

DEMONSTRATION OF LONGITUDINAL STABILITY AND SPINNING QUALITIES DURING SAILPLANE PILOT TRAINING

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Summary

The author is not a flight instructor but is quite an experienced sailplane test pilot. During flight testing of the sailplanes he designed, he observed that longitudinal stability and behavior in spins may change dramatically well inside the approved center of gravity range of a sailplane. He therefore proposes to demonstrate these changes of qualities during pilot training or as a first step for flight instructor training.

Longitudinal stability

During flight training the pilots are told that the center of gravity (c.g.) has an important influence on longitudinal stability of a sailplane and that the stability may get marginal when the rear limit is reached or even exceeded.

How can longitudinal stability be quantified and shown to the pilot in diagrams?

Test pilots are trained to demonstrate longitudinal stability by measuring stick displacement versus speed as well as stick force versus speed. These tests have to be done in order to demonstrate whether a sailplane fulfils minimum requirements or not so that it can be certified or needs

improving modifications.

Positive longitudinal stability shown by stick force versus speed

A sailplane flies stable when it can fly with its trimmed speed "hands off", which means that the stick keeps its position without control force in calm air. Even minor turbulence should not disturb the trimmed speed too much.

To fly higher speeds than trimmed it must be so that the stick must be pushed forward with higher force the faster one wants to fly or the stick must be pulled back with some force to fly slower.

Figure 1 shows the stick force versus indicated airspeed for the ASW 24 sailplane at foremost and aftmost c.g. positions.

It is quite visible that the stick force changes more with foremost c.g. position and much less with rearmost c.g. position. The effect however is not too dramatic and we all know it from experience. The flight instructor however can really learn, that a lightweight (lady) pilot has to control a quite "sensitive" tail heavy sailplane whereas a heavy pilot (like the author) feels a "stable" nose heavy sailplane with a "frozen" stick.

Therefore it is a good custom to give a lightweight pilot a more stable sailplane by making it more nose heavy by additional trim weights in the front fuselage than required as a minimum to just be forward of the aftmost c.g. position.

Longitudinal stability shown by stick displacement versus speed

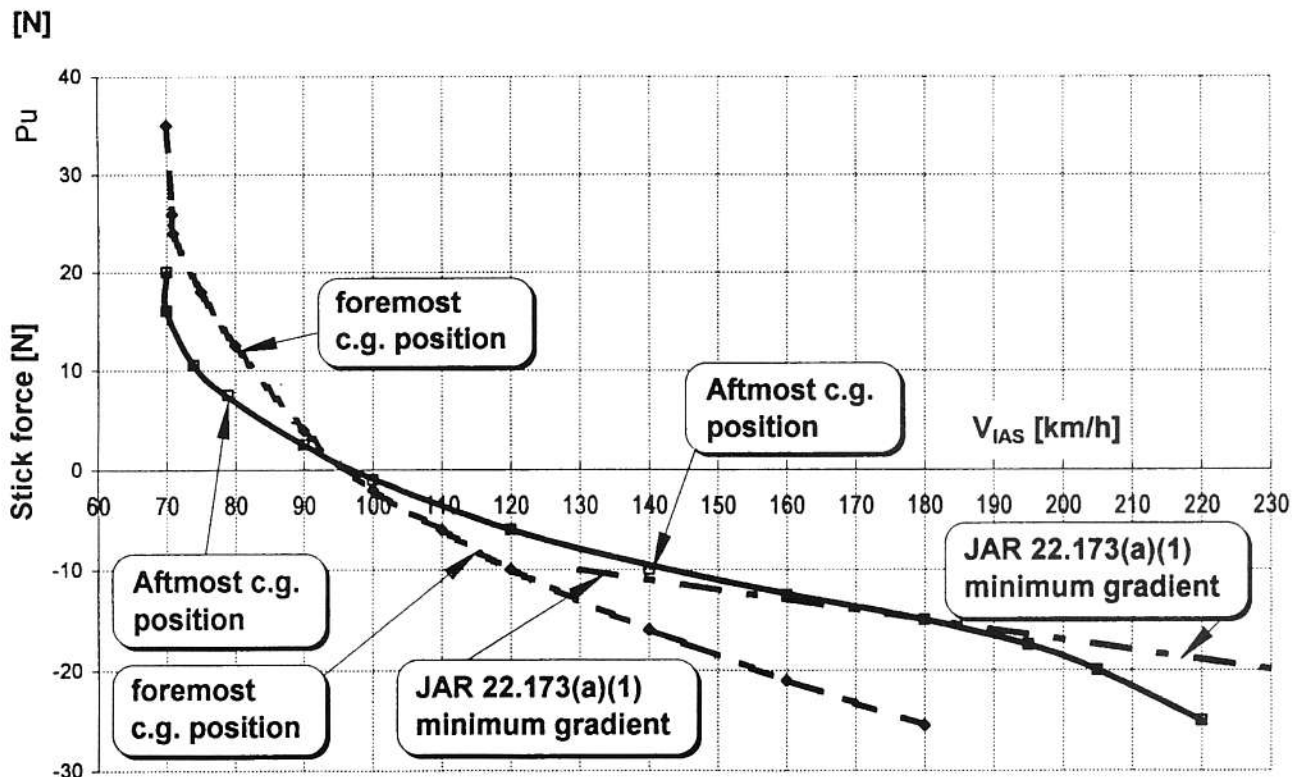


Figure 1. Stick force versus speed, ASW 24.

In Figure 2, stick displacement versus speed is shown for an ASW24 at foremost c.g. limit which is reached when heavy pilots are on board and at aftmost c.g. limit which is reached when a lightweight pilot flies.

Here it is very visible that the nose heavy sailplane with heavy pilots on board has quite different stick positions, forward for high speed and rearward for slow speed, almost fully back near the stall.

The lightweight pilot however has almost the same stick position over the whole speed range. This does not mean that this pilot must not move the stick at all! To pick up speed, he must push the stick a short while forward, but must return to the old position to maintain the new higher speed. To fly slow, he must hold the stick a short while back and must again return to the old position to maintain the new slow speed. In other words, the lightweight pilot has to balance on a needle to maintain speed. He can only rely on the stick pressure feel according to the section before.

Behavior in spins

Pilots are told during their training that c.g. position has a significant influence on behavior in spins. Most pilots think that unacceptable spin behavior restricts the approved c.g. range and recovery from spins is impossible or at least difficult when the aftmost c.g. limit is exceeded. This may be indeed the case for some sailplane models but not necessarily so.

Results of spin tests of a modern sailplane

The spin tests for the ASW 24 certification have been performed by a very prominent test pilot (Gerhard Stich of DLR Braunschweig) and well documented in order to detect possible effects of small winglets to spin behavior.

At the foremost c.g. position, only 1/2 spin turns could be achieved followed by spiral dive and self recovery regardless of the aileron control position or whether water ballast was on board or not.

At a c.g. position of only 3 cm in front of the aftmost limit the spin behavior changes so significantly that it was recorded. Still only one spin turn was possible when the aileron control deflected against the direction of the spin whereas more than 5 stationary spin turns were possible when the aileron control was held in neutral or in the direction of the spin.

Almost at the rearmost c.g. limit 3 spin turns followed by spiral and self recovery were noted when the aileron

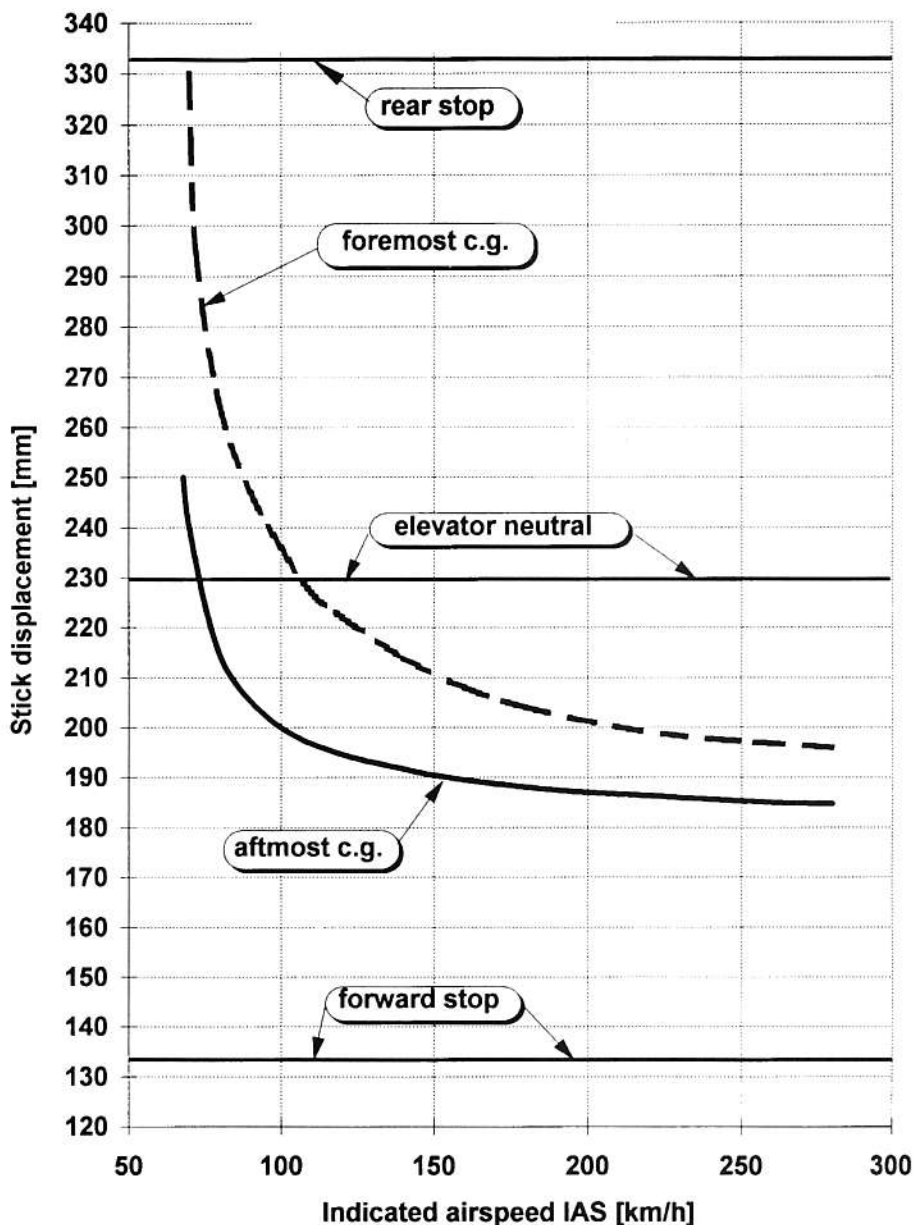


Figure 2. Stick displacement versus speed, ASW 24.

control was held neutral. The first turn was not stationary but getting steeper in the second turn and stationary and steep in the third turn. For neutral aileron control or aileron in the direction of the spin turn results in five or more spin turns with a pitch oscillation of 1 1/3 turns period.

According to JAR-22 and other earlier requirements c.g. positions 1 cm or 1% mean aerodynamic chord aft of aftmost approved c.g. limit must comply with the minimum requirements for safe recovery. At a c.g. position 1.2 cm aft of the aftmost limit 5 spin turns were possible regardless which aileron control position was chosen. Only with aileron control against the direction of the spin the spin got steeper with a tendency for self recovery. In other aileron control positions an oscillatory spin mode of 1 1/3 turn period was observed with less pitch oscillation in neutral aileron control position. See tables 3a through 3c.

It is my experience that such a wide variety of spin modes

is representative for almost all sailplanes which were certified during my 34 years at the A. Schleicher factory. I invite our colleagues to join us with their findings. Needless to say, Rudy Kaiser's ASK 21 shows this wide range of spin behavior and is therefore not liked for spin instruction at least when pupil and instructor are on board.

The USAF uses the ASK 21 for training test pilots. Therefore USAF tested this sailplane additionally and over a wider range than approved for in normal operation. "The test team considered the aircraft to be an excellent spin trainer because c.g. could be accurately controlled using tail weights."

Recommendations

With the effects experienced and documented so frequently, the author strongly recommends, that as a minimum flight instructors should be educated in flying the training sailplane near the rearmost c.g. limit. This can be achieved by adding adequate tail ballast to the sailplane. Operational procedures to safely do this must be developed and agreed to. Swiss as well as USAF experience show that:

- Weight scales must be available at the point where the flight crew enters the sailplane
- Tables must be prepared in advance showing the necessary tail weights depending from the weights of the pilot in the front and rear seat separately.

When the training of flight instructors with tail weights simulating rear c.g. positions is successful it must be considered that a pupil makes some last flights with his

instructor, where some tail weights balance the flight instructor's weight, so that both fly the c.g. position the pupil will experience when he goes solo. Needless to say, for the solo flight instructor the tail weights have to be removed. The author is very sure that all flight instructors will let their pupils fly only with adequate nose weights after they experienced (in a new training program using tail weights) how sensitive a sailplane is near aft c.g. with one lightweight pilot.

Conclusions

The author cannot see, why additional weight on the tail is dangerous when used in an approved range of c.g. positions and inertia.

Tail dollies are painted in strong contrast to the appropriate sailplane and are not often forgotten in operation. When nose weights for light weight pilots are forgotten the sailplane is operated outside the approved range. These weights are not visible from the outside!. So I cannot see why very visibly painted tail weights cannot be accepted. They will not be used to operate the sailplane outside the approved c.g. range. To make the ASK 21 spin, it is not necessary to trim it to the aftmost c.g. position. A position 8 cm in front of the aftmost position is needed to demonstrate sustained spins. The author hopes he can motivate LBA, DLR and Idaflieg to test operational conditions under which the use of nose and tail weights are safe and if the effects of demonstrating pilots the change of stability and spin behavior due to c.g. position are helping to achieve significant improvement in flight safety.