



SAGE 1

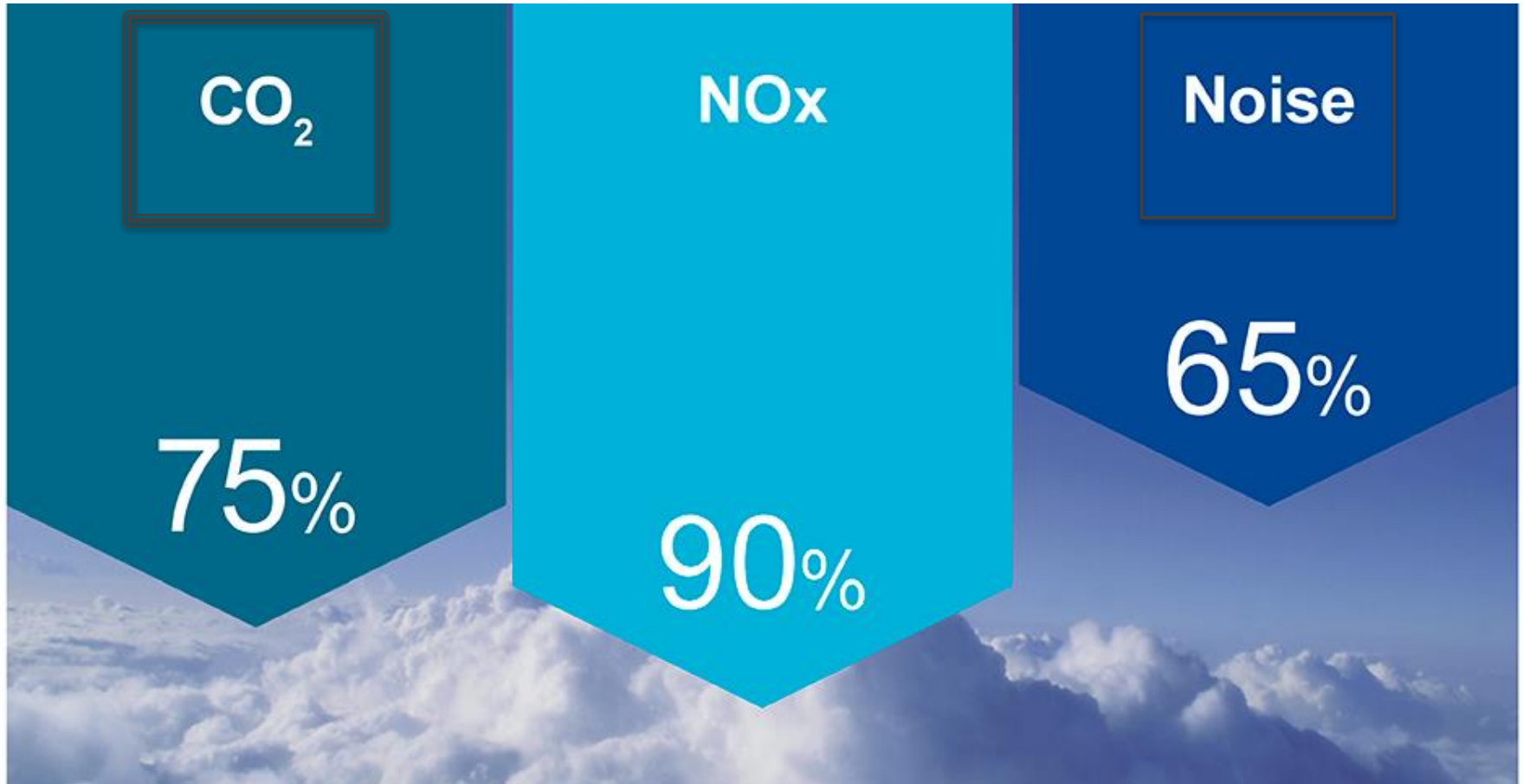
Open Rotor

Clean Sky Close out review
22nd March 2017, Brussels

Innovation takes off



The sustainability challenge



ACARE FP2050 targets relative to a new aircraft in 2000

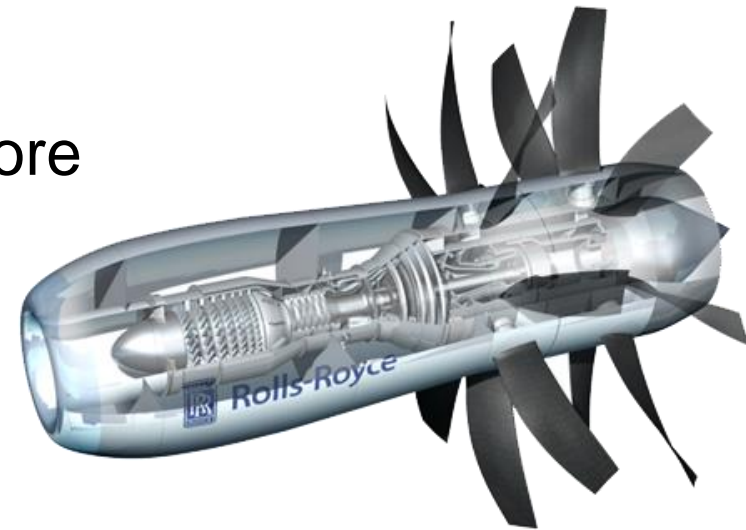
Flightpath 2050
Goals to take ACARE beyond 2020

Private – Rolls-Royce Proprietary Information



SAGE 1: Project scope and objectives

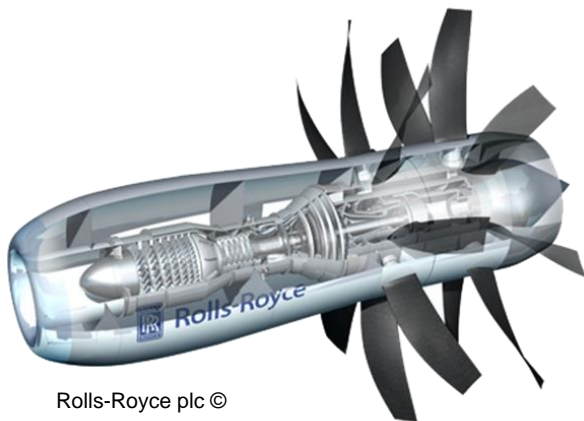
- **Architecture studies for Open Rotor:**
 - Push or pull?
 - Structural load management
 - Application of state of the art core technologies
 - Integration with the aircraft
- **Manufacturing techniques**
 - Propeller blades
 - Load bearing structures
- **Aerodynamic prediction methodologies**
 - Efficiency optimisation
 - Noise suppression
 - Management of aero-elastic effects e.g. flutter



SAGE 1: major partnerships

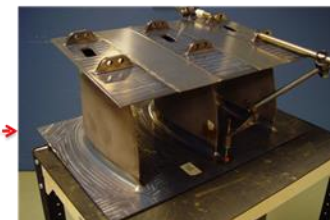
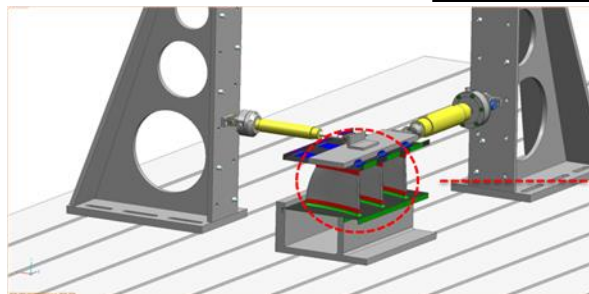
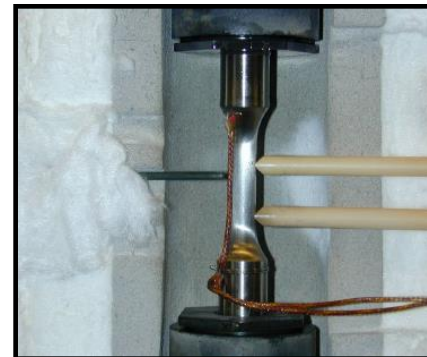


Rolls-Royce



Rolls-Royce plc ©

- Overall architectural design studies and airframe integration



- Develop and manufacture the Rear Rotating Structure.
- Modify an intermediate case to match the requirements for the core engine



SAGE 1: Partners

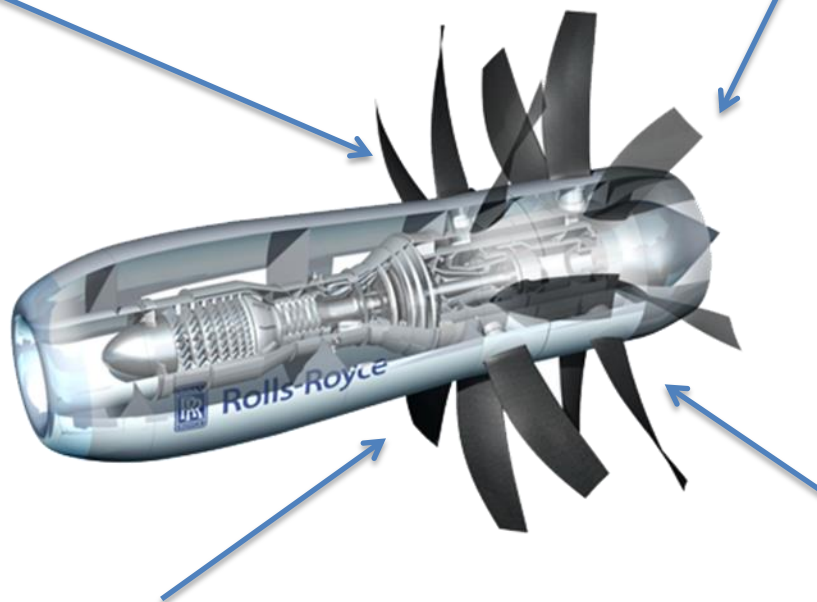


Imperial College London

Steady and unsteady aerodynamics
Blade/shaft coupling

University of Southampton

Broadband Noise prediction for
Open Rotors



University of Oxford

Materials and
manufacturing methods
for open rotor blade
materials



University of Cambridge

CFD Fast solver
Thrust, Efficiency, Angle of Attack



SAGE 1: Achievement of targets

Technology description	TRL at 2016	
	Target	Current status
Propeller blade	3	3*
Aero-Methods	4	4
Noise	4	4
Component Integrity	4	3**
Aero-Elasticity	4	4

*Fully representative propeller technology was lab tested to TRL3.
The methods for aero, noise & aero-elasticity have been proven to TRL4 through use of Rig data.

**Component integrity reached TRL3 through the laboratory testing and analytical methods with a clear path to achieve TRL4 defined.



SAGE 1: Reducing CO2 emissions

Sub-system		Environmental targets (cf. current state turbofan)
		CO2 [%]
Open rotor propulsor	Target	-10 to -15%
	Current status	10%*
		Noise [EPNdB]
	Target	-6 to -9
	Current status	0**

Improvement in CO2 based for engine only

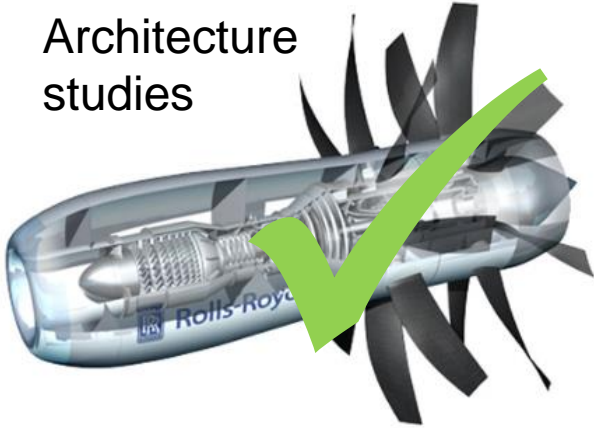
*LP system only – core engine benefits will be additive

**Open rotor engine technology is projected to now generate the same noise levels as an equivalent advanced turbofan.

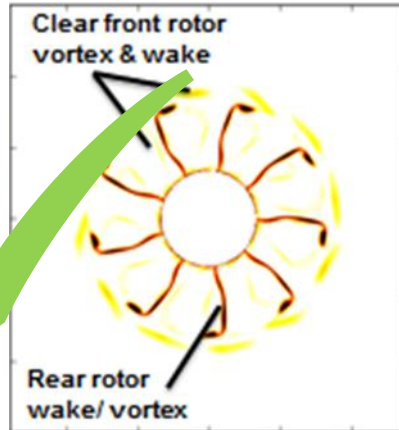
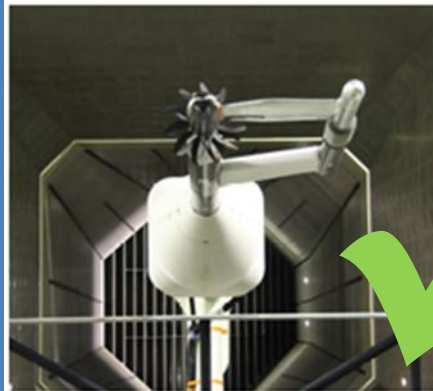


SAGE 1: Delivering Technology

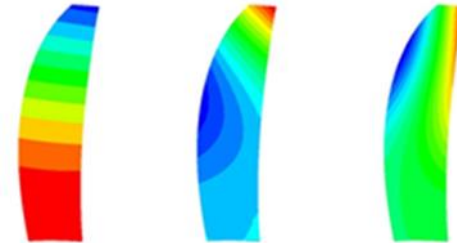
Architecture studies



Manufacturing & material characterisation



Aerodynamic / aero elastic & noise prediction methods



RIG Z08 MOUNTED IN AN INSTALLED CONFIGURATION
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SAGE 1: Conclusions

- Rolls-Royce and partners have produced a concept for an open rotor engine that can meet the required noise and efficiency requirements including:
 - Validated tools for the prediction of near field and far field noise and for the prediction of aerodynamic behaviour of open rotor designs.
 - Materials and methods for open rotor designs
- Underlying methods have been developed that would allow an open rotor to be designed and demonstrated on an aircraft

