Chapter 5: Intermediate Equipment | Contents | Chapter 7: Intermediate Flying

Chapter 6: Intermediate Trimming

Properly trimming an aircraft is critical to getting the most out of a sailplane. Former world champions have stated that trimming is second only to stick time in squeezing the last bit of performance out of your plane.

Trimming your plane is a continuous process. It is not something you do one afternoon, then casually dismiss. The dedicated pilot knows that his plane will never be completely trimmed. He makes minor adjustments on every flying session, always striving to get just a little more out of the aircraft. One may devote a day to launch settings, a day to landings, and another to windy weather. Though the plane will never be perfect for all conditions, these minor improvements quickly accumulate to give one pilot the competitive edge.

6.1 Center of Gravity

No subject draws heated opinions more quickly than the proper setting for a sailplane's center of gravity (CG). If you ever want to get bombarded by email, just drop a message on any of the RC soaring exchanges saying that you have the *one true solution* for setting the optimal CG on all planes. It's like setting a bomb off in a crowded airport.

6.1.1 What's all the fuss about?

The argument focuses on how narrow the *static margin* on your plane should be. Put most simply, the static margin is the difference in position between the center of gravity and center of lift on a plane. If the static margin is positive or stable, the center of gravity is forward of the center of lift. In this stable condition, the plane will, quite amazingly, continue to fall forward in the air and keep flying. Conversely, if the center of gravity is behind the center of lift with a negative static margin, the plane will be unstable. In the extreme, the plane will tend to fall tail first, be nearly uncontrollable, and stall constantly. Somewhere in the middle, just on the stable side of the so called *zero static margin* , the plane will perform optimally but still be controllable.

A plane with a large static margin is more stable and controllable. What's wrong with having the CG too far forward then? The extra stability comes at a price -- less performance. When the CG far forward of the center of lift (CL), the moment (CG-CL) is offset by the elevator. In essence, the elevator is trimmed slightly upwards to keep nose up and offset the moment caused by the CG forward of the CL. The elevator therefore creates drag, hurting the performance of the sailplane.

Perhaps equally important for thermal and slope soaring, the more stable plane reacts slower to external input. If a big static margin plane flies through a tiny thermal, the pilot on the ground may never know it. His plane is so rock steady it will take a huge thermal to wag its wings. Another plane flying through the same thermal with a small static margin may see his plane swing its wings or wag its tail. The second plane may hook the thermal that the first will completely miss. On the slope or speed run, the small static margin plane will react faster to control inputs, again providing for better overall performance.

Finally, the rearward trimmed plane may actually be several ounces lighter. While wing loading is not as big an issue as it was in the days of "floaters", the more lightly loaded plane will in general perform better than its heavy counterpart.

Before I'm accused of oversimplifying things, I need to note that hundreds of other factors come into play with CG. First, the center of lift on a wing changes with speed, so a plane can be stable at one speed and unstable at another. It also varies with angle of attack, ambient pressure, temperature, altitude, and a dozen other factors. Different models have different sweet spots because of hundreds of tiny choices made during design including size of control surfaces, tail arm length, and airfoil. Important, too, is the skill level of the pilot at the controls. Generally the more skilled pilot can fly a less stable plane. It would be difficult for an intermediate pilot to fly a truly zero static margin plane, for example. The CG must be set to match the skill level and personal taste of the pilot.

A quick survey of recent literature produces a broad range of opinions. Most experts report better performance with a rearward CG. "The Old Buzzard" Dave Thornberg recommends pushing the CG back, but maintaining some positive static margin in his *Old Buzzard's Soaring Book* . World Champion's Joe Wurts and Daryl Perkins both advocate a rearward CG, pushed to the limits of a pilot's ability. Others, including Martin Simmons (RCSD July 1992) advocate a stable setting. They point out that the drag created by the elevator is negligible compared to the overall drag of the plane. Further, they explain that the extra manual corrections needed to control a less stable plane probably create more drag than a comparable forward balanced plane.

Though the majority of *experts* advocate a rearward CG, few of us will ever develop the high level of skill needed to fully exploit *zero static margin* . Also, some planes will actually perform better with a forward CG than a rearward one. For example, my TG-3 foamie develops a very bad stall if the CG is too far to the rear. I keep the CG pretty close to the mid-spar position shown on the plans. Even some selected high performance planes actually do fly better with a somewhat forward CG. Setting of the CG, then, is a combination of plane, personal choice, and pilot skill. Along those lines, I will attempt to present several methods for setting the CG. Use these as a list of possible tools, since none are applicable for every possible situation.

> **Tip 25:** Setting the CG is largely a matter of personal preference.

6.1.2 Methods for Setting the CG

Having said only a small portion of what can be said regarding the theory of CG's, let us now move on to practical guidance for setting your CG.

Lets start with some basic assumptions. First, lets assume you have just finished your new *Worldbeater 1000* intermediate plane, and you want to set the CG. The manufacturer's recommended position is usually the center of the spar, and represents a good *safe bet* for the first few days of flying. I'm not suggesting you want your brand new plane to fly like a dog, but its very important to get some flying under your belt before you begin any serious trimming. One of the worst things you can do is try to set the CG the first time you fly your plane. Get at least 15-25 flights under your belt before you begin any serious CG trimming.

A Little at a Time

The first method I will outline is one I call *a little at a time* . This method is perhaps the safest and simplest way to get your CG in the correct position for your plane and skill level. The method consists of removing lead from the nose of your plane 1/4 of an ounce at a time until it becomes difficult to handle, then add a little back. The idea is to locate the CG to suit your individual skills and taste.

Start on a nice day, where it's not too windy or turbulent. The early morning or late evening calms are great times for trimming. On each flight, take the plane up and perform a few reasonably tight thermal turns at altitude at slow speed. Remove 1/4 oz of lead on each subsequent launch. You will probably need to dial in additional down trim as you remove the weight. Continue until you reach a state where the plane is becomes a little unstable or tends to tip stall in tight turns. Pay attention also to its slow speed handling and pitch characteristics. When the plane gets mushy, tip stalls a lot, or starts slow oscillated pitching you are probably getting near your ideal CG. When you get there, add a 1/4 oz to the nose and call it good.

This is not to say that your CG trimming is done. The next challenge is to fly the plane in less favorable turbulent conditions and see if it is indeed controllable. One sloppy stall in competition will cost more than an extra 1/2 oz of lead in the nose. Depending on your skill with the plane, you may need more weight for windy conditions. Similarly, as you accumulate more stick time on a particular plane, you may be able to push the CG forward or back again. By making the changes in very small increments, you may be able to find the sweet spot for your particular plane and skill level.

The Dive Test

The dive test is a controversial subject, primarily because it assumes that there is a *correct CG* for a given plane regardless of pilot skill. I've also heard that it does not work well for all planes, some designs favoring a more forward setting.

The Dive test was formally described by Frank Deis in a March 1992 RCSD article. The dive test's chief advantage is simplicity. Trim the plane for normal speed, level flight. Next, put the plane in a shallow dive then take your hands off the sticks. If the plane very gently pulls out of the dive, it is properly trimmed. If it pulls out rather sharply, it is nose heavy -- remove some weight. If the plane tucks under or sharpens the dive, additional nose weight is needed. Repeat the test until a very gentle dive recovery is observed.

There are many variations based on dive angle, recovery time, and so on. Several experienced fliers recommend examining the time between stalls. A 10 second time between dive initiation and recovery to a stall is good. Others recommend measuring time between subsequent stalls. Stall the plane gently, then without touching the controls measure the time between subsequent stalls. Approximately 10-15 seconds between stalls is considered by many to be a reasonably stable setting for a competition plane. Still other methods vary the dive angle. Some fliers advocate a steep dive (45 degrees or more) while others recommend a shallow dive. Airplane speed plays an important part. The center of lift moves rearward at high speed, so the plane may recover slowly or even tuck under or flutter at high speed. I recommend a fairly shallow dive over a steep one for thermal planes because these planes are rarely flown in the high-speed regime, and the test is safer overall.

Despite widespread criticism, and the many variables involved (plane, pilot skill, dive angle, trims), many pilots report that the dive test works for them. Others report that the dive test provides a great starting point for further trimming, perhaps later adding or removing a few 1/8th oz weights. I believe it is one more tool in the CG trimming toolbox.

Inverted Flight Test

A method used by some of the more advanced pilots in the business is the inverted flight test. I say advanced pilots because this method results in a CG that is very near the zero static margin point, and difficult for less skilled pilots to control. The inverted flight test was originally developed for trimming powered pattern planes.

The inverted flight test consists of trimming the plane for level flight, then inverting it. Roll or half-loop the plane onto its back and level it out inverted. A properly trimmed, zero-margin plane will maintain inverted flight with little or no down elevator pressure. Trimming using this method consists of removing weight until the plane will fly inverted with little or no elevator input.

Let me mention only one criticism of the inverted flight test. Many airfoils used in R/C soaring are either cambered or flat bottomed, and have very poor performance when inverted. Therefore it would be difficult to trim these airfoils to fly inverted without trimming a positive angle of attack. Another method for setting the CG might be more appropriate for flat-bottomed and highly cambered airfoils. The inverted flight test is most suitable for semi-symmetrical airfoils such as the RG-15 flown by advanced F3B pilots.

Chapter 5: Intermediate Equipment | Contents | Chapter 7: Intermediate Flying