



Helicopter Noise & Vibration Reduction

## **Final Publishable Report**

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## Final Publishable Report

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**Acronym:** HeliNOVI

**Title:** Helicopter Noise & Vibration Reduction

**Co-ordinator:** DLR D

**Partners:**

- |  |    |
|--|----|
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| 2 Eurocopter SAS (EC)  | F  |
| 3 Eurocopter Deutschland (ECD)                                     | D  |
| 4 Sener Ingenieria y Sistemas (SENER)                              | E  |
| 5 Vibratec (VIBRATEC)  | F  |
| 6 Centro Italiano di Ricerche Aerospaziali (CIRA)                  | I  |
| 7 QinetiQ Ltd (QINETIQ)  | GB |
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| 9 Office National d'Etudes et de Recherches Aéropatiales (ONERA)   | F  |
| 10 National Technical University of Athens (NTUA)                  | GR |
| 11 Univ. of Manchester Institute of Science and Technology (UMIST) | GB |

**Reference period:** 1<sup>st</sup> April 2002 to 31<sup>st</sup> March 2006

**Starting date:** 1<sup>st</sup> April 2002

**Duration:** 36 months +12 months extension

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Thanks to a very intense research on noise reduction technologies, European manufacturers are producing the quietest helicopters in the world. HeliNOVI is focussing on noise and vibration reduction of rotary wing aircraft in support of maintaining their lead position as well as getting prepared to comply with new and increasingly stringent noise regulations.

HeliNOVI started on 1st April 2002 and was successfully completed on 31st March 2006.

The overall RTD objective was the performance enhancement of helicopters while at the same time increasing safety and ride comfort. The target was to reduce the blade vortex interaction noise by 60%, which are more than 7 EPNdB, and to reduce rotor induced vibrations by up to 90%.

Figure 1 provides an overview on the noise generating flow patterns dealt within HeliNOVI.

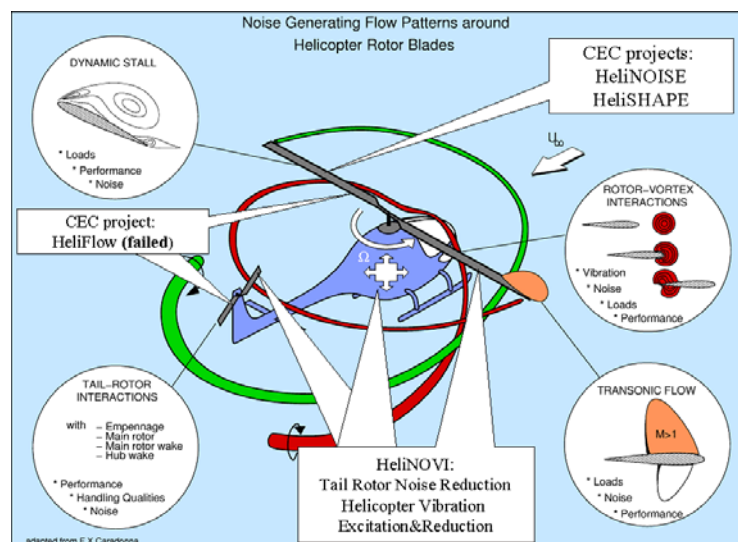


Figure 1: Interactional phenomena between main rotor, fuselage, and tail rotor

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 a high interested 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.

Figure 2 shows the experimental acoustic set up of the model helicopter in the DNW-LLF 8m by 6m open jet. The microphone array (red plane) - with more than 120 microphones - moves with the microphone traverse. The setup allows to measure noise pattern and directivity.

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.



Figure 2: Acoustic test set-up with model helicopter & microphone array

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 compared to transport helicopters with small main rotor shaft lengths. The latter are showing high interference factors between 1 and 3. In a parametric study clearance between main rotor and fuselage was systematically reduced in order to analyse the hereby increasing vibration level of a top fairing of the wind tunnel model. The interference factor of the wind tunnel model was modified to approximately 2 by the top fairing.

The aerodynamic influence of the fuselage on vibratory loads increases with flight speed underlining the high importance of this interaction for operational needs.

The higher harmonic vibratory flap bending loads in the rotating system contribute to the 4/rev roll and pitch moments in the airframe system leading to a difference of at least 33%. Higher differences are expected for increased wind speeds. The theoretical results are consistent to the experimental data.

These HeliNOVI test results confirm the importance of interactional aerodynamics on helicopter vibration characteristics for industrial design considerations. They underpin the importance of the comprehensive data analysis and code validation work performed in this project. In summary the following results are available:

- A unique database for high resolution air loads on rotor blades and fuselage as well as for the radiated noise has been generated. Such database is presently not available in Europe. The now available test data are providing work for many years to come after HeliNOVI. Each partner has a full set of data (> 60 Gigabyte) available for future analysis work.
- The prediction tools for tail rotor noise including main/tail rotor interactions have been validated. They are available for future aircraft design and retrofit purposes.
- Tail rotor noise and vibration reduction potentials have been demonstrated and validated theoretically and experimentally.

For the wind tunnel tests a complex, fully operational helicopter model was used as shown in Figure 2. Despite a fatal breakdown of the model helicopter's gearbox the test was successfully completed covering almost all of the envisaged experiments thanks to the insurance coverage of the test. However, the interruption of the test caused a one year delay of the project.

In order to effectively disseminate HeliNOVI's results the final project meeting was arranged as open workshop at DLR's Braunschweig facility in Germany.

The consortium would like to thank the European Commission for supporting HeliNOVI.