



Trimming from the Ground Up

By Dean Pappas

Picking Up Where We Left Off: In the first installment of this “Trimming From the Ground Up” series we dealt with the subject of pitch trim. As it turns out, it’s a whole lot more than just moving the transmitter trim lever a few clicks or beeps until the model flies without climbing or diving.

Airplane trimming is similar to setting up a race car: even when a crew chief says the “race car was fast right out of the trailer,” he really means that the team was able to go through the entire list of setup checks quickly. That usually means few or no adjustments were necessary, but it doesn’t mean every little thing wasn’t checked anyway.

As it turns out, there aren’t all that many things to check when test-flying a new airplane, but if one of the tests described here shows a problem, you are working harder than you need to when flying your aircraft. If your model is intended for the all-important one of training mission, that’s a bad thing. If you are a more advanced flier, you are simply missing out on flying and looking better than you already do.

The mission of this series is to describe the tests and corrective actions, in a systematized way, to help you make your airplane fly better. None of it is any great effort, and you don’t have to attack it all at once. Your model’s pitch behavior can be investigated separately from something such as the unfortunate tendency the airplane has to turn left immediately after takeoff.



A good ground stance has the wing sitting at a small but positive angle of attack: somewhere between 0° and 3° positive.



A nose-down stance, like a bloodhound, forces the model to accelerate beyond the necessary airspeed for flight and then leap into the air, resulting in a steep climbout.



Nose-up stances cause two problems: overly sensitive steering caused by “wheelbarrowing” and premature liftoff, leading to departure stalls.

Engine Right Thrust: I’ve already written about the adjustment of downthrust, so now it’s time to discuss right thrust.

Some years ago I attended a Scale Masters Qualifier meet. The airplanes sure were beautiful; there just aren’t enough people who build like that! One of the competitors was flying a Cessna L-19 Bird Dog: a slow-flying, military, forward-air-control-type airplane. The same aircraft, in civilian livery, has been used as a trainer and glider tow airplane for decades.

We were taking off from right to left that day, and every one of the pilot’s takeoffs veered left, over the flightline—and the pits—and the parking area! Many of you have seen this one, right? No, left! It’s particularly tough for a student to deal with, and it’s a serious safety hazard as well. This is what happens when the right thrust is not correctly set up.

The full-scale pilots deal with this situation differently—emphasizing the proper application of right rudder to counteract “torque” on takeoff. Although that is an excellent skill to develop, the fix for most aeromodels is to put the proper amount of right thrust into the engine. This minimizes the rudder corrections that are necessary during takeoff.

This is important for the beginner pilot, who is still learning to take off. Should we let the beginner give everyone in the pits a haircut until he or she learns to use his or her rudder hand simultaneously and independently of the right hand? I think not. Actually most model-airplane fliers never really master accurate and independent control with their rudder hand, but it is a worthy goal.

Before I describe how to put right thrust into the model and how to test for whether or not the airplane has the correct amount of right thrust, I need to discuss the nature of the right-thrust trimming adjustment. Right thrust is a compromise because it is used to counteract an airspeed-dependent problem. As it turns out, it is usually a good compromise.

The Application: At low and part throttle the effect of right thrust is minimal. Here’s where the compromise comes in. We set the right thrust to straighten out a full-power takeoff climb and accept the small, unwanted influence it has at cruise.

In the glide the right thrust has practically no effect, so it’s no problem. Assuming that the airplane is trimmed to glide in a straight line in calm air, the job of right thrust is to preserve that straight flight path under full power.

That’s all there is to it. Typically, the right-thrust adjustment determines how straight the airplane climbs after takeoff. Good landing-gear setup will reduce the steering workload until the student gets a model in the air. The landing-gear discussion comes later.

Let’s adjust the right thrust. As you read a bit ago, the requirement is for the model to go straight in the glide with the engine idling and at full throttle in a takeoff climb. For now let’s assume the airplane glides without turning since it was trimmed for straight and level flight at cruise power. (In the next installment we will discuss making the model fly straight at all

airspeeds.)

What we really need to do is adjust the engine right thrust so it adds the right amount of correction for “engine torque” during climb. Engine torque makes the airplane turn left. The word “torque” is a misnomer, but it is a convenient catchall.

The Right-Thrust Test: To start with, let’s make sure the model is trimmed to fly nice and straight at cruise power. Next, I like to set the airplane up so it is pointed straight away from me and headed either directly into the wind or directly downwind. You don’t want to do this lined up with a crosswind because the sideward wind drift hides the turn for which you are looking.

Now that you are lined up, add full throttle and smoothly pull up into a climb, at the same angle as your steepest post-takeoff climb. We typically climb into the wind, but doing this downwind also works, and it allows you to pick the direction so you don’t have to fly over the pits or the safety line at the field.

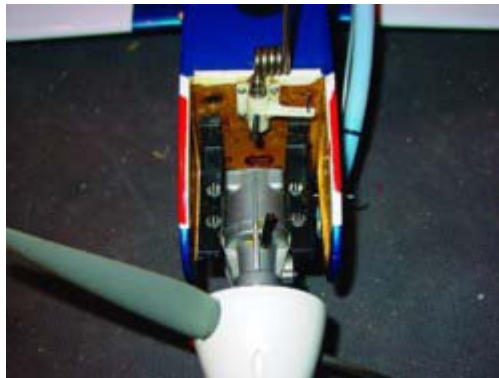
You don’t want to climb so steeply that the model is stalling, but you do want to climb as steeply as your horsepower will permit. The airplane will lose airspeed during the climb, and it may become more easily influenced as the flying surfaces lose some of their control power. In all likelihood the model will start to turn.

If the airplane deviates to the left, you will have to add more right thrust. On the next flight retrim for straight and level flight (probably just a click of rudder) and repeat the test until the model climbs straight.

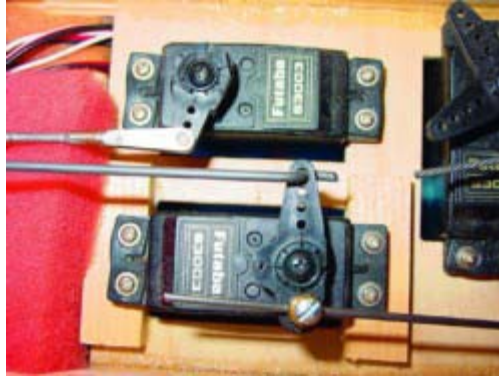
If the airplane has too much right-thrust, it will deviate to the right in the climb. That doesn’t happen often.

If the right thrust is close to correct, and if there is enough wind to make the model bounce around, you may have to repeat the test a couple times to be sure of which direction the airplane is turning. That usually means you are getting close.

It is best to adjust the right-thrust angle one degree at a time and repeat the process. Most airplanes have, or at least need, 2°-3° of right-thrust, although a rare few need much more.



The proper ratio between rudder throw and nose-wheel throw is usually had when the rudder pushrod is connected to the outside of the rudder-servo wheel/arm and the nose-gear pushrod is connected to the innermost hole on the servo wheel (above) and the outermost hole of the nose-gear arm (below).



Right-Thrust Measurement: The easiest way I have found to determine the right-thrust angle is to measure the distance from each propeller tip to the tail post. With a 12-inch propeller the difference between the two measurements will be 3/16 inch for every degree of right-thrust. Three degrees of right-thrust works out to 9/16 inch difference between the two measurements from the tail post. With a 16-inch propeller this ratio works out to 1/4 inch per degree.

You might have to readjust the right thrust a time or two, but if you start with it adjusted as the kit recommends, you should have to make only a fine adjustment or two. Many kits and ARFs may not make how much right thrust is recommended entirely clear, but if you can't find anything on the plans or in the instructions, start with 21/2° or so.

Landing Gear: An airplane that rolls straight and responds predictably to steering input, especially on takeoff, will be easier to fly. If you want to look like a hero at the flying field, die-straight takeoffs and smooth landings that roll to a straight stop will help.

On the other hand, if you really crave attention, zigzagging across the runway will have everyone watching you—as they run for cover! That's not how you want to be noticed, so we will devote some attention to describing good landing-gear setup. Most trainers are designed with tricycle landing gear, so I will cover models with that kind first, followed by tail-draggers.

A few problems can afflict a tricycle-gear airplane. The most common is the use of a nose-wheel steering linkage that has way too much throw.

The model does not need to be able to turn within its own wingspan; the minimum turning radius should be roughly 15 feet with full rudder control applied. That probably works out to only 5° of turn at the nose wheel.

This is accomplished by connecting the linkage to the innermost hole of the servo arm and the outermost hole on the nose-strut steering arm. It is sometimes helpful to drill a new hole in the servo arm that is as close as possible to the center post. Too much steering throw not only makes it difficult to steer straight at speed, but it can overload the rudder servo and prematurely age or damage it.

The next problem is an overly flexible steering linkage. You need positive control, and a springy linkage does not offer that. If the steering linkage has too much give in it, the nose-wheel may even twist sideways at touchdown (impact?). This makes the airplane “curtsy” in the middle of the runway and can even tear out the firewall if repeated often enough.

Some fliers will tell you that a springy linkage can save the servo, but the best way to do that is to give the servo maximum mechanical advantage, as described in the preceding. As for the linkage itself, whether you prefer a wire in a plastic tube or flexible cable, the linkage should be as straight as possible.

I prefer a 0.050-inch-diameter wire in a plastic tube, provided the run from servo to steering arm is almost straight. Sharp bends are a no-no, and any binding that causes the steering to center inconsistently must be avoided. It also helps to move the nose-wheel steering arm up as high as practical, while avoiding interference with the fuel tank.

The next problem has to do with that nose-wheel twisting tendency. If, when you look from the front, the contact patch of the tire is not directly in line with the axis of steering rotation, every bump in the runway will try to twist the nose wheel to one side. This really eats servos. This problem is only worsened by a flexible steering linkage.

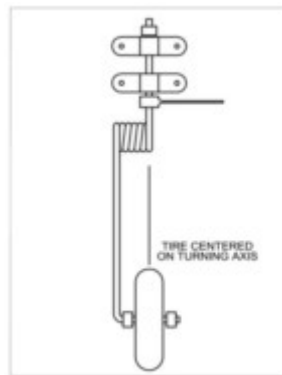
Attitude Adjustment: The nose-high or nose-down attitude of the airplane on the ground has a strong effect on how much up-elevator control is necessary to perform the liftoff.

A nose-down attitude forces the model to accelerate for longer on the runway, until the airspeed is greater and the elevator control becomes powerful enough to lift the nose. This is bad because it leads to a sudden leap into the air as the full up-elevator finally takes hold. What almost always follows is a too-steep climb and a loss of airspeed and control.

A nose-up stance causes bouncing on landing when the nose wheel touches down first. On takeoff the nose-high stance can lead to “wheelbarrowing” at high speed.

Did you ever try to make a gentle turn while running with a fully laden wheelbarrow? It tried to tip, didn't it? The same is true with a tricycle-gear airplane if it is running up on only the nose wheel.

The ideal attitude is with the wing chord line (or flat bottom) within a few degrees of level with the ground. A well-set-up trainer will lift off with just a tiny touch of up-elevator when the airspeed is right. For trainers with flat-bottomed wings, this stance will lift off by itself when the airplane is going fast enough.



If the tire contact patch is not directly in line with the axis of steering rotation, the impact of landing will try to twist the nose-wheel sideways.

The last tricycle-gear problem is the fore and aft location of the main gear. If the main gear is placed too far aft, the airplane has a great deal of weight on the nose wheel. This also makes the high-speed steering more sensitive and requires lots of up-elevator input to break ground. Try pushing down on the stabilizer to lift the nose wheel, to get a feel for how much force the up-elevator control has to make.

Again, this can lead to an overly steep departure after an excessively long takeoff roll. It also causes the airplane to “slap” onto the ground during landing; that can add to the wear and tear on the nose gear.

The ideal location for the main gear makes the nose wheel very light when the fuel tank is empty. Either bend or shim the main gear so that the wheels move forward. The model should almost sit on its tail when the tank is empty.

There is one problem that afflicts tail-draggers and tricycle-gear models: overly springy landing gear. Sometimes the kit comes with wire landing gear that is too springy for the airplane's weight. That can make bounce-free landings difficult; anything less than a grease job is turned into a roller-coaster ride.

The solutions to this problem range from wire and rubber-band reinforcements to replacing the gear with a beefier aluminum unit.

So Why Are You Dragging Your Tail Around? Tail-draggers have different versions of the same problems as tricycle-gear airplanes, with one interesting difference: the fore-and-aft location of the main gear.

If the main gear is mounted too far aft, the airplane tends to nose-over easily. That's

embarrassing at the very least.

What is not as often appreciated is that if the mains are mounted too far forward, you get that high-speed wheelbarrow problem I previously discussed. The airplane will be difficult to keep straight at high speed just before liftoff.

The “ideal” location is just far enough forward to not nose-over easily. It’s that simple.

This means that if your home field is paved, you will be setting up your landing gear farther aft than someone who calls a grass field home. Since most aluminum landing gear are made with a small amount of rake, or angle, you can move the wheels a half inch or so just by turning the gear around. You can also change the wheel position with tapered shims between the landing gear and fuselage.

Toe-in and camber adjustments are interesting, but they are secondary to the position of the main gear itself. Keep the wheels lined up straight, and you’ll do fine.

Tail-wheel linkages are simpler than nose wheels. Too much control throw is rarely a problem, but sloppy or overly springy connections to the rudder can make precise corrections on takeoff almost impossible. You want just enough give to act as a servo saver.

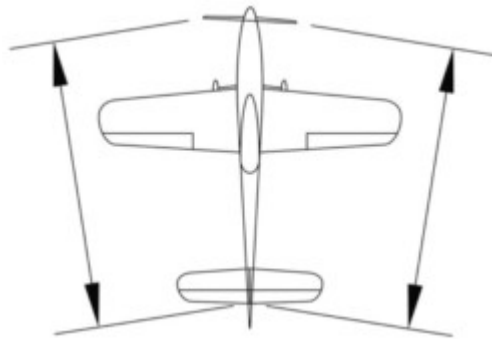
The other trick that helps save servos is to put less caster in the tail-wheel assembly. Although it looks “real” to have the wire tail-wheel strut bent way back, it also strengthens the mechanical advantage of any sideward landing impact to rip the guts out of the rudder servo, beat up the bottom rudder hinge, and mangle the rudder pushrod or cables.

A short, nearly vertical strut with a small spring coil works well. For airplanes weighing 5-10 pounds, a 3/32-inch-diameter-music-wire 1/2A nose-wheel strut works beautifully.

If you still find it difficult to keep the airplane straight on takeoff because of overcontrol, the tail-wheel throw needs to be reduced. This is actually easy to do. For those of you using the “two springs”-type steering linkage, all you need to do is hook up to the inner end of the rudder horns and the outer end of the tail-wheel horns.

If you used the “tiller arm”-type linkage, where a single piece of wire runs along the bottom of the rudder and is attached with some kind of clip, it’s a bit tougher to do this unless you are still assembling the airplane; then it is easy.

All you need to do is move the tail-wheel pivot forward and find a location for the clip on the bottom of the rudder where the steering throw is reduced. This is simple and offers positive steering control.



The simplest way to measure the right-thrust angle is to measure the distance from the propeller tip to the tail post on both sides. Either use that trigonometry you forgot or remember that with a 12-inch propeller, 3/16-inch difference equals 1°.

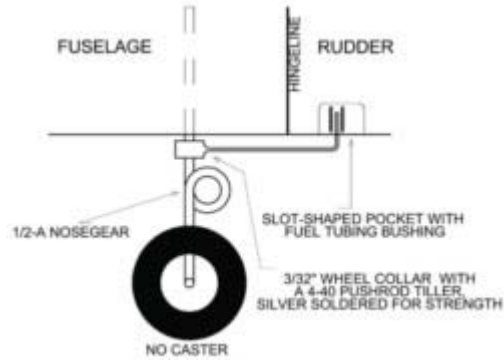
Takeoff, Climbout, and the CG: Let’s cover what happens on takeoff when the airplane is nose-heavy. A severely nose-heavy model will require lots of up-elevator to lift the nose wheel and break ground. The problem could also be landing-gear position, the ground stance, or the CG.

The last two are easy to eliminate, but you need the information you gathered in the air to tell whether to move the landing gear or not. If the CG is in the right spot, holding a constant climb angle is easier. If the airplane is nose-heavy, you will find yourself needing a quick elevator adjustment a split second after liftoff.

Let’s look at the other, more urgent side of the problem. On takeoff, tail-heaviness often

shows itself as climbouts that quickly become too steep, even when they did not start out that way. If you find yourself chasing the elevator in a pilot-induced oscillation (PIO), you've probably got a tail-heavy airplane.

Tail-heavy airplanes tend to snap roll too, and that is usually how they get turned back into their component parts. Try moving the CG forward temporarily, and see if it's easier to fly a smooth departure climb.



This tail-wheel assembly has no caster so that side loads can apply no twist to the rudder. The pivot location, ahead of the rudder hinge line, and the connection of the tiller a short distance behind it reduce the tail-wheel throw to roughly half the rudder throw.

Pitch Trim Revisited: Now that the airplane is departing nicely, it is time for Part 2 of the "From the Ground Up" series on basic trim to depart as well. I'll land back here next month and wrap things up.

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