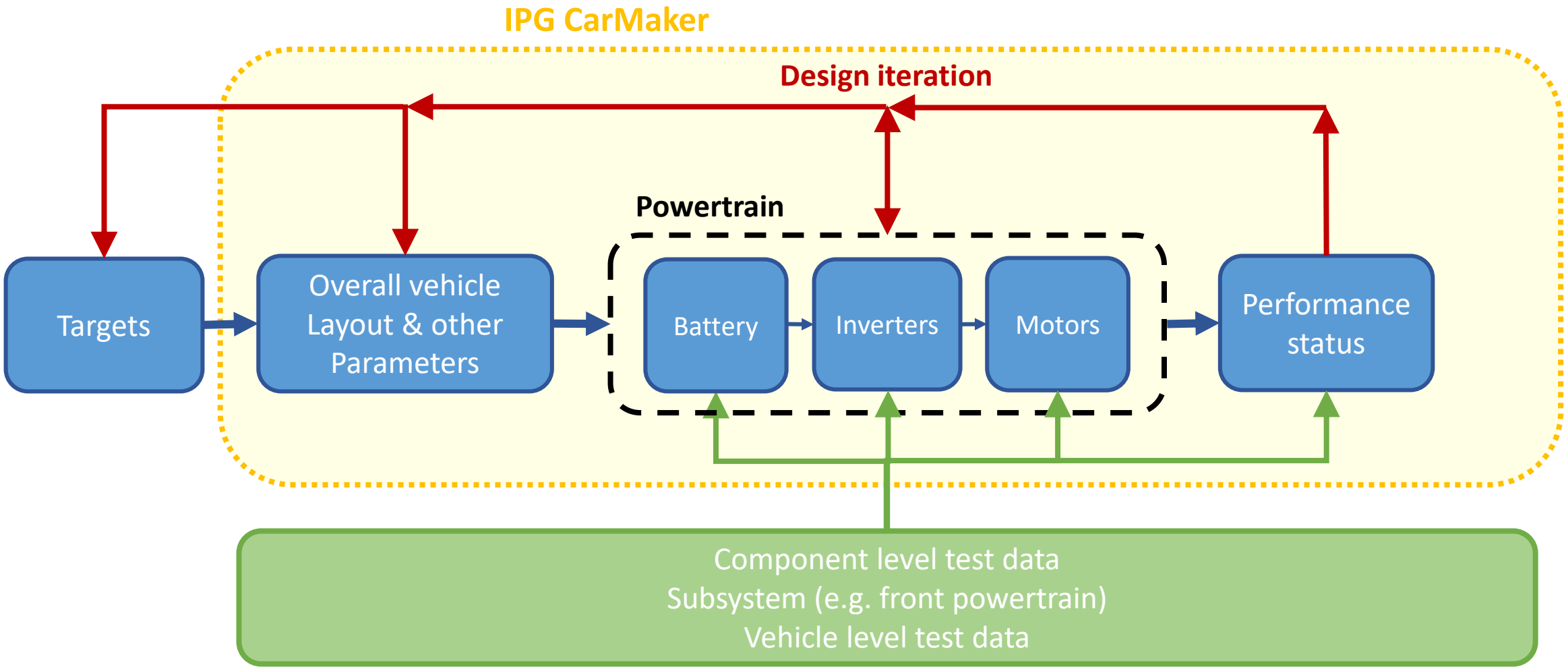


THE CHALLENGE FOR EV HYPERCARS

Rapid prototyping and flexibility to adapt and include latest EV technology
… or risk being left behind by competitors!

“If you aren’t first you’re last” – Ricky Bobby

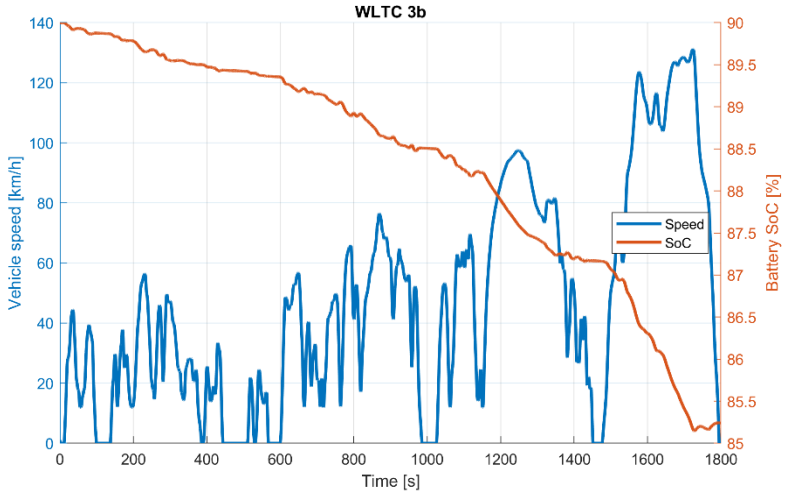
THE DEVELOPMENT PROCESS

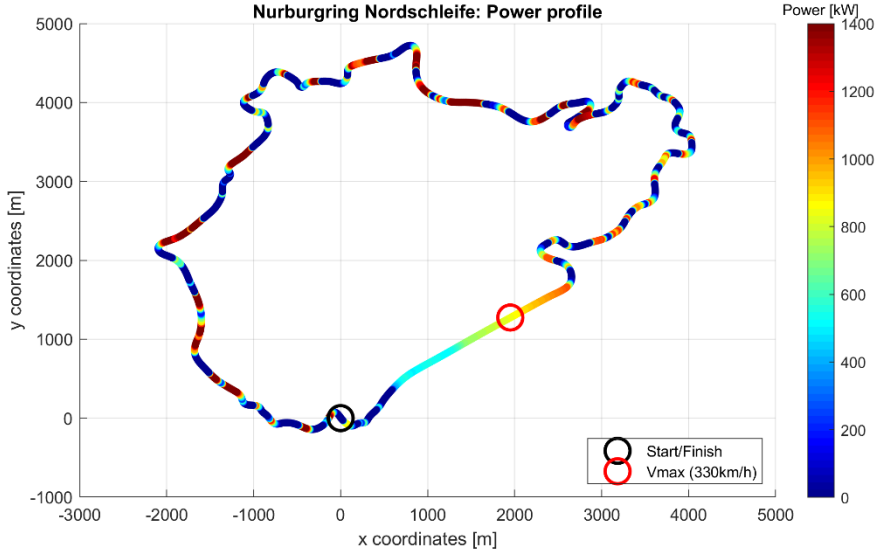


TARGETS*

**Targets listed does not represent actual targets of the Rimac C_Two*

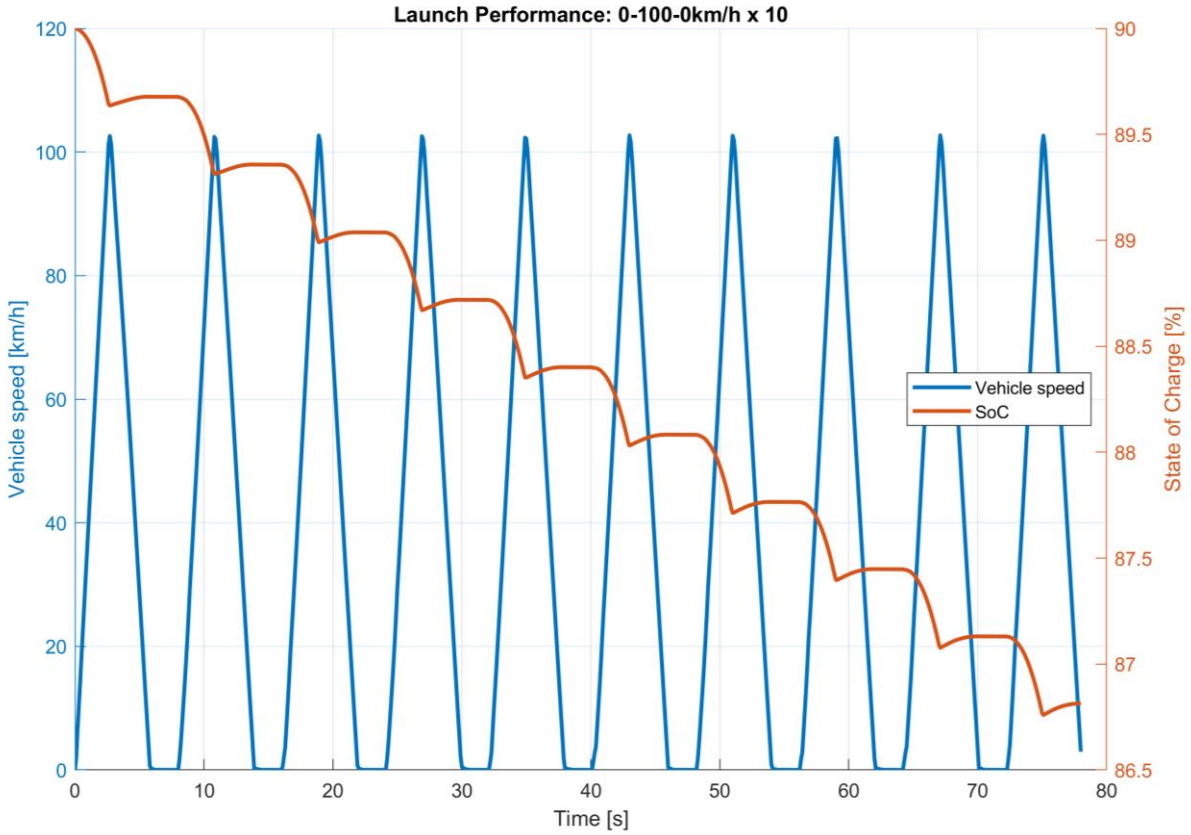
- Performance:
  - Longitudinal
    e.g. 10 x 0-100-0 km/h without overheating/de-rating
  - Track
    e.g. 1 lap of Nürburgring, Nordschleife without any power de-rating
- Range:
  e.g. 550+km on WLTP

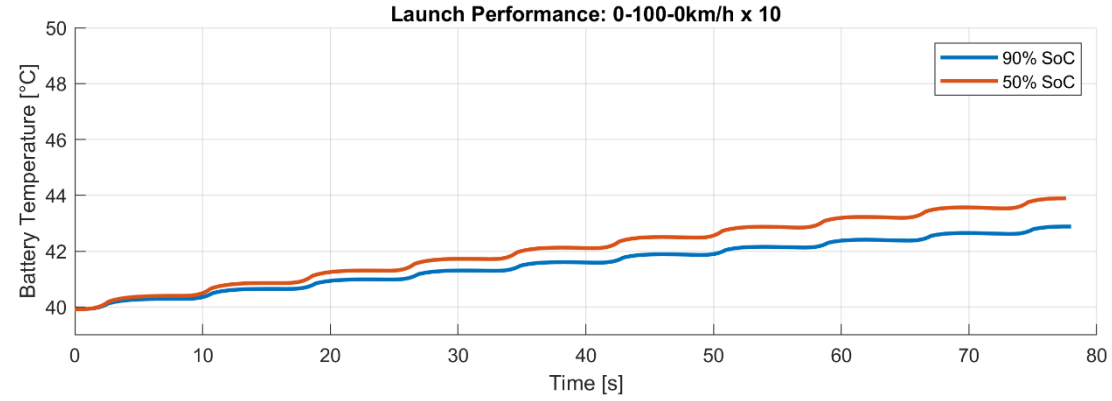


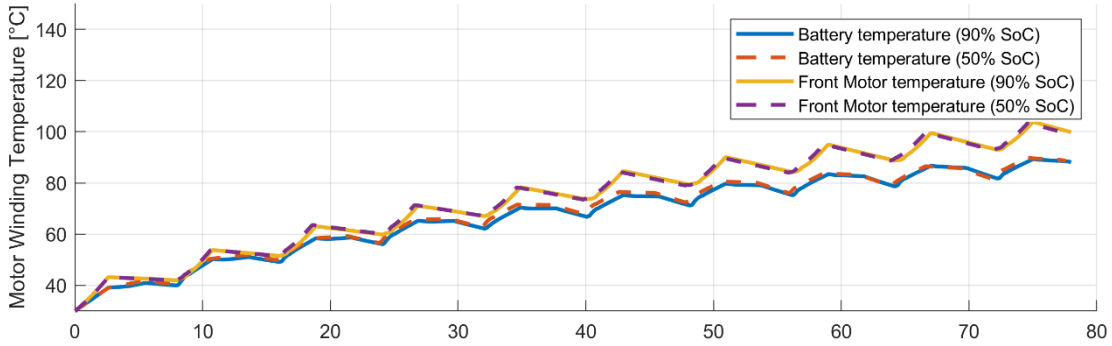


LONGITUDINAL PERFORMANCE

Performance analysis at lower SoC



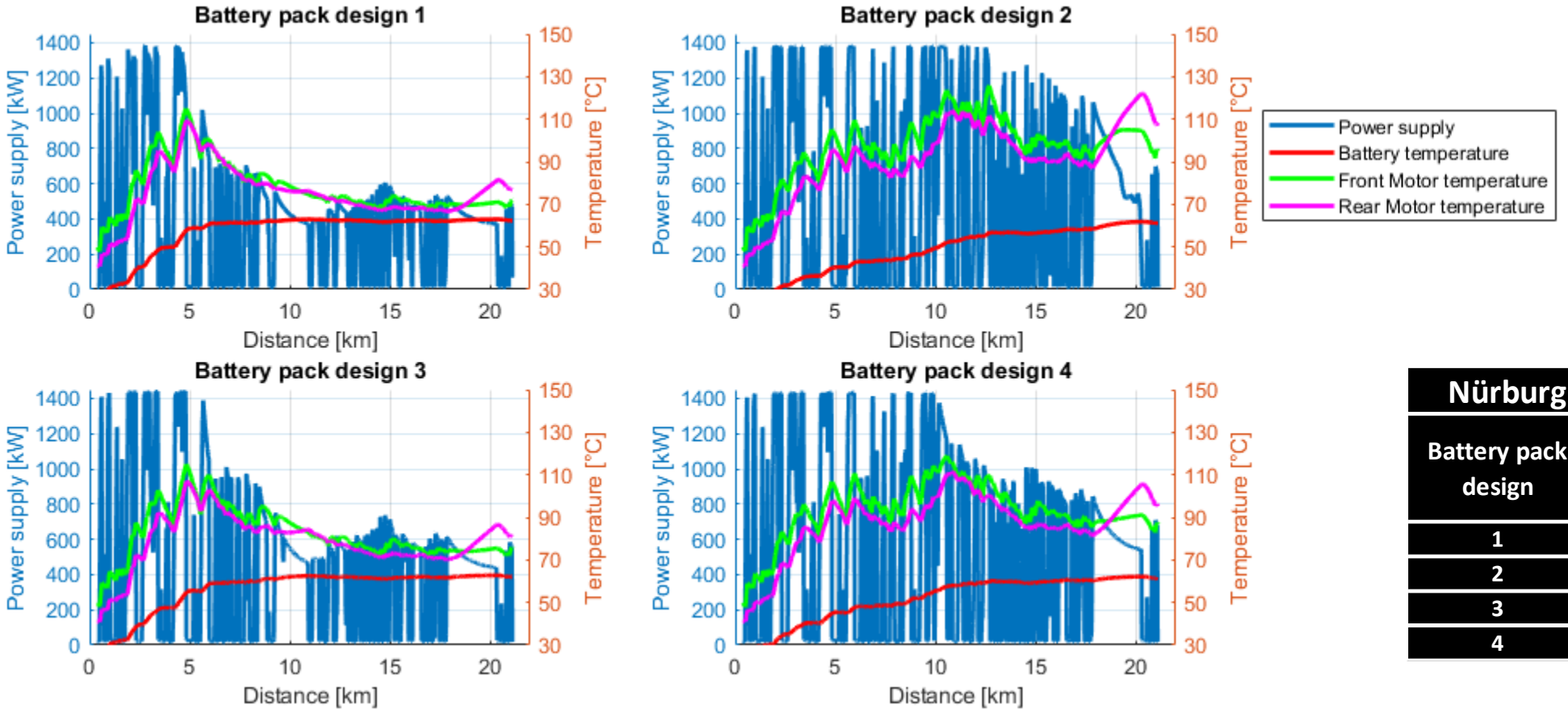




NOTE: Results are given as an example, data is not representative of current, nor previous status

TRACK PERFORMANCE ANALYSIS: Nürburgring Nordschleife

Performance comparison of different battery pack designs



Nürburgring Nordschleife	
Battery pack design	**Difference in Simulated Lap Time [s]**
1	0.0
2	-20.3
3	-6.8
4	-17.3

NOTE: Results are given as an example, data is not representative of current, nor previous status

ELIMINATE BOTTLENECKS FOR A HOLISTIC DESIGN

RANGE AND EFFICIENCY ON WLTC CYCLE

Consumption and identifying losses

WLTC consumption, range and losses			
Consumption			XXX.X Wh/km
Range			XXX.X km
Contribution of Losses	Aerodynamic Losses		23.4%
	Powertrain Losses	Battery	1.5%
		Inverters	11.8%
		Motors	13.5%
		Gearbox	6.8%
	Friction Brakes		2.8%
	Tyre Rolling Resistance		31.9%
	Auxliary		8.3%

Powertrain efficiency based on WLTC cycle		
	Front	Rear
Motor	92.0%	91.0%
Inverter	96.0%	95.0%
Gearbox	97.6%	97.5%

NOTE: Results are given as an example, data is not representative of current, nor previous status

CORRELATION AND VALIDATION OF SIMULATIONS

COMPONENT LEVEL

- Battery
- Motor & Inverter
- Gearbox

SYSTEM LEVEL

- Front and/or Rear Axle
- Controlled operating conditions
- Controlled cooling environment

VEHICLE LEVEL

- Full system integration with all control systems
- Variable operating conditions
- Driver in the loop
- Limited control

For any additional information you might need, feel free to contact me.

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