THE NEXT 20 YEARS :

THE CHALLENGE OF ENVIRONMENT

IN EUROPE

Christian Mari

PART 1

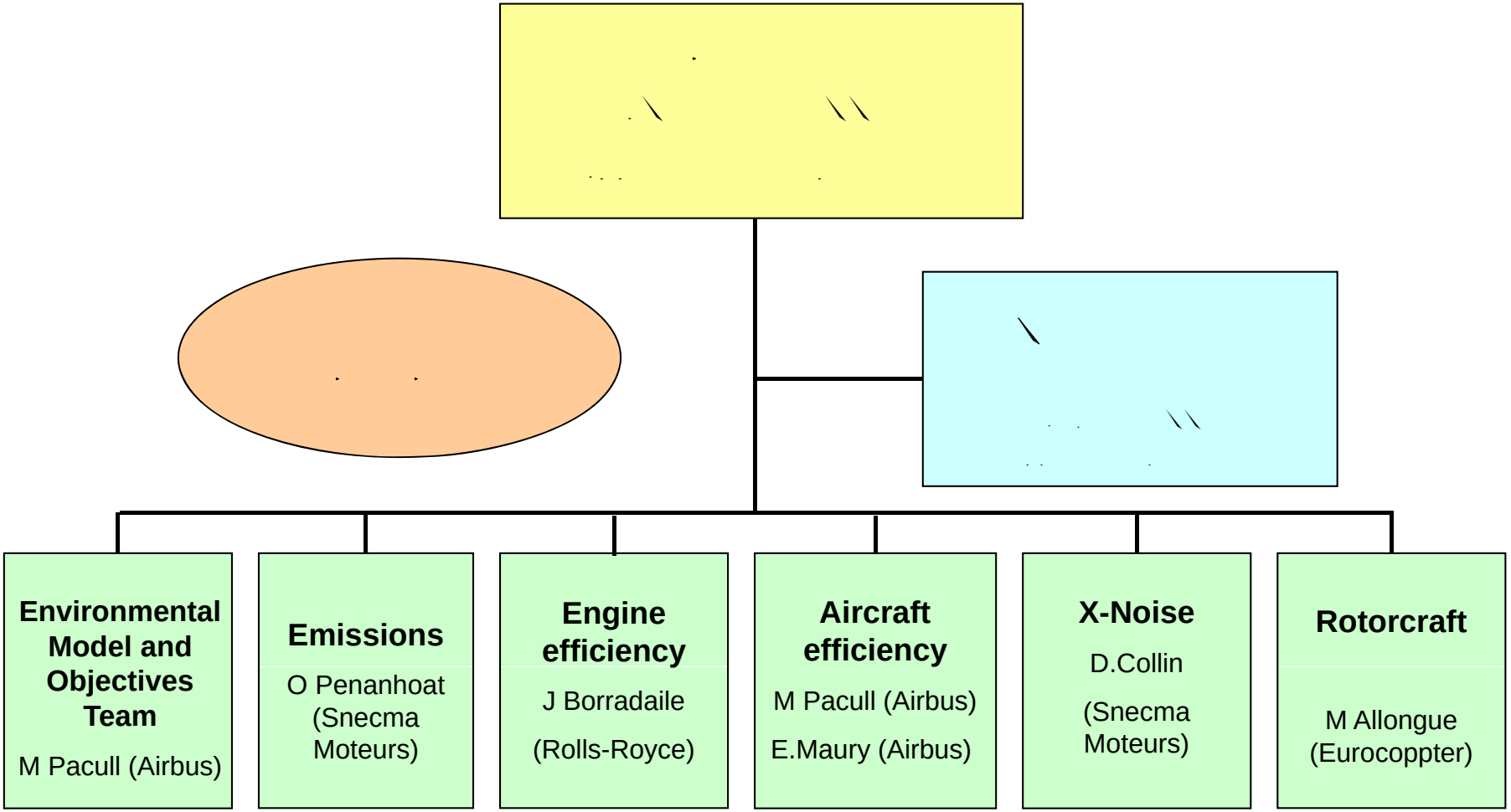
ACARE

STRATEGIC RESEARCH AGENDA

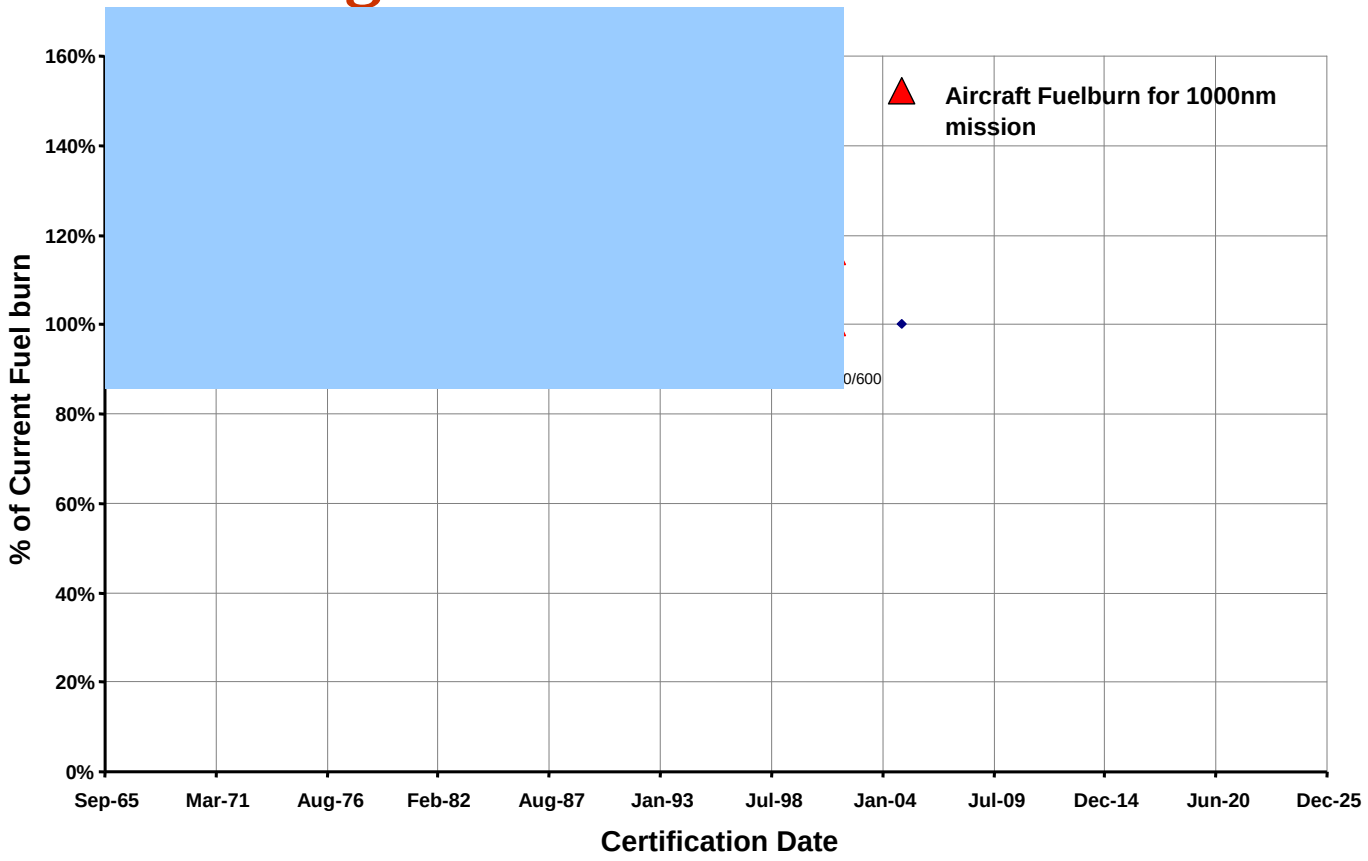
THE CHALLENGE OF ENVIRONMENT

WORKING TEAM 2

SRA1 : Organisation of WT 2 - Environment



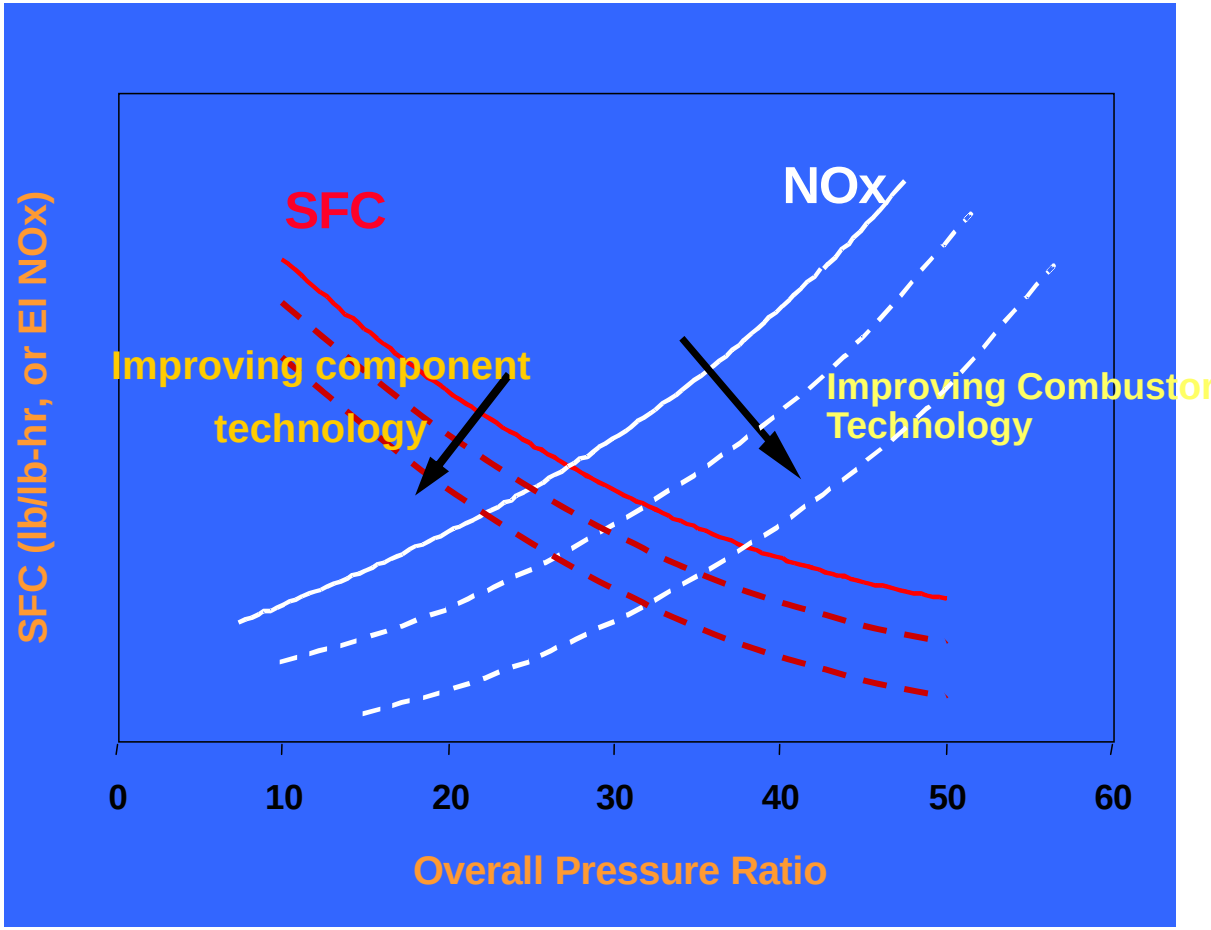
Background for CO2 Emissions



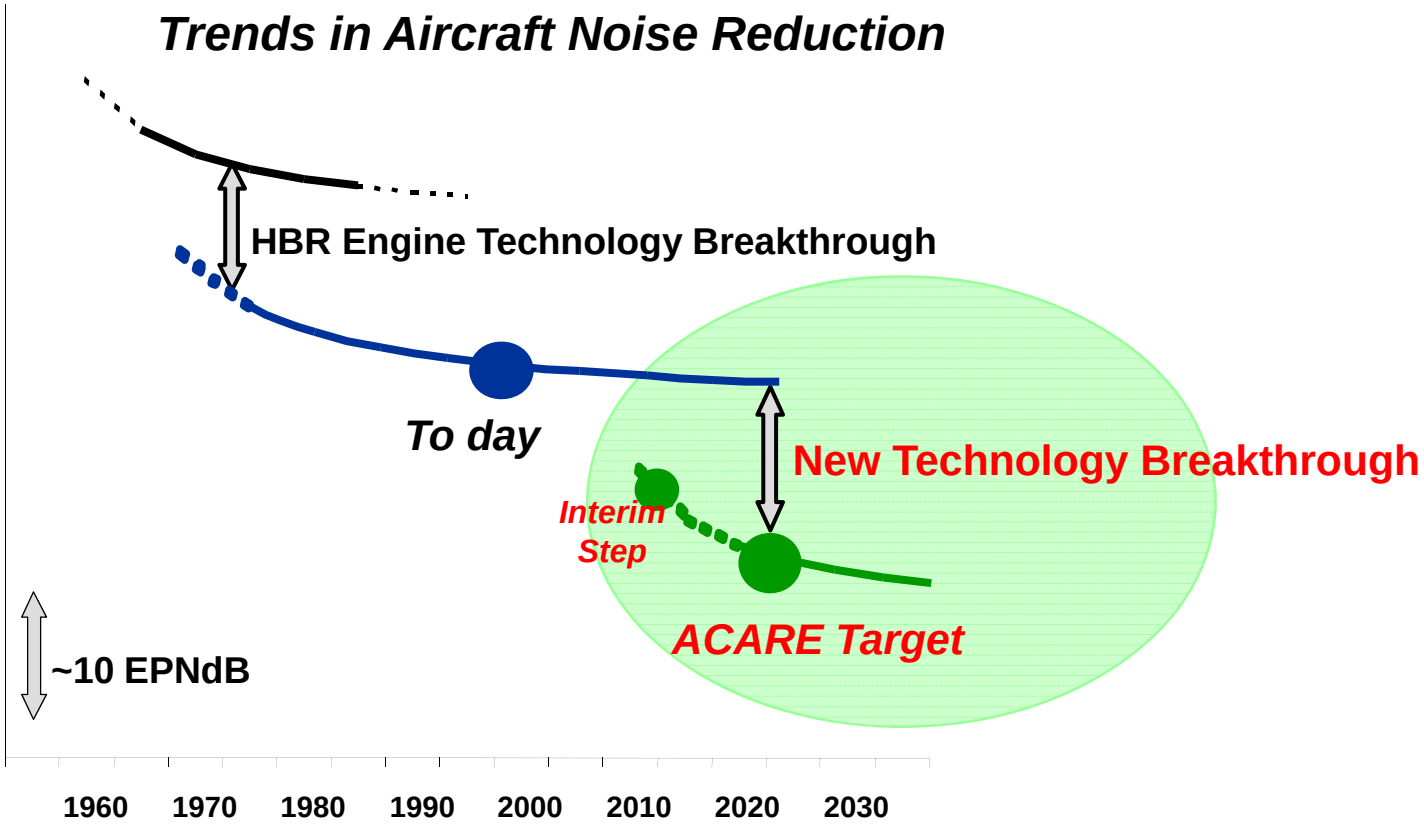
- Introduction of high bypass-ratio turbofan engines in the 1970's and then increasing cycle pressure ratio and BPR have reduced fuel consumption
- But increasing cycle pressure ratio increases Nox emissions
- To reach the 2020 targets : need for breakthrough technologies

Trade-off between CO2 and NOx

- Higher engine pressure ratio and bypass ratio reduce CO_2 by improving fuel efficiency (SFC) and facilitate noise reduction by reducing exhaust jet velocity
- Higher pressure ratio requires higher flame temperature, reducing CO & HC, but increasing NOx formation rate
- Better NOx technology is needed to avoid increased emissions
- Better engine technology is needed to avoid CO_2 increased emissions



Background for Noise



- High bypass-ratio (BPR) turbofan engines represented a technology breakthrough allowing a 20 db noise decrease in 40 years.
- To reach the 2020 targets : need for new breakthrough technologies

SRA1 Objectives

1) Reduce CO2 by 50% per passenger kilometre (assuming Kerosene remains the main fuel in use)

2) Reduce perceived noise to one half of current average levels

3) Reduce NOx emissions by 80%

4) Minimise the industries impact on the global environment

Contributors

10 contributors to the 4 goals :

1) Reducing CO2 emission
   - The efficient Aircraft
   - The efficient Engine
   - ATM of the future
   - Alternative fuels
2) Reducing external noise
   - The Quiet Aircraft
   - The Rotorcraft of the future
   - Noise abatement procedures
   - Community impact management
3) Reducing Nox and other species
   - The Clean Engine
4) Environmentally Friendly Manufacturing, Maintenance and Disposal (MMD) Process
   - The green MMD

Objective 1 : Reducing the Co2 Emissions

Contributors :

- The Efficient Aircraft
  - Improvement, by conventional technologies, of aerodynamics and weight
  - Radically new aircraft concepts.
- The Efficient Engine
  - Improvement, by conventional technologies, of propulsive and thermal efficiencies
  - New engine concepts.
- ATM of the Future

  A more efficient ATM system (optimised routes, reduced holdind and taxiing…) will contribute to CO2 emissions reduction
- Alternative fuels

  Bio-fuels, synthetic fuels, H2, CH4...

Reducing Co2 Emissions : The efficient Engine

- Fuel efficiency of civil engines (= CO2 emissions) has been improved by :
  - Increased overall pressure ratio
  - higher temperature cycles
  - better materials and cooling
  - more efficient turbo-machinery and high BPR architecture
- Nox emissions have remained relatively steady since the rising compressor delivery temperature associated with overall pressure ratio favours Nox production
- Noise optimised solutions also tend to compromise fuel efficiency
- Contribution of engines to the target of 50 % reduction in CO2 = 15 to 20 % specific fuel consumption (SFC) decrease
- SFC decrease target will not be achieved without unconventional, higher risk solutions.

Objective 2 : Reducing External Noise

Contributors :

- The Quiet Aircraft
  - Conventional Technologies improvements
  - Engine integration
  - Radically new Aircraft concepts
- The Rotorcraft of the Future
  - Conventional technologies improvements
  - Radically new vertical lift vehicles concepts
- Noise Abatement Procedures

  Need for new procedures to be included in the future ATM approaches that will enable low noise flight profiles
- Community Impact Management
  - Physical, biological, psychological and sociological factors study
  - Harmonised view at local, regional and national levels

Towards SRA 2

October 2002

- Strategic Research Agenda (SRA1) Publication
    - WT 1 : Quality and Affordability
    - WT 2 : Environment
    - WT 3 : Safety and Security
    - WT 4 : ATM

January 2003

Decision to prepare SRA2 aimed at integration and implementation of SRA1

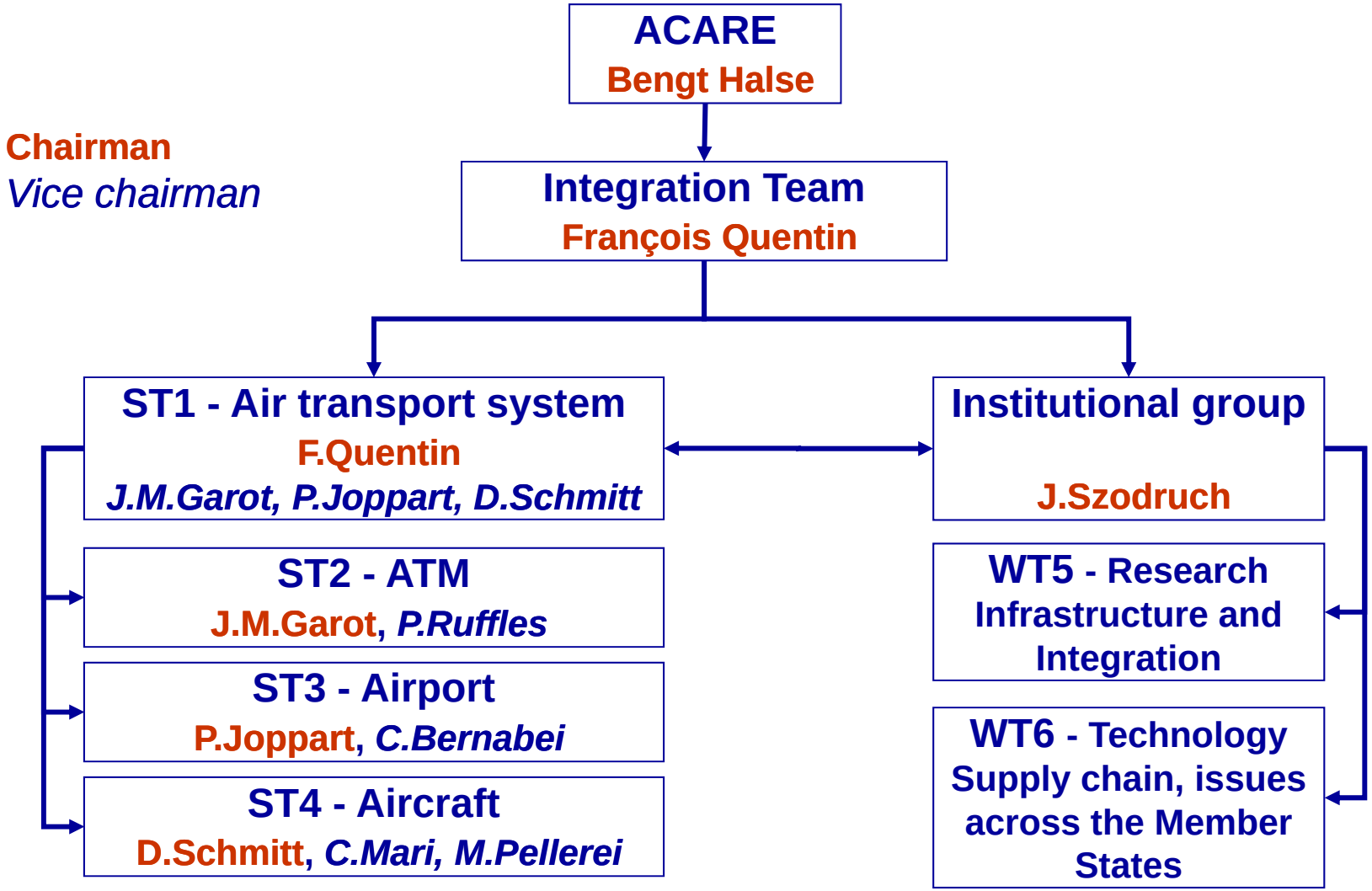
Mid-2003

Launch of the new working structure for SRA2 and presentation of the “Target Concepts”

June 2004

Publication of SRA2

Towards SRA 2



PART 2 :

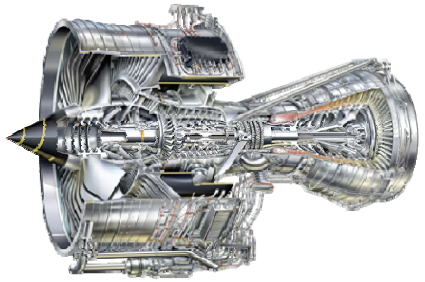
THE CHALLENGE OF ENVIRONMENT

THE ANSWER OF THE EUROPEAN AERO-ENGINE COMMUNITY

ACARE : Implications to Aero-engine

The ACARE Goals 2020

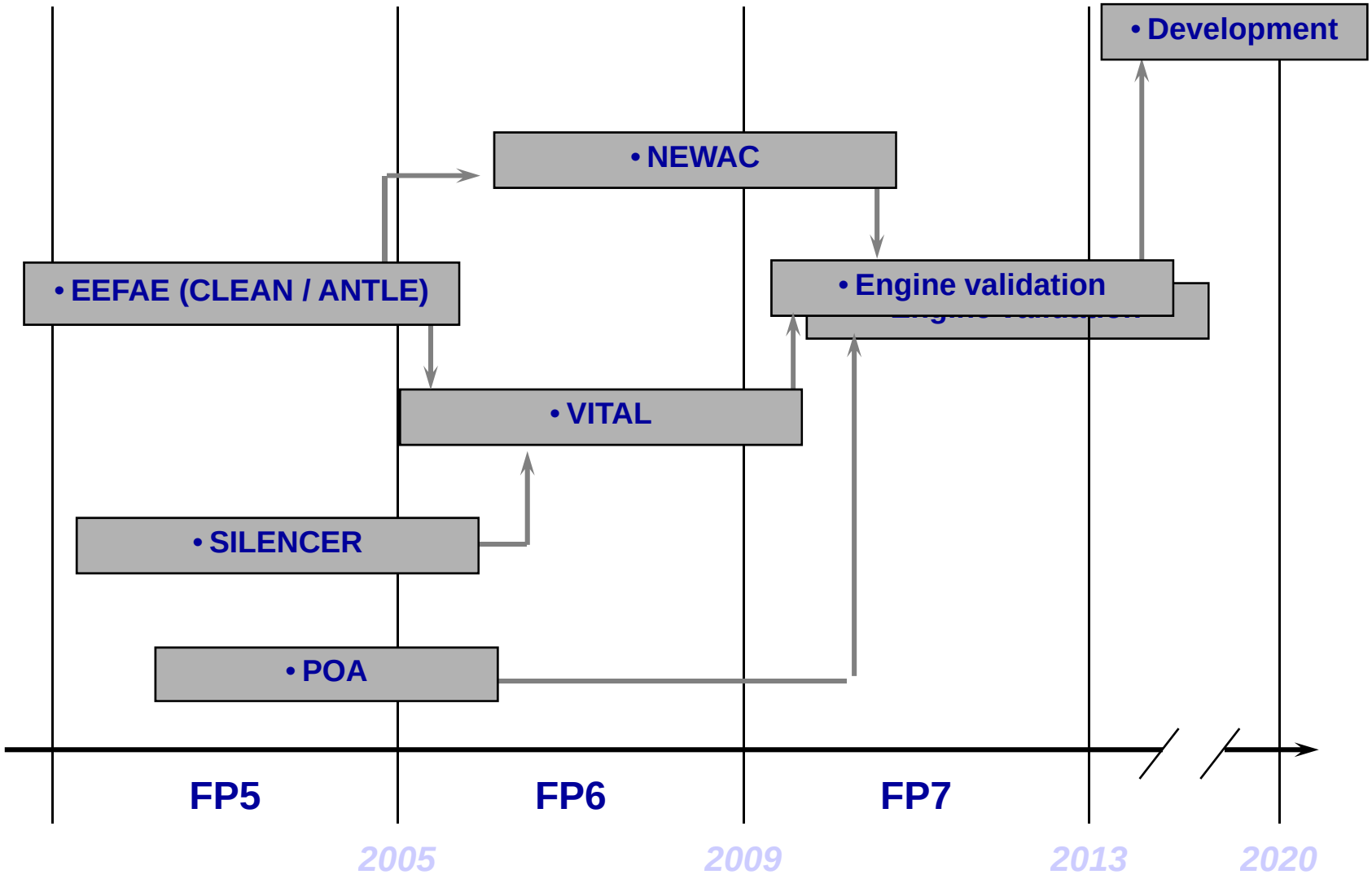
- **Half** current perceived average noise levels
- **80%** cut in NOx
- Reduce CO_2 by **50%** per passenger km
- Affordability



Engine contribution to ACARE goals (relative to 2000 in service engines)

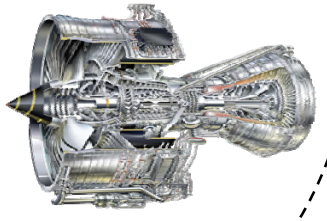
- **6dB** noise reduction at each certification point
- **80%** reduction in Nox
- **20%** fuel burn reduction
- Affordability

Towards the ACARE Goals



Evolution of Engines for Noise

Datum : Engine in service in 2000



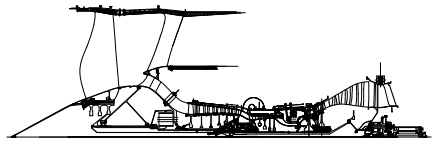
Evolutionary Technologies

SILENCER
FP5

Noise reduction technologies on conventional aircraft/engine configuration

Revolutionary technologies for SRA Objectives

Conventional Fan



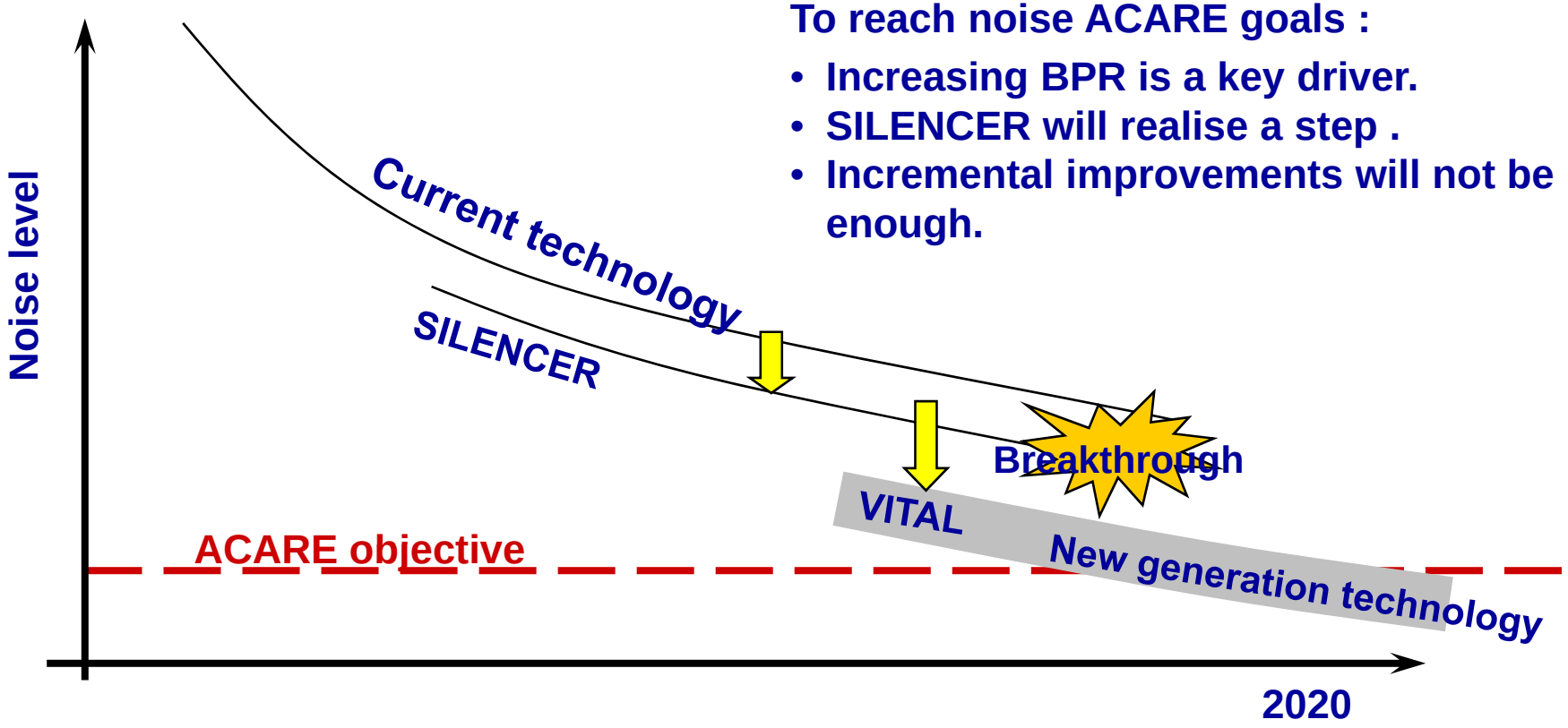
Geared Fan

Contra Fan

VITAL
FP6
2nd call

Novel engine architecture for noise and fuel burn reduction

Noise Issues



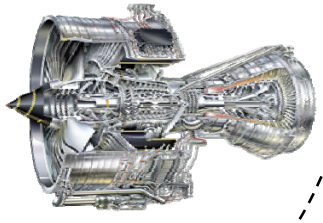
To reach noise ACARE goals :

- **Increasing BPR is a key driver.**
- **SILENCER will realise a step .**
- **Incremental improvements will not be enough.**

A technology breakthrough is needed

Evolution of Engines
for Nox and CO2 Emissions

Datum : Engine in service in 2000



-12% CO2
- 60% Nox

ANTLE
FP5

CLEAN
FP5

-20% CO2 partial demonstration
-80% Nox

SRA1 objectives

VITAL
FP6
2nd call

-20% CO2 mainly from propulsive efficiency

SRA1 objectives

NEWAC
FP6
3rd call

-20% mainly from thermal efficiency