The background features a collage of aviation-related images: a large white commercial airplane in flight, a blue globe, a yellow and orange aircraft, a rocket, and various smaller aircraft. The ONERA logo is prominently displayed at the top center, consisting of the word "ONERA" in a bold, black, sans-serif font, underlined by a thin black line. The overall color palette is dominated by light blues, yellows, and whites, creating a clean and professional aesthetic.

ONERA

Propulsion for the Future : The Environmental Challenges

*Francois Garnier, ONERA, Propulsion
Activities Coordinnator*

*Speaker - F. Paun, ONERA, France
Deputy Director New Business*

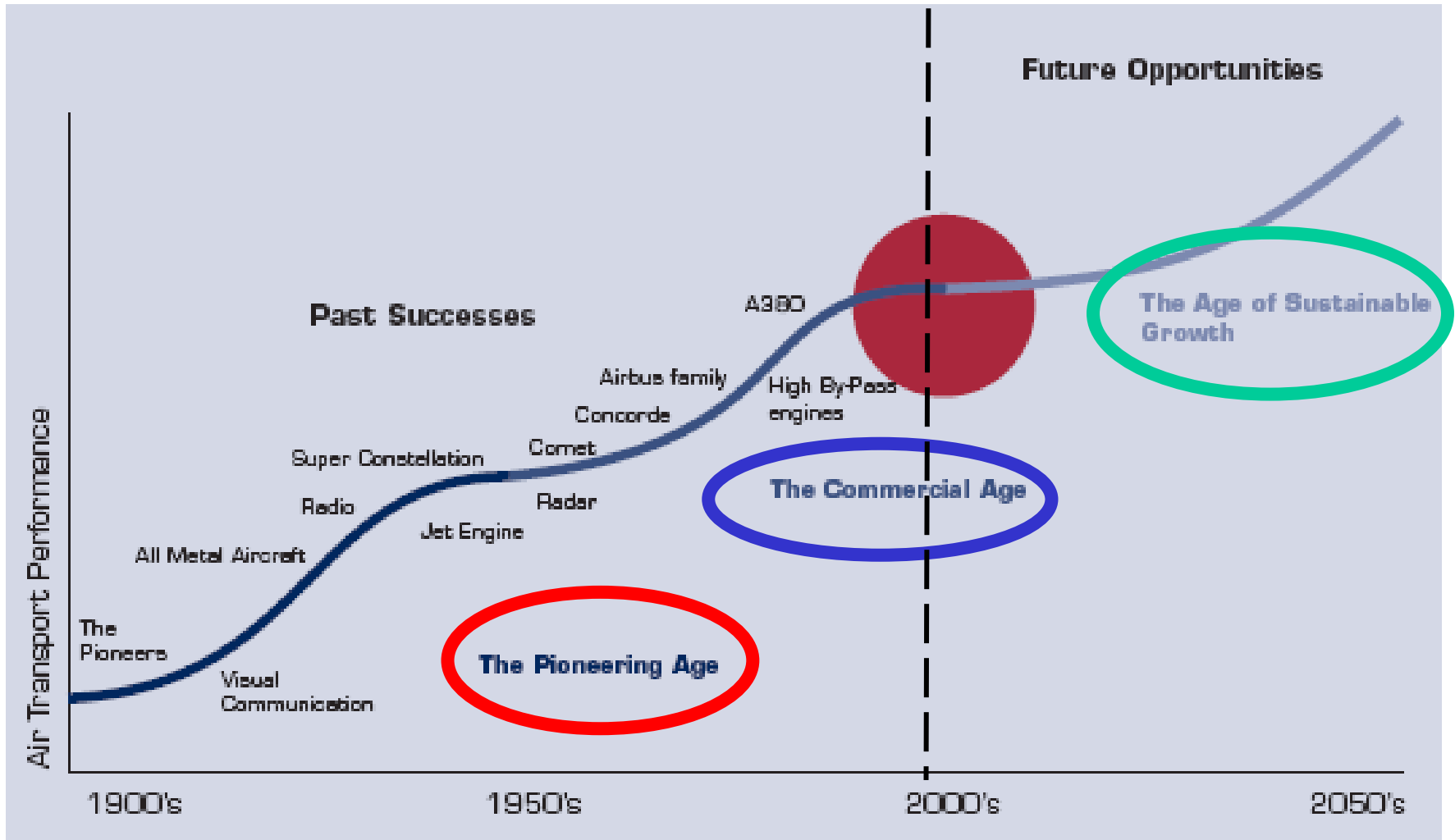
Workshop
Bucharest - September, 2008

Onera- The French Aerospace Lab,
www.onera.fr

21st Century Air Transport Performance



Air Transport Performance: Safety, Capacity, Mobility, Noise and Emissions

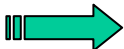


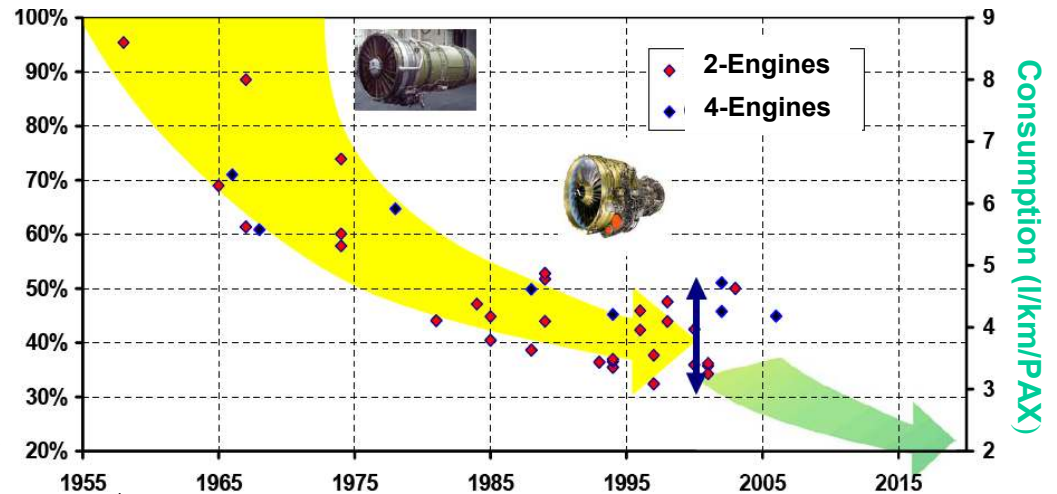
Significant fuel burn reduction and significant noise reduction


Engine fuel consumption per Seat-kilometre (% Ref. Aircraft of 1960)

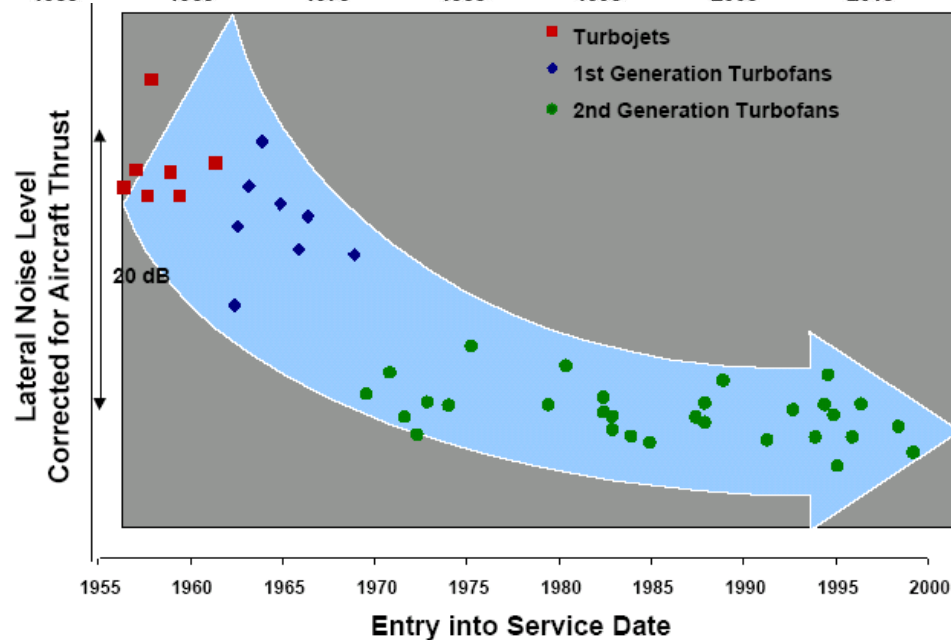
Between 1960 and 2000 

60% of consumption reduction
(i.e. CO₂ emission)

Modern aircraft consumption
 between 3 and 5 l/100 km/PAX



Noise reduction 
Significant progress has been made....



Future requirements for Research and Technology



The European Vision ACARE (*) 2020 Horizon

Ambitious (but realistic) research goals are set through European and USA programs.



NASA Program: Ultra Efficient Engine Technology



Noise



**Performance/
Environnement**

GOALS

Total engagement by the industry in the task of studying and minimising the industry's impact on the global environment.

A reduction in perceived noise to one half of current average levels.

Eliminate noise nuisance outside the airport boundary by day and night by quieter aircraft, better land planning and use around airports and systematic use of noise reduction procedures.

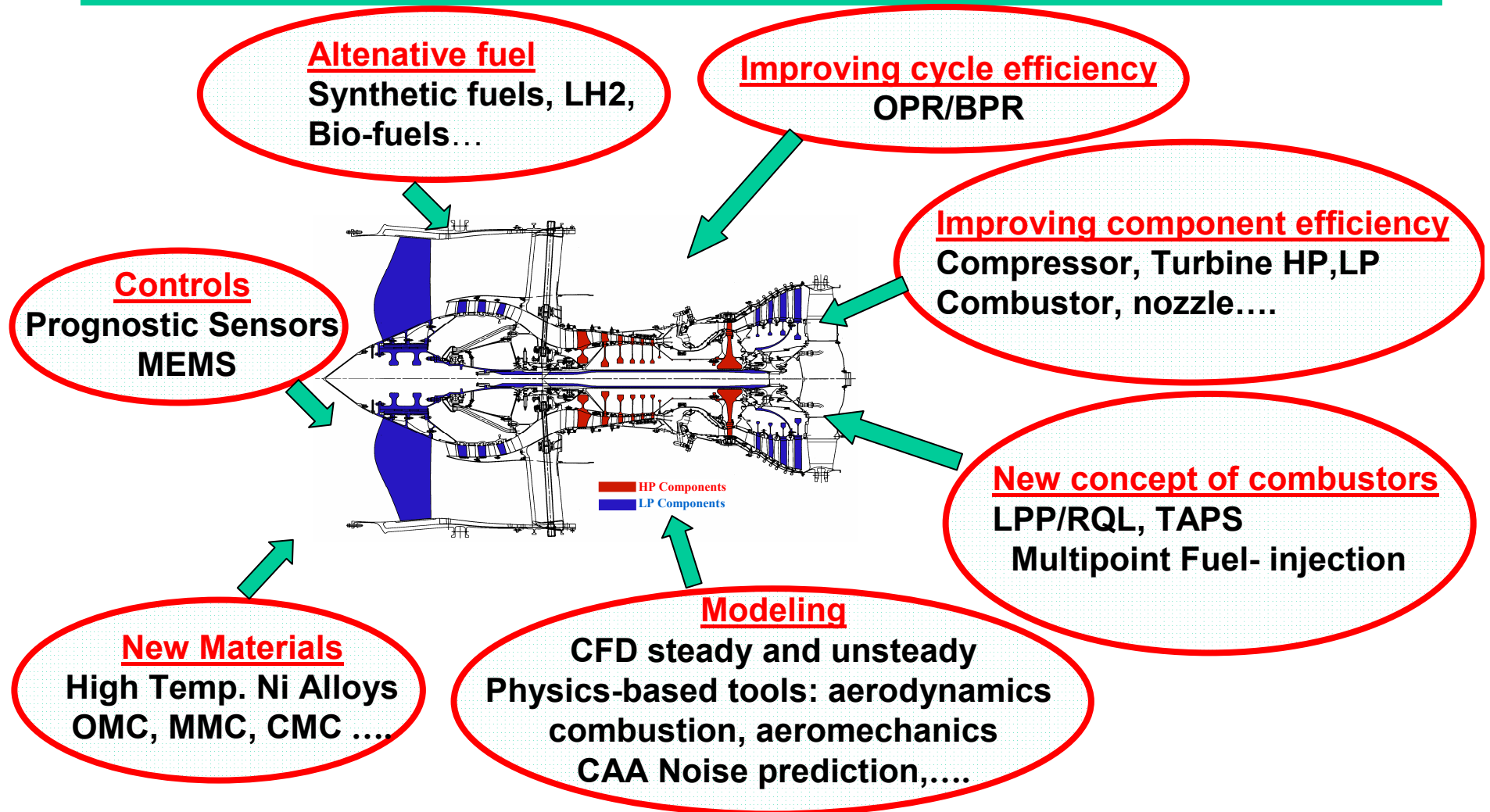
A 50% cut in CO₂ emissions per passenger kilometre (which means a 50% cut in fuel consumption in the new aircraft of 2020) and an 80% cut in nitrogen oxide emissions.

(*) : Advisory Council for Aeronautics Research in Europe



Aeropropulsion vision for emissionless, silent aircraft

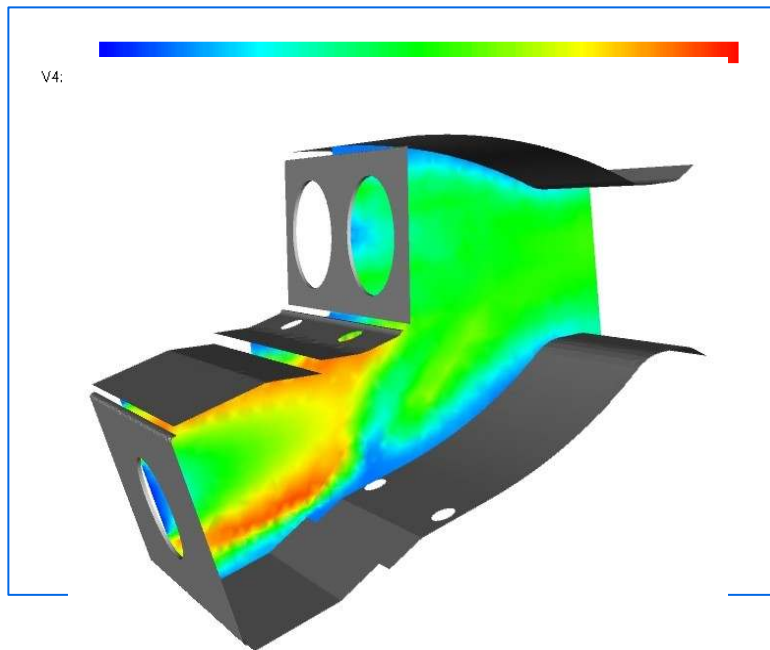
ONERA Proactive in **Research & Technology** minimising Environmental impact → Future Involvement in key Areas



Low Emission Research: staged Combustor Concept

Experimental and numerical study in a Two-Heads combustor within the framework of the European project SIA-TEAM (2001-2005)

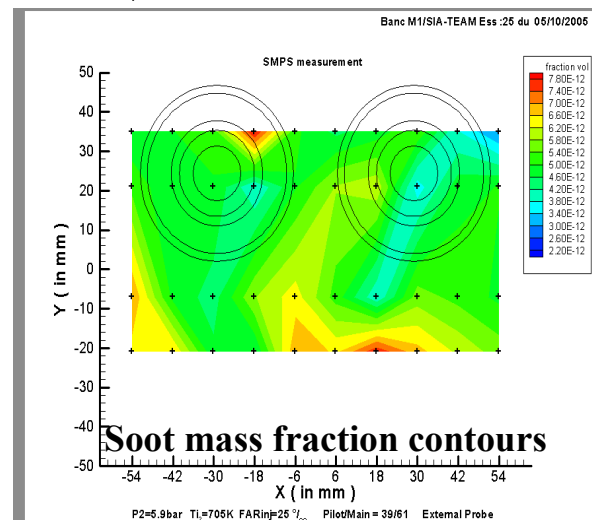
- Prediction of pollutants (CO_2 , CO, NO_x , soot)



Radiative Fluxes with ASTRE code
(PdF PEUL model, two phases)

LPP: Lean Premixed Prevaporised
RQL: Rich Quench Lean

↳ 50 % Reducing the NO_x emissions

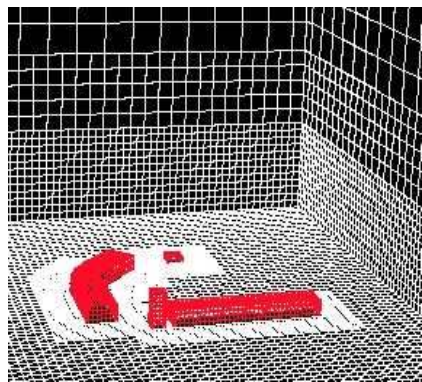


Gas and soot analysis measurements
at the combustor sector outlet

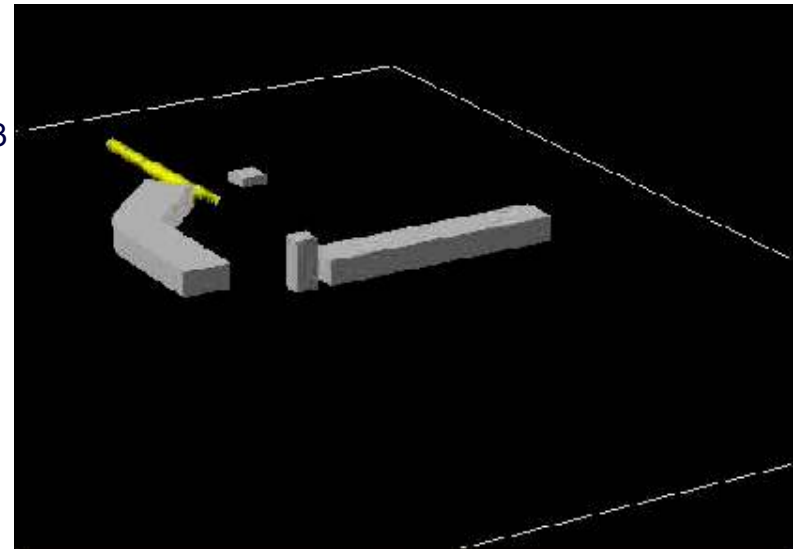
Local Emission impact: Air Quality

ONERA Research Project dealing with Airport air quality assessment studies « AIRPUR »

➔ **Multi-scale numerical simulations of Paris-Orly airport:**

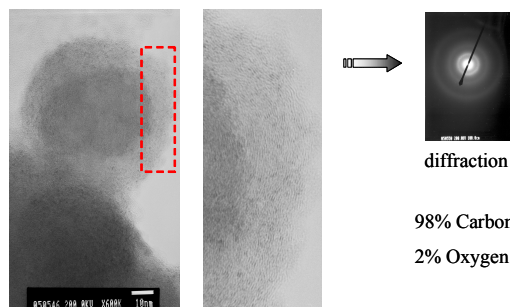


Buildings: 1-100 m
Runway: 10-1000 m
Domain: 2000x2000x1500 m³

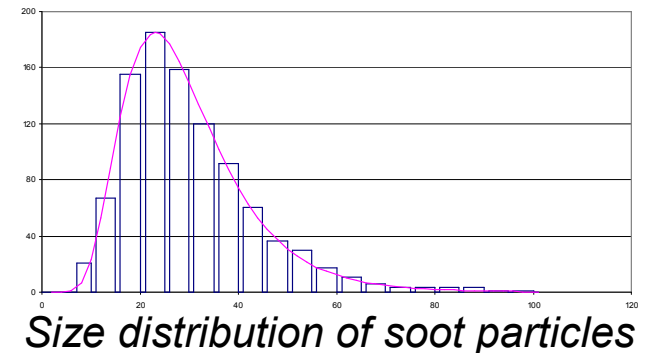
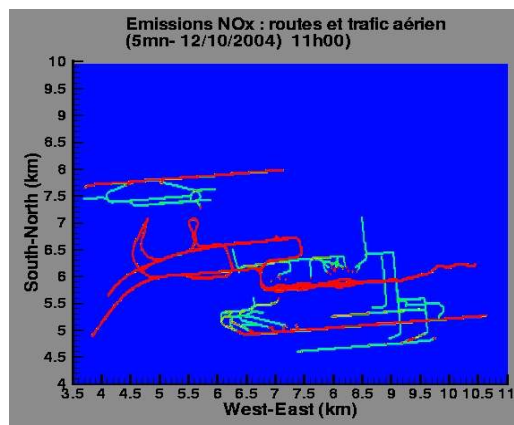


➔ **Particle and gas measurements behind engine test areas**

Photograph, diffraction and X analyses (TEM) of soot



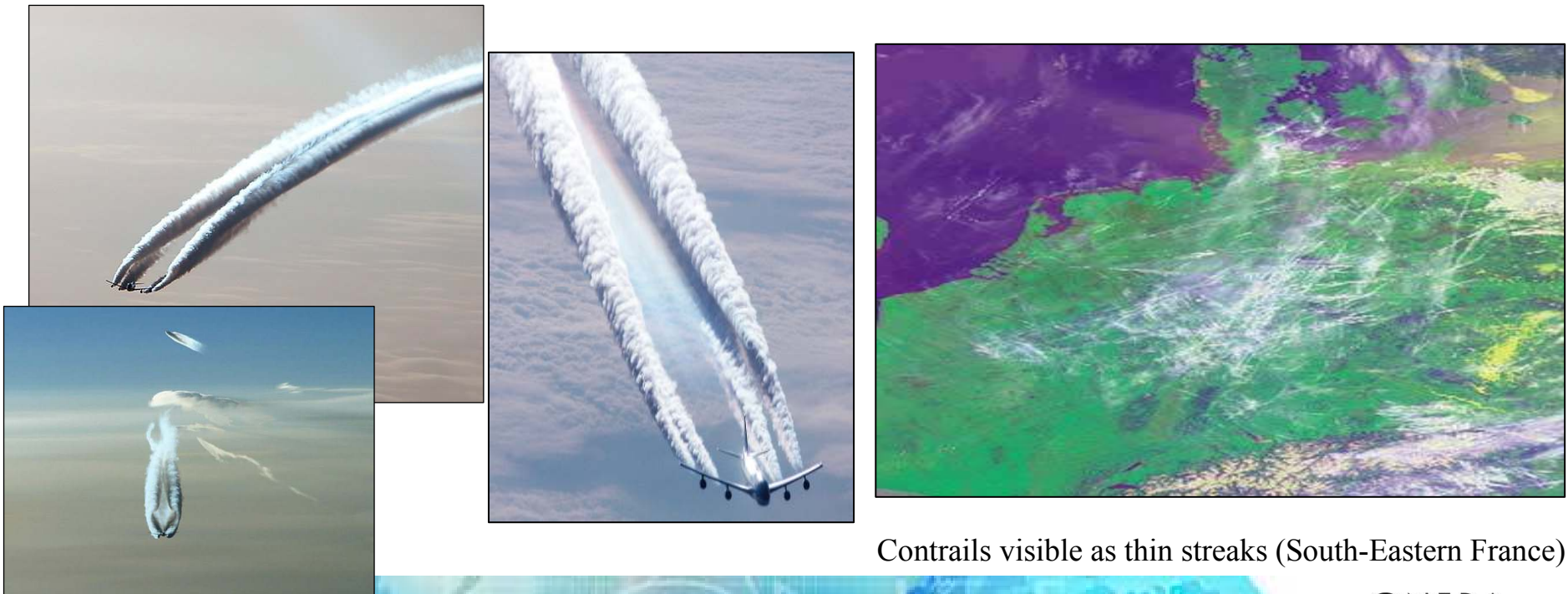
Emission database: LTO cycle and ground access vehicles



Global and Local Impact of aircraft emissions: Contrail study

National research programs in partnership with the aircraft companies and the universities → ONERA coordinator

- Contrails artificially increase cloudiness and trigger the formation of cirrus clouds, thus altering climate on **local** and **regional/global** scales
- Nature article (2002): anomalous increase in DTR (daily temperature range) reported over US during the no-flight days of 11-14 Sept. 2001, which is thought to be due to absence of contrails

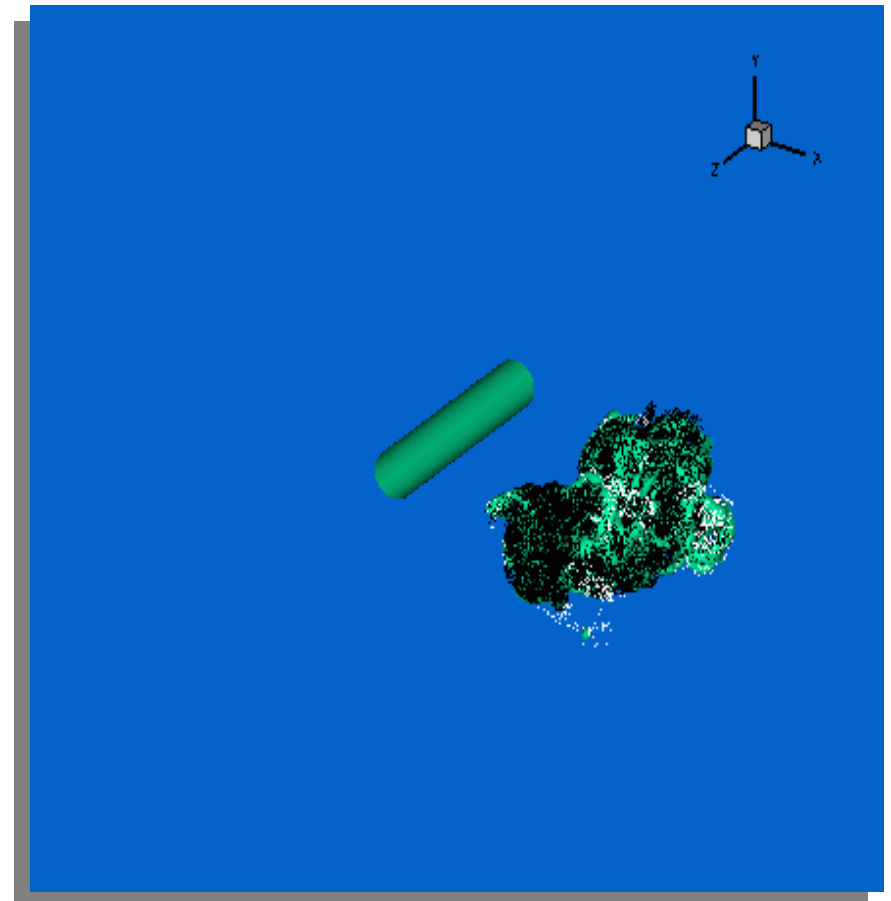


Contrails visible as thin streaks (South-Eastern France)

Numerical simulation of contrail formation



➔ Contrails are ice clouds formed by condensation of water vapour on nucleation sites, like **soot or aerosols**, emitted by aircraft engines



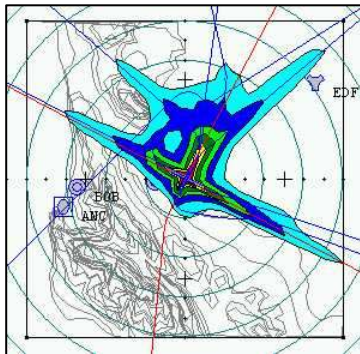
■ Engine jet is entrained by the vortex field

■ Vortex **increases mixing** of the jet with cold air (**favours ice formation**)

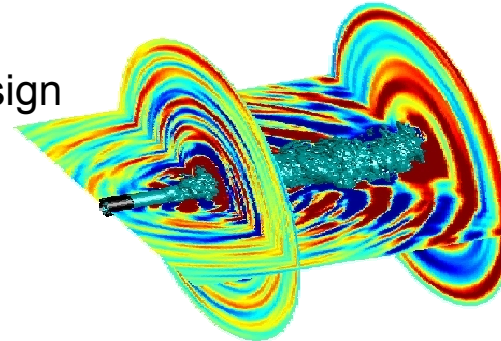
IROQUA, a new French initiative to reduce noise around airports

ONERA (coordinator) is teaming up with the national scientific research center (CNRS), Airbus, Dassault, Eurocopter and SNECMA (SAFRAN Group) in a new aircraft noise reduction initiative

→ To reduce noise at the source, by working on the design and shape of aircraft engines

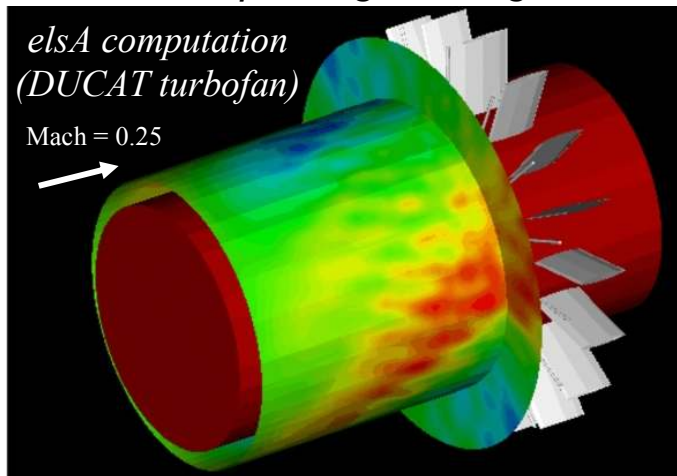


- Exhaust nozzle design
- Turbine speeds
- Bypass Ratio..

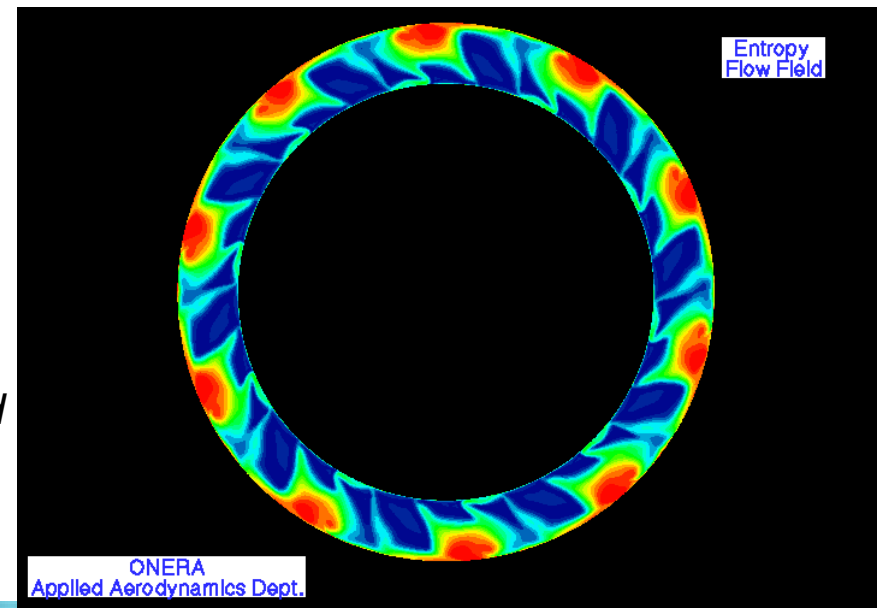


Numerical Simulation of Fan Interaction Noise

Interaction spinning mode generation



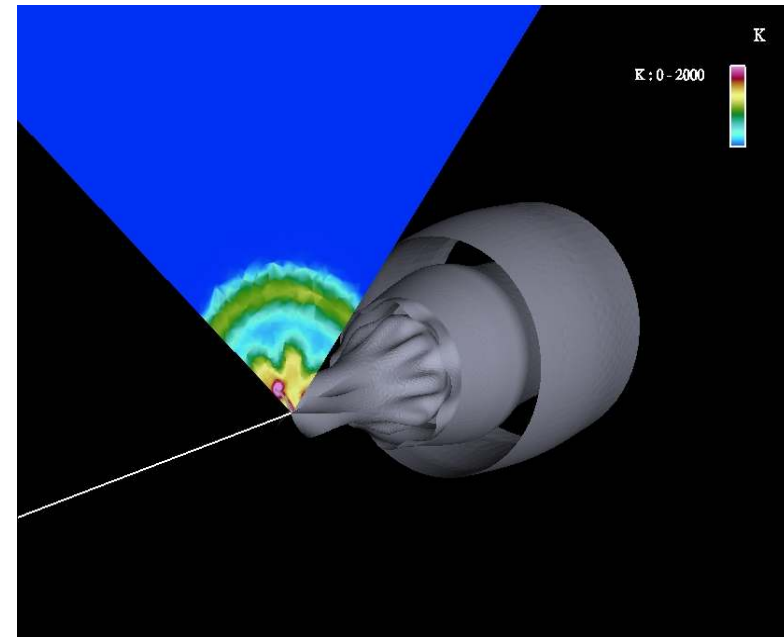
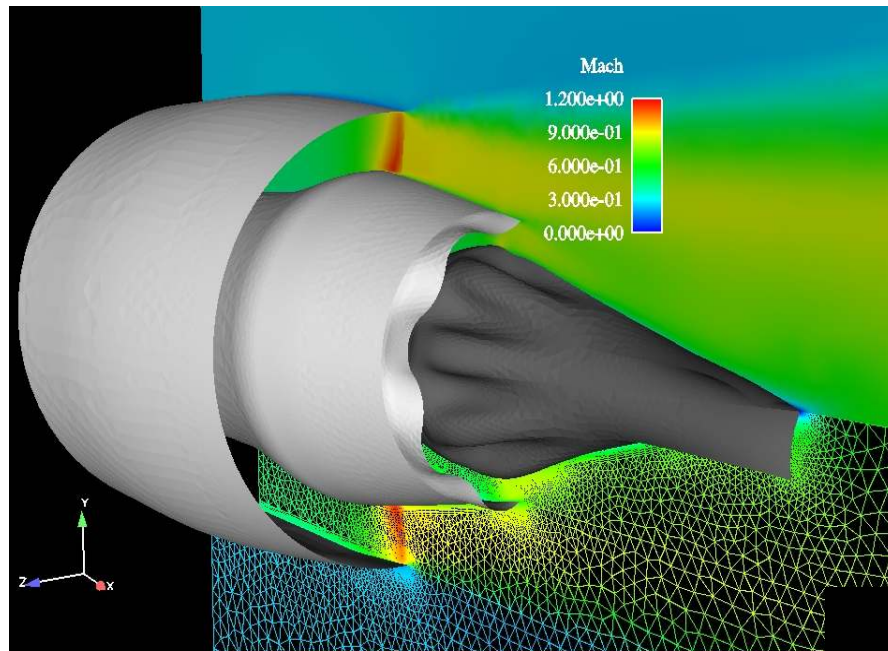
Pressure field



Numerical Simulation of exhaust jet flow (SNECMA configuration) to predict engine noise



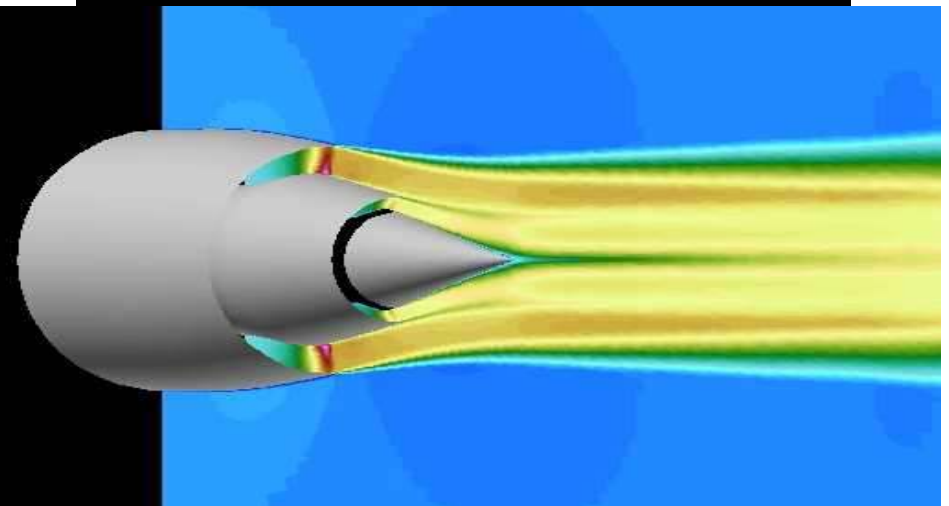
→ within the framework of the European program SILENCE® (2001-2006)



Hybrid grid Centaur / CFD code
CEDRE: Multisolvers, Multiphysics,
RANS, LES

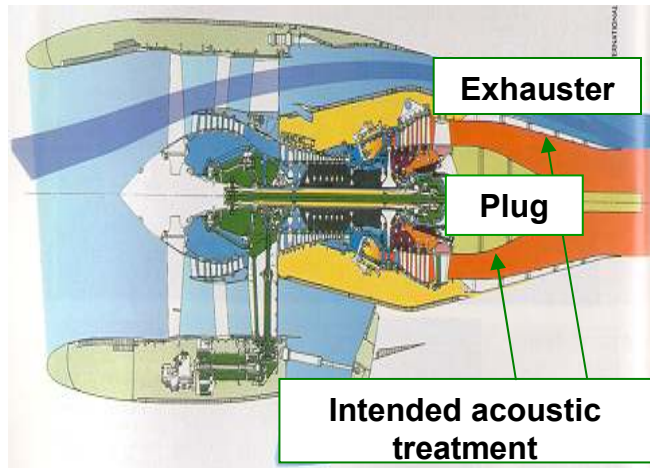
1.5 million nodes

Mach number fields





Towards « system » approach → multiscales and multiphysics

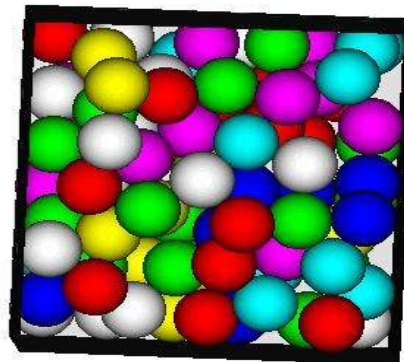
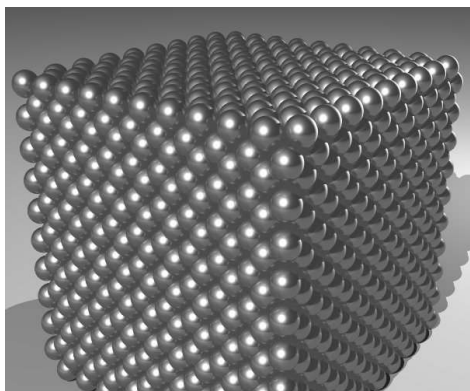


Hot stream acoustic liner
acoustic involving
Temp/pressure resistance,

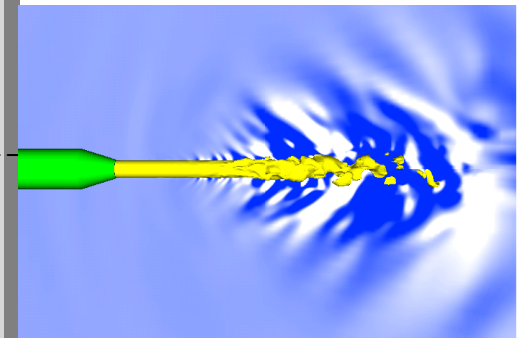
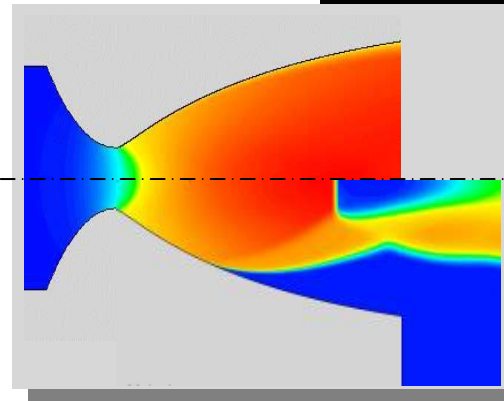
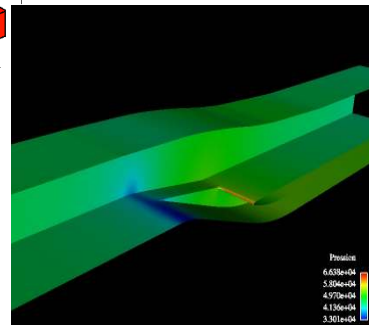
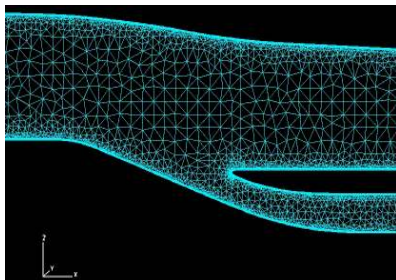
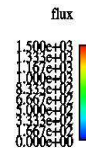
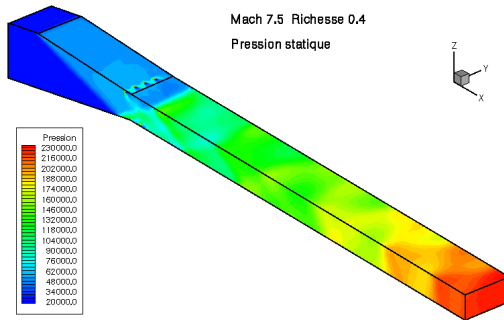
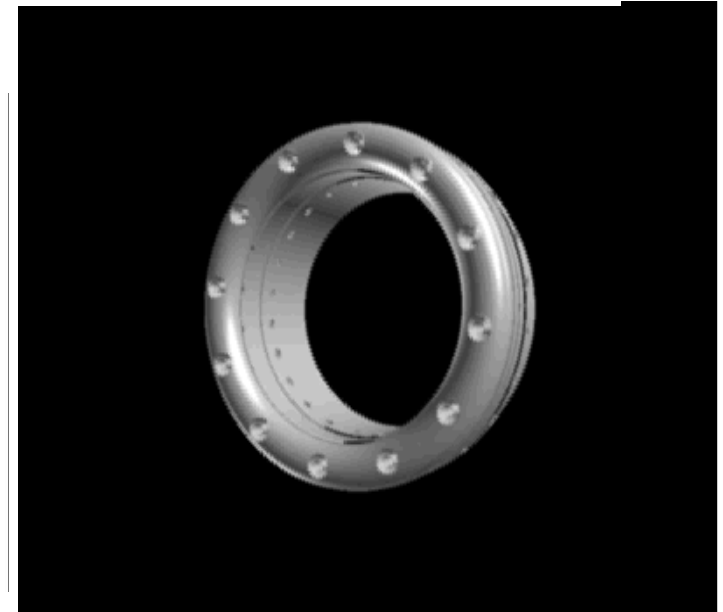
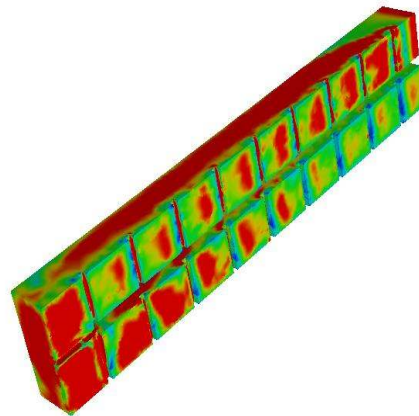
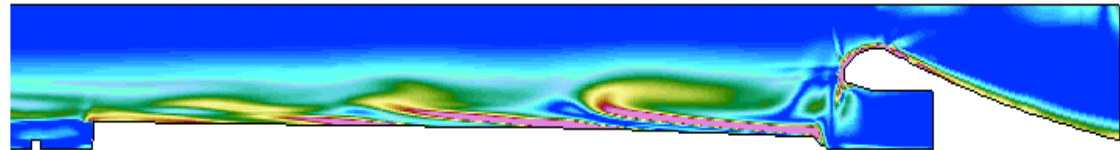
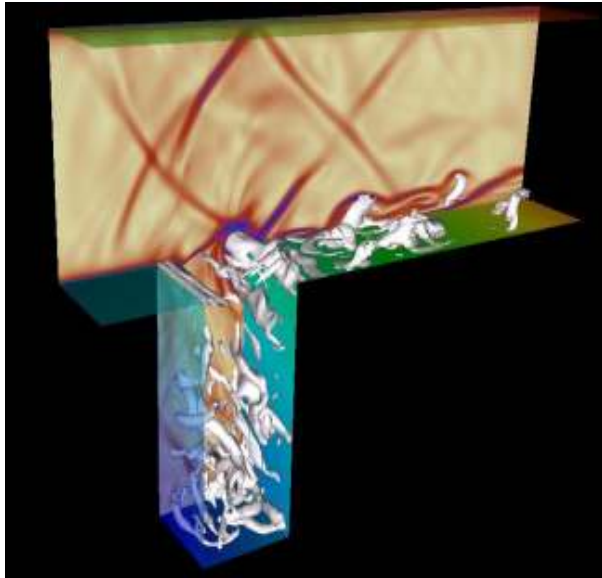
Understanding/Evaluating/
Predicting/manufacturing

→ Materials by design

Material Choice - Superalloy hollow spheres based material (model material FCC)
- further non regular – compromise (costs/reproducibility)



Recent Applications of CFD CEDRE Code




ONERA Research Activities for Aero-propulsion System



Need for multidisciplinary scientific competencies

Fields of contribution

- Aerodynamics, Heat transfer and Icing
 - Acoustics and Aeroacoustics
 - Materials and Structures
 - Aeroelasticity and Vibration
 - Combustion and Emissions
 - Engine controls
- 
- Modeling and CFD simulation
 - Improving cycle and component efficiency
 - New materials: thermal barrier coating
 - New concept of combustors
 - Controls and analysis tools : sensors...
 - Alternative fuel

