German
Aerospace Center

DLR and NASA: making the helicopters of the future quieter

06 April 2011

A helicopter relies on its rotor to be able to take off and land vertically. The rotor is also responsible for the noise a helicopter makes during flight. Researchers at the German Aerospace Center (Deutsches Zentrum für Luft- und Raumfahrt; DLR) in Göttingen and NASA are investigating the exact origin of this rotor noise. The aim is to make the helicopters of the future quieter.

The collaboration between NASA and the DLR is the subject of a bilateral agreement. "Our speciality at DLR Göttingen is optical measurement technology for fluid flows," says Markus Raffel, head of the helicopter department at the DLR site in Göttingen. NASA scientist James T. Heineck confirms: "The team at Göttingen is among the best in the world." NASA researchers are contributing the most up-to-date measurement technology and their experience with experiments in the largest wind tunnel in the world.

Vortices as noise sources

"Almost everything you hear from a helicopter is aerodynamic noise. A large part of this comes from what are called rotor tip vortices," says Raffel. Blade tip vortices occur at the outer end of the rotor blade. "Reduced pressure on the top of the blade draws air upwards producing a vortex. The blade tip vortex is then directed downwards," explains DLR researcher Karen Mulleners, who is carrying out the tests in collaboration with NASA colleagues. "When other rotor blades subsequently come into contact with these vortices, the 'chopping' or throbbing noise that is characteristic of helicopters is produced."

researchers are using a test stand with a rotor model from RWTH Aachen for their investigations. They are using seven high-speed cameras, lasers and high-powered LEDs to make the vortex visible. "The special thing here is the simultaneous use of three different optical measurement techniques," explains Raffel. The density and the velocity fields in the vortices and the deformation of the rotor blades are recorded. As in medicine, multiple investigative methods help reach the correct diagnosis. Thanks to the latest high-speed cameras, filming at speeds of up to 4000 frames per second is possible. This enables the turbulent, constantly changing vortex to be observed continuously for the first time. Until now, the time resolution of cameras has only been sufficient to capture snapshots.

Vortices can restrict visibility

The rotor tip vortices are also responsible for another problem; when they touch the ground during take-off or landing, dust or snow can be swirled up. This can put the pilot in danger as he faces what is known as a 'brownout' – a complete loss of orientation.

The current measurements will form the basis for future tests in a wind tunnel. Research using a real helicopter is planned for the future.

Measurement techniques	
Particle Image Velocimetry (PIV)	Measurement of the velocity fields in vortices
Background Oriented Schlieren Method (BOS)	Visualisation of density gradients
Speckle Pattern Recognition (SPR)	Measurement of rotor blade deformation

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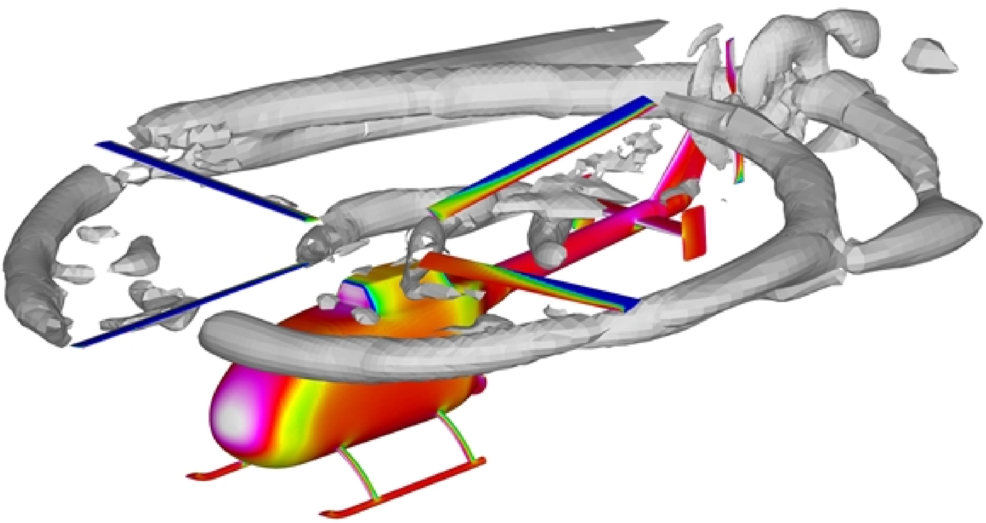
Lasers and high-speed cameras track down rotor noise

Karen Mulleners from DLR Göttingen adjusts the model of a helicopter rotor in preparation for taking measurements.

Computer simulation of vortices



Reduced pressure on the top of the blade draws air upwards; this produces a vortex – the blade tip vortex – that is then directed downwards. When other rotor blades subsequently come into contact with these vortices, the 'chopping' or throbbing noise characteristic of helicopters is produced.

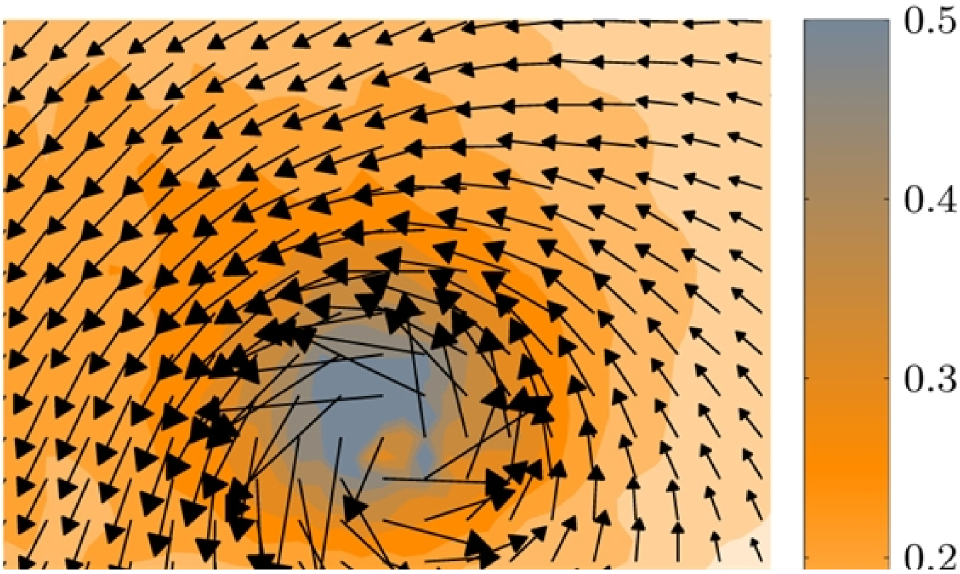
Credit: DLR (CC-BY 3.0).

Visible vortices

This image shows the vortices that form at the ends of rotor.

Credit: US Navy.

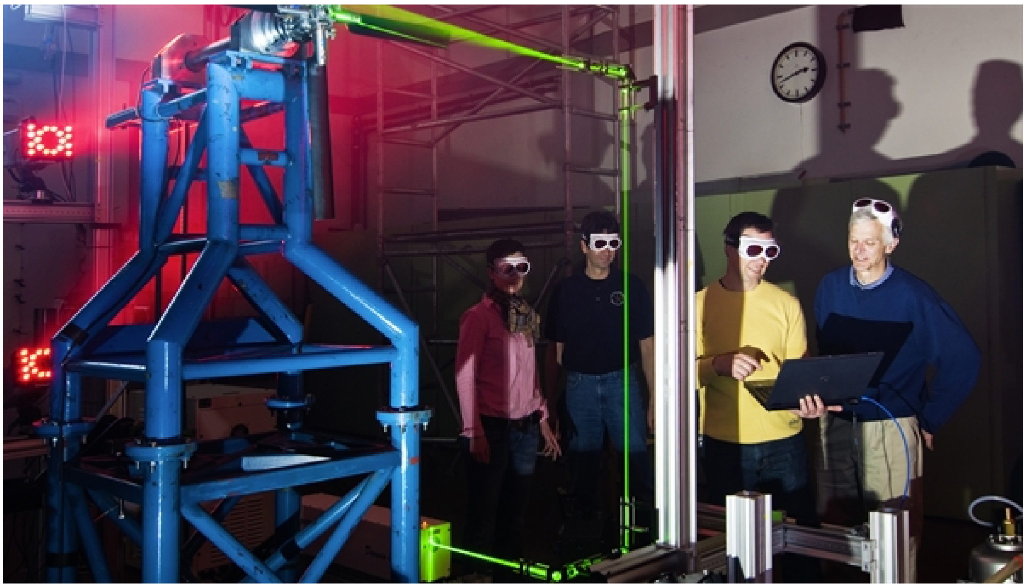
Measurement result



This measurement image shows the instantaneous velocity field in a rotor tip vortex.

Credit: DLR (CC-BY 3.0).

DLR and NASA researchers at the rotor test stand



DLR and NASA researchers are jointly investigating the origin of helicopter rotor noise. From left to right: Karen Mulleners and Markus Raffel (DLR), and James T. Heineck and Edward Schairer (NASA).

Credit: DLR (CC-BY 3.0).
