



RIMAC
TECHNOLOGY

VE EXPO 2022



Making the most of Twin-Motor Drive Units



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RIMAC

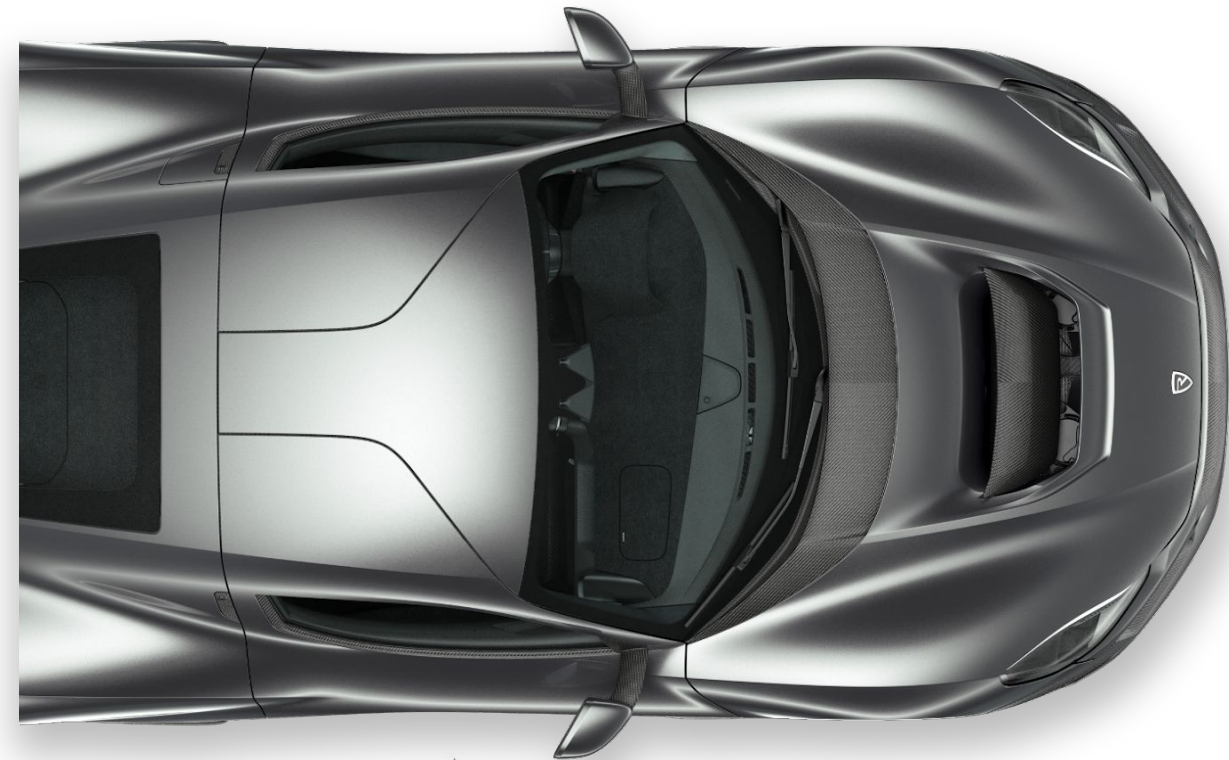


GQ

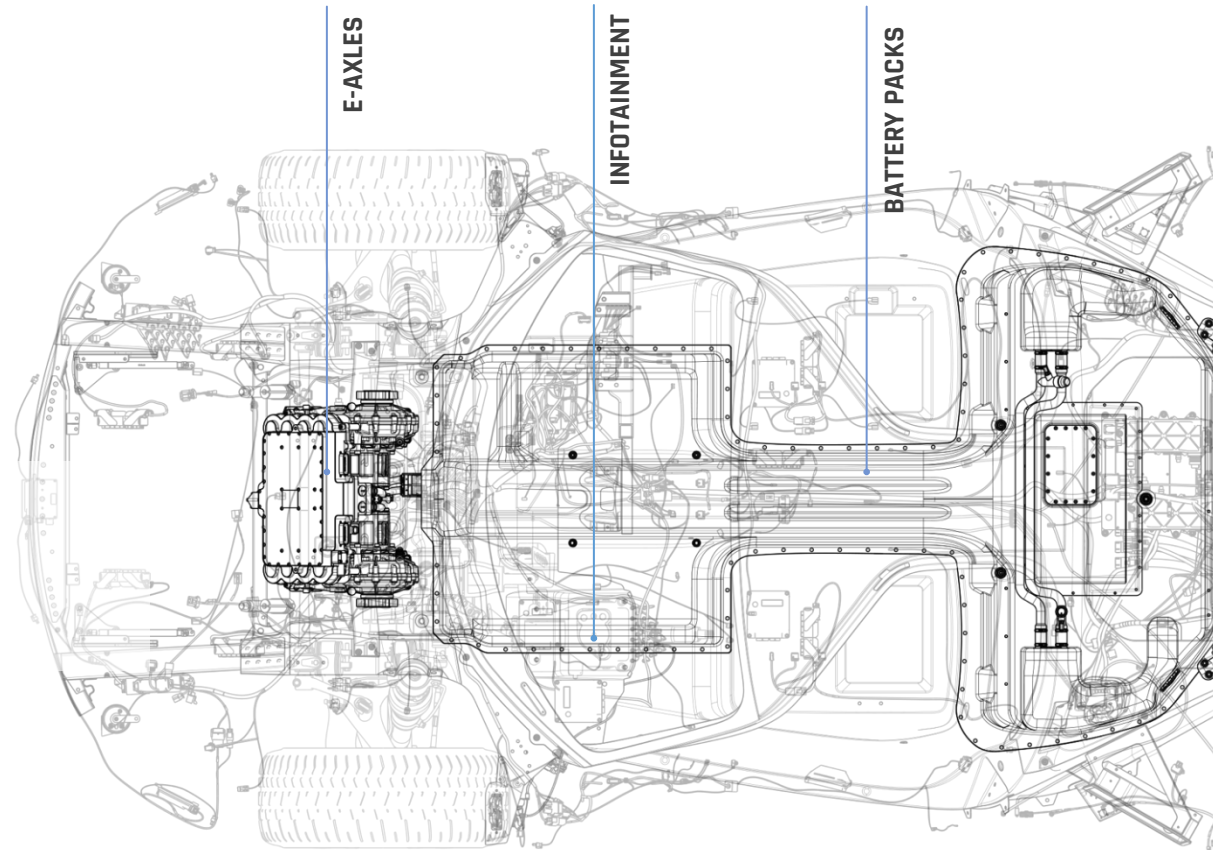
HYPERCAR OF
THE YEAR 2022

MAKING THE MOST OF TWIN-MOTOR DRIVE UNITS

RIMAC Group: Two Complementary Companies



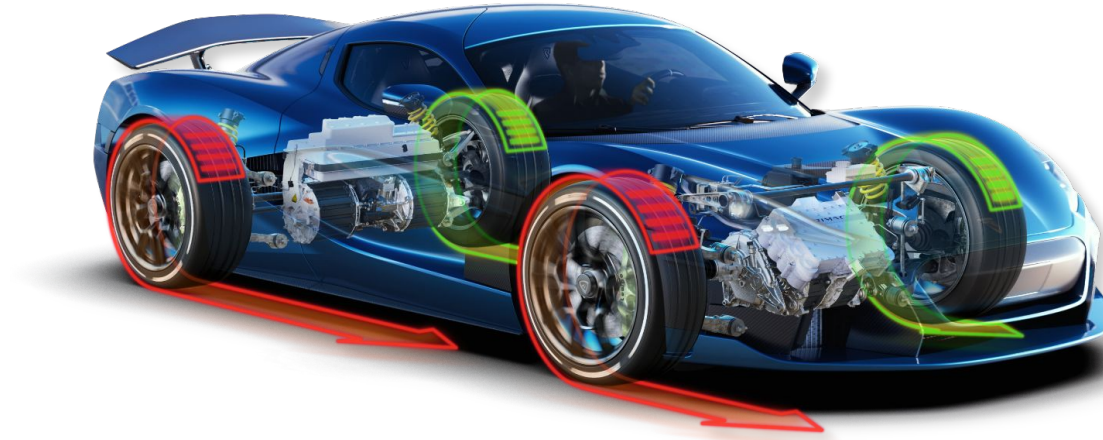
Developing and building the world's most advanced hypercars.



Designing and producing advanced key components for OEM's hybrid & electric cars

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Quad Motor for Ultimate Performance



At Rimac we believe 3-motor and in particular 4-motor vehicle architectures are the right future solution for high-performance vehicles:

- Torque vectoring capability
 - Improving performance, stability and handling
- New EDU architectures and opportunities



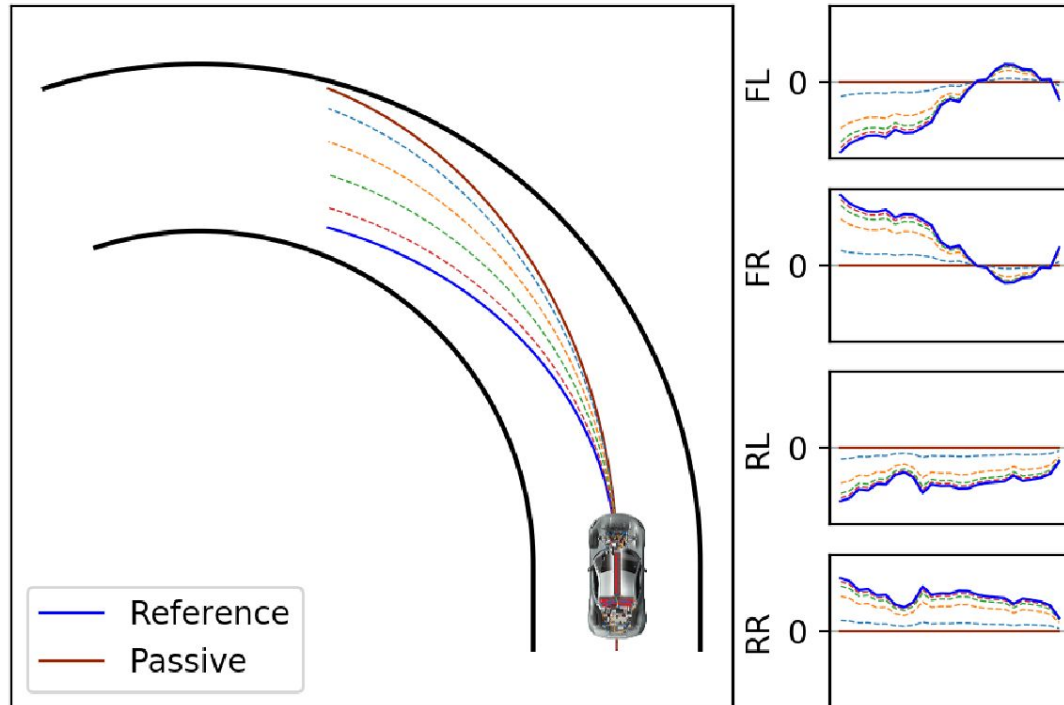
Downsides commonly associated with twin-motor EDUs:

- Increased part count, cost, and weight
- Reduced drive unit efficiency

At RIMAC we are challenging the assumptions above by designing dedicated twin-motor drive units rather than assembling from modular components based on single motor EDUs.

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Torque Vectoring



- Optimizes the torques sent to all four wheels independently in order to improve
 - Stability and safety
 - Performance and handling
 - Regen braking utilisation
- Allows significant calibration freedom and can be used to achieve different goals
 - Efficiency optimisation (extended range)
 - Lateral performance
 - Lap time
- Highly integrated with multiple vehicle control systems (brake stability controls, safety systems, etc.)

"The secret sauce here, of course, is the torque vectoring, a fiendishly complex set-up that effectively turns the Nevera into five cars in one. [...] This hurricane force isn't a surprise, but the agility, poise and its handling smarts are. It feels, oh, half a tonne lighter than it is, like a car with a low centre of gravity and optimum weight distribution" – Top Gear

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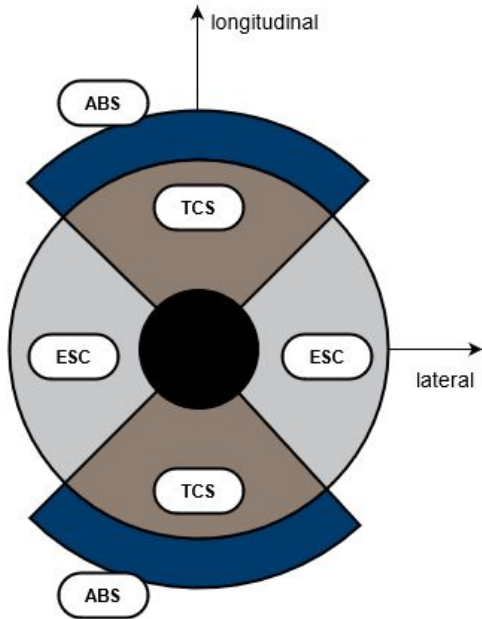
Torque Vectoring

Increasing number of 3 and 4-motor vehicles entering the market, capable of things no combustion engine vehicle can do...



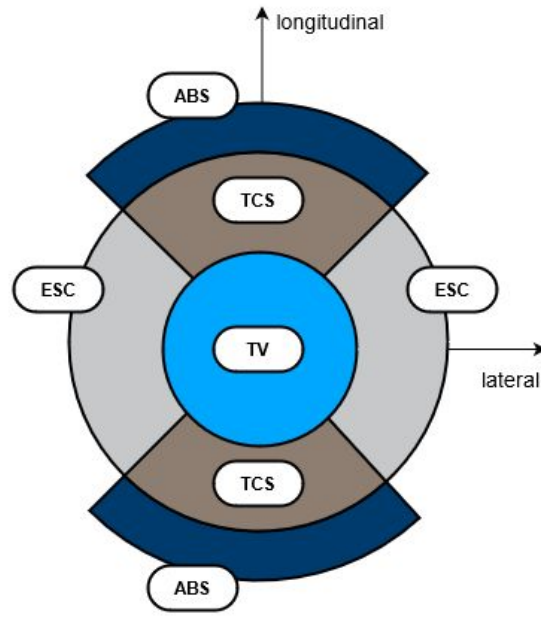
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Ultimate Control



No TV

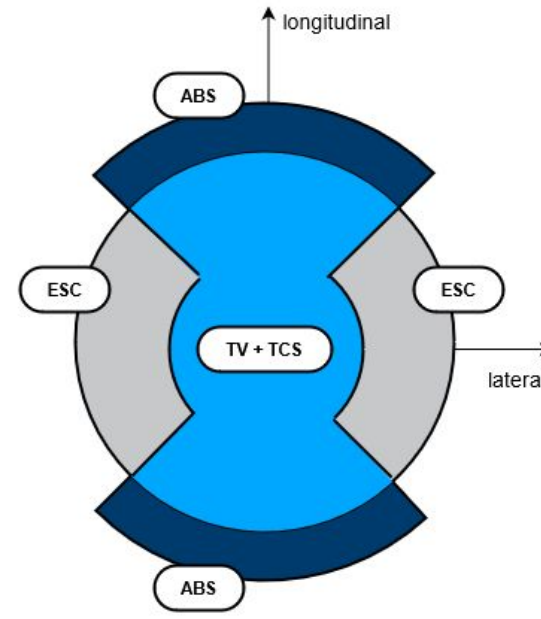
Vehicle dynamics and brake actuation controlled not considering performance and without integration between different control systems



Not integrated VDC controls

TV focuses on the lateral dynamics of the car. Its preventive action allows to narrow the field of action of TCS and ESC

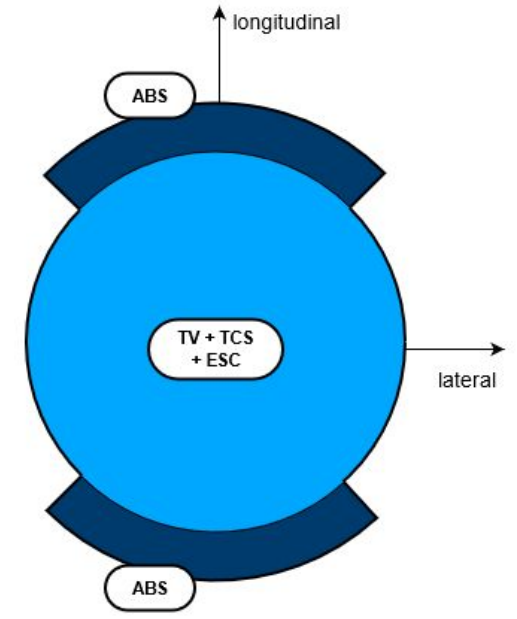
- TCS and/or ESC takeover could limit performances



Integrated TV and TCS

TV and TCS provided by RT and controlled by the same ECU. Integration of the two systems allows for better performance

- only ESC takeover could limit performance
- Reduced slip duration, amount and frequency
- Smooth integration, driver can't tell which system is acting



Integrated TV, TCS and ESC

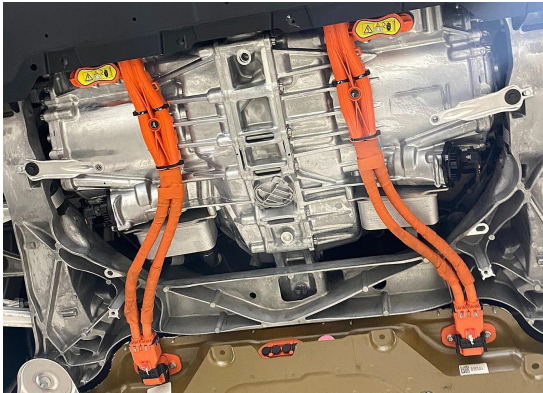
TV, TCS and ESC provided by RT and controlled by the same ECU. Complete integration of the vehicle dynamics and actuation of the friction brake. The goal is to prevent wheel slip and lockup, maximizing the performance.

- No external takeover
- Slip duration, amount and frequency reduced to minimum

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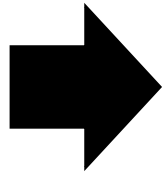
Enabling More Compact EDU Architectures

By designing EDUs and components specifically for dual-motor applications we can achieve much more compact and integrated solutions



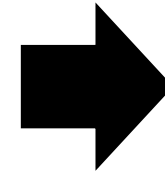
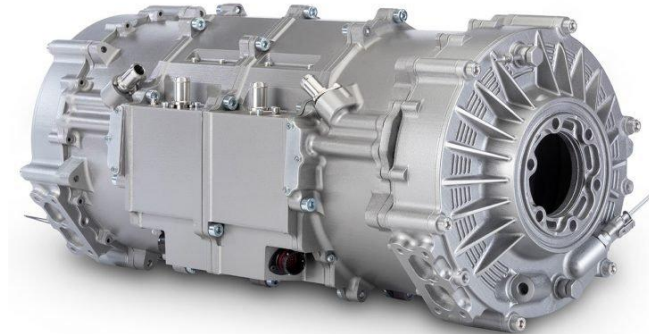
Tesla Plaid

Clearly 2 independent EDUs bolted together



Koenigsegg Terrier / Lotus Evija

New architectures enabled with single-stage planetary gearboxes and more integrated housings



Future

Ground-up design as a dedicated twin-motor EDU. Further part count and mass reduction etc

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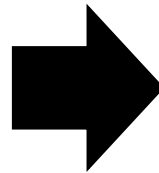
Component Sharing and Integration

Does a twin-motor axle need double the number of components?

- No change to biggest cost drivers such as the SiC dies or permanent magnet content.
- What about “in-active” components such as housings, connectors, cooling components etc?

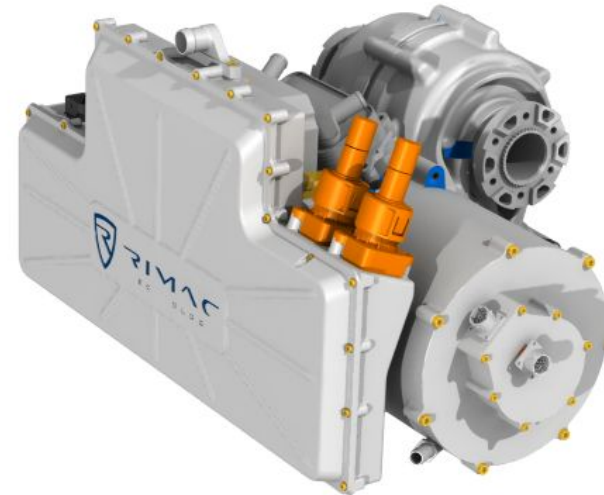
Nevera Rear Axle

- Single inverter housing
- Single gearbox housing
- Shared inverter cooling system



RIMAC New EDU

- Single DC input
- Single DC capacitor banks
- Single PCB
- Shared control modules
- Shared housings
- Fully integrated cooling systems



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Component Reduction

Can we actually remove components vs a single-motor EDU?

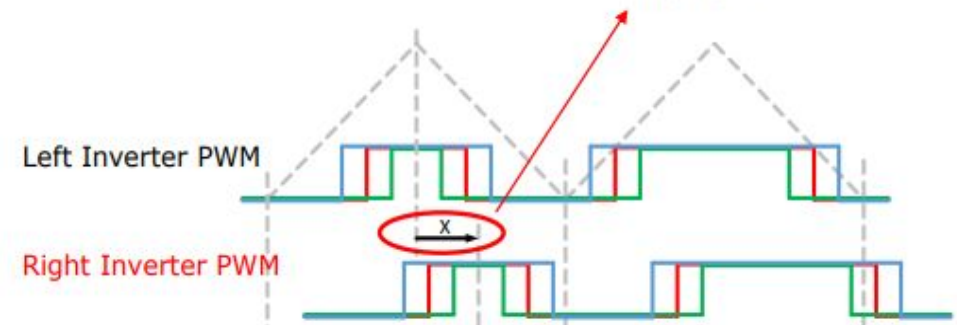
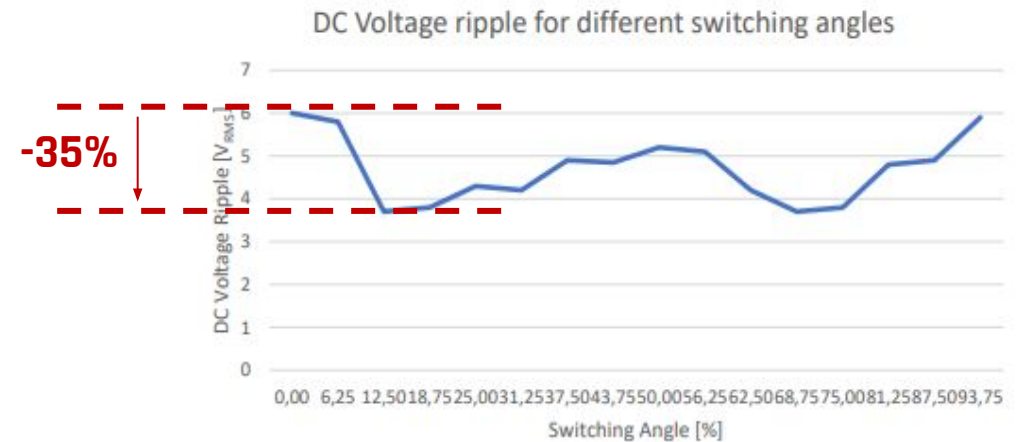
Mechanical:

- Removal of differential and additional shafts.
 - Especially beneficial if looking at a more complicated setup such as LSD, active diff.



Electrical:

- Interleaving of inverter switching between left and right motors
 - Results in reduced DC current ripple
- Enables significant reduction in DC capacitor size reduction (-35%)
 - One of the largest volume and weight components in the inverter
- Also enables DC filter size reduction



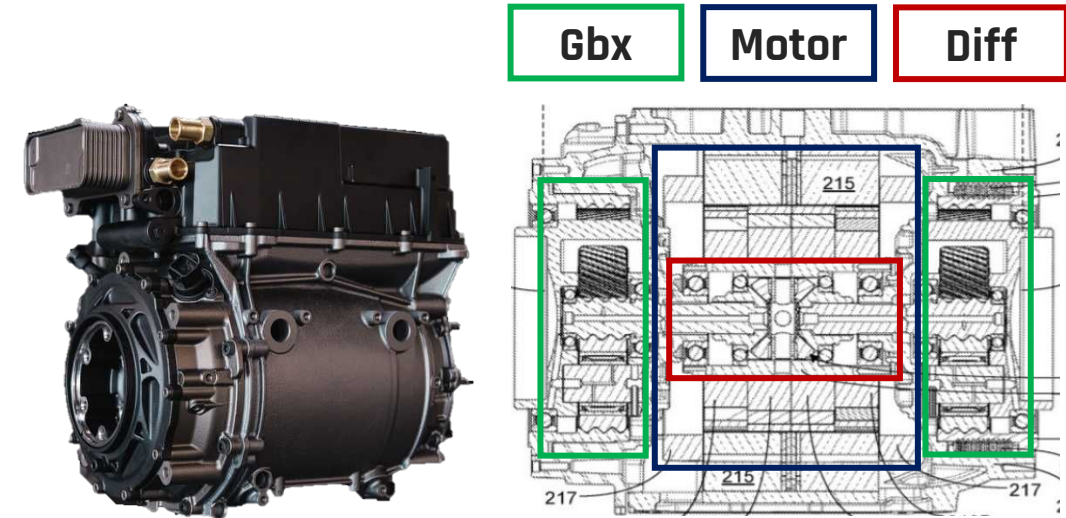
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Efficiency Opportunities

Are twin-motor EDU's less efficient than single motor designs?

Case Study 1: Lucid Air

- 520 mile range, AWD vehicle with great efficiency
- Single motor EDU but... with dual gearboxes
- Bearing count has increased (as it does with twin-motor EDUs) but not necessarily losses... load cancellation enables bearing size reduction

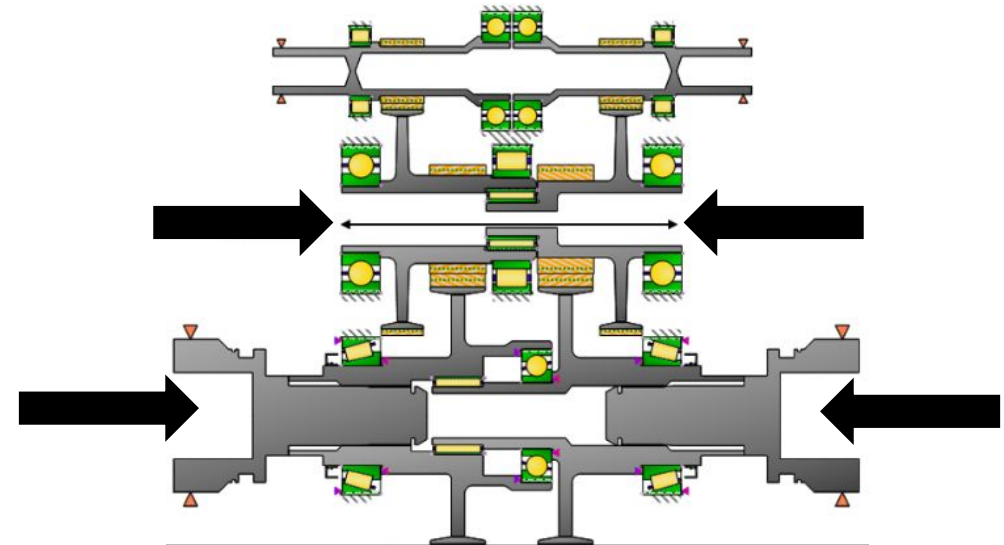


Case study 2: Nevera gearbox

- Axial load generated by the helical gears cancelled out between left and right intermediate and output gears

Just the beginning:

- Going forward other clever ways for load cancellation and bearing size reduction (reduce mechanical losses on highway cruise by 20%)
- And other whacky ideas... Are there ways to couple the two motors together and drive with one while free wheeling the other?



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Summary

Ground-up twin-motor EDU architectures such as those being developed by Rimac can enable:

- More compact and lighter mechanical architectures
- Significant reduction in part count, mass and cost vs unoptimized twin-motor designs
- Opportunities for cost and mass saving even vs single-motor layouts (interleaved capacitors etc)
- Efficiency improvement opportunities via load cancellation and other means
- And of course torque vectoring functionality...





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