German Aerospace Center

The world seen from a propeller hub – for the first time DLR researchers make the deformation of a propeller blade during flight visible

27 June 2014

Scientists at DLR Göttingen have achieved a world first – showing the deformation of an aircraft propeller blade during flight. They have developed a special camera that can resist the enormous forces exerted during rotation. Their findings could not only help to improve aircraft propellers, but also helicopter rotors and wind turbines.

Metal container

Fritz Boden and Boleslaw Stasicki from the DLR Institute of Aerodynamics and Flow Technology carried out the experiments at Kunovice in the Czech Republic, using a single-engine Evektor VUT 100 Cobra. The researchers developed a special stereoscopic high-speed camera and installed it in the propeller hub. The camera was aligned with a propeller blade and rotated in synchrony with the propeller during flight. The camera was thus subject to vibrations and centrifugal forces of up to 20-times Earth's gravitation. Because of this, it was previously not considered possible to observe propeller deformation during flight, as the required sensitive measurement technology would be destroyed by such stresses. However, the Göttingen researchers have found a solution. They placed the camera, a miniaturised computer and other electronics inside a metal container to protect them from damage. In this way they were able to take thousands of images of a special pattern of dots placed on the propeller blade. This enabled the smallest deformations to be rendered visible and measured even during extreme flight manoeuvres.

Propeller deformation in flight

"We wanted to know precisely how a propeller behaves during flight. This is because the performance of the propeller changes when the blades deform," says Boden. "Our results can help manufacturers find out how the effectiveness and service life of propellers can be improved," adds Stasicki. Both the material and the shape can affect the way propellers deform during flight. The results might also help pilots. "Previously, pilots have set the rotation speed and angle of attack of the propeller by 'feel'," explains Boden. As the effects can now be measured, "a pilot will be able to know what setting will give the lowest fuel consumption or the highest speed without placing an unnecessarily high load on the propeller. This also increases flight safety."

Dot pattern makes forces visible

Not just the camera and its housing have been developed by the DLR researchers in Göttingen – so too has the measurement technology employed. This involves using two camera sensors with different angles of view (a stereoscopic camera) to acquire images of the object under investigation. Using specially developed software, the entire surface being observed can be represented in 3D. Until now, it has not been possible to measure the actual shape and position of propeller blades under actual flight conditions. The only option thus far was to attach sensors to the blades. The disadvantage of this is that these sensors only measure individual points, and they affect the airflow. In addition, the wiring required is often problematic.

This new technique also allows researchers on board the aircraft to start and stop the imaging from the cabin via a wireless network, review the images and, if necessary, change the camera settings. The camera uses an integrated GPS receiver to simultaneously log the position of the aircraft and when the image was taken.

"Use of a rotating camera is a new technology that has now matured. It can be used to precisely measure the position and deformation of fast-rotating objects throughout an entire revolution and without actually having to contact the object in question," says Stasicki.

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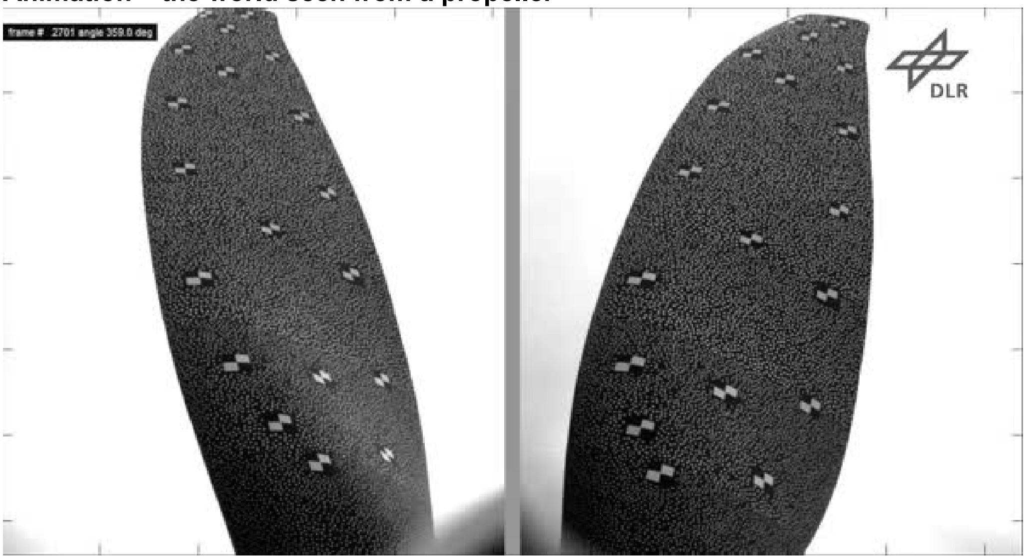
Animation – the world seen from a propeller



How the world looks from the perspective of a propeller. The background rushing past is the world appearing to revolve. In reality, the propeller rotates more than 2000 times per minute – and with it a new camera system created by DLR researchers at Göttingen. Thousands of recordings have enabled them to make deformation of propeller blades in flight visible for the first time.

Video - Experiments with the propeller camera

Scientists at DLR Göttingen have achieved a world first – showing the deformation of an aircraft propeller blade during flight. They have developed a special camera that can resist the enormous forces exerted during rotation. Their findings could not only help to improve aircraft propellers, but also helicopter rotors and wind turbines.

First flight with the propeller camera

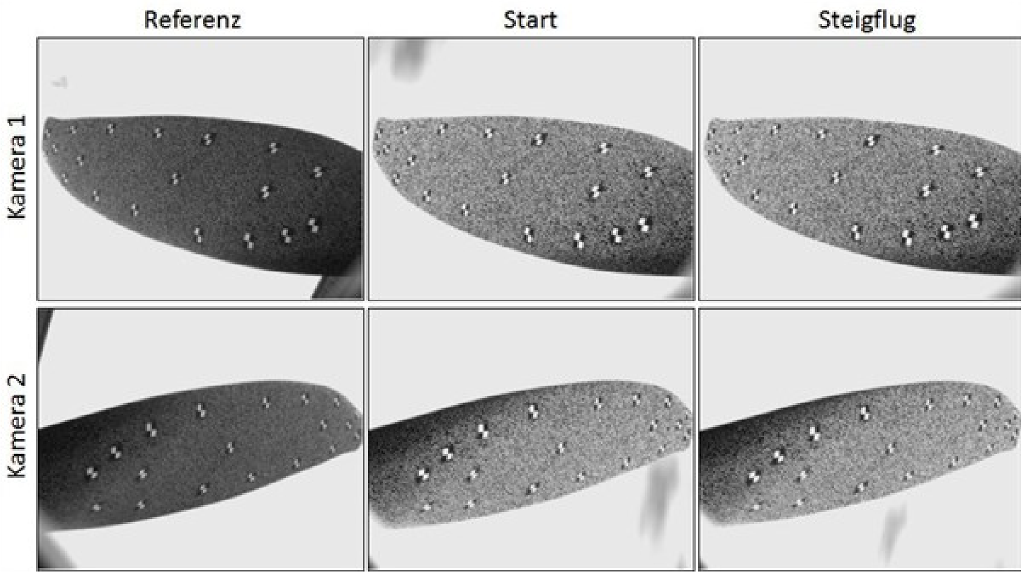
The initial flight with a rotating propeller camera took place in Kunovice in the Czech Republic, on a single-engine Evektor VUT 100 Cobra.

Researchers in front of their invention

Fritz Boden and Boleslaw Stasicki from the DLR Institute of Aerodynamics and Flow Technology in front of their invention – a rotating camera mounted in the hub of a propeller. They have used this to make the deformation of a propeller blade during flight visible for the first time.

Credit: DLR (CC-BY 3.0).

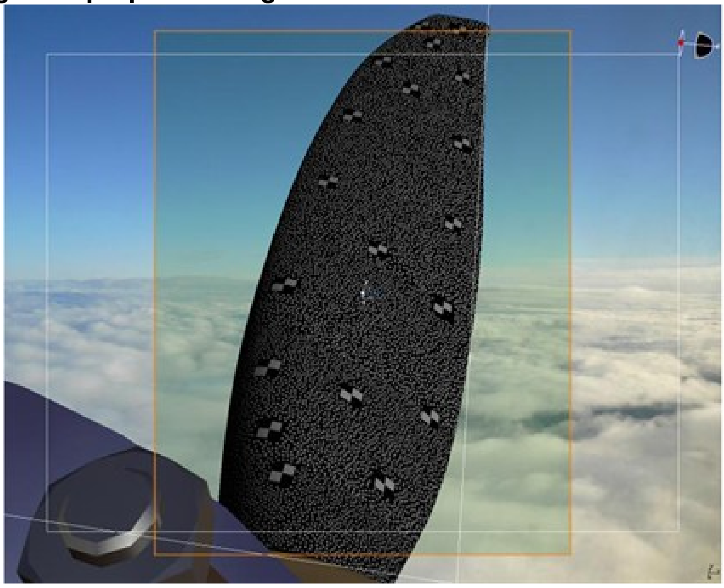
How the propeller looks in flight



Sequence of images from both cameras. The propeller blade is seen from various viewing angles and in different flight situations.

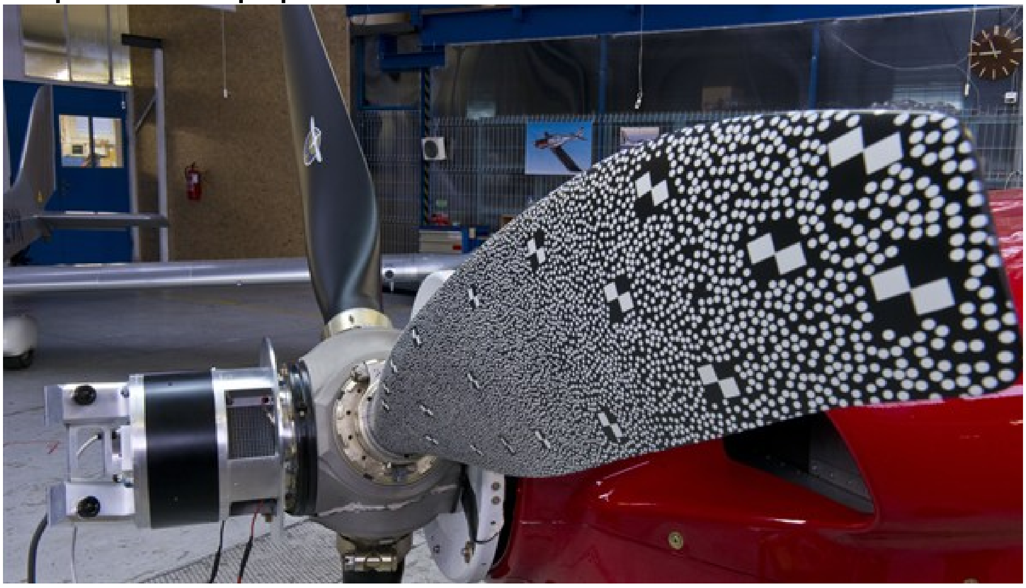
Credit: DLR (CC-BY 3.0).

Photomontage of a propeller in flight



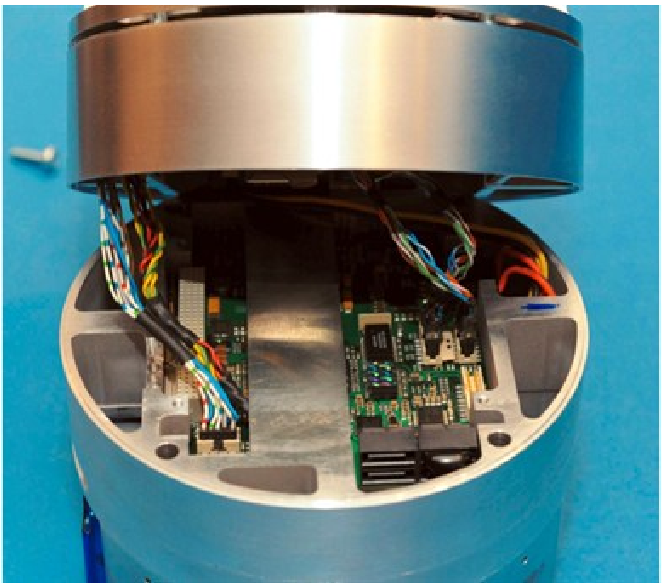
Photomontage from a recording of a propeller blade in flight against a background of clouds.

Dot pattern on the propeller



Not just the camera and its housing have been developed by the DLR researchers in Göttingen – so too has the measurement technology employed. This involves using two cameras with different angles of view (stereoscopy) to take images of the object under investigation. A computer identifies the equivalent points in the images – the dot pattern helps with this. Knowing the position and attitude of the cameras enables the entire surface being observed to be represented in 3D.

Inside the camera container

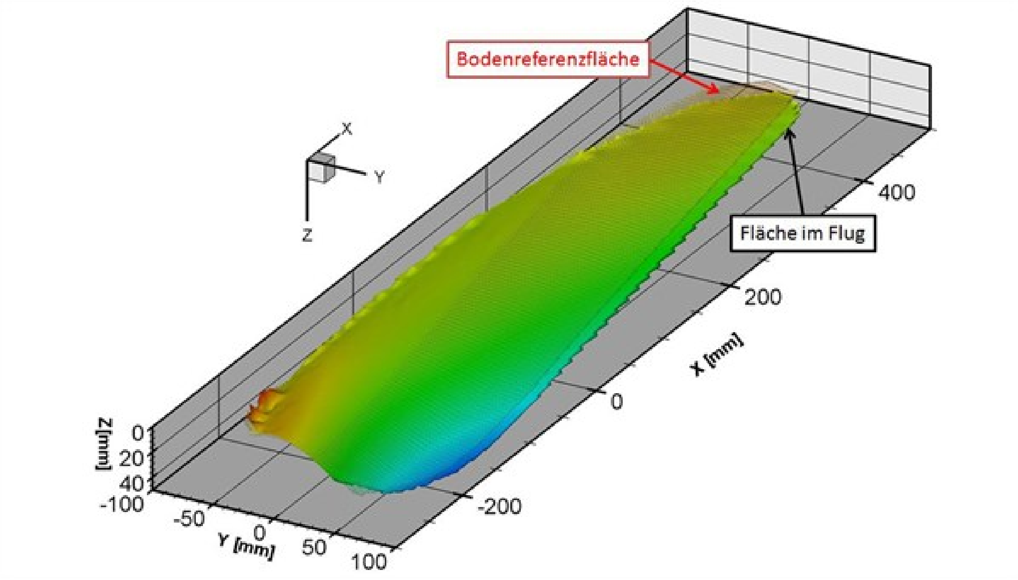


The researchers from Göttingen placed the camera, a miniaturised computer and other electronics inside a metal container that protects them from the extreme loads exerted by the rotating propeller.

Exterior of the camera container

The researchers from Göttingen placed the camera, a miniaturised computer and other electronics inside a metal container that protects them from the extreme loads exerted by the rotating propeller.

Computer representation



Computer representation of the surface of the propeller calculated during flight. A deflection can be seen in flight (Fläche im Flug) compared to the shape on the ground (Bodenreferenzfläche).

Credit: DLR (CC-BY 3.0).

Wireless transmission of images

The camera is aligned with the propeller blade and rotates in synchrony with it. The images are transferred to a computer via a wireless network.

Credit: DLR (CC-BY 3.0).

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