Noise Reduction Trends

Average Noise Reduction in Decibels per Operation

- **B737-200**
- **B727-200**
- **A320 / CFM56-5A**
- **B737 NG / CFM56-7**
- **A320 / CFM56-5B**

- **B737 CL / CFM56-3**

**5 dB**

- High bypass ratio engines entry into service
- Optimization of noise reduction technologies

- **140-160 pax**
- **7 to 8 dB reduction per operation**

- **110-130 pax**

**1.5 dB reduction per operation**

- **2000 * Entry Into Service Year**

---

*Entry Into Service Year*

Noise Footprint Example

SAME AIRCRAFT: **GENERATION 1 ENGINES** vs **NEW GENERATION ENGINES**
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Noise Certification Scheme

AVIATION ENVIRONMENTAL PROTECTION ICAO ANNEX 16 Vol.1 Chapter 3 (THIRD EDITION 1993)
JOINT 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)

\[ dB = 10 \log_{10} \left( \frac{\text{acoustic pressure}}{20 \, \mu\text{Pa}} \right) \]

Acoustic unit used for aircraft noise certification

EPNL = Noise integration on T

TPNL (Tone corrected Perceived Noise Level)

EPNL (Effective Perceived Noise Level)
ICAO Acoustic Certification - Stage 3 Limits

EPNL vs. Airplane MTOW (Tons)

- CUT-BACK 4 ENGINES
- APPROACH
- CUT-BACK 3 ENGINES
- SIDELINE
- CUT-BACK 2 ENGINES
Acoustic Reglementation

ICAO Noise Rules Evolution

NOISE STRINGENCY IS INCREASING WITH YEARS

Uncertified Aircraft (« Stage 1 »)

« Stage 1 » Phaseout

Stage 2

Stage 3

Stage 2 Production Stop

Stage 2 Phaseout

US
Europe

Stage 4 (St3 - 10 dB Cum)

CAEP V (2001)

Noise Level


Noise Level

ICAO Decision

ICAO Decision

ICAO Decision
Stage 4 Noise Regulation

CAEP V PROPOSAL FOR STAGE 4

• STAGE 4 LIMIT FOR CUMULATIVE MARGIN 10 EPNdB MORE STRINGENT THAN STAGE 3 LIMIT
• NO TRADES ALLOWED re. to STAGE 3
• ANY 2 POINTS MUST HAVE MARGINS VS STAGE 3 THAT SUM TO AT LEAST 2 EPNdB
• APPLICABLE BY JANUARY 1ST, 2006 TO CERTIFICATION OF NEW TYPES (NEW OR DERIVATIVE A/C)
• NO GLOBAL PHASE-OUT

STAGE 3 REGULATION

AIRCRAFT CERTIFIED AFTER OCTOBER 06, 1977

1977 2001 2006 Date of application

STAGE 4 REGULATION

AIRCRAFT CERTIFIED AFTER OCTOBER 06, 1977

1977 2001 2006 Date of application

STAGE 3 REGULATION

AIRCRAFT CERTIFIED AFTER OCTOBER 06, 1977

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

THE POWER OF FLIGHT
Snecma Moteurs has prime responsibility for Noise Engineering on all CFM56 Programmes.
ICAO CHAPTER 3 LIMIT

Cumulated Margin (EPNdB)

-20
-15
-10
-5
0


Certification Year

Noise improvement on A320 engined by CFM56

Noise margin improved by 50% over 10 years

A Continued Effort To Reduce Noise
CFMI Engines Certified Noise Cumulative Margin

CUMULATIVE MARGIN (EPNdB)

MTOW (t)

STAGE 3

A321 / CFM56-5B acoustic kit

STAGE 4
Strong Integration in Engine and Aircraft Development Processes

Advanced Project  Engine Component Definition  Noise Guarantees  Development  Certification

1  2  3  4  5

Thrust Reduction

≈ 1000ft

Sideline

6500 m

6500 m

Approach

2000 m

FlyOver

2000 m

6500 m
Specific Prediction Tools to support all Engine Programme Steps

Advanced Project

Engine Component Definition

Noise Guarantees

Development

Certification

Fan Noise
Combustor Noise
Turbine Noise
Jet Noise

Installation / Flight Effects

Airframe Noise

Propagation Effects

Perceived Noise Level

Community Noise Impact

- 75dBA ISO noise contours
- Intl. T/O procedure

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Noise Sources & EPNL Calculation
Low Noise Engine Component Design

Advanced Project

Engine Component Definition

Noise Guarantees

Development

Certification

Aérodynamics

Acoustics

Mécanical Design

Fan Module

Nozzles
Optimisation of Noise Reduction Systems

Advanced Project

Engine Component Definition

Noise Guarantees

Development

Certification

Aérodynamics

Acoustics

Mécanical Design

Advanced Models & Prediction Techniques

3DOF Multilayer Liner Design

3D Duct Propagation Method

Entrée d'Air

Demi-Sphère 3 Diamètres

85 dB
80 dB
75 dB
70 dB
65 dB
Experimental Validation

Advanced Project  Engine Component Definition  Noise Guarantees  Development  Certification

1  2  3  4  5

Anechoic Wind Tunnel  Outdoor Engine Test Facility

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Experimental Validation

Anechoic wedges

Fixed microphones

Exhaust nozzle

Wind Tunnel nozzle

(\( \Phi = 2 \text{ m} \))
Experimental Validation
CFMI 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
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Noise Family Plan Concept

- BASELINE AIRCRAFT FLIGHT DATA
  - BASELINE AIRCRAFT FLIGHT NPD (EPNL)
    - BASELINE AIRCRAFT STATIC TO FLIGHT PROJECTION NPD (EPNL)
      - BASELINE ENGINE STATIC DATA
        - STATIC TO FLIGHT PROJECTION
          - BASELINE AIRCRAFT STATIC TO FLIGHT PROJECTION NPD (EPNL)
            - RESIDUAL NOISE
              - ANNEXE 16 PROCEDURES & CORRECTIONS
                - DERIVED AIRCRAFT STATIC TO FLIGHT PROJECTION NPD (EPNL)
                  - DERIVED AIRCRAFT FLIGHT NPD (EPNL)
Noise Certification
Noise Family Plan Application

1st Version: Certification using an acoustic flight test

Change on propulsion system

Acoustic impact study

Individual Impact < 0.3 EPNdB

- YES: Analysis Dossier
- NO: Cumulative Impact < 5.0 EPNdB

- YES: Outdoor Acoustic Engine Static Test
- NO: Flight Test
B737NG / CFM56 Example

2 CERTIFICATION STATIC TEST + 1 CERTIFICATION FLIGHT TEST = SEVERAL AIRCRAFT / ENGINE NOISE CERTIFICATION
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Current CFMI Engines Typical Noise Signature

- Engine Noise Sources:
  - Forward Fan Noise
  - Aft Fan Noise
  - Combustor Noise
  - Turbine Noise
  - Jet Noise

- Graph showing noise distribution for:
  - Approach
  - Cutback
  - Sideline

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**Today's Noise Technologies**

Current Noise Reduction Technologies

- **CYCLE OPTIMISATION**
  - Rotating Speed Reduction

- **BLADES NUMBER OPTIMISATION**
  - BLADES / VANES SPACING OPTIMISATION

- **ACOUSTIC LINING**

- **CYCLE OPTIMISATION**
  - Fan Pressure Ratio Reduction

- **CYCLE OPTIMISATION**
  - Speed Reduction

- **MIXER**
Today's Noise Technologies

Improvement of Current CFM56 Engines

Fan Noise Reduction through 3D OGV Aeracoustic Design

Jet Noise Reduction through Chevron Nozzle Design
Nacelle Noise Reduction Systems

Improvement of Liner Efficiency through 3D Impedance Optimisation

Extension of Attenuation Bandwidth towards Low Frequency Range

3 Degree-of-Freedom Inlet Liner

Hollow Sphere Exhaust Liner
Nacelle Noise Reduction Systems

Finite Element Duct Propagation Model to support Negatively Scarfed Inlet Design

- 3-Diameter Sphere
- INLET
- Observer Plane

- 85 dB
- 80 dB
- 75 dB
- 70 dB
- 65 dB
Future Engine Applications

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

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 aerocoustics modelling and appropriate testing facilities will support such activities.
# Today's Noise Technologies

Technologies Panel to support Optimum Aircraft System Definition

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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 90 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
Project Coordinator: Snecma Moteurs

Main Innovations:
Noise Evaluation of Advanced Engine Concepts
- Validation of Novel Noise Reduction Solutions:
  - Low Noise Engine Component Design
  - Nacelle and Nozzle Liner Concepts
  - Active Noise Control Applications
  - Inlet and Nozzle Advanced Design

Adaptation of Solutions to Helicopter Engine
- Validations of Airframe Noise Reduction Solutions;
  - Landing Gear
  - High Lift Devices

Project Duration: 4 years (Start 04/01)

Total Budget: 112 MEuros (50% EC Support)

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

ENVIROMENTALLY FRIENDLY

THE POWER OF FLIGHT

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