# The flying eye

**Camera makes currents visible in gliding flight**

For a glider to glide as long as possible, air has to flow perfectly around the airfoils. To find out if it does, you need either a multi-million Euro wind tunnel or some 3 m wool threads and a USB camera.

*Figure 1: Around 50 red wool threads follow the progression of the air current and indicate undesirable turbulence.*

"Victor Echo, the cable is taught." The two-seater glider is positioned at the start of a 1 km asphalt runway at the Aalen-Elchingen Airport. It's connected to a motorized tow plane with a cable. Glider pilot Tobias Lohner reports back to his colleagues: "The cable is taught." "Victor Echo starting on two seven." The glider jerks as the powered plane accelerates to 130 kph. Half a minute later, they both lift off. At an altitude of 600 m, the pilot releases the tow cable and the aircraft transitions to smooth gliding flight.

The "fs 33" is a high-performance glider with a 20 m wingspan. Externally, it's not any different from other planes. What makes this model unique is that it was built by hand over the course of 6 years by students at the University of Stuttgart. In the "Akaflieg" academic flying club, aerospace engineering students develop their own aircraft. Since 1926, the club has created more than a dozen prototypes and provided many important impetuses for the aircraft construction field. Around 20 members spend several thousand hours working on each aircraft, from aerodynamic design using computers to the production of female molds, which are constructed with carbon fiber fabric and then painted, to the finishing polish. "It doesn't leave you with much time for other hobbies," admitted Lohner, current president of the active group. In return, the students receive their pilot training for free.

While the successor model "fs 35" is already in the process of being built, the "fs 33" is performing test flights above the airport near Aalen. The objective of the flights is to find prospects for aerodynamic optimization. Indeed, the 400 kg "fs 33", which has a top speed of 280 kph, already possesses good flight handling characteristics. After undergoing many test flights, however, it became apparent that the upward angled wing tips (the winglets) are not optimally designed. Winglets minimize the resistance of the wings, which allows the glider to glide longer. With the fs 33, however, unfavorable air vortices sometimes arise. For a student research project, Tobias Lohner took on the challenge of examining these currents. But how do you make air vortices visible?

The students had a simple, but effective idea for a solution. They attached about 50 red wool threads to one of the winglets. Only one end was connected to allow the threads to move freely with the current. Ideally, the wool threads would lie smoothly on the wing while in flight. During some flying maneuvers, however, turbulence occurs and the wool threads stand up on the airfoil, sometimes even opposite the direction of flight. To precisely document the behavior of the wool threads while in flight, the academic pilots sought out a compact USB camera with a robust mount. Nearby camera manufacturer IDS Imaging Development Systems GmbH supplied just the right model, including the lenses and accessories.

*Figure 2+3: The UI-1240SE USB camera with a 1.3 megapixel sensor records every movement of the wool threads in the video.*

A 40 cm metal arm holds the model UI-1240SE camera securely to the left wing during the flight. The uEye SE model line features a metal housing with many screw holes, which makes "wind-proof" mounting easy. The lens, which features a

9 mm focal length, covers the wingtip area so that the red threads are easy to see. The camera and lens are attached at a 90° angle to make better use of the narrow field of view along the wing. An 8 m USB cable is led along the airfoil and through a small window into the cockpit of the two-seater, where it is connected to a laptop computer. The co-pilot operates the DirectShow software, which records videos of the flight. The pilot follows a predetermined sequence of speeds, curves and angles of yaw so that the flight maneuvers and the behavior of the wool threads can later be matched up.

When carrying out the subsequent analysis, the various currents are easy to see. The powerful 1.3 megapixel color sensor of the UI-1240 supplies 25 frames per second via USB. This ensures both smooth video and sufficient detail. A special feature of the CMOS model is the global shutter readout mode, which is usually only found with CCD sensors. It enables even quickly-moving objects to be captured without geometric distortions. One challenge that presented itself while recording video in sunny skies were the changing light conditions. The uEye camera is able to automatically adapt the exposure time to the ambient brightness so that the red wool threads always remain easily visible.

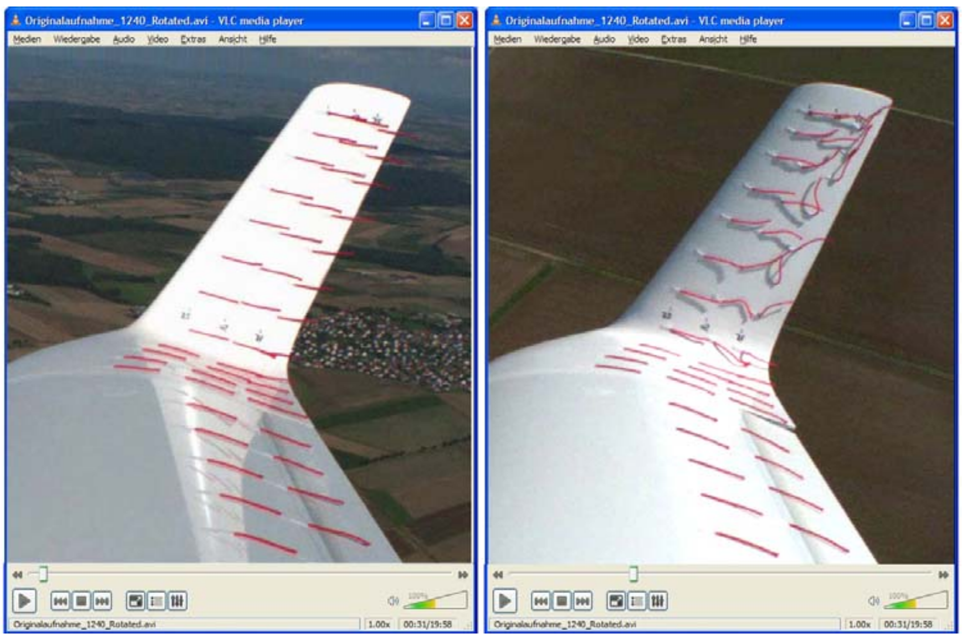


*Figure 4: The video analysis makes the currents clearly visible. On the left, the threads lie smooth as they should, but during the flight maneuver on the right, unfavorable air vortices arise.*

After flying for 15 minutes, the "fs 33" begins its descent and then soon comes to a halt on the grass runway. Tobias Lohner is very satisfied with the image quality of the video recordings. For the analysis, he'll carry out a current simulation using a digital model of the wing. The videos from the USB camera supply valuable comparative data for checking the validity of the simulation. Until the results of the winglet examination are in, the prospective aerospace engineer is going to have to view quite a few videos, but he's already thinking about his next project. "After this, I'd like to examine the current at the wing root, the transition between the fuselage and the airfoil." It looks like the uEye will still see lots more air time on board the "fs 33".

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