

CIRCLING THE HOLIGHAUS WAY - OR DO YOU REALLY WANT TO KEEP THE YAW STRING CENTERED?

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ANSWERS:

1. During Straight Flight – YES, that minimizes drag and maximizes the sailplane's performance.

2. During Turns – NO, not really, because then the sailplane is actually in a slight skid, and more-than-necessary cross aileron is required to prevent over-banking. That will be explained below.

3. During Circling Flight - NO, that does not minimize drag, and the possibility of an inadvertent spin entry can be reduced significantly if one maintains a true mild sideslip while circling.

INTRODUCTION

The well-known German sailplane engineer, designer, Schempp-Hirth factory owner, and sailplane pilot Klaus Holighaus generously brought the benefits of maintaining a mild sideslip while circling to my attention some 30 years ago while we were both competing at the World Gliding Championships in Yugoslavia. He was flying his beautiful new Nimbus 2 sailplane for the German Team, and I was flying an equally fine ASW-17 for the US Team. I was and always have been impressed with his knowledge, generosity and sportsmanship. He died in an unfortunate mountain soaring accident some 9 years ago, but his legend will always live on.

WHY MAINTAIN A MILD SIDESLIP WHILE CIRCLING?

Essentially all sailplanes are designed with positive wing dihedral. During a sideslip, that causes the windward wing to achieve a slightly higher angle-of-attack relative to the airstream than the leeward wing. That creates a rolling moment toward the leeward wing.

That is easy to prove. During straight and level flight while holding the control stick fixed, push on one of the rudder pedals and note your sailplane's roll response. It should definitely roll toward whichever rudder pedal that was depressed. That is known as positive roll stability.

The beneficial effect of positive roll stability is not so obvious during circling flight, but it is still there. The lowered inside wing panel has less airspeed, and hence less lift than the raised outside wing panel. To compensate for that, while keeping the sailplanes' skid ball centered, one must deflect the lower wing's aileron downward to increase its lift so that the lower wing's lift equals that of the upper wing. If that is not done, the sailplane would keep increasing its bank angle, and a steep spiral dive would result.

When the lowered wing's aileron is deflected downward, not only is its lift increased, but also its drag is increased, and a skidding turn will be induced. The skid can easily be corrected for by adding some top rudder to keep the skid ball centered. The danger here is that when the aileron is deflected downward, it is more prone to stalling. When that happens, an out-of-control spin will likely result unless corrective action is promptly taken.

Figure 1 shows a cross section of a typical sailplane wing airfoil and its airflow streamlines. The upper airfoil represents a relatively high angle-of-attack thermalling condition with the aileron un-deflected. There both the upper and lower surface airflows stay attached to the wing surfaces and near maximum wing lift is achieved. The lower airfoil shows the same airfoil, but with the aileron deflected downward. If the aileron is deflected downward far enough, the airflow will separate from the upper portion of the aileron surface, and that will increase the

wing drag and decrease its lift. If a pilot then increases the aileron downward deflection angle in an attempt to compensate for its lost lift, it only makes things worse. A spin entry is likely, unless the aileron deflection angle is neutralized, and/or the wing angle-of-attack is promptly reduced.

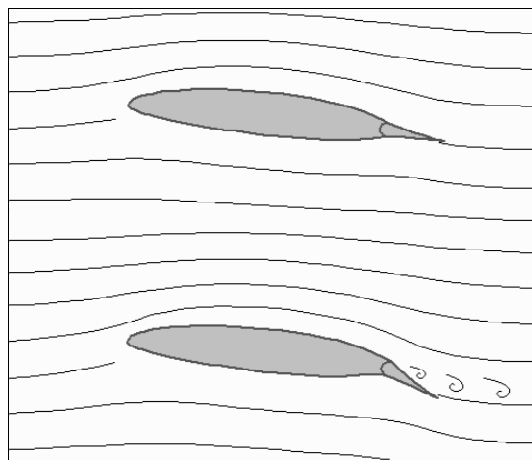


Figure 1. Sailplane airfoil with streamlines

How does one require less-aileron deflection while circling? That is easily achieved by just maintaining a small angle of sideslip and let the sailplane's dihedral effect provide some additional lift to the lower wing. [Figure 2](#) depicts how the wing dihedral combined with a sideslip increases the lift on the windward wing, and decreases lift on the leeward wing.

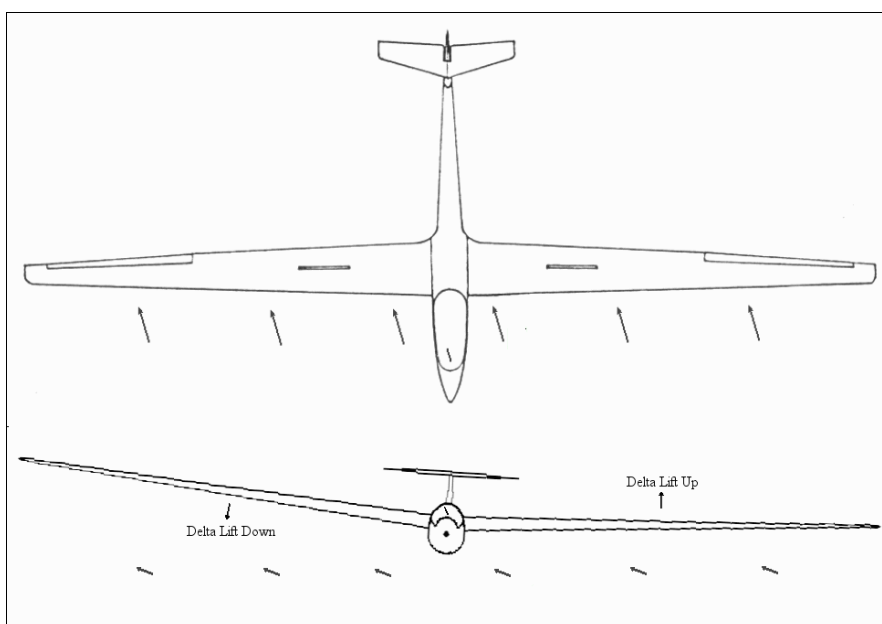


Figure 2. Dihedral in side slip

Klaus recommended maintaining a gentle sideslip while circling. The optimum degree of sideslip depends to some degree on both the sailplane's wingspan and dihedral angle. After many hours of flying my 16.6 meter Ventus A and similar sailplanes, I find that my best overall circling performance and handling characteristics occur while the canopy mounted yaw string is deflected about 10 degrees on the high side of the turn (a gentle sideslip actually), because the yaw string forward placement error accounts for about half of the 10 degrees. See section below.

THE SKID-BALL INDICATOR

A skid-ball indicator is a curved glass tube filled with a clear compass-like fluid, and within which a round ball is free to roll from side-to-side. It is mounted laterally on an instrument panel and is designed to sense and indicate lateral accelerations of the sailplane. Commonly it is called a ball-bank indicator in the US, but it does not actually indicate bank angles, just lateral acceleration.

Under that optimized circling condition, my Ventus instrument panel mounted skid-ball is **not** centered, but rests about ½ ball diameter on the low side of the turn. [Figure 3](#) illustrates a hypothetical sailplane cockpit view while efficiently thermalling in a slightly slipping circling flight condition. The instrument panel includes a ball skid indicator, and the canopy sports a typical forward mounted yaw-string.

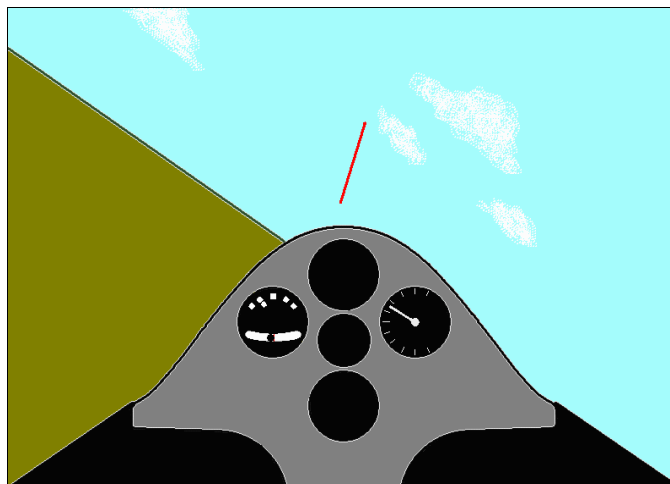


Figure 3. Cockpit view while efficiently thermalling

WINGLET PROBLEMS

I did not have winglets installed on my 16.6-meter wings during that flight-testing, and they often are prone to stalling during slipping or skidding flight. Sailplanes equipped with winglets likely need to just keep the skid-ball centered to avoid winglet-stalling problems. Place some wool tufts on the inboard sides of your winglets and see for yourself during a test flight.

YAW STRING LONGIDUDINAL LOCATION YAW EFFECT

[Figure 4](#) depicts a plan-view of a sailplane while thermalling. Circling with the yaw string centered actually results in a slightly skidding turn because the yaw string is mounted well ahead of the sailplane's CG. That concept is true, and [Figure 4](#) illustrates that point.

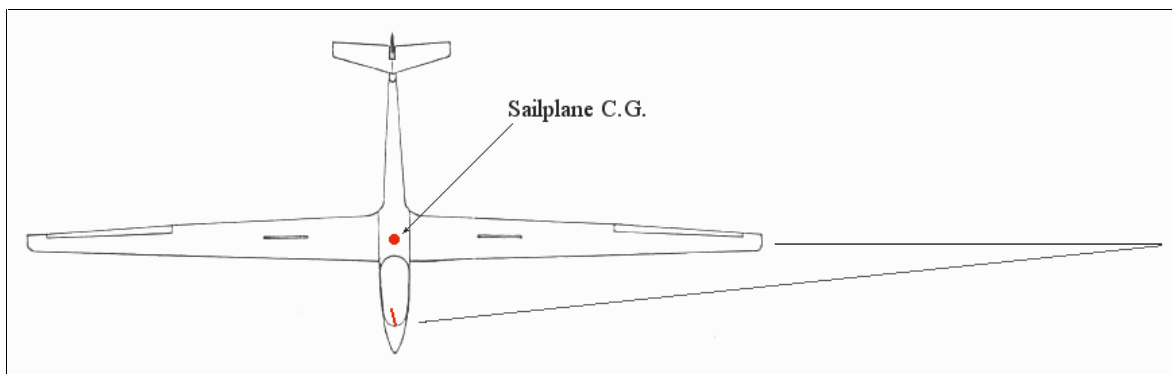


Figure 4. Effect of forward placement on yaw string

The yaw-string is mounted about 2 meters or so ahead of the sailplane's CG; therefore the air approaching the yaw-string arrives slightly from the left of the sailplane's nose. Another way to view this turning flight situation is to consider the sailplane to be motionless in space, while the thermal is rotating at say 45 kts. That makes it easier to appreciate the effectively curved airflow approaching the nose-mounted yaw-string.

Although many single-seated sailplanes do not carry ball skid indicators today, fortunately most 2-seated training sailplanes come equipped with them mounted on their instrument panels. The canopy mounted yaw string angle errors can easily be seen during turning flight by referring to the true ball-slip indicator. In a tandem 2-seater with separate yaw strings, one can compare the difference in the angles between the rear and front cockpit yaw strings, and see the differences.

If the yaw-string could somehow be mounted at the sailplane's CG, and utilized by the pilot, the yaw-string would then show zero yaw deflection when the sailplane was being flown with the skid-ball centered. Because of its normally well-forward mounting location, the yaw string indicates a slight sideslip, even though the sailplane's more accurate skid-ball shows none. Obviously, the skid-ball more accurately portrays the sailplanes' true flight condition.

CANOPY CROSS-AIRFLOW MAGNIFYING EFFECT

During both straight-ahead yawed flight, and also during skidding and slipping circling flight, the canopy air cross-flow has a magnifying effect on the local airflow direction. The actual sailplane slip or skid angles are likely about half that indicated by the yaw string.

SUMMARY

For safety's sake never skid a turn, unless a spin entry is to be an acceptable condition. Never fly with the yaw string on the low side during any turn because that is a dangerous skidding flight condition, and too much aileron deflection is required to prevent over-banking. To do so is an indication that too much pro-turn rudder is being applied. At low airspeeds that can easily lead to a highly unwanted loss of roll control and a dangerous spin.

It is very important that a yaw string be installed on modern sailplanes, but it is also prudent to have a simple skid-ball mounted on the instrument panel. Next to the airspeed indicator, the yaw string is, in my opinion, the most important sailplane safety instrument. Although its ability to correctly indicate a skid or slip is only fair, it is cheap and simple. Its most redeeming feature is its mounting location, squarely in the pilot's forward field-of-view.

ADDITIONAL PICTURES

**Red yaw string mounted on forward centerline of Ventus A canopy,
with ± 20 degree yaw lines marked in black ink.**



Author's Ventus A cockpit view during a properly coordinated left turn, with yaw string kept about 10 degrees on the high side during the turn.



**Ventus A instrument panel and canopy view during a gentle right turn.
Skid ball is at advocated $\frac{1}{2}$ ball width on the low side of center.
Unfortunately, the electric turn indicator is un-powered.**