AIRCRAFT C.G. AND MEAN AERODYNAMIC CHORD

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A question often asked during any gathering of aerobatic pilot is, "How much does your aircraft weigh?" It's a good question for we've all seen how important it is to have a light fuel/pilot/aircraft package powered by high horsepower. But have you ever thought of walking up to a competitor and asking, "By the way, where is your competition C.G. on your mean aerodynamic chord?"

Well, dropping a question like that just before someone buckles up for their shot at the box might be thought of as psyching out the competition. But in fact, the location of the competition C.G. on the mean aerodynamic chord of the wing can be more important than the operational weight of an aircraft for a given size engine.

Now let's try to clear the fog and explain just what we're talking about. First, as you fly your competition sequence, your aircraft's wing or wings are creating three forces: aerodynamic lift, drag, and pitching moment. Everyone knows about the lift created by the wings and the resultant aerodynamic drag, but what about the pitching moment force? Let's take a look at a classic diagram from our private pilot's text:

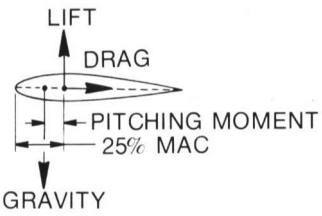


FIGURE 1

1. The straight dotted line drawn from the center of the leading edge to the trailing edge is called the Aerodynamic Chord.
2. The Aerodynamic Center is that point on the Aerodynamic Chord at which the force of lift and drag act. The Aerodynamic Center is usually at the 25% point on the chord line aft from the leading edge of the airfoil.

For every wing or combination of wings, there will be an imaginary aerodynamic chord line that will represent the mean position of all of the component airfoil stations on the aircraft. This is the Mean Aerodynamic Chord (MAC) and its Aerodynamic Center is the mean center of lift of the aircraft. Now if the competition C.G. lies forward of the Aerodynamic Center there is a positive pitching moment force. The aircraft is positively stable in the pitch axis and will tend to seek level flight.

Well, for the hot stick who has no interest in engineering what does it mean if his competition Belch Fire Special has positive pitch stability? Well, it means the pitch axis stick forces will be heavier; a clean stall into a spin and a clean, tight snap roll will be more difficult to achieve; more of the aircraft's energy will be dissipated in the pitch to the vertical; and the radius of the pitch will be greater. It means that for this aircraft there will be less energy to project the vertical line once the vertical is established and it will be tougher to fly a tight sequence with sharp corners that establish the horizontal quickly.

If the aircraft C.G. falls aft of the Aerodynamic Center there is a negative pitching moment; the aircraft is negatively stable and will tend to go flat in a spin and stay flat. Locating the aircraft C.G. at the Aerodynamic Center is the configuration to aim for. One caution though, doing so is fine for competition but be careful when you load in the luggage aft of the pilot for the cross country to the contest. You may find yourself flying with a difficult to manage negative pitch stability.

Now before the aerodynamicist in the audience leaves New Balance prints all over these humble authors, this is a simplified evaluation as we have not taken into consideration the effect of the lift from the horizontal tailplane upon the final Aerodynamic Center point on the Mean Aerodynamic Chord. But suffice it to say, the 25-26% point of the aircraft's Mean Aerodynamic Chord is the best placement of the competition configuration C.G.

Now let's get down to cases. How do you figure where your aircraft's MAC is so you can calculate what percent of the MAC your C.G. is flying at during competition? Finding the MAC on a constant chord, straight wing monoplane like the Citabria or Decathlon is easy. The MAC, in this case, is the same as the actual wing chord, Figure 1, and is located halfway to each wing tip from the aircraft's centerline. To calculate the percent of the MAC that you're flying at, first, calculate the competition C.G. in inches aft of the datum. Subtract from this number the distance that the leading edge of the MAC lies from the datum. Divide the resultant number by the length of the MAC, multiply by 100 and you have the percentage of the MAC you're flying at in competition.

A swept wing aircraft of constant chord is measured the same way, see Figure 2. A taper wing type aircraft is slightly more difficult as seen in Figure 3. The biplane configuration requires you to find both upper and lower wing MAC leading edge points. Measure the distance between these two points; half of this is the point where the MAC representing both wings can be plotted and then compared to the aircraft competition C.G. This, of course, assumes that both wings have the same chord, as with the Pitts series aircraft.

Well, there you have it, you're ready to charge about the ramp spouting commentary about aircraft C.G. and MAC. As this is our first theory article, Worldclass Aerobatics, Inc. would like to announce that each month we hope to present a pure theory article such as this for education, discussion, and counterpoint development. We think the WHY can be as interesting as the HOW, and it will make all of us sharper enthusiasts, designers, and competitors.

BIPLANE CONFIGURATION (Pitts Type)
*Swept Upper Wing
*Straight Lower Wing
*Upper and Lower Wings With Equal Chord

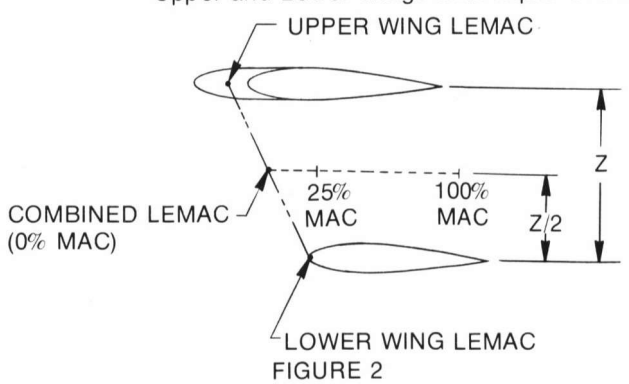
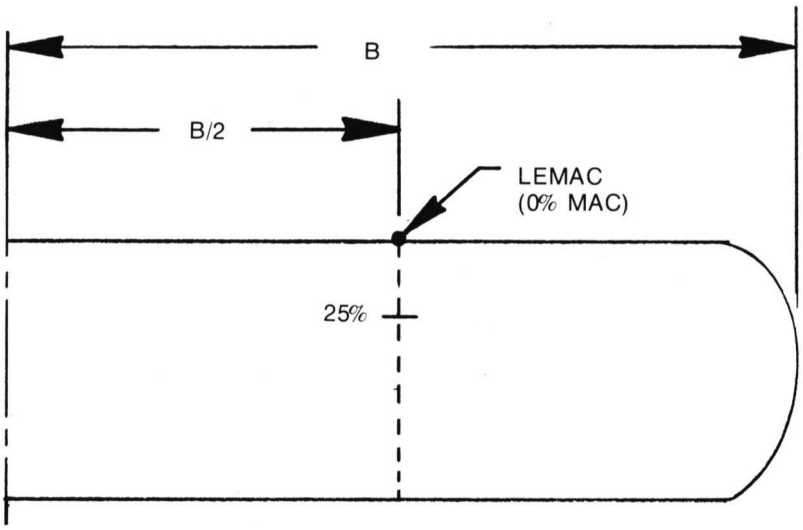
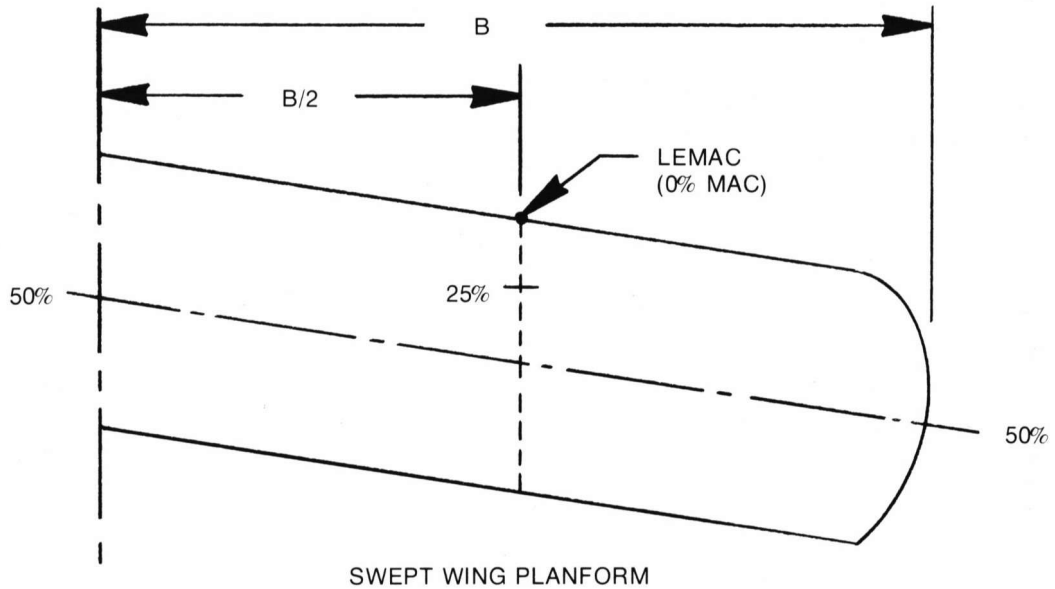


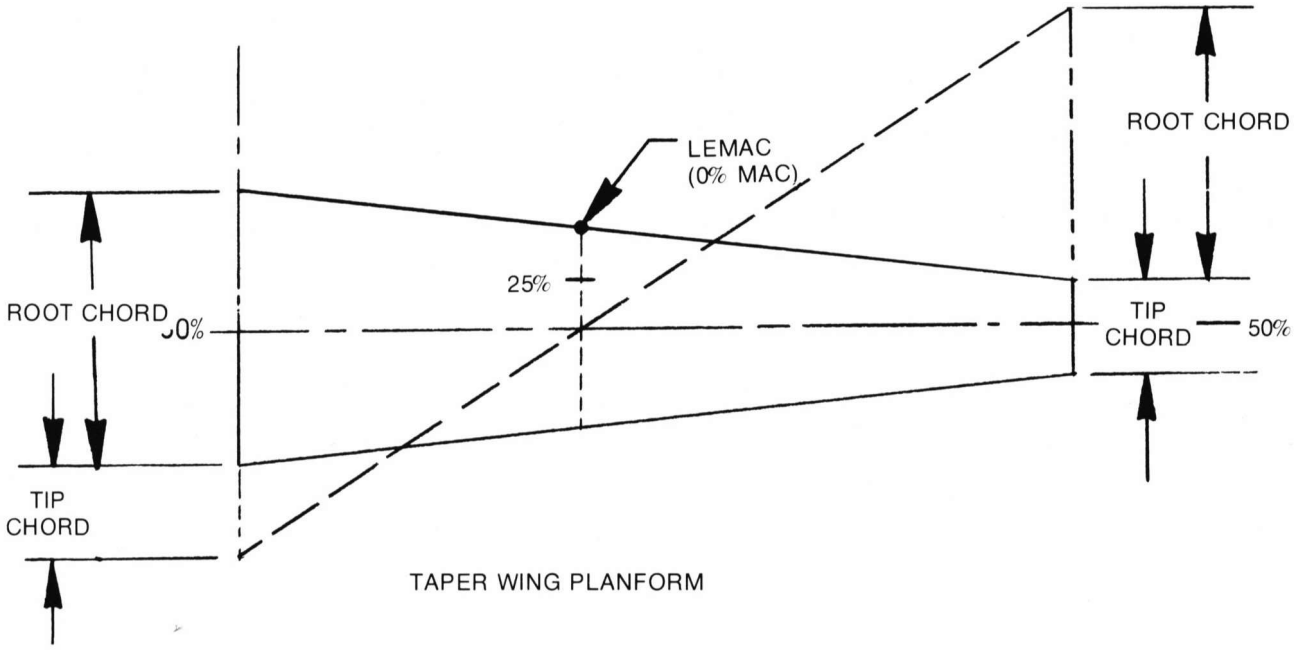
FIGURE 2



STRAIGHT WING PLANFORM



SWEPT WING PLANFORM



TAPER WING PLANFORM

FIGURE 3