DETERMINING CENTER OF GRAVITY ON YOUR AIRCRAFT

by Jerry Neuberger

An article published in the November 2011 issue of Tailspin, The New England Flying Aces News, Mike Nassise, editor

A number of important factors such as wing area, wing loading, and tail volume, play a role in how well airplanes can fly, however, most airplanes can fly well with many of these factors out of norms. The center of gravity (CG), on the other hand, is critical. If the CG is too far forward, the airplane will be very stable while flying, but as it slows down to land, more up elevator is needed to hold the excess nose weight up until the elevator either runs out of travel or stalls. If the CG is too far aft, the airplane will be unstable in flight and uncontrollable. So, how do you figure out the CG point? It's pretty easy, actually. Acceptable CG ranges for almost all airplanes is between 25% - 33% of the mean airfoil chord (MAC). The hardest part of figuring CG is the "mean" part.

On an airplane with a constant chord wing, such as a Piper Cub (see figure 1), the MAC is a snap to determine since the chord of the wing is constant (remains the same). Just measure back 25% - 33% of the chord from the leading edge and that's where the airplane should balance (its CG). If the chord is 10", the airplane will be in balance if the CG is between 2.5 and 3.3 inches back from the leading edge. Unfortunately, not all airplanes have constant chord wings and that is where the "mean" part starts to get complicated.

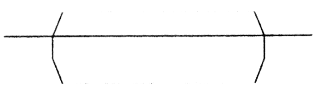

Figure 1

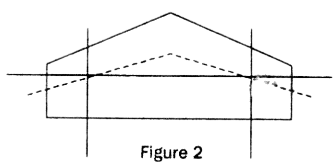

Figure 2

Figure 2 shows a wing with a leading edge taper so that the chord at the wing root is considerably larger than the chord at the tip, causing the mean chord to be somewhere in between the two. To figure the MAC, measure back 25% - 33% at the root and mark it. Then, measure back 25% - 33% at the tip and mark that. Connect the two marks with a dotted line. Now, measure the wingspan from the center of the wing to one of the tips (be sure to include the part of the wing covered by the fuselage). Go to half that distance to obtain the mean chord point on the wing. Do the same for the other side of the wing and draw a line between the two points. Now you have the balance point (CG) of the airplane. Note that the balance point at the tip is nearly at the leading edge of the wing so it's critical that you mark where the balance point is. If you just measure back 25% from the leading edge at the tip, the airplane will be nose-heavy. Although Figure 2 only shows a tapered leading edge, this method also works with trailing edge taper and even for wings with both leading and trailing edge taper (as often found on jet aircraft).

Figure 3 shows a wing with sweep, and once again, figuring the CG is a simple matter of finding The 25% - 33% point at the root and tip, then finding the point at the half span and drawing a line between the two. Notice that the CG is ahead of the tip leading edge and behind the root trailing edge. Once again, it's important that you know where on the wing you're going to balance the airplane.

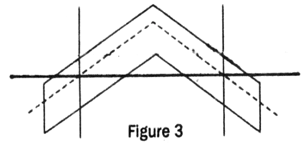

Figure 3

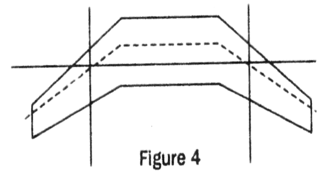

Figure 4

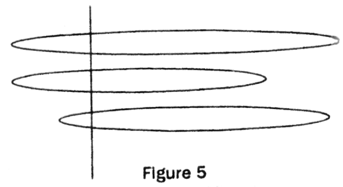

Figure 5

The most complex wing design you are likely to encounter is shown in figure 4. This wing has a constant chord section, a tapered section, and sweep. How do you figure the MAC in this situation?' Well, interestingly enough, it's just as simple as with any of the other wing types. You find the MAC of the constant chord section and the MAC of the swept and tapered section. Then, you find the mean chord on the wing. The only thing that could get you in trouble here is forgetting to include the part of the wing covered by the fuselage. It should be pointed out that the sweep angle in figure 3 and in figure 4 is exactly the same, but you'll notice the CG line is further forward on the wing with the constant chord section. This is the effect of the constant chord area reducing the total area of the swept section.

How does this work with a biplane and two wings? Once again, the answer is simple. Figure 5 shows the wings of a biplane looking from the tips of the wings (nose to the left). To figure the MAC on a biplane, just consider both wings as a single wing for CG purposes and measure from the leading edge of the forward wing (usually the tip wing) to the leading edge of the aft wing. Consider the span to be a single wing (shown by the top oval in figure 5). Then, use the 25% • 33% of that total as the CG location. Notice that the balance line is well aft of the 25% point on the top wing and well forward of the 25% point on the bottom wing. Only one wing type will not work with this system, a delta wing. This type of wing has considerable aft shift of the center of pressure so using this method will result in the CG being much too far forward. There must be some chord at the tip (not the case with delta planforms) for this to work.