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#RTR2026

RHODaS PROJECT FINAL RESULTS

Objectives, Key Results, and Impact for Heavy-Duty Transport

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2ZERO ERTRAC CCAM European Commission | With the support of BATT4EU Batteries European Partnership

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Overall project presentation

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CONSORTIUM

COORDINATOR

UNIVERSITAT POLITÈCNICA DE CATALUNYA BARCELONATECH

BUDGET

€ 5,956,938.00

PARTICIPANTS

AARHUS UNIVERSITY

AUSTRIAN INSTITUTE OF TECHNOLOGY

BOSMAL

Kneia

nvision

TECHNISCHE UNIVERSITÄT WIEN

Valeo

Valeo eAutomotive

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PROJECT OBJECTIVES & TARGETS

TO1. Improve efficiency and performance of power converters while increasing affordability of powertrains for heavy-duty Evs	40% reduction of termal losses, temperature operation up to 175ºC, truck driving range + 10%
TO2. Reduce size and weight of the power converters	50% reduction of size, 30% reduction of weight, 15 dB reduction of EMI noise
TO3. Effective application of digital technologies and sensors for advanced on-line monitoring and intelligent estimation and prediction of states based in advanced modelling and prediction techniques using Big Data Analysis and Artificial Intelligence	30% reduction of failures, 20% reduction of costs, 25% extensión of lifetime
TO4. Effective integration of the power electronics and TMS in a modular and compact IMD to evaluate the overall performance in a complete e-axel test bench	IMD efficiency increase >5%, RUL prediction accuracy >75%; 75% reduction in converter losses
TO5. Integration of eco-design, material criticality and circularity considerations into the RHODaS powertrain solution, as well as viable circular business models for their future commercialization	25% extension of life, 30% improvement in environmental and circular performance
TO6. Promote collaborative research and interaction between academia and industry throughout the entire supply chain	8 networking events

Results presentation

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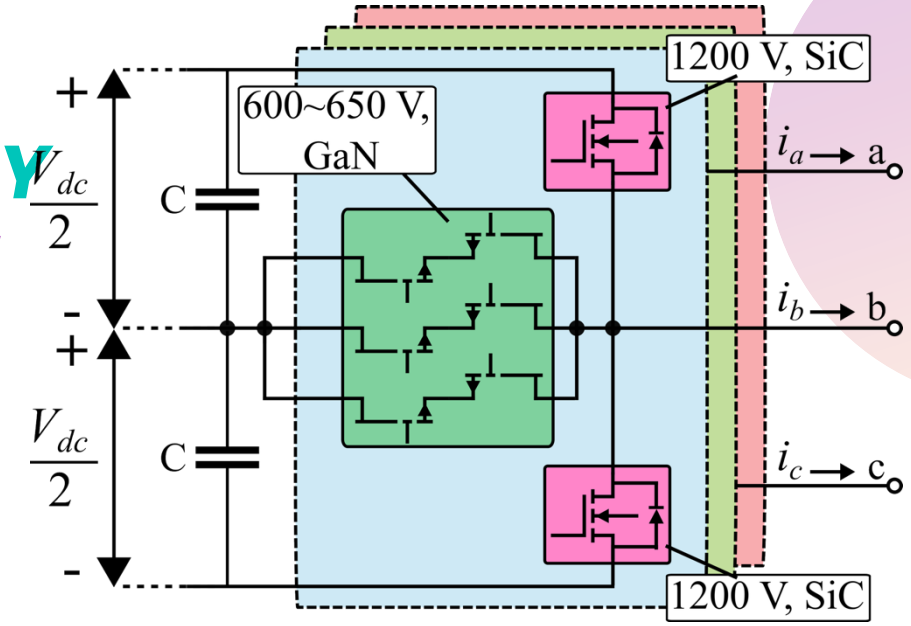
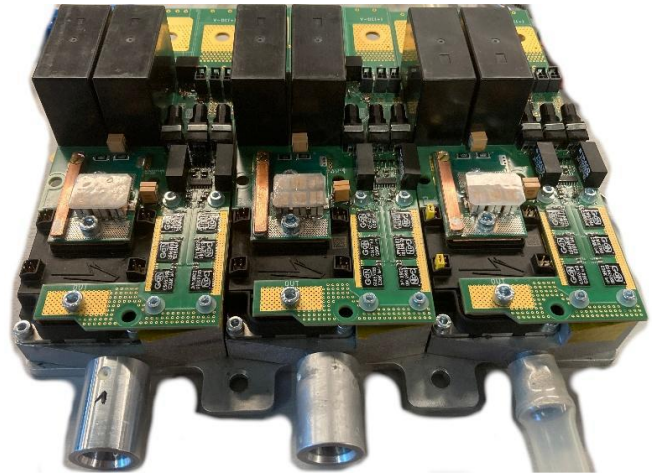
EFFICIENT POWER CONVERTER DESIGN

HYBRID T-TYPE MULTILEVEL TOPOLOGY

- ***Architecture:*** *Combines 1200V SiC and 650V GaN switches.*
- ***Benefit:*** *Maximizes efficiency while reducing passive component size.*
- ***Thermal Management:*** *Optimized heatsink design using CFD sensitivity analysis for uniform cooling.*
- ***Modulation:*** *Validated SVPWM & CB-PWM algorithms with adaptive level-shifting.*





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CLOUD-BASED ARCHITECTURE & DIGITAL TOOLS

3-LEVEL ARCHITECTURE

Integration between the Converter ECU (Local), On-board Gateway (Edge), and Microsoft Azure (Cloud).

FAULT TOLERANCE

Dynamic reconfiguration logic: System automatically switches from 3-Level to 2-Level mode upon failure, ensuring vehicle availability.

DECISSION SUPPORT

AI-driven Decision Support System (DSS) using edge sensors for vibration analysis and predictive maintenance.

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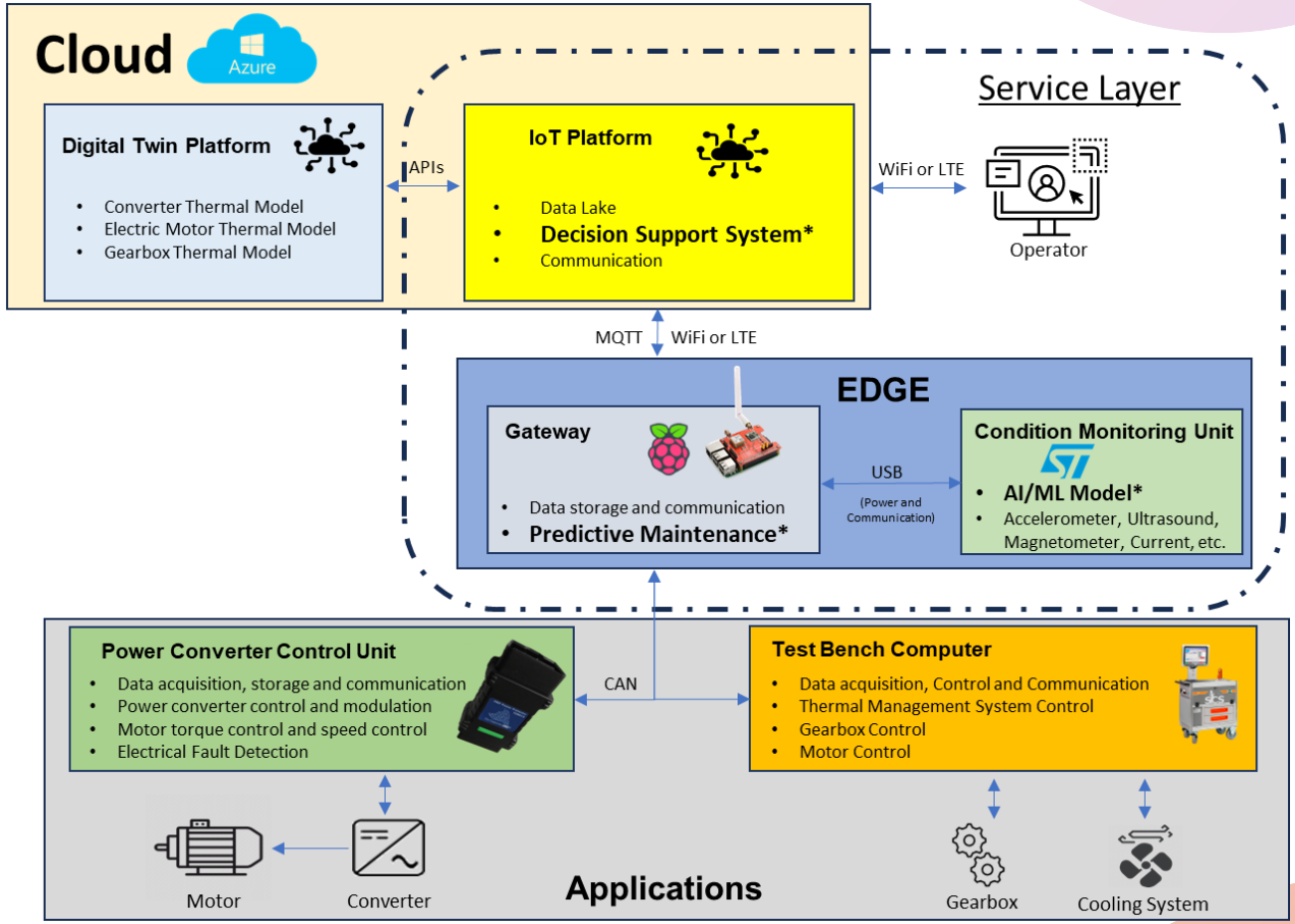
DIGITAL TWIN & IOT PLATFORM

VIRTUAL SENSING & MONITORING

The project developed a comprehensive Digital Twin that includes thermal models for the Power Converter, E-Motor, and Gearbox.

- **Key Features:**
  - *Estimation of junction temperatures where physical sensors cannot reach.*
  - *Real-time data visualization via a web dashboard.*
  - *Integration with DSS for early fault detection.*

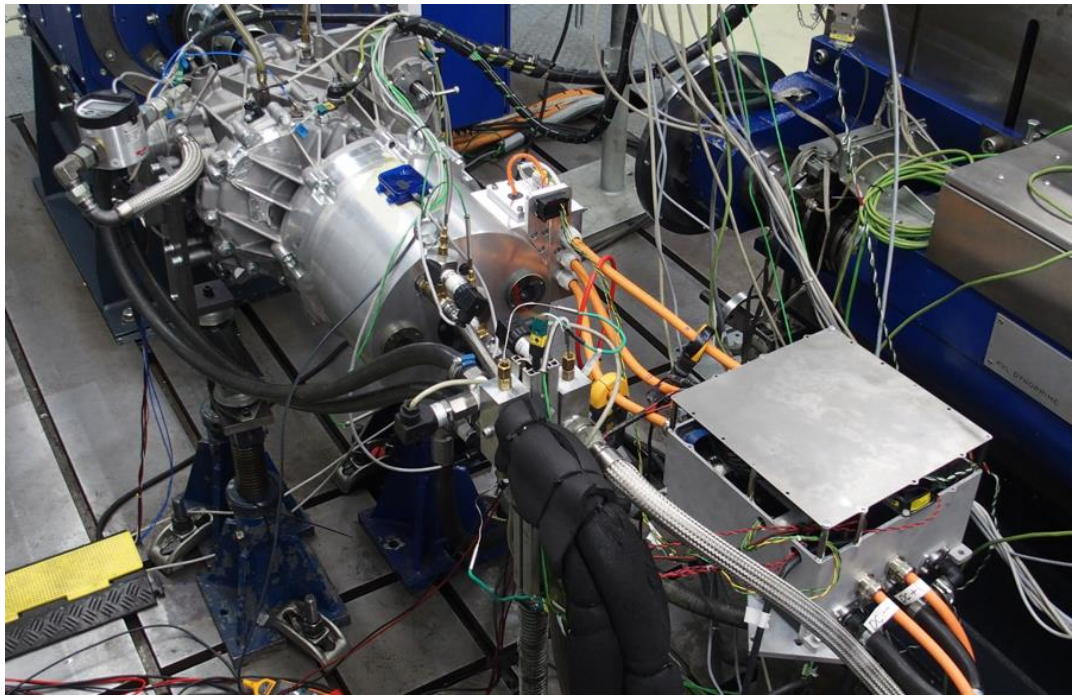


IMD INTEGRATION & VALIDATION

Validation

The modular IMD underwent rigorous testing at BOSMAL test facilities.

- *Run-in Tests*
- *Efficiency Mapping: Measured based on ISO 21782-3 standards.*
- *Thermal Rise*
- *Limit Operation: Max net power characterization per ECE-R85.*



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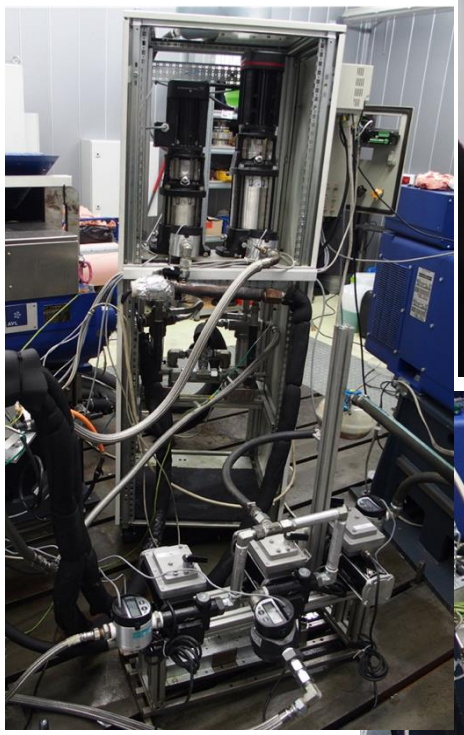

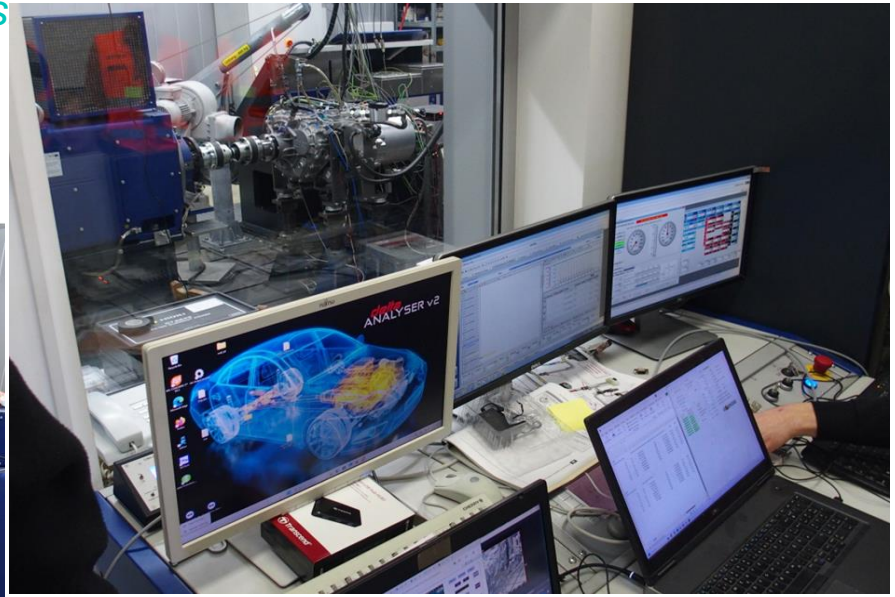

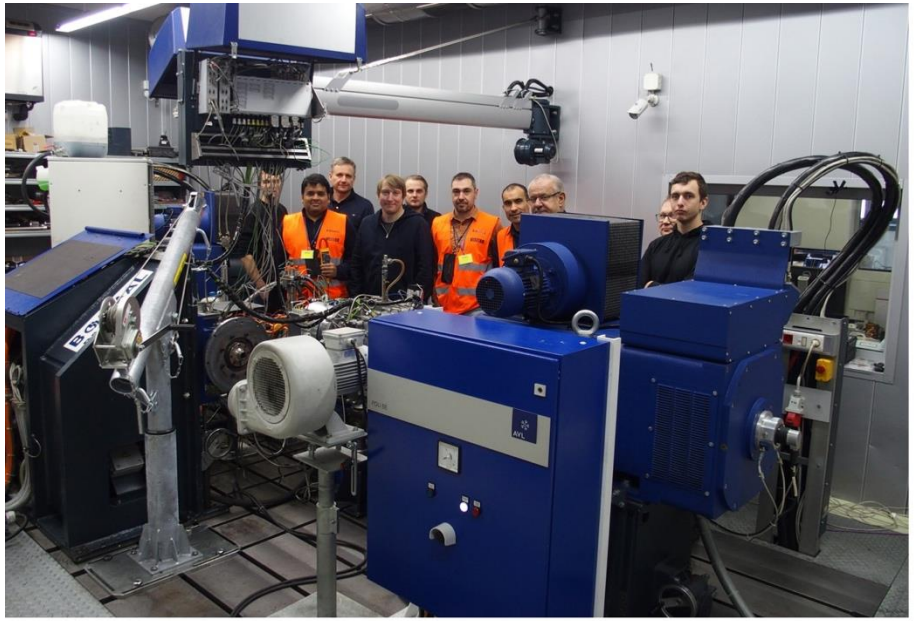

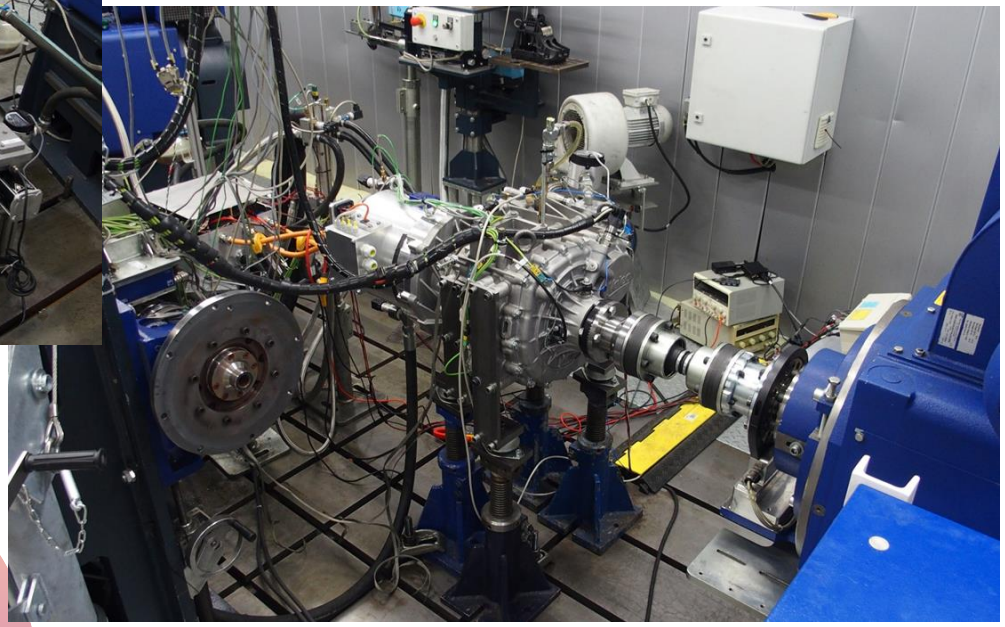

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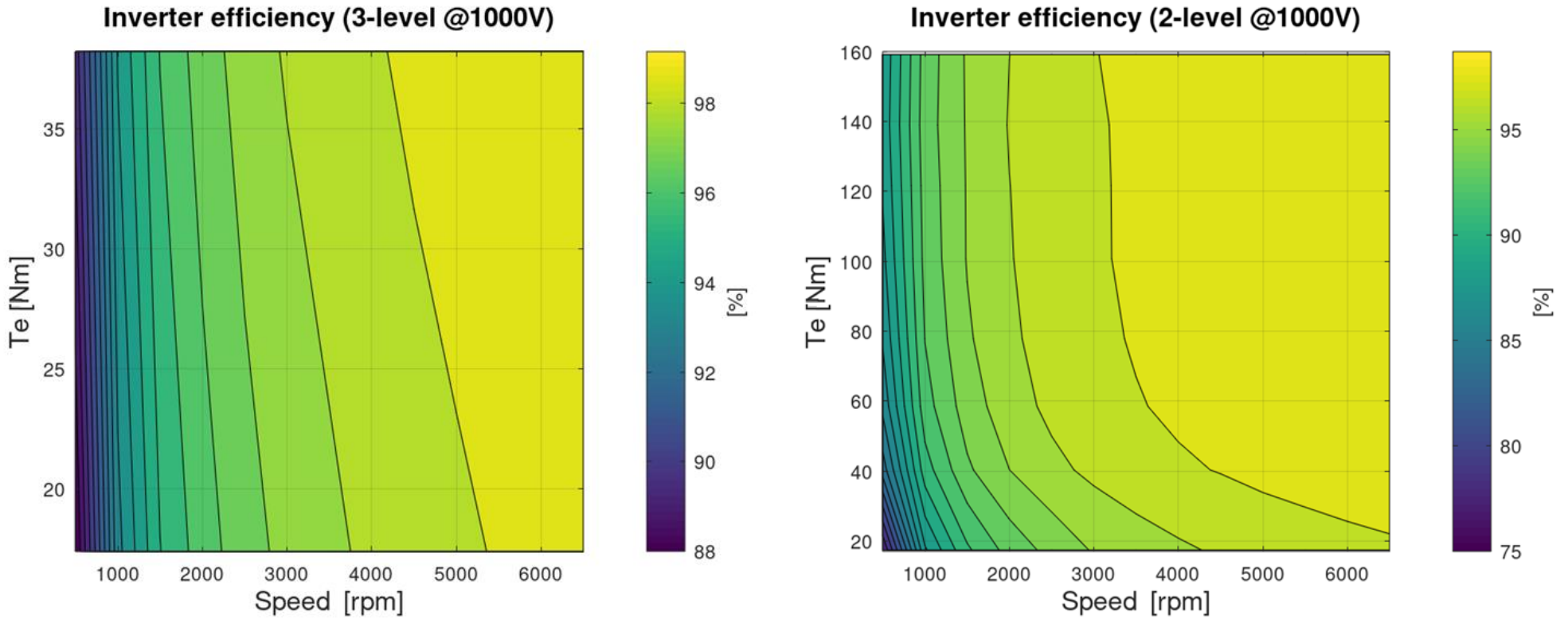
Power converter test results

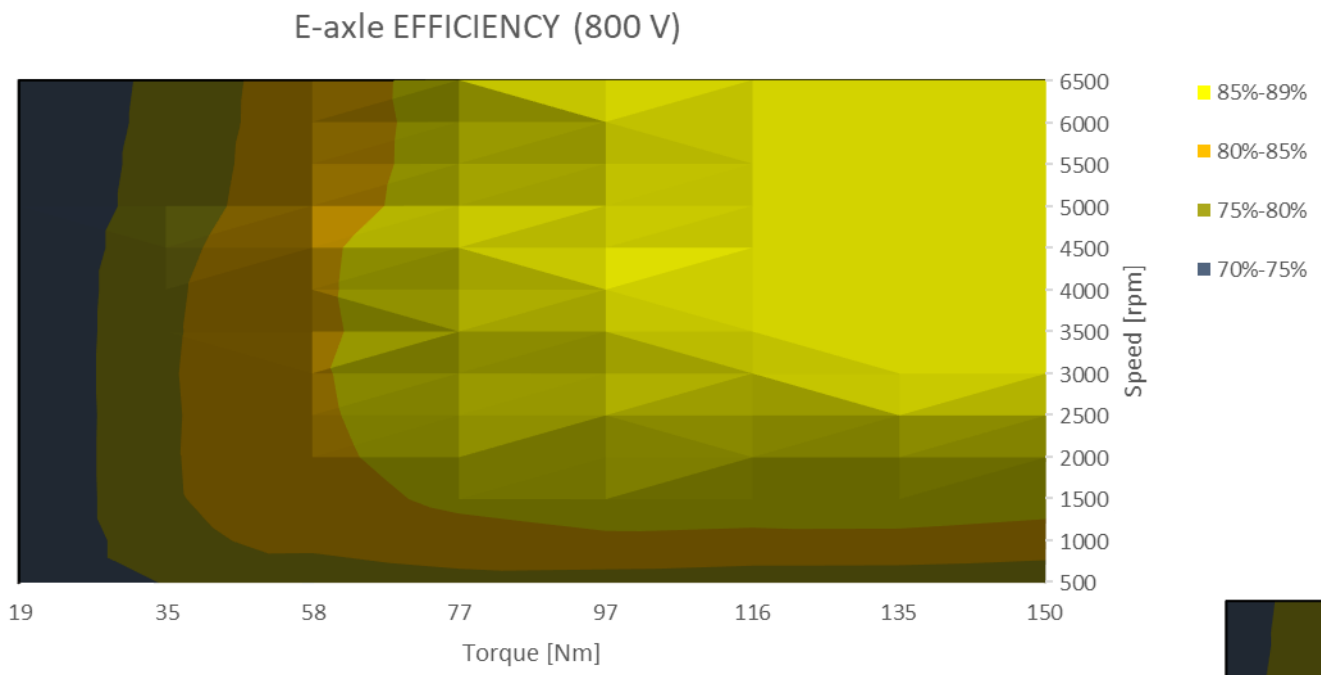


TC003- Efficiency Map

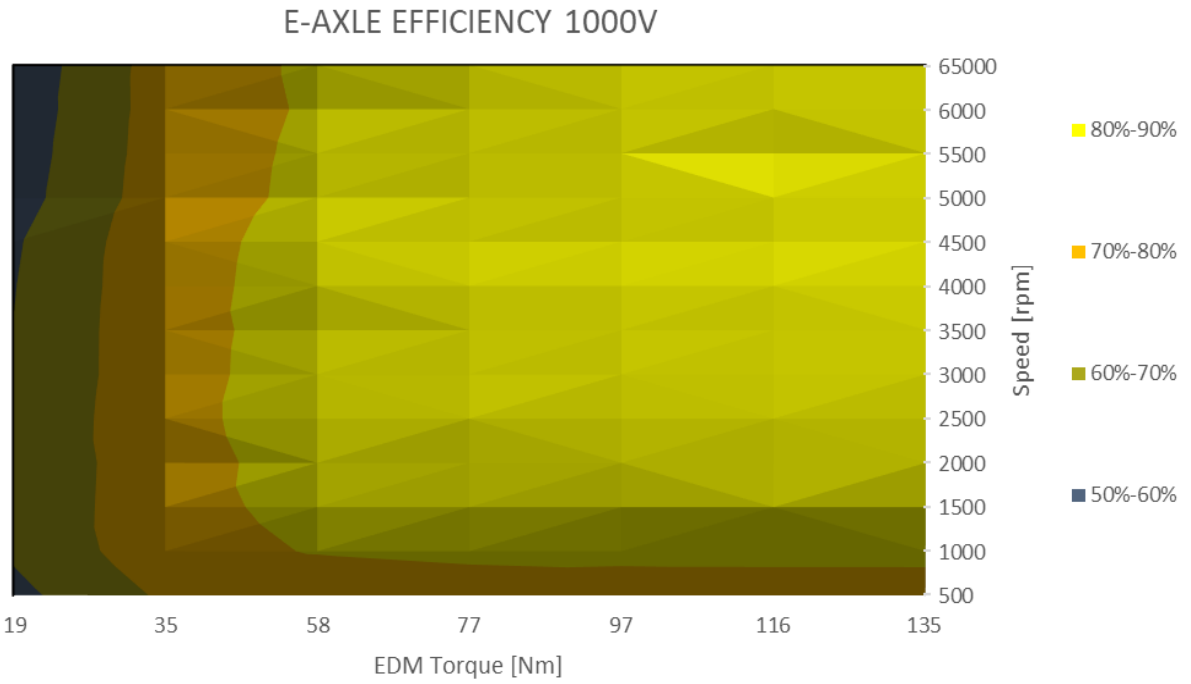
Inverter test - Measurement of loss, efficiency and conversion rate

Test performed on e-axle assembly (IMD + gearbox)
Torque range: -160 Nm ÷ 160 Nm
Speed range: 0 ÷ 6500 rpm
Voltage level: 800V (2L & 3L) and 1000V (2L & 3L)
Operation mode: 2L (0 ÷40 Nm), 3L (0 ÷160 Nm)

E-axle test results



TC003- E-axle efficiency Map



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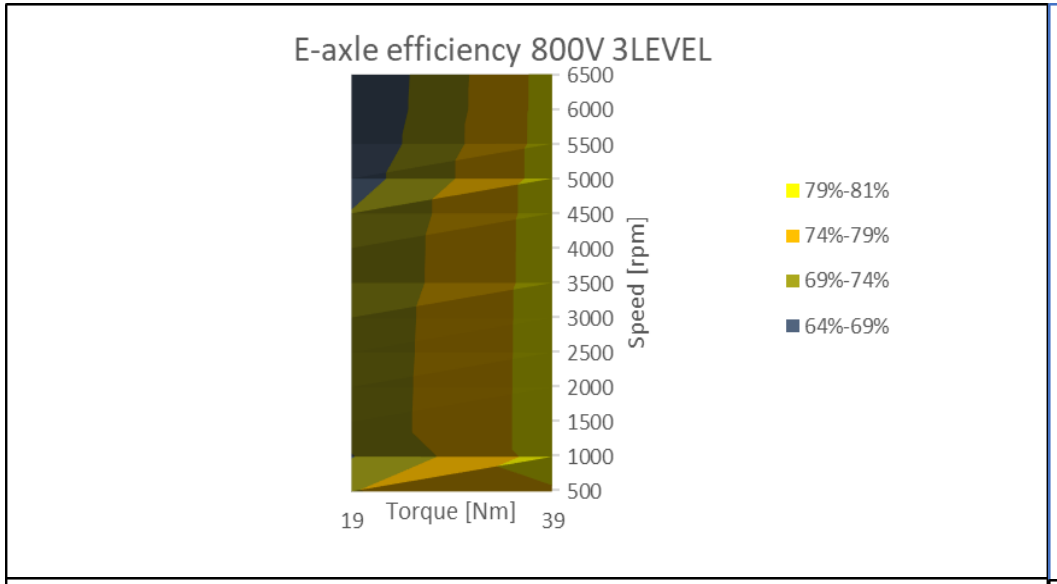
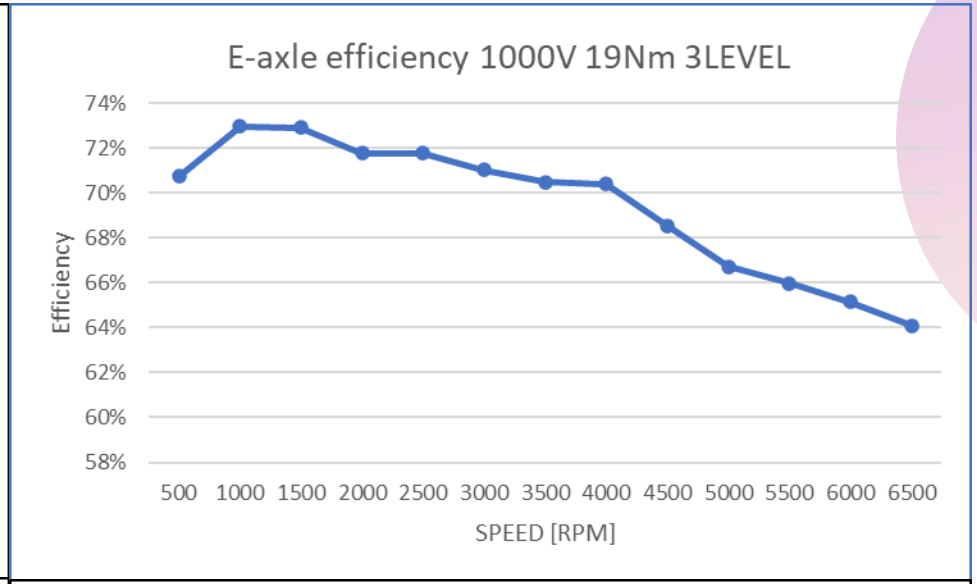
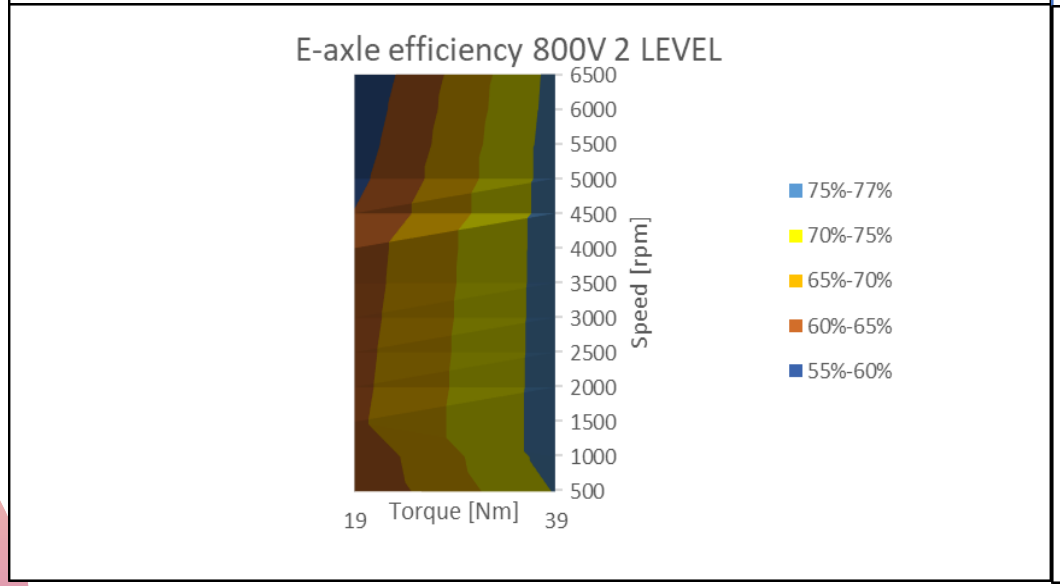
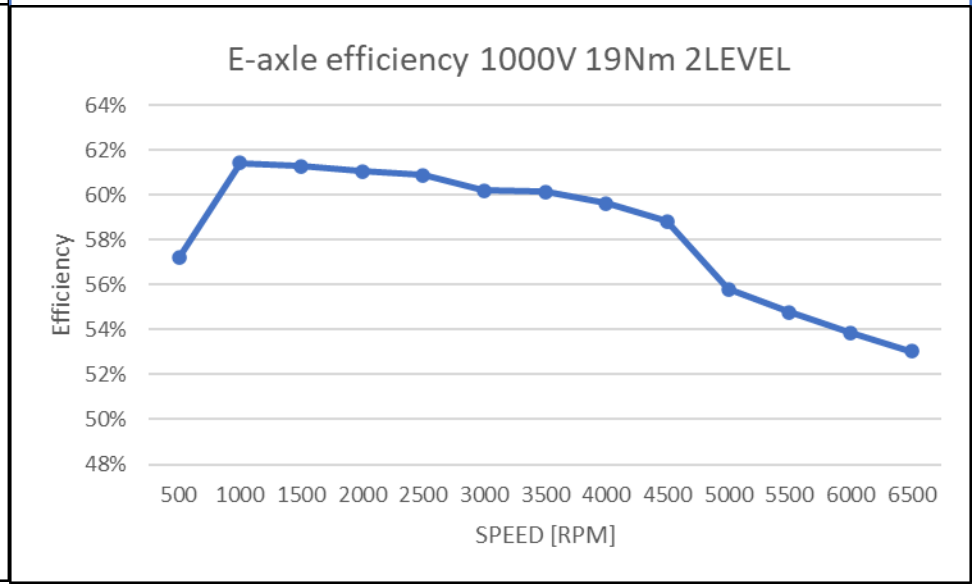
E-axle & Power converter test results

TC003- E-axle efficiency Map + comparision

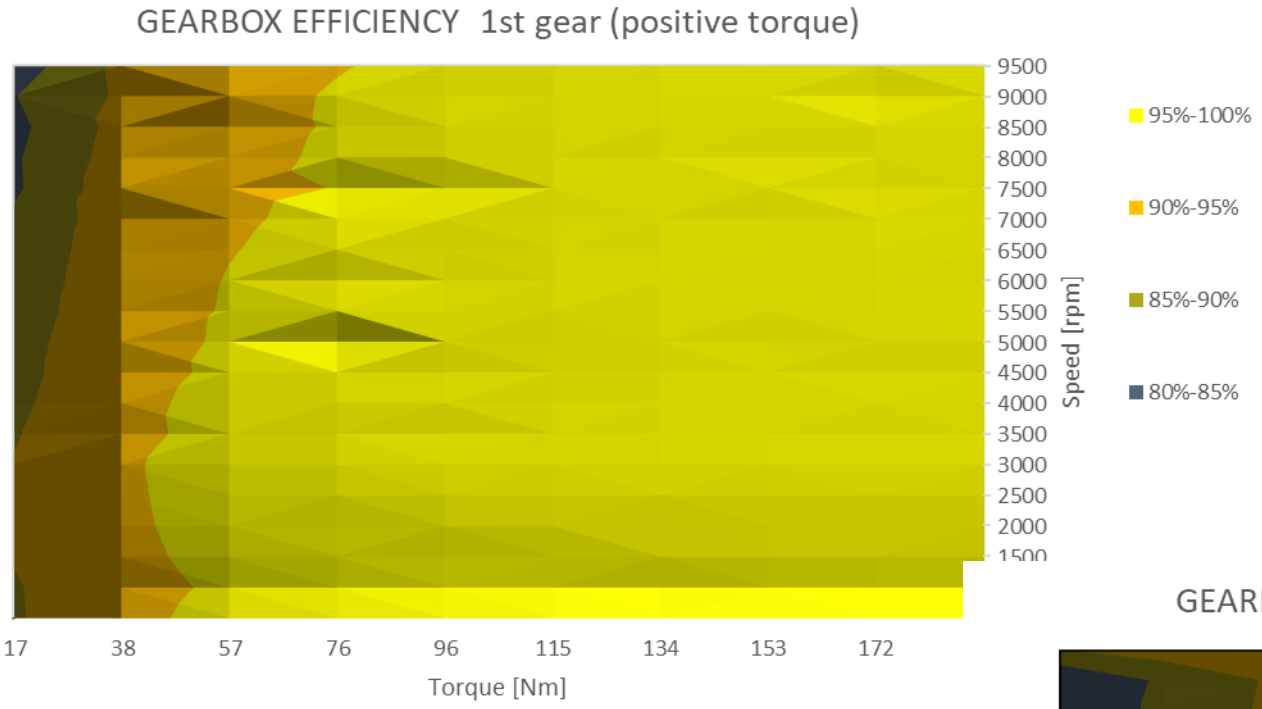






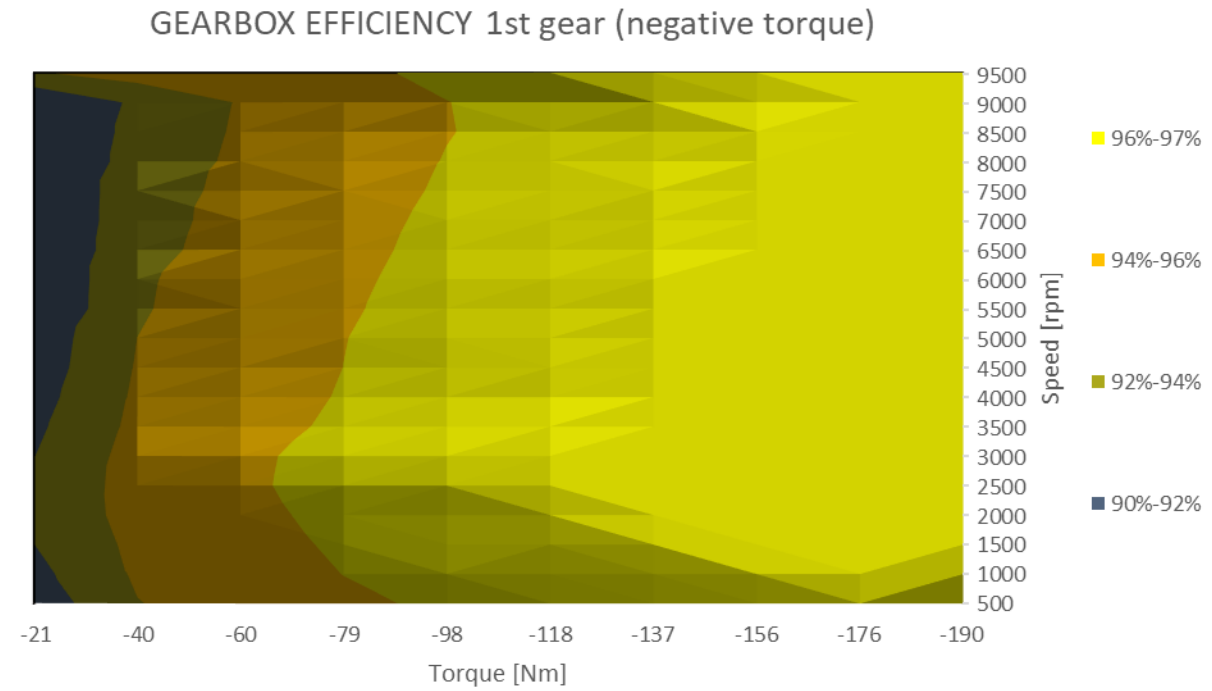


Gearbox test results



TC003- Gearbox efficiency Map

Test performed at:
Torque range: -190 Nm ÷ 190 Nm
Speed range: 0 ÷ 9500 rpm)



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SUMMARY OF KEY ACHIEVEMENTS

KPI Target	Status	Key Results & Observations
KPI-1: -40% Thermal Losses	**Achieved**	Validated reduction of 39-70% in simulations vs. conventional SiC converters.
KPI-2: 175°C Operation	**Limited**	Limited to 125°C due to current WBG encapsulation and GaN chip constraints.
KPI-4: -50% Size (Volumetric power density)	**Achieved**	High-power converter: 97.66 kW/L. (Target 100 kW/L) Integrated IMD: 36.54 kW/L (Surpassed target 33 kW/L).
KPI-5: -30% Weight (Gravimetric power density)	**Partially achieved**	IMD: 5.58 kW/kg (Target 5 kW/ kg). Inverter: 27.8 kW/kg (Target 50 kW/kg) .Modular design prioritized for repairability/circularity.
KPI-6: -15 dB EMI Noise	**Achieved**	Confirmed experimentally on low-power unit via CB-PWM modulation.
KPI-7: -30% Failures	**Achieved**	Detection Accuracy: 100% (Temp/Volt), 94% (Abnormal Motor Vibrations.), 90% (IMD Thermal Models).

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The main achievements of RHODaS

- **Hybrid Converter Development**: *Development of a hybrid T-type converter based on SiC and GaN.*
- **Modulation Strategy**: *Design of novel modulation techniques to optimise the converter's high-frequency operation (improving efficiency, EMI, and harmonic distortion).*
- **Cloud Platform**: *Creation of a cloud-based platform for real-time validation of converter performance and predictive maintenance.*
- **High-Density IMD**: *Design of a high power and gravimetric density Integrated Motor Drive (IMD) incorporating the new converter.*
- **Testing & Standardisation**: *System testing based on the latest automotive standards, including proposals for regulatory updates to accommodate testing for this new generation of converters.*

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Mid to long term expected impacts of the project

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TECHNOLOGICAL & ENVIRONMENTAL IMPACT

SUSTAINABILITY

- ***Eco-Design:*** *Prioritized components using Environmental & Criticality Matrices. Targeted 30% GWP reduction via LCA screening (ISO 14040).*
- ***Circularity:*** *Modular design allows individual phase/component replacement, significantly extending product life and reducing e-waste.*

ECONOMIC

- ***Reduced O&M Costs****: Predictive maintenance enabled by the Digital Twin and DSS is expected to lower operation costs by ~20%.*
- ***Efficiency:*** *>98% efficiency directly translates to lower energy consumption and longer range for heavy-duty logistics operators.*

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SOCIETAL IMPACT & POLICY CONTRIBUTION

- **EU Green Deal Support:** Directly contributes to the decarbonization of the heavy-duty transport sector, a critical pillar of EU climate goals.
- **Standardisation:** Activities adhered to and validated against ISO and ECE standards, paving the way for future regulatory frameworks in EV powertrains.
- **Skills Development:** The project boosts expertise in advanced Wide Bandgap (SiC/GaN) technologies and Digital Twin applications, training the next generation of engineers and researchers.
- **Future Research:** Identified needs for higher switching frequency operation (> 100kHz) will guide future EU-funded research topics.

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THANK YOU

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- **Website** - https://www.rhodas.eu/
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- **Multi-Stakeholder Platform** - https://stakeholders.rhodas.eu/
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