Reducing Aviation Noise - Technology and Beyond

- Setting the Scene
  - The Balanced Approach framework for Aviation Noise Mitigation

- Challenges and Opportunities for Aviation Noise Research
  - Technology Integration: addressing a wider agenda
  - Implementing the Balanced Approach at European research level
  - Building a research community
ICAO Balanced Approach Framework

Four key areas involved in aircraft noise mitigation

- Noise Reduction At Source
- Land Use Planning and Management
- Operational restrictions
- Noise Abatement Procedures
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Powerplant Noise Reduction Options
Need to Be Balanced With Other Environmental Design Requirements

**Typical Design Tradeoffs**

- **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

Source ICCAIA
Allowing for higher Bypass Ratio (and Lower noise)

Fuel Burn

Larger diameter…
...weight and drag impact

Noise

Low weight technologies

Breakthrough technologies to minimize the weight and drag impact

BPR

3D Composite Fan Blade

Composite Fan Case

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Reducing Aircraft Noise Further
Some Outstanding Challenges

Influence of
Installation
Effects?

BPR 0-3: Jet Noise

BPR 5-7: Jet Noise
Fan Noise

BPR 9-12: Jet Noise
Fan Noise
Core Noise
Airframe Noise
Installation Effects

UHBR (>12) under Wing

Pro-Green Concept
(NACRE)

Silent Aircraft
(Cambridge – MIT)

Investigating Novel Aircraft Configurations

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ACARE Framework

Environmental Objectives

2020 relative to 2000

-10 EPNdB / Operation

Source Noise Reduction (The Quiet Aircraft)

Enablers
NRT* Generation 1
NRT* Generation 2
Novel Architectures

Noise Abatement Procedures

Community Impact Management

* Noise Reduction Technologies
Aircraft Noise Technology Evaluation Process (ANTE)

Defined in 2000, developed 2001-2005 through Silence(R) project.
Implemented in VITAL, NACRE, OPENAIR, ARTEM and in a wider form in CLEAN SKY.
Reducing Aircraft Noise Further

Some Outstanding Technology Challenges

Joint Technology / NAPs Evaluation

Noise Reduction At Source

Noise Abatement Procedures

Operational Restrictions

Land Use Planning and Management

Influence of Installation Effects?

Footprint comparison: Fleet equipped with and without Low Noise Technologies, with and without Operational Improvements
Result: Average noise reduction potential in dB

Research Aspects

ICAO Balanced Approach Framework

Noise Abatement Procedures

Land Use Planning and Management

Operational Restrictions

Noise Reduction At Source

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Noise Reduction At Source

Influence of Installation Effects?

Joint Technology / NAPs Evaluation

Noise Abatement Procedures

Management of Noise Impact

Development of Knowledge and Tools

Footprint comparison: Fleet equipped with and without Low Noise Technologies, with and without Operational Improvements

Result: Average noise reduction potential in dB

Annoyance Related Research

Dose - Response Relationship

Evidence of more recent trends (Individual airport studies)

Post 1992 fleet quieter (all chapter 3 + 4) > Lower noise of individual movements

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Over 20 years, more than 35 noise dedicated projects aimed at implementing ACARE agenda, plus participation in large architecture oriented multidisciplinary projects.

Complementary effort on noise impacts initiated.
Over 20 years, more than 35 noise dedicated projects aimed at implementing ACARE agenda, plus participation in large architecture oriented multidisciplinary projects. Complementary effort on noise impacts initiated EU Aviation Noise Research Effort Summary.
Current EU Aviation Noise Projects

Further project details available at:
http://ec.europa.eu/research/index.cfm?pg=events&eventcode=B80E68D2-FDCC-5E05-822E0CA15367976F

Workshop organised by the EC in January 2018
ACARE Framework

Environmental Objectives

- **CO₂**
  - 50% reduction by 2020 relative to 2000
  - 75% reduction by 2050 relative to 2000

- **Noise**
  - 50% reduction

- **NOx**
  - 80% reduction

Advisory Council for Aviation Research and Innovation in Europe
The key action areas addressed in Volume 1, build upon the key elements from the first issue that remain valid:

- Air vehicle design not only reinforces the requirement for evolutionary change but emphasises the need for revolutionary change that must start now.

- This is supported by the need to develop alternative sources of energy including bio-fuels but also looking to future options to support revolutionary air vehicle design changes such as electrification.

- Emphasises the need to manage key emissions such as NOx, particulates and noise and addresses more than the ACARE target but the direct impact and annoyance factors.

- Increased use of recycling and remanufacturing.

- Environmental impacts of airports and infrastructure have been refreshed.
Common Strategic Research Roadmap for Aviation Noise Reduction” under definition (ANIMA Project)

Management of Noise Impact Enablers

2035 Enablers / NRT Gen.3 + NRT Gen.1/2

Common Strategic Research Roadmap for Aviation Noise Reduction

Radically different propulsion concepts

Radically different vehicle concepts

UHBR TurboFans

CRORs

Novel Aircraft Architectures (T&W)

Novel Aircraft Architectures (HWB)

Operational Practices

Advanced Configurations & Novel Architectures

ENABLERS: Generation 3 Noise Reduction Technology (NRT) Solutions

Management of Noise Impact
ICAO Balanced Approach Framework

Research Aspects

Reducing Aircraft Noise Further

Some Outstanding Technology Challenges

Joint Technology / NAPs Evaluation

Operational Practices

Advanced Configurations & Novel Architectures

ENABLERs: Generation 3 Noise Reduction Technology (NRT) Solutions

Management of Noise Impact

Noise Abatement Procedures

Noise Reduction At Source

Dedicated Simulation Process

Management of Noise Impact Enablers

Annoyance Related Research

Development of Knowledge and Tools

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Over 20 years, more than 35 noise dedicated projects aimed at implementing ACARE agenda, plus participation in large architecture oriented multidisciplinary projects

Complementary effort on noise impacts initiated

Significant mobilization of research actors and well balanced participation between Industry and Research Organizations

A large majority of EU and Associated States participating

As of FP6, international participation in proposed projects from Russia, Brazil, China, Canada, US

Achieved international recognition linking with similar networks worldwide and providing input to ICAO regular reporting on research efforts
Network active since 1998 through X-Noise, X²-Noise and X³-Noise Coordination Action projects supported by EU funding. Fourth phase work programme (X-Noise EV CSA) completed at the end of 2015.

Now partly supported through ANIMA project.

3-Pillar Approach

- Definition & Assessment of Research Strategies
- Dissemination & Communication
Aviation Noise Research Network

Main Features & Objectives

Vision of National Programmes within the EU (Noise Reduction at Source)
More than 100 PhDs in total (2011-2015)

<table>
<thead>
<tr>
<th>Research Area</th>
<th>Industry Oriented</th>
<th>Generic</th>
</tr>
</thead>
<tbody>
<tr>
<td>Computational AeroAcoustics and Source Modelling</td>
<td>46%</td>
<td>33%</td>
</tr>
<tr>
<td>Fan/Turbine Noise</td>
<td></td>
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<tr>
<td>Jet Noise</td>
<td>2%</td>
<td>14%</td>
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<tr>
<td>Airframe Noise</td>
<td>5%</td>
<td>14%</td>
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<tr>
<td>Combustion Noise</td>
<td>26%</td>
<td>14%</td>
</tr>
<tr>
<td>Acoustic Liners / Propagation models</td>
<td>9%</td>
<td>14%</td>
</tr>
<tr>
<td>Active Noise Control Systems</td>
<td>12%</td>
<td>11%</td>
</tr>
</tbody>
</table>

European Impacts Research 2009 - 2015

Budget distribution of national/local studies vs scientific focus

Research Community Network

Definition & Assessment of Research Strategies

Dissemination & Communication
● 3-Pillar Approach

- Definition & Assessment of Research Strategies
- Dissemination & Communication
- Environmental Synergies
- International Collaboration

Aviation Noise Research Network
Main Features & Objectives
International Research Programmes (2017)
Aviation Community Noise Reduction

Research counterparts identified and engaged in discussions
Aviation Noise Research

- Strong technology component addressing outstanding challenges
- Joint technology / NAPs evaluation process
- Increased support to impacts-related research
- Impacts-driven Strategic Research Roadmap
- Global multi-disciplinary Research Community
- Research effort maintained in the long run
Thank You for Your Attention