Rolls-Royce Technology for Future Aircraft Engines

RAeS Hamburg

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Rolls-Royce Deutschland

Trusted to deliver excellence

Rolls-Royce

Content

1. Introduction to Rolls-Royce: Power Systems for 4 Markets

Civil aerospace
200,000 people in the air at any one time

Defence aerospace
160 customers in 103 countries

Marine
30,000 vessels use our equipment

Energy
customers in 120 countries

2013 Financial Highlights

order book	underlying group revenue	underlying profit
£71.6bn	£15.5bn	£1.76bn

employees	facilities in over
45,000	50 countries

Development compared to 2012

order book	+ 19%
underlying revenue	+ 27%
underlying profit	+ 23%

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Rolls-Royce in Germany

RRDVcom 13001

Rolls-Royce Deutschland 2013 at a Glance

Umsatz	Investitionen	Mitarbeiter	Produktionszahlen
€1,763 Mrd.	**€2,3 Mrd.**	**~3.500**	**666** Triebwerke

Programmverantwortung

BR710

BR715

BR725

A400M

Tay

V2500

Spey

Dart

Gnome

T56

Tornado SPS

Sustainable Growth in Germany

Rolls-Royce in Germany

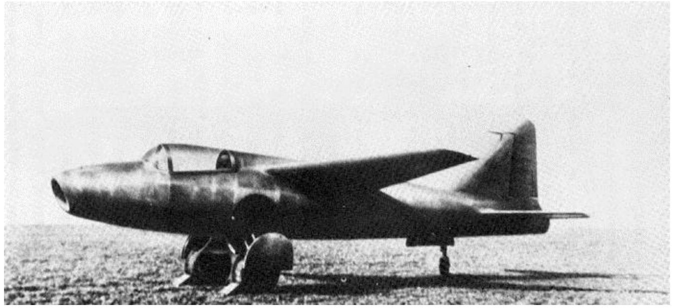
World-leading power systems provider with own sites in Germany

- Civil and defence aerospace - as well as marine sites in Germany

Dahlewitz:	Development, assembly, engine overhaul and test, CSME HQ
Oberursel:	Manufacturing
Hamburg:	Marine Service Centre
Arnstadt:	Engine overhaul

2. Engine Technology in the Past

- **First jet propelled flight took place 75 years ago:**
  Heinkel He 178 with HeS3
  designed by Pabst von Ohain,
  27.08.1939 Rostock

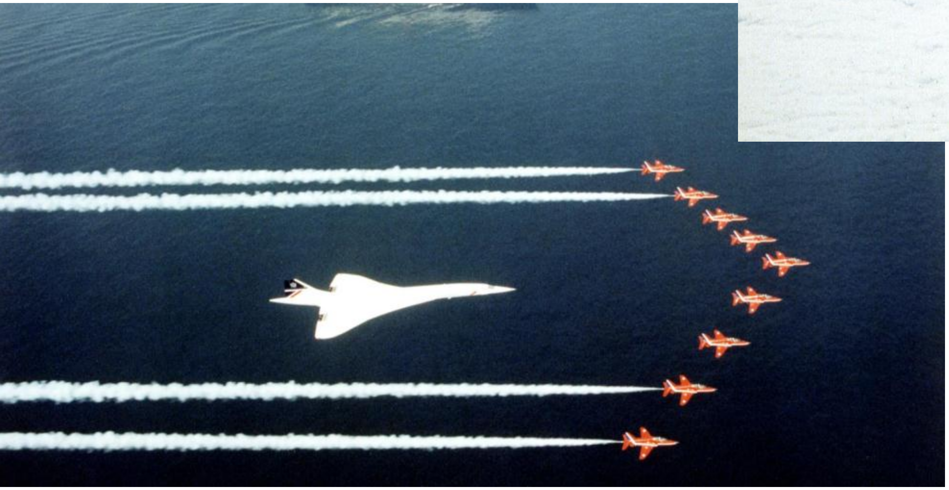


Source: Wikipedia

- **First commercial jet airplane 1949/52:**
  DeHavilland Comet DH106
  DeHaviland Ghost at first flight.
  Rolls-Royce Avon engines on production aircrafts.
  (later also in S.A. Caravelle)

Supersonic

Concorde, RR/Snecma Olympus, Turbojet Engine

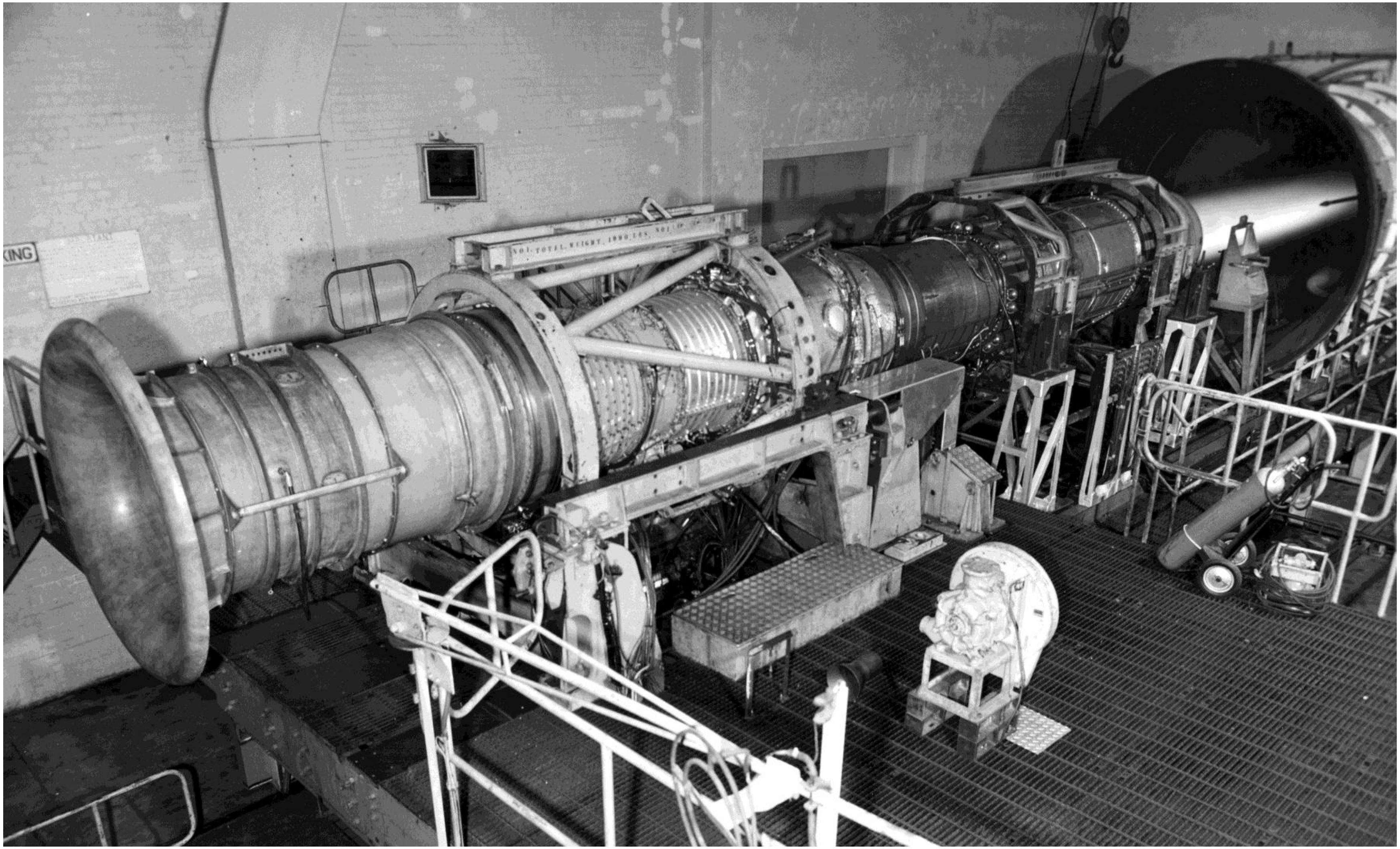


First flight: 21.01.1976

No of Aircraft built: 16(+4)

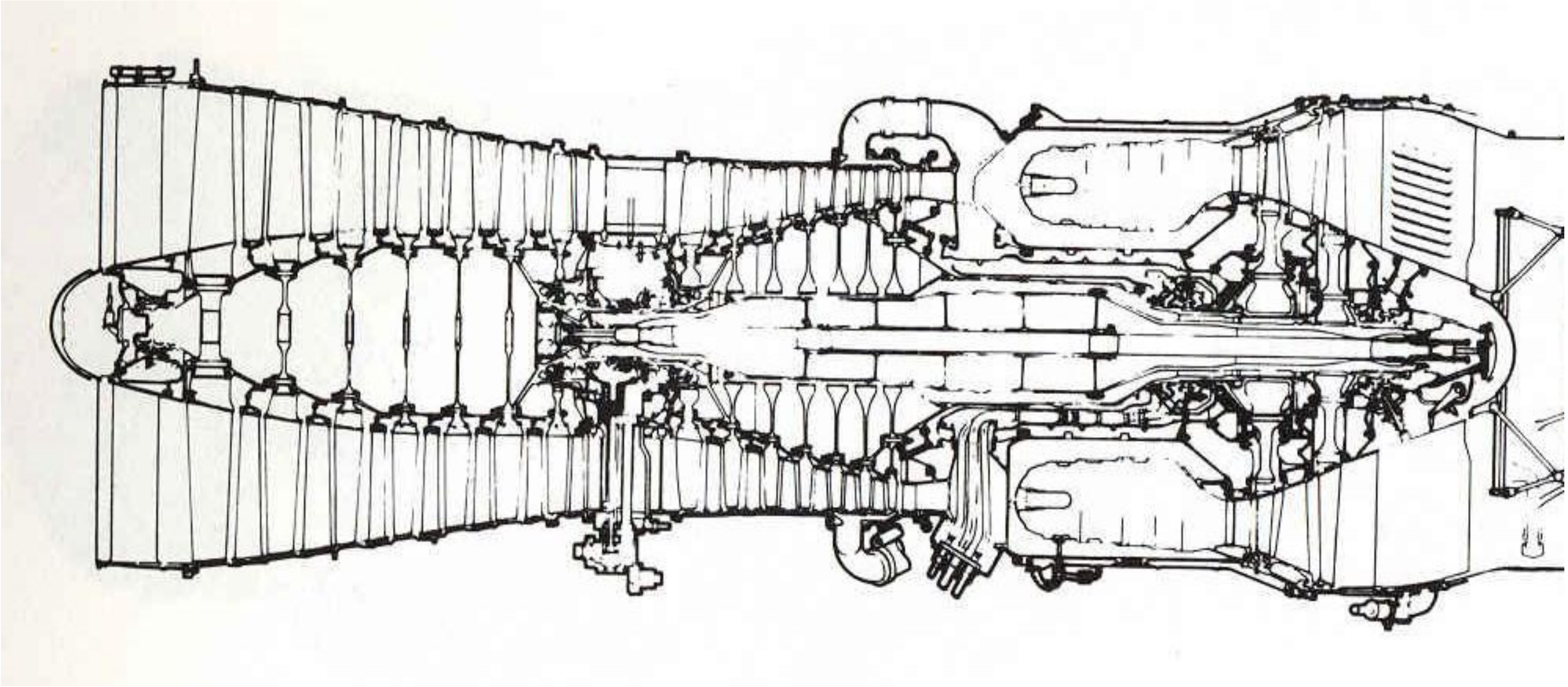
Cruise Speed: Ma 2,2

RR Olympus, developed by Bristol Aero Engines for Vulcan Bomber



Engine Design RR Olympus

- Turbojet engine, no bypass flow
- Medium pressure ratio
- Variable geometry at inlet and exhaust (afterburner)
- Minimum frontal area



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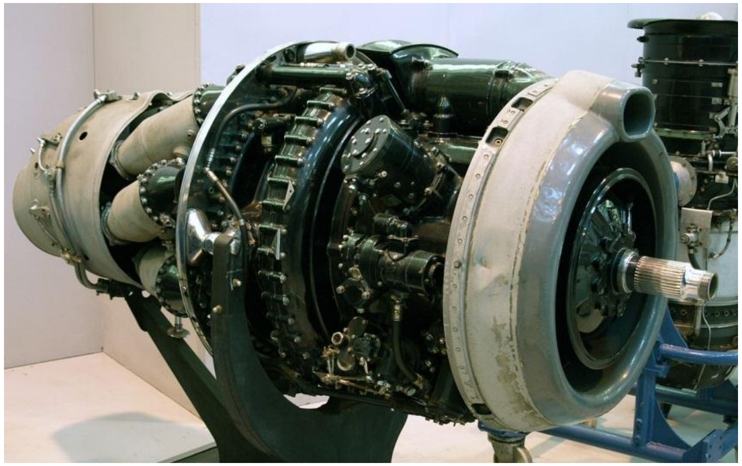
Turboprops

Turboprop Engine RR Dart

- 2 axial-centrifugal compressors
- Tubular combustor
- First run 1946



Source: Wikipedia

Commercial airplanes:

- Fokker F27 Friendship
- Vickers Viscount
- Douglas DC-3 re-engineing
- Gulfstream GI
- Convair 600/640
- YS-11

Turboprops

Turboprop Engine RR Tyne

Applications in military aircraft:

- Breguet Atlantique, maritime patrol
- Transall C-160
- First flight Atlantique: 21.10.1961

- Medium air speed, conventional propeller delivers good efficiency
- Low fuel burn requires moderate pressure ratio of about 13,5. Two shaft core engine allows very effective components

Source: Wikipedia

Turboprops

Airbus A400M
EPI TP400 D6

- Air speed nearly at jet level (Ma 0,72) => modern propeller with complex control required (one power lever to control per engine)
- Low fuel burn on long missions => Turboprop with high pressure ratio(ca. 26); optimum component efficiencies; 2 shaft core, free power turbine
- First flight of the engine on C-130 testbed: 17.12.2008

Bypass Engine RR Conway

- First bypass engine in commercial service
- 2 shafts, 2 axial compressors
- BPR=0,6

Commercial airplanes:

- Boeing 707
- Douglas DC-8

Source: Wikipedia

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High Bypass Engine RR RB 211

- **3 shafts**
- **BPR ca. 5**
- **Wide Chord Fan (Honeycomb) on later versions (-535, -524)**

Commercial airplanes:

- **Boeing 757, 767, 747**
- **Lockheed L 1011 Tristar**

Source: Wikipedia

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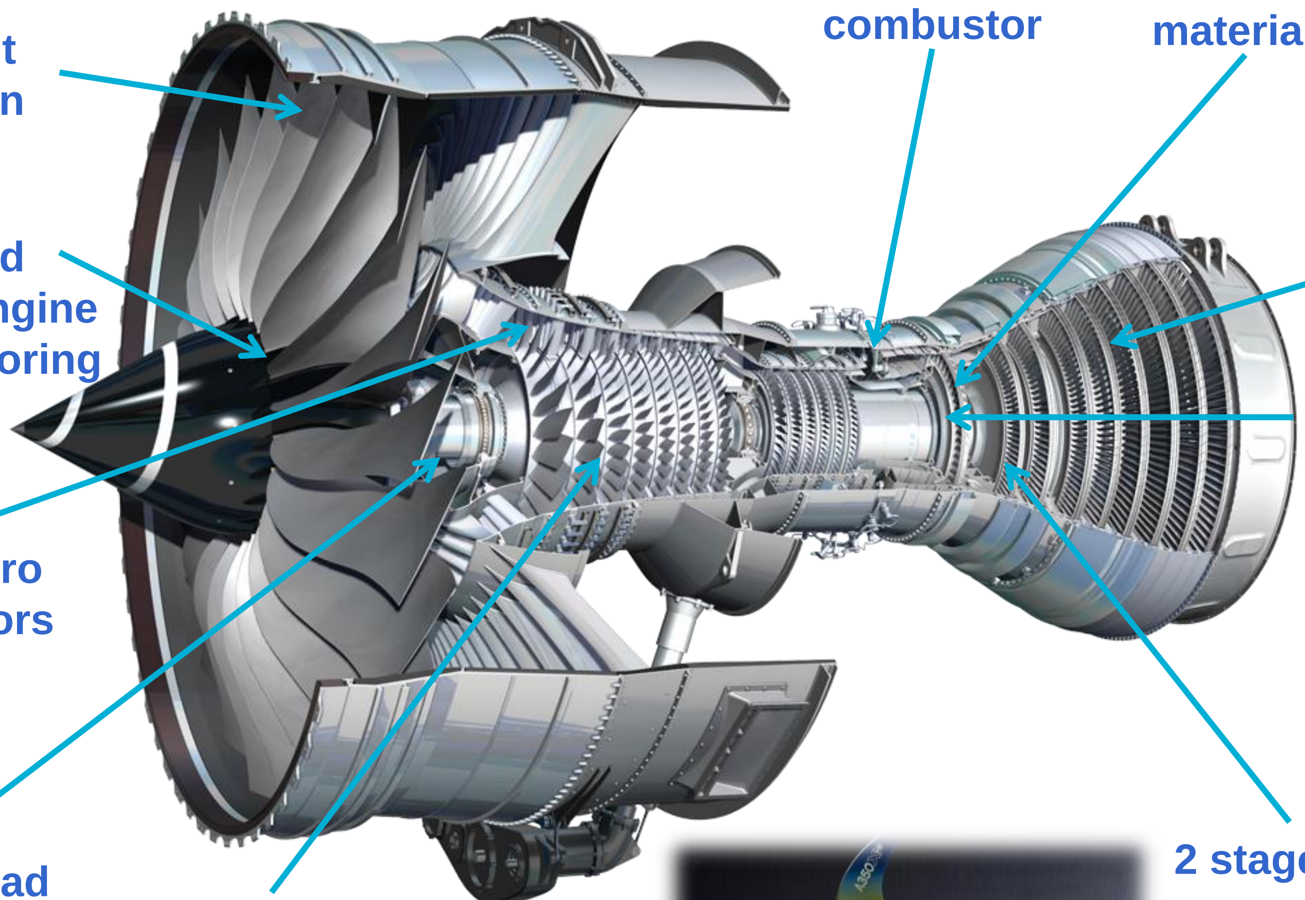
Modern Commercial Jets

A380, RR Trent 900

Trent XWB - Advanced Technology for A350



Copyright: Airbus

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Milestones Business Jets

Gulfstream	GI	RR Dart
Gulfstream	GII	RR Spey
Gulfstream	GIII	RR Spey
Gulfstream	GIV	RR Tay

Gulfstream	G350/450	RR Tay 8C
Gulfstream	GV/G550	BR710
Gulfstream	G650	BR725

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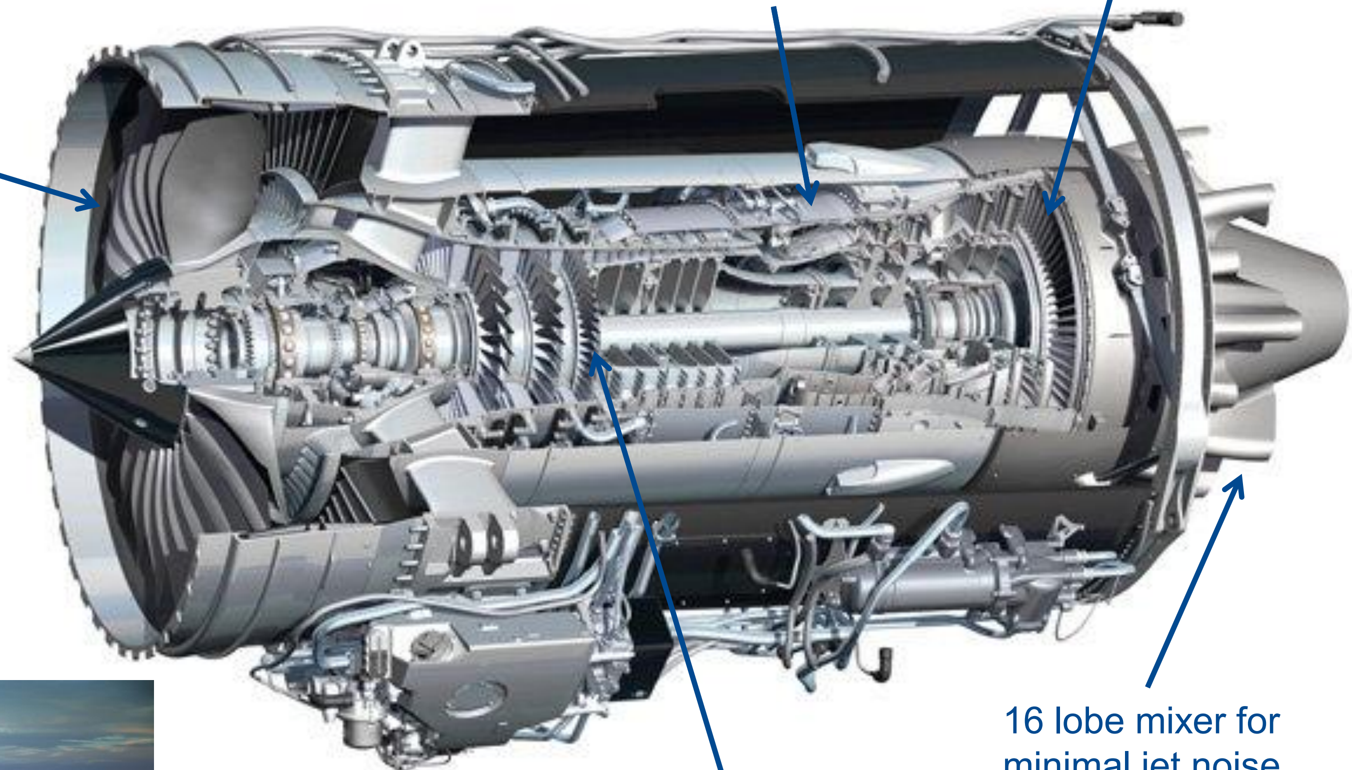
BR725 Engine for Gulfstream G650

New swept fan,
Trent technology,
increased diameter,
increased bypass ratio

Smoke free
combustor

New 3stage LPT



16 lobe mixer for
minimal jet noise

Improved HPC with
5 stages of blisk

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3. Sustainable Aviation

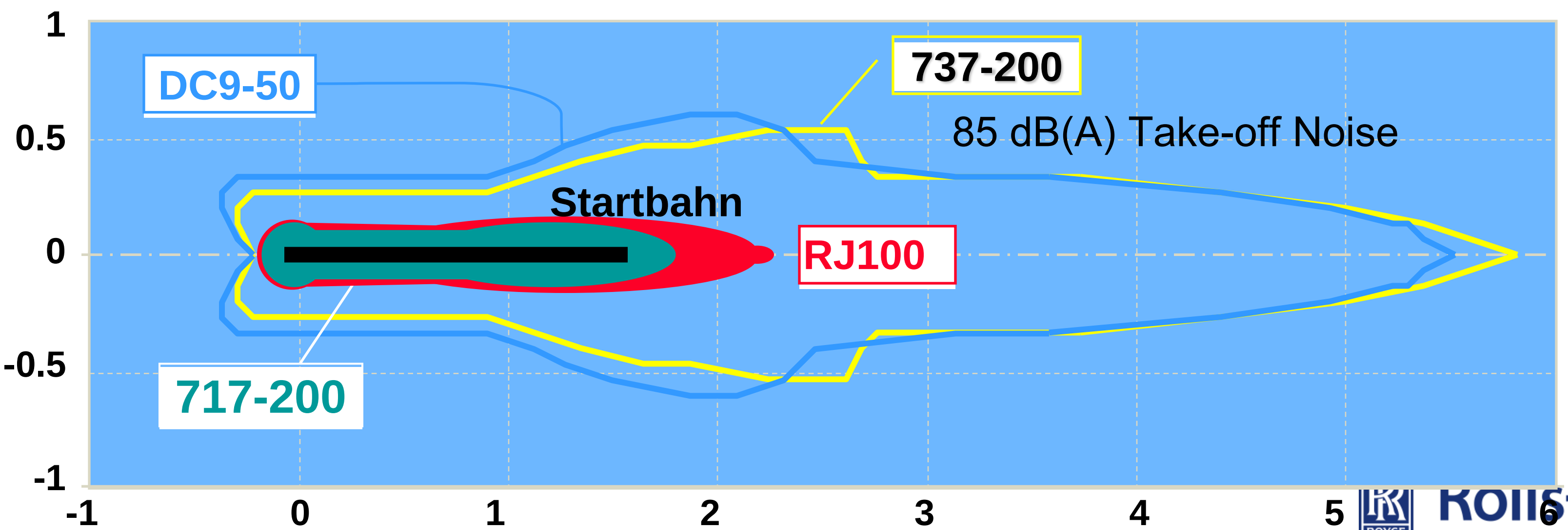
- **Climate Change (CO_2 Emissions)**

Circa 1900

Today

Pasterz Glacier, Austria

- **Noise**
- problematic close to Airports



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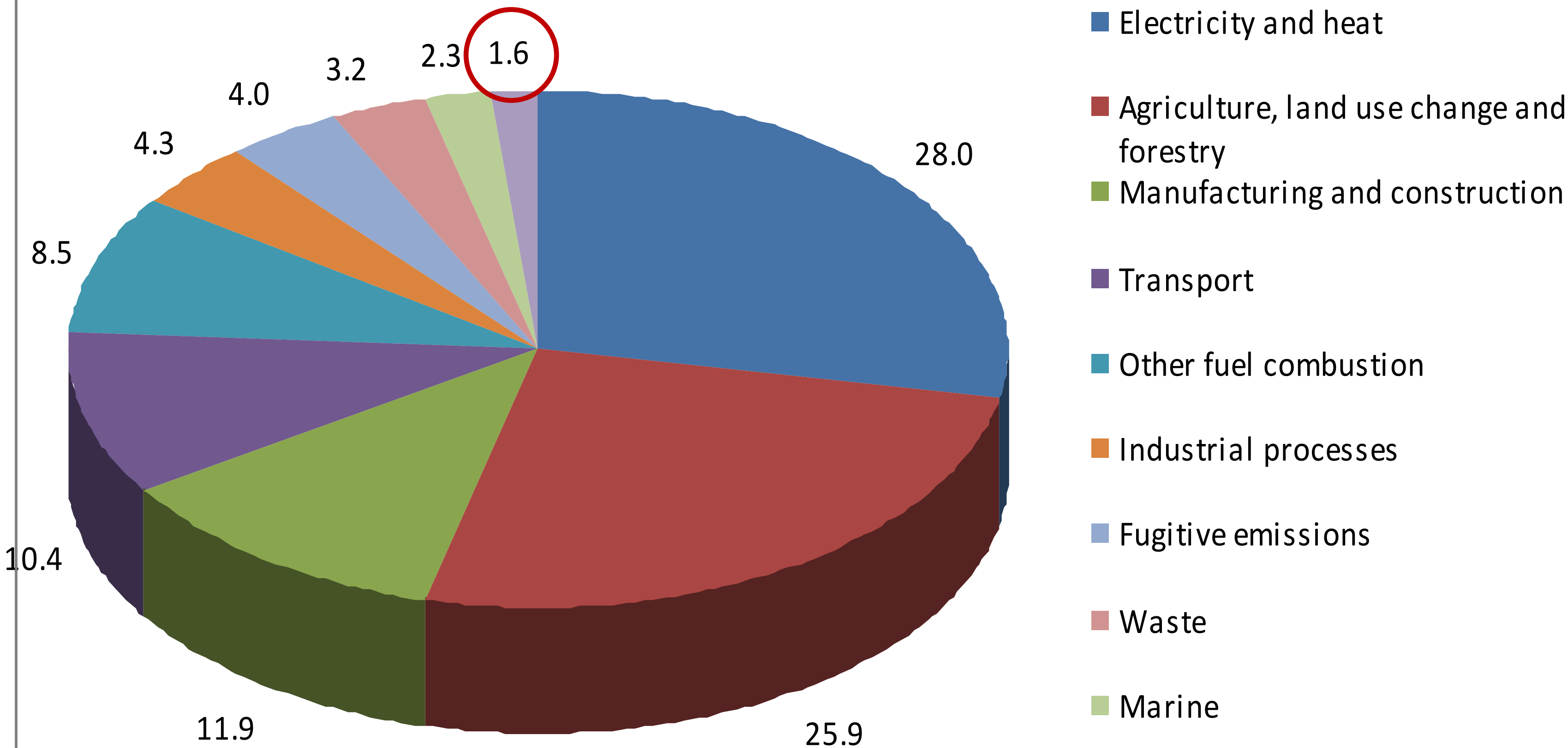
Man-made greenhouse gas emissions (all gasses)



Source: World Resources Institute 2005

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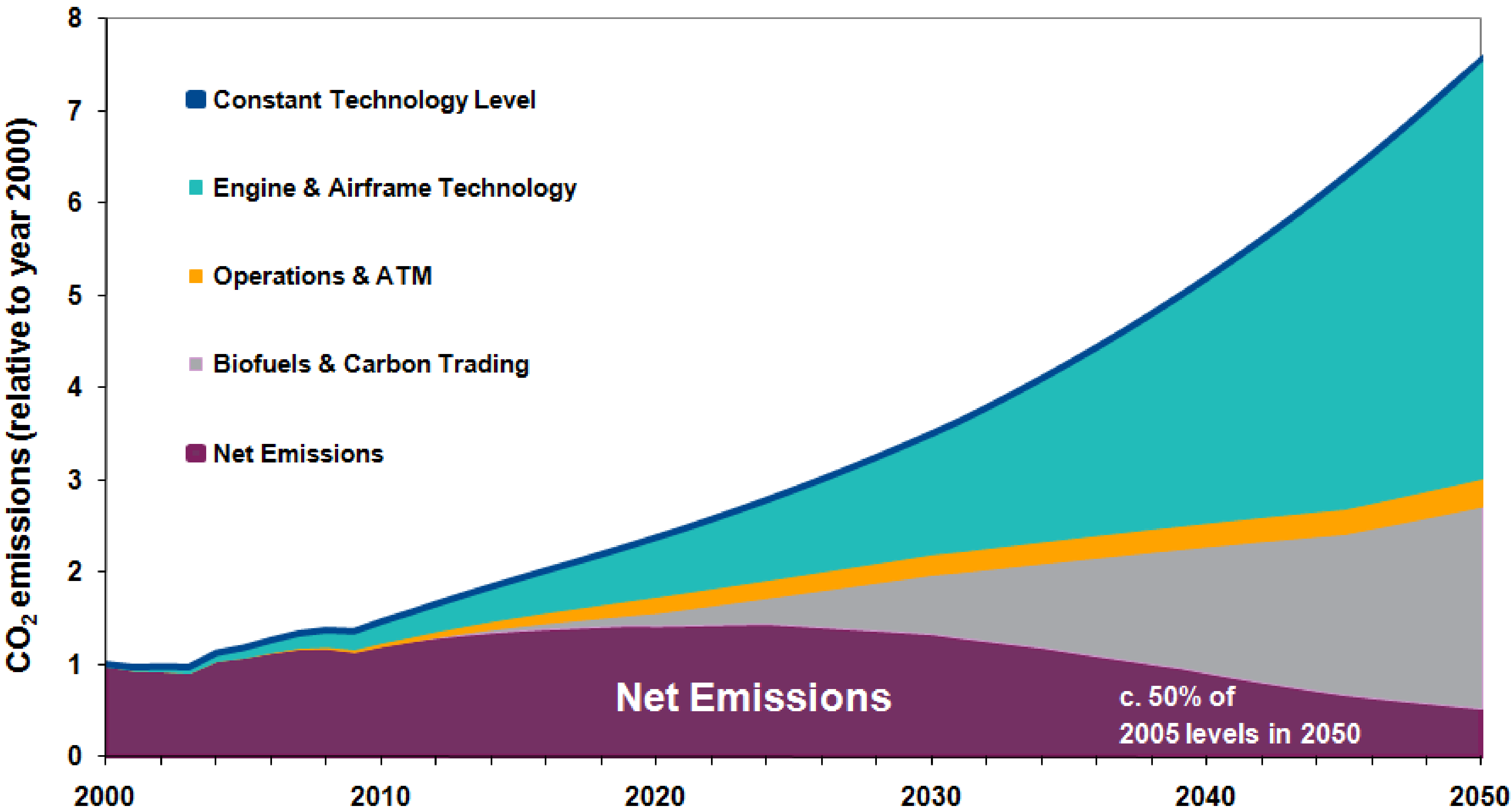
Global Aviation CO_2 Emissions Scenario



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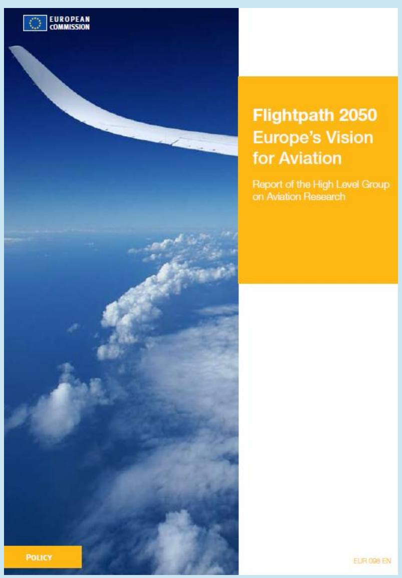
Flightpath 2050

Goals to take ACARE beyond 2020

The Advisory Council for Aviation Research and Innovation in Europe (ACARE) has set new technology goals to achieve by 2050

- 75% reduction in CO_2 per passenger kilometre
- 90% reduction in NOx emissions, and
- 65% reduction in noise



ACARE

Requires Improvement in all areas

Airframe

Engine

ATM & Operations

Strategic Research & Innovation Agenda – goals:

- Meeting Societal and Market Needs
- Maintaining and Extending Industrial Leadership
- Protecting the Environment and the Energy Supply
- Ensuring Safety and Security
- Prioritising Research, Testing Capabilities & Education

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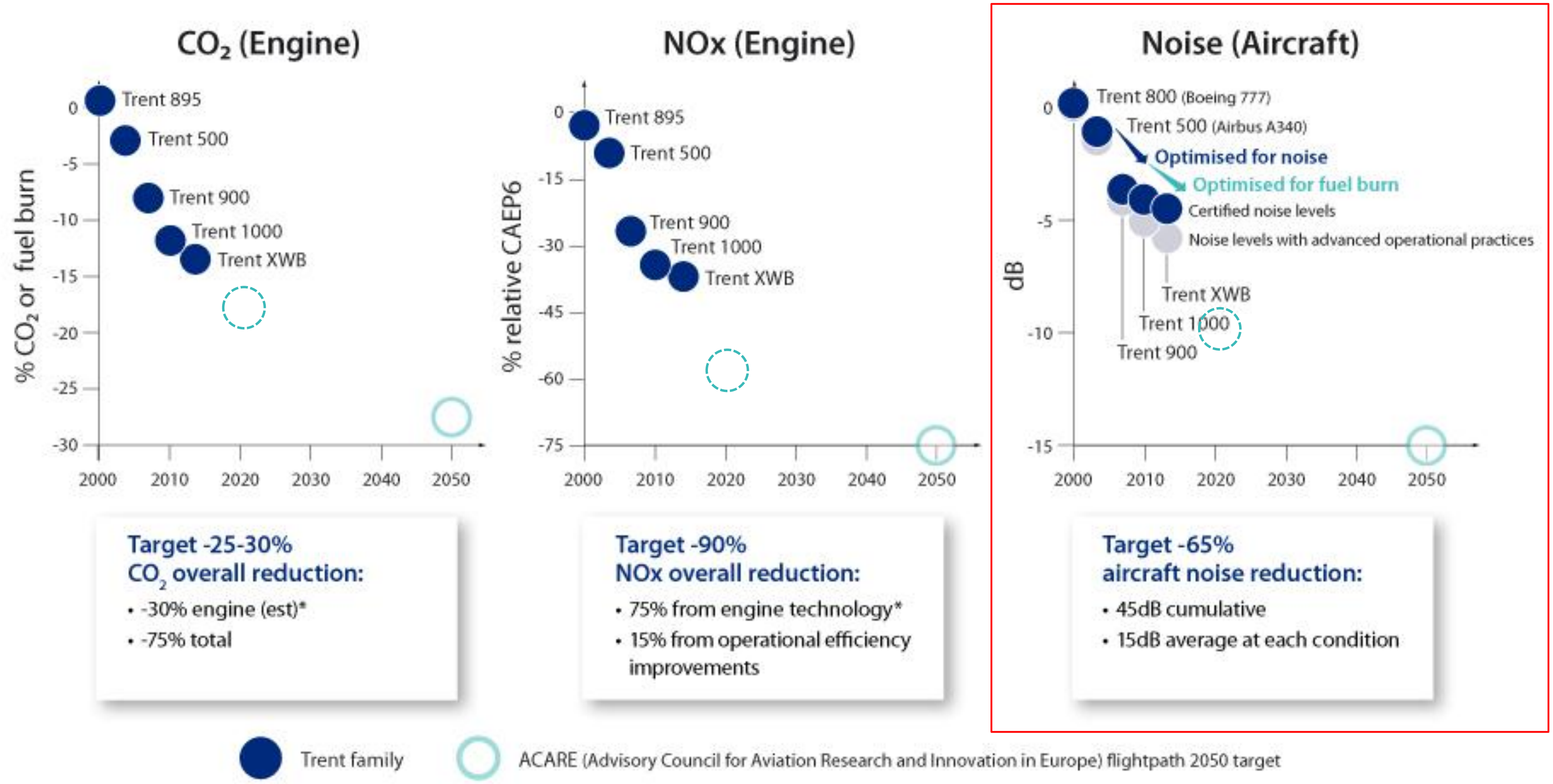
ACARE 2020 and Flight Path 2050 Targets



Trent 1000 is 12% more fuel efficient than Trent 800

Alternative Fuels

Suitability + **Sustainability** + **Industrialisation**

energy density
fuel specification

CO_2 benefit
Food / water

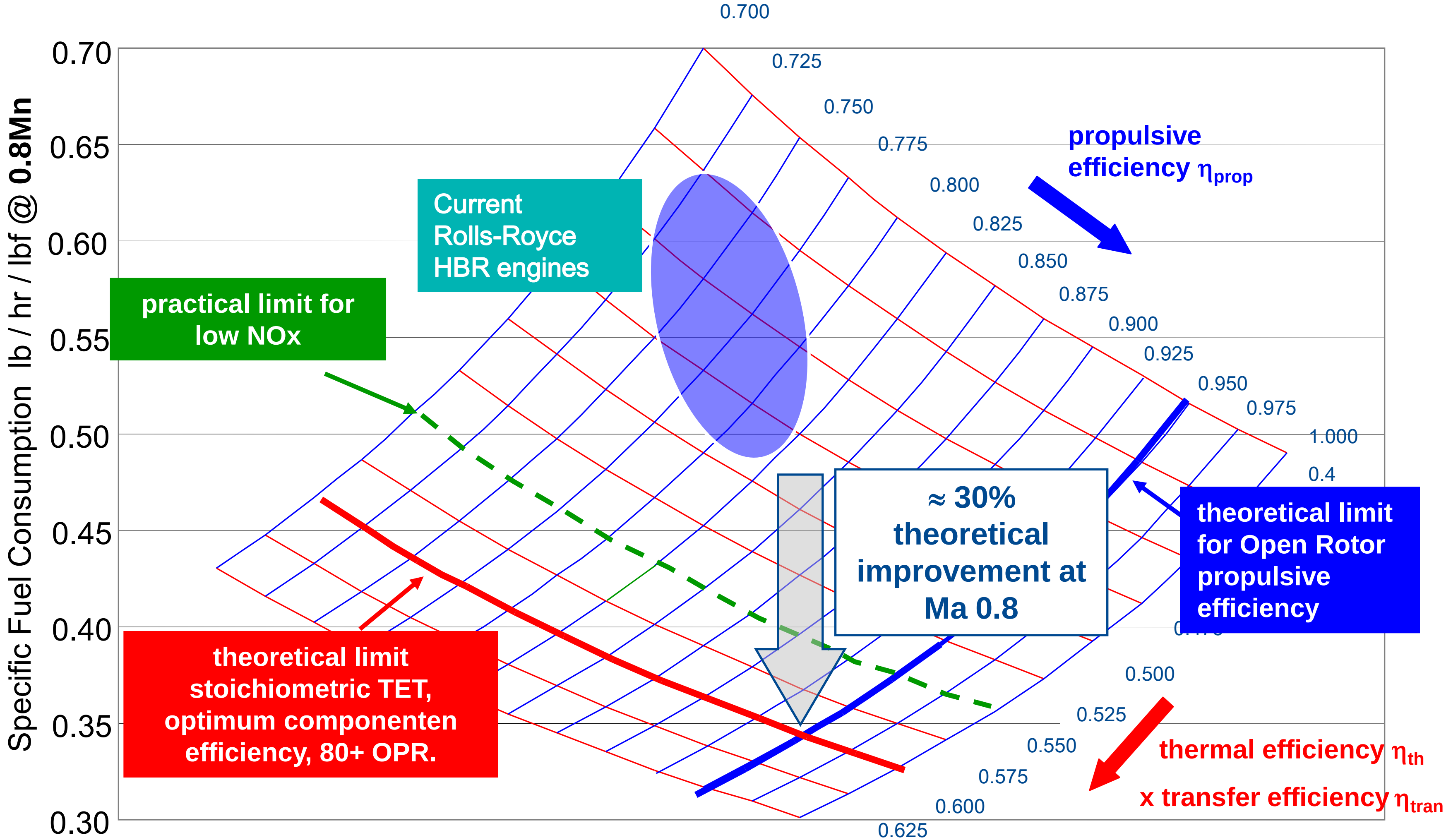
mass production
global distribution

Projections of biomass production show that it will be a scarce resource and a holistic analysis shows that biofuels are best used near the geographic place of their origin for energy use

Offering longer term potential

4. Technology Development at Rolls-Royce

Turbofan Thermodynamic Cycle Efficiencies



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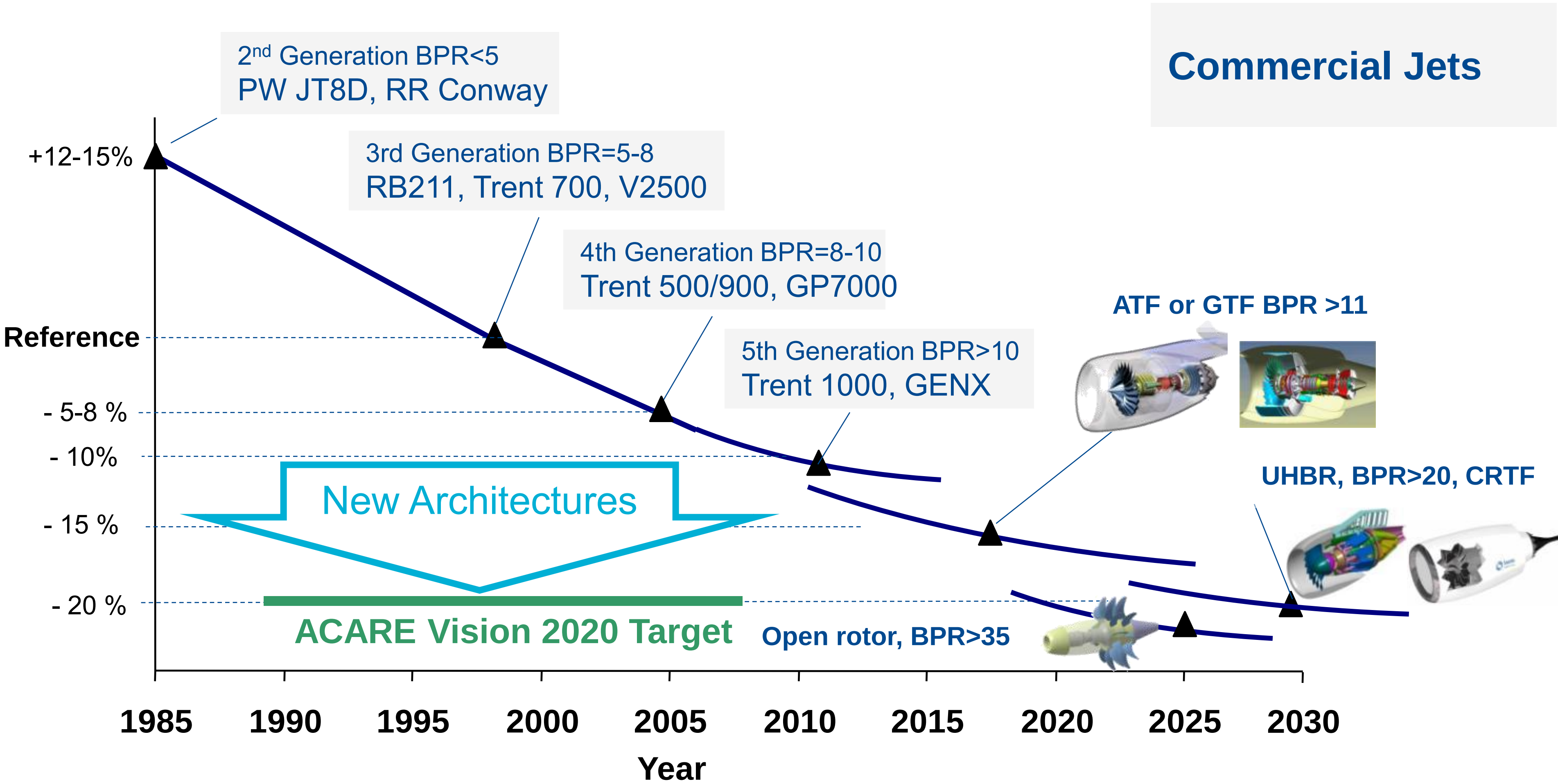
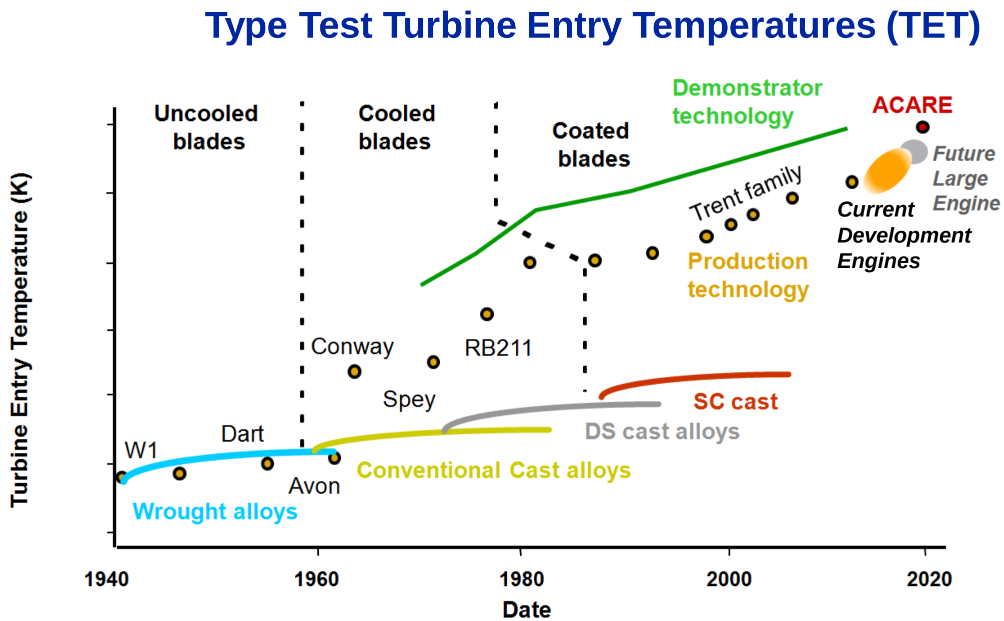
Fuel Burn Reduction and CO_2 Improvements

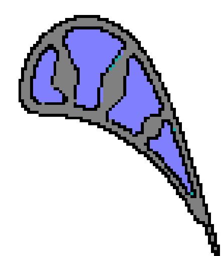


Process Temperatures, Trends

- **High OR cycles increase turbine entry temperatures**

- **Required HPT technology:**
  - Materials & Coatings
  - Cooling design & airsystem design





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Composite Fan Research today

- Key Composite programme 2010 –2014
  - Rig tests
    - bird-strike, fan blade-off, fatigue
  - Indoor tests
    - performance, flutter, bird ingestion
  - Outdoor tests
    - strain-gauge, cross-wind, noise

Successful VITAL fan blade testing completed 2008

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Rolls-Royce Carbon-Titanium Fan, CTi Fan

- **Composite/Ti fan blade for next generation large engine**

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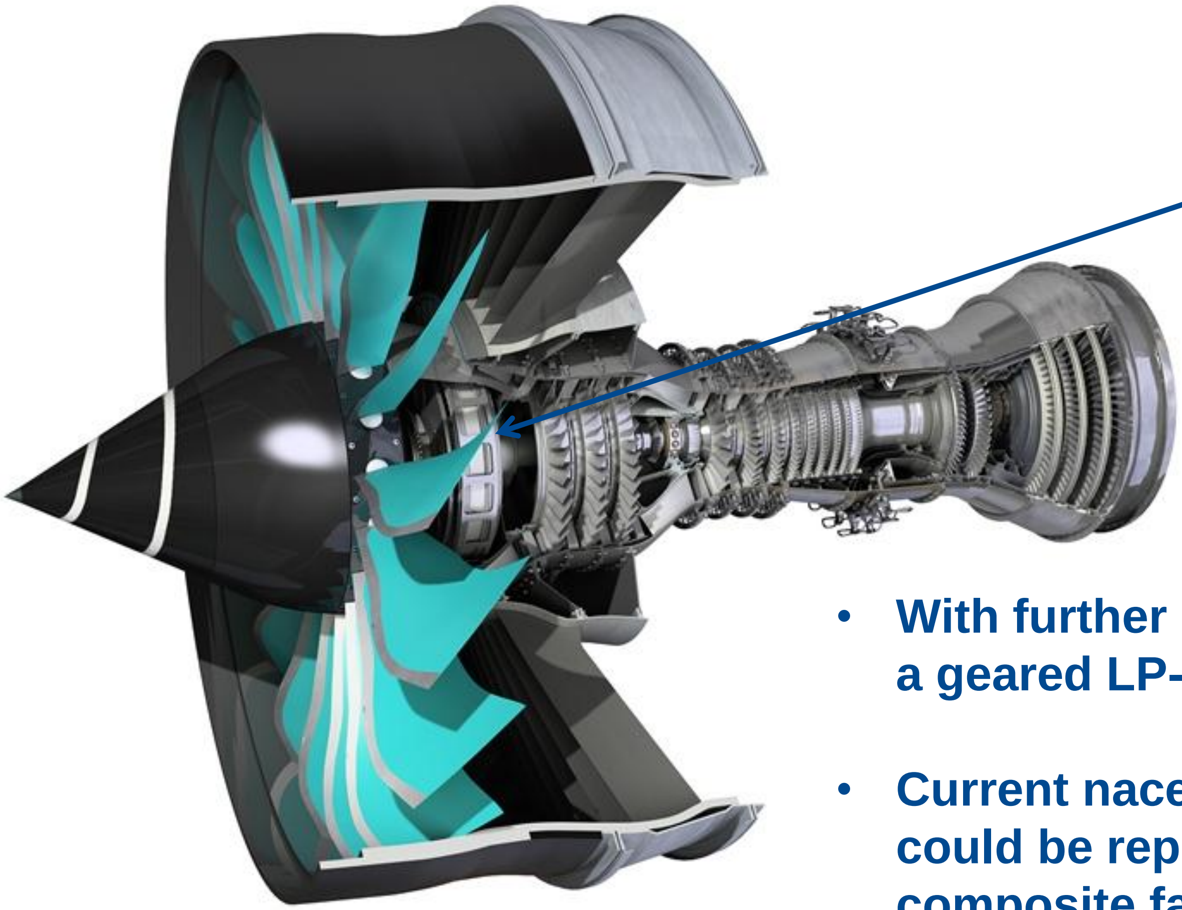
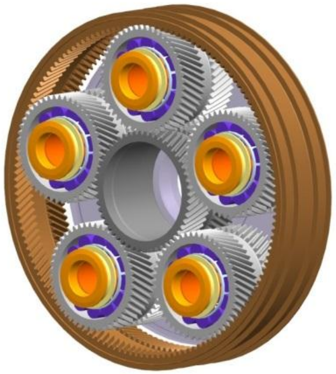
Rolls-Royce UltraFan





- **With further increasing bypass ratios, a geared LP-system offers benefits**
- **Current nacelle designs with TRU could be replaced by variable pitch composite fan (VP fan) and variable area nozzle (VAN)**

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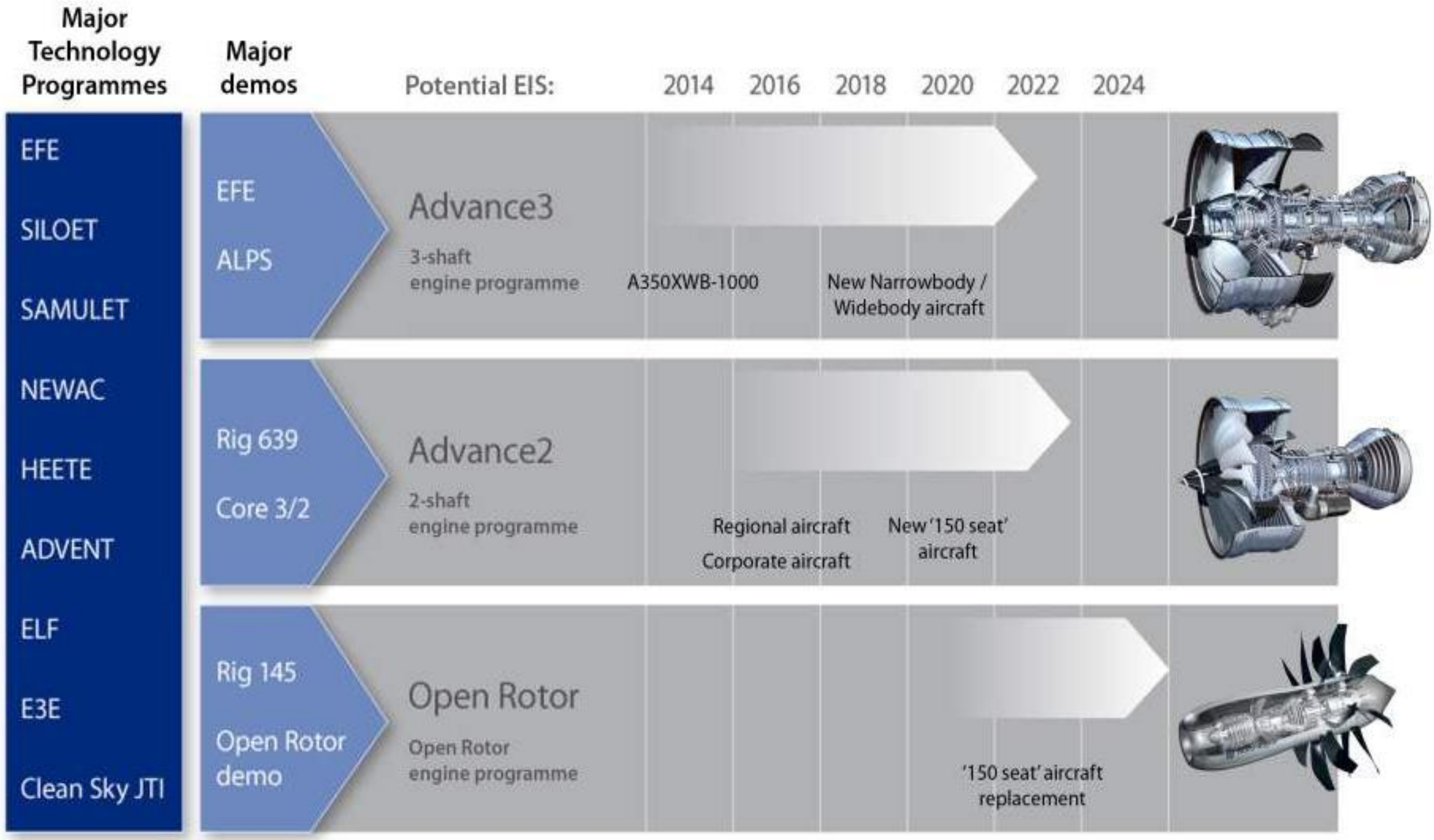
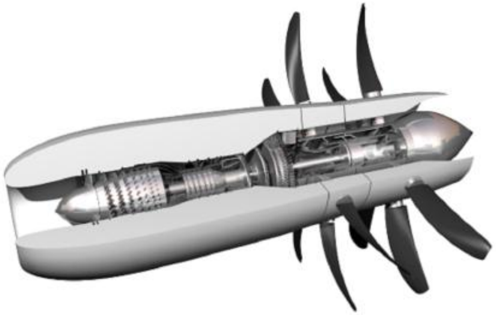
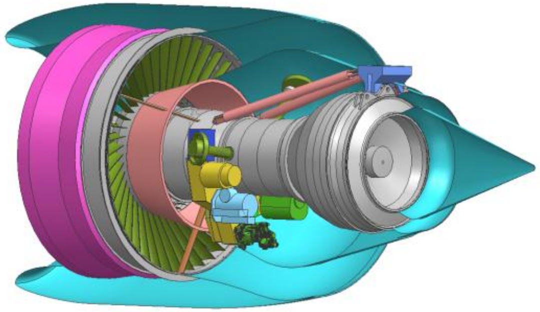
Technology Demonstrators



Potential "Game Changers"

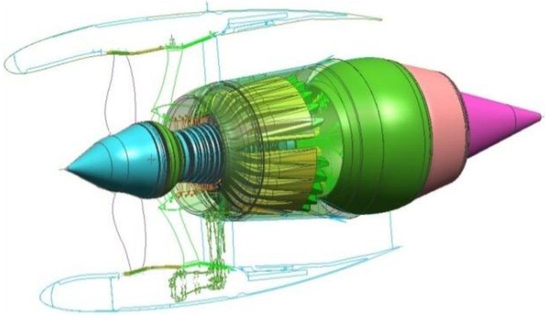


Open rotor

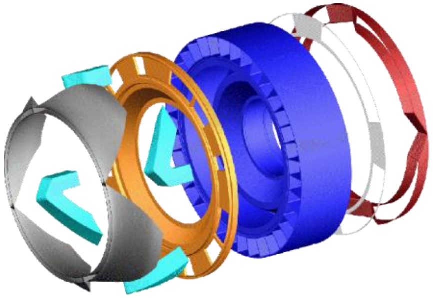


Integrated electrical systems

Engine – Airframe Optimisation



Advanced Cycles ICR



Pressure Gain Combustion

Adaptive cycles

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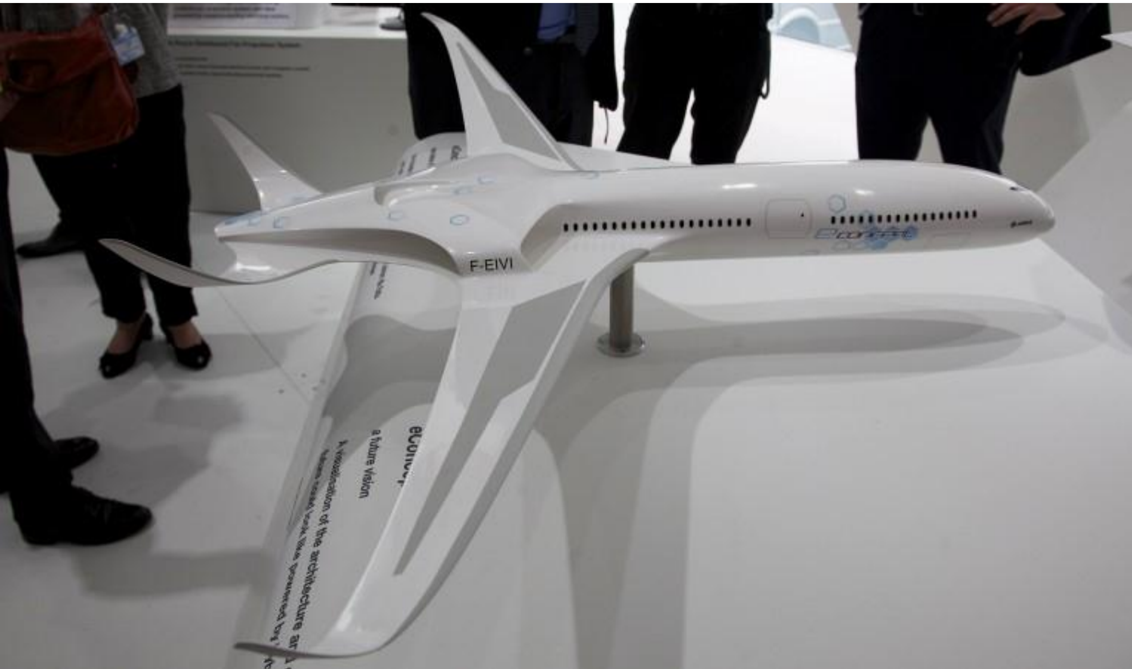
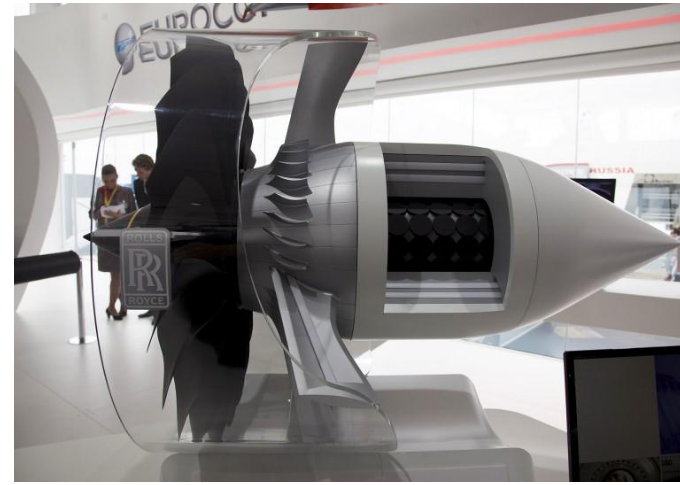
Turboelectric Hybrid Propulsion (NASA Concept)

Source: Paper ISABE 2011-1340

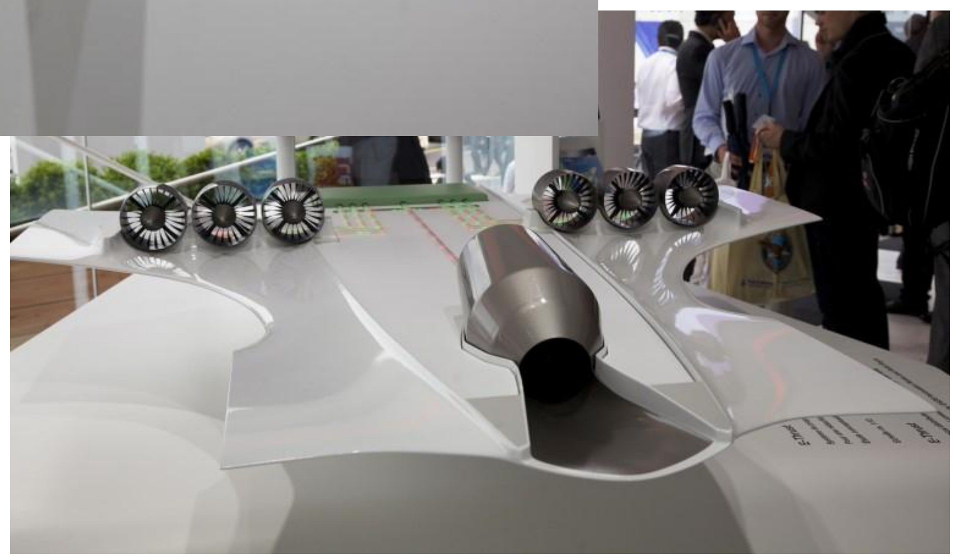
- **Seperate power- and thrust generation**
- **Blended wing body with maximum L/D ratio**
- **Electrcally driven fans with wing boundary layer suction**
- **Gas turbine in wing tips generates electrical power**

eConcept (Airbus/Rolls-Royce)





Source: Airbus



eConcept presented by EADS at Aero Salon Paris 2013

- **Blended Wing Body**
- **1 GT-Engine with Generators**
- **6 electrically driven Fans**
- **Battery to store electrical energy**

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Summary

- **Gasturbines still have a lot of potential in aircraft propulsion**
- **Rolls-Royce and the aerospace industry carry out a lot of research to fulfil the challenging ACARE targets which will make air travel more sustainable.**
- **This overview presented some of the technologies on which RR works currently**
- **My personal opinion about future air transport:**
  - In 20 years we will still fly, and probably subsonic
  - Gasturbines will largely generate the power for aircraft propulsion
  - We will see more propellers and hybrid systems in use on aircraft

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