How More Electric Technology is Shaping Aero Engine Design

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Eddie Orr, FIET
Chief of Sector – Aerospace
Rolls-Royce Electrical Capability Group
Introduction: Rolls-Royce products today

Civil Aerospace
Our engines keep up 400,000 people in the air at any one time

Defence Aerospace
160 armed forces around the world depend on our engines

Marine
30,000 commercial and naval vessels use our marine equipment

Power Systems
Develop, produce and service energy markets under the MTU and Bergen engine brands

Nuclear
Design authority for the Royal Navy's naval nuclear plant
The move to More Electric Propulsion

• Over the last 100 years, since Rolls-Royce developed its first Aero Engine the “Eagle”, transportation has become increasingly electrified

• This trend has increased sharply over the last decade with the Boeing 787 ‘More Electric Aircraft’ and the ‘Full Electric Propulsion’ Type 45 Destroyer

• As we look to the future we see this trend only increasing ...

• ... Rolls-Royce is addressing the challenges, including those for Aerospace Engines
More Electric Propulsion

The Past –
‘Electric’ Warship

The Present –
The More Electric Aircraft
Hybrid Electric Rail &
The All Electric Warship

The Future –
The All Electric Aircraft?
Aerospace Industry Challenges
Overall ACARE* Environmental Targets for 2020

Targets are for new aircraft and whole industry relative to 2000

- Reduce perceived external noise by 50%
- Reduce fuel consumption and CO₂ emissions by 50%
- Reduce NOₓ emissions by 80%

The ACARE targets represent a doubling of the historical rate of improvement...

* Advisory Council for Aerospace Research in Europe

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Propulsive Efficiency Evolution

HBPR turbofan
Trent based core

HBPR turbofan
Advanced core

VHBR Ultrafan
Advanced core

VP Ultrafan
Embedded machine
Parallel hybrid / BLI

VP ‘fan’
Parallel hybrid
Partially distributed

VP ‘fan’
Fully distributed
Turbo-electric / series hybrid

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3 key areas of focus for product innovation

- Continue to optimise the gas turbine
- Increased integration between airframe and engine
- Electrification
The Trent 1000
Tailored for the More Electric Aircraft

The Trent 1000 was tailored for the Boeing 787 Dreamliner™

Built on the success of the Trent family, the Trent 1000 offers airline operators a unique combination.

• Trent family experience
• Advanced technology
• Smart design
Intermediate Pressure Power Off-Take

Unique to 3-shaft architecture
- Fuel savings on short range
- Best Compressor Operability
- Lower idle thrust
- Lower noise

However these improvements do have limits
Can a More Electric Engine help?

- Electric Starter / Generator
- Electrical Accessories
- Electric Actuators
- Accessory Gearbox Removed?
- Can support a Bled or Bleedless architecture

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Could embedding the generator provide additional benefit?
The Challenges Of Going More Electric

- Technology
- Integration
- Risk
New ACARE Targets for 2050

Targets are for new aircraft and whole industry relative to 2000

- Reduce perceived external noise by 65%
- Reduce fuel consumption and CO$_2$ emissions by 75%
- Reduce NO$_x$ emissions by 90%

Potential targets

- Aircraft movements are emission-free when taxiing.
- Air vehicles are designed and manufactured to be recyclable.
- Europe is established as a centre of excellence on sustainable alternative fuels
Will requirements drive a change in engine technology?

The S-Curve of Technology Cycles

Innovation:
- Evolutionary
- Disruptive

Aircraft Engines

What’s Next?

Brayton Turbofan

Lot of cash, little improvement

Multiple Rapid Incremental Component & System Improvements

Otto cycle IC

Major Tech Obstacles Overcome

Brayton Turbojet

Capability or Value

Time or Investment $
2nd & 3rd areas for product innovation

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Aerospace Industry Challenges

• **Radical New Aircraft Designs**
  • New potentially disruptive markets and fleet missions
  • New airframe configurations
  • Integrated solutions
  • Development of operating standards

• **Development of Integrated Power and Propulsion System**
  • Integrated power generation
  • Integrated propulsor
  • Electrical power system (@ high voltages)
  • Energy storage technology

• **Demonstrator Platforms**

• **Integrated Testing**

• **People and Skills**
Fully Distributed Propulsion Concept Layout

- Single Advanced Gas Turbine
- Power Electronics
- Electrified-Powered Fans
- Energy Storage
In Conclusion

• Electrical technology is becoming increasingly important across all Rolls-Royce business sectors
  • Already exploiting the benefits in Marine where weight and space are less important
  • Big potential in Aerospace however challenges remain
  • Need to learn from other industries eg Automotive

• Rolls-Royce is looking forward to the next 100 years

Thank you for your time & attention