Validation of radical engine architecture systems

the alternative solution for a cleaner future

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Validation of Radical Engine Architecture Systems (DREAM)

Our mission

“To develop and validate technologies aimed at significantly reducing the engine specific fuel consumption and reducing the CO₂ while achieving acceptable noise levels”
Background

1980s – High fuel costs resulted in pressure to achieve reductions in fuel consumption. It was known that conventional propeller engines offer significant fuel burn advantages compared with turbofan engines operating at lower Mach numbers (M < 0.6).

Aero-engine manufacturers looked to develop open rotor propellers operating at the higher cruise Mach numbers typical of the 1980s short-range aircraft (M = 0.78 to 0.8).

The General Electric GE-36 (the UDF™ with direct drive contra rotating propellers)

The P&W/Alison 578-DX (the Propfan™ engine with a reduction gearbox driving the propellers)

These were able to deliver high Mach speeds (0.72 to 0.8) and reduced SFC, but noise levels were well in excess of those achieved by existing turbofan engines.
Background (continued)

Loss of Interest In Developing Open Rotors at the end of the 1980s

The drop in oil prices in the 1980s and little focus on the impact of CO₂ on climate change resulted in less interest from the airlines, and further development of the Open Rotor concept was stopped - Consequently no large commercial passenger aircraft incorporating contra-rotating open rotor engines have been produced.

More Recent Developments

In 2000, an increased focus on climate change resulted in the creation of the ACARE 2020 goals:

- Reduce fuel consumption and CO₂ emissions by 50% (20% for the engine alone)
- Reduce perceived external noise by 50%
- Reduce NOx by 80%

In addition, fuel prices continue to oscillate, but the trend is likely to be upwards over the coming years.
Background (continued)
Objectives

The DREAM objectives are for the engine and pylon in isolation

• CO₂ - 9 % over and above VITAL/EEFAE TRL4/5 (7 % better than ACARE or 27 % better than Year 2000 engine)

• Noise - 3 dB per operation point (~ –9dB cumulated on 3 cert points) versus the Year 2000 engine references at TRL4 with improved methods, materials and techniques developed on past and existing noise programmes

• NOx – no specific objective but will be reduced accordingly with engine specific fuel burn reduction
Objectives (continued)

To support achievement of these objectives, DREAM is studying a range of novel designs for both contra-rotating open rotors and turbofans by:

- Exploiting progress made since 1990 in 3D fluid dynamics methods in steady and unsteady conditions
- Performing tests on contra-rotating rigs to measure aerodynamics and noise that will feed the simulation models
- Developing novel engine technologies complimentary to the technologies developed in the NEWAC and VITAL projects
- Validating the use of alternative fuels in these aero engines and demonstrating green house gas emission reduction.
Background

Y2K Turbofan

Game changing concept

Improved component efficiencies
Improved thermodynamic

Advanced Turbofan

Open Rotor

Noise Reduction [dB]

% sfc Improvement

(continued)
DREAM - Optimum Open Rotor Design?

- Increasing weight
- Increasing SFC
- Tip Speed increasing
- Reducing drag
- Increasing diameter
- Reducing SFC and noise

Installation limitation

Noise level limitation

Open Rotor Optimum Design Region

Increasing fuel burn

? (continued)
Project Size and Duration

Framework 7 Call 1 Level 2 Project

Gross project budget: €40.2m
Funding: €25.0m
Start Date: February 2008
Duration: 36 Months + 12 Months Extension
Project Organisation

- 44 partners from 13 countries
- Expertise and capability from within the EU, Switzerland, Russia and Turkey.
- The variety of organisations involved in the project including larger OEMs, SMEs, Universities and Research establishments
SP1
Whole Engine Architecture

Engine Assessment
• Comparison of engine architectures benefits vs Year 2000 engines.
• Analysis has confirmed promising figures for fuel burn target

Techno-economic Environmental Risk Analysis Model
• concept models of open rotor modules created and verified against available data and OEM experience
• These are integrated into a fully operational optimization environment, enabling sensitivity and trade off analysis regarding fuel burn, emissions and noise
SP2
Geared Opened Rotor

Comprises of five work packages:-

• Architecture and Specification
• Installed and uninstalled aero/acoustic rig testing
• Pitch Control and System Integration
• LP Turbine Design
• Hot Structures
SP3
Direct Drive Open Rotor

SP3 has carried out research on a Direct Drive Open Rotor under five Work packages:

• Architecture and Specification

• Open Rotor propeller blades detailed design and evaluation

• Development and design for a contra-rotating turbine

• Design of the Open rotor Propfan LP compressor

• Evaluate the aero and acoustic performances of the Contra Open Rotor Blades and Pylon
SP4
Innovative Systems

Comprises four work packages providing technologies for low weight, low cost and active turbines solutions:-

• Overall Specification and Assessment

• Cold Structures: active vibration control with piezo actuator damping systems and elastomeric damping rings for passive vibration control and cost efficiency and Low Noise Structural Fan OGV

• Novel Structure for Mid Turbine Frame: Two TMTF designs have been aero-dynamically designed and tested and High Velocity Oxy Fuel coatings tested

• Active Turbine: A panel ACC system designed and manufactured, radial running clearance sensors were engine tested and a closed-loop ACC system was validated with a software demonstrator
SP5
Alternative fuels demonstration

Demonstrate the performance of existing available alternative fuels

The requirements are:

• No significant modification of aircraft or engine is needed (‘drop-in’ fuels);

• Investigate the advantages on emissions of pollutants (NOx, CO, HCs, soots…);

• Contribute to the reduction of green house gas emissions (CO₂ emissions will be measured and compared with standard aviation fuel);

• The demonstration will be conducted on a small turboshaft engine and a paper work extension to aero-engines will be performed.

Shell GTL type and a 3rd generation UOP SPK (HVO) fuel from Camelina (continued)
Comprises of three Work packages:-

- Engine component tests: Rubber immersion, and fuel systems tests, Combustion tests and ignition tests at low temperature
- Engine demonstration on a small turbo-shaft engine

*TM Arrius 2B2 engine installed for endurance tests*
DREAM Technology Roadmap for the Framework Programmes

POA
Integrated
Power
Systems

NACRE
Aircraft
Structures

VICE
Lowspool
Components
For DDTF, GTF
And CRTF

NEWAC
Core
Components

DREAM
ValiDation of
Radical
Engine
Architecture
systeMS
TRL4/5

CLEAN SKY
SAGE 1 & SAGE 2
TRL 6+

Advanced
Module
Demonstrator
In Engine
Call 6

ACARE
Reference

(continued)
Summary of DREAM technologies (1)

- **Hot structure design and optimisation**
  - Optimised blade sets in test or tested

- **Mid turbine structure design and optimisation**
  - Rigs built and tests completed
  - Mid turbine structure design optimisation

- **Low pressure compressor**
  - Low noise blades

- **Contra-rotating turbine**
  - Low pressure compressor

- **Alternative fuels**

(continued)
Summary of DREAM technologies (2)

Open rotorblade damping
Acoustically damped Fan
OGVs
Active clearance controlled power turbine
Active and passive rotor damping
Turbine boundary layer control

Performance models defined
Final assessment In progress

Validation test Complete
Actuators tested
Blade tests Complete
Actuation solutions assessed
Testing Complete

Solutions analysed
Rig testing Complete

(continued)
The Final DREAM Workshop
20th – 23rd September 2011
Derby Enterprise Centre • Derby

For more information contact:
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The alternative solution for a cleaner future

This workshop will present an exhibition and conference to include over 40 technical presentations on innovative aero-engine technologies and the solutions developed in DREAM.

Workshop objective
The DREAM workshop is the culmination of 4 years of international collaborative research led by Rolls-Royce. The workshop is open to everyone professionally involved in aeronautic activities, including scientists, researchers, manufacturers, suppliers and public authorities.

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www.dream-project.eu
Thank you very much for your attention

http://www.dream-project.eu/