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Emerging Trends in the Electrification of Aerospace – a Rolls-Royce Perspective

Rob Watson – Director of Rolls-Royce Electrical

Lloyd's lecture: February 2019

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Our vision

Pioneering the power that matters

We pioneer cutting-edge technologies that deliver the cleanest, safest and most competitive solutions to meet our planet's vital power needs

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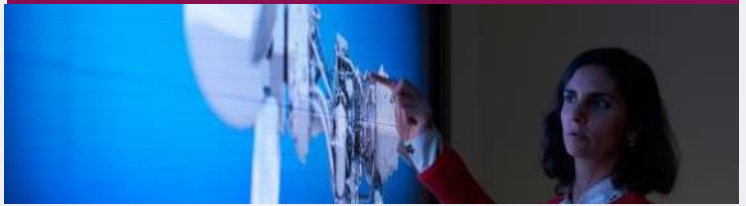
Our strategy

Champion electrification

Reinvent with digital



Vitalise existing capabilities

Transform our business

Build balanced portfolio

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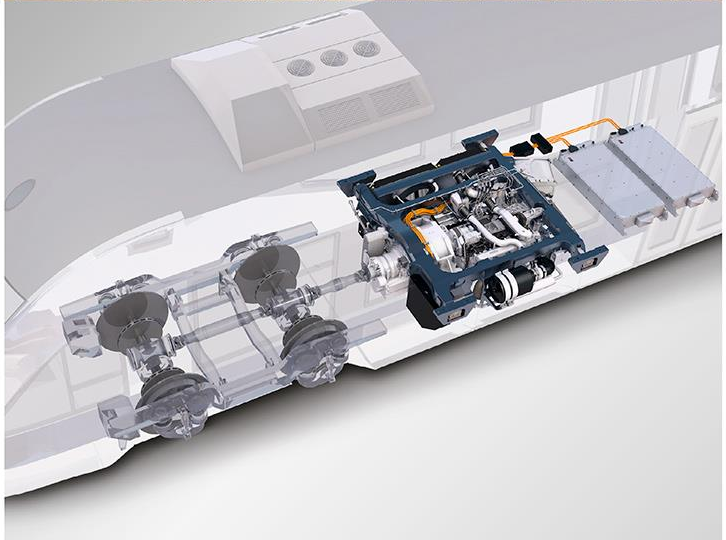
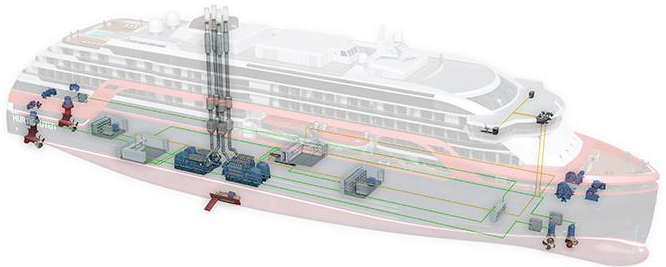
Electrification is not new to Rolls-Royce

We have a wealth of experience in electric and hybrid electric applications across different business sectors.

Electrification is delivering a fuel saving of between 15% and 50%.





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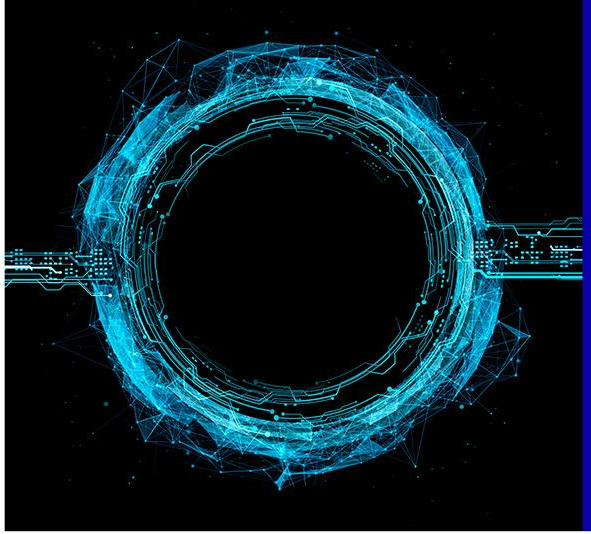
The trend for electrification is accelerating



Potential game-changer for society

- Population growth and more mega-cities
- Opportunity to increase connectivity sustainably
- Reducing level of infrastructure/investment required

Potential game-changer for our industry

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

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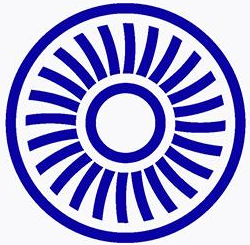
Potential benefits of (hybrid) electric propulsion

Exciting opportunities to be explored across the product lifecycle

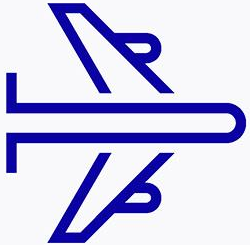


Efficiency

Power can be augmented as and when required

Allows energy use optimisation

Opens up design space



Capability

High level of control

Easily configurable

Allows greater propulsion and airframe integration

Emissions

Reduced noise

Reduced NOx

Reduced CO2

Maintenance

Single engine, twin reliability

Power management control to improve reliability

Predictability to improve availability

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There are two major dynamics

Evolutionary (incremental)

- More electric aircraft
- Electrical content increases e.g. mechanical and hydraulic systems
- Understanding of electrical technology becomes more important across the industry

Revolutionary (disruptive)

- Electric and hybrid electric aircraft/propulsion
- New airframe and /or transport concepts now appearing
- Scope of supply will change
- New entrants will appear in the market
- Market could structurally change

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Rolls-Royce programmes

- A route map from full electric to megawatt hybrid

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ACCEL

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 demonstrator aircraft

Flight testing in
2020

Investing in a start-up to help us learn differently

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E-VTOL

Opportunity to collaborate with a range of strategic partners.

Battery provides additional take-off, hover and landing capability Wings rotate to 90 degrees with option to take off and land vertically or conventionally.

Adaptable to personal & public transport, logistics & military.

Deploys M250 (helicopter) gas turbine technology to generate electricity to power 6 electric propellers.

A concept hybrid electric vertical take-off and landing vehicle for up to 5 passengers. Could travel up to 500nm at 250mph.

Could take off in the early

2020s

Concept shown at Farnborough International Airshow 2018

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Aston Martin Volante

Powered by a Rolls-Royce hybrid propulsion solution (based on M250 gas turbine).

Offering fast, efficient urban, and inter-city congestion-free air travel for 3 people.

Developing high-performance battery technology and integrated motor and power electronics.

A design study to show how electric propulsion technology can be used to create exciting new air vehicles.

Could enter into service

mid 2020s

In partnership with:

Cranfield University

Cranfield Aerospace Solutions

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E-Fan X

Developing the world's most powerful flying generator.

A parallel hybrid designed to test serial hybrid electric propulsion

A stepping stone towards hybrid electric commercial aircraft at the scale of today's single aisle family

A hybrid electric demonstrator vehicle (Avro RJ100), integrating a 2MW electric propulsion unit, an AE2100 gas turbine with an integrated 2.5MW generator and a 2MW battery

Scheduled to fly in

2020

In partnership with:

Airbus

Siemens

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The challenges are significant……..

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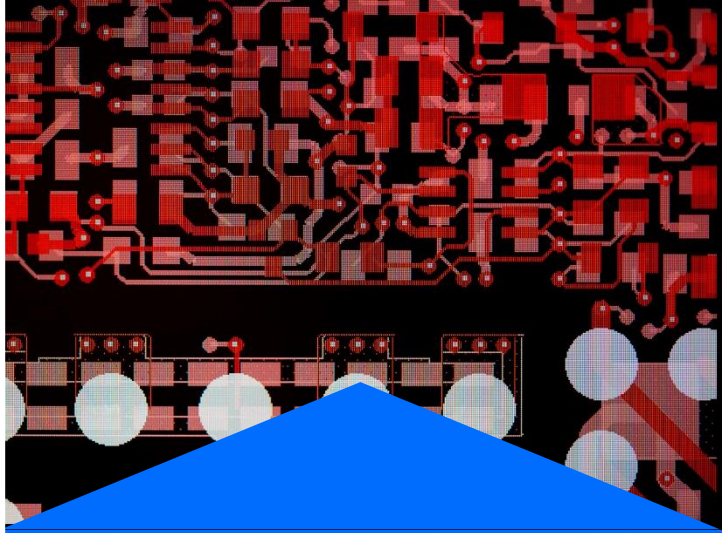
Electrification brings challenges

And this is just the propulsion system……



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

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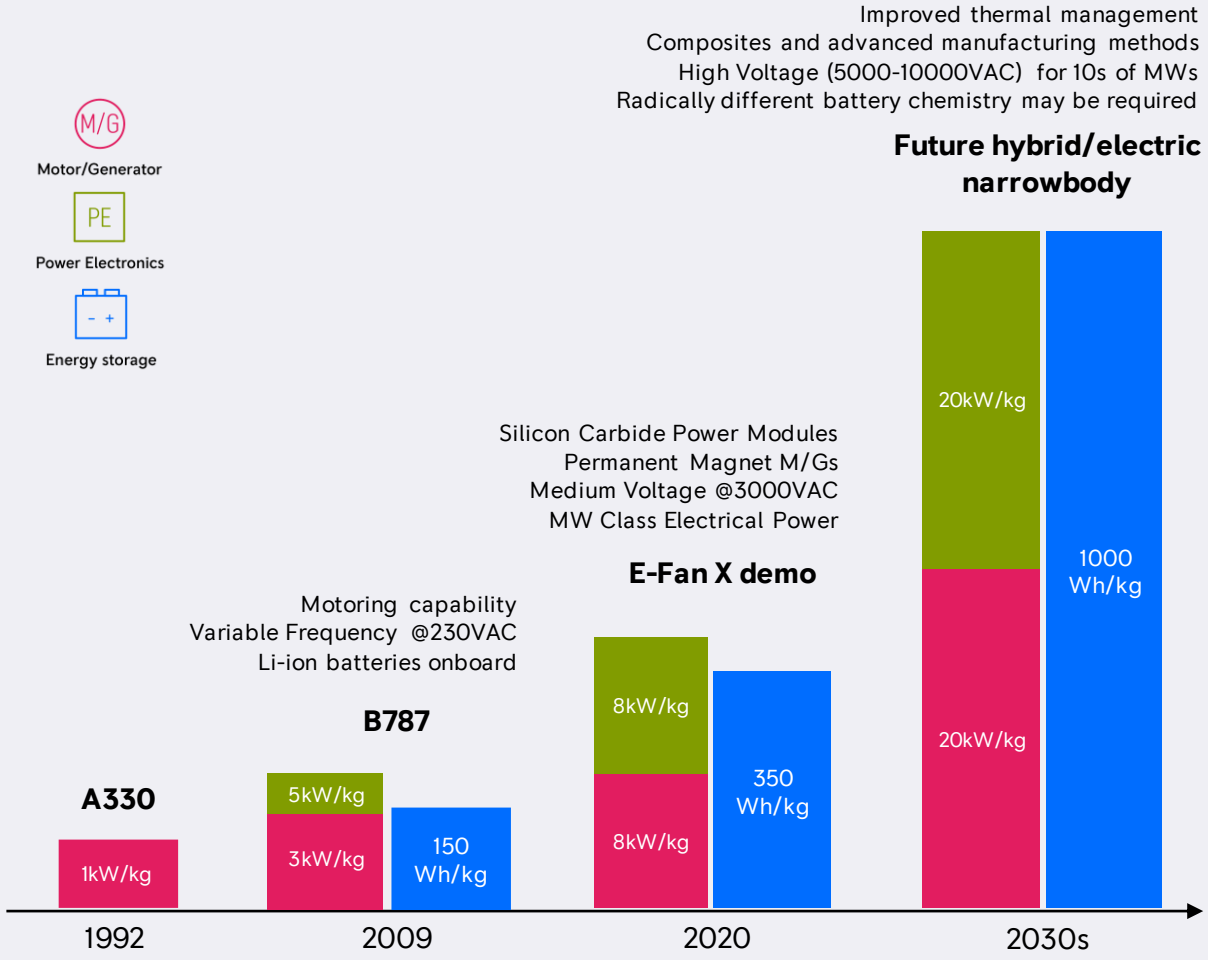
Electrical capability is growing rapidly

And will pace progression



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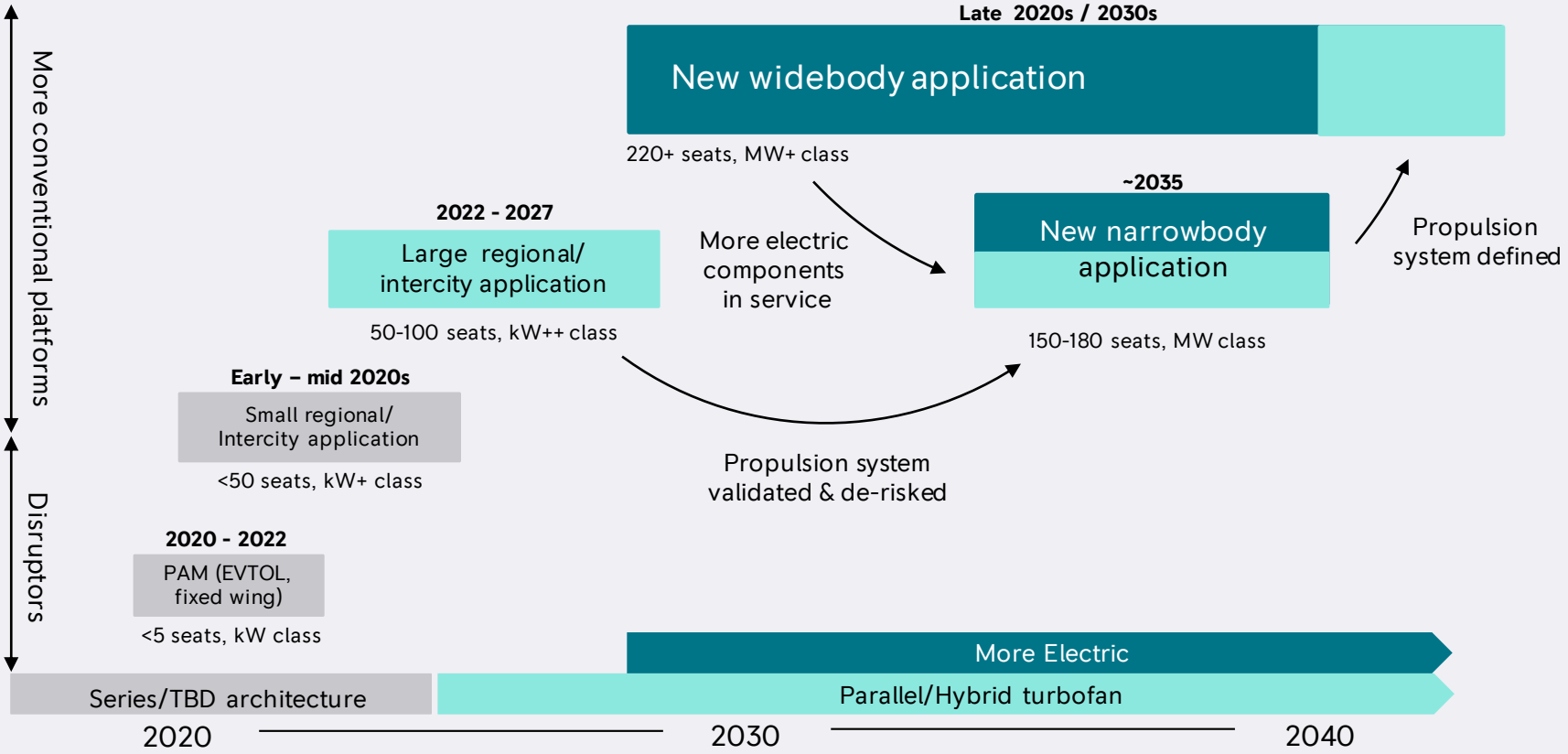

Possible future Rolls-Royce Civil Aerospace applications

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Market segmentation is important……

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Electrification and Civil Aerospace

Timing and size of impact in each market is uncertain.

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

Personal Air Mobility (PAM)	Small Regional	Large Regional	Narrowbody	Widebody
<5 seats 200nm	<50 seats 400nm	50-100 seats 850nm	150-180 seats 1,500nm	>220 seats 4,000nm

All electric

Hybrid electric

More electric

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Disruption in short/medium travel.

	Short Range	Medium Range
1-4 pax	1 Personal Transport	Time Saver: Congestion Beater / Convenience Option
4-20 pax	2 Regional VTOL	VTOL unlocks new Markets: Local Commuter / Potential to take share of small business jet market
20-100 pax	3 Regional Hybrid	An alternative to both rail and current aircraft; Economic advantage over new Rail Infrastructure; Ability to operate closer to destination than conventional aircraft

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We all have work to do……..

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Creating an ecosystem

Realising full potential will require significant incremental effort

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Still some work to do to enable the ecosystem:

Dynamic air traffic management

Certification and safety standards

Noise and emission regulations

New policies on transportation subsidies

Airport designs, charging, ticketing and infrastructure

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And still some work to do to populate it

- Single Pilot operation
- Autonomy
- Avionics
- Physical and Cyber Security

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In Summary

An amazing opportunity to shape the future:

- Paced by technology at propulsion and platform level
- Characterised by multiple markets
- Enabled by an ecosystem

Significant challenges exist across all three areas:

how does industry work to solve them?

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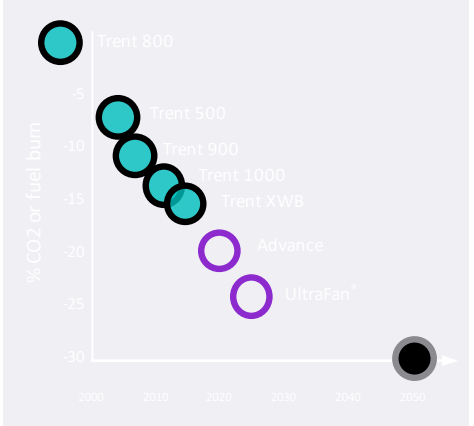
ROLLS
ROYCE

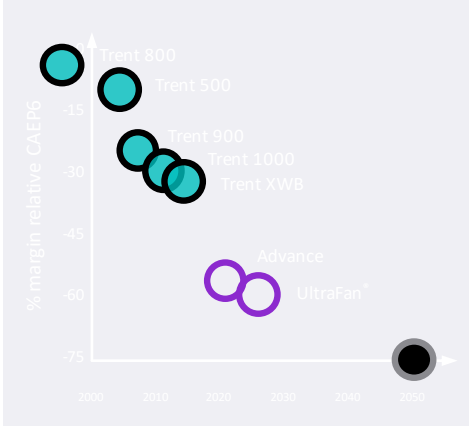
Working towards our FP2050 goals

CO_2 (Engine)



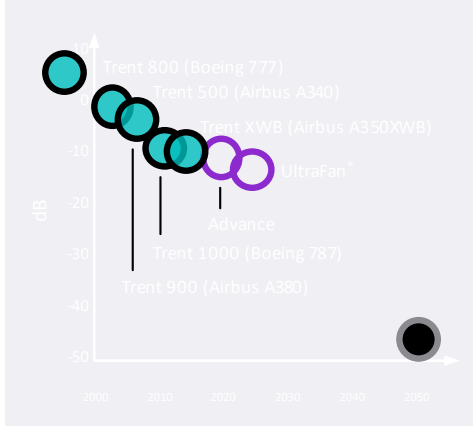
75%

NOx (Engine)



90%

Noise (Aircraft)



65%

Must ensure we remain competitive and meet customer requirements with efficient, environmentally-friendly aircraft

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