

ENabling Optimized DISruptivE airframe-propulsion integration concepts

H2020 Research and Innovation Action
Grant Agreement No 860103

Deliverable Reference Number: D8.8

Deliverable Title:
Guidelines: noise mitigation in aeronautics & other fields

Lead participant: ECL
Contributing participant(s): all

30 September 2024

Start date of project: 1st of June 2020
Duration: 54 months

Type		
R	Document, report	X
DEM	Demonstrator, pilot, prototype, etc.	
DEC	Websites, patent fillings, videos, etc.	
ORDP	Open Research Data Pilot	
Dissemination Level		
PU	Public	X
CO	Confidential, only for members of the consortium (incl. Commission Services)	

APPROVAL

Title	Issue	Revision
Guidelines: noise mitigation in aeronautics & other fields	1	1
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1 Introduction

The ENODISE project aims to reduce noise emissions in the aviation sector by investigating and optimizing the integration of propulsion systems with airframes. The research outcomes provide valuable insights that can be transferred to non-aeronautical sectors where noise mitigation is of great importance. This document provides guidelines for applying advanced noise mitigation strategies to the following sectors:

- Wind turbines
- Automotive fans (HVAC) and cooling systems (electric vehicles in particular)
- Building ventilation systems
- Computer cooling systems
- Unmanned Aerial Vehicles (UAVs) and drones
- Ship propellers
- Cabin noise reduction in ground and air transportation

2 General Principles of Noise Mitigation

Noise mitigation strategies developed in ENODISE can be broadly categorized into passive and active methods. Each sector has unique characteristics, but the fundamental principles remain the same:

1. **Aerodynamic Design Optimization:** Minimizing flow separation and turbulence around blades or moving components reduces noise generation. These concepts have been extensively studied in WP5.
2. **Material Selection:** Using advanced materials that absorb sound or dampen vibrations can reduce noise at the source. Porous materials in particular have been studied in WP6.
3. **Shape Modifications:** Modifications to the shape of moving components, such as serrated edges on blades or fans, help break up coherent noise-producing vortices. Cost-efficient design and simulation of trailing-edge serrations have been analyzed in WP6
4. **Integration of Acoustic Treatments:** Using sound-damping enclosures or liners around noise-generating systems, where possible. Acoustic Over-the-Rotor liners have been designed, manufactured, and tested in the context of WP6.

3 Wind Turbines

Objective: Reduce aerodynamic noise caused by blade interaction with airflow.

- **Blade Shape Optimization:** Implementing serrated trailing edges or slotted blades to reduce noise-producing vortices.
- **Flow Control:** Explore passive devices like vortex generators to mitigate turbulent boundary layer separation.
- **Materials:** Incorporate sound-dampening materials within blades or turbine nacelles to absorb structural noise.

4 Automotive Fans and Cooling Systems (Electric Vehicles)

Objective: Reduce noise generated by HVAC systems and cooling fans in electric vehicles.

- **Fan Design:** Use optimized fan blade designs with serrated or slotted edges to reduce tonal noise.
- **Damping Materials:** Apply acoustic damping materials around cooling fans and HVAC components.
- **Shape Modifications:** Design fan enclosures to limit flow disruptions that lead to noise production.

5 Building Ventilation Systems

Objective: Mitigate noise from ventilation fans and air handling units.

- **Fan Blade Optimization:** Employ low-noise fan designs with improved blade shapes to minimize turbulent flow interaction.
- **Duct Design:** Smooth airflow transitions in ventilation ducts to prevent noisy flow separations.
- **Noise Absorbing Materials:** Install acoustic insulation in ducts and fan housings.

6 Computer Cooling Systems

Objective: Reduce fan noise in computer systems while maintaining cooling performance.

- **Fan Blade Shape:** Design fans with asymmetrical or serrated edges to minimize noise.
- **Acoustic Enclosures:** Use soundproof casings around noisy components like power supplies and CPU coolers.
- **Smart Control:** Implement dynamic fan control algorithms to operate at low RPMs during low workloads, reducing noise.

7 UAVs and Drones

Objective: Minimize the noise generated by propellers, particularly for urban or residential applications.

- **Propeller Shape Optimization:** Utilize low-noise propeller designs, such as those with tapered tips or serrated edges.
- **Active Flow Control:** Explore flow control techniques like distributed propulsion or leading-edge devices to mitigate noise.
- **Material Damping:** Use lightweight sound-dampening materials in the construction of UAVs.

8 Ship Propellers

Objective: Reduce cavitation-induced noise from ship propellers, which is also linked to energy efficiency.

- **Blade Design:** Optimize propeller blade shapes to minimize cavitation and turbulence.
- **Material Damping:** Apply sound-absorbing materials to ship hulls near the propeller area to reduce transmitted noise.
- **Flow Control:** Use vortex generators or other flow devices to smoothen the flow around the propeller.

9 Cabin Noise (Ground and Air Transportation)

Objective: Reduce noise transmitted to passengers in transportation vehicles.

- **Noise Isolation:** Use noise-insulating materials in vehicle cabins to absorb and block external noise.
- **Vibration Damping:** Implement materials and design features that reduce vibrations transmitted from the engine or propeller systems to the cabin.
- **Shape Optimization:** Ensure aerodynamic shapes of vehicle bodies minimize turbulent flow and wind noise.

10 Conclusion

The noise mitigation strategies developed within the ENODISE project have broad applicability beyond aeronautics. By adapting these advanced strategies to different non-aeronautical sectors, significant noise reductions can be achieved, improving efficiency, comfort, and environmental impact across industries.