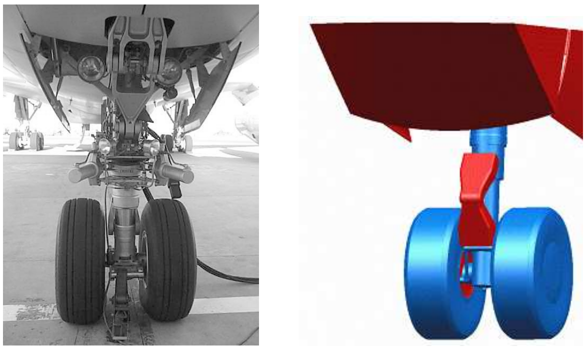

Figure 3.3-86 *A340 baseline and low noise advanced nose landing gear design.*

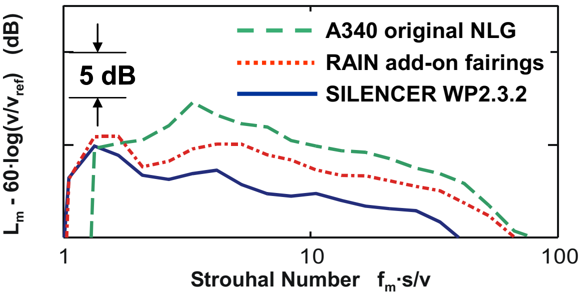

Figure 3.3-87 *Measured noise reduction for the advanced low noise nose landing gear in comparison with the baseline gear and with add-on fairings, respectively.*

Quantification and Reduction of Gear-Wake / Gear Interaction Noise and Gear-Wake / Flap Interaction Noise Sources

For large aircraft it is necessary to employ more landing gears to support the correspondingly higher aircraft weight. Some of these gears might have an almost in-line arrangement under the fuselage. The turbulent wake from the upstream gear will impinge upon the downstream gear and may cause the latter to produce excess aerodynamic noise. The interaction noise study comprised (i) gear wake measurements to quantify the steady and unsteady inflow conditions to a downstream located gear and (ii) interaction noise measurements. The latter were conducted in DLR's AWB employing different arrangements of an upstream installed centre- and downstream positioned main landing gear model. In contrast to what was expected a noise reduction was observed, which was most pronounced for an in line gear installation. The reason for this result is that the downstream gear operates in the local flow deficit of the upstream gear wake. This reduction in inflow velocity overcompensates the adverse effect of additional inflow turbulence to the downstream gear.

The impingement of the main landing gear wake onto the deployed fowler flap was considered another potential source of interaction noise. A joint acoustic test was carried out by NLR and DLR in the AWB on a 1/13 scaled 2D wing section including a generic main landing gear. A microphone array and far field microphones were used to localize and quantify different noise sources.

The test results indicated the presence of interaction noise originating from the flap leading edge for the standard landing configuration (*Figure 3.3-88*). Porous metal liners, when flush-mounted in the flap leading edge, provided a 2 dB broadband noise reduction.

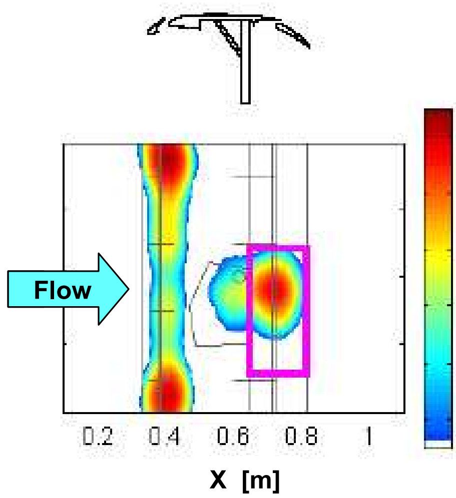

Figure 3.3-88 *Noise source distribution (red corresponds to high levels) indicating the location of gear-wake / flap interaction effects (additional slat noise sources are due to edge horse shoe vortices), source: NLR.*

3.3.8 Environmental Noise Prediction

Analysis of Noise Impact at Airports

Within the frame of the interdisciplinary DLR-Project "Leiser Verkehr" first practice-oriented applications of DLR's aircraft noise modeling tool SIMUL showed very promising results: Investigations on long-term weather effects on noise around civil airports confirmed, that the assumptions used by the simplifying practical models are a reasonable approach for the average weather influence. A result of practical importance was the new model on the noise of auxiliary power units (APUs, see *Figure 3.3-89*). It was adopted by the officially prescribed German Air Traffic Noise Act within the actual revision.

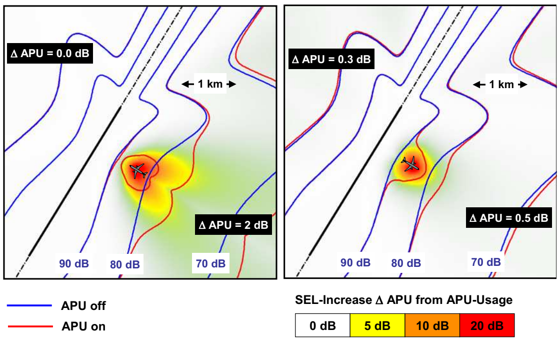

Figure 3.3-89: *Influence of APU on Sound Exposure Level SEL (1 LTO-cycle of an A320 combined with 30 min APU-usage) for different orientation of the aircraft.*

The project "LAnAb" was launched by the German research network "Leiser Verkehr". It was dealing with noise abatement flight procedures (NAPs) for civil aircraft. Within this project the SIMUL tool was improved by a better airframe noise module in order to make it a suitable tool for the development of noise abatement approach procedures, where airframe and high-lift devices are important acoustic sources. The improved model was validated by a measuring campaign using an A319 aircraft. The model results showed a good agreement with the measurements (see *Figure 3.3-90*). Hence the SIMUL model could be proved to be a cost-efficient and powerful approach for the development of NAPs.

Fly-Over Measurements

The two major objectives of flyover noise measurements are

- to validate airframe noise source models as derived from wind tunnel studies and
- to identify excess noise sources and develop add-on noise reduction measures.

Flyover noise tests were performed on a Boeing MD11 and an Airbus A319 aircraft under contract of Lufthansa German Airlines and within the LuFo3 project LAnAb. By means of DLR's "Autonomous Large Area Microphone System" the noise directivities in flight direction and lateral to the flight trajectory were acquired by means of a total of 36 single microphones in an area of about 80,000 m². Flyovers were performed for different aircraft configurations (flaps and gears), flight speed and engine rpm, respectively. As one result the prominent rear arc low frequency slat noise directivity, initially derived from scale model wind tunnel tests, could be validated (*Figure 3.3-91*). As another outcome annoying tonal excess noise, originating from flow over the fuel vent holes in the lower A329 wing surface (see chapter 3.3.4.3), could successfully be suppressed through small add-on vortex generators.

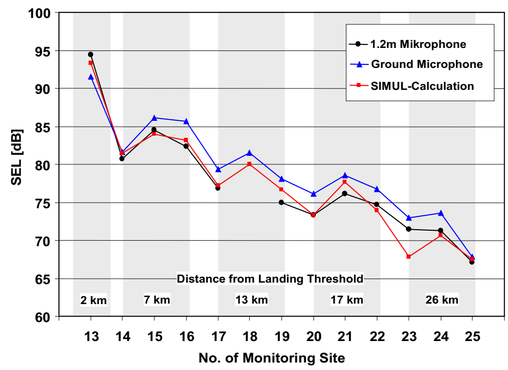

Figure 3.3-90: *Comparison of measured and calculated Sound Exposure Levels SEL for approaches of an A319 at different distances from the landing threshold.*

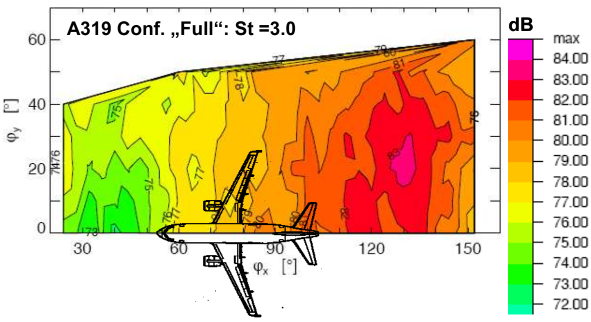

Figure 3.3-91 *Example of slat noise directivity from A319 flyover noise tests.*

3.3.9 Cabin Comfort

During the development of modern aircraft passenger comfort plays an increasing role. Especially, the rising demand of the airlines for individual cabin designs leads to faster cabin development cycles.

According to the German work share at Airbus the institute addresses aerodynamics and passenger comfort in aircraft cabins already for a couple of years as a topic with high strategic relevance and priority.