06/10/2025

High Speed Motor Evaluation for Next-Gen 4WD SUVs with ePOP

Project Overview

Jaguar Land Rover (JLR) used the electrified powertrain optimization process (ePOP) software to quickly identify the most promising designs for their next generation electric drive units (EDUs) - before committing to costly prototyping. By virtually exploring thousands of design possibilities, ePOP enabled JLR to balance performance, weight, and sustainability targets in record time, reducing engineering risk and accelerating decision-making. This early insight gave their teams a clear, data-driven path toward high-speed electric motors that meet demanding performance requirements while supporting ambitious CO_2 reduction goals.

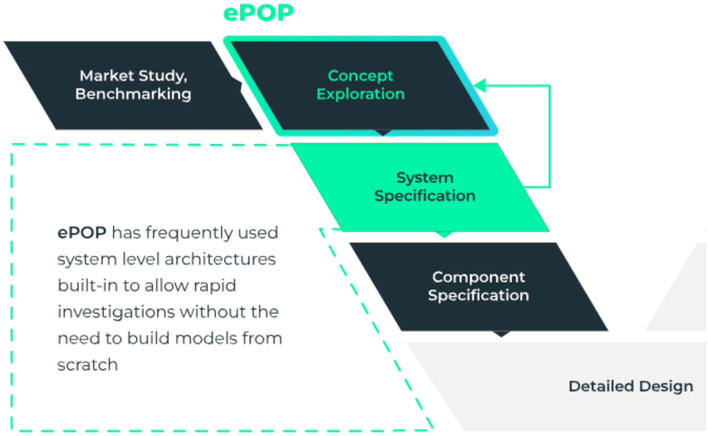


Figure 1: ePOP's Positioning in V-Model

JLR was exploring possibilities to meet weight constraints of their high-speed electric motors while still achieving vehicle performance requirements.

As a partner in the APC (Advanced Propulsion Centre) project consortium Zebeyond used ePOP to explore the design space of high-speed electric motors and feedback the optimum for more detailed design work (Figure 2).

ePOP studies showed an optimal motor speed range which gave the best balance of engineering performance targets and from a life cycle analysis (LCA) perspective showed embedded CO2eq. emissions in keeping with targets of a 20% reduction vs. internal benchmark EDUs. These results were used to inform subsystem specifications for detailed design in the JLR engineering teams in the next stage of the project.

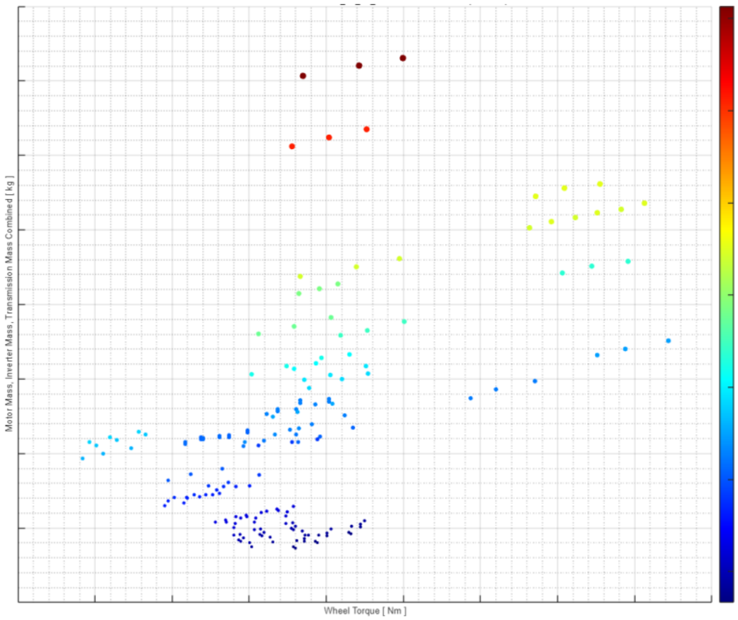
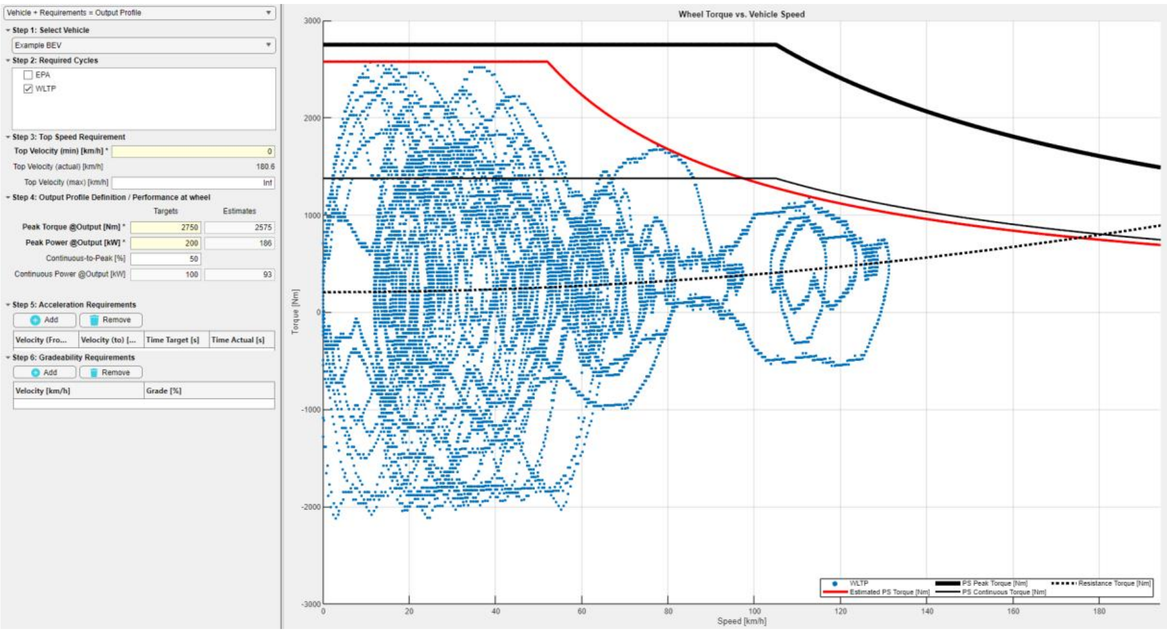


Figure 2: Anonymized ePOP Study Results

Methodology

Vehicle level performance targets were input to ePOP's power source sizing and requirements analysis toolset which calculated motor torque and transmission ratio specifications at different motor speeds (Figure 3).



Vehicle + Requirements = Output Profile

Step 1: Select Vehicle

Example BEV

Step 2: Required Cycles

☐ EPA
☑ WLTP

Step 3: Top Speed Requirement

Top Velocity (min) [km/h] * 0
Top Velocity (actual) [km/h] 180.6
Top Velocity (max) [km/h] Inf

Step 4: Output Profile Definition / Performance at wheel

	Targets	Estimates
Peak Torque @Output [Nm] *	2750	2575
Peak Power @Output [kW] *	200	186
Continuous-to-Peak [%]	50	
Continuous Power @Output [kW]	100	93

Step 5: Acceleration Requirements

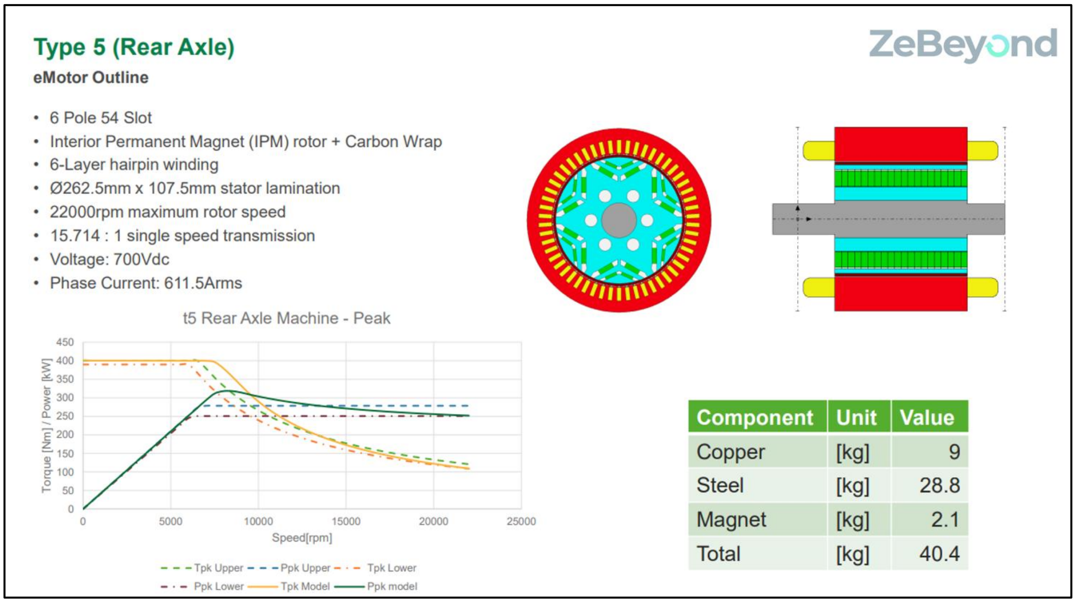
Velocity (Fro...	Velocity (to) [...	Time Target [s]	Time Actual [s]

Step 6: Gradeability Requirements

Velocity [km/h]	Grade [%]

Figure 3: Example of ePOP vehicle requirements analysis

To support motor design, ZeBeyond partnered with Drive System Design (DSD), an automotive consultancy, to develop multiple electric machine concepts using Ansys MotorCAD. These machines spanned a comprehensive design space, for example covering speeds from 18,000 to 35,000 RPM as well as other design variations (Figure 4).



Type 5 (Rear Axle)

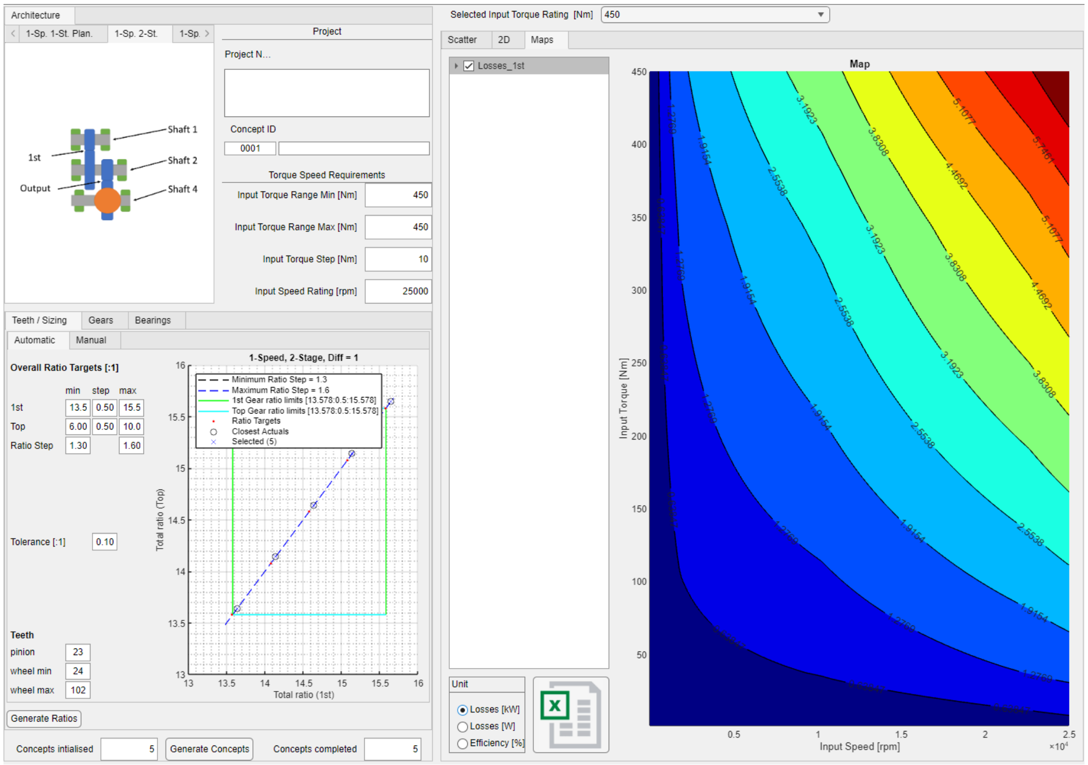
eMotor Outline

- 6 Pole 54 Slot
- Interior Permanent Magnet (IPM) rotor + Carbon Wrap
- 6-Layer hairpin winding
- Ø262.5mm x 107.5mm stator lamination
- 22000rpm maximum rotor speed
- 15.714 : 1 single speed transmission
- Voltage: 700Vdc
- Phase Current: 611.5Arms

t5 Rear Axle Machine - Peak

Component	Unit	Value
Copper	[kg]	9
Steel	[kg]	28.8
Magnet	[kg]	2.1
Total	[kg]	40.4

Figure 4: Example electric motor overview



Project N…

Concept ID: 0001

Torque Speed Requirements

Input Torque Range Min [Nm]: 450

Input Torque Range Max [Nm]: 450

Input Torque Step [Nm]: 10

Input Speed Rating [rpm]: 25000

Overall Ratio Targets [:1]

	min	step	max
1st	13.5	0.50	15.5
Top	6.00	0.50	10.0
Ratio Step	1.30		1.60

Tolerance [:1]: 0.10

Teeth
pinion: 23
wheel min: 24
wheel max: 102

Concepts intialised: 5

Concepts completed: 5

Selected Input Torque Rating [Nm]: 450

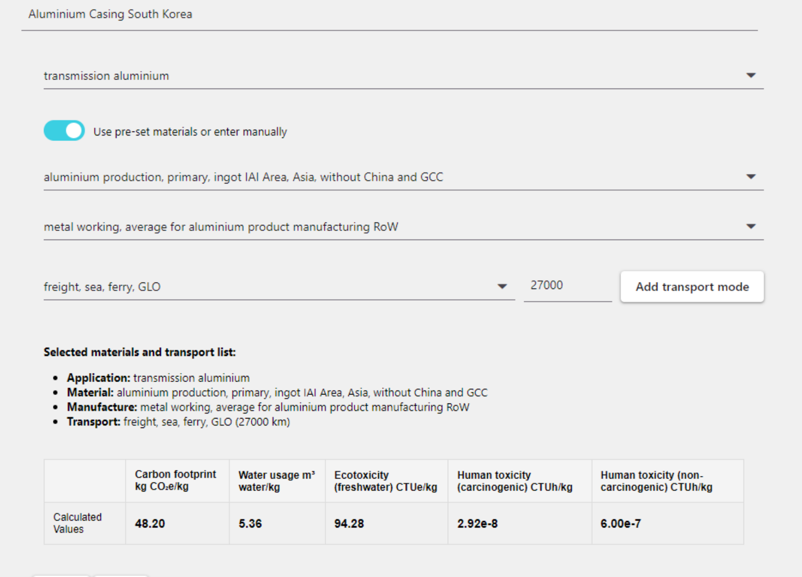
☑ Losses_1st

● Losses [kW]
○ Losses [W]
○ Efficiency [%]

Figure 5: Example use of TGEN to create transmission models

Using ePOP's integrated import wizard, the MotorCAD e-machine models were efficiently imported and paired with appropriate inverters selected from ePOP's extensive part library. Additionally, transmissions for these high-speed e-machines were created using TGEN (Figure 5), a transmission concepting module available as a part of ePOP's software package.

A library of materials was developed through ePOP's plugin to ecoinvent™ - a LCA materials and processes database. This was done in collaboration with the JLR LCA team with sample data validated against internal calculations. The materials library was used for LCA analysis in ePOP (Figure 6).



Aluminium Casing South Korea

transmission aluminium

Use pre-set materials or enter manually

aluminium production, primary, ingot IAI Area, Asia, without China and GCC

metal working, average for aluminium product manufacturing RoW

freight, sea, ferry, GLO

27000

Selected materials and transport list:

- **Application:** transmission aluminium
- **Material:** aluminium production, primary, ingot IAI Area, Asia, without China and GCC
- **Manufacture:** metal working, average for aluminium product manufacturing RoW
- **Transport:** freight, sea, ferry, GLO (27000 km)

	Carbon footprint kg CO₂e/kg	Water usage m³ water/kg	Ecotoxicity (freshwater) CTUe/kg	Human toxicity (carcinogenic) CTUh/kg	Human toxicity (non-carcinogenic) CTUh/kg
Calculated Values	48.20	5.36	94.28	2.92e-8	6.00e-7

Figure 6: Example LCA material creation

Results

Result values are anonymized to protect consortium IP. ePOP simulation results showed an optimal electric motor speed range, giving the best balance of efficiency and low mass. Study results revealed that three stage transmissions required at the highest speed electric motors added mass and losses to the system, which outweighed the benefits of downsizing the motor (Figure 7).

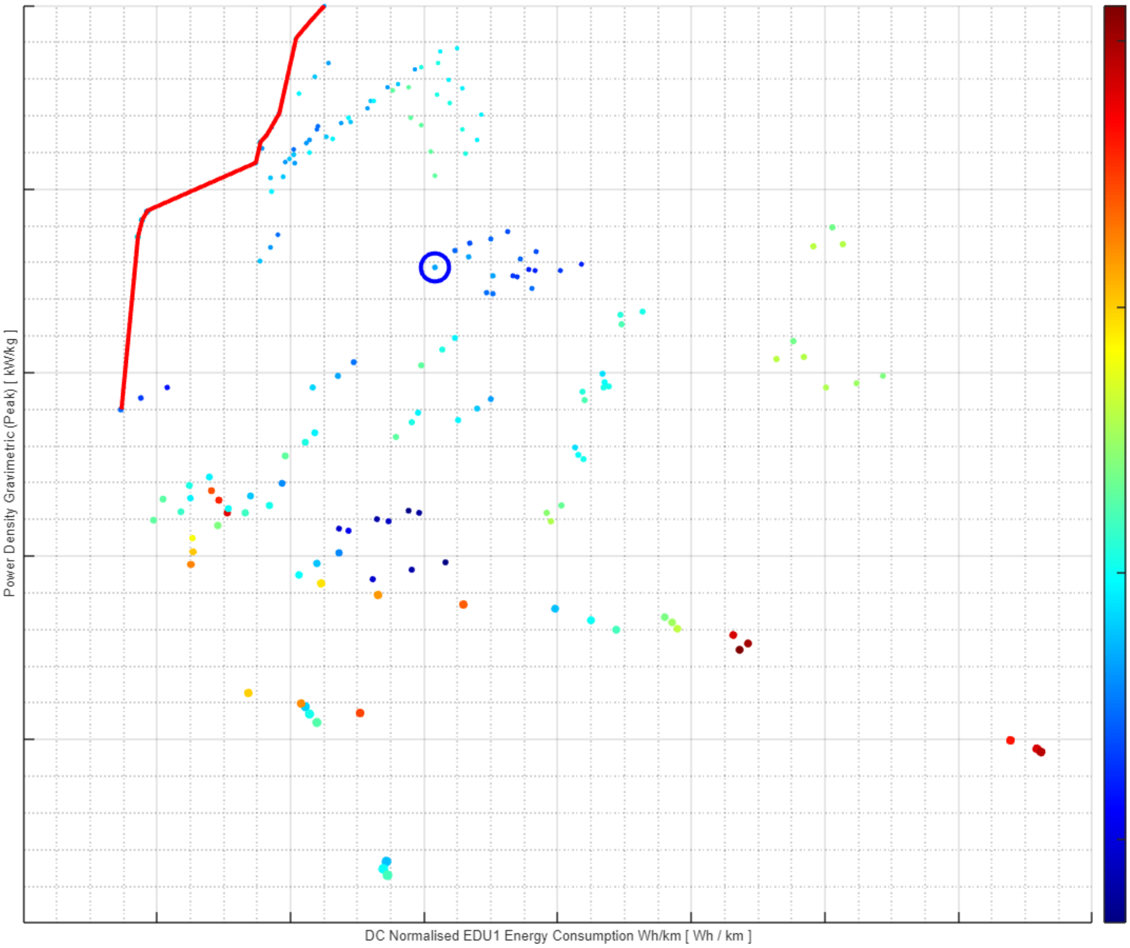


Figure 7: ePOP study results scatter plot

Furthermore, LCA analysis of the EDUs showed that embedded CO2eq. values were in keeping with target reductions. Candidate solutions on the mass vs. efficiency Pareto front were analysed in more detail before final decisions were made on subsystem specifications for detailed engineering design and optimization. Figure 8 shows an example of ePOP's concept comparison view.

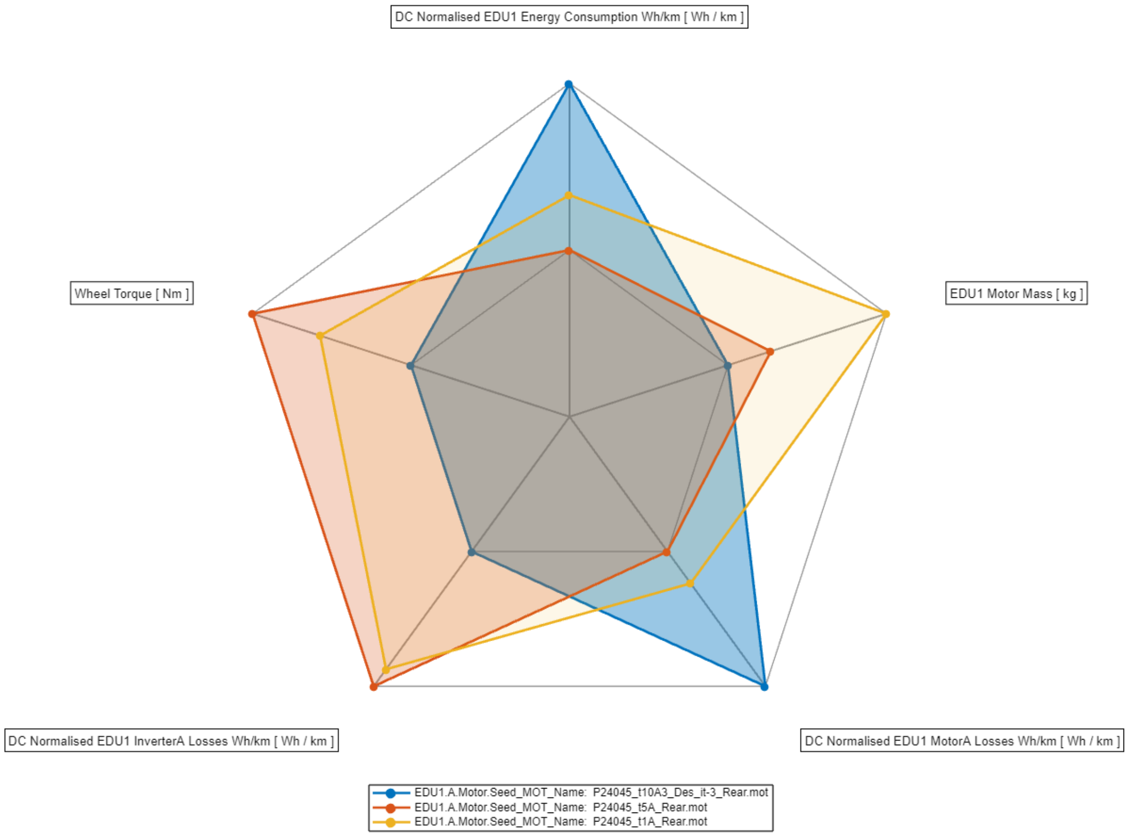


Figure 8: ePOP selected powertrain spider plot comparison for example powertrain

Next Steps & Conclusion

With these insights, JLR confidently advances to the detailed design phase of their EDU, reassured by early-stage validation of their approach. This project underscores the value of employing system-level simulation tools, such as ePOP, early in the design process. Effectively reducing development risk and ensuring strategic alignment with sustainability and performance objectives.

Testimonial

“The ePOP studies that we have been running have been adding additional data sets to the balance of machine speed design and transmission ratios within the context of our project and the scope of analysing higher speed machines.

It has been able to show how multiple different attributes are affected with different EDU designs and provides directional data for attribute trade-offs. The ability to show sustainability in both a directional design and at a more detailed design stage is very useful.”

Sam Lupine
Electric Concepts EDU System Design PO
Jaguar Land Rover