

EM-TECH

Innovative e-motor technologies covering e-axes and e-corners vehicle architectures for high-efficient and sustainable e-mobility

Martin Weinzerl – AVL List GmbH



EM-TECH

Overall project presentation



Consortium

- Project Duration: 36Months
- 10 partners
- Total cost: € 3 834 550,00
- Coordinator: AVL List GmbH



Objectives



Radial flux in-wheel motor (IWM) for high torque density (>150 Nm/litre) and high efficiency (>20% motor energy loss reduction)



On-board axial flux motor (AFM) for high power density (>30 kW/litre) and high efficiency (>25% energy loss reduction)



Circularity: update of LCA/LCC methodologies taking into account remanufacturing and recycling; Reduction of the use of rare earth resources (>20% for IWM and >60% for AFM)



Costs: achieving <6 Euro/kW for IWM and 5 Euro/kW for AFM



Digital twinning and distributed XiL solutions for accelerated testing of electric drives and vehicle corners

Results presentation

emtechproject.eu/results/



In-wheel motor

- Main drivers for the electric motor design

- Implementation of the mechanical e-Gear [incl. change of 400 -> 800V system]
- Direct cooling method implementation
- Reduction of HRE material content in permanent magnets

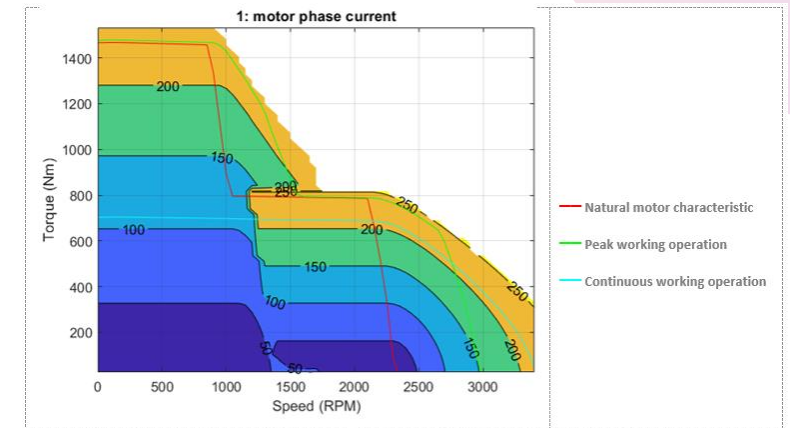


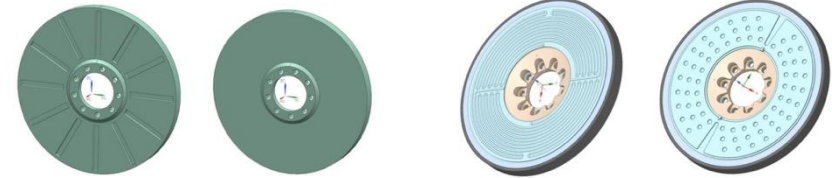
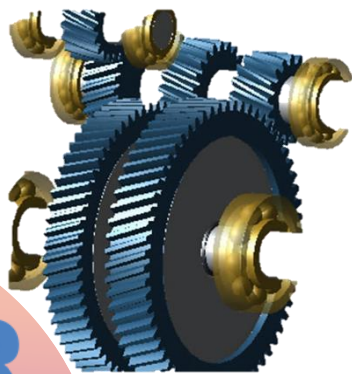
Figure 4 Map of motor current (A) and operational range of L1500 motor at 730V with mechanical e-gear



Action & Objective	EM-TECH	Comment
Torque density	44,5 Nm/kg	15% increase compared to the baseline motor
Power density increase	124 kW	86% increase
HRE content reduction	39% reduction	Surpassed the 20% target
Direct cooling method & e-Gear integration	Improved continuous power level	More than doubled
IWM BOM cost target	5,73 EUR/kW	Target was < 6 EUR/kW

Axial flux motor

- *On-board drive technologies improvement*
 - *Compact mechanical design*
 - *Explore innovative manufacturing processes*
 - *Optimized gearbox design with ML*
 - *Tailored power electronics for modular axial flux motor*

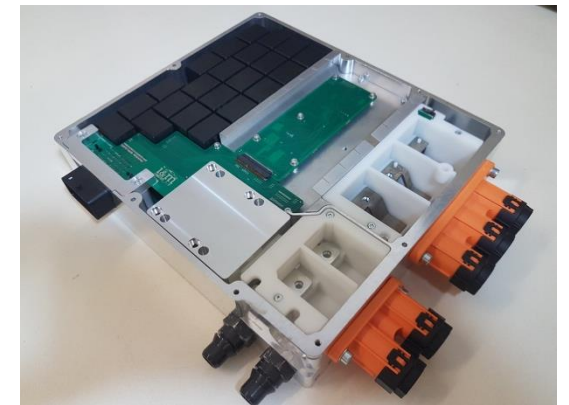


Flat rotor disc concept

Cold plate concept



Final prototype & standard Traxial AFM



Power electronics with power density > 50kW/l

Objective	EM-TECH Result	EM-TECH Target
Gravimetric Power Density	10.15 kW/kg	10 kW/kg
Volumetric Power Density	33 kW/l	30 kW/l
Heavy rare earth content	0.5%	0.5%
Magnet mass reduction	60.1%	60%
BOM Cost	3.9 €/kW	< 5 €/kW

Circularity

- *Use of recycled permanent magnets in traction machines*

- End-of-life scenarios for IWM and AFM
- Cost evaluation EoL for IWM and AFM

Preparation and implementation



- Recyclability assessment
 - Theoretical recyclability
 - Technical recyclability
 - Real recyclability

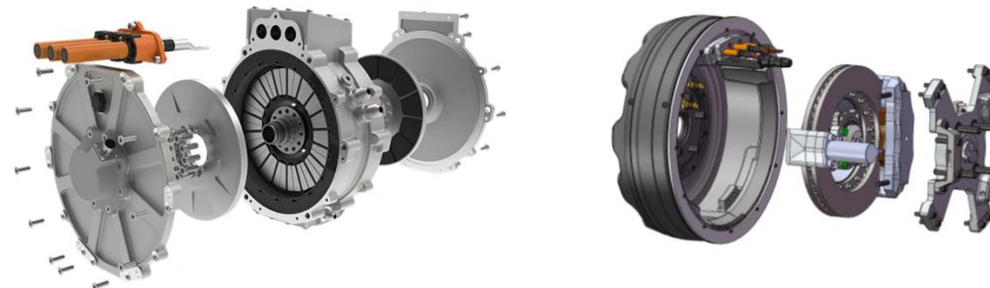


Circularity design



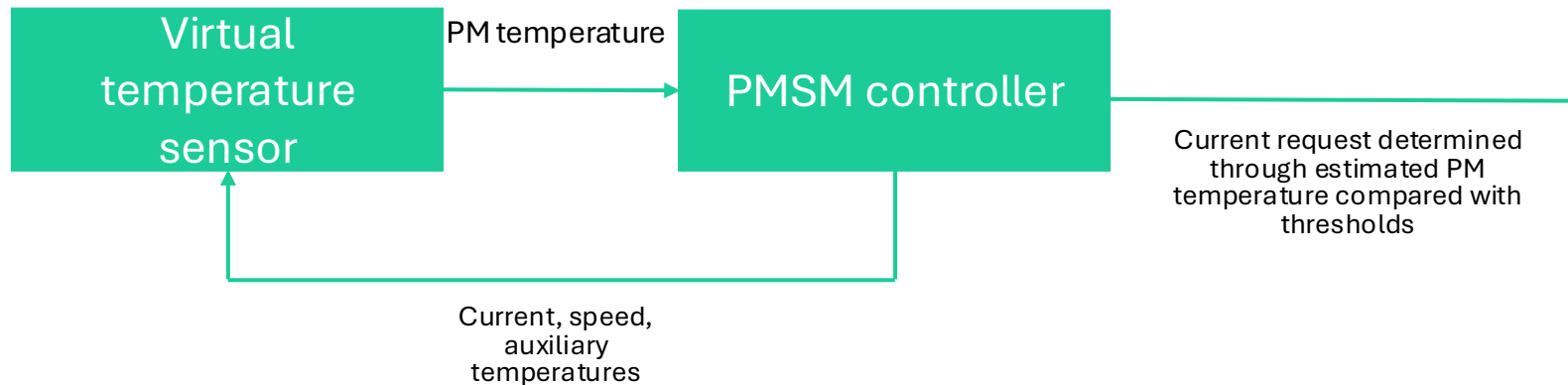
Eco-design strategies

- Engineering services for electric drive LCA and LCC



Innovative control strategies

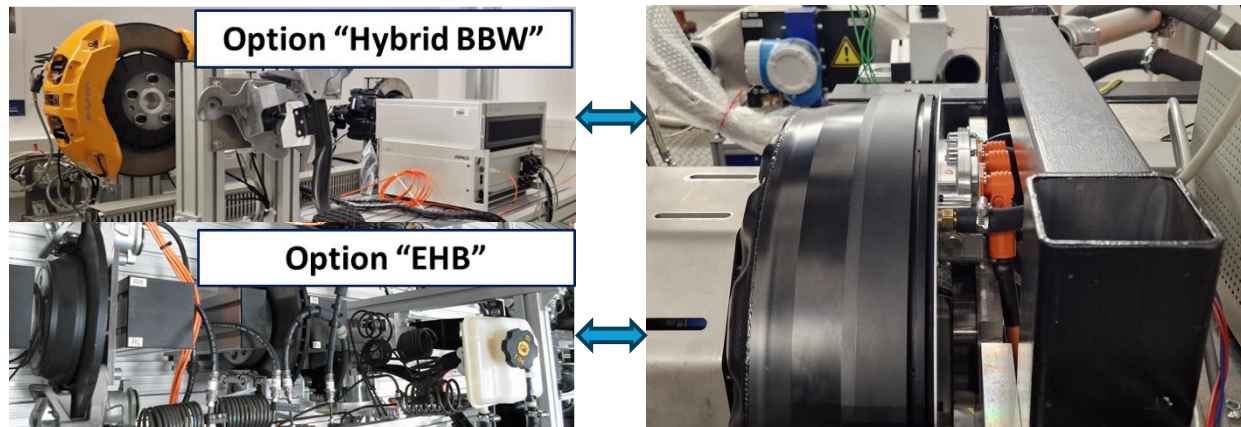
- *Enabling control strategies through virtual sensing*



- *Rule-based Gear-shifting strategies for e-gear IWM*
- *Deep reinforcement learning based traction control applications*
- *AI-based traction control applications*

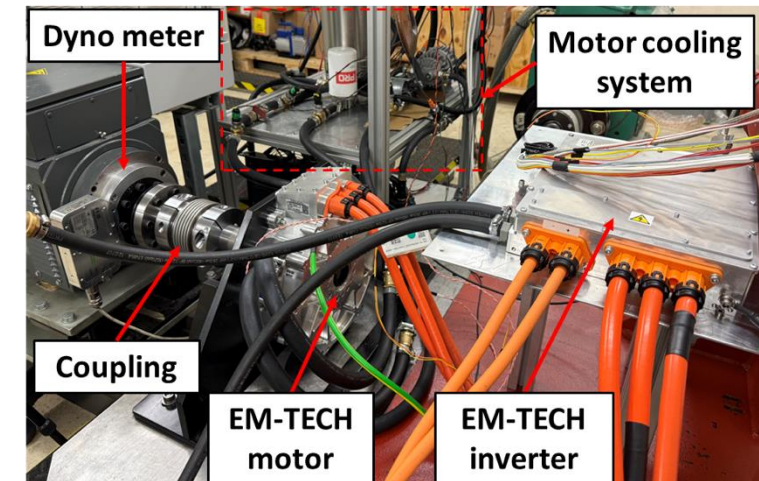
Virtual and experimental testing

- *Distributed XIL: Usability & Impact*
 - *Experiments in the case of non-availability of required test setups within the same host / lab*
 - *Multilateral benchmarking of models and controllers*



BBW & EHB installed at the test bench at TU Ilmenau

IWM installed at the test bench at IAAPS /Bath



On-board AFM (Traxial) installed at the test bench of University of Surrey

- *Efforts decrease for technology introduction*
- *Cost benefits for virtual integration and hardware testing*
- *Optimisation of testing time*
- *Collaborative R&D*

Mid to long term expected impacts of the project



Outcomes



Technological: Highly efficient, affordable in-wheel and on-board electric motors demonstrating 20-25% energy loss reduction along driving cycles.



Economic: EM technologies providing cost red. 5-6 €/kW and decrease in (i) rare magnets usage >20% (for IWMs) and (ii) total rare earth content >60% (for OBM).



Scientific: New validated research methodologies on (i) virtual sensing in electric power-train applications, (ii) LCA/LCC, (iii) smart EM control within e-corner/e-axle frameworks.



Automotive quality level demonstrated in realistic testbench environments



2x **patents**, 9x prototypes, 3x demonstrators

Impact



Technological: new generation of electric motors, considering recyclability, reduction of (rare earth) resource usage, cost criticality, and a full product life-cycle assessment



Market penetration^{1,2}: expected **CAGR of >30%** for in-wheel motor and axial flux motor technologies



Ecosystem: close interaction with a vivid ecosystem (4 sister projects, E-VOLVE cluster) to create a **critical mass for R&I efficiency and uptake of research outcomes**



Social: Increased EM performance and reduced rare earth content is contributing to **more sustainable transportation and positively impacting the acceptance of EVs**



Environmental: Improvement of vehicle efficiency and therefore a reduction of energy usage and finally of CO2 emissions



#RTR2026



THANK YOU

Martin Weinzerl, AVL List GmbH
martin.weinzerl@avl.com



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