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# Environnemental challenges in Aeronautics

« Research in Advanced Aeronautics Combustion Chambers »

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## Engine contribution to environmental objectives

**Objectives ACARE 2020**
(Advisory Council for Aeronautics Research in Europe)

- ➢50% reduction of noise
- ➢80% reduction of NOx emission
- ➢50% reduction of CO2

ATM Contribution

Aircraft Contribution

Engine Contribution

- ➢6 db Reduction of noise
- ➢60 to 80% Reduction of Nox
- ➢20% Reduction of kerosene consumption

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## Physical principles for an environmental compromise

**Increase the pressure ratio**
- ➢Reduction of fuel / CO2 ratio by an enhancement of the energetic efficiency
- ➢Reduction of unburnt HC and CO emissions
- ➢Increase of NOx emissions due to an increase of the combustion chamber temperature
- ➢Increase of the maintenance cost

**Increase of the by-pass ratio of the engine**
- ➢Reduction of fuel / CO2 ration by an enhancement of propulsive efficiency
- ➢Reduction of noise by reduction of the rotation speed of the fan, the pressure ratio, exhaust velocity of gases
- ➢Increase of weight, shear and maintenance cost

**Enhancement of aerodynamics and weight reduction**
- ➢Efficiency level already reached
- ➢Reduction of CO2 by enhancing the fuel efficiency and the thrust
- ➢Reduction of noise by reducing the needed thrust
- ➢Reduction of Nox emissions by reducing the combustion temperature

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## Research challenges

**Development of new physical models for:**
- ➢Development of chemical kinetic models (combustion, NOx and particles production ,..)
- ➢Development of numerical tools (mesh, equation solving,.) for chamber design

**Need of experimental studies for numerical validation**
- ➢Validation of physical models in academic experimental configurations
- ➢Development of adapted diagnostic techniques, using often laser (hostile mediums, weak or any optical acces for measurements (velocity, turbulence, temperature, chemical composition, pressure, noise, location of reactive zones, .. )
- ➢*Full scale tests*

**Developpement of new alloys**
- ➢Weight reduction
- ➢Material behaviour during thermal cycles

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## Identified Research challenges

1. **Chemical kinetics**
2. **NOx formation:**
   **New Concepts of combustion chambers**
   **LPP regime** Lean premixed prevaporized (Air exces)
   **RQL Combustion** Rich Quenching Lean
3. **Turbulent combustion**
4. **Chamber design – numerical tool development**
5. **Wall cooling**
6. **Fuel atomisation**
7. **Gas and particle radiation**
8. **Alternative kerosene**
9. **Hydrogen or natural gas turbines**
10. **New combustion modes in aeronautical turbines**

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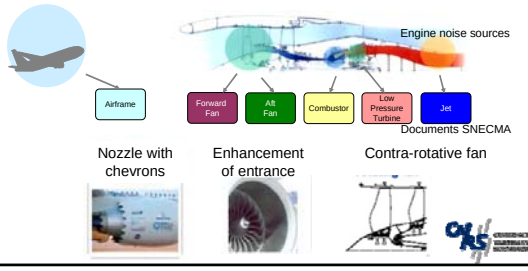
## Conclusion : research challenges

- Optimisation of the 2-phase combustion chambers for a reduction of **CO2, NOx, CO and particle emission**
- Optimisation of the **wall cooling** for chambers and turbine **blades**
- Reduction of **noise**




Nozzle with chevrons



Enhancement of entrance



Contra-rotative fan



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## Conclusion : research challenges

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- Reduction of **noise**
- Development of **new alloys** (weight reduction, material behavior at high temperature, thermal cycles,…)

Composite fan case

Highly loaded compressor

Light weight Composite mixer

Next-gen RTM composite fan

Ceramic-matrix composite blade

Novel titanium alloys

Documents SNECMA