An aero-engine vision of 2020

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November 2004

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Overall ACARE* environmental targets for 2020

Reduce perceived external noise by 50% (30db Cumulative)

Reduce fuel consumption and CO_2 emissions by 50%

Reduce NO_X emissions by 80%

Targets are for new aircraft and whole industry relative to 2000

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

* Advisory Council for Aerospace Research in Europe

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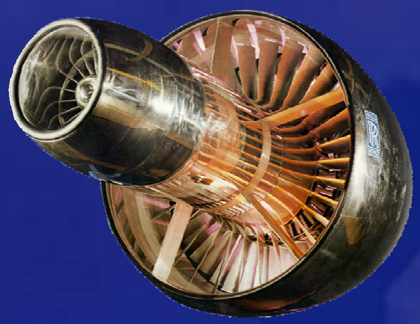
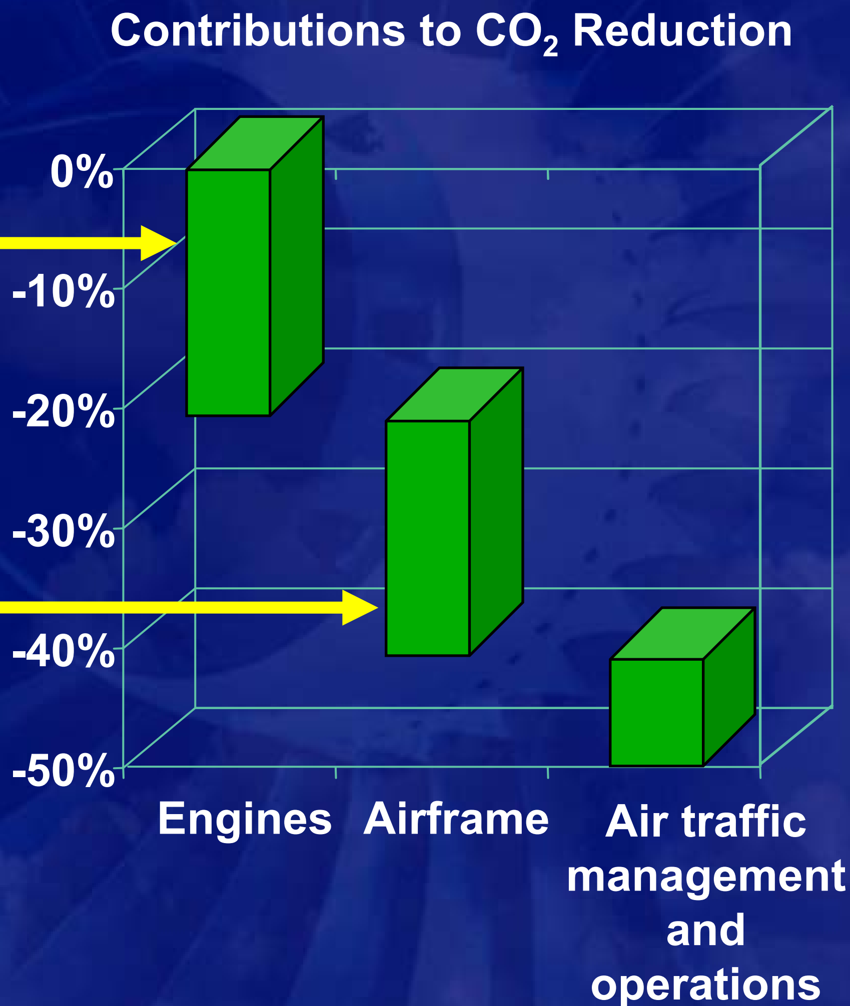
Meeting the 50% fuel burn target needs changes in all areas



Possible design solutions



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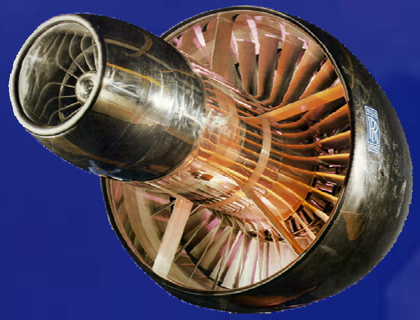
Meeting the 30dB noise target needs changes in all areas



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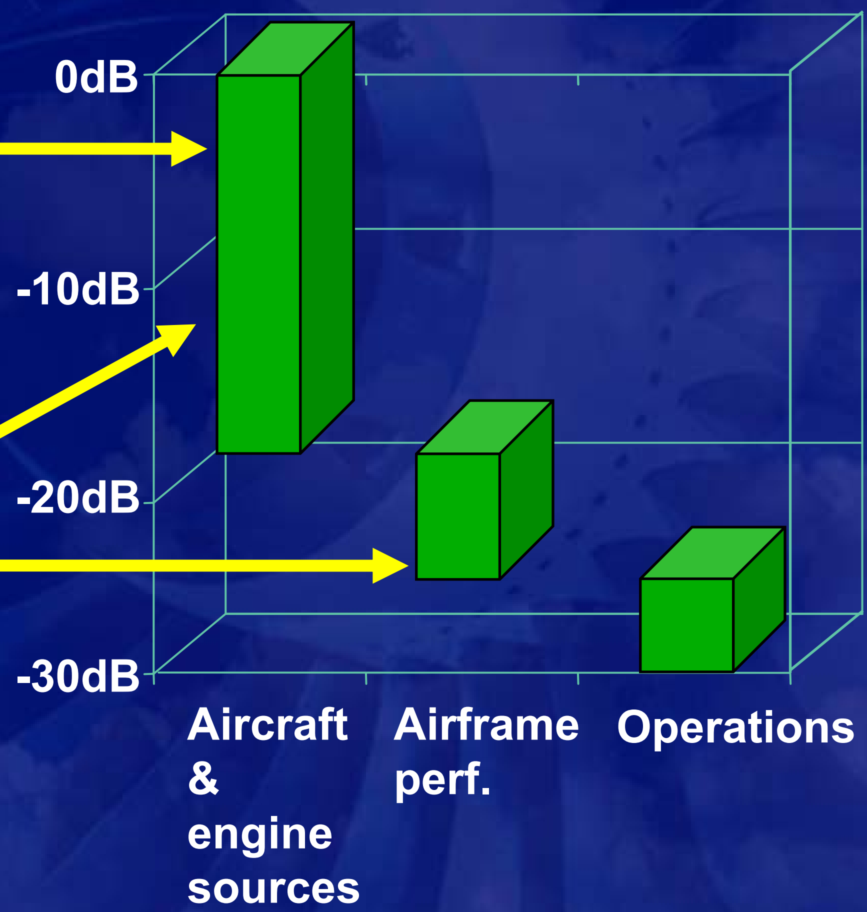

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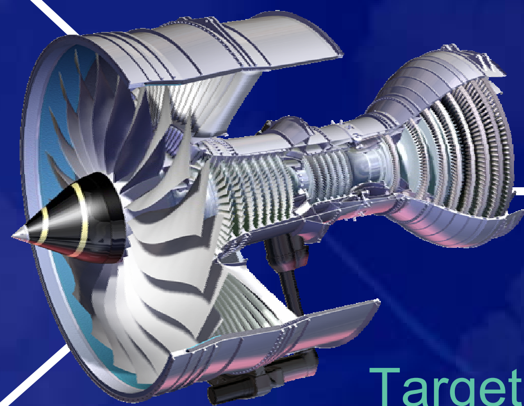
Engine ACARE* environmental targets for 2020

Reduce perceived external noise by 18 dB Cumulative



Reduce fuel consumption and CO_2 emissions by 20%

Reduce NO_X emissions by 80%

Targets are for new engines and whole industry relative to 2000

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

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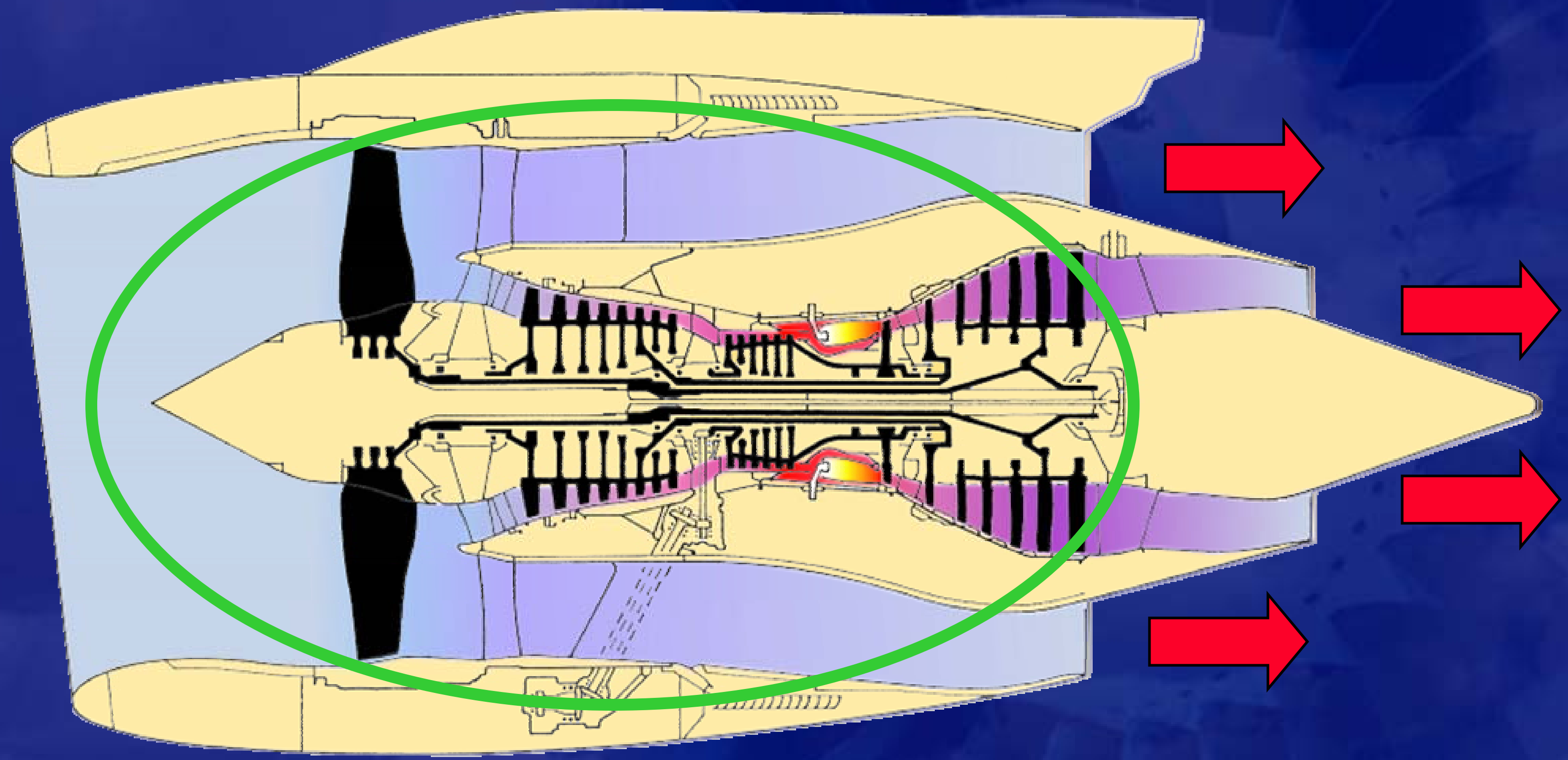
Turbofan Engine



Thermal and transfer efficiency

Propulsive efficiency

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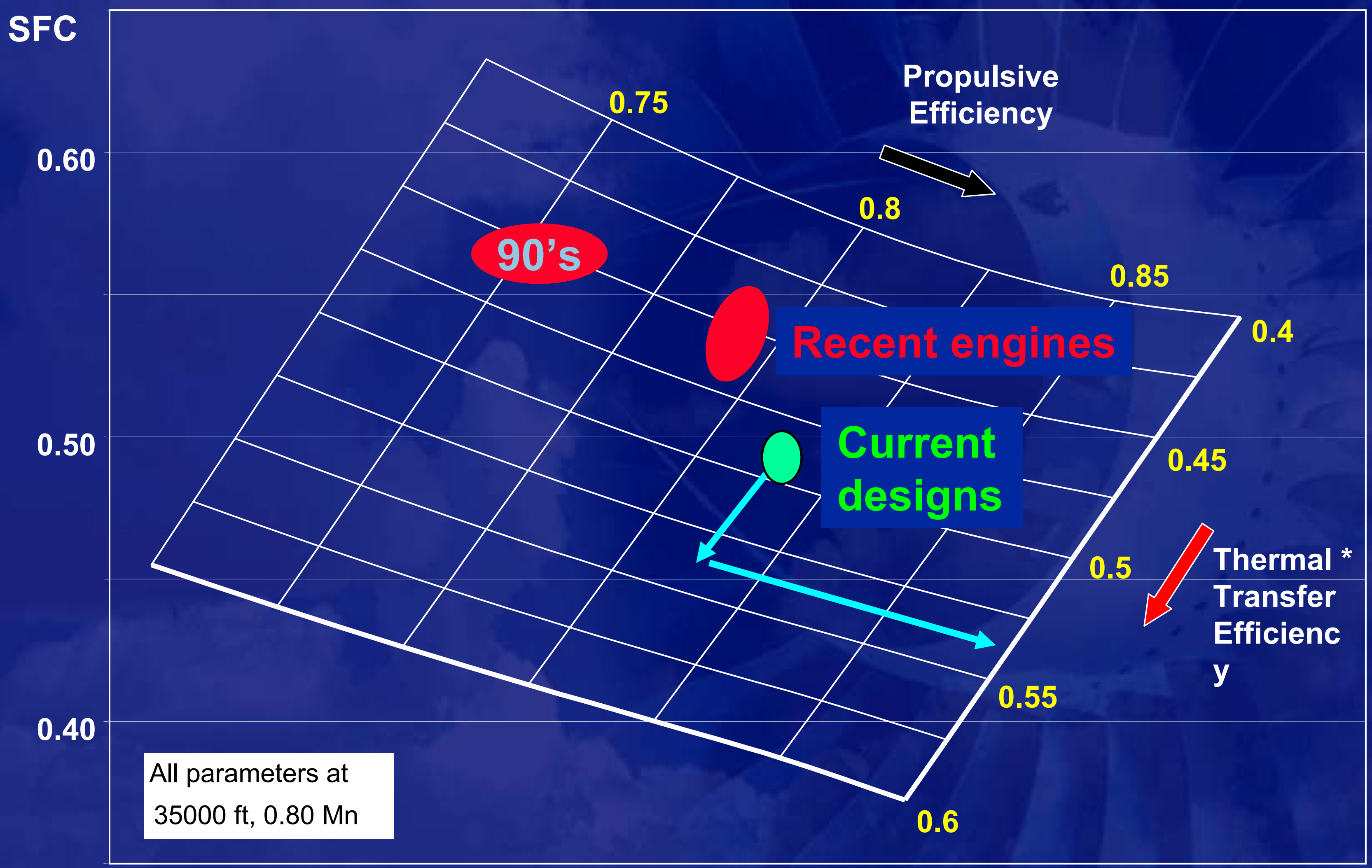
Affect on Future Product Capability



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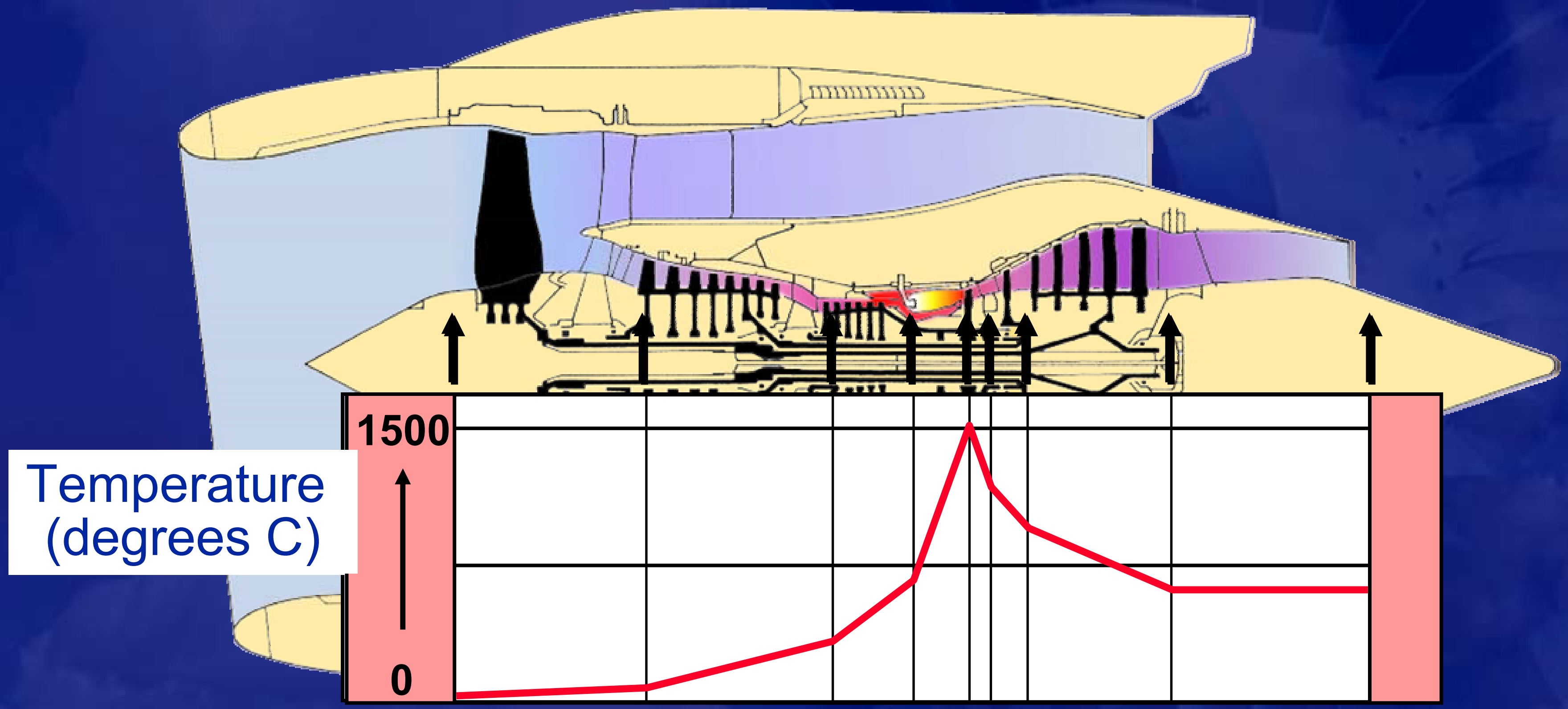
Turbofan Engine



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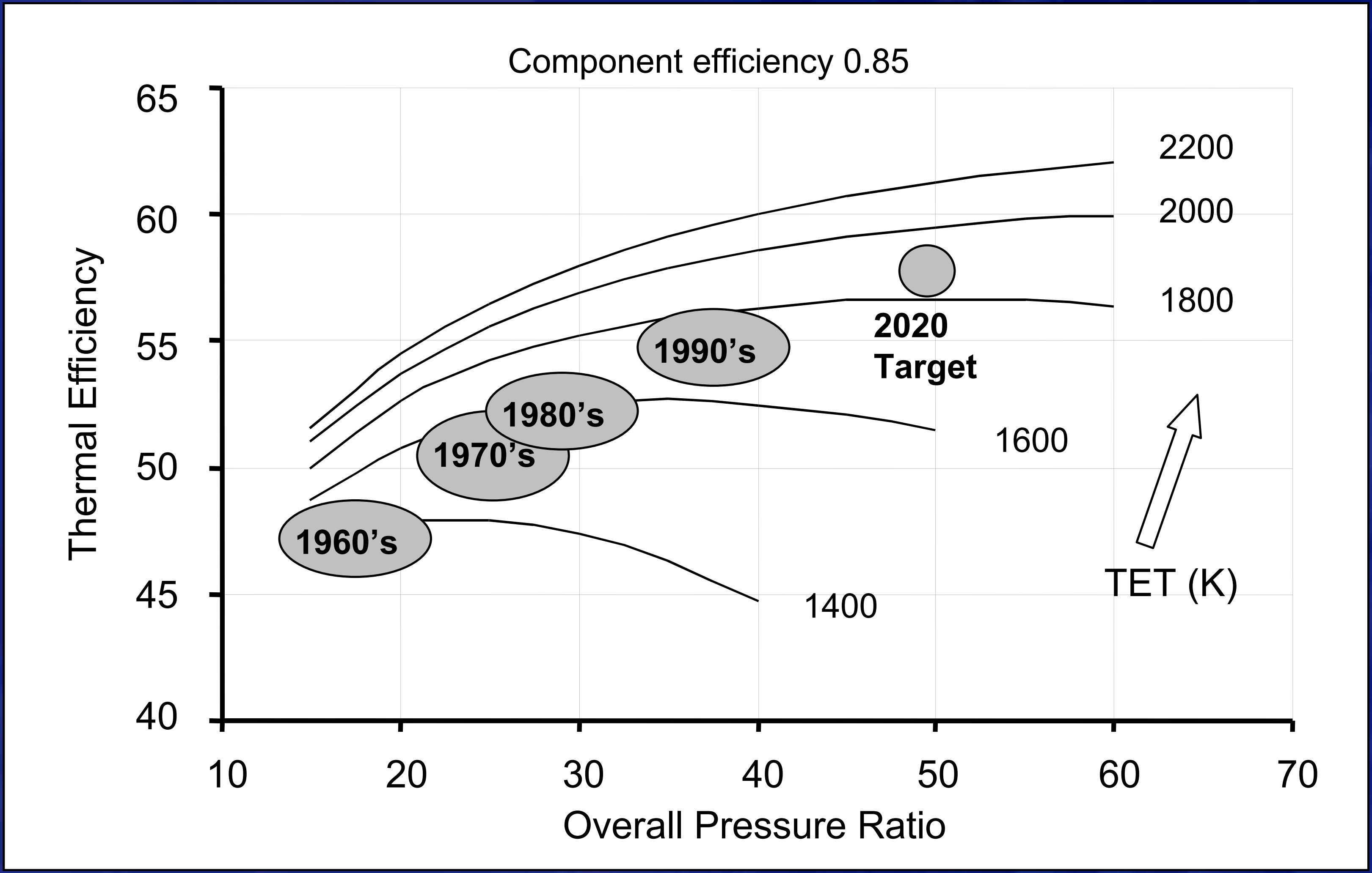
Factors influencing thermal efficiency



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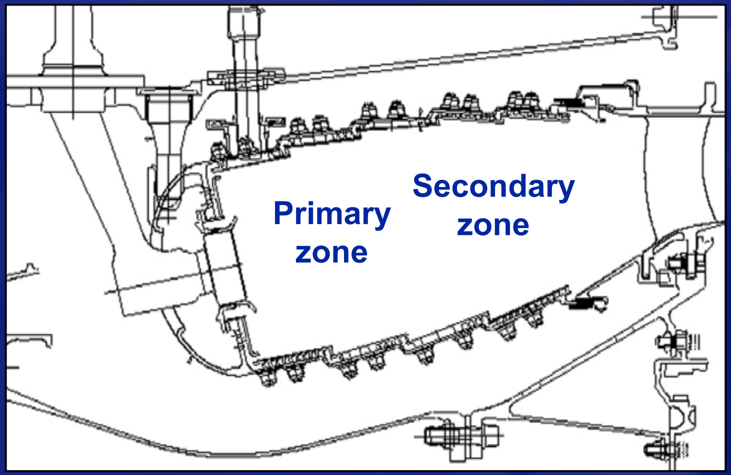
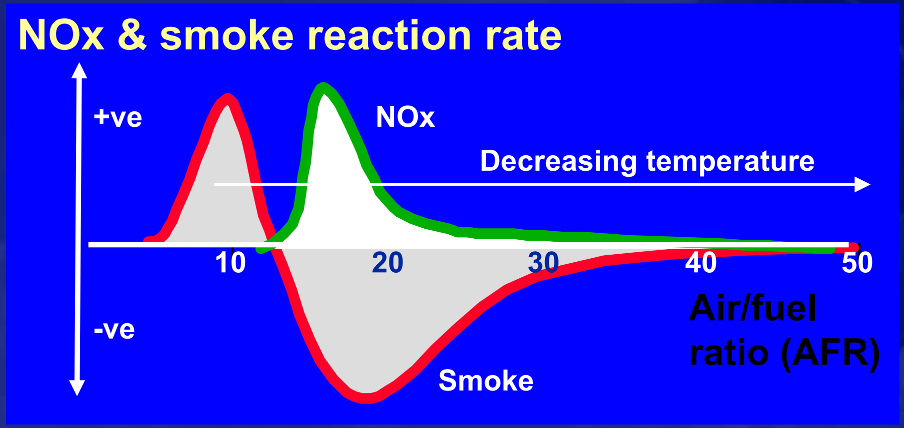
Emissions constraints





At idle:

- Combustor pressure and temperature are low, and primary zone is weak (high AFR)
  - — inhibits chemical reaction which creates CO and UHCs

At high power:

- Combustor temperature and pressure are high and primary zone is rich (low AFR)
  - — a fuel-rich mixture creates smoke which is burned off in secondary zone
  - — secondary combustion creates NOx establishing a trade with smoke

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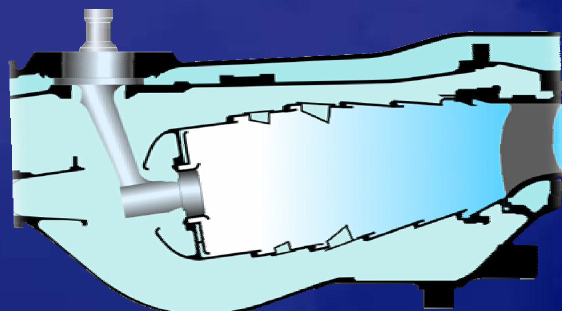
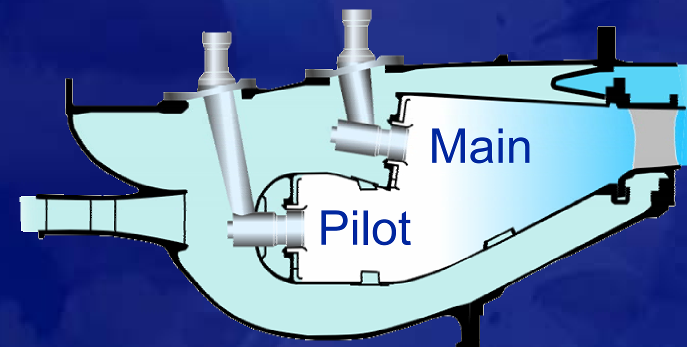
Forcing down emissions through innovation



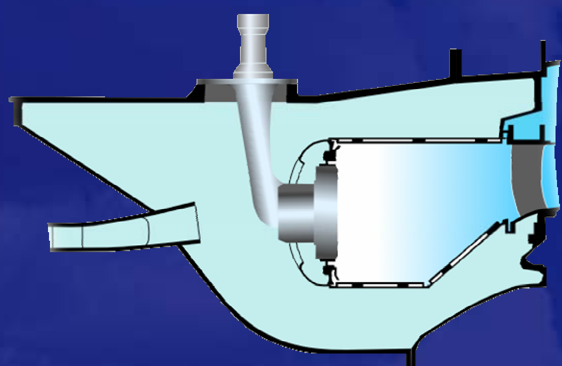
Single-annular combustor
70% CAEP 2

55% CAEP 2



Double-annular combustor

40% CAEP 2



Direct injection, lean burn single-annular combustor

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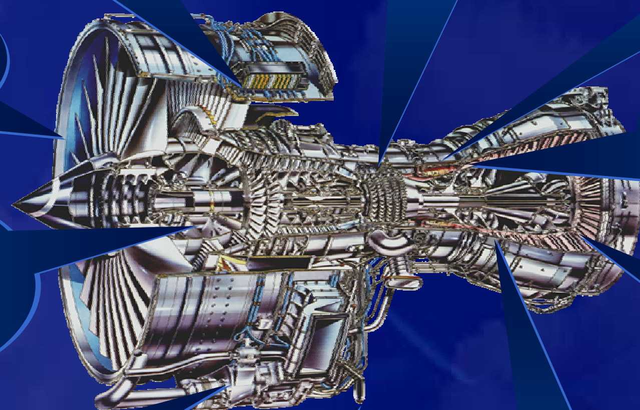
EEFAE - ANTLE - proving technology for 2008

Trent 500 baseline engine with new technologies incorporated



ANTLE = Advanced Near-Term Low Emissions

EU and UK government funded

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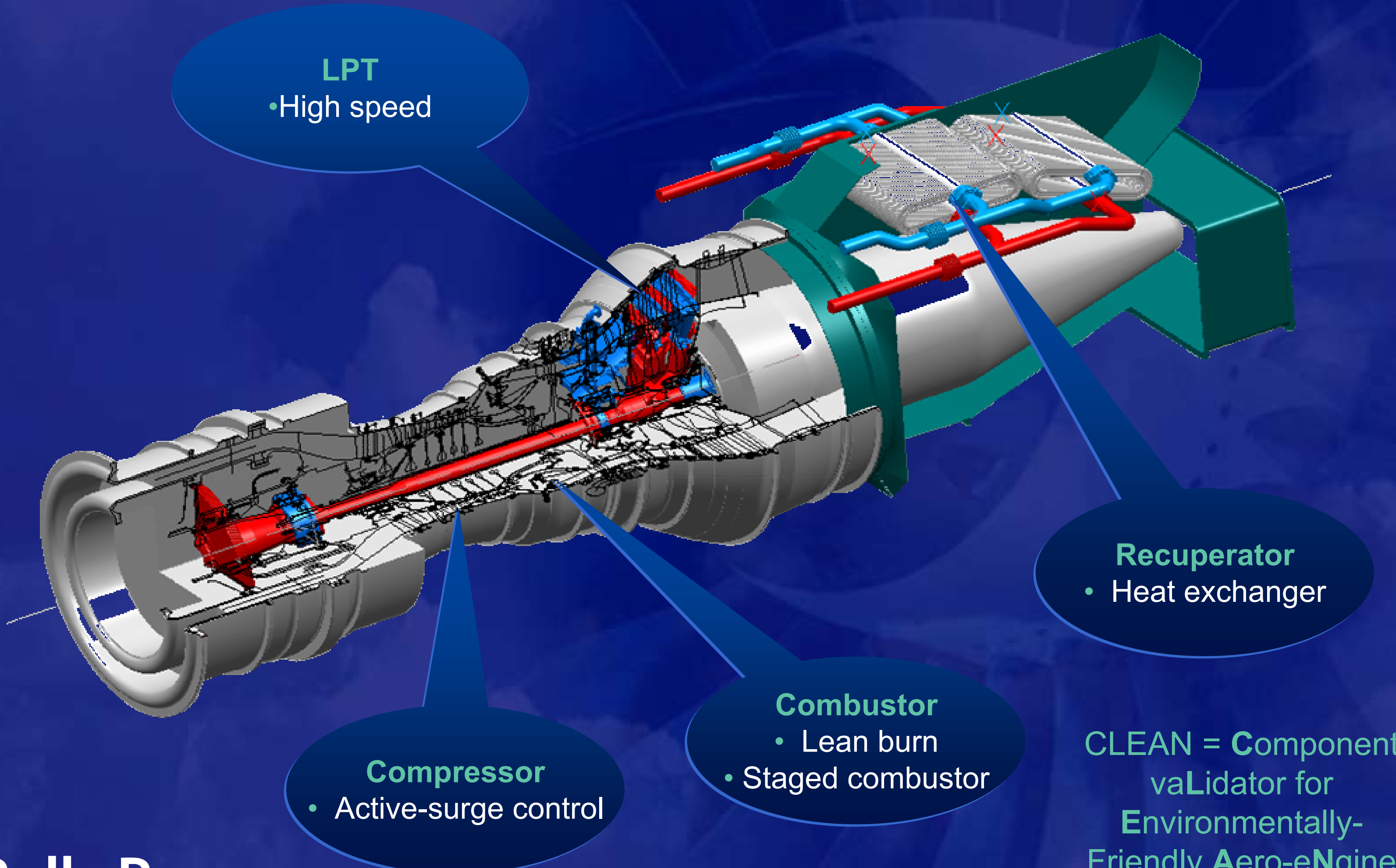
EEFAE – CLEAN for 2012 - 2015

HP core and LPT with new technologies incorporated



CLEAN = **C**omponent va**L**idator for **E**nvironmentally-Friendly **A**ero-e**N**gine

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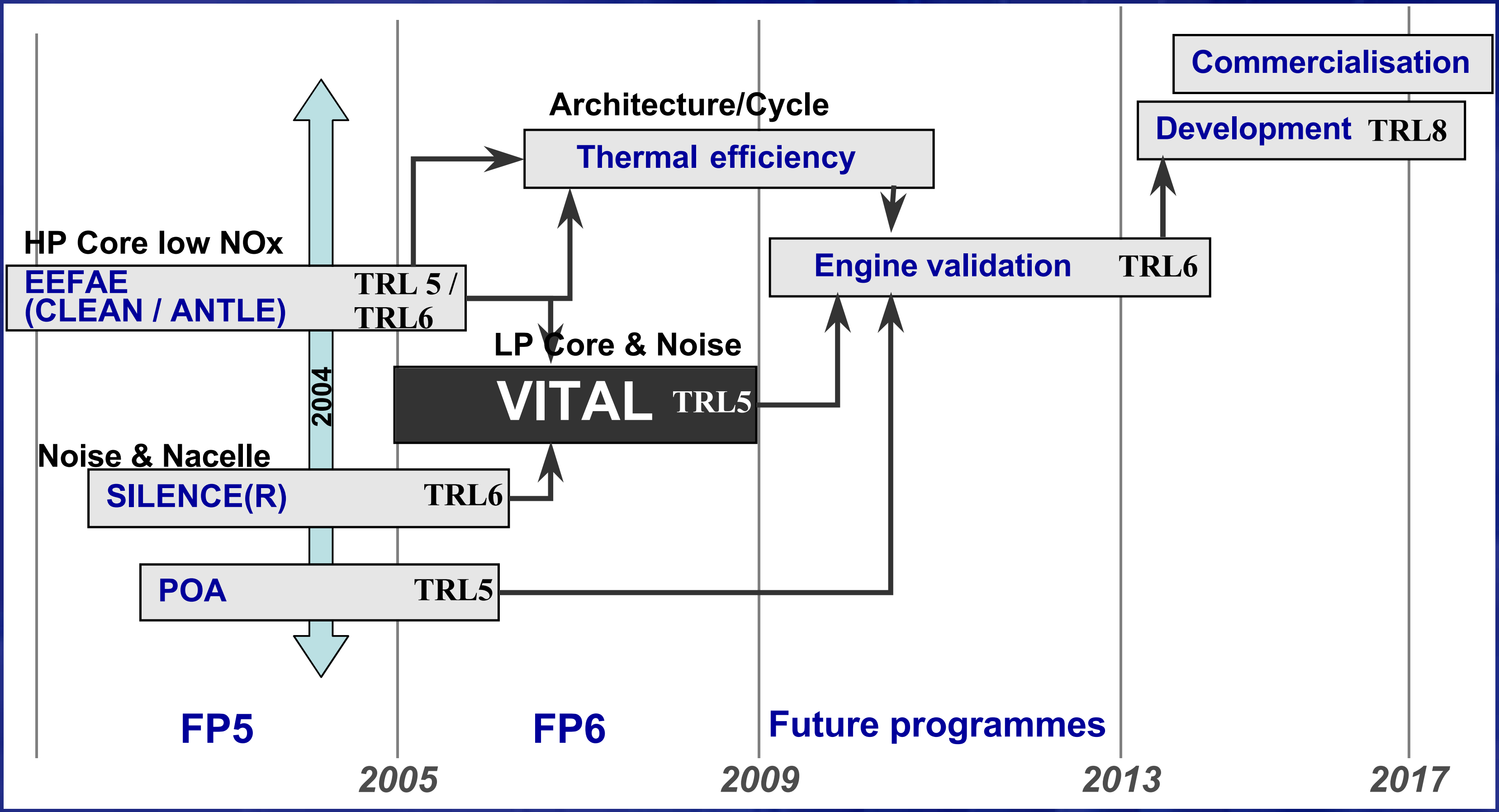
Engine technology development



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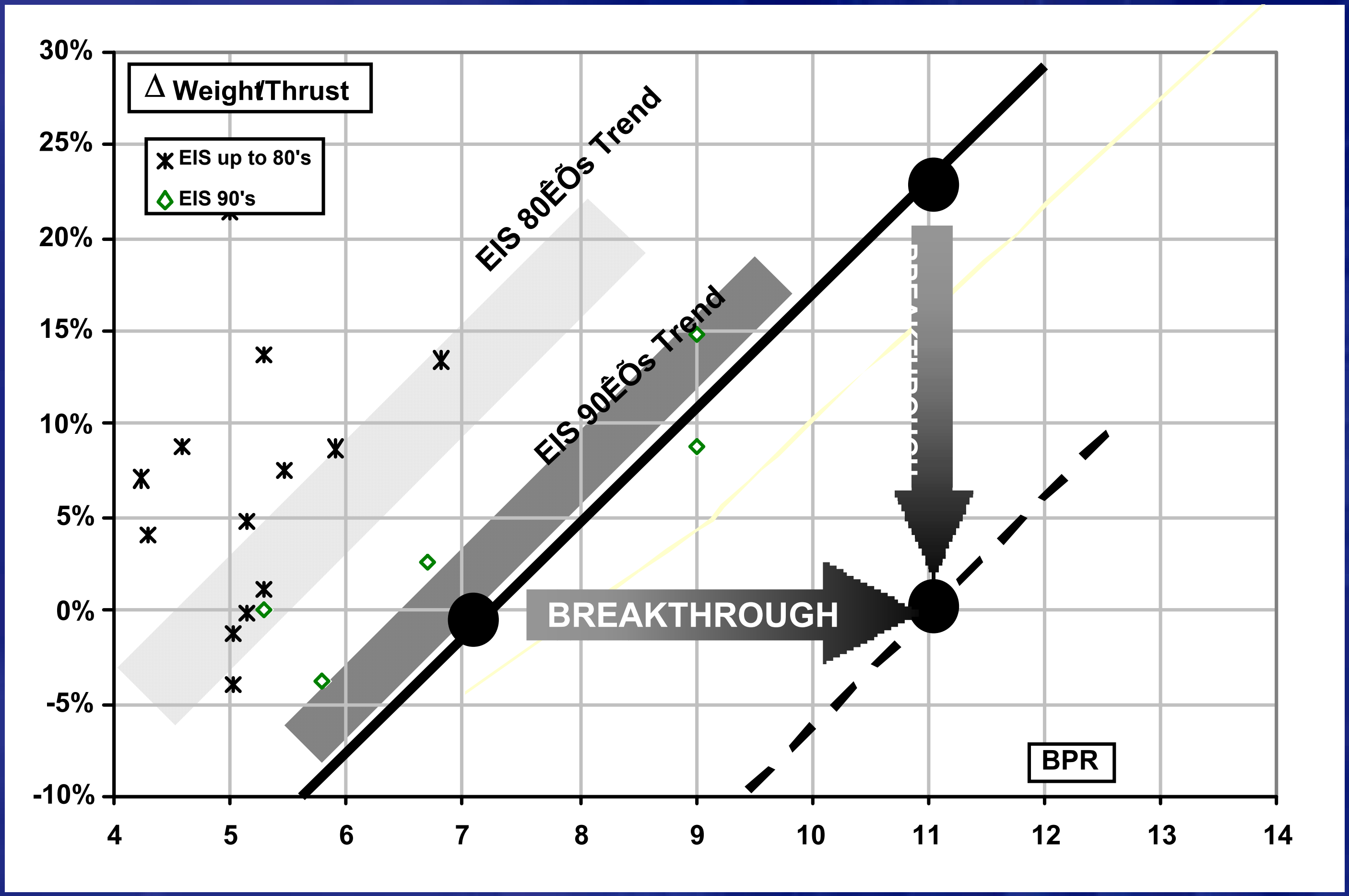
Objective of VITAL



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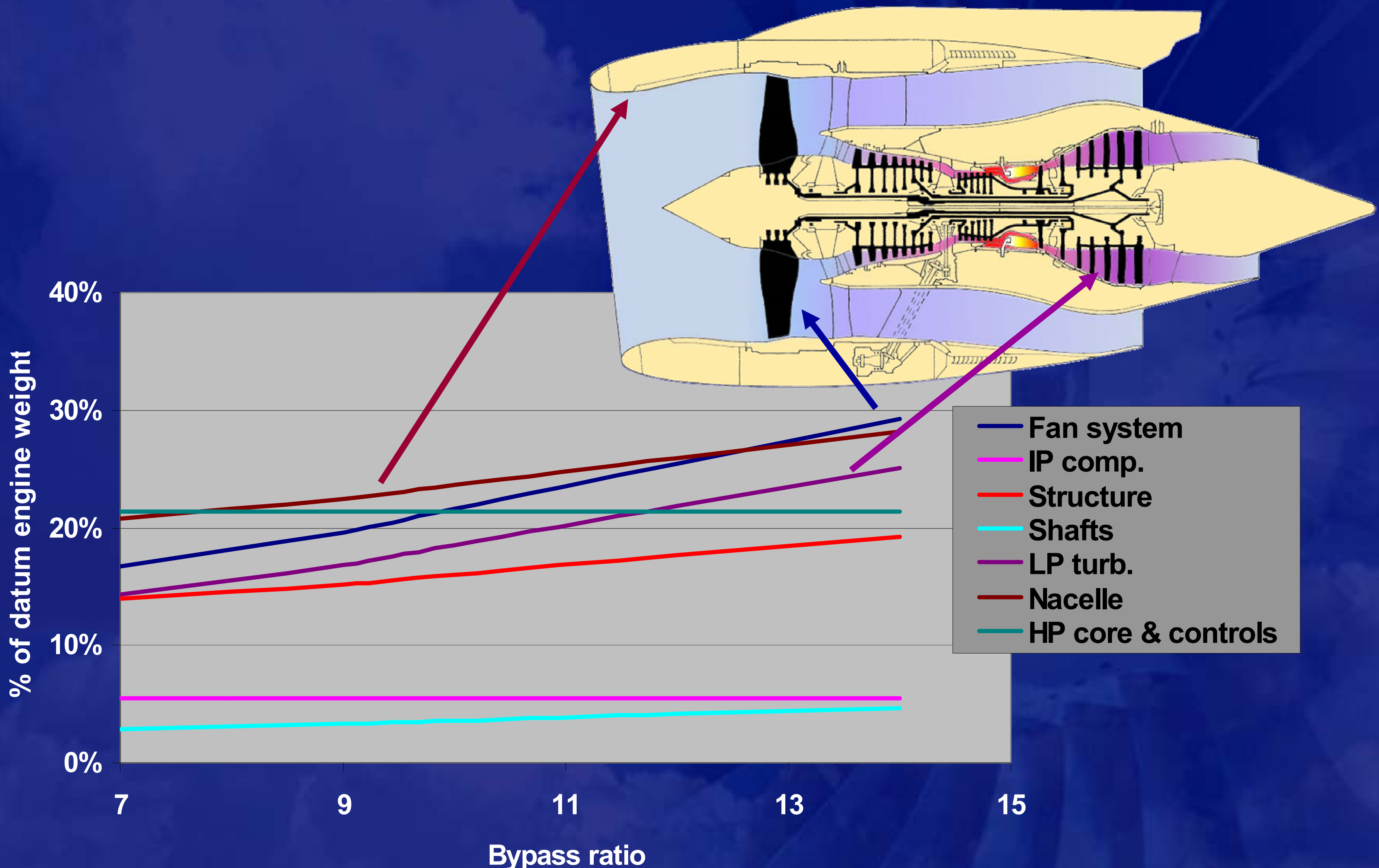
Weight breakdown of high BPR three shaft turbofan

	Proportion of total
Fan rotor & casing	18%
IP Comp.	5%
Structures	15%
Shafts	3%
LP Turb.	16%
Nacelle	22%
Core & externals	21%
	100%

Weight trends of subsystems



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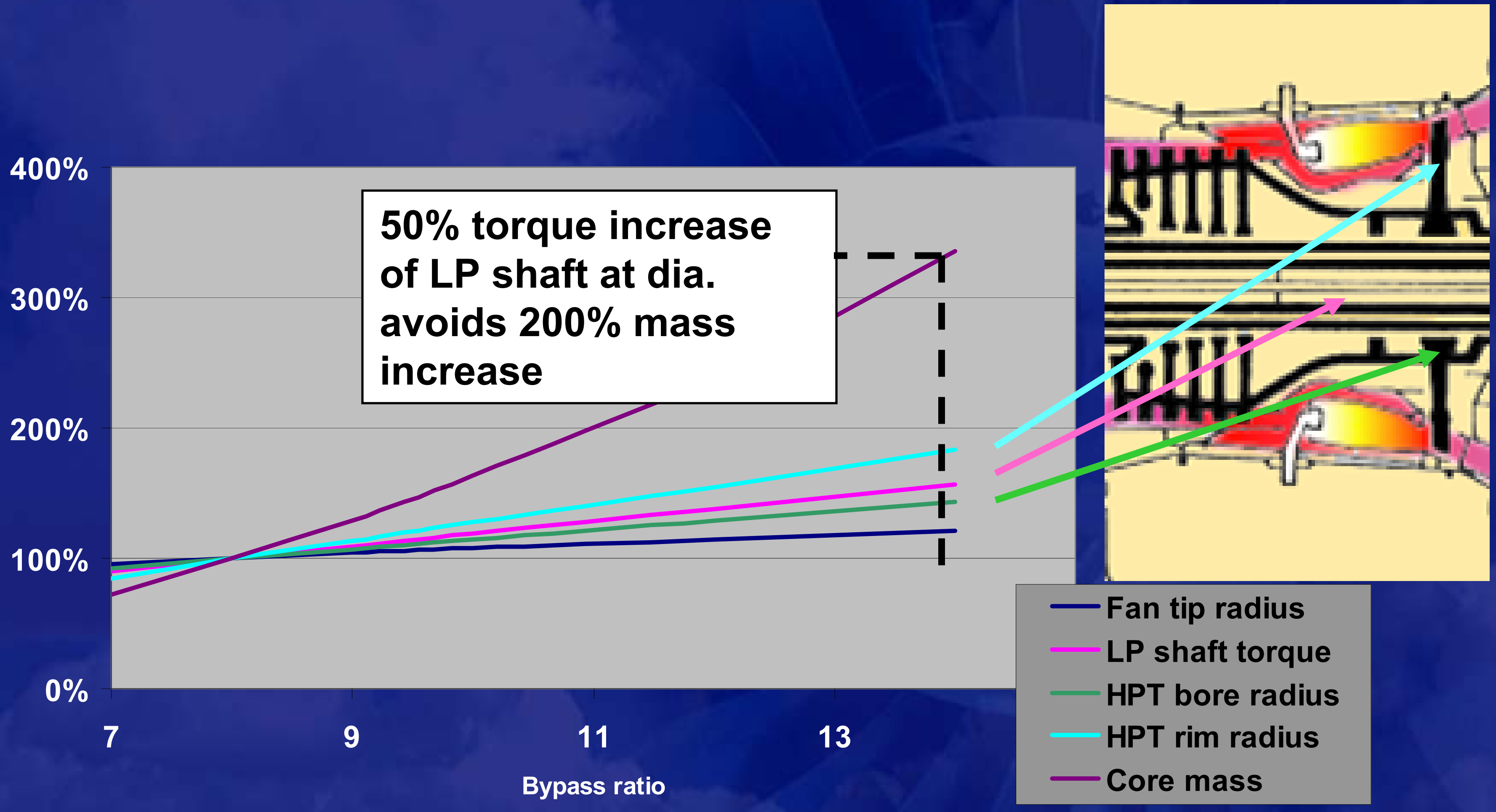
Effect of BPR & shaft torque on core mass



EU VITAL programme

Fan/IGV interaction

Noise optimised VHBR fans

Lightweight containment case

Lightweight structures

Lightweight Turbine

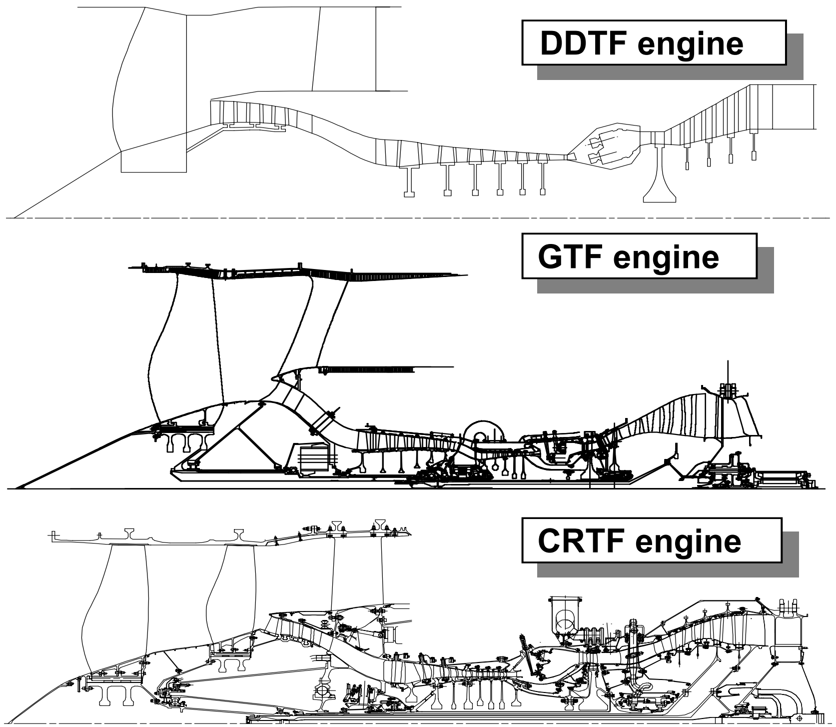
High Torque shaft

Low Noise Turbine

Lightweight Nacelle

Lightweight novel materials

Manufacturing techniques



DDTF fan

High Speed booster

Low Speed booster

Low noise OGV

Variable Nozzle

Contra rotating fan

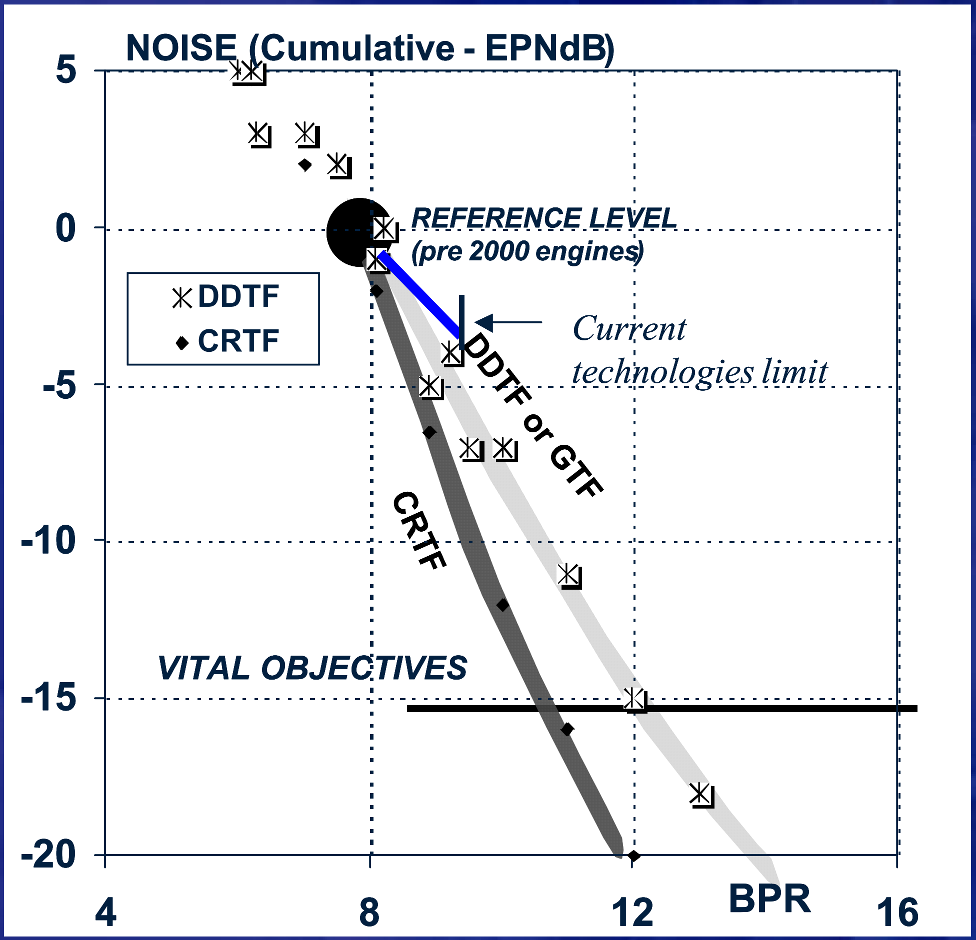
CR Turbine study

Applicable to all 3 VITAL engine concepts

Specific to a VITAL engine concept

Also applicable to other industries

Noise benefit from increased BPR



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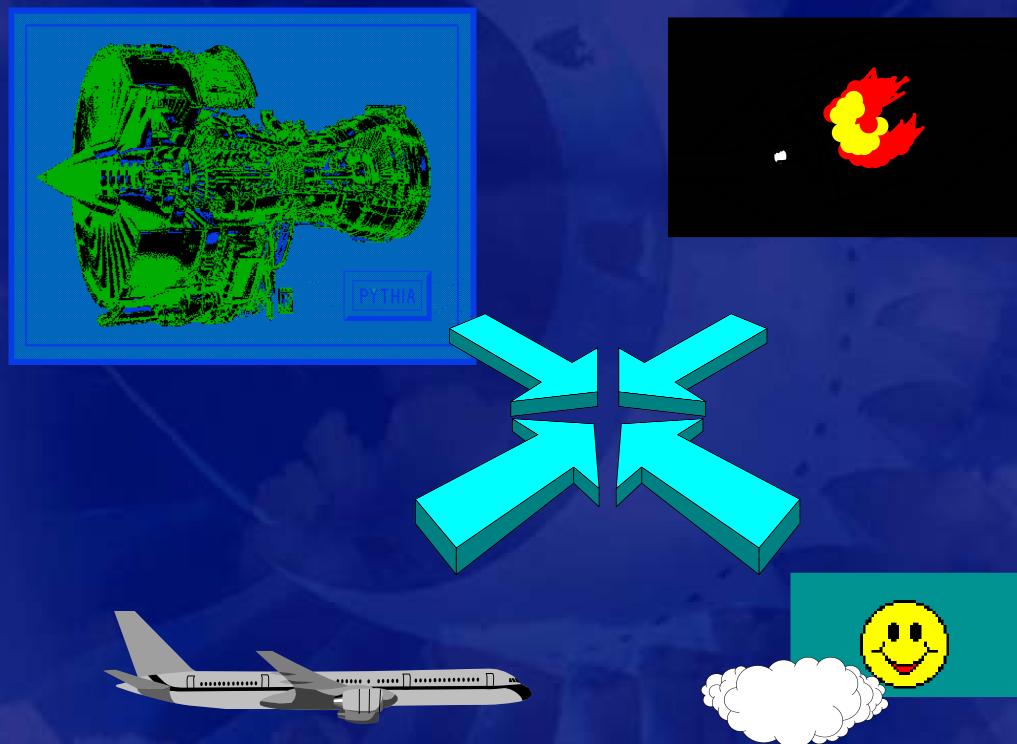
University lead modelling work

- **Assessing impact of VITAL technologies**
- **Combines**
  - Atmospheric modelling
  - Routes/ fleet mix
  - Aircraft performance
  - Engine performance
    - Parametric
  - Engine weight
    - Parametric
  - Engine emissions
  - Economic modelling
- Optimiser software seeks ‘sweet spot’ for any scenario



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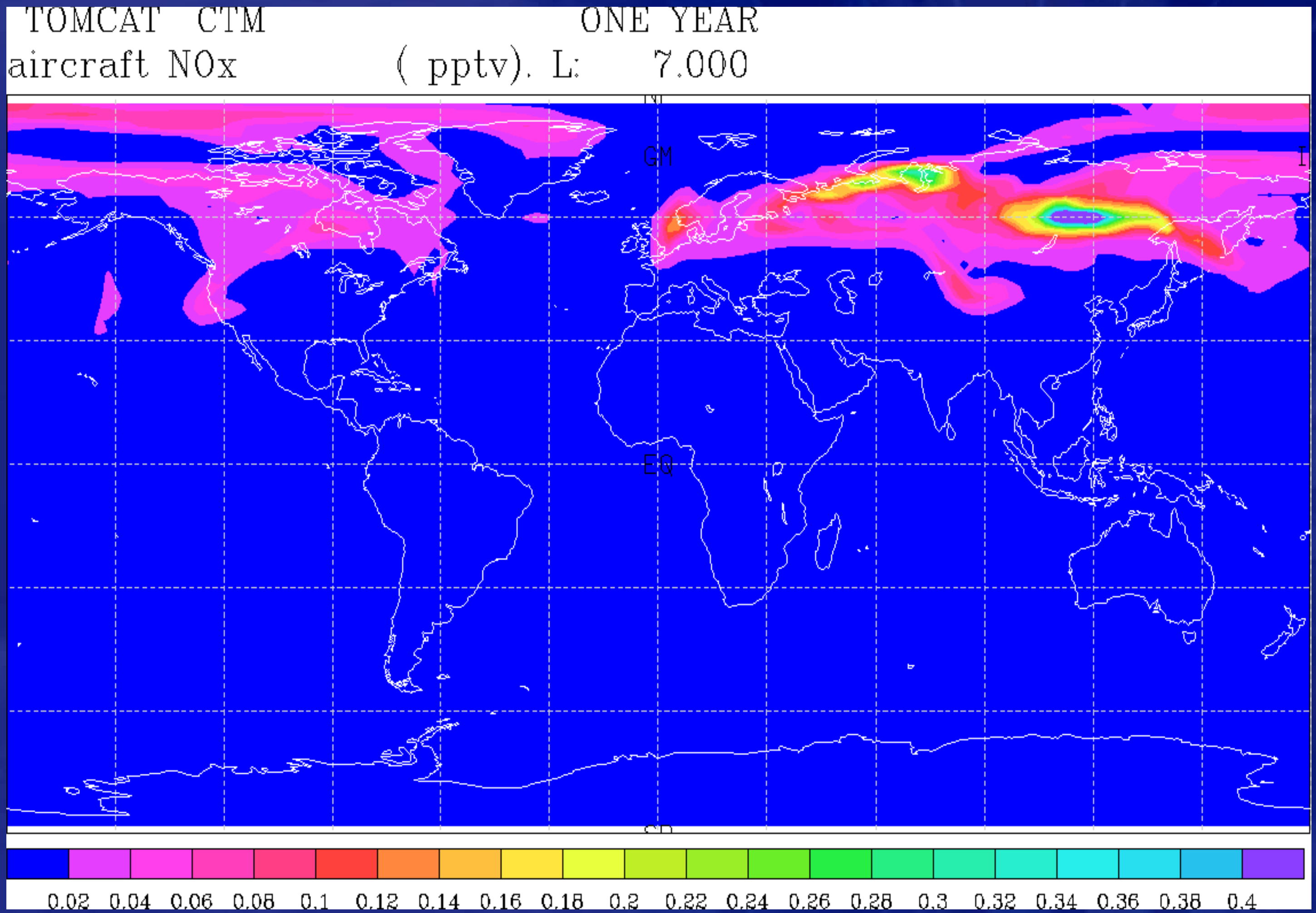
Mission NO_X modelling



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Trent 1000

- Latest in evolution of Trent series of engines
- Achieves improvements in line with ACARE goals

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Fuel consumption (and CO_2) reduction

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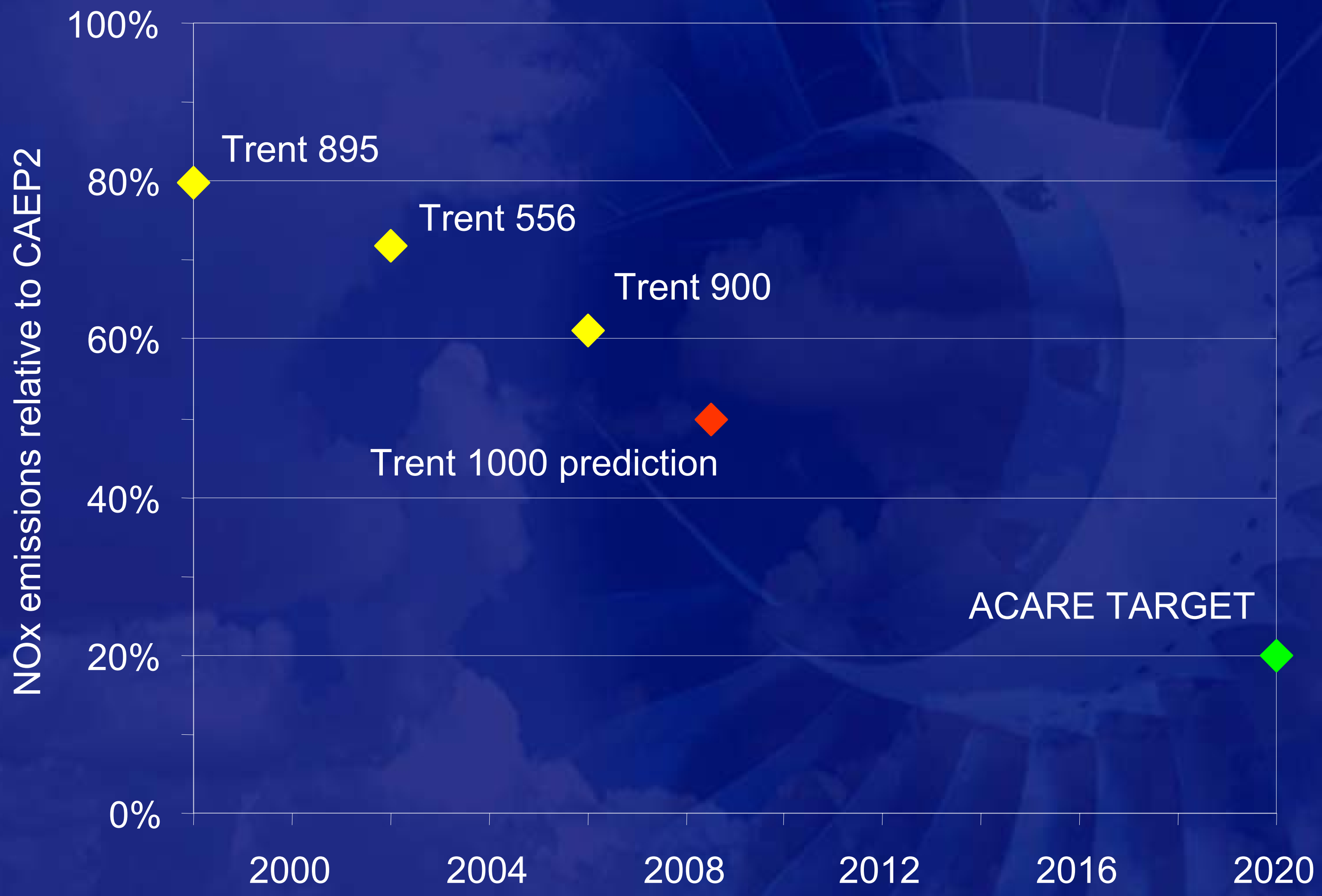
NOx emissions reduction



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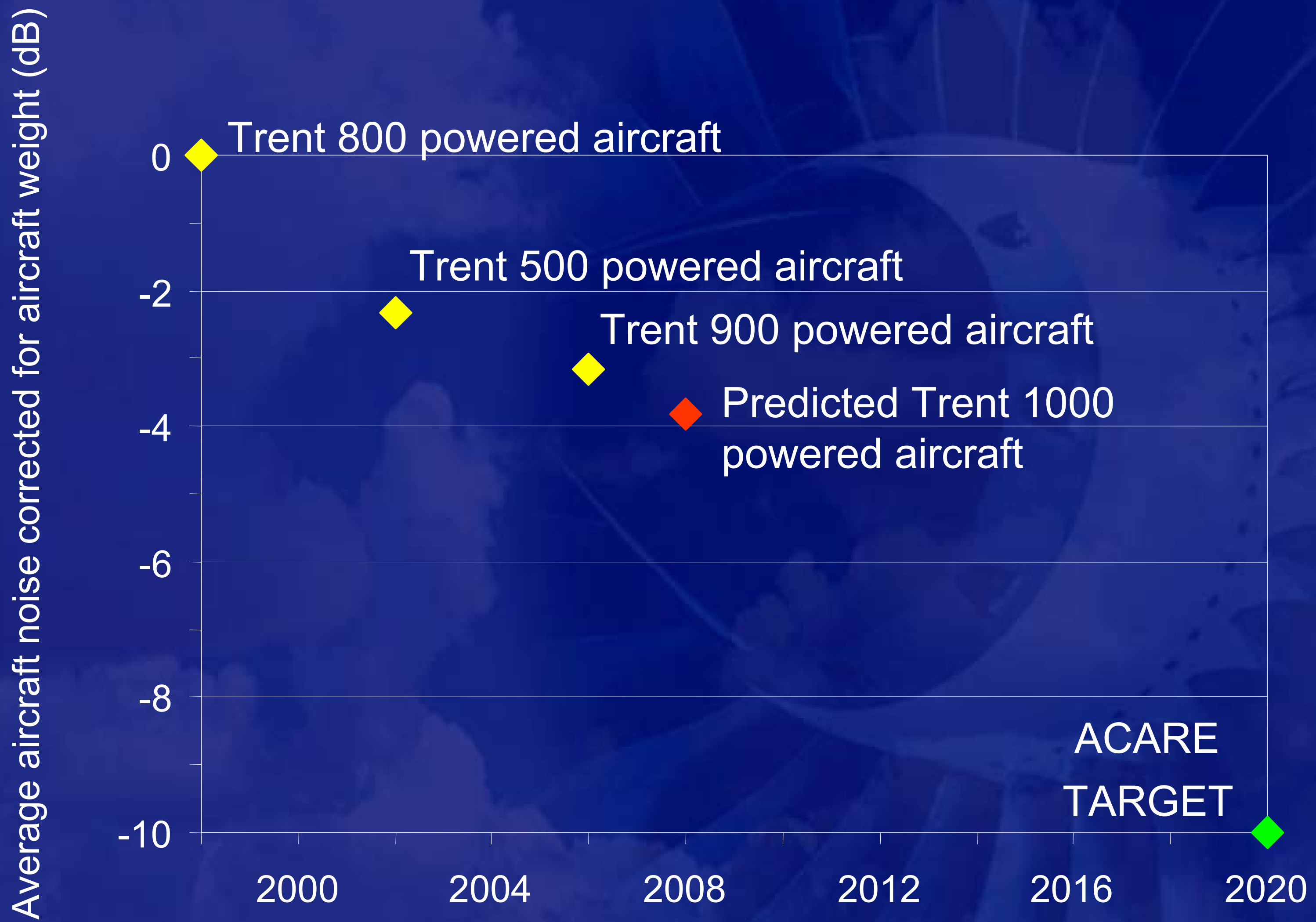
Aircraft noise reduction



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Summary

- There is significant potential for technology to further reduce the environmental impact of aviation
- ACARE targets focus on noise, NOx and fuel burn (CO_2 emissions)
- Good progress is being made towards these targets by combining the efforts of all
- Sustained and increased levels of investment in technology will be required to achieve ACARE goals

- But……although they are extremely challenging, are the ACARE goals sufficient for sustainable aviation?

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