

# BLUECOPTER™ DEMONSTRATOR: THE STATE-OF-THE-ART IN LOW NOISE DESIGN

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## Abstract

The present paper intends to present the state-of-the-art in current rotorcraft noise reduction technologies using the example of the innovative BLUECOPTER™ demonstrator (Figure 1). All described noise reduction features, notably the active rudder and the Fenestron® noise measures such as the advanced rotor blades, the evolved stator design and the innovative Fenestron® lining concept, contribute to the challenging and ambitious objective of reducing the noise emission of the rotorcraft directly at the source in a wide range of operationally relevant flight states. The paper incorporates results from the latest BLUECOPTER™ acoustic flight test campaign in final configuration and demonstrates the exceptional low noise signature of the BLUECOPTER™ demonstrator in various flight conditions.

## NOMENCLATURE

MTOW	Maximum TakeOff Weight
EPNL	Effective Perceived Noise Level
HOGE	Hover Out of Ground Effect
FLM	Flight Manual
BETA	Side Slip Angle

## INTRODUCTION

Reports about noise related annoyance and community complains triggered by rotorcraft operations in densely populated areas have become a more and more frequent phenomenon in recent years.

As a major manufacturer of rotorcraft in all weight classes Airbus Helicopters proactively develops unique solutions to continuously reduce the noise of its products but also actively contributes to the generation and improvement of industry-wide guidelines and the implementation of best-practice solutions.

Furthermore Airbus Helicopters is well-known for the development of innovative low noise solutions.

The silent shrouded tail rotor anti-torque concept Fenestron®, the design of advanced main rotor blade geometries and the implementation of automatic rotor rotational speed laws are successful examples of innovative ideas that have been serialized and continuously evolved over the years. The results are clearly visible in the exceptionally low noise characteristics of the current Airbus Helicopter fleet (Ref. [2]).

This paper intends to present the state-of-the-art in current rotorcraft noise reduction technologies focusing on the innovative BLUECOPTER™ demonstrator (Ref. [1]) and describing in particular the applied Fenestron® noise reduction measures as well as the final acoustic flight test results.



**Figure 1: BLUECOPTER™ demonstrator**

Details on the dynamic challenges of the BLUECOPTER™ demonstrator are given in Ref. [8].

## LOW NOISE DESIGN

Though the main rotor represents the dominant noise source in most flight conditions, a comprehensive noise reduction at all sources is needed to further reduce the noise related annoyance of helicopters. However the global benefit of noise reduction technologies applied to individual components as well as the related impacts on other design parameters are often hard to predict with sufficient accuracy without relevant flight test data. In order to assess the benefits of promising new technologies but also to identify and quantify possibly associated risks on interrelated design disciplines, Airbus Helicopters has created the BLUECOPTER™ demonstrator. Based on an H135 platform the helicopter was modified in a step by step approach to integrate many promising new technologies with the final goal of pushing the frontier of technical feasibility in terms of noise reduction and fuel efficiency while at the same time raising the maturity of these technologies to a new level. The collected data additionally serves as basis for the assessment of the prediction capability.

The first step of the demonstrator project was the replacement of the 4-bladed rectangular main rotor with a parabolic tip by an innovative five-bladed bearing-less main rotor featuring the distinctive BlueEdge™ (Ref. [4]) style leading edge as shown in Figure 2. The concerted non-linear distribution of blade chord and twist in combination with new developed airfoils and a consequent low tip speed design additionally contributes to the silent rotorcraft design.



**Figure 2: BlueEdge™ style main rotor blade**

In the same project phase also a completely new helicopter tail unit was introduced including an

evolved Fenestron® stator design marked by a reduced number of stator vanes, an optimization of their azimuthal positions and an inclination of the stator vanes in the Fenestron® duct. Generally, maximizing the distance between the Fenestron® rotor blades and the stator vanes reduces the interaction noise. This can be achieved by sweeping the stator vanes out of the rotor plane. However the duct length introduces a physical limit to the maximum sweep angle. Therefore the leading edge shape of the stator vanes was aerodynamically optimized (curved leading edge design) in order to reasonably maximize the distance between rotor and stator in the given geometrical constraints, as illustrated in Figure 3.



**Figure 3: Fenestron® stator design**

Special care has to be taken when designing the Fenestron® drive shaft fairing, as the fairing is identified as acoustically dominant in comparison to the stator vanes (configuration with two stator vanes). Therefore the shape of the drive shaft fairing was aerodynamically optimized in order to minimize the acoustic interferences and the obstruction in the duct (Ref. [1]).

The next step was the integration of an acoustically enhanced Fenestron® rotor (Figure 4). The noise levels are reduced by an unequal spacing of the blades, thus distributing the acoustic energy over the entire frequency spectrum. Moreover the low tip speed design is consistently applied to the Fenestron® rotor. Additionally the advanced Fenestron® rotor blade design includes an S-shaped leading edge and a non-linear twist and chord distribution. This leading edge design reduces the

acoustic effect of the drive shaft fairing by avoiding parallel interaction during the passage of the rotor blades.



**Figure 4: Fenestron® rotor design**

By implementing an active rudder in the vertical fin, illustrated in Figure 5, one additional degree of freedom in the yaw axis is gained. Besides flight mechanics and performance, the main focus of the active rudder is on acoustics.



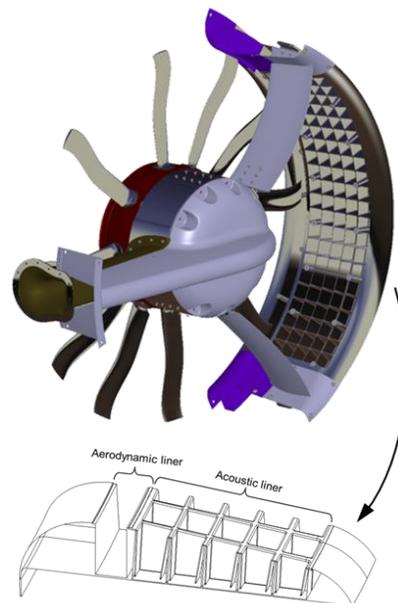
**Figure 5: Active rudder**

Previous wind tunnel measurements conducted to identify the Fenestron® noise characteristics showed that for each defined flight condition a specific Fenestron® thrust setting can be found that leads to minimum noise emission. This finding was

also confirmed in side-slip flight tests performed by DLR (Ref. [5]). The objective is to avoid reverse flow and very low thrust conditions of the Fenestron® by deflecting the active rudder. Additionally, the loading of the Fenestron® at high torque condition as during takeoff can be reduced.

The concluding step is the integration of the most innovative feature, the Fenestron® lining concept, shown in Figure 6 and Figure 7, focusing on the reduction of the Fenestron® noise emission and the improvement of the overall Fenestron® noise characteristics, including the field of psycho acoustics.

The core idea is to combine an acoustic liner for broadband sound absorption and a so-called aerodynamic liner for source strength reduction of blade tip clearance flow noise. The spectral absorption range of the acoustic liner was tuned to the most annoying frequency range between 400Hz and 3kHz. The liner design must therefore allow sound absorption within this range while respecting geometrical boundary conditions that allow its integration into the shroud.



**Figure 6: Fenestron® Lining Concept**

The acoustic liner combines a Helmholtz resonator, absorbing sound in the lower frequency range, and a  $\lambda/4$ -resonator for noise reduction at the mid and higher frequencies.

The aerodynamic liner consists of an annular channel around the rotor covered by a flow resistance optimized facing sheet. This liner is particularly intended to reduce the acoustic source strength of blade tip clearance noise. Turbulent velocity fluctuations within the blade tip clearance will be reduced inside this facing sheet.



Figure 7: Integrated Fenestron® liner

### FENESTRON® DESIGN APPROACH

Besides numerical simulations the development of the Fenestron® rotor blades got along with bench test measurements at the Airbus Group Innovations facility in Ottobrunn (Ref. [3]). For this purpose an existing counter rotating open rotor (CROR) test bench was used and extended with a 70%-scaled H135 Fenestron® model as shown in Figure 8.



Figure 8: Fenestron® test bench at Airbus Group Innovations (Ottobrunn)

Main focus of the measurement campaign was the experimental substantiation and finally the selection of the aeroacoustic Fenestron® rotor blade design. Additionally the already defined Fenestron® stator vane and drive shaft fairing design was verified. Overall five different blade sets were available for the acoustic measurement campaign, one reference blade set (H135 shape) and four acoustic blade sets. The reference blade set and the first two acoustic blade sets were measured in a first phase of the campaign. After evaluating the aeroacoustic results, the shape of the third and fourth rotor blade was defined and measured in the second phase of the campaign. The influence of the leading edge shape of the stator vanes was additionally investigated using two sets of interchangeable stator vanes (curved and straight).

Figure 9 and Figure 10 exemplarily demonstrate that the predicted trends are well substantiated by the laboratory test results.

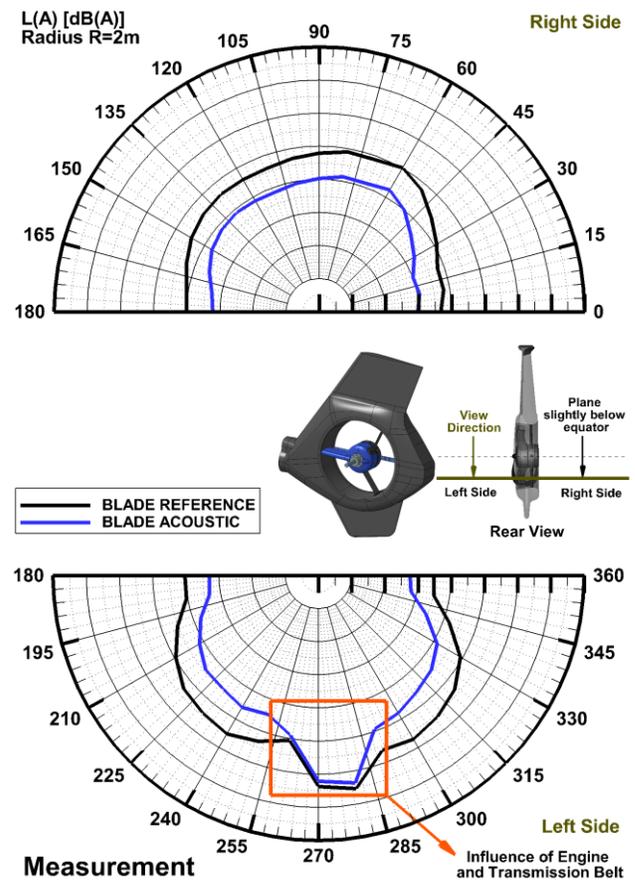


Figure 9: Bench test: directivity – blade design

The directivity patterns of the reference (black solid line) and one acoustic (blue solid line) Fenestron® blade configuration in an equator plane are presented. Even if the configurations are not identical (the configuration of the measurements only includes two scaled rotor blades and the rotational speed is limited to 3000 RPM whereas the configuration of the numerical simulation represents the complete BLUECOPTER™ configuration) the acoustic trends are reasonably well preserved.

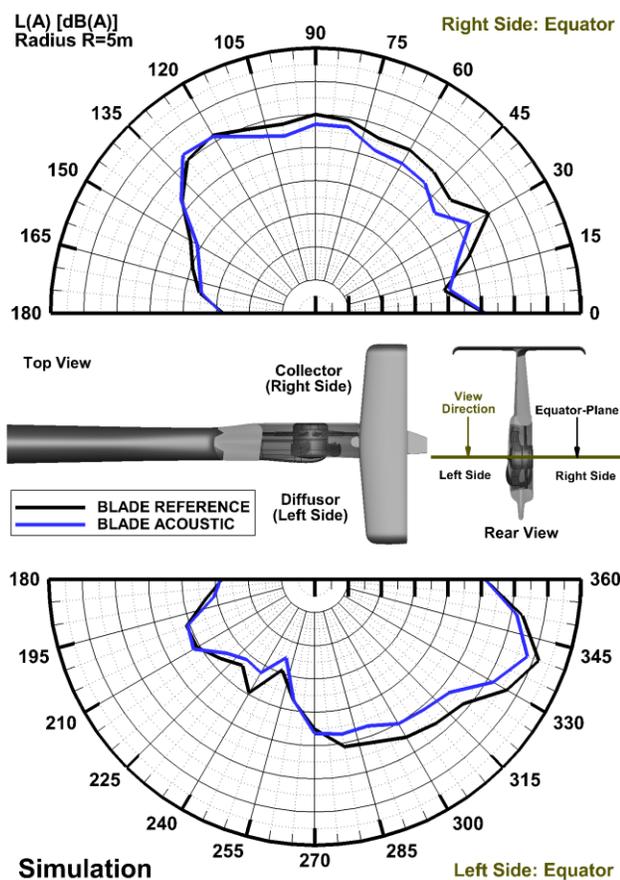


Figure 10: Simulation: directivity - blade design

The special CROR test bench configuration enables the determination of the acoustic influence of the drive shaft fairing and the number of stator vanes by successively removing these components.

Basically, aeroacoustic interactions of the Fenestron® rotor blades with the stator vanes and the drive shaft fairing increase the noise at the blade passing frequency and its harmonics and side bands.

Velocity disturbances, caused by interactions of periodic trains of viscous wake velocity defects from the upstream rotor blades with the stator vanes and the drive shaft fairing (exemplarily shown by means of a simulated energy distribution at a cylindrical cutting plane at a radius of 90% in Figure 11), produce fluctuating lift forces at the stator vanes that radiate as an array of dipole sources and thereby account for the noticeable harmonic noise component. Moreover stator broadband interaction noise additionally contributes to the overall Fenestron® noise emission.

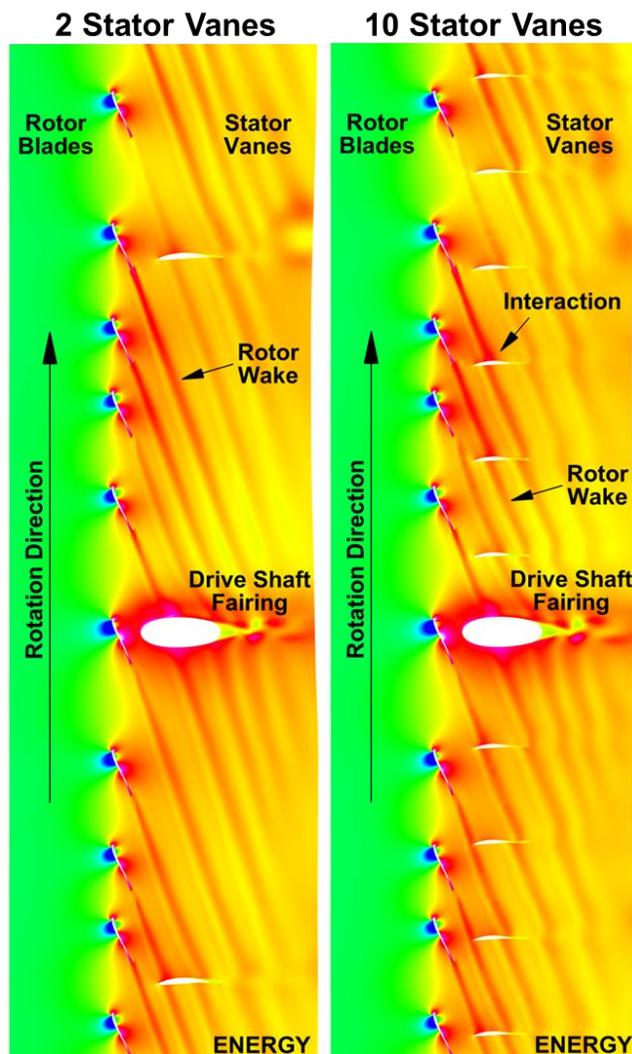


Figure 11: Energy distribution at a cylindrical cutting plane at a radius of 90% (simulation)

The investigation results (Figure 12) show that reducing the number of stator vanes generally

results in less noise emission. Moreover the drive shaft fairing can be identified as acoustically dominant in comparison with the stator vanes.

### Rotor-Stator-Interaction

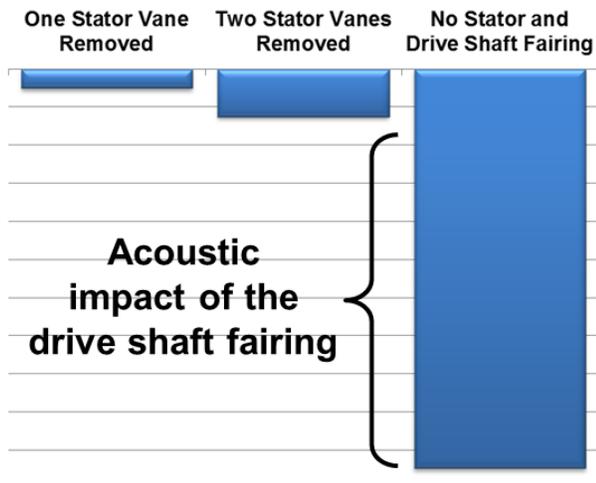


Figure 12: Acoustic influence of the drive shaft fairing and the number of stator vanes

There is an opportunity to reduce the interaction noise between the rotor and drive shaft fairing by introducing a special treatment at the leading edge, shown in Figure 13. This acoustic treatment enables that turbulent velocity and pressure fluctuations are partially reduced by the permeable surface during the passage of the rotor blades. This leads to less interaction noise. Generally, the leading edges of the stator vanes can be treated analogue.



Figure 13: Special acoustic treatment at the leading edge of the drive shaft fairing

Future investigations will assess the potential of the acoustic treatment at the leading edge in detail and an appropriate acoustic mesh will be determined.

In order to assess the predictive capability, the simulation results are additionally compared with measurement data of a ground run. For this purpose the helicopter was tied down and a Fenestron® thrust polar was performed. The thrust is measured and determined by means of the tailboom lead-lag moment. Since the lining concept cannot be simulated with CFD and Ffowcs Williams Hawkins, the chosen configuration comprises only the new Fenestron® stator and rotor design. The resulting noise vs. thrust polar is shown in Figure 14. Three different Fenestron® pitch angles are compared. As apparent from the figure the simulated noise levels are generally lower compared to the measured ones. Various factors contribute to that fact. The numerical simulation does not consider the influence of the main rotor and the impact of the ground. Additionally reflection and shading effects are presently not considered. Since the numerical results are not perfectly periodic small disturbances occur and can negatively influence the aeroacoustic result. On the measurement side it is difficult to separate the complete tonal content of the Fenestron® from the total signal. Finally the computed thrust is slightly higher compared to the determined thrust from the lead-lag moment of the tailboom.

### NOISE vs. THRUST

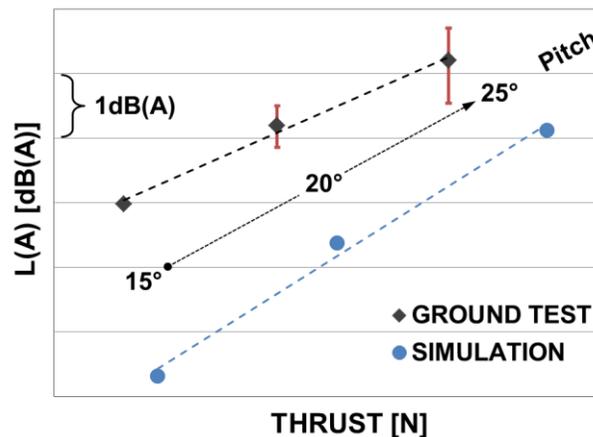


Figure 14: Fenestron® noise vs. thrust polar

Nevertheless the gradient of the noise vs. thrust polar is predicted well by trend.

When comparing the narrowband spectra of the left and right T-Tail microphone, shown in Figure 15 and Figure 16, two points are clearly visible: The absolute peak noise levels and the broadband noise are presently not properly predicted.

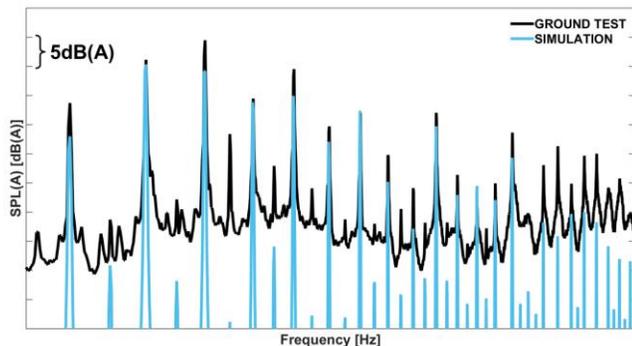


Figure 15: Left side microphone (pitch: 20°)

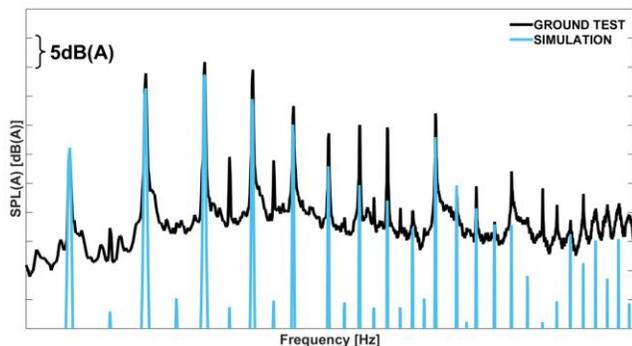


Figure 16: Right side microphone (pitch: 20°)

The ground test additionally includes overall eight 1.7m-height microphones placed in a circular distance of 50m and an azimuth step size of 20°. The height is chosen to be in the equator plane of the Fenestron®. With this setup the directivity pattern can be compared and is demonstrated in Figure 17. Generally, the shape of the directivity pattern is quite well predicted. However, the noise levels of the simulation are higher compared to the measurement, which is an opposite behavior compared to the T-Tail microphones. In future the influence of the main rotor, the ground impact and reflection and shading effects will be investigated in more detail.

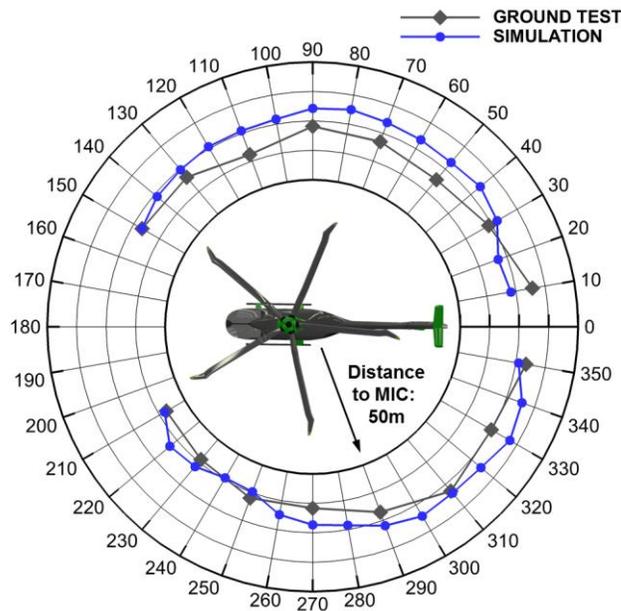


Figure 17: Directivity pattern

Overall, this approach shows a high potential to allow an acoustic assessment of the effect of different Fenestron® designs on the physical noise generation mechanisms in the design phase. Moreover, current research projects improve the prediction capability by introducing treatments for reflection and shading effects and broadband noise.

The Fenestron® lining concept was designed by Airbus Group Innovations and tested on the Fenestron® bench in the anechoic chamber in Ottobrunn. Detailed information are given in Ref. [3] and therefore not further discussed in this paper.

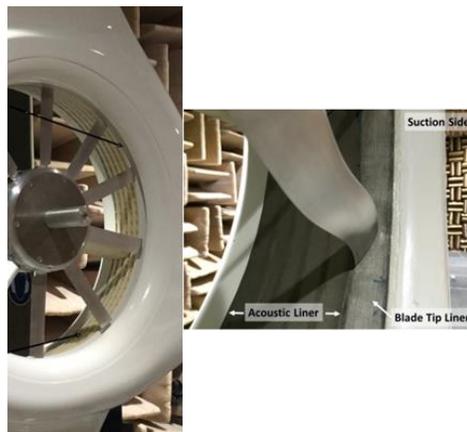


Figure 18: Fenestron® lining concept on the bench

## FLIGHT TEST RESULTS

This section highlights selected acoustic results of performed measurements. Since the effort of testing the different BLUECOPTER™ technologies solely on the basis of ground microphones is too high, two surface microphones were installed on the left and right lower side of the T-Tail, indicated by an orange circle in Figure 19. This enables an efficient acoustic evaluation of the different Fenestron® components and the active rudder in flight.



Figure 19: Right T-Tail surface microphone

### Active Rudder

In order to identify the minimum noise position for different flight states, acoustic rudder flights with different rudder deflection angles were performed. The maximum rudder deflection is 20° to the left and to the right, respectively. These flights are marked by additional microphones installed in the duct of the Fenestron® (duct configuration without acoustic liner). Three microphone planes were defined (one upstream the rotor plane, one between the rotor and stator plane and one downstream the stator plane) with each plane containing three circumferential positioned microphones as shown in Figure 20.

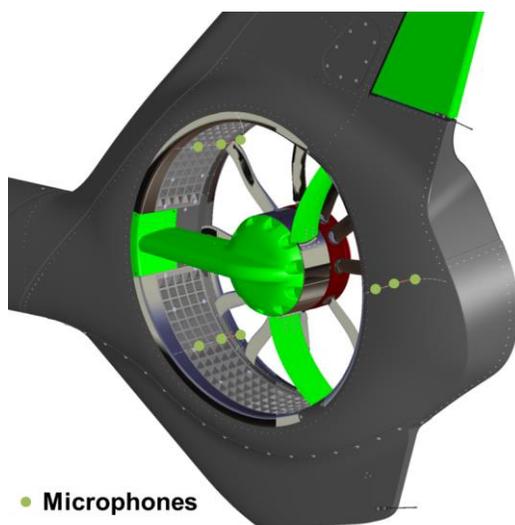


Figure 20: Fenestron® duct microphones

Based on these microphones Figure 21 shows the impact of the active rudder on the acoustic emission. Considering the takeoff condition, by deflecting the rudder the vertical stabilizer gets aerodynamically more effective indicated by reduced Fenestron® pitch values and therefore supports the Fenestron® rotor balancing the main rotor torque which results in reduced noise levels. A positive side effect is that additionally the rate of climb increases due to a lower power consumption of the Fenestron® rotor and with it also the vertical distance between the helicopter and the microphones. This generates an additional acoustic benefit. In approach the Fenestron® pitch is often slightly negative, depending on the basic setup of the vertical fin. However reverse flow or very low thrust condition (around zero) of the Fenestron® has to be avoided from an acoustic point of view. Therefore the rudder is used to shift the Fenestron® pitch into the positive range. But compared to the takeoff condition, the acoustic benefit of the active rudder in approach and also in flyover is less.

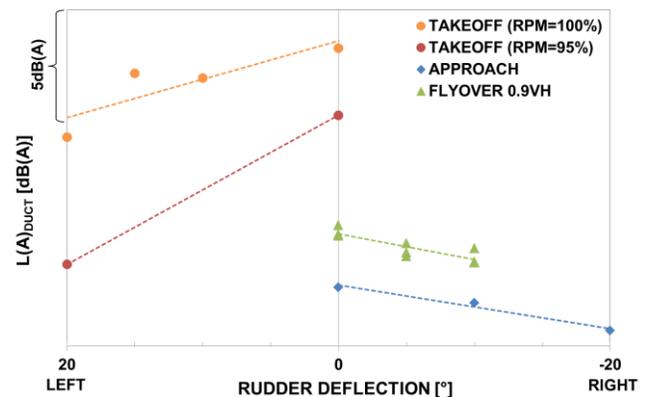
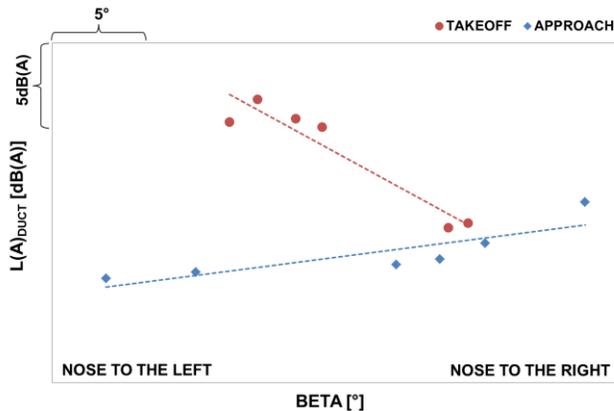


Figure 21: Influence of the active rudder on the acoustic emission of the Fenestron®

Furthermore the influence of side slip angle on the acoustic emission was determined (Figure 22). The noise emission can be reduced for both the takeoff and the approach condition. Changing the side slip angle has a similar effect like the rudder since the Fenestron® pitch is modified. Noise levels are reduced for the takeoff condition when flying the helicopter with the nose to the right (depending on the sense of main rotor rotation). In this case, nose to the right implies reduced Fenestron® pitch values and therefore lower noise levels. Contrary, for

approach the helicopter nose to the left is acoustically beneficial.



**Figure 22: Influence of the side slip angle on the acoustic emission of the Fenestron®**

In particular for takeoff the effect of side slip angle can be used for additional low noise procedure recommendations in the helicopter flight manual (Ref. [5]) and to extend the AFCS by a “low noise takeoff” mode applying a different Fenestron® control philosophy.

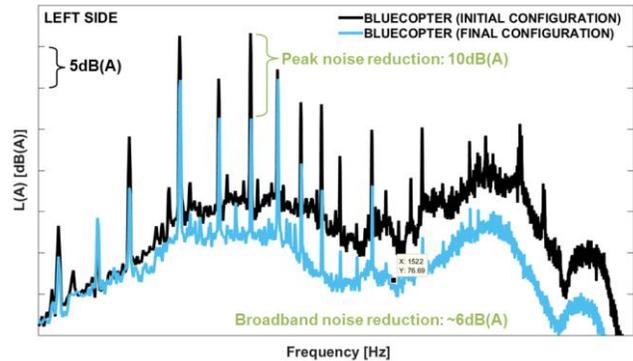
**Fenestron® Rotor, Stator and Lining Concept**

The Fenestron® components such as the rotor, stator and acoustic lining concept are assessed on the bases of the T-Tail microphones for the demonstrator in initial and final configuration. The initial configuration comprises the H135 serial Fenestron® rotor and the standard duct. The optimized drive shaft fairing and evolved stator design is already included in the initial configuration. Contrary, the final configuration consists of the advanced Fenestron® rotor blades and innovative Fenestron® lining concept. It has to be mentioned that due to manufacturing issues and an ambitious test schedule the acoustic liner had to be replaced by a sound absorbing foam for the short term. Therefore it is clear that the acoustic liner could not show the maximum noise reduction potential, especially the potential of tonal noise reduction.

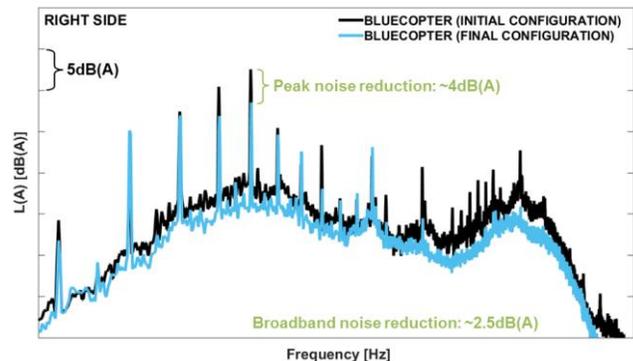
In the subsequent figures the narrowband spectra of the left and right T-Tail microphone are compared for takeoff and approach. Here the black spectra represent the initial configuration and the blue ones the final configuration. Note that the flyover condition

cannot be assessed on the basis of the T-Tail microphones since the Fenestron® noise is masked by high wind noise caused by the high flight speed.

The left side is defined as the Fenestron® diffuser or outlet whereas the right side is hallmarked by the Fenestron® collector or inlet. Basically both a peak noise and broadband noise reduction is clearly visible in all narrowband spectra. However the benefit is generally higher for the takeoff condition which probably arises from the correct flow direction from rotor to stator in the duct. In approach the Fenestron® pitch is slightly negative which implies a high probability of a reverse flow situation in the duct which could negatively influence the noise emission. Therefore the liner could not work as efficient as for the takeoff condition. Furthermore the left side is acoustically more efficient compared to the right side due to the directivity induced by the lining concept. While on the diffuser side both the aerodynamic and acoustic liner affects the noise emission, on the collector side only the aerodynamic liner can reduce the noise levels.



**Figure 23: TAKEOFF: left side**



**Figure 24: TAKEOFF: right side**

Figure 23 demonstrates an achieved peak noise reduction of up to 10dB(A) on the left T-Tail microphone in takeoff. Moreover the broadband noise level is reduced by approximately 6dB(A). In contrast, Figure 24 confirms on the Fenestron® collector side a limited peak noise reduction of up to 4dB(A) and a broadband noise reduction of about 2.5dB(A) for this flight state.

As already mentioned in approach the achieved noise benefits are somewhat less compared to the takeoff condition. Anyway the measured peak noise reduction can be up to 8dB(A) and the broadband noise reduction can be up to 2dB(A) in approach.

For hover a comparable noise benefit as in takeoff is expected and confirmed in the overall footprint reduction. A breakdown to individual components was not possible due to a lack of intermediate configuration steps.

### Global Helicopter

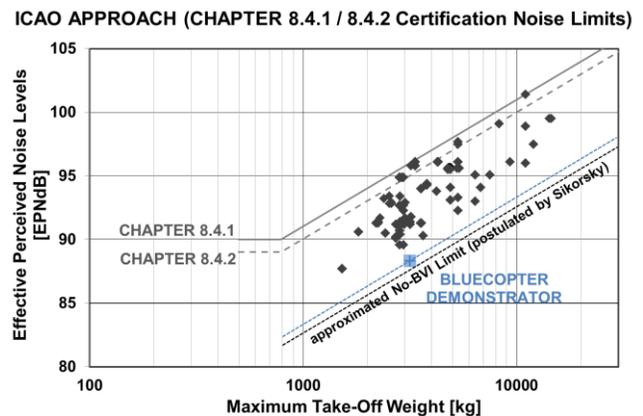
Basically, the noise measurements were performed in accordance to noise certification regulations respecting tolerances on flight speed, RPM, helicopter weight, flight trajectory and meteorological conditions in order to assess overall acoustic characteristics of the BLUECOPTER™ demonstrator. This enables a direct comparison of certification noise levels of different helicopters. The acoustic tests were conducted at the military dropping area near Manching (Phase1A) and due to availability reasons also at the air field of Genderkingen (Phase1B). The microphone setup includes three 1.2m-height microphones which were installed perpendicular to the flight track at lateral distances of 0m and ±150m and additionally five microphones placed above ground plates at lateral distances of 0m, ±75 and ±150m. For statistic reasons each flight condition was repeated three to six times.

In the following the effective perceived noise levels of the BLUECOPTER™ demonstrator are highlighted and compared with the noise certification levels of the world fleet. For this purpose the EPNL values are presented as function of maximum takeoff weight. The noise levels of the world helicopter fleet are extracted from the EASA Type Certificate Data

Sheet for Noise database. Figure 25, Figure 27 and Figure 28 demonstrate the margins to ICAO certification noise limits (based on Chapter 8.4.1) of the BLUECOPTER™ against the world fleet for the corresponding ICAO certification conditions.

### APPROACH:

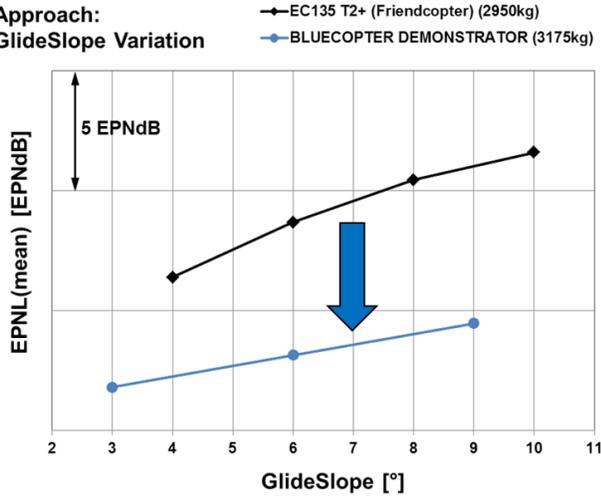
Regarding the ICAO certification approach the BLUECOPTER™ demonstrator shows best-in-world fleet noise signature with about 7.8EPNdB below the ICAO limits. Furthermore the noise signature is very close to the approximated No-BVI limit previously postulated by Sikorsky (Ref. [6]).



**Figure 25: ICAO certification APPROACH**

Even though the noise levels are exceptional low for the design point (ICAO certification approach) a robust low noise design is only achieved when the acoustic emission is reduced also a wide range of operationally relevant off-design points. Therefore different aerodynamic glide slope angles were measured at best rate of climb speed (Ref. [1]). Basis for the comparison is the Friendcopter database (Ref. [7]). Within this campaign the EC135T2+ (S01) was used. It has to be mentioned that there is a difference in the maximum gross mass of around 225kg. As already demonstrated for the design point, the BLUECOPTER™ also clearly shows remarkable reduced noise levels up to 6EPNdB for the flown aerodynamic glide slope angles (Figure 26). Therefore a well-balanced main rotor blade design is available for a wide range of glide slope angles which is important for noise mitigation in real life.

**Approach:**  
**GlideSlope Variation**

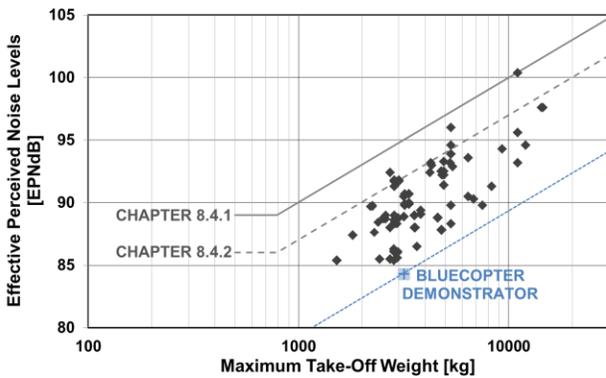


**Figure 26: Glide slope variation**

**TAKEOFF:**

Also for the ICAO certification takeoff condition the BLUECOPTER™ achieved best-in-world fleet noise signature with about 10.7EPNdB below the corresponding ICAO limit.

**ICAO TAKEOFF (CHAPTER 8.4.1 / 8.4.2 Certification Noise Limits)**



**Figure 27: ICAO certification TAKEOFF**

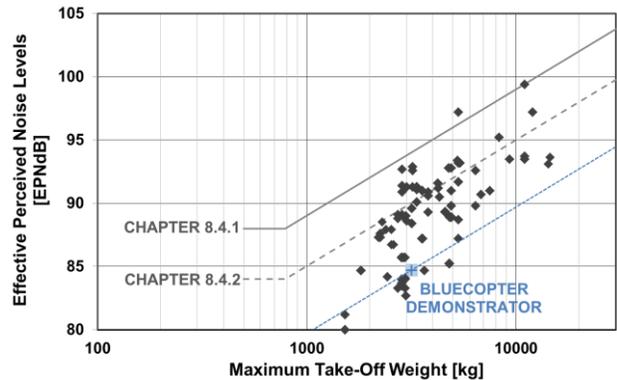
**FLYOVER:**

The BLUECOPTER™ shows excellent noise levels for ICAO certification flyover condition with a margin to the limits of about 9.3EPNdB. Indeed for this flight state the best-in-world fleet noise signature is not achieved, however the BLUECOPTER™ still remains highly competitive.

Contrary to the above mentioned flight states operational noise mitigation for level flight is possible for instance by “flying higher” or by smart routing

concepts. Therefore the flyover result of the BLUECOPTER™ can be further improved to a large extend by smart routing concepts. Finally, with the achieved flyover noise levels the BLUECOPTER™ at 3175kg is compliant with the US Grand Canyon National Park (GCNP) noise limitation for all configurations with 6 or more passenger seats and can therefore be designated a Quiet Technology Aircraft.

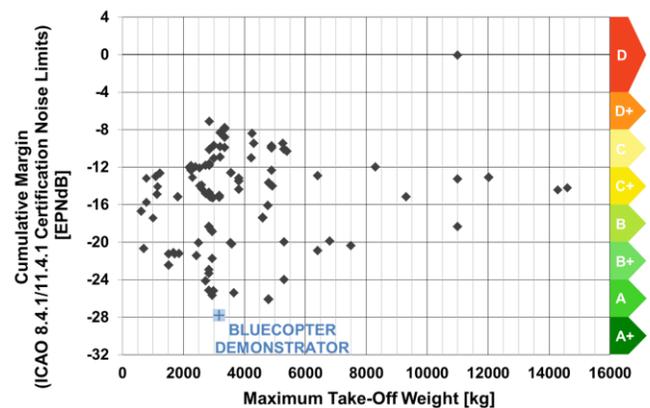
**ICAO FLYOVER (CHAPTER 8.4.1 / 8.4.2 Certification Noise Limits)**



**Figure 28: ICAO certification FLYOVER**

**GREEN METRICS PHILOSOPHY:**

Considering the cumulative margin to the ICAO certification limits, shown in Figure 29, the value of the BLUECOPTER™ is with 27.8EPNdB very close to the yet unreached A+ rating, starting at 28.0EPNdB.



**Figure 29: Green Metrics Philosophy**

Therefore the overall acoustic performance of the BLUECOPTER™ demonstrator combining the ICAO certification flight states is exceptional.

### HOVER (OUT OF GROUND EFFECT):

Since certification regulations do not provide a procedure to evaluate the noise emission of helicopters in hover, this flight condition is acoustically assessed by means of a comparative measurement. The flight procedure comprises hovering out of ground effect (HOGE) at an altitude of 300ft above ground level (AGL) at several azimuthal positions with reference to the line of microphones using a step size of 45°. Both the BLUECOPTER™ and the reference helicopter (H135) are at maximum gross weight. Note that the maximum gross weight of the BLUECOPTER™ is 3175kg and of the H135 is 2980kg. The rotational speed of the demonstrator is 100% as provided by the RPM law whereas the reference helicopter is in high NR mode at 103% as required by the FLM for high takeoff weights.

As already demonstrated for the certification flight conditions, the BLUECOPTER™ shows significantly reduced noise levels also for the hovering flight condition and that in all directions. Considering the relevant noise contour lines and the corresponding area enclosed by these lines, the affected area is reduced up to 50% compared to the reference helicopter, shown in Figure 30 and Figure 31. The helicopter nose is facing upwards. From one dashed contour line to the next one there is a 5dB(A) difference.

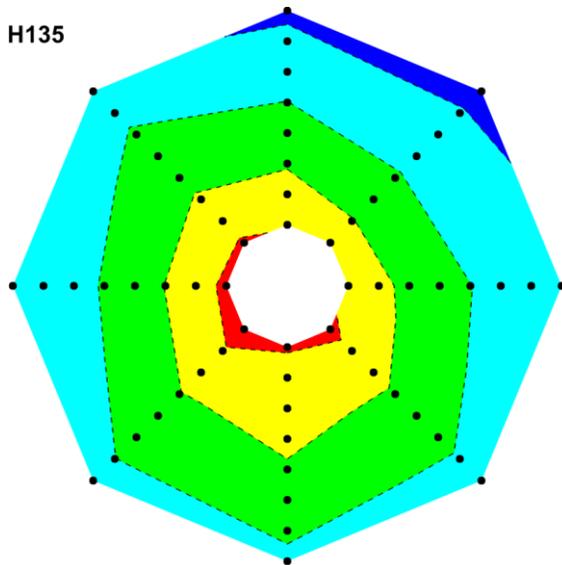


Figure 30: H135 hover noise footprint

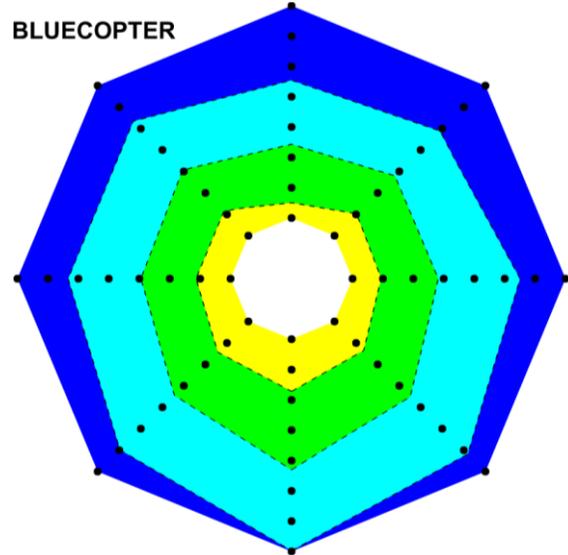


Figure 31: BLUECOPTER™ hover noise footprint

The key for the reduced noise levels in hover is the advanced Fenestron® and low RPM design. Further noise reduction potential is given by the engine (intake and exhaust) which however was not addressed on the BLUECOPTER™ demonstrator.

### OPERATIONAL ASPECTS:

The impact of helicopter operational noise can be reduced by two strategies: Either noise reduction by operational means or noise reduction directly at the source.

The introduction of noise abatement procedures promises significant benefits but their application is oftentimes limited due to mission requirements and safety aspects to certain heights above takeoff or landing decision point. Therefore, there is an additional need for reduced source noise levels coming from the helicopter design to reduce the noise exposure of residents.

And here the BLUECOPTER™ demonstrator shows its unique strength. In particular for the approach marked by the most annoying sound characteristic (impulsive blade vortex interaction noise) a break-through in noise reduction is achieved and noise levels are significantly reduced. Aside from the pure numerical value also the perceived annoyance is significantly reduced due to the mitigation of impulsive noise peaks. Thanks to the

consequent low blade tip speed design and the advanced Fenestron® measures noise mitigation is also possible for the hover flight condition while maintaining the highest level of safety for crew and passengers. The takeoff condition further benefits from the active rudder and the very good climb rates. Finally the level flight is important for frequently used routes, i.e. touristic flights, shuttle service, surveillance and it is a criterion for operations in the Grand Canyon National Park. In this area “flying higher” or using varying routes can oftentimes mitigate the annoyance in addition to low noise design.

Overall this is a strong differentiator for our customers in urban mission like Helicopter Emergency Medical Services (HEMS), Public Services or passenger transport.

## CONCLUSION AND OUTLOOK

Reducing helicopter community noise is a complex task that can only be achieved by a close cooperation between all the stakeholders involved. Airbus Helicopters is strongly committed to reduce the environmental impact of its products and therefore pushes the limits of feasibility with the development and testing of innovative noise reduction technologies. Mature technologies are regularly introduced in the serial fleet. Furthermore the manufacturer’s knowledge on helicopter noise emission characteristics is fully deployed in developing and communicating helicopter specific pilot guidance for low noise operations in the rotorcraft flight manuals. Beside these helicopter specific measures, generalized pilot training and complaints management material as included in the ‘Fly Neighborly’ guide published by the Helicopter Association International (HAI) as well as the noise initiative launched by the American Helicopter Society (AHS) are important contributions towards an improved communication and interaction between the involved parties.

The BLUECOPTER™ demonstrator results and the associated lessons learned represent a major step towards a better relationship between helicopter operations and public perception.

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