HELIINOVI

Helicopter Noise and Vibration Reduction

Funding: European (5th RTD Framework Programme)
Duration: Apr 2002 - Mar 2005
Status: Complete with results

Background & policy context:

The conventional helicopter is close to the edge of its performance envelope. In the future emphasis is on making it a more efficient, environmentally friendly mode of transport. Both, vibration and noise, are major nuisance to aircraft occupants. In addition, they increase the pilot’s strain during flight and reduce his capability to safely pilot the aircraft.

Noise radiated from aircraft is a general nuisance for the community. Vibrations cause major problems for the operation and maintenance of the aircraft. Induced by the complex interaction between main rotor and airframe, vibrations may cut the fatigue life of helicopter components down to 50% creating major costs for the aircraft operator.

Helicopter noise not only bothers helicopter occupants, but the total flight environment of the aircraft. Recognising that police and health/rescue services helicopters are often operated in populated areas, noise reduction is of major importance and a strong marketing aspect. A quite helicopter is benefit for the community in quest of a quite environment.

Objectives:

HeliINOVI’s overall research objective is the enhancement of helicopter performance, safety and ride comfort.

In detail the objectives are to:

- investigate complex configurations which may reduce noise by at least 7EPNdB;
- double the lifetime of components by decreasing the vibration energy;
- improve passenger comfort for high fidelity ride esp. in medical service;
- shorten the time needed for helicopter type certification;
- expand the maintenance cycles of the helicopter structure and avionics.

Methodology:

The methodology within the ‘Tail Rotor Noise Reduction Potential’ will comprise:

- Adaptation, upgrade, or refinement of rotor aerodynamic and acoustic simulation codes for the prediction of high resolution unsteady blade surface pressures and the radiated noise. Objectives are to conduct pre-test predictions for code-to-code and later code-to-test comparisons. As regards the noise calculations, in all cases this is done in an a posterior procedure closely related to the aerodynamic calculations which makes them all indispensable.
- Design of a wind tunnel test employing the existing powered 40%-scaled BO 105 helicopter model featuring pressure instrumented main and tail rotor blades. Measurements will cover simultaneous acquisition of aerodynamic, dynamic, acoustic, and operational data all to be carefully analysed. Objective is the generation of a quality data base for code validation and assessment of tail rotor noise palliatives.
- Validation of the simulation codes by performing code-to-test comparisons using the prediction, wind tunnel, and flight test results (to be complementary provided by DLR). Analysis of potential
discrepancies will lead to improved simulation tools. Objective is to improve the understanding and prediction capability of tail rotor (and main rotor) noise for a more accurate prediction of acoustically relevant design changes.

- Quantification (numerically and experimentally) of the tail rotor noise reduction potential through variation of blade air load and tip speed, through change of the tail rotor sense of rotation, and by modifying the tail rotor position (to minimise or avoid the interaction with the main rotor wake). Objectives are to assess the acoustic benefit in view of realistic helicopter operation and to eventually establish design guidelines for future less noisy helicopters with conventional tail rotor.

The methodology for the 'Vibration Reduction Potential' consists of the following key topics:

- Wind tunnel test results of a scaled helicopter model will be analysed in detail for tools validation purposes. Measurements will cover both aerodynamic (PIV, pressure pick-ups) and dynamic issues (blade gauges, hub balance). Objective is the validation of design codes and modelling techniques for the prediction of dynamics affected by interactional aerodynamic effects.
- The results of the wind tunnel tests and complementary theoretical investigations will

**Parent Programmes:**

FP5-GROWTH KA4 (AERONAUTICS) - New Perspectives in Aeronautics

**Institute type:** Public institution

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**Partners:**

- DLR - Deutsches Zentrum für Luft- und Raumfahrt (D) - Co-Ordinator,
- Eurocopter SAS (F),
- EUROCOPTER Deutschland GmbH (D),
- SENER Ingeniería y Sistemas S.A. (E),
- VIBRATEC (F),
- CIRA - Italian Aerospace Research Centre (I),
- QINETIQ (UK),
- NLR - Nationaal Lucht- en Ruimtevaartlaboratorium (NL),
- ONERA - French aerospace research centre (F),
- NTUA - National Technical University of Athens (GR),
- UMIST - University of Manchester Institute for Science and Technology (UK).

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**Key Results:**

The first major step in the programme was the creation of a data base capable to cover interactional phenomena between main rotor, tail rotor and fuselage. Such data base is necessary firstly to evaluate the noise and vibration reduction potential. Secondly it allows evaluating the simulation capability of the prediction tools with respect to interactional phenomena. Once the tools have been validated, they can be used to locate the main noise and the vibration radiating areas of the aircraft as basis for future research and design work.

There is high interest of the industry to tackle noise and vibration phenomena which have significant impact on type certification, crew and passenger comfort, and the life cycles of helicopter components.

The goal of reducing noise by 60% was achieved by changing the tail rotor sense of rotation from "Advancing Side Down" to "Advancing Side Up". When comparing with tail rotor in "Advancing Side Down" mode, an average noise reduction of between 5 to 8 dBA has been measured depending on the flight condition. There was no performance penalty observed by the reversing tail rotor sense of rotation.

As a result of tip speed reduction, an averaged noise reduction value of more than 2 dBA was observed for all flight conditions. The reduction of main rotor BVI noise, especially in the retreating side area, was
even more than 3dBA.

The experimental acoustic set up of the model helicopter (in DNW-LLF 8m by 6m open jet) measures the noise pattern and directivity. The microphone array (red plane) - with more than 120 microphones - moves with the microphone traverse. The helicopter model is a 40% Mach scaled Bo-105. The diameter of the main rotor is 4 meter. In most of cases the experimental noise reduction benefits were confirmed in numerical simulations.

Tail rotor modifications were also analysed in order to study the vibration reduction potential based on interactional aerodynamics. The investigations and also the theoretical results confirmed that the tail rotor configuration can be optimised without affecting the vibratory behaviour.

In particular the clearance between main rotor and fuselage was studied in some detail. The Bo-105 as small helicopter has a large relative clearance leading to an interference factor of 0.6 compar

**Technical Implications**

See key results

**Policy implications**

See key results

Documents:

[HELINOVI HN-Final Publishable Report-05May06.pdf (Final report)](HELINOVI HN-Final Publishable Report-05May06.pdf)

**STRIA Roadmaps:** Vehicle design and manufacturing

**Transport mode:** Air transport

**Transport sectors:** Passenger transport

Safety/Security, Societal/Economic issues, Environmental/Emissions

**Transport policies:** aspects

**Geo-spatial type:** Other