On the ’Wing... #142

Trimming planks for slope flying

Plank planforms are incredibly easy to build, and are a delight to fly. Additionally, when given the appropriate airfoil and wing loading, they can be made to be anything from a light air floater to a speed demon. Not surprisingly, there are a number of planks which are designed for slope flying which seem to do well in a wide variety of conditions, from five knots up to 40 knots and more, without the need to add ballast. The “trick” is in how to trim the chosen airfoil.

Perhaps the easiest plank planform to imagine is the rectangle. In this case, a constant chord wing is attached to some sort of fuselage which houses most of the radio gear. Such aircraft have been built for many years using a few ribs, a spruce spar, and a fuselage of sheet plywood. More modern renditions are made of styrofoam and packing tape, or EPP foam. Sometimes the elevons are barn door affairs extending over the outer half of the wing, but more commonly they are nearly full span and of relatively narrow chord. If the goal is to be able to trim for a wide range of lift conditions, the latter set-up is preferable because the entire trailing edge is moveable.

RC aircraft of any kind must be set up on the ground to be pitch stable in the air. That is, the CG must be forward of the aircraft neutral point, and there must be some available aerodynamic downforce behind the neutral point to keep the nose up. Let’s take these two points one at a time.

CG and neutral point

The neutral point is generally considered to be at 25% of the mean aerodynamic chord (MAC). When computing this location for tailed aircraft, the horizontal stabilizer is taken into account. For our simple plank, which has a constant chord, the MAC is wing chord at the fuselage centerline. The neutral point is then 25% of the chord behind the leading edge.

If the CG is behind the neutral point, that is at a location greater than 25% chord, the aircraft will be unstable. There are “black box” methods of making such aircraft fly, but without such elaborate affairs the aircraft will not be flyable.

If the CG is at the neutral point, that is at 25% chord, the aircraft will be neutrally stable. It will tend to continue flying at the attitude it has when the controls are set to neutral. Such aircraft are barely flyable. The pilot needs to be extremely attentive, and is usually inputting control surface changes on a continuous basis.

If the CG is in front of the neutral point, at a point less than 25% chord, the aircraft will be stable in pitch. When placed in a dive, the aircraft will recover by itself once the controls are neutralized. Control input by the pilot is minimized. Best flying characteristics are usually obtained when the CG is between 22.5% and 15% MAC (static margin 2.5% to 10%).

Rearward aerodynamic downforce

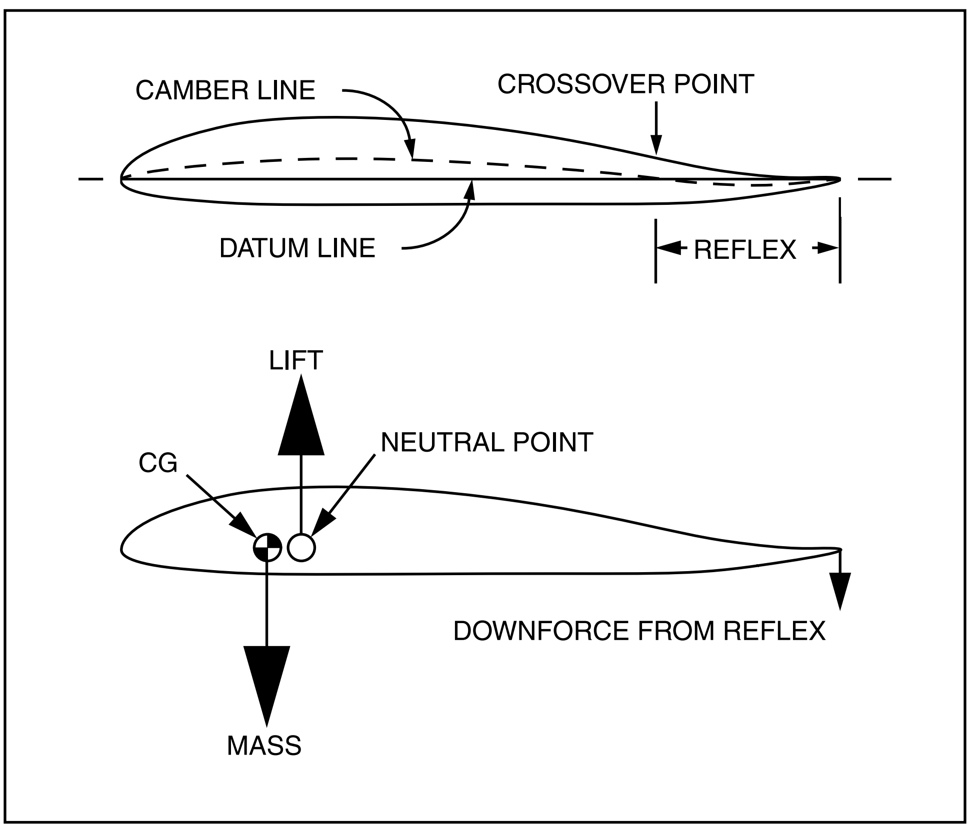
Airfoils used for plank designs must incorporate some amount of reflex, or the elevons of the completed aircraft must have some amount of up trim. Without that reflex or elevator trim, the airfoil will tend to follow its camber line and pitch forward. Additionally, the CG is in front of the neutral point and is applying a downforce to the forward part of the wing. To maintain level flight, there must be some downforce behind the neutral point - either airfoil reflex or elevon up trim.

The reflex applies a force which is directly related to air speed. A plank which has no flying speed and is simply dropped, will rotate nose down because it CG is in front of the neutral point. As speed increases, the reflex applies a larger and large force to the aft portion of the wing. At some point the reflex will rotate the aircraft in pitch and bring it out of its dive.

Obtaining level flight

At normal flying speeds, there is a balance between the forward CG trying to rotate the nose down, and the reflex which is trying to rotate the nose up.

Applying a small amount of down trim changes the pitching moment of the wing, reducing the normal down force or creating an upforce if the trim change is excessive. This causes the aircraft to rotate nose down, reducing the coefficient of lift and increasing the flying speed. Too much down trim causes a shallow dive and a higher sink rate.



Up elevator, on the other hand, increases the downforce on the aft portion of the aircraft and hence the nose rotates upward. The pitching moment is now more positive. The wing is operating at a higher coefficient of lift. The aircraft can be made to fly at a higher angle of attack and slower speed. The angle of attack can eventually be made to be great enough that although the lift is high, the drag is of such intensity that the sink rate begins to dramatically increase.

Trimming for wind speed on the slope

If we take our simple plank out to the slope on a relatively calm day, we'll need to maximize the coefficient of lift, so we put in some up trim. If the winds are very calm, we may want to put in a great deal of up trim. What we find in the latter case is that the plank doesn't gain any height at all, but rather mushes to the bottom of the slope. The sink rate is astoundingly high. This is because the elevator down force is so great that it's adversely affecting the wing maximum coefficient of lift. (Remember, lighter aircraft can fly more slowly.)

On the same slope with a higher velocity wind, we will want to put in some down trim. We want the aircraft to fly faster, and reducing the coefficient of lift achieves that goal.

In winds of very high velocity, the down trim required may be so great that the aircraft is obviously diving continuously as it flies across the face of the slope. In this case the overall sink rate is identical to the average upward velocity of the wind.

A couple of points to ponder

The trimming method we've outlined above utilizes elevator trim for flying in various conditions. This is equivalent, as mentioned previously, with changing the trim of a conventional tailed aircraft for the same changes in conditions. This is not a very efficient method of trimming for flying speed, however, as the sink rate is grossly affected. The conventional way of dealing with increasing wind speed is to incorporate a way to add ballast. Increasing the wing loading will increase the flying speed but have relatively little effect on the sink rate. We've heard of some pilots doubling and even tripling the weight of their aircraft through addition of ballast. Just make sure the wing can take the additional loads!

Reflex and elevator trim are directly related to the static margin. The greater the static margin the greater the required reflex or elevator trim. Rather than changing the elevator trim to compensate for slope conditions, we should be able to move the CG. A variation of the Panknin formula can be used to determine the CG location for various desired coefficients of lift. Such an arrangement was used in an F3B World Championships by one of the European teams some years ago. It was not a successful venture because the aircraft flew differently for each CG location, and there was no way the pilot could obtain consistent performance. But on a slope 'ship such a consideration may be a minor issue. The CG location can be either predetermined by slope conditions before flight, or adjusted during flight by an additional servo.

Conclusion

For simple planks used for fun flying and combat, it seems like elevator trim is the best route, particularly when the entire trailing edge is moveable. But for high performance aircraft there are two trimming methods which deserve attention - use of ballast and a moveable CG. Both of these methods allow more optimized control surfaces. Adding ballast is a tried and true method of improving performance in high winds without resorting to elevator trim. The incorporation of a moveable CG is still in the experimental stage, and we encourage inquiring minds with some technical expertise to investigate this possibility.

Comments, questions, and suggestions for future columns may be sent to us at either P.O. Box 975, Olalla WA 98359-0975, or <bsquared@b2streamlines.com>.