GET THAT CG RIGHT

A first step in trimming free-flight models

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An Article published in the September 2006 issue of MaxFax, the journal of the DC Maxecuters, Stew Meyers, Editor

Here is a simple procedure I have found to be helpful when trimming a new free-flight model, either rubber scale or sport. It is a summary of part of an article that appeared in the August, 1982 Model Aviation magazine. It describes the important first step of finding a good combination of center of gravity (C.G. or balance point), and the wing and stab incidence angles. Only after getting a satisfactory C.G. and incidence setting is it safe to move on to power tests to find the best thrustline offsets for powered flight. Initial C.G. and incidence adjustments determine to a large extent how stable and well behaved the model will be under power and in the glide as you finalize your trim settings. To work, the steps must be followed in sequence. It will only take a few minutes, but in the long run can save a lot of time and minimize those annoying trim flight accidents.

Basically, we'll get the glide and C.G. adjusted first, and only then proceed to the power phase. The first trimming objective is to achieve a reasonable, but minimum amount of longitudinal (or pitch) stability. But wait a minute - isn't stability good? Can you have too much stability? Yup, you can. The reason we don't want too much stability is because it adds drag; but worse, it makes the model prone to zooming and stalling at high speed - like at launch! That means we would have added drag plus need huge amounts of downthrust to overcome the excess stability — not good. On the other hand, we do want some stability, of course, so our model will recover from gusts and other minor upsets. In general, the further forward the model's C.G. is, and the larger the angular difference between wing and stab, the greater the stability-and vice versa.(see Figure A). Luckily, we can easily trim our model to have enough, but not too much, longitudinal stability and simplify the whole trimming process to boot by just following the steps outlined below.

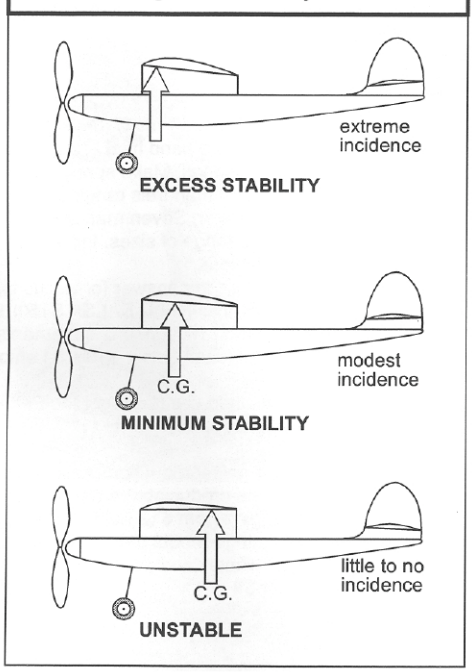


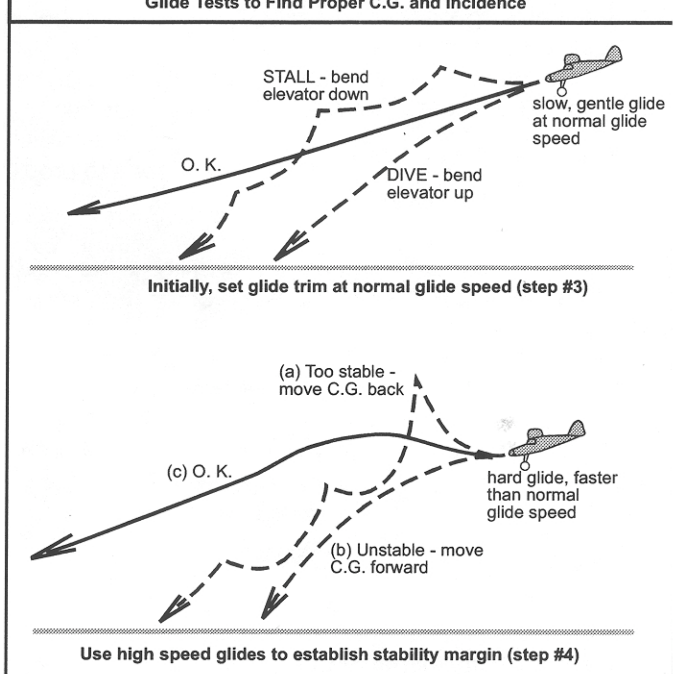
Figure A
C.G. , Incidence Difference, and Longitudinal Stability

1. Since each model tends to be unique, there is no simple formula to predetermine exactly the correct CG and wing/stab angular differences. Test gliding is the best way to find out; and besides, it's more fun than doing math anyhow. The idea here is to test glide our model to determine the combination of C.G. and wing and tail angular difference that provides satisfactory pitch stability. Make sure you have some means of accurately adjusting the angular difference between wing and stab. If you have an adjustable elevator, you can use that, but usually, the simplest and most common way to allow some stab angular adjustment is to tack glue either the leading or trailing edge of the stab to the fuselage, and allow for some shimming of the other, loose edge. When adjustment is complete, you can then cement the stab permanently in place if you wish. The very best method to provide for very accurate and repeatable adjustments is to make use of a small nylon machine screw (2-56 or 0-80 size) to change the stab angle. Moving the CG is most easily done by simply adding bits of clay to nose or tail.

2. First of all, make sure that all flying surfaces are straight and free of warps before testing. Use modeling clay if necessary to place the C.G. at a reasonable spot about one-third the distance between the wing's leading and trailing edge as a good starting point. Also as a first guess, approximately 1º to 3º angular difference between wing and stab should be OK. Keep the rubber motor in the model under tension so it doesn't flop around and change the C.G. during glide tests. If your model has a free-wheeling prop, it is best to remove the propeller and replace it with a piece of modeling clay of equal weight. The model's behavior, and the changes we want to observe will be easier to see without the drag of the propeller. For models with a folding prop, keep the prop attached.

3. Begin by gently gliding the model several times at normal gliding speed. Adjust the *stab (or elevator) angle only* until you get a nice, smooth descending glide. Several glides with each stab adjustment will be necessary to make sure you eventually have the best glide possible.

Figure B
Glide Tests to Find Proper C.G. and Incidence



4. Continue gliding the model while slowly increasing the speed of launch, until you are tossing it considerably harder than a normal launch; about twice as fast at least. The shape of the model's trajectory at these higher speeds indicates how stable the model is.

(a) If the model tends to zoom upward very sharply as launch speed increases, and then repeats the climb/dive path, it has excess stability.

(b If, on the other hand, it tends to tuck the nose under or dive toward the ground, it is unstable. The trim setting we are after is like path (c), when the model, after a fast launch, rises in a shallow climb and then glides smoothly to the ground as shown in Figure B.

Table 1 **Summary of process for finding suitable C.G. and incidence angular differences**

	Glide Result	Adjustment
INITIAL STEP Test glides at slow, normal flight speeds	Stalls	Bend elevator trailing edge down
	Dives	Bend elevator trailing edge up
	Smooth, good glide	Go to next step
NEXT STEP Harder, faster test glides	Zooms or tends to loop	Move C.G. rearward and repeat slow glides
	Model dives or nose tucks under	Move C.G. forward and repeat slow glides
	Model climbs slightly & glides smoothly	Finished; go to power tests

5. Here are the adjustments to make if your model followed path (a) or (b). If the model was too stable and zoomed upward sharply as in (a), move the C.G. about 1/8" to 1/4" *rearward* by adding some clay to the tail, and bend the stab trailing edge *down* a tweek. If the model was marginally stable as in (b) and did not climb at all or dove down during the fast launches, move the C.G. *forward* about 1/8" to 1/4" and bend the stab trailing edge *up* a tweek.

6. Now return to the slow, gentle glide test described in Step 3. and again fine tune the stab angle as necessary to get a smooth, good glide. Next, return to Step 4, and repeat the fast launch tests. Cycle through the process till you find the C.G. and incidence angles that results in a smooth, slow glide, and a slight climb and recovery during the faster launches as in path (c).

At this point you can safely assume your C.G. and incidence settings have been finalized. You can move on to power tests during which you only make appropriate thrust line adjustments to achieve a satisfactory climb pattern. No more cycling through repeated C.G. and incidence adjustments during power, then glide, then back to power, etc. Table 1 summarizes the process much more clearly than these words.

MORE ON TRIMMING FROM THE SAME MAXFAX ISSUE

The classical process of trimming a free flight is first to establish the glide. The center of gravity is set, according to the plan usually about the quarter chord point. The horizontal decalage is adjusted to achieve the desired glide with a gentle launch aimed at a point about twenty feet away. This is best done with the propeller removed and replaced with a dummy weight equal to it. Glides without the rubber motor will be slower and result in less damage in the case of poor trim. Warps especially asymmetrical wing washin or washout will show up here and should be corrected for a smooth straight ahead glide.

Once a smooth glide is achieved, the model should be thrown hard at the same point about twenty feet away.

The object here is to see how the model will recover from flight disturbances. You can then install a motor and prop, and move on to power trim.

Dave Aeronsten defines "trim" vs. "stability" rather well in the following article from an old issue of MaxFax when he was a local member.

Stability is the tendency of a system to return to an equilibrium condition. In the case of an airplane, that condition is the model's equilibrium angle of attack and flight speed. "Trim" refers to the specific value of that equilibrium angle of attack or flight speed. "Stability" refers to what happens when the model is perturbed from that equilibrium condition.

Now this is the hard part for most modelers: Stability is controlled entirely by the position of the center of gravity, relative to the model's flying surfaces. Incidence, or decalage, has NO EFFECT ON STABILITY. If your center of gravity is ahead of a certain point — called the "aerodynamic center" or "neutral point" — then your model will be stable. The farther forward the c.g. is, the more stable the model will be. However, it might not be properly trimmed.

Unlike stability, trim does depend on decalage as well as c.g. position. For any reasonable center of gravity, there is exactly one value of decalage angle that will give you proper trim. The farther forward the c.g. is, the more decalage will be needed to trim.

A couple of extreme examples to illustrate. If the c.g. is, say, well ahead of the wing leading edge, then the model will be very stable - it will want to dive, and it will quickly return to its diving condition even after a large disturbance. Is that stable? Yes. Is it desirable? No. Stable, but not properly trimmed for duration flying.

On the other hand, if the c.g. is behind the neutral point, you can still trim the airplane, using negative decalage (tail at higher angle of attack than wing), to trim at any desired flight speed. But, if it is perturbed, it will diverge. That means, if it is put into a shallow dive then the dive will become steeper; and if it is put at a higher angle, it will slow down practically to a stop and then execute a severe stall. This is the case of trimmed, but not stable.

If a model exhibits that kind of behavior — flies well until it is perturbed, then diverges - or shows tendencies to either stall or dive with the same set of adjustments - then you need to make it more stable by moving the c.g. forward. Then you will have to restore the proper trim by increasing the decalage.