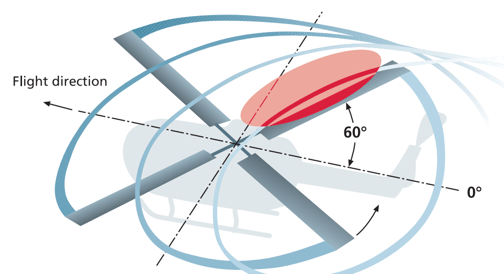
Whisper Mode for Helicopters

- **Noise Reduction with dSPACE Prototyper**
- **Helicopter noise reduced by 50%**
- **Major step towards production level**

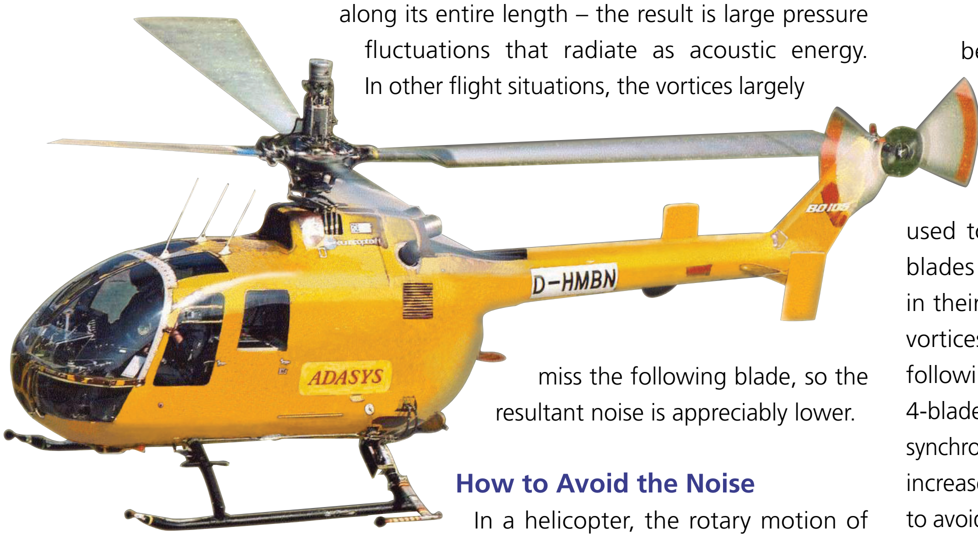
Anyone who has ever been near to a helicopter when it was landing knows the phenomenon: On top of the "normal" helicopter noise, there is an unpleasant, rhythmic drone. Eurocopter Deutschland has implemented a control for noise reduction, in cooperation with the European Aeronautic Defence and Space Company (EADS), ZF Luftfahrttechnik (Aviation Technology) and the German Aerospace Center (DLR): With the help of dSPACE Prototyper, the rotor blades' angle of attack is modified to change the air flow, cutting the resultant noise by half.

Blade Vortices Cause Noise

The noise created on a helicopter's approach to landing is called blade vortex interaction (BVI) noise. Blade vortex interactions arise when the air vortex leaving one rotor blade collides with one of the following blades. Blade vortex interactions can occur in many flight situations, but they are particularly intense during descent at approx. 120 km/h and a flight path angle of 6-8 degrees. Under these conditions, a rotor blade can be completely submerged in the trail of the preceding blade, so that collides with the vortex along its entire length – the result is large pressure fluctuations that radiate as acoustic energy. In other flight situations, the vortices largely miss the following blade, so the resultant noise is appreciably lower.



▲ *The rotor blades collide head-on with air vortices in the area marked red. This causes a large part of the aircraft noise.*

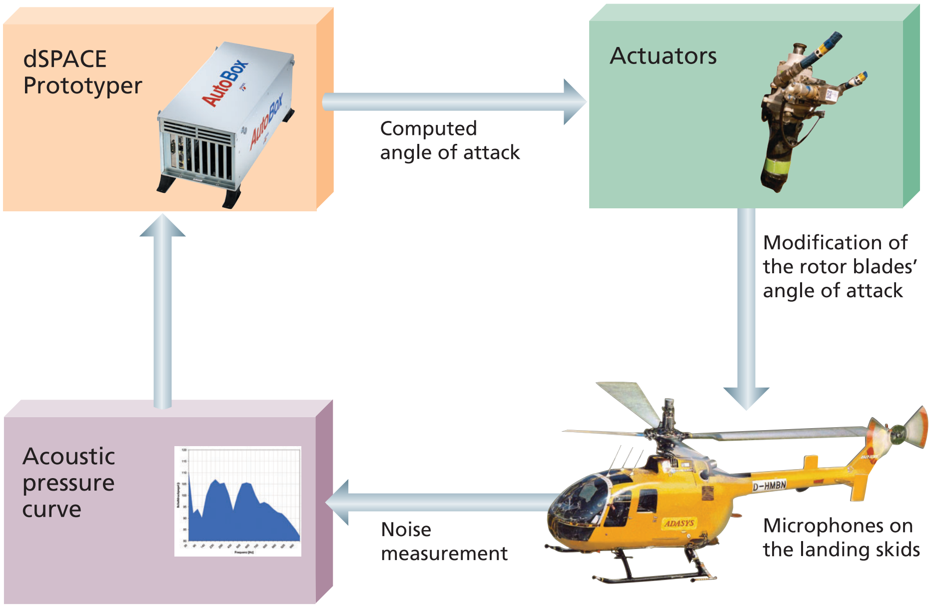


▲ *Type BO 105 helicopter. Microphones for noise measurement are mounted on the landing skids.*

How to Avoid the Noise

In a helicopter, the rotary motion of the blades and the straight motion of the craft overlap, giving rise to a particular kind of air flow behavior. In the rear right quadrant of the rotor disk, there is a zone in which rotor blades and vortices move towards each other and collide head-on. The result is a high noise level. If a method could be found to suppress the collisions between rotor blades and air vortices in this zone, a large part of the overall aircraft noise would be eliminated.

To achieve this, dSPACE Prototyper was used to modify the angle of attack of the rotor blades for fractions of a second at specific points in their rotation. This changes the direction of the vortices that are shed, which then largely miss the following rotor blade – minimizing the noise. On a 4-bladed helicopter, the angle of attack needs to be synchronously reduced for 2 blades and simultaneously increased for the other 2 blades. This is the only way to avoid additional pressure fluctuations. The pilot has the feeling that the helicopter is behaving normally, as it would without the additional rotor blade control. The modification to the angle of attack is only 1.4 degrees at a maximum – very little in comparison to the angles of up to 30 degrees that can occur in common flight maneuvers.



◀ The noise level is measured by 6 microphones on the landing skids. The noise behavior is then used to compute the angle of attack for the rotor blades that will minimize blade vortex interaction and noise.

Using dSPACE Prototyper as a Silencer

To test the principal function of the individual rotor blade control, a type BO 105 helicopter was modified.

- A total of 6 microphones were mounted on the landing skids to measure noise behavior. The optimum rotor blade control for minimizing noise was then computed from the noise behavior.
- Instead of the usual rigid control rods on the rotor blades, an actuator was connected to each of the 4 blades, allowing additional adjustment to the angle of attack for each blade separately.
- Pressure sensors were mounted on the rotor blades to measure the sharp pressure fluctuations on impact with a vortex.

This imposes tough demands on the dSPACE hardware, as it is inundated by measurement signals coming from the microphones and blade pressure sensors, which it has to process fast and convert into a control signal for the rotor blades. The blades rotate at approx. 7 revolutions per second. The noise level on the landing skids, the pressure fluctuations on the rotor blades and other factors are measured 512 times per revolution. High sampling frequencies of up to 5 kHz are needed to compute useful control signals for the rotor blades. This is the reason we chose dSPACE Prototyper. The entire experiment was configured with MATLAB®/Simulink® and monitored by means of ControlDesk.

Noise Cut by Half

During trial flights carried out in November 2001, a reduction in noise of 6.8 dB was achieved during descent using the setup described above, at a flight path angle of 6 degrees. This means that the noise as perceived at ground level was cut by half.

In addition to this noise control concept, a modern vibration control is also being tested in a new test setup. Both systems will then be adapted to the flap blade currently being developed at Eurocopter and tested. The flap blade has a new generation of actuator (with fast piezotechnology replacing slower hydraulics), and instead of moving the whole rotor blade, only the integrated flaps need to be adjusted in order to change the vortex. This is a significant step towards bringing these systems up to production level in the near future.

▲ Each of the 4 rotor blades has an actuator for modifying its angle.

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