

Tiny new control device improves lateral stability of airplane

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Engineers at Lehigh University have designed and successfully flight-tested a new control device that a pilot can use to tailor the lateral stability of aircraft.

Joachim Grenestedt, associate professor of mechanical engineering and mechanics, designed "canted tabs" that are attached to the ailerons, the movable control surfaces on the wings that are used to roll an aircraft upright.

Grenestedt, an aeronautical enthusiast who owns and flies his own two-seater, said the tabs measure a few inches in length and width. The tabs rotate around an aluminum tube that is inserted into the aileron.

Three tabs were mounted on each aileron for the test flights, which took place at the National Test Pilot School (NTPS) in Mojave, Calif. The tabs used in these tests could be adjusted in flight by as much as 30 degrees.

When tested on an Aermacchi AM-3 "Bosbok" observation-reconnaissance plane with 8-foot-long ailerons, the tabs made the laterally unstable aircraft stable, Grenestedt said.

"We took an unstable aircraft, fitted it with the canted tabs and made it stable. When the plane started to side slip, the tabs applied force to the ailerons, causing the plane to bank, or roll, and regain lateral stability."

The Aermacchi does not possess the ability, required of civilian planes,

to be rolled upright using the rudder alone.

"Normally, you roll an airplane upright using ailerons," said Grenestedt. "If you lose the primary roll control, then you have to use the rudder." The Aermacchi lacks this back-up feature.

Russ Stewart, a test pilot instructor with NTPS, said the canted tabs enabled him to roll the Aermacchi using rudders only.

"The canted tabs actually made the plane handle properly," said Stewart, who has more than three decades of test-pilot experience. "When they started to deploy to about a third of their range, they turned stick forces to the proper direction."

Stability is the tendency of an airplane to fly straight, level and in an upright position. Positive lateral stability means an airplane has the tendency, if disturbed, to return to its original stable position without corrective action by the pilot. Neutral stability means the restoring forces are absent and the plane neither returns from its disturbed position nor moves further away.

Negative stability means the plane will tend to move further from its original position.

In the case of the Aermacchi, the canted tabs were used to increase lateral stability. However, Grenestedt said the canted tabs could also be used to reduce lateral stability and thus decrease Dutch Roll tendencies and stick forces during cross wind takeoffs and landings. Dutch Roll is an oscillatory motion, combining roll, slip and yaw. These oscillations typically have a short period that is a challenge for the pilot to overcome. A moderate amount of Dutch Roll, while not fatal, tends to provoke nausea, especially in passengers.

Grenestedt and Lehigh research scientist Bill Maroun modified a set of conventional ailerons for the Aermacchi, and fitted them with the canted tabs.

"We did not know exactly how the Aermacchi would perform," said Grenestedt, who did all the design calculations with pencil and paper. "But the canted tabs showed that they can fix lateral stability deficiencies.

"The largest benefit of the canted tabs may be to serve as a cure for lateral stability deficiencies in existing aircraft, reducing the need for extensive airframe modifications."

Stewart took the modified Aermacchi on two solo flights to verify its safety and flutter resistance. He and Kent Nelson, an NTPS flight test engineer instructor, completed four more flights with instruments to measure linear and angular accelerations, rudder and aileron deflections, stick force, air speed and altitude.

To measure lateral stability, the pilots used various maneuvers, including steady heading side slips, rudder releases, bank-to-bank rolls, and spiral stability flights. In particular, the steady heading side slips showed the effect of the canted tabs. "Deploying half rudder," said Stewart, "the canted tabs changed stick forces from 1 or 2 pounds negative [implying negative lateral stability] to up to 10 pounds positive."

Each test flight lasted about an hour and reached an altitude of 5,000 feet.

Grenestedt said the idea of mounting canted tabs on ailerons was proposed by his friend Sven-Olof Ridder, a fluid dynamics expert in Sweden who is well-known for his airplane and yacht designs.

Source: Lehigh University

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