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Electrification in the Aerospace Industry

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Who we are

We are one of the world's leading industrial technology companies.

Our purpose is to pioneer the power that matters to connect, power and protect society.





What we do

We believe in the positive, transforming power of technology.

We deliver cleaner, more sustainable power for the world's most vital needs.





Our challenge

Our activities have a tremendous impact on the world today – and tomorrow.

We have always pursued clean, safe and competitive solutions. Now, that task is more urgent than ever.



Our technology will play a fundamental role in enabling the transition to a low carbon global economy.



Our commitment

Few companies are better placed than us to help society transition to a low-carbon economy and this will drive our competitive advantage in the long term.



We are committed to playing a leading role in enabling the vital sectors in which we operate to get to net zero emissions by 2050.



What we do

We are tightly focused into three core operating businesses.

Our activities have an impact on the world.

Civil



34

types of commercial aircraft powered by us



14,000

engines in service around the world

Power Systems



1,200

development, service product, and dealerships locations



20,000

reciprocating engines sold per year

Defence



160

customers in over 100 countries

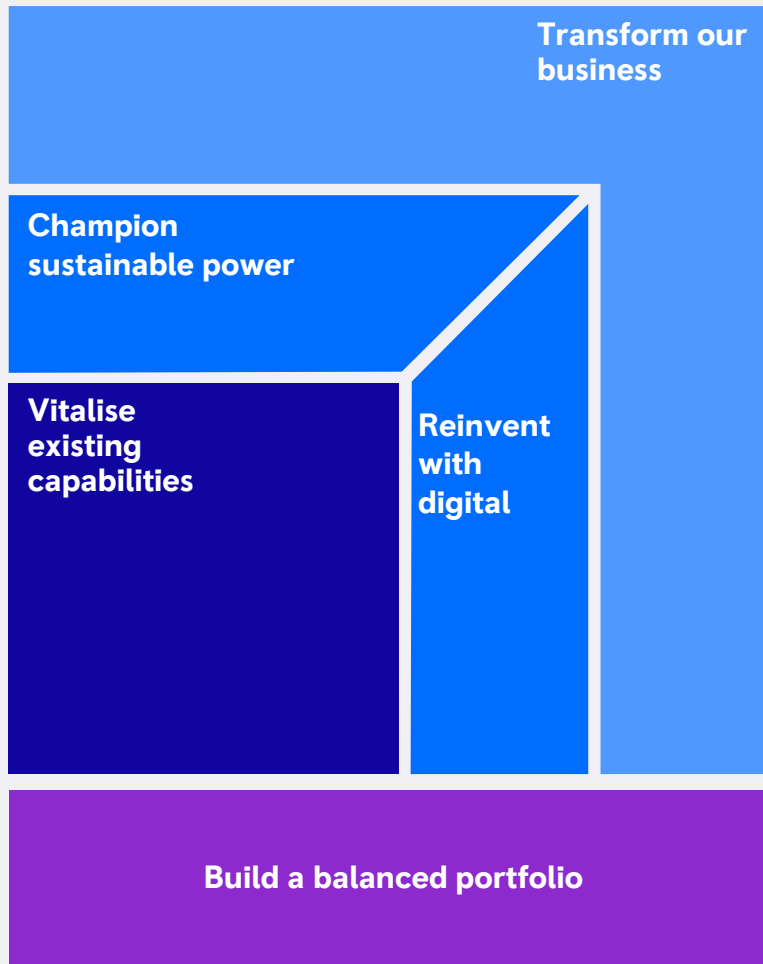


16,000

engines in service around the world



Our strategy



- Horizon 3
- Horizon 2
- Horizon 1



Electrification is not new to Rolls-Royce

We have a group-wide team with a wealth of experience in electric and hybrid-electric applications across different business sectors.



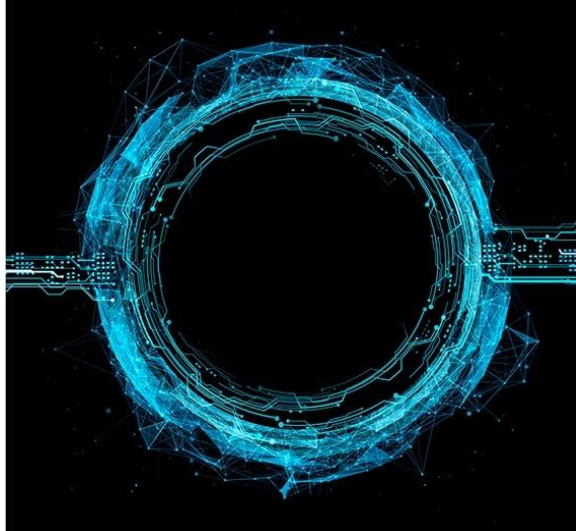


Why are we championing electrification in civil aerospace?

As a leading technology company, we have a key role to play

We want to offer world-class modular and scalable electric power and propulsion systems for multiple uses

© Airbus Helicopters



Potential game-changer for society

- Population growth and more mega-cities
- Opportunity to increase connectivity sustainably
- Different approaches to infrastructure and investment required

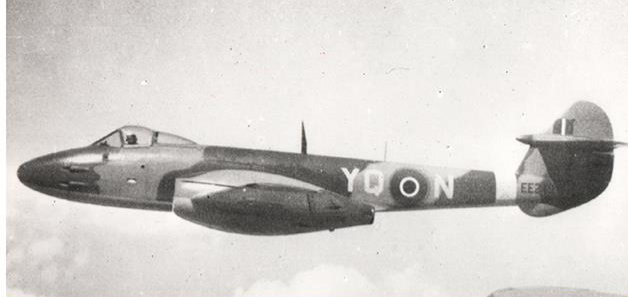


Potential game-changer for our industry

- Radical new aircraft/engine designs
- Gains in efficiency and emissions reduction
- New entrants and new scope of supply



Vickers Vimy



Meteor Welland



Comet



Concorde



Harrier Pegasus



Trent XWB powered Airbus A350-1000



Bell Boeing V-22 Osprey



Lockheed Martin F35-B



Trent 1000 powered Boeing 787-10



Potential benefits of (hybrid) electric propulsion

Exciting opportunities to be explored across the product lifecycle

Across the car industry, electrification is already saving 15-25% of fuel in a typical light passenger vehicle

A radical new approach needed for Services



Efficiency

Power can be augmented as and when required

Allows energy use optimisation

Opens up design space



Capability

High level of control

Single engine, twin reliability

Easily configurable

Allows greater propulsion and airframe integration



Emissions

Reduced noise

Reduced NOx

Reduced CO₂



Maintenance

Power management control to improve reliability

Predictability to improve availability



We have unique expertise and capability

Electrification brings challenges but we believe we are well placed to overcome these

We are one of the few providers of total 'energy source to thrust' solutions



Systems integration

The ability to integrate mechanical, electrical and thermal systems

- Safety and certification
- Electro mechanical integration
- Thermal management & cooling
- Controls

Component technology

The ability to design high performance, high integrity components

- Lightweight, high power density machines
- High temperature electrical materials
- Fault tolerant power electronics



A rapidly growing global footprint

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USA



Norway



Singapore



UTC & Research Network



UK



Germany



Hungary



Electrification in Civil Aerospace

Timing and size of impact in each market is uncertain.

Maintaining options is key to developing capability and supporting potential market requirements.



All electric

Hybrid electric

More electric





Small Propeller Aircraft



- Efficient and more silent flight at reduced operating cost & low emission
- Preparing the industry for electric products at scale



eVTOL



- Enhancing urban mobility concepts on fixed routes and on-demand
- New market creation



Commuter Aircraft



- Retrofit & new concepts for cost efficient regional transport and thin-haul cargo
- Reinvigorating regional airports, shortening travel time and connecting remote communities





Small Propeller Aircraft



eVTOL



Commuter Aircraft

Preparing for EPS launch for each market within this decade

- Efficient and more silent flight at reduced operating cost & low emission
- Preparing the industry for electric products at scale



1-4



50 – 300 kW

2020

2025

2030



16

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- Enhancing urban mobility concepts on fixed routes and on-demand
- New market creation



1-4



< 1 MW

2020

2025

2030



- Retrofit & new concepts for cost efficient regional transport and thin-haul cargo
- Reinvigorating regional airports, shortening travel time and connecting remote communities



< 19



< 2 MW

2020

2025

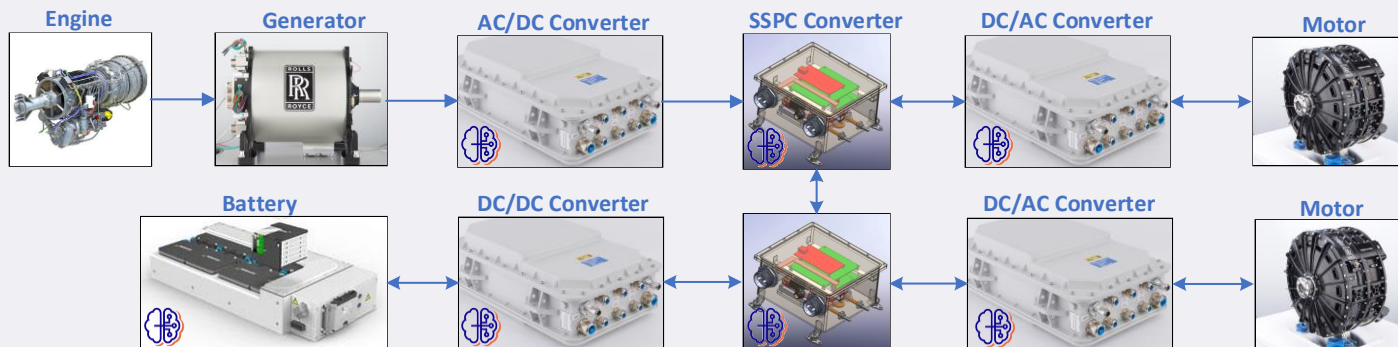
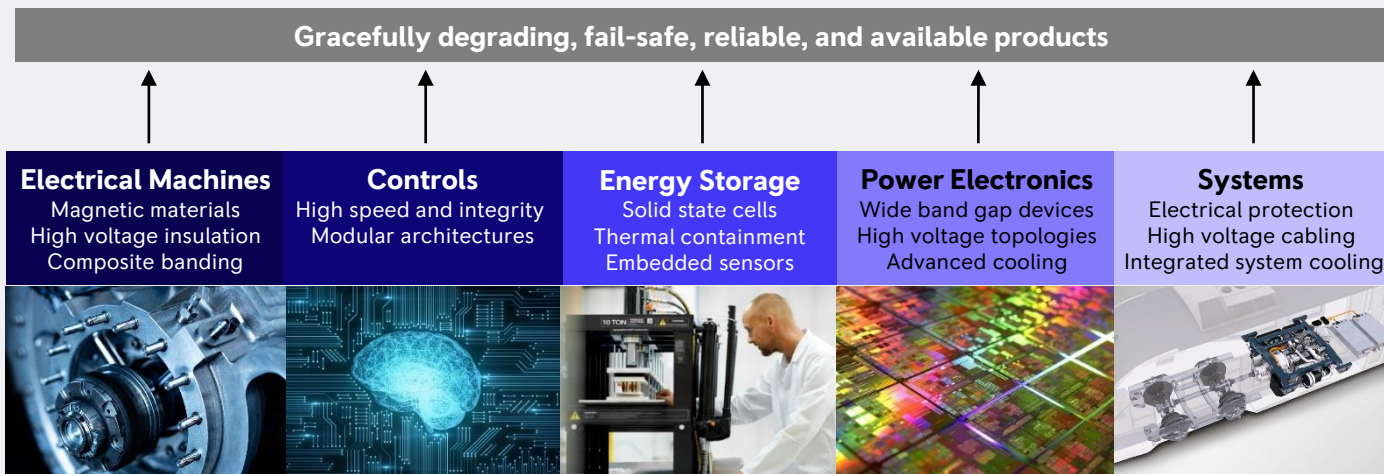
2030





Technology for electrical power and propulsion systems

Complete system to meet market demands





ACCEL

Accelerating the Electrification of Flight

Aims to stimulate electrical supply chain, provide an independent path to electrical system capability acquisition plus learning how to de-risk electrical concepts.

Potential for zero carbon electric powered short-range regional and commuter travel.



A small, fast, all-electric single-seater demonstrator aircraft flying ~200nm

the world record attempt for the fastest all-electric flight, which is now targeted to happen in H1 this year

In partnership with:
Electroflight Ltd UK
YASA UK
UK Government



APUS i-5

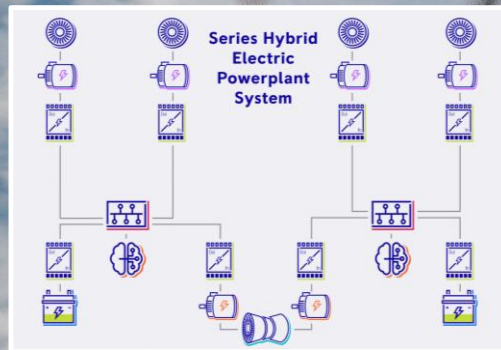
Serial-hybrid electric propulsion

Deploys a newly developed serial-hybrid electric system based on an M250 turbine with 4 distributed propellers.

Integrates newly developed 150 kW electric motors, a high energy density battery system, a 500 kW electric generator, power converters and an advanced power management and control system.



Supported by Brandenburg Government



Demonstrating competitive performance, low noise and reduced fuel consumption

Experimental flights on aircraft after 2023

In partnership with APUS and Brandenburg University of Technology



Tecnam P-Volt

Rolls-Royce will work with Tecnam and other partners to develop this innovative 11-seat commuter aircraft.

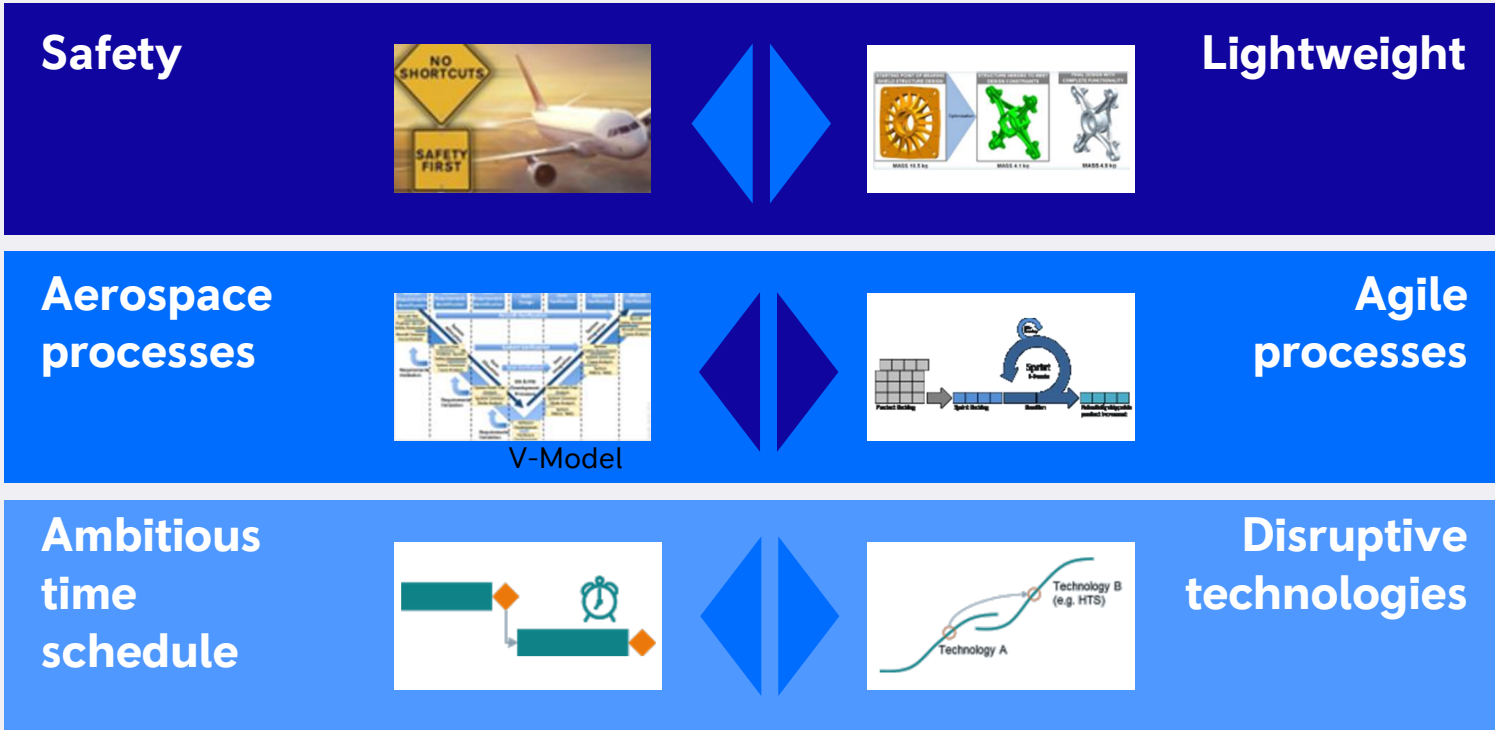


All-electric, twin engine
commuter aircraft

Covering short and
medium ranges

Serving several missions
- passenger transport,
cargo, medical
evacuation, special
missions

Aerospace Product Challenges: Rapidly Evolving Markets & Fast Pace Technology





Certification

Turning prototypes into airworthy products through testing, documentation and close collaboration with authorities

Cutting-edge innovation

Further advancing technologies to meet aerospace requirements in terms of power density, efficiency and reliability

Championing electrification

Collaboration

Working closely with airframers on system optimization and integration for highly efficient platform products

Ecosystem

Building a qualified supply chain for production at scale, engaging with infrastructure providers & society for widespread adoption of technology



Business areas of Power Systems

Marine & Defense



Solutions for

- Commercial marine
- Yacht
- Naval & authorities
- Land defense

Power Generation



Solutions for

- Continuous power
- Prime power
- Grid and stability power
- Standby and mission critical power

Industrial



Solutions for

- Rail
- Oil & gas
- Mining
- Construction & industrial
- Agriculture

Service solutions

Digital solutions for smart maintenance and asset management, 24/7 service and technical support, dedicated training and documentation



Marine & Defense



MTU PRODUCTS AND SOLUTIONS

Diesel Systems



Gas Systems



Battery Systems



Marine Gensets



Combined/Hybrid Systems



Integrated Propulsion Systems



Auxiliary & Noise reduction solutions



Emission reduction solutions



Control, Automation & Integrated Bridge



SERVICE SOLUTIONS

ValueCare Agreements



Upgrades & Modernizations & Retrofit



Repower & Overhaul Capabilities



Project Development/Engineering



Integrated Logistic Support (ILS)



Equipment Health Management System





Power Generation



MTU PRODUCTS AND SOLUTIONS

GenDrive Engines 

Diesel & Gas Gensets 

Control / Automation 


Dynamic UPS 

Battery Systems 

Microgrid & Hybrid Solutions 

SERVICE SOLUTIONS

ValueCare Agreements 

Upgrades & Modernizations 

Repower & Overhaul Capabilities 


Project Development/Engineering 

PARTNER / INTEGRATION

Financing Support 

Grid Interface & Trading 

Wind Power 

Photovoltaic 

Balance of Plant 





Industrial: Rail



MTU PRODUCTS AND SOLUTIONS

Diesel
Systems



PowerGen
Systems



Combined/
Hybrid
Systems



Propulsion
Systems



Noise
reduction
solutions



Emission
reduction
solutions



Control /
Automation



SERVICE SOLUTIONS

ValueCare
Agreements



Upgrades &
Modernizations



Repower &
Overhaul
Capabilities



Project
Development/
Engineering





MATLAB and Cross Sector System / Sub-System Design

- Power System Analysis and Design
 - Integrated Power System Optimization, Evaluation and Design Tool
 - Battery Modelling, Energy and Power Management System Design
 - Dynamic Simulation Tool: validate the asset size, control, protection etc.
 - Design optimization, co-simulation, and Interface with NON-Mathworks Simulation tools
- Predictive Maintenance and Digital Twins
 - Digital Electrical System: Data based modelling through cloud and its linkage to physical controllers
 - Predictive Health Monitoring for electrical equipment
- Frontloading of System Design and Testing
 - Real-Time Virtual Demonstrator: testing of controller and control mechanism without the full hardware setup
 - Controller design and simulation
- Sharing Application and Deployment
 - Generate HDL code, C code and shared libraries from design models
 - Creating standalone application from Simulink models
 - Deployment of optimization tool as a Web App

Products: MATLAB, Simulink, Optimization Toolbox, Global Optimization Toolbox, Parallel Computing Toolbox, Simscape Electrical, Simulink Control Design, HDL Coder, Embedded Coder, MATLAB Web App Server





MATLAB and our Power Converter System Design

Model-Based Design for DO-178C certification and other standards

System Design and Simulation

- Modelling and Simulation: Control concept verification, protection system simulation and stability analysis
- System level simulation and integration with the electrical distribution system and electro-mechanical system

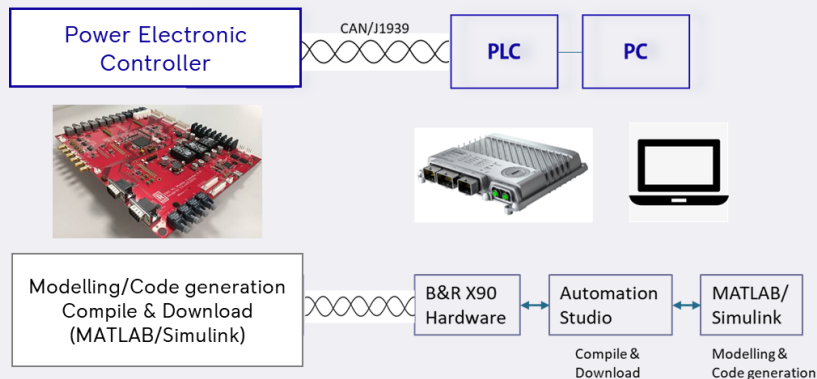
Controller Design and Code Generation

- Control of power converter through CAN/J1939 communication protocol
- C- code generation for controller developed in MATLAB/Simulink; HDL code generation for targeting FPGA
- Code generation for PLC (B&R X90) and upload through Automation Studio

Verification, Validation and Test

- Hardware in the Loop testing (HIL Testing) or HIL simulation for controller hardware validation
- DO-178C certification workflow and IEC Certification (EN 50128)

Products: DO Qualification Kit, IEC Certification Kit, MATLAB, Simulink, Simulink Requirements, Simulink Design Verifier, Simulink Test, Polyspace, Simulink Report Generator





Conclusions

- Our technology will play a fundamental role in enabling the transition to a low carbon global economy.
- We are committed to playing a leading role in enabling the vital sectors in which we operate to get to net zero emissions by 2050.
- We have a group-wide team with a wealth of experience in electric and hybrid-electric applications across different business sectors.
- We want to offer world-class modular and scalable electric power and propulsion systems for multiple uses
- Aerospace Product Challenges: Rapidly Evolving Markets & Fast Pace Technology
- Four key aspects of Championing Electrification: Certification, Collaboration, Cutting Edge Innovation and Ecosystem
- MATLAB products are enablers for our component, sub-system and system design, simulation and verification.



Thanks for your attention!