

# Magnomatics

The dawn of magnetic gears: Collaborating on MAGSPLIT® magnetic powertrain technology



**“The work on the MAGSPLIT® project has demonstrated Romax’s ability to model and analyse a complex hybrid vehicle powertrain at a concept design level. It has also equipped us with powerful proof that the MAGSPLIT® hybrid system is more efficient than other options currently available. We believe that MAGSPLIT® has the potential to be a market leading DHT (Dedicated Hybrid Transmission).”**

**David Latimer,**  
CEO at Magnomatics

Legislation over carbon emissions is becoming more stringent, with heavy fines for manufacturers who do not meet the targets. Hybrid and electric vehicles are an increasingly important solution, but their many design options require fast concept investigation, using whole-system models that appropriately balance speed and fidelity. In order to design truly low emission vehicles, it is crucial that the simulation uses drive cycles that are representative of real-life driving, to avoid actual fuel consumption being higher than manufacturer’s figures.

The MAGSPLIT® project combined Magnomatics’ pioneering magnetic gear technology with Romax Technology’s expert R&D team and their proprietary rapid concept design exploration tool, which quickly analyses whole system models against multiple drive cycles, giving Right First Time design that matches simulation in real-life performance.

Magnomatics’ magnetic gear technology offers high performance for efficiency, durability and noise, as the non-contact design creates very little resistance, does

## Client

Working across hybrid, renewable, aerospace, marine, and rail industries, and formed out of the University of Sheffield's internationally renowned Electrical Machines and Drives research group, Magnomatics Limited develops truly innovative magnetic gear technology.

## Challenge

To optimise a magnetic power-split dedicated hybrid transmission for use in the Ford C-MAX Hybrid; to investigate a wide variety of possible design options very quickly, using multi-fidelity models and multiple drive cycles for realistic, reliable simulation.

## Solution

The R&D team at Romax Technology, using their concept simulation tool for fast assessment of hybrid electric vehicle design candidates across several drive cycles (with no additional time penalty).

## Benefits

Achieve an optimal design, quickly, which will match simulation performance in real-life: in this case, resulting in a device that takes modern hybrid vehicle transmission systems to a new level, with improved fuel efficiency, compact construction, and higher reliability than existing eCVT systems.



Magnomatics' proprietary mCVT - MAGSPLIT® technology

not wear, and does not require lubrication or maintenance. Its natural properties include resistance to damage (overloading simply results in the gear slipping until excess load is removed) and damping, which also give it very low noise and vibration.

Magnomatics have developed two products based on magnetic gears: Pseudo-Direct Drive (PDD) – a very efficient high torque low speed motor/generator; and MAGSPLIT® – a very simple, highly efficient power-split dedicated hybrid transmission combining a contactless, lubricant-free magnetic gear with an electric machine.

## Magnomatics' gear technology meets Romax's rapid concept design tool

For the development of the MAGSPLIT® device, Magnomatics led a project co-funded by Innovate UK, and supported by partners Romax Technology, Ford Motor Company, and Arnold Magnetic Technologies. Romax's task was to create a model of the existing Ford planetary power split hybrid, and optimise the design. David Latimer, CEO at Magnomatics, comments: "We needed a simulation partner to carry out rapid design studies using multiple drive cycles – Romax were the obvious choice, as they have the perfect simulation tools for this type of work."

The tool used by Romax Technology's R&D team allows rapid design exploration across the spectrum from pure electric to pure conventional, using an iterative design-analyse-redesign loop with component efficiency models integrated into the full drivetrain simulation, to optimise the control strategy for the best overall system efficiency. It allows multiple drive cycles to be used to inform engineering decisions, with no time penalty, due to its statistical (rather than time-domain) approach, allowing it to run at least 10 times faster than time domain simulations. It uses multi-fidelity models to ensure fast running times with sufficient detail to pinpoint the best concept designs based on targets including cost, efficiency and performance, but not so detailed as to compromise the speed.

For the MAGSPLIT® project, Romax's experienced R&D team used their proprietary tools to perform a very rapid broad-based concept design study for sizing and ratios, and to investigate design sensitivity to different drive cycles. This ensures that the design parameters are optimised for fuel efficiency across the full range of driving conditions, not just optimised for one drive cycle with the risk of sub-standard performance under real-world driving conditions. Romax ran multiple simulations for various possible MAGSPLIT® designs, and compared the results to establish the device's fuel saving potential. Latimer comments: "Thanks to Romax, Magnomatics have gained

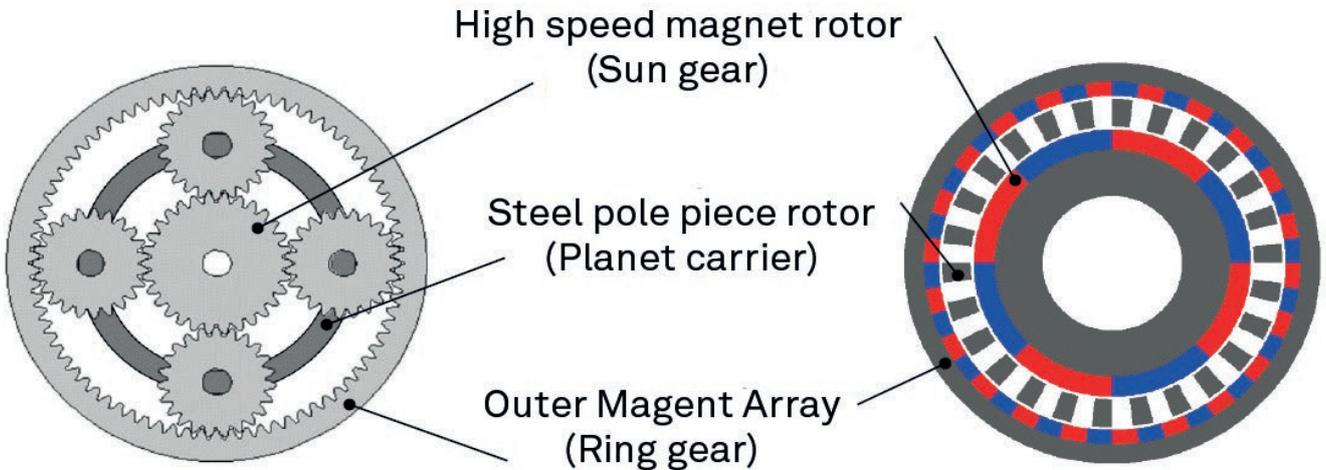
insight into the design optimisation of the MAGSPLIT® topology and its system integration challenges, resulting in a reduced development time and cost.”

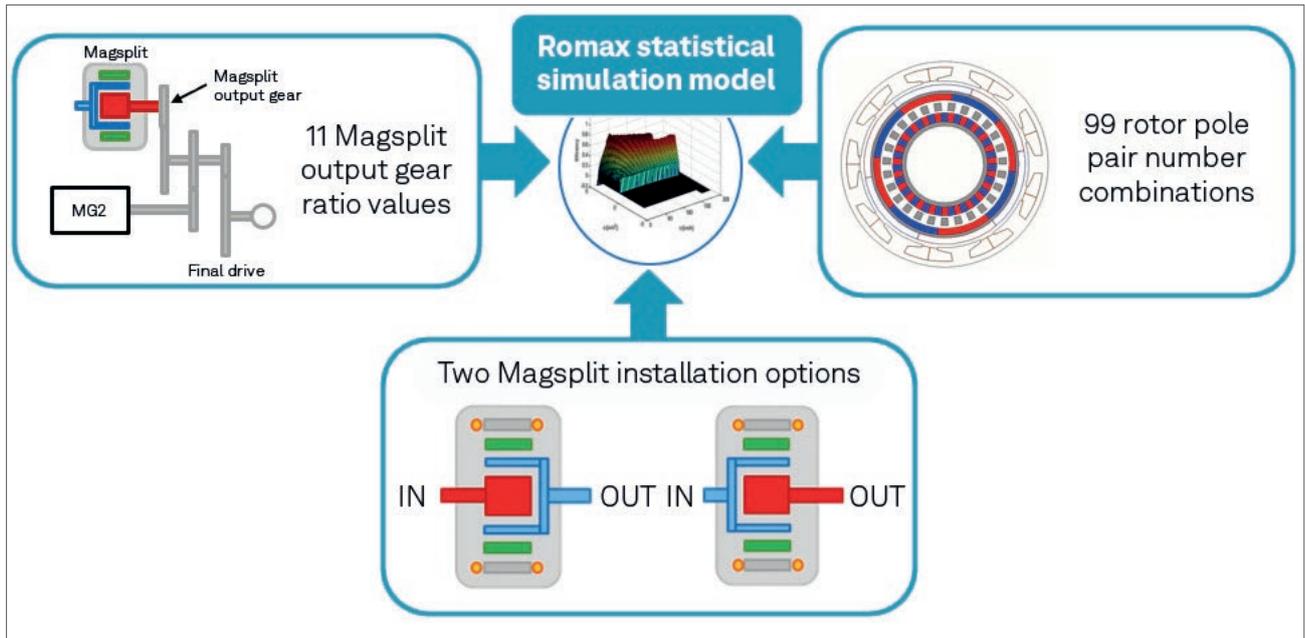
Within one week, 2000 variants, each with their own control strategy, had been created and analysed. The sensitivity studies allowed the design which was least sensitive to differences in drive cycles to be selected. Romax simulations estimated a 3.3% reduction in fuel consumption for the MAGSPLIT® hybrid system over the current planetary system in the Ford C-MAX Hybrid. Further investigations were then carried out to assess the fuel saving potential in a range of vehicles, and to investigate the feasibility of alternative control strategies. Latimer concludes: “The work on the MAGSPLIT® project has demonstrated Romax’s ability to model and analyse a complex hybrid vehicle powertrain at a concept design level. It has also equipped us with powerful proof that the MAGSPLIT® hybrid system is more efficient than other options currently available. We believe that MAGSPLIT® has the potential to be a market leading DHT (Dedicated Hybrid Transmission).”

### Future collaborations

A follow-on project from MAGSPLIT, named IMPACT (Integrated Magnetic Powersplit Advanced Control and Testing), brings Romax and Magnomatics together with consortium partners Changan Automotive UK, CMCL Innovations and the University of Sheffield, and is funded by Innovate UK. The aims are to develop and evaluate Magnomatics’ MAGSPLIT® for future Changan vehicles, including developing, simulating, building and testing a MAGSPLIT® drivetrain demonstrator with engine, transmission, electric machine, power electronics and battery. The project will include the complete electromechanical powertrain design process and system integration, as well as a dynamic analysis of the whole system to capture electromechanical system interactions, and correlation of the full simulation model with test results for efficiency and dynamic behaviour. This will result in the delivery of a tested MAGSPLIT® transmission prototype ready for vehicle installation.

## Mechanical vs Magnetic Planetary Gears





**The final design used for MAGSPLIT® has multiple benefits over existing eCVTs:**

- More efficient – no contact/friction/wear means there is a 3-5% fuel saving over a conventional eCVT, and a 35-40% saving over comparable conventional vehicles
- More compact (a 200Nm MAGSPLIT® device is just 110mm deep and 340mm in diameter)
- Improved crash performance (the reduction in size means the crash rails can be moved closer together under the vehicle)
- Unparalleled reliability
- Scalability
- Reduced system complexity
- Lower overall system cost

**Romax’s contribution to the development project brought about the following benefits:**

- Optimal final design achieved through rapid investigation of the concept design space
- Time savings in the development process using multi-fidelity models for an appropriate balance between speed and accuracy
- Confidence in real-life performance of final design across various operating conditions achieved through analysis for multiple drive cycles

Hexagon is a global leader in sensor, software and autonomous solutions. We are putting data to work to boost efficiency, productivity, and quality across industrial, manufacturing, infrastructure, safety, and mobility applications.

Our technologies are shaping urban and production ecosystems to become increasingly connected and autonomous – ensuring a scalable, sustainable future.

Romax, part of Hexagon’s Manufacturing Intelligence division, provides world-leading solutions for the design, analysis, testing and manufacture of gearboxes, drivetrains and bearings. Learn more at [romaxtech.com](http://romaxtech.com). Hexagon’s Manufacturing Intelligence division provides solutions that utilise data from design and engineering, production and metrology to make manufacturing smarter.

Learn more about Hexagon (Nasdaq Stockholm: HEXA B) at [hexagon.com](http://hexagon.com) and follow us [@HexagonAB](https://twitter.com/HexagonAB).