Noise – a driver for Change
An Aircraft Manufacturer’s View

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Overview

• History of noise reduction: components, from engine only to whole airframe

• Societal & economical needs: both driver and challenge

• Another step: aircraft operation

• Configuration design for noise: the balanced view
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The early domination of jet noise

- 2nd Generation Turbofans
- 1st Generation Turbofans
- Turbojets

Entry into Service Date

Lateral Noise Level Corrected for Aircraft Thrust

20 dB


Aeroacoustics of New Aircraft and Engine Configurations - G.A.Dirks - Airbus S.A.S

November 2004
The evolution of engine noise sources

Noise of a typical 1960s engine

- Compressor
- Turbine & Combustor
- Jet

Noise of a typical 1990s engine

- Compressor
- Fan
- Turbine & Combustor
- Jet
More and more technologies to address several balanced noise sources

- Integrated Fan Design
- UHBR Fan
- LP Compressor
- ANTLE & High Speed LP Turbines
- Low Noise Fan Nozzle
- Low Noise Core Nozzle w/ internal/external Plug
- 4 different Treated Plug Technologies
- HF Treated Nozzle
- UHBR Gear Box

- Negatively Scarfed Intake
- 3D Distributed Liner
- 0 Splice Passive Liner
- Intake Lip Liner
- Anti-Icing Adaptive Liner
- Adaptive Liner
- Active Wall-Mounted System
- Active Stators (2 concepts)
- Exhaust Splitters (radial or circum.)
An example: Fan noise

**BETTER...**
Zero Splice liner allowing the maximal attenuation from liner thanks to reduced acoustic mode scattering

**MORE...**
Extension of liners and further reduction of acoustic mode scattering allowing maximal attenuation

**INTO A RESHAPED NACELLE...**

**Negatively Scarfed Intake Principle**

...AND STILL TAKING CARE OF EXHAUST NOISE

**Diversion of noise toward sky**

**Treated primary nozzle lip (squid)**
Aircraft noise: A complex mix of different sources

- **Take-off:** Jet & Fan
- **Approach:** Fan, Airframe & Turbine

![Diagram showing noise sources](image)

- **FAN, TURBINE AND COMBUSTOR NOISE**
- **AIRFRAME NOISE**
- **FAN AND COMPRESSOR NOISE**

**Take-off**
- 5 dB
- Fan
- Compressor
- Turbine
- Jet
- Engine Total
- Aircraft Total

**Approach**
- 5 dB
- Fan
- Compressor
- Turbine
- Jet
- Engine Total
- Aircraft Total
Approach noise

**IMPORTANCE OF AIRFRAME NOISE IN APPROACH**

High Lift Devices:
- Add-on Treatment & Low Noise Design

Landing Gear:
- Fairing & Low Noise Design

**A340-300 APPROACH NOISE**

- **TOTAL**: 5dB
- **ENGINE**:
- **AIRFRAME**:

**AIRFRAME NOISE**

- CLEAN AIRFRAME
- SLATS/FLAPS
- L/G
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A societal expectation for more travelling

Revenue Passenger Kilometer (RPK) is forecasted to triple from year 2000 to 2020

The Airbus Global Market Forecast may also be found on the Internet at http://www.airbus.com
An increased community noise?

At the same time the traffic increase may lead to growing noise impact.

![Diagram showing population exposed to noise > DNL55* (millions) projections: CAEP/5, CAEP/6.](image)

- **Population exposed to noise > DNL55* (millions)**
  - Projections: CAEP/5, CAEP/6

- **Regions**:
  - **North America**
  - **Europe**
  - **Japan, Australia & New Zealand**

**Formulas:**

\[ L_{dn} = 10 \log \left( \frac{1}{\Delta t} \left( \sum_{\text{day}} 10^{L_{dn}/10} + 10 \sum_{\text{night}} 10^{L_{dn}/10} \right) \right) \]

* * Ldn = 10 log \left[ \frac{1}{\Delta t} \left( \sum_{\text{day}} 10^{L_{dn}/10} + 10 \sum_{\text{night}} 10^{L_{dn}/10} \right) \right]
Noise Reduction - The Challenge

High pressure on aircraft noise:

- regulation
- “QC” system,
- landing fees, night time operation,
- public uproar, airports extension…

Noise issue might be limiting the foreseen traffic growth (tripling by 2020)

Pushing further existing technologies has strong negative operating cost impact

Thus: Strong demand for cost friendly low noise technologies
The challenge has been transformed in the **Vision 2020 Goals:**

- **Reduce CO2 by 50%**
- **Reduce NOx by 80%**
- **Reduce perceived noise by half**
- **Eliminate noise nuisance outside airport boundaries**
- **Substantial cuts in operating costs**
- Five-fold reduction in accident rate
- Drastic reduction in the impact of human error
- 99% of flights within 15 minutes of timetable
- New standards of quality and effectiveness
- Halve the time to market
- Improve synergies between civil and military research
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Noise abatement procedures

Parameters to be optimised

- Increased ILS glide interception altitude
- Delaying stabilisation of landing configuration
- Flap setting
- Increased ILS glide slope
- Continuous descent approach
Aircraft Operation

Noise abatement procedures require:

• New functionalities such as A380 FMS handling thrust management for low noise

• New aircraft capabilities, i.e.: High lift systems enabling steeper trajectories without increased component noise

• ATC / ATM handling the new procedures
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Noise: An integral part of the design process

CONCEPT
- Requirements
  - 550 pax
- Ch.4 - X

Aerodynamics
- Performance
- Structure
- Maintainability

DEFINITION
- Multidisciplinary validation
- Risk assessment
- Risk assessment
- Risk assessment
- EPNL

DEVELOPMENT
- Trade-offs
- Selected design
- Noise reduction
Aircraft noise needs to be balanced with other aircraft design requirements

- Environmental requirements
- Noise Emissions Fuel Burn
- Reliability Fuel Cost Life-cycle Cost
- Operating costs
- Payload Range
- Timing Cost Market
- Business case
- Aircraft performance
- Operating costs
- Business case
- Environmental requirements
- Noise Emissions Fuel Burn
- Reliability Fuel Cost Life-cycle Cost
- Operating costs
- Payload Range
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- Business case
- Aircraft performance
Unlocking today’s constraints: aero performance

Future capabilities: driven by a family of concepts tailored to fit specific sets of requirements

The idea is to select concepts to explore the most relevant capabilities and meet the widest range of challenges

Important: these are not intended to be future Airbus products but extreme configurations to develop our capabilities
Low noise configurations

Airbus recognize a need to investigate these configurations in order to reach 10 dB noise reduction per aircraft operation.

Masked sources
- inlet fan
- combustion
- turbine

Masked sources
- inlet & aft fan
- compressor
- combustion
- turbine
Vision 2020 - Emissions

Despite much improvements,

- Reduce CO2 by 50%
- Reduce NOx by 80%
- Reduce perceived noise by half
- Eliminate noise nuisance outside airport boundaries
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We are committed to go even further
An Example: CO2 Reduction Potential for Conventional Aircraft

Technology - Status

AERODYNAMICS (Lift, Drag)

ENGINE TECHNOLOGY (Spec. Fuel Cons.)

WEIGHT (Materials, Systems, Structure)

CONFIGURATION

L/D

SFC

W

Target

Weigh (Materials, Systems, Structure)
Noise & Gaseous Emissions From Engines: Friends & Foes

- **Benefit**
  - Reduced Fuel Consumption & CO₂ emissions
  - Reduced Noise

- **Penalty**
  - Increased NOₓ
  - Increased aircraft weight and drag (influences range and operating costs)

**Higher Component efficiencies**

**Increased Overall Pressure Ratio & Temperatures**

**Increased Bypass Ratio**

**Nacelle Definition:** long versus short duct
Low Noise Configurations & Gaseous Emissions

What is the breakdown of potential emissions reduction for these aircraft?

Are these configurations conflicting with emissions reduction targets compared to conventional configurations?

What are the possible trades offs if needed?
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