

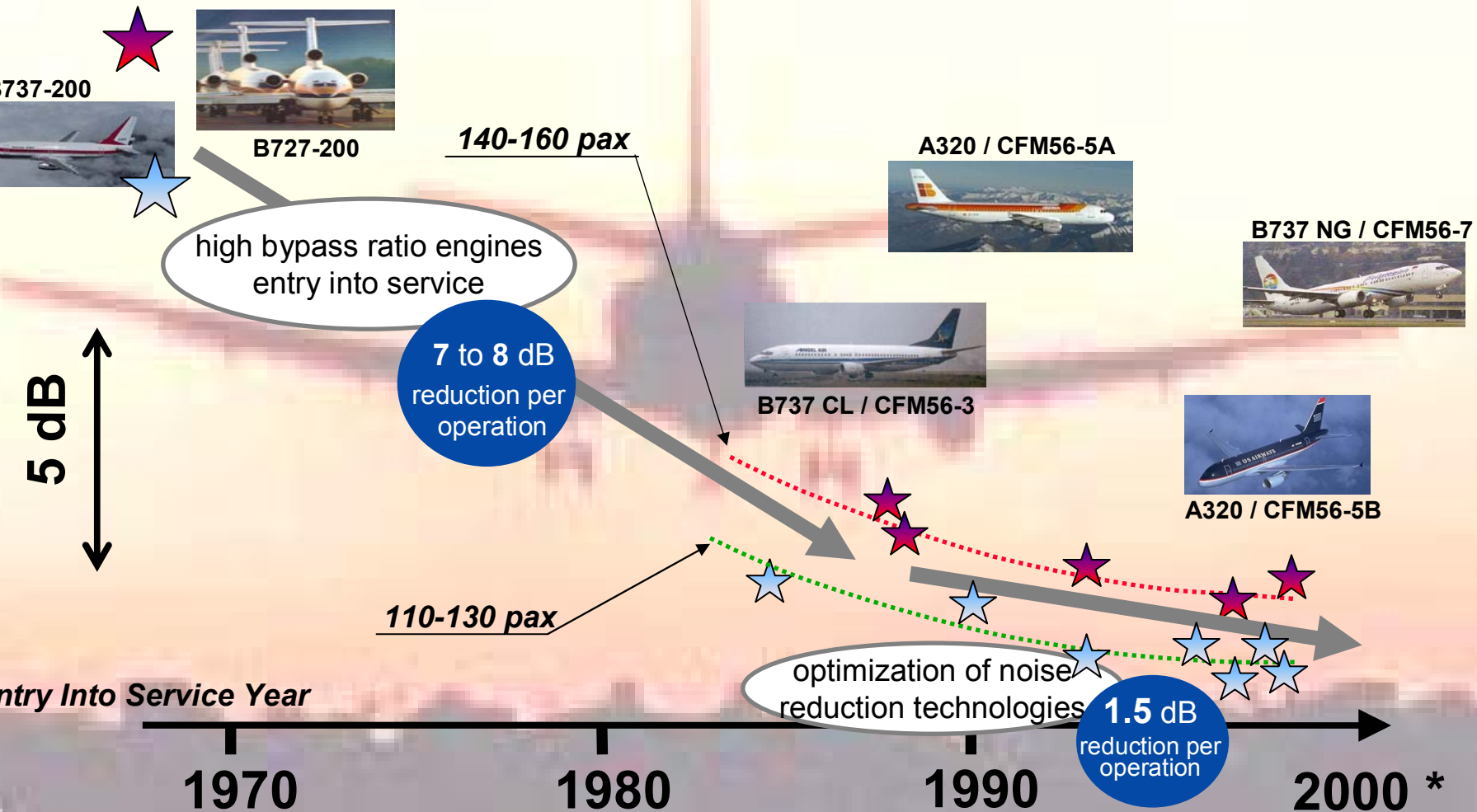
AIRCRAFT ENGINE NOISE

ROME AERONAUTICAL ENGINEERING UNIVERSITY

May the 28th, 2004

Noise Reduction Trends

Average Noise Reduction in Decibels per Operation

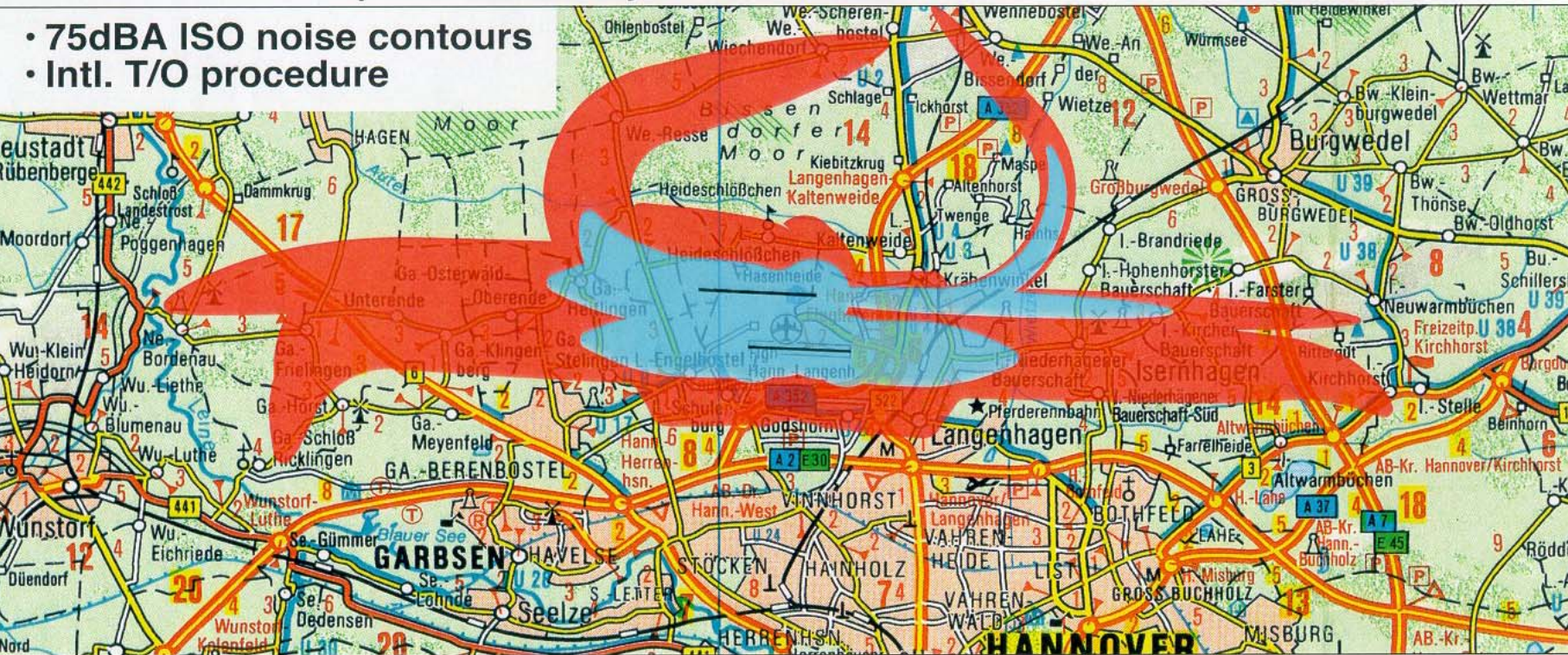




Snecma Moteurs
groupe snecma



Noise Footprint Example



SAME AIRCRAFT : **GENERATION 1 ENGINES** vs **NEW GENERATION ENGINES**



 INTRODUCTION

 **ACOUSTIC REGLEMENTATION**

 CFMI NOISE SITUATION

 NOISE INSIDE A NEW ENGINE PROJECT

 NOISE CERTIFICATION

 TODAY'S NOISE TECHNOLOGIES

 FOR A QUIET FUTURE

 QUESTIONS

Acoustic Reglementation

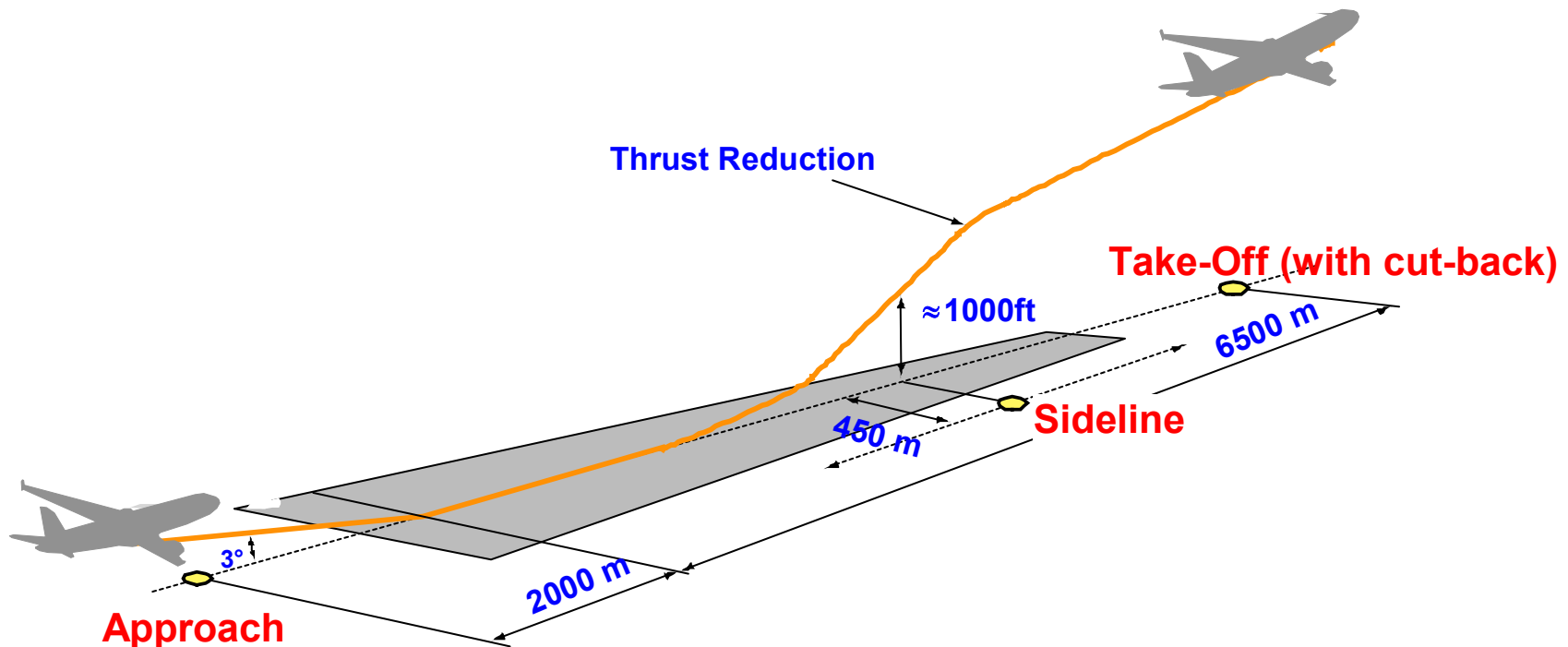
Noise Certification Scheme



Snecma Moteurs
groupe snecma



AVIATION ENVIRONMENTAL PROTECTION **ICAO ANNEX 16** Vol.1 Chapter 3 (THIRD EDITION 1993)
EUROPEAN AVIATION REQUIREMENTS : **JAR 36** (1997)
FEDERAL AVIATION REGULATIONS : **FAR 36** (1993)
RUSSIAN AVIATION REGISTRATION : **AP-36** (AVIATION REGULATION - 36)



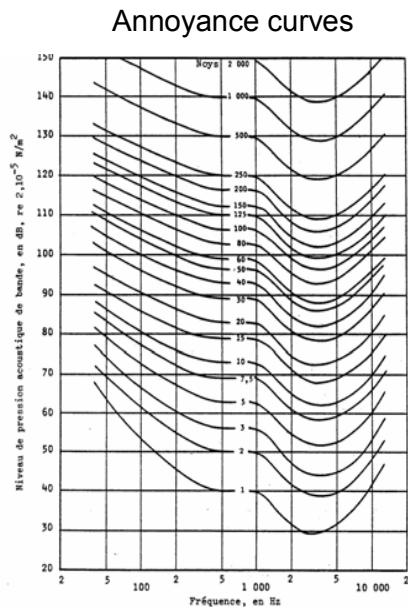
EPNL : the noise aeronautical unit

Measure Physical Unit : the **décibel (dB)**
 $\text{dB} = 10 \log_{10} (\text{acoustic pressure} / 20 \mu\text{Pa})$

Physiological Correction

Physical units
Representing annoyance

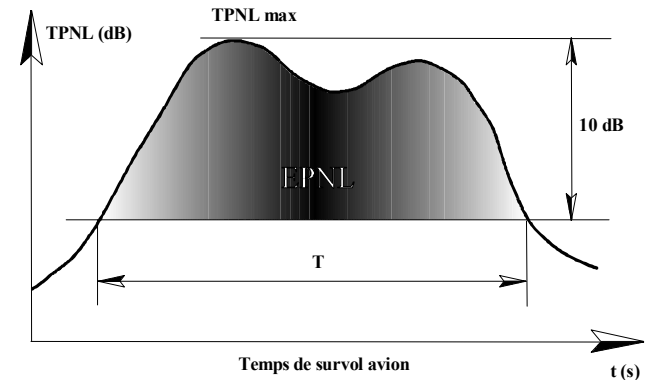
Acoustic unit used
For aircraft noise certification



PNL (Perceived Noise Level)

**TPNL
(Tone corrected
Perceived Noise Level)**

EPNL = Noise integration on T



EPNL (Effective Perceived Noise Level)

isochronal lines same perception
For human ear
Vs frequency

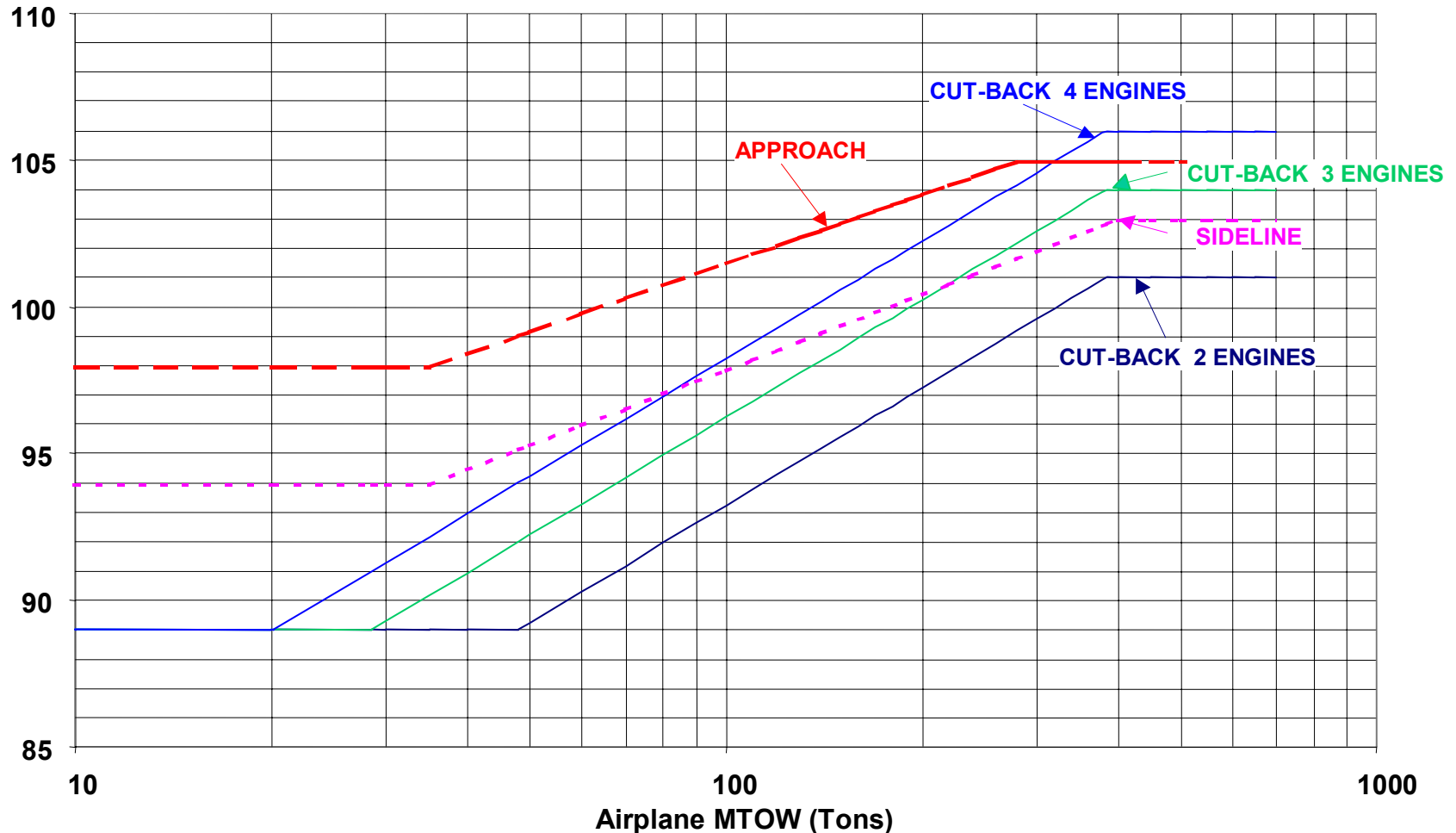
Acoustic Reglementation



Snecma Moteurs
groupe snecma



CAO Acoustic Certification- Stage 3 Limits



Acoustic Reglementation

ICAO Noise Rules Evolution



Snecma Moteurs
groupe snecma



Uncertified Aircraft (« Stage 1 »)



« Stage 1 » Phaseout

« Stage 1 »
Production
Stop

Stage 2



ICAO Decision

Stage 3

ICAO Decision

Stage 2
Production
Stop

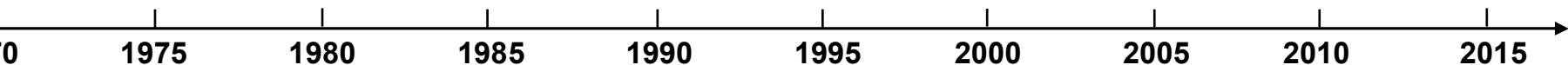
ICAO Decision

Stage 2 Phaseout

US Europe

Stage 4 (St3 - 10 dB Cum)

CAEP V (2001)



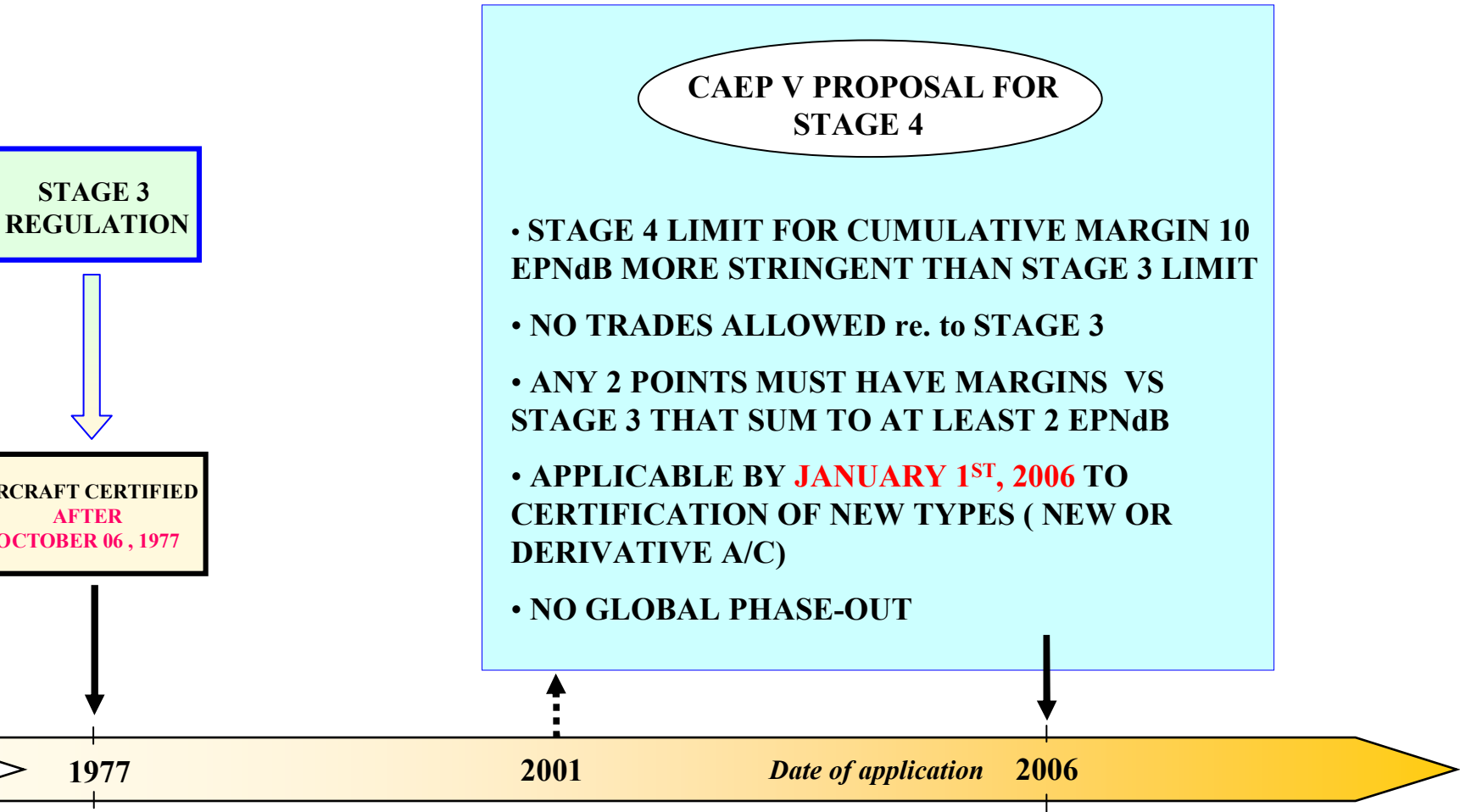
NOISE STRINGENCY IS INCREASING WITH YEARS

Acoustic Reglementation

Stage 4 Noise Regulation



Snecma Moteurs
groupe snecma





- ☎ INTRODUCTION
- ☎ ACOUSTIC REGLEMENTATION
- ☎ **CFMI NOISE SITUATION**
- ☎ NOISE INSIDE A NEW ENGINE PROJECT
- ☎ NOISE CERTIFICATION
- ☎ TODAY'S NOISE TECHNOLOGIES
- ☎ FOR A QUIET FUTURE
- ☎ QUESTIONS



Sneema Moteurs
groupe sneema



***CFM International
is a Joint Company of
Sneema Moteurs, France
and
General Electric Co., U.S.A.***



**THE POWER
OF FLIGHT**

CFMI Noise Situation



CFM56-3B/C



CFM56-7B



CFM56-5A & 5B



CFM56-5C



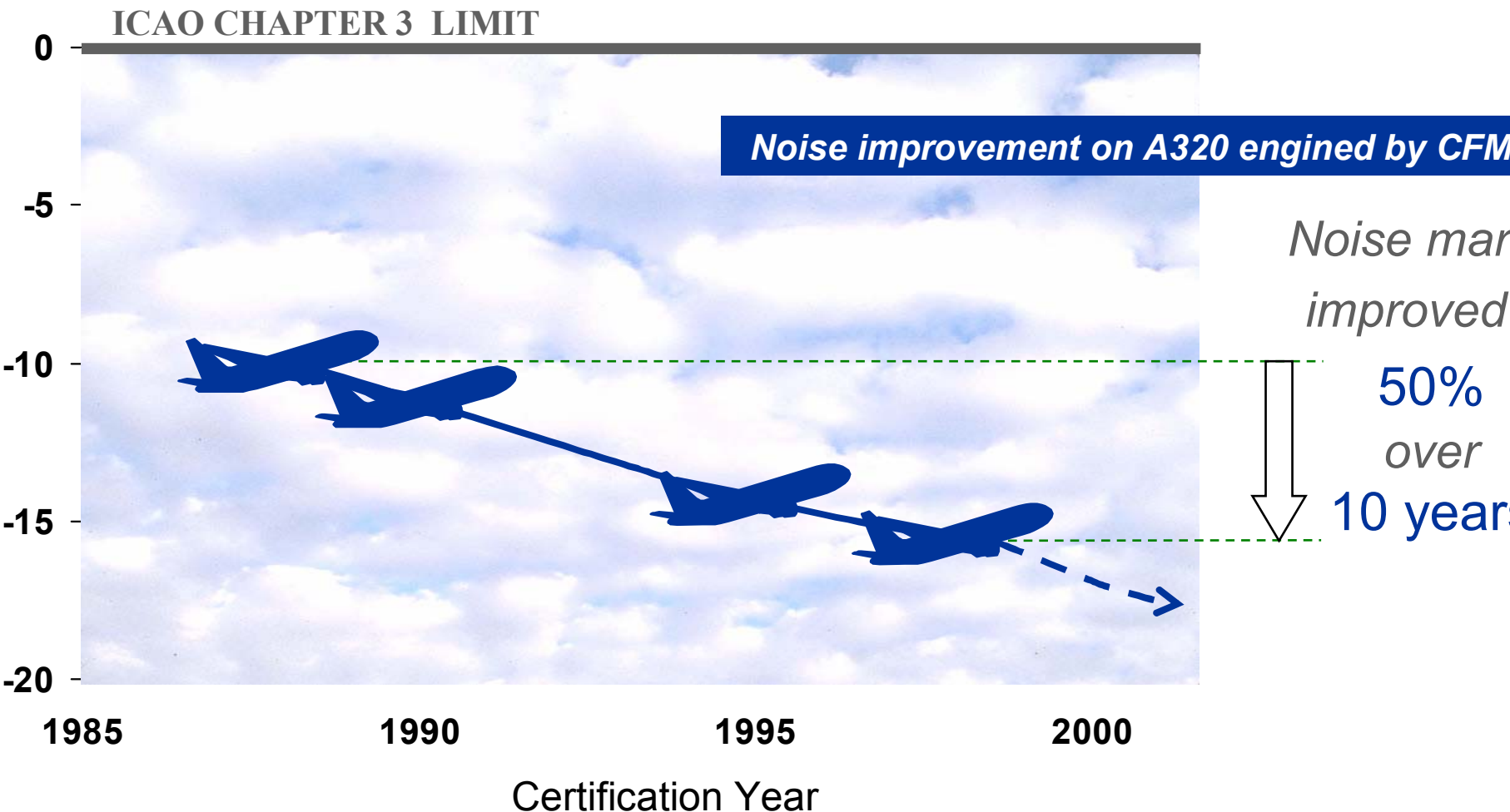
**Snecma Moteurs has
prime responsibility
for Noise Engineering
on all CFM56 Programmes**

CFMI Noise Situation

Continued Effort To Reduce Noise

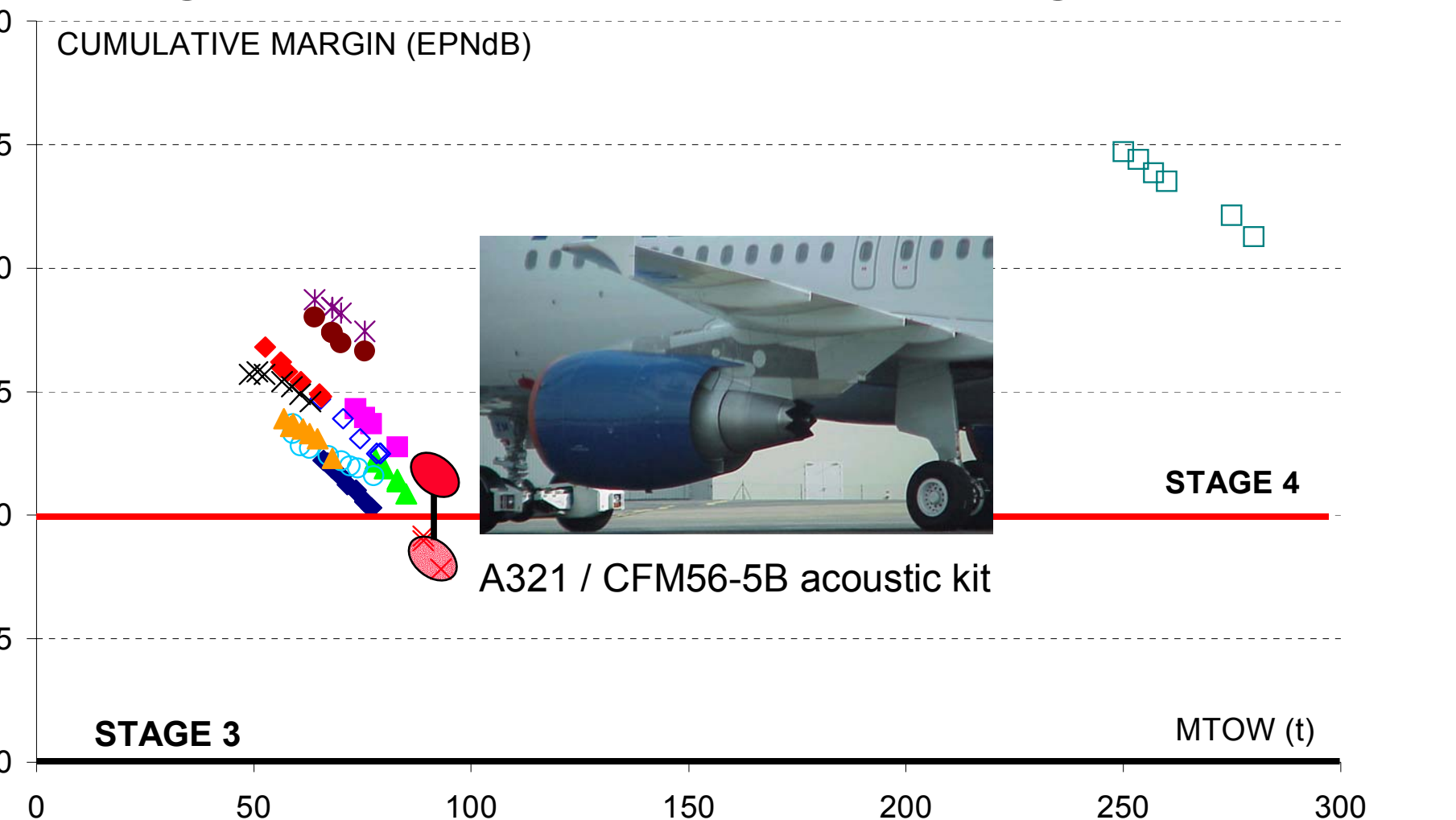


Snecma Moteurs
groupe snecma



CFMI Noise Situation

CFMI Engines Certified Noise Cumulative Margin

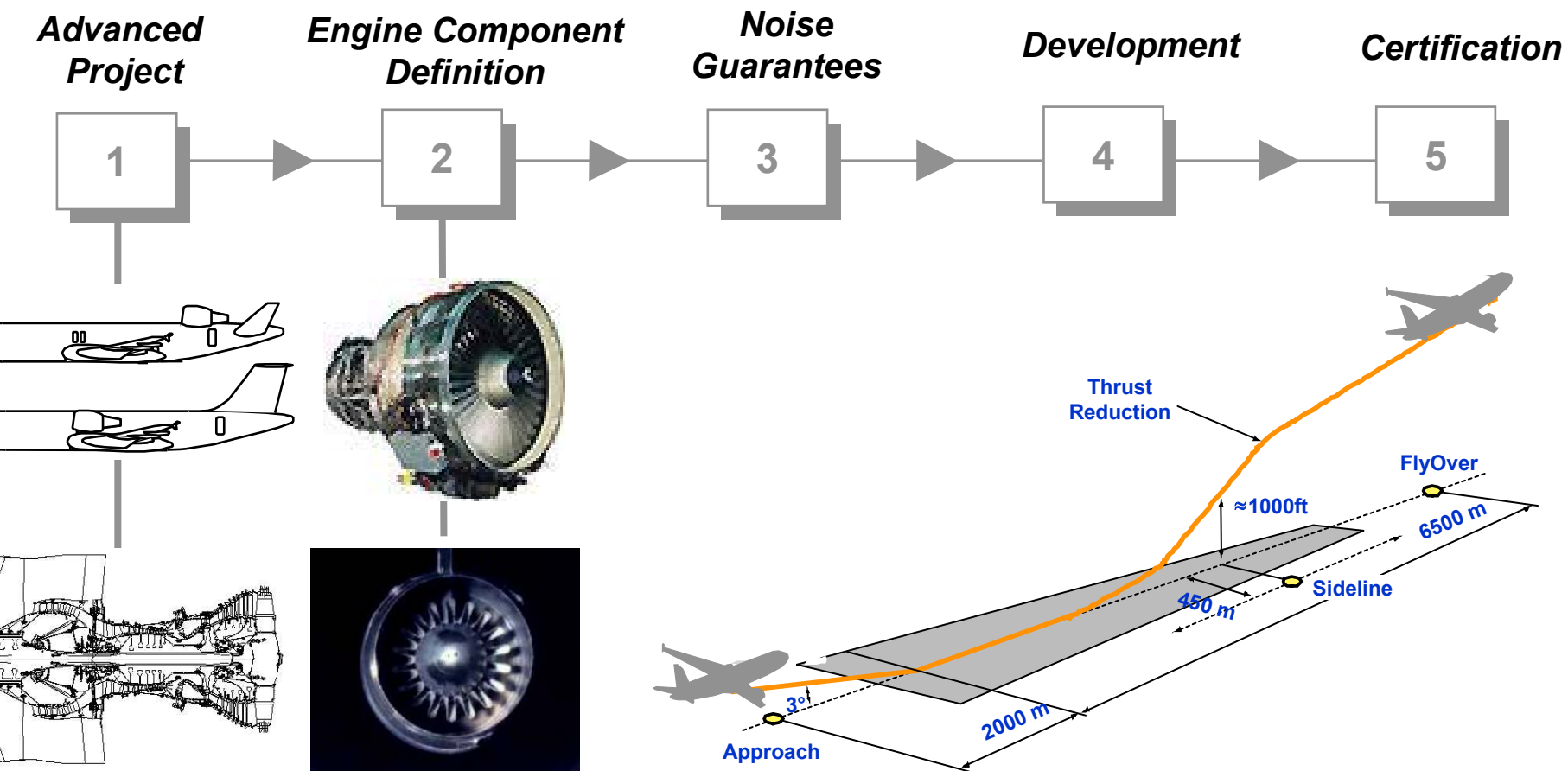




- ☎ INTRODUCTION
- ☎ ACOUSTIC REGLEMENTATION
- ☎ CFMI NOISE SITUATION
- ☎ **NOISE INSIDE A NEW ENGINE PROJECT**
- ☎ NOISE CERTIFICATION
- ☎ TODAY'S NOISE TECHNOLOGIES
- ☎ FOR A QUIET FUTURE
- ☎ QUESTIONS

Noise inside a new Engine Project

Strong Integration in Engine and Aircraft Development Processes



Noise inside a new Engine Project

Specific Prediction Tools to support all Engine Programme Steps

Advanced Project

1

Engine Component Definition

2

Noise Guarantees

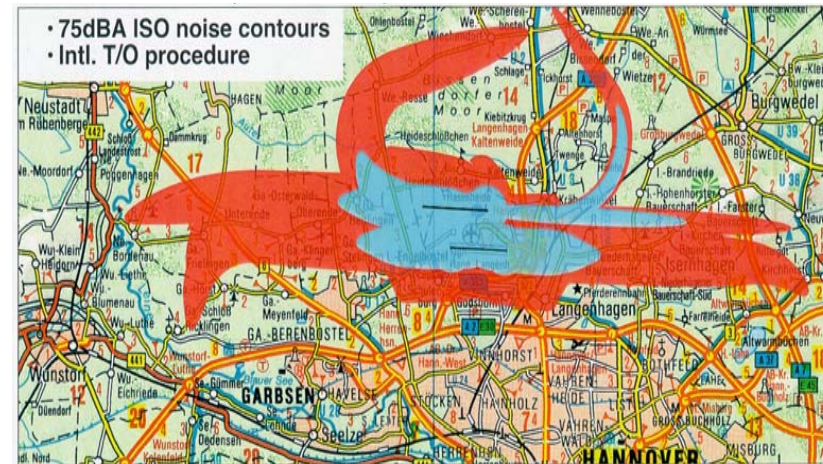
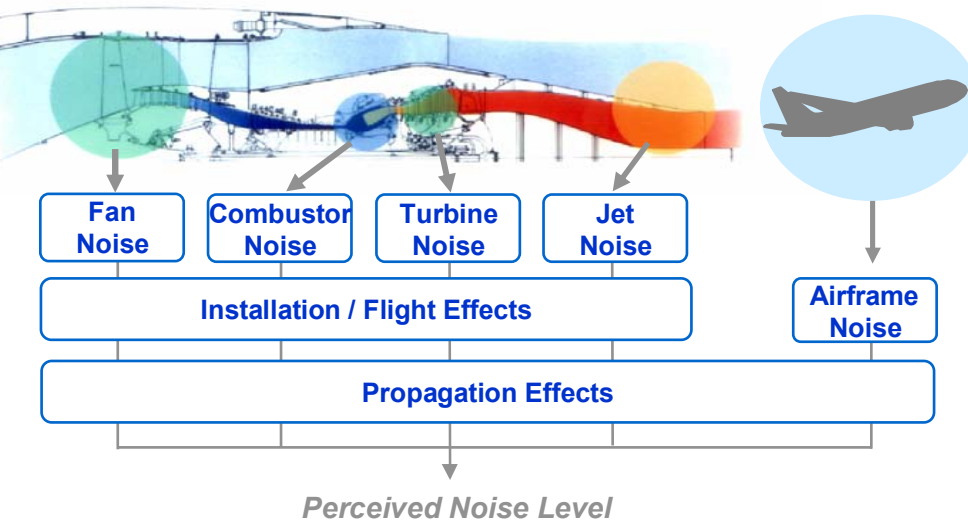
3

Development

4

Certification

5



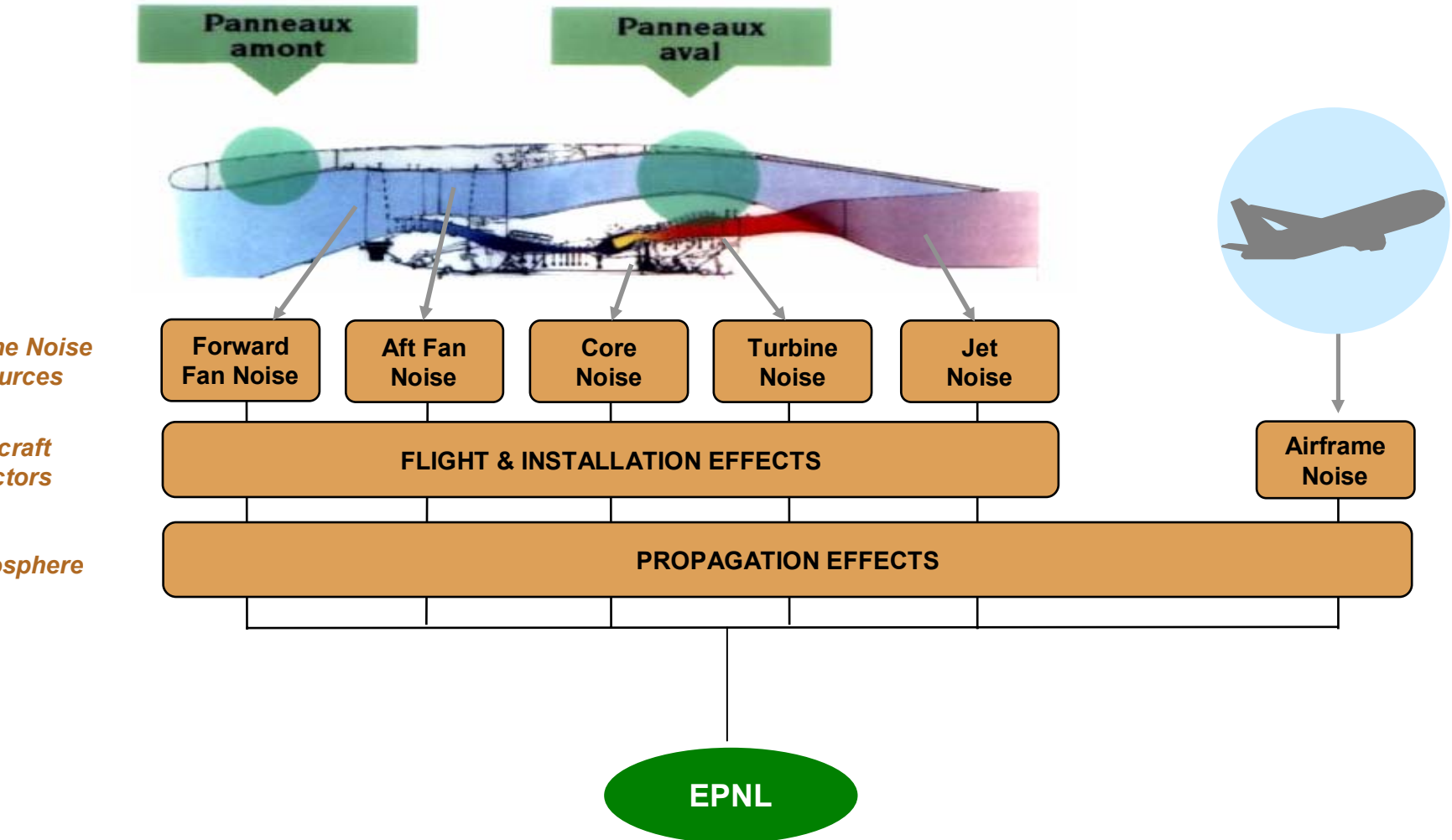
Community Noise Impact

Noise inside a new Engine Project

Noise Sources & EPNL Calculation



Snecma Moteurs
groupe snecma



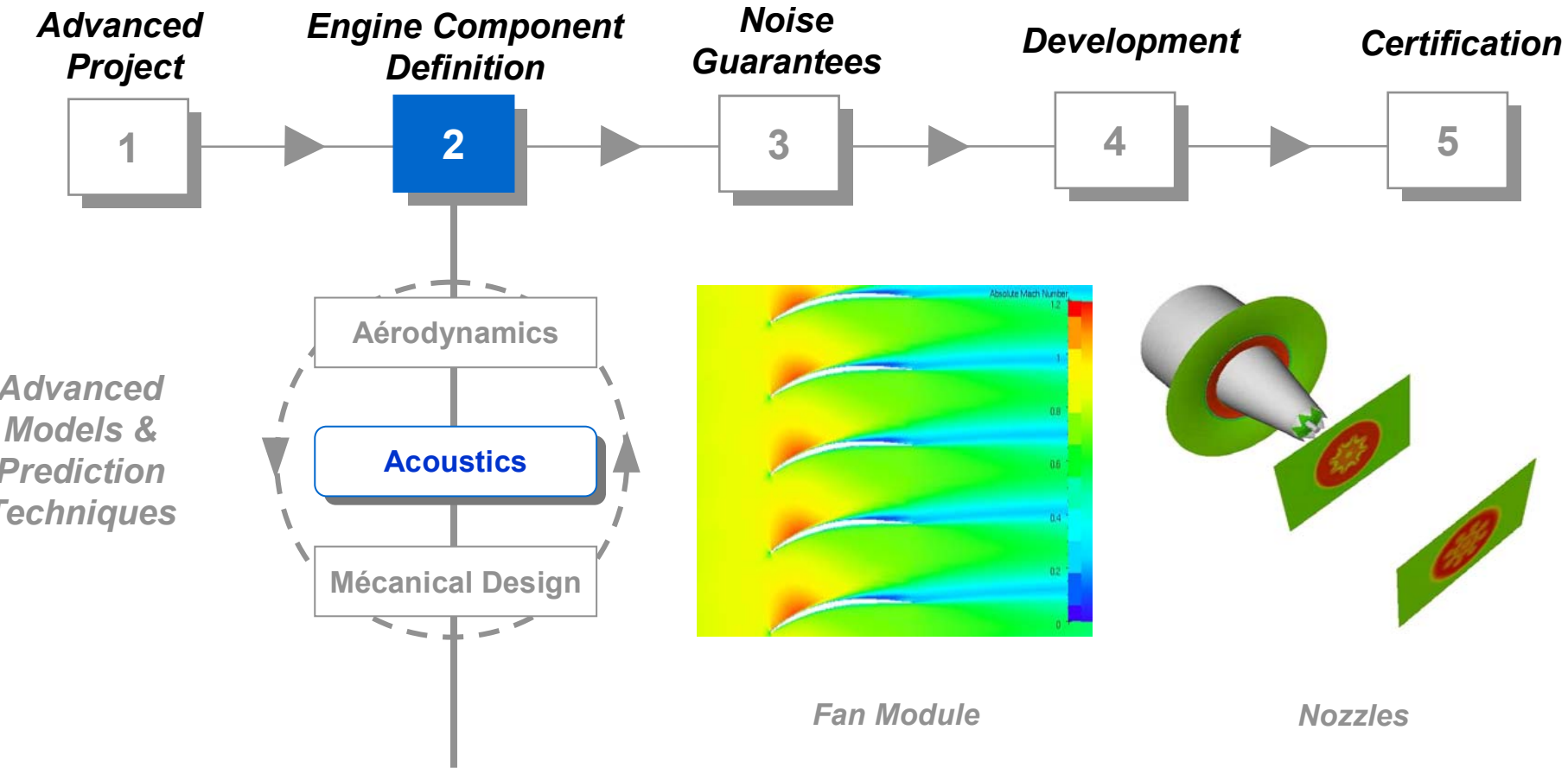
Noise inside a new Engine Project



Snecma Moteurs
groupe snecma

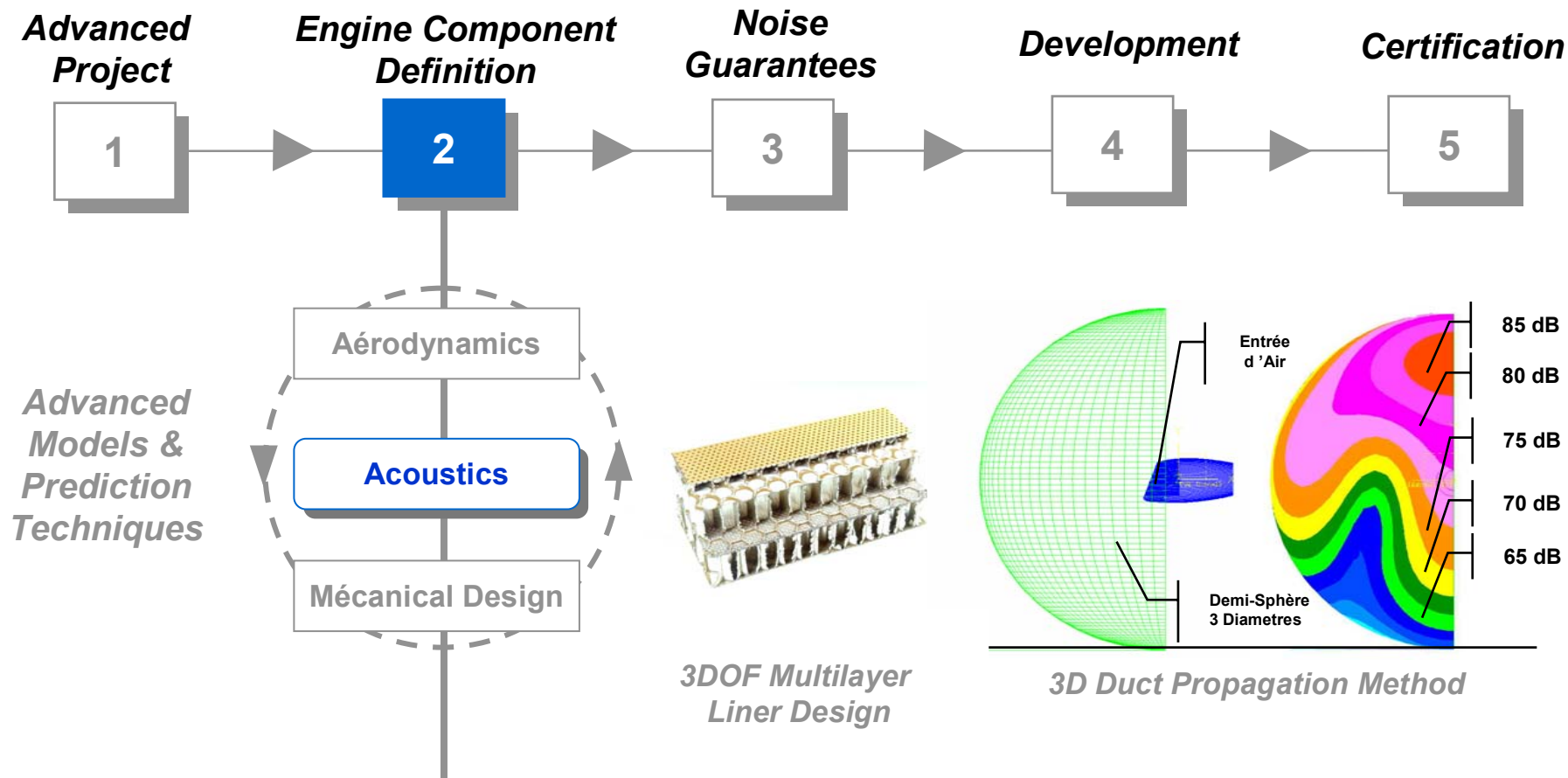


Low Noise Engine Component Design



Noise inside a new Engine Project

Optimisation of Noise Reduction Systems



Noise inside a new Engine Project

Experimental Validation

Advanced Project



Engine Component Definition



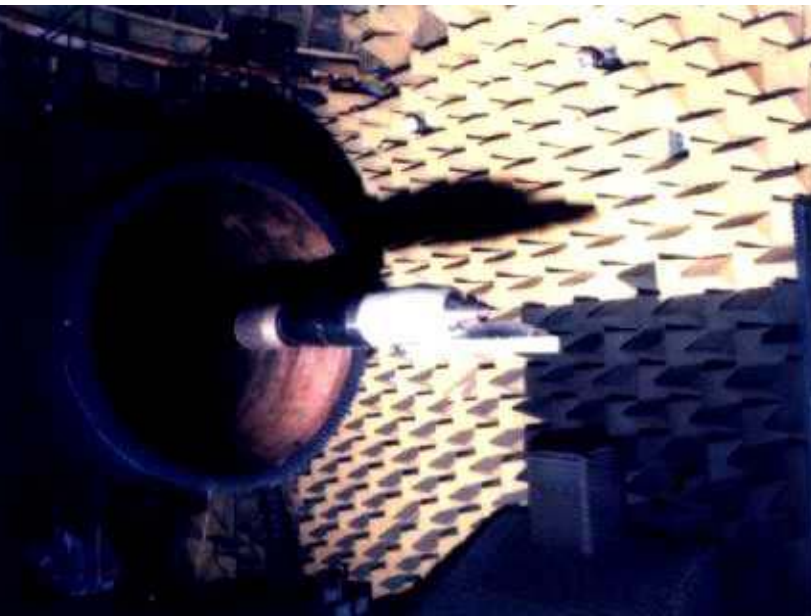
Noise Guarantees



Development



Certification



Anechoic Wind Tunnel



Outdoor Engine Test Facility

Noise inside a new Engine Project

Experimental Validation

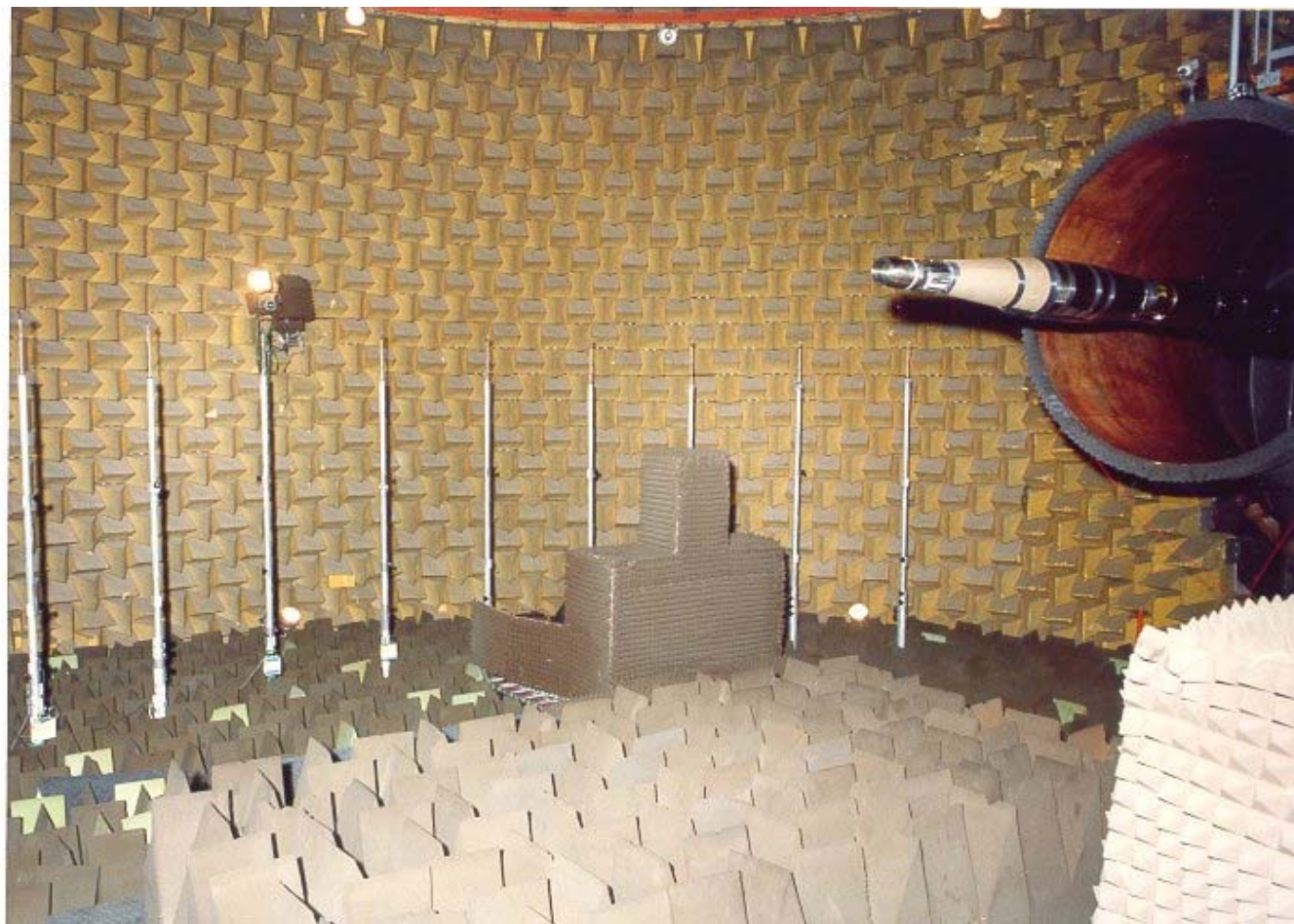


Snecma Moteurs
groupe snecma



anechoic wedges

ed microphones



Exhaust nozzle

Wind Tunnel

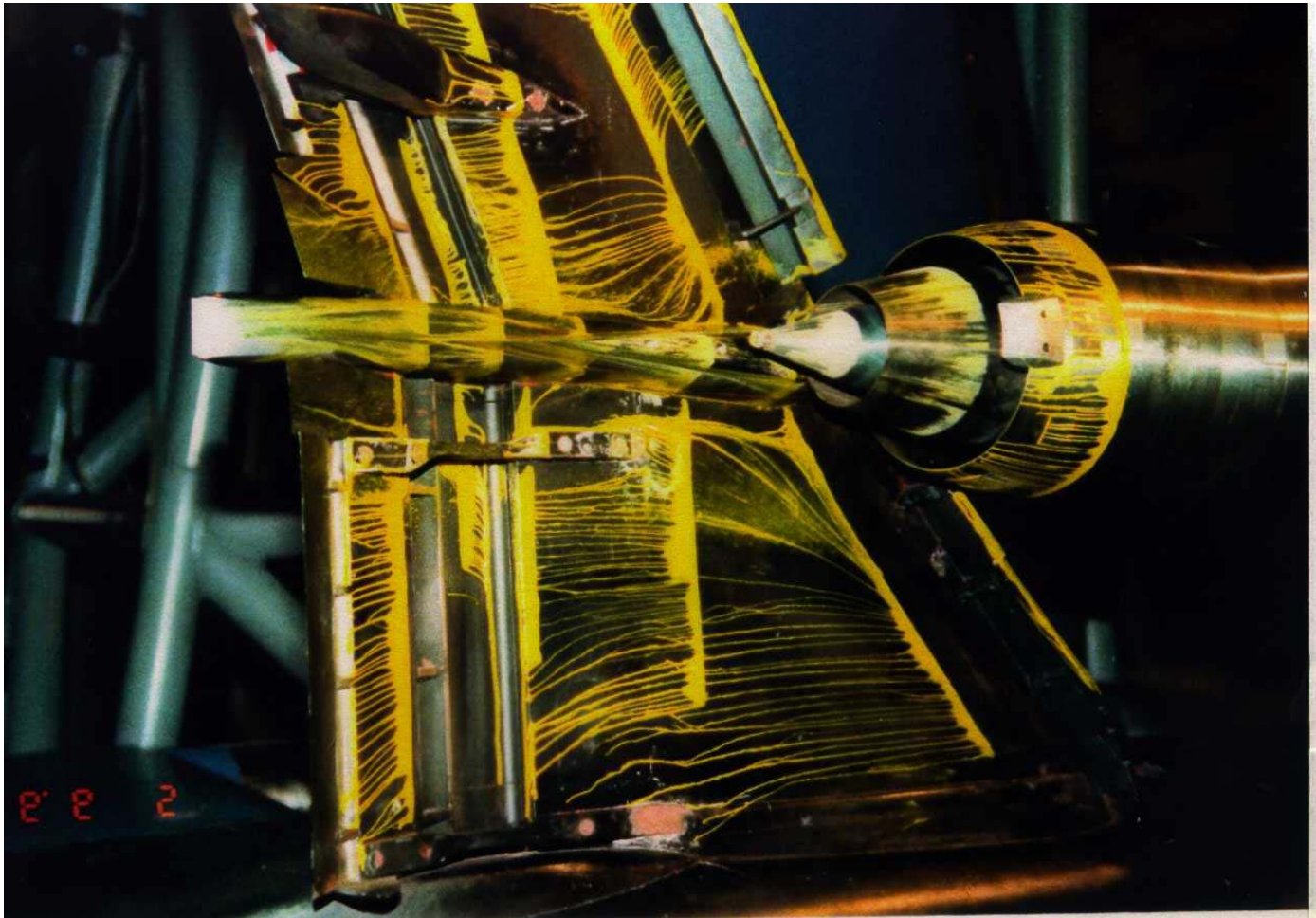
($\Phi = 2$ m)

Noise inside a new Engine Project

Experimental Validation



Snecma Moteurs
groupe snecma



CFMI Proprietary Information -
Unauthorized Disclosure, Use, or Export are Prohibited.

Noise inside a new Engine Project



Snecma Moteurs
groupe snecma



FMI Noise Experience / Experimental Database

Jet noise model in wind tunnel

- 12 campaigns since 1985, more than 60 configurations

Engine static test

- more than 15 static engine acoustic certification
- more than 20 campaigns
- more than 120 configurations including acoustic liners

Flight test

- 9 engineering flight tests
- 6 certification flight tests



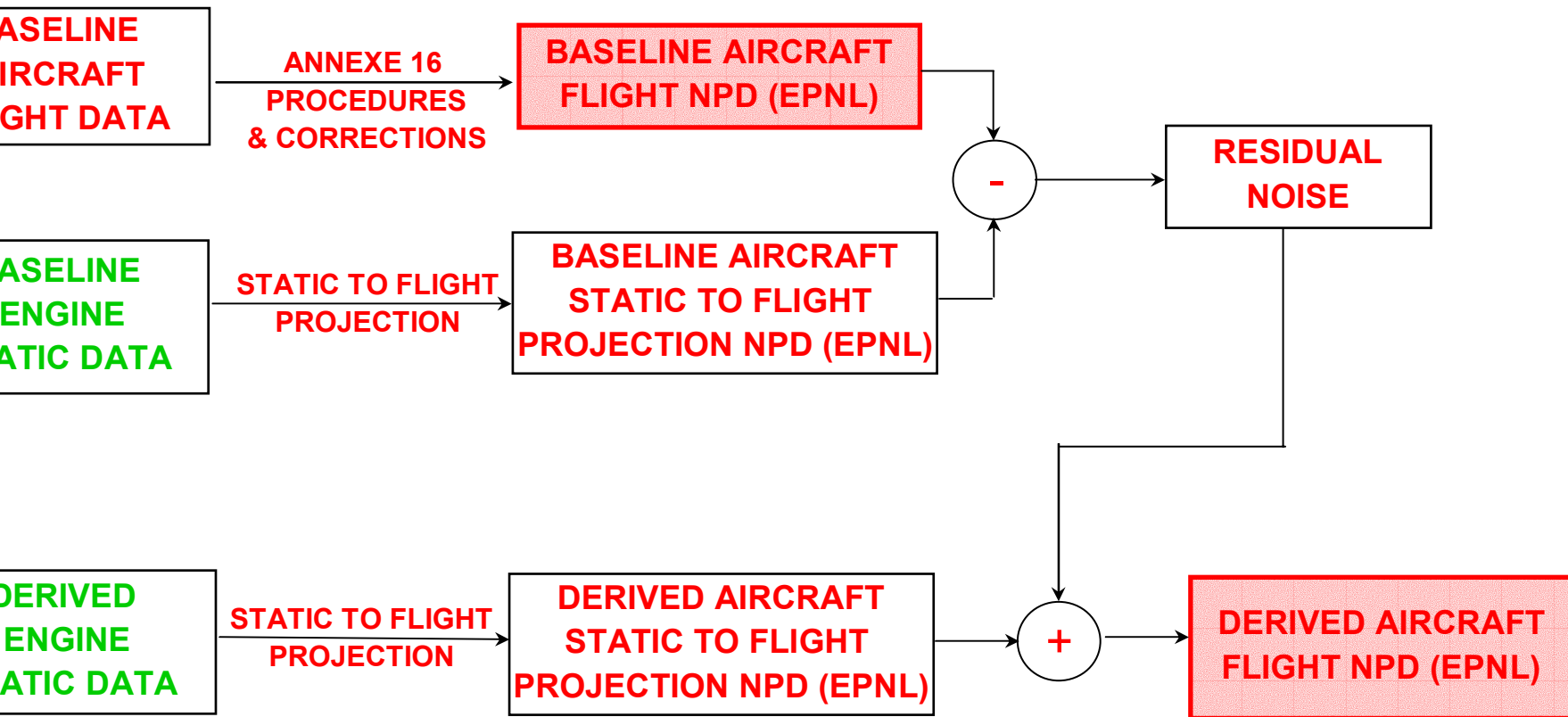
- ☎ INTRODUCTION
- ☎ ACOUSTIC REGLEMENTATION
- ☎ CFMI NOISE SITUATION
- ☎ NOISE INSIDE A NEW ENGINE PROJECT
- ☎ **NOISE CERTIFICATION**
- ☎ TODAY'S NOISE TECHNOLOGIES
- ☎ FOR A QUIET FUTURE
- ☎ QUESTIONS

Noise Certification

Noise Family Plan Concept

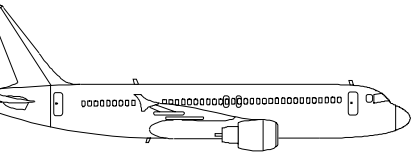


Snecma Moteurs
groupe snecma

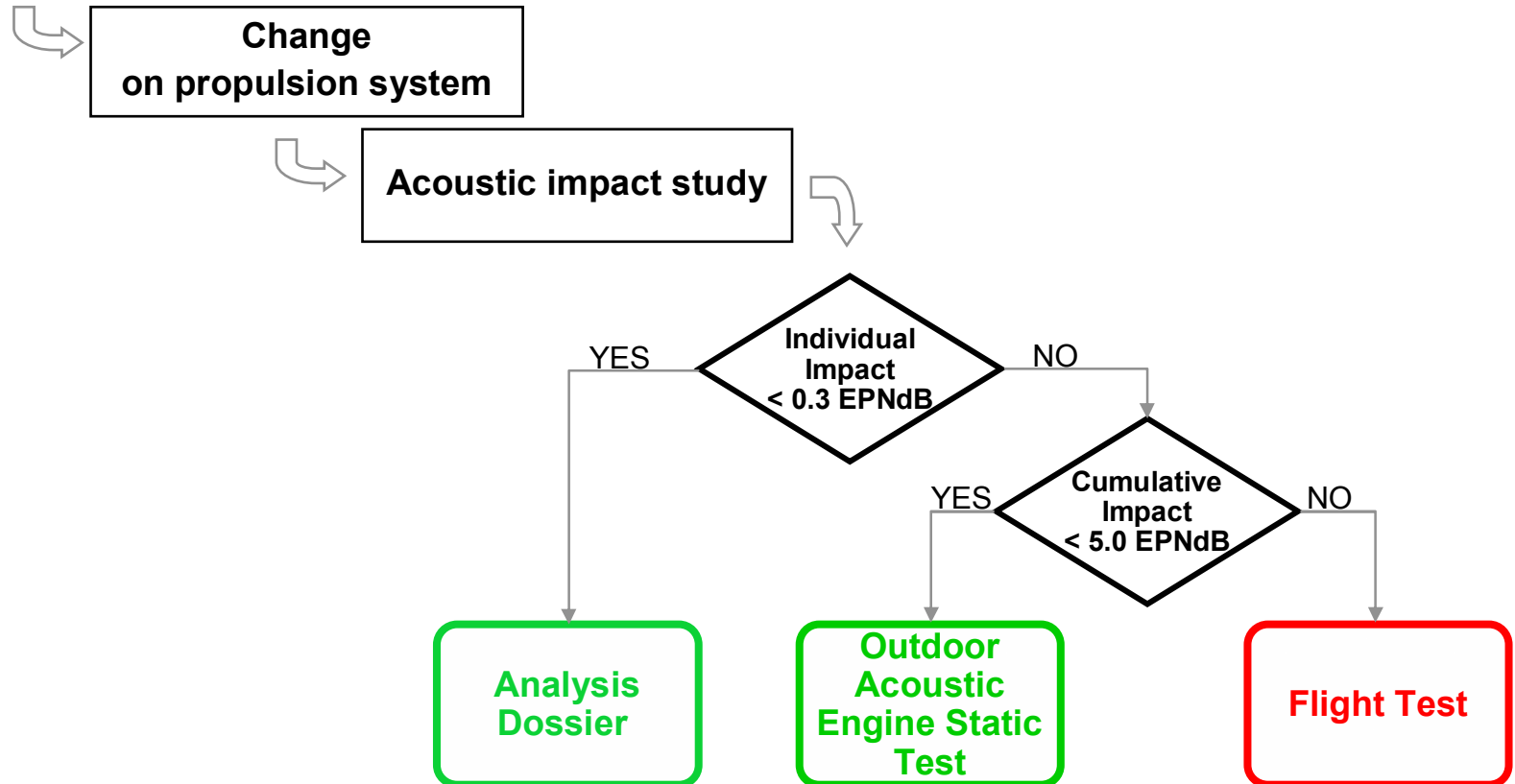


Noise Certification

Noise Family Plan Application

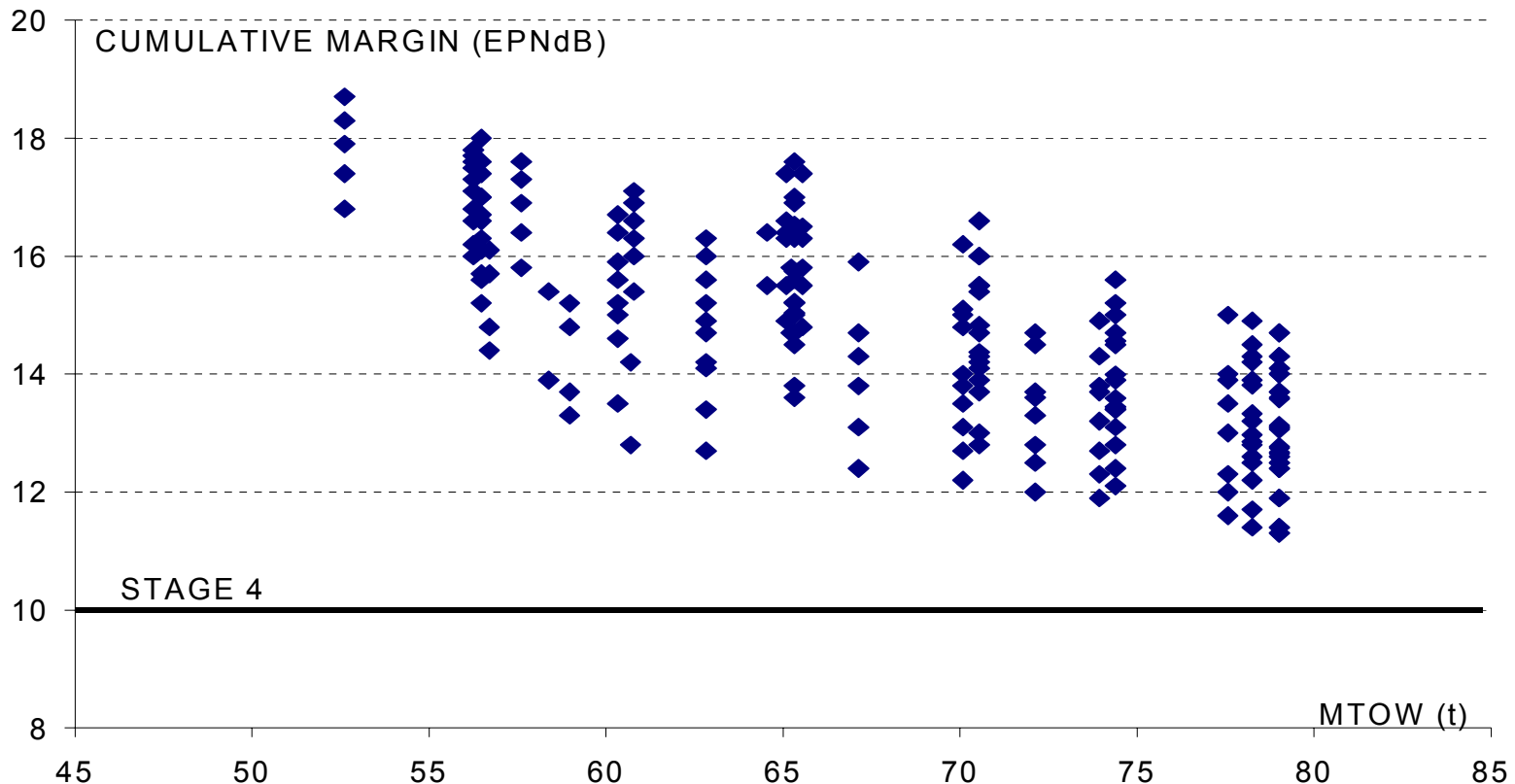


1st Version : Certification using an acoustic flight test



3737NG / CFM56 Example

**2 CERTIFICATION STATIC TEST + 1 CERTIFICATION FLIGHT TEST
= SEVERAL AIRCRAFT / ENGINE NOISE CERTIFICATION**

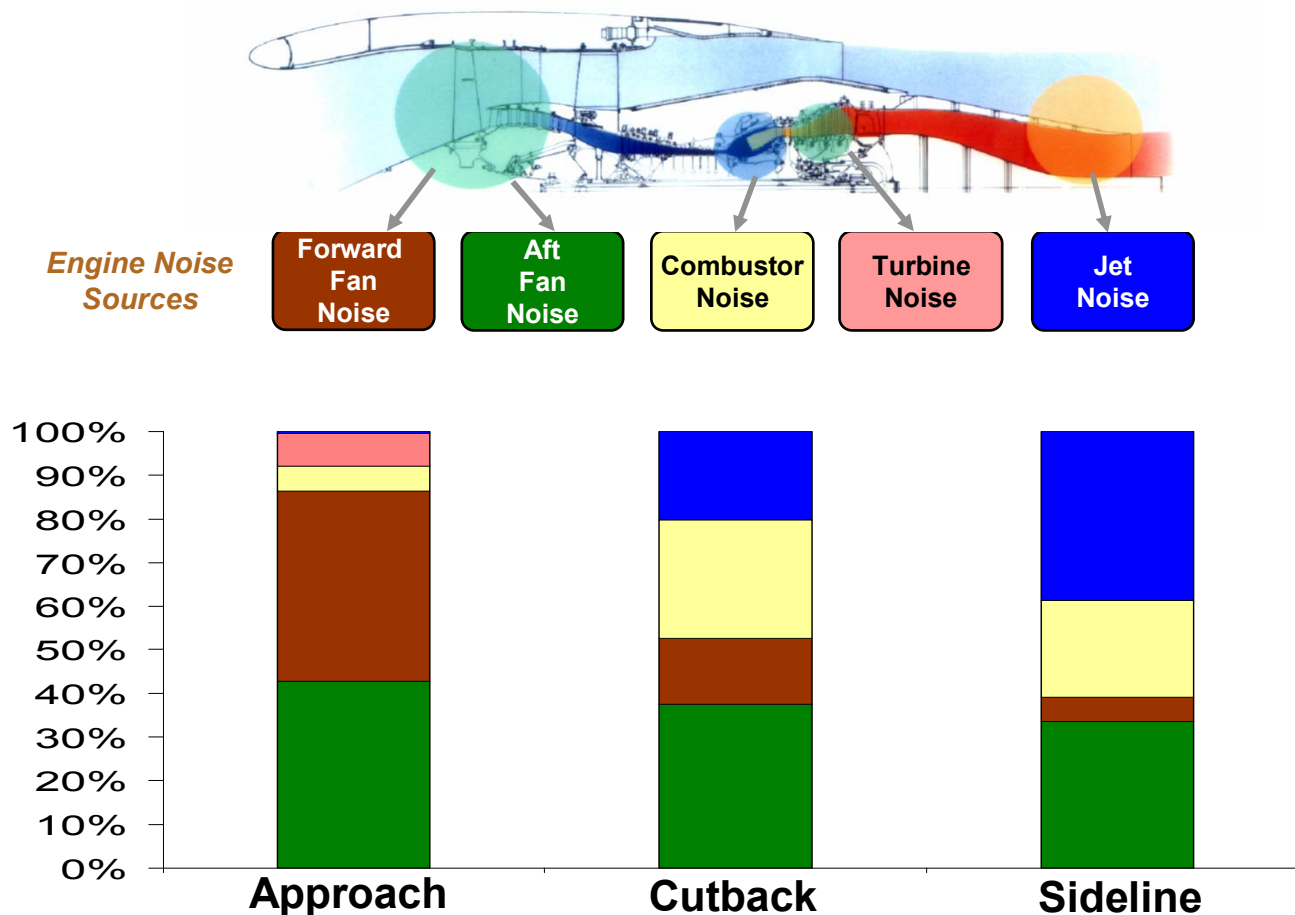




- ☎ INTRODUCTION
- ☎ ACOUSTIC REGLEMENTATION
- ☎ CFMI NOISE SITUATION
- ☎ NOISE INSIDE A NEW ENGINE PROJECT
- ☎ NOISE CERTIFICATION
- ☎ **TODAY'S NOISE TECHNOLOGIES**
- ☎ FOR A QUIET FUTURE
- ☎ QUESTIONS

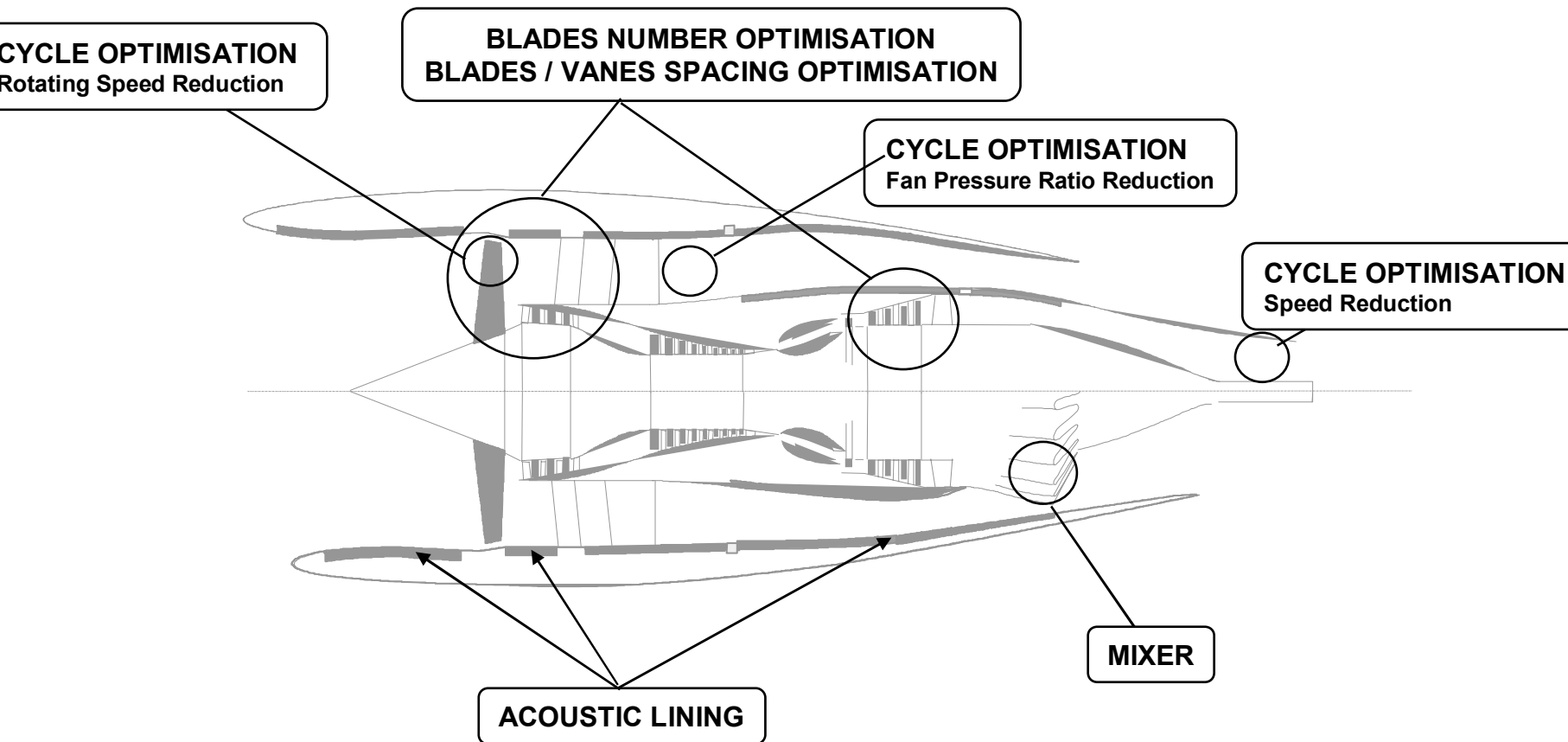
Today's Noise Technologies

Current CFMI Engines Typical Noise Signature



Today's Noise Technologies

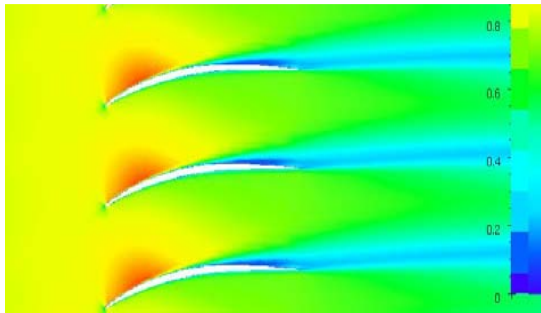
Current Noise Reduction Technologies



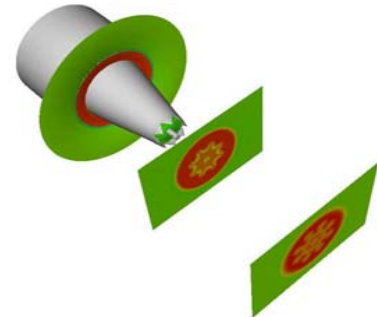
Today's Noise Technologies

Improvement of Current CFM56 Engines

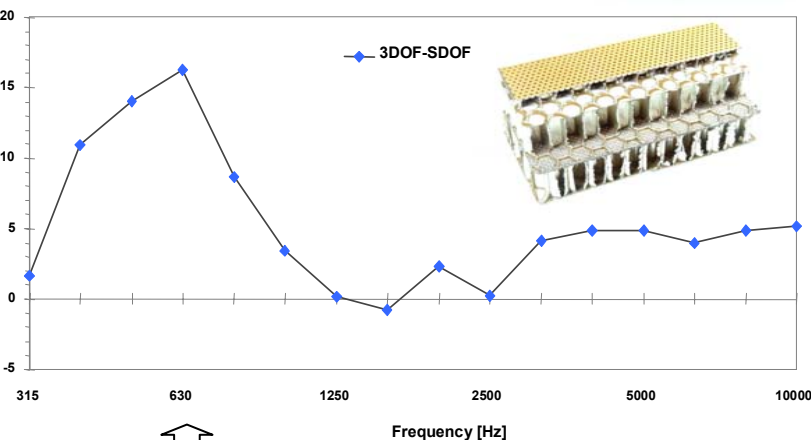
Fan Noise Reduction
through 3D OGV Aeracoustic Design



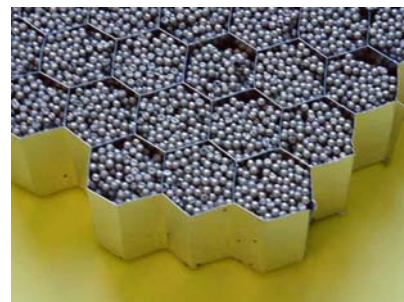
Jet Noise Reduction
through Chevron Nozzle Design



Extension of Attenuation Bandwidth
towards Low Frequency Range



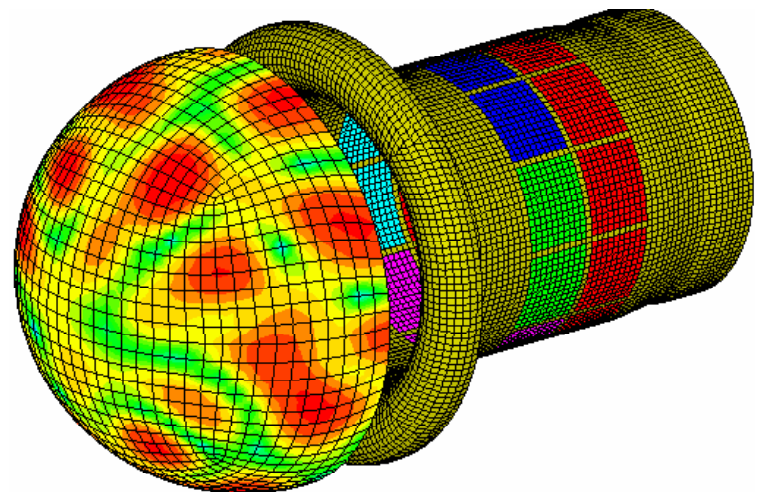
3 Degree-of-Freedom
Inlet Liner



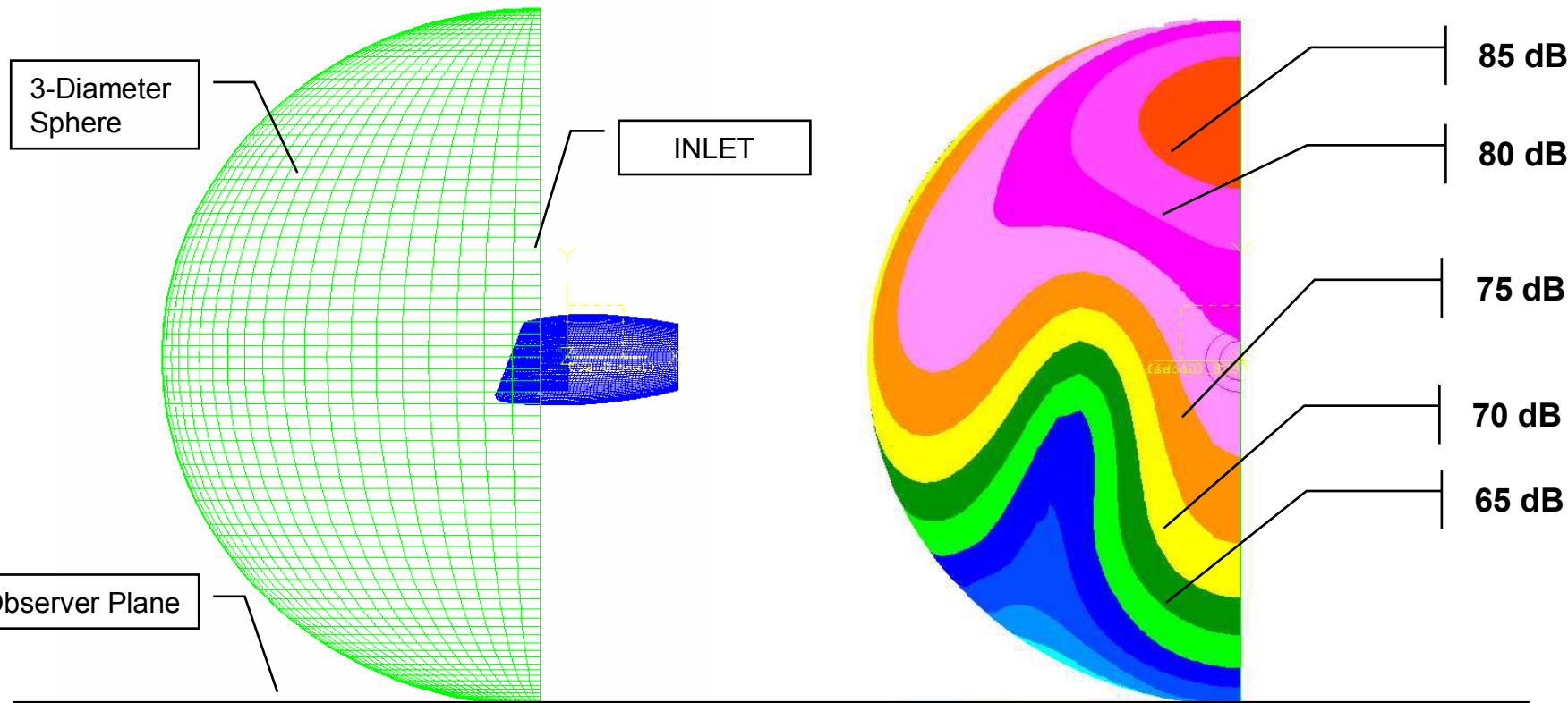
Hollow Sphere
Exhaust Liner



Improvement of Liner Efficiency
through 3D Impedance Optimisation



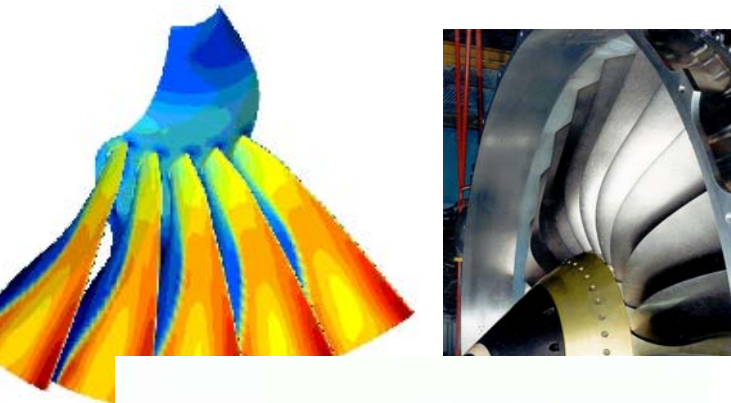
Finite Element Duct Propagation Model to support Negatively Scarfed Inlet Design



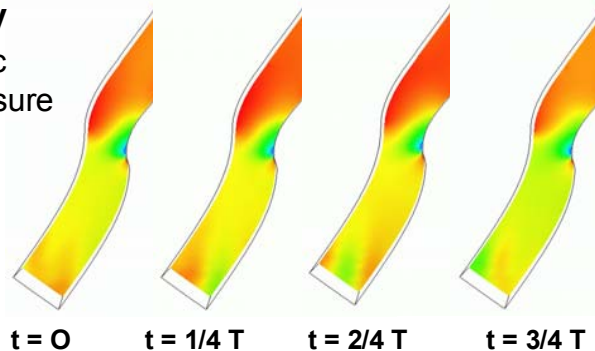
Today's Noise Technologies

Future Engine Applications

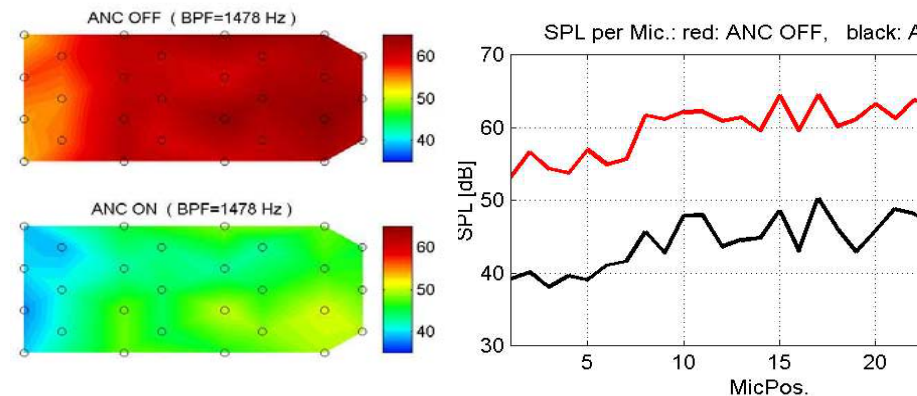
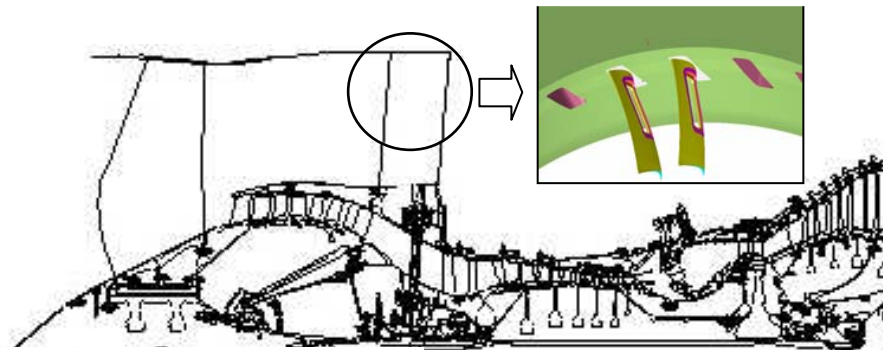
Full Implementation of CAA capabilities
to achieve Low Broadband Noise Fan Design



OGV
Static
Pressure

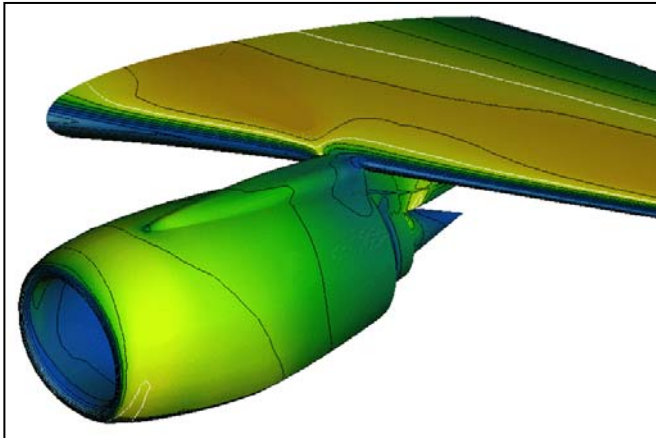


Active Technologies applied
to Low Frequency Fan Tones Reduction



Low Noise Aircraft Design- Engine installation

- Optimisation of future aircraft designs should consider powerplant installation factors as an opportunity for further noise reduction
- Significant development of aeroustics modelling and appropriate testing facilities will support such activities



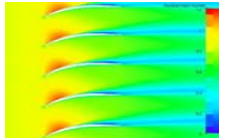
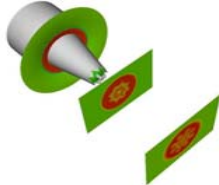
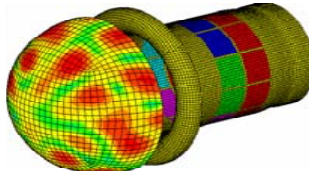
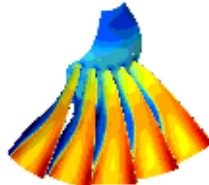
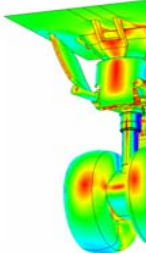

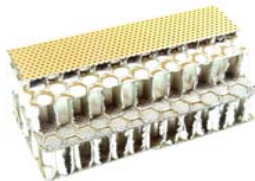

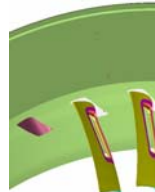
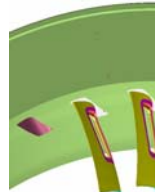



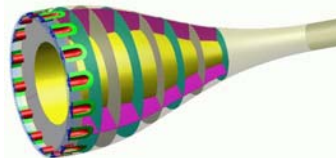
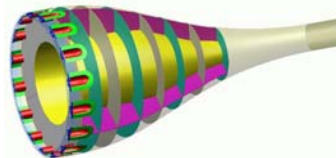





Today's Noise Technologies



Sneema Moteurs
groupe sneema



Technologies Panel to support Optimum Aircraft System Definition

Tools Source standing	Advanced CFD Models Source Models Propagation Models					
Machinery Noise Prediction Technology	Noise Reduction at Source Noise Reduction Systems					
Exhaust Noise Prediction Technology	Nozzle Design & Liner Technology					
Engine noise Prediction Techniques	High Lift Devices & Landing Gear					



- ☎ INTRODUCTION
- ☎ ACOUSTIC REGLEMENTATION
- ☎ CFMI NOISE SITUATION
- ☎ NOISE INSIDE A NEW ENGINE PROJECT
- ☎ NOISE CERTIFICATION
- ☎ TODAY'S NOISE TECHNOLOGIES
- ☎ **FOR A QUIET FUTURE**
- ☎ QUESTIONS

Upcoming Challenges

Goal to introduce in service by 2010 products allowing traffic growth at no environmental cost (Ex : 10 dB cumulative margin re Chapter 4 for a typical 100 Tons MTOW Twin Engine Aircraft) :

- ⇒ Development of appropriate panel of noise reduction technologies to support individual optimisation of aircraft system components:
 - Engine
 - Nacelle
 - Landing Gear
 - High Lift Devices
- ⇒ Combined optimisation of powerplant and aircraft taking into consideration installation factors and flight performance

For a Quiet Future

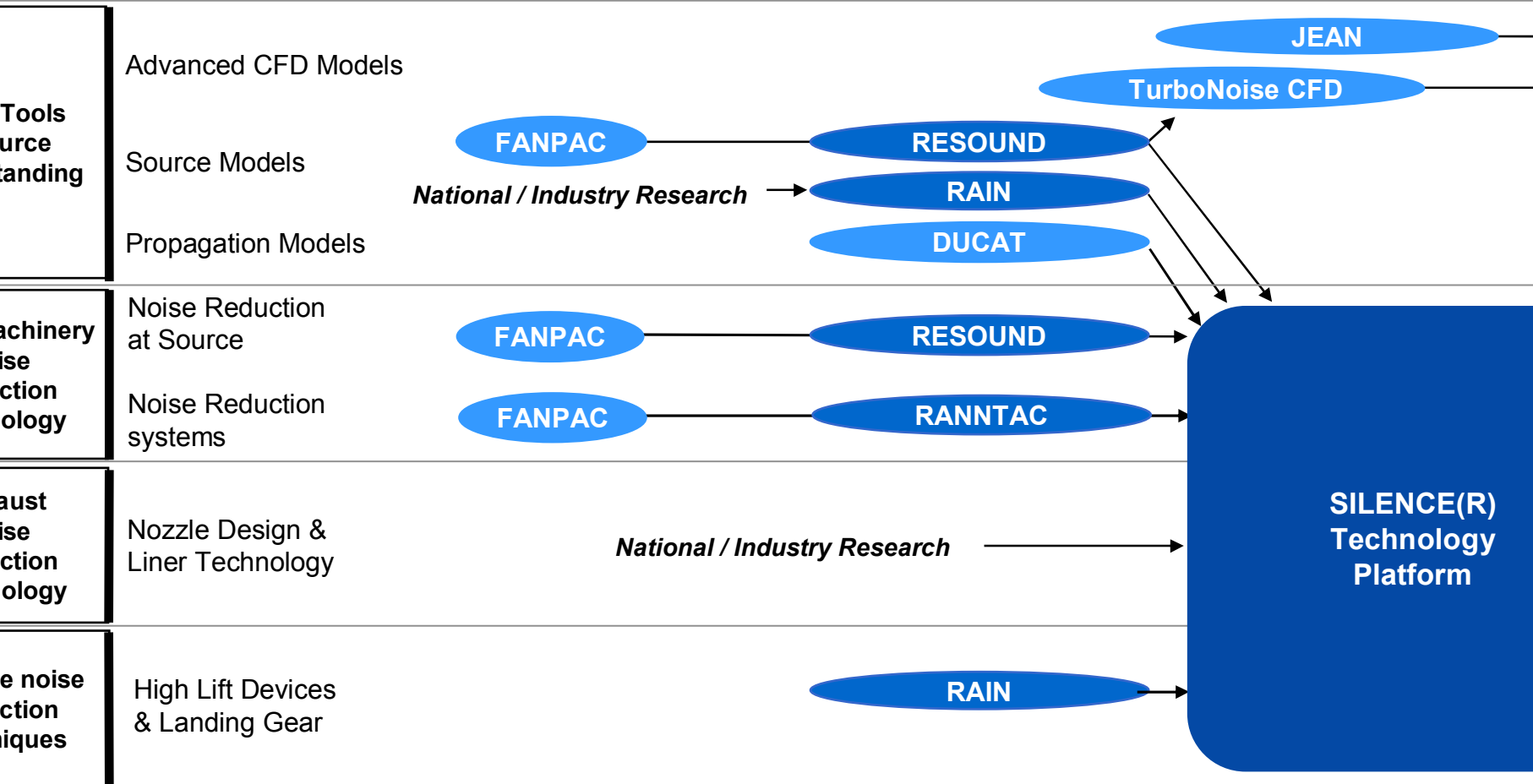
European Aircraft Noise Research Initiative



Snecma Moteurs
groupe snecma



Years→ 93 94 95 96 97 98 99 00 01 02 03 04





Project Coordinator : Snecma Moteurs

Innovations :

- Evaluation of Advanced Engine Concepts
- Development of Novel Noise Reduction Solutions:
 - Low Noise Engine Component Design
 - Nacelle and Nozzle Liner Concepts
 - Active Noise Control Applications
 - Inlet and Nozzle Advanced Design
- Evaluation of Solutions to Helicopter Engine
- Development of Airframe Noise Reduction Solutions;
 - Landing Gear
 - High Lift Devices

Project Duration : 4 years (Start 04/01)

Budget: 112 MEuros (50% EC Support)

**Participation: 51 partners from 14 EU countries
+ 2 Associated States.**



Questions ?

