



MANOEUVRES

Manoeuvring Noise Evaluation Using Validated Rotor State Estimation Systems

State of the art – Background

Radiated noise is among the main factors that limit public acceptance of rotorcraft vehicles, hindering a wider diffusion of these unique machines that still exhibit a considerable growth potential in terms of performance, cost effectiveness and social usefulness at large. The problem is particularly felt when operating in proximity to the ground, as in approach and departure procedures, in densely populated areas.

Several European research projects have already dealt with identification of optimal rotorcraft trajectories, minimising the noise emitted nearby populated area. At the moment, all these developed noise optimization tools use static acoustic maps that neglect the influence of flight. MANOEUVRES investigates these limitations and **seeks improvement** performing real-time noise estimation based on in-flight rotor flapping measurement. Furthermore, while actual blade flapping sensor systems are experimental applications, the MANOEUVRES system is **intended for application on production helicopters** (designed from the beginning taking into account constraints and requirements of a possible future certification under CS 27/29), so design and development consider all relevant requirements, in particular regarding safety, operating and environmental conditions, human-machine interface and software implementation.

Objectives

The MANOEUVRES project aims to **study and develop enabling technologies** towards an **innovative approach to noise abatement in rotorcraft manoeuvres** by way of an enhanced **pilot noise awareness**. This is based on the real-time presentation of the emitted noise level, through a new cockpit instrument: the **Pilot Acoustic Indicator (PAI)**. By monitoring the PAI, the pilot will be able to appropriately adjust flight controls, to avoid highly disturbing flight conditions, such as those when strong main rotor BVI (Blade-Vortex Interaction) occurs. Emitted noise will be estimated through a **suited acoustic database** fed by information retrievable on-board (advance ratio, thrust coefficient) plus an innovative in-flight measurement of the main rotor tip-path-plane angle of attack. This measurement

represents the core technology of the project and will be performed through a **novel contactless sensor system** able to estimate the blade flapping angles.

Description of work

In order to fulfil the project goals, MANOEUVRES is organised in three main research activities – **acoustic prediction, innovative measurement system development, and in-flight monitoring tool development** - plus an effort towards the development of **innovative control laws**.

The project is articulated in **5 Work Packages**.

WP1 is devoted to **acoustic prediction**, including both the development of the necessary database for the in-flight noise estimation algorithm and an in-depth study of the non-steady effects of manoeuvring flight on noise prediction.

WP2 and WP3 are dedicated to the **flapping measurement system**: in the first year, preliminary design, analysis and testing of two competing candidate methodologies are carried out up to the selection of the final concept to be developed full-scale in the second year, reaching a final integration on-board a real helicopter for ground testing. The exploitation of the flapping sensor to improve flight control laws aiming at reducing pilot workload in manoeuvring flight is also investigated.

WP4 concerns **in-flight noise monitoring**, including the development of the noise estimation algorithm and of the PAI prototype, to be eventually tested on an helicopter manufacturer flight simulator for final evaluation.

Finally, WP5 is devoted to **project management, dissemination and exploitation**.

The MANOEUVRES consortium brings together two universities **Politecnico di Milano, Università degli Studi Roma Tre**, and two SMEs **Logic Spa, Vicoter**. Politecnico di Milano coordinates the project and leads the activities related to innovative measurement system development and in-flight monitoring tool development. Università degli Studi Roma Tre is responsible for the acoustic prediction. Vicoter supports the activities on innovative measurement system development, focusing on mechanical installation, workbench design and realisation, experimental testing, data acquisition and processing.

Logic provides the necessary skills for the requirement definition phases of the activities.

Expected results

The project involves the design, develop and testing of a **novel sensor system** intended to return run-time information on vehicle noise in non-steady conditions.

The MANOEUVRES system will include:

- an innovative on-board apparatus devoted to the measurement of main rotor flap angles;
- the necessary signal conditioning system;
- an estimation algorithm for main rotor angle of attack (AOA);
- an acoustic prediction algorithm;
- a graphical display (Pilot Acoustic Indicator) of the noise signal to the pilot.

a) Timeline & main milestones

The project duration is 24 months.

Three technical work packages (WP1, WP2, WP4) are running since the beginning of the project. WP3 focusing on the flapping measurement system development is starting at Month 14. Support activities (WP5) are ongoing for the whole period.

The PAI solution, to be implement and tested, will be chosen by the first 9 months of the project.

A noise prediction algorithm will be developed by month 8, thereafter the preliminary candidate measurement systems specifications and results will be detailed. Unsteady noise predictions and correlation with flight test data will be performed at the beginning of the second year of the project, together with a preliminary implementation of the PAI, that will be finally demonstrated by the beginning of 2015.

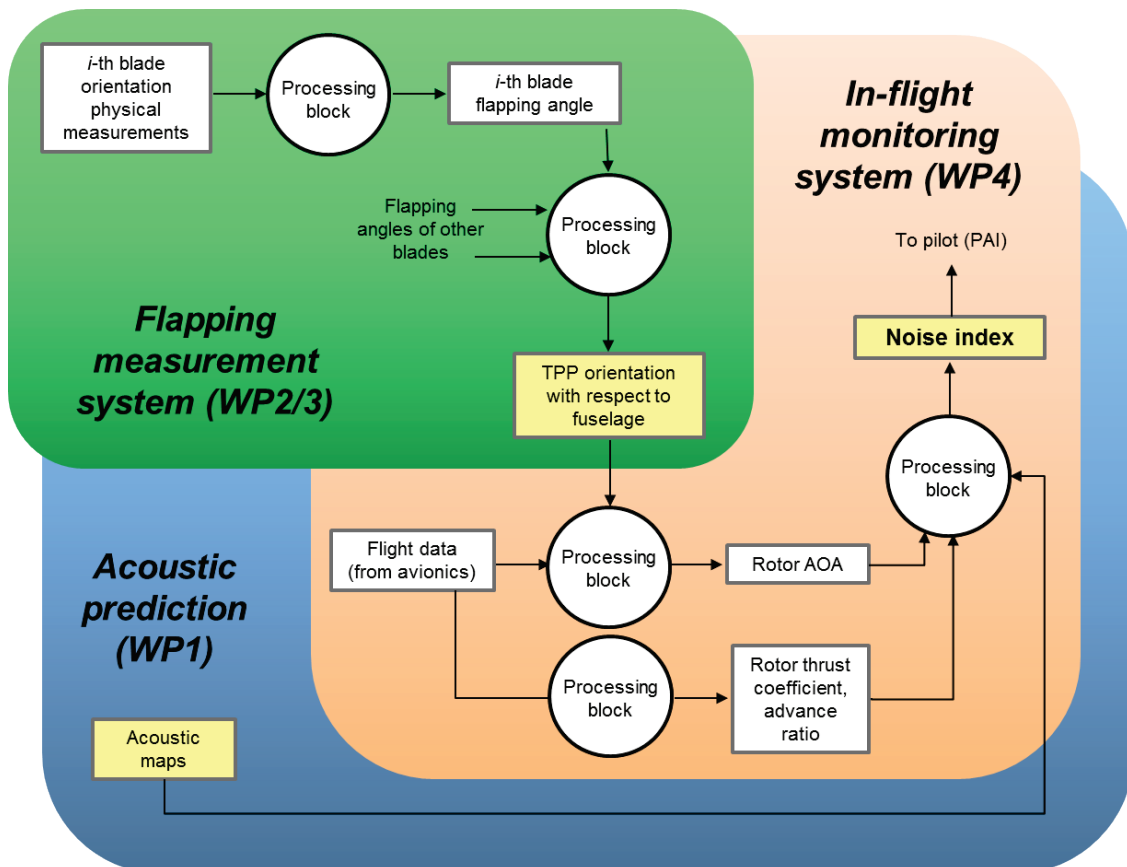
The MANOEUVRES system will be integrated and tested on a ground test vehicle (AW139) in the last 6 months of the project for final validation and functional/performance assessment.

b) Environmental benefits

The MANOEUVRES system will significantly contribute to the reduction of rotorcraft environmental impact in term of noise emissions, including during non-stationary manoeuvring flight conditions, enhancing public acceptance of rotary wing operations in populated/environmentally sensitive areas.

c) Maturity of works performed

A full-scale integrated prototype of the rotor state measurement system will be installed on a ground test vehicle (AW139) and validated, demonstrating a level of maturity up to TRL5. The pilot acoustic indicator will be assessed through a test campaign on an industrial R&D flight simulator.



MANOEUVRES integrated concept layout

Project Summary

Acronym : MANOEUVRES

Name of proposal: Manoeuvring Noise Evaluation Using Validated Rotor State Estimation Systems

Technical domain: Innovative measurement and monitoring system for accurate on-board acoustic predictions during rotorcraft approaches and departures

Involved ITD Green Rotorcraft
Environmentally friendly flight paths

Grant Agreement: 620068

Instrument: Clean Sky

Total Cost: 1 499 383 €

Clean Sky contribution: 1 124 537 €

Call: SP1-JTI-CS-2013-01

Starting date: October 2013

Ending date: September 2015

Duration: 24 months

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