Validation of radical engine architecture systems

the **alternative** solution
for a cleaner future

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SEVENTH FRAMEWORK PROGRAMME

Validation of radical engine architecture systems

the **alternative** solution
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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 CO_2 while achieving acceptable noise levels"

SEVENTH FRAMEWORK PROGRAMME

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.

(*continued*)

Background (*continued*)

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

The drop in oil prices in the 1980s and little focus on the impact of CO_2 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

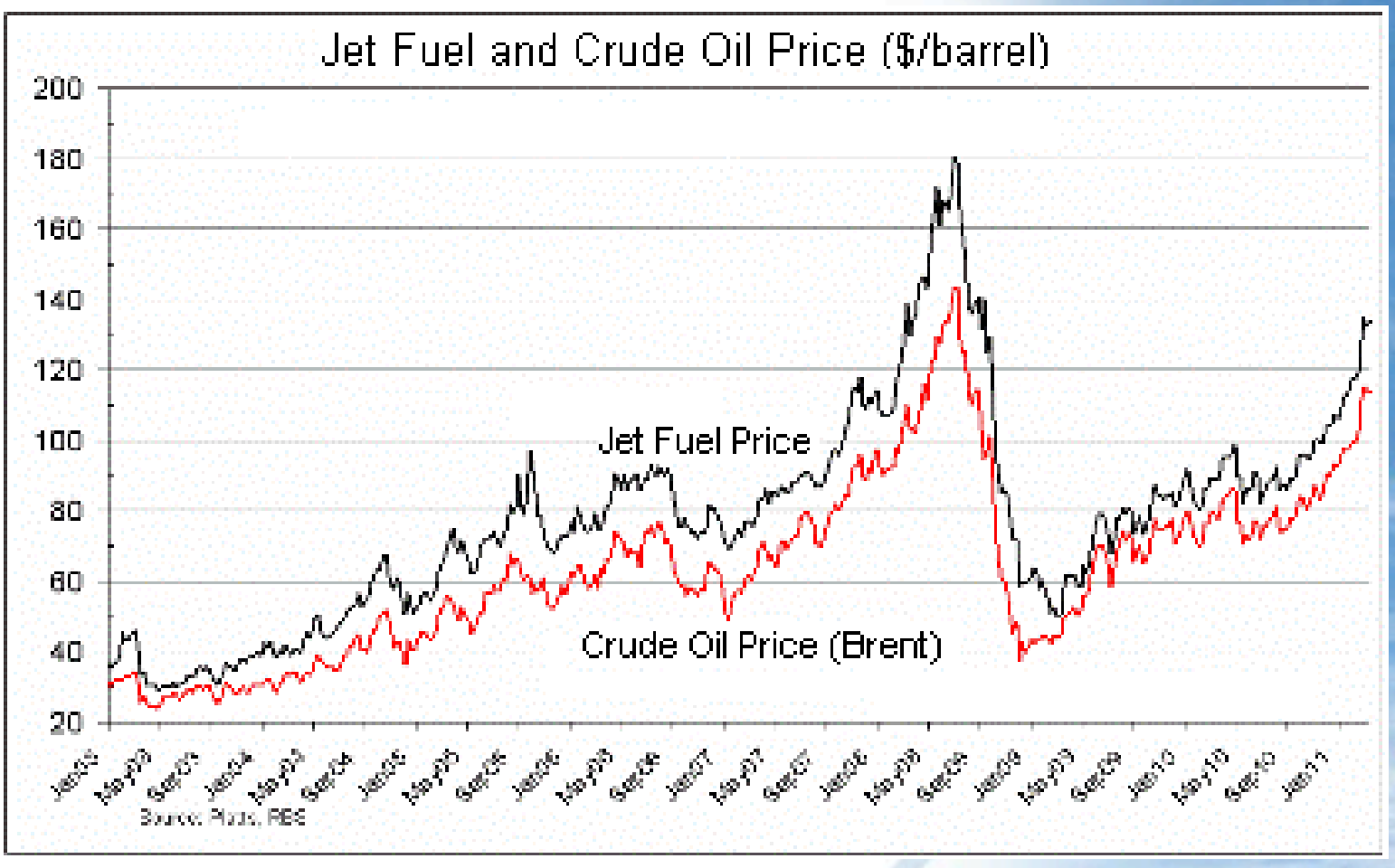
In 2000, an increased focus on climate change resulted in the creation of the ACARE 2020 goals:

- **Reduce fuel consumption and CO_2 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.

(*continued*)

Background (*continued*)



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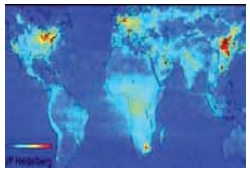
Objectives

The DREAM objectives are for the engine and pylon in isolation

- CO_2 - 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

(*continued*)

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.

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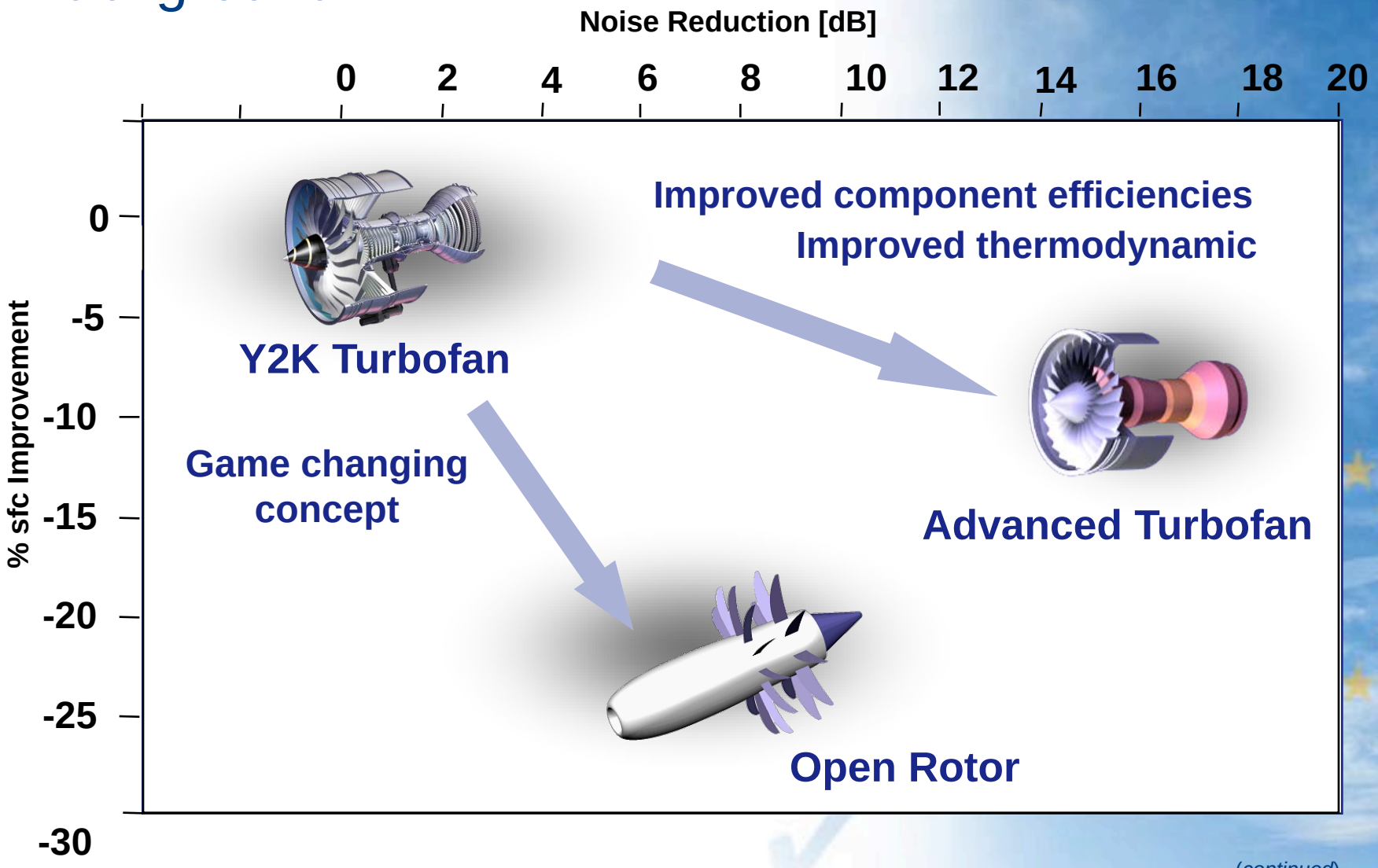
Background



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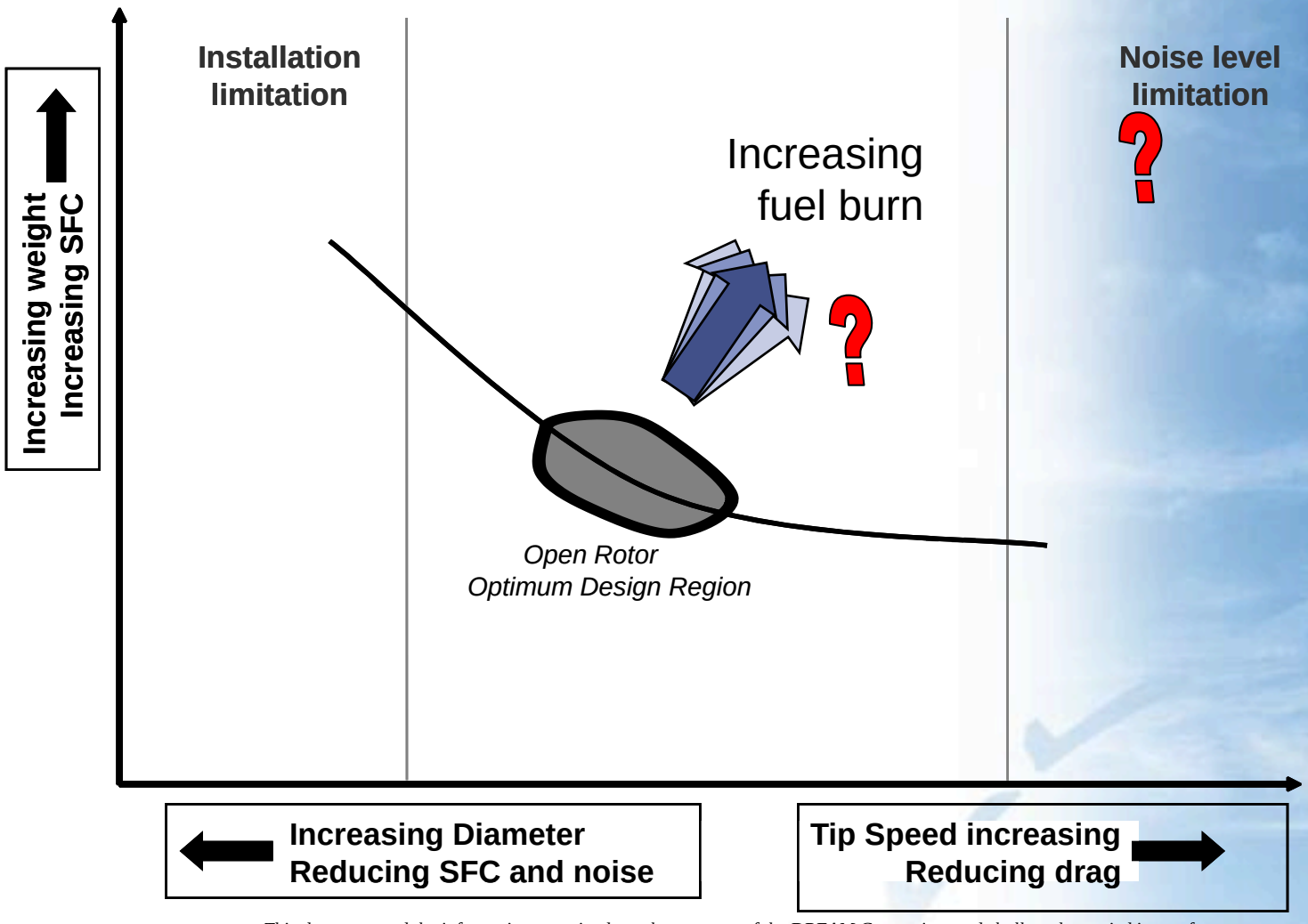
DREAM-
Optimum Open Rotor Design?



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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

(*continued*)

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

(*continued*)

SP1

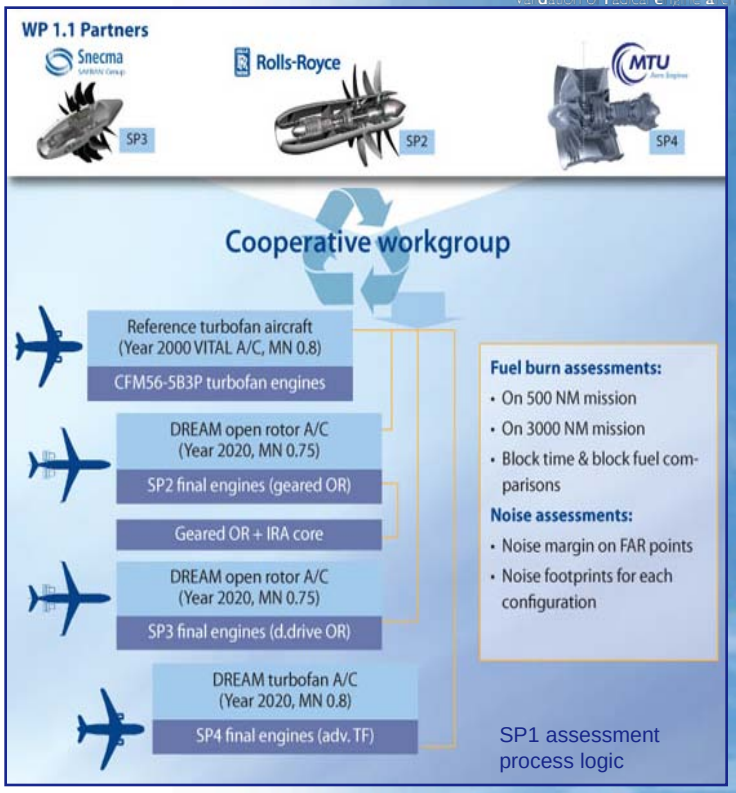
Whole Engine Architecture

Engine Assessment

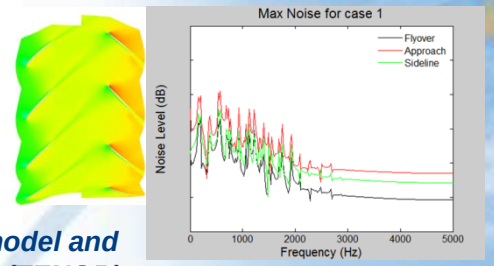
- Comparison of engine architectures benefits vs Year 2000 engines.
- Analysis has confirmed promising figures for fuel burn target

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



SP1 assessment process logic



Noise model and outputs (TENOR)

(*continued*)

SP2

Geared Opened Rotor

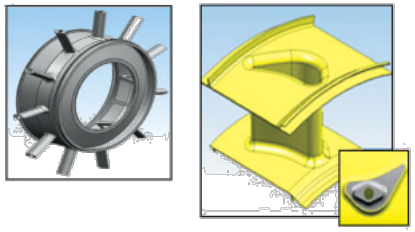
Comprises of five work packages:-

- Architecture and Specification
- Installed and uninstalled aero/acoustic rig testing
- Pitch Control and System Integration
- LP Turbine Design
- Hot Structures

Rig Testing

Pitch Control Bearing rig

LP Turbine



Hot Structures

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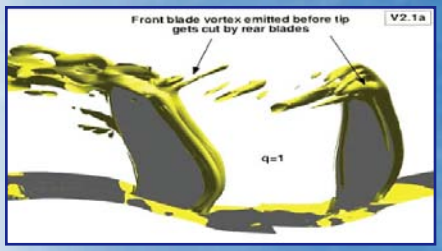
SP3

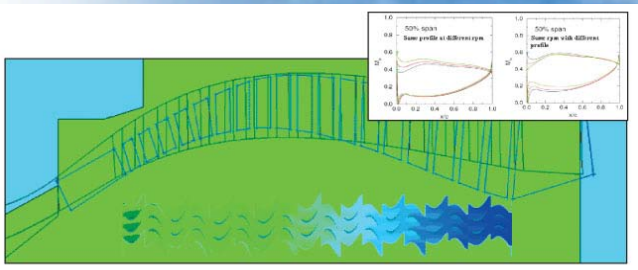
Direct Drive Open Rotor

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



Chorochonic computations (ONERA)



Turbine layout and Aero Design

5 Stages High speed open rotor Booster (CIAM)

R4 bench (Von Karman Institute)

WT104 tests (TsAGI)

WT107 tests (TsAGI)

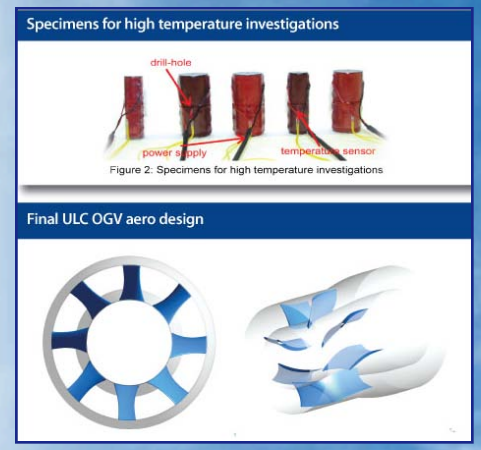
(continued)

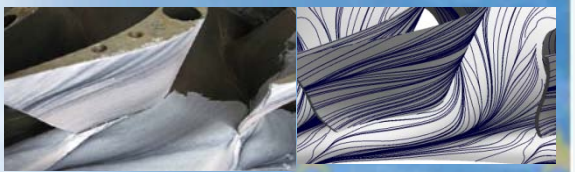
SP4

Innovative Systems

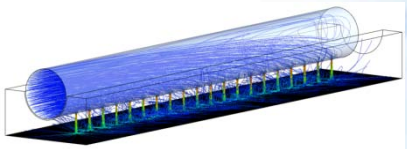
Comprises four work packages providing technologies for low weight , low cost and active turbines solutions:-

- 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

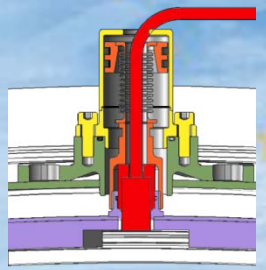




Oil flow visualisation, measurements (left) CFD (right)



CFD simulation of impingement cooling



radial gap sensor

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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 (CO_2 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

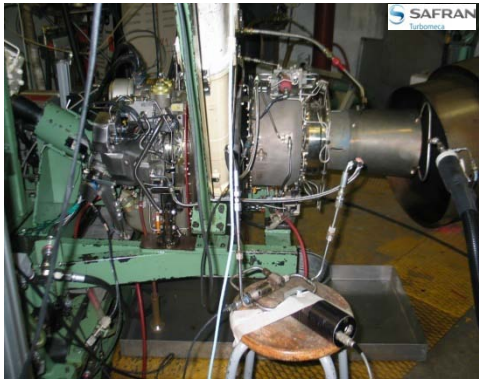
(*continued*)

SP5

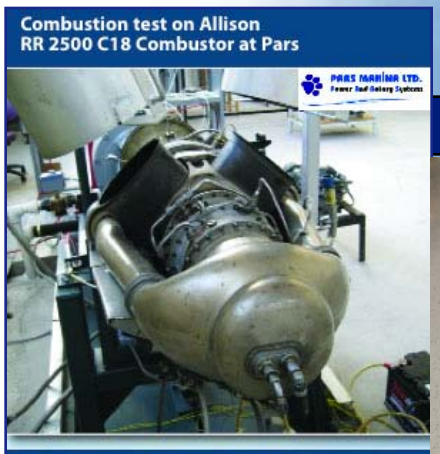
Alternative fuels demonstration

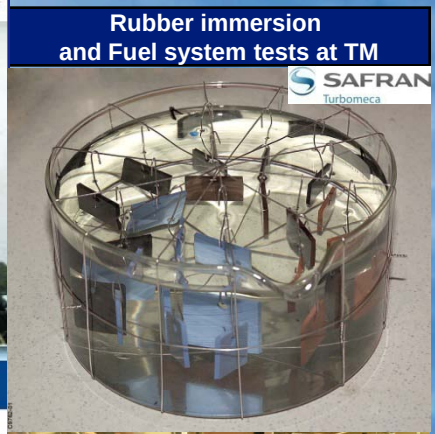
Comprises of three Work packages:-

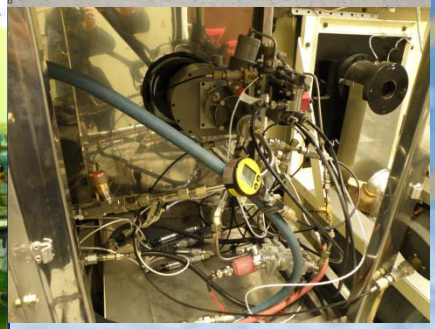
- Fuel selection. Fuel suppliers identification. Fuel purchase.
- Engine component tests: Rubber immersion, and fuel systems tests, Combustion tests and ignition tests at low temperature
- Engine demonstration on a small turbo-shaft engine



TM Arrius 2B2 engine installed for endurance tests







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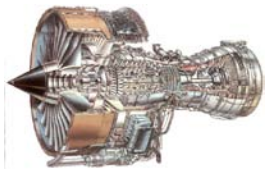
DREAM Technology Roadmap for the Framework Programmes



ACARE Reference

FP5

FP6

FP7

POA
Integrated Power Systems

Noise Technology
SILENCER
COJEN
X-NOISE

EEFAE
CLEAN
COJEN
ANTLE

NACRE
Aircraft Structures

VITAL
Lowspool Components For DDTF, GTF And CRTF

NEWAC
Core Components

Installation

Noise Methods

CRTF, Shafts

IRA Assessment

DREAM

ValiDation of Radical Engine Architecture systeMs

TRL4/5

Further Technology Evolution

Advanced Module Demonstrator In Engine Call 6

Technology Transfer

CLEAN SKY

SAGE 1 & SAGE 2

TRL 6+

(*continued*)

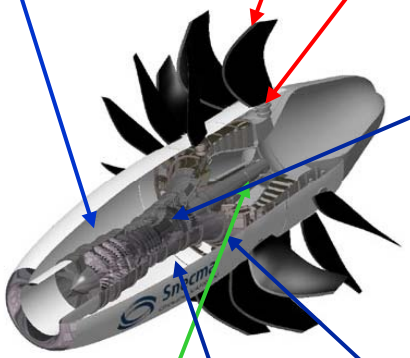
Summary of DREAM technologies (1)

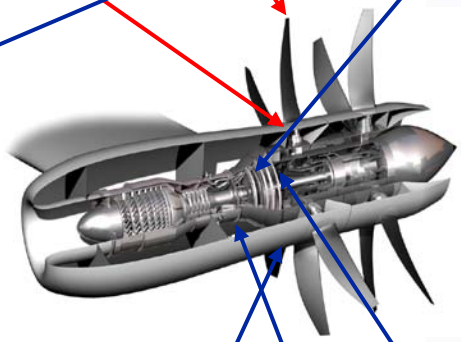
Optimised blade sets in test or tested

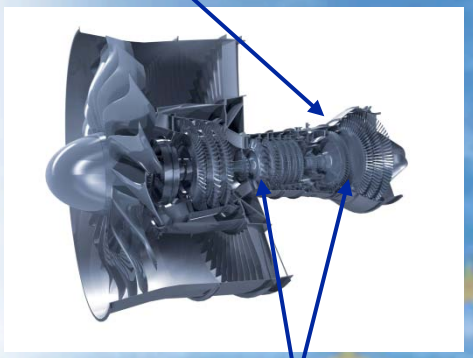
Rigs built and tests completed

Low pr… Rig ready for Test …or

Mid turb… …ure des… …ptimisation Rig complete







Design complete Damping & impact tests completed

Hot st… Design optimisation complete Component tests completed 2nd set of fuel tests Completed

High… Design optimised And rig tests complete

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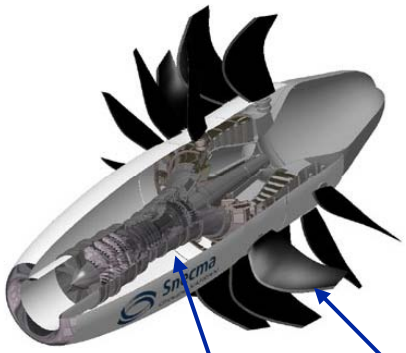
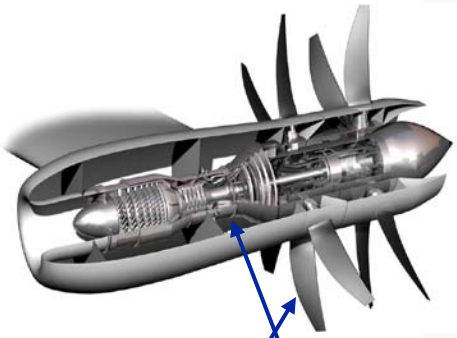
Summary of DREAM technologies (2)

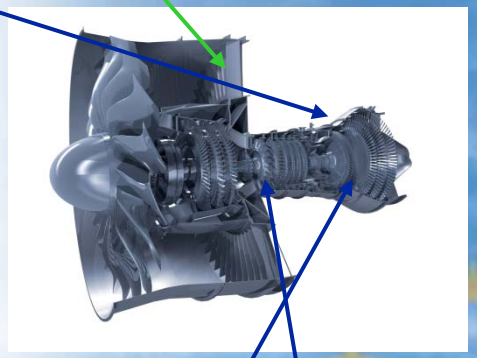
Performance models defined
Final assessment In progress

Validation test Complete

Solutions analysed
Rig testing Complete







Actuators tested
Blade tests Complete

Actuation solutions assessed

Testing Complete

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dream

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The Final DREAM Workshop

20th – 23rd September 2011
Derby Enterprise Centre
Derby

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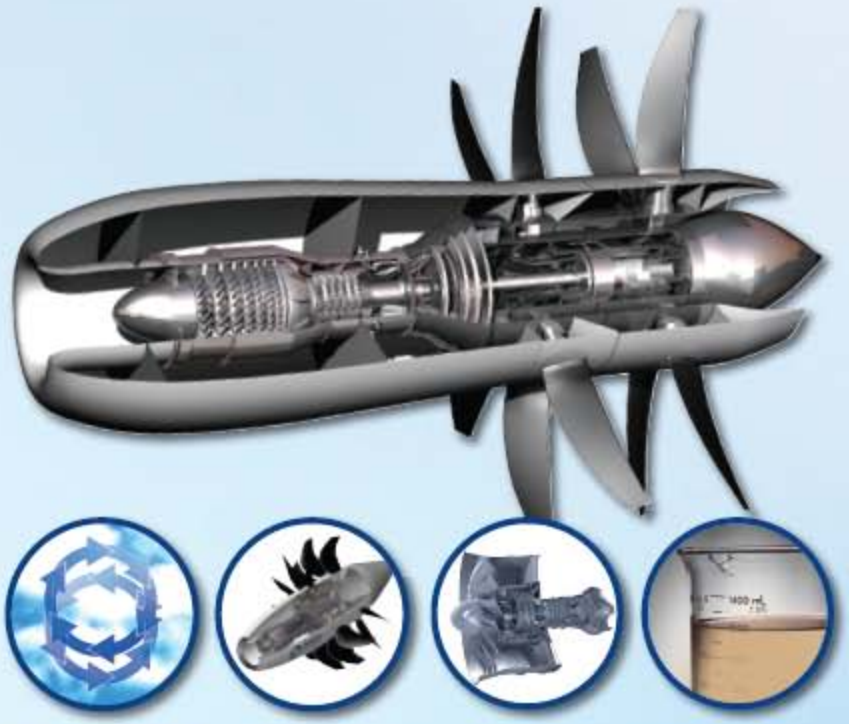
dream

Validation of radical engine architecture systems

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.

Our mission

"To develop and validate technologies aimed at significantly reducing the engine specific fuel consumption and reducing the CO_2 while achieving acceptable noise levels"

www.dream-project.eu

Thank you very much for your attention

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

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