Sam's Trimming Guide for Challenging Aircraft

The purpose of this guide is to help folks that might be intimidated by trying a low wing airplane. I'm not sure why low wing airplanes have such a mystique that they're difficult to trim, but I must admit, at this point, I don't think twice about whether an airplane has a high wing or a low wing if it's something I want to build.

This guide has been inspired by a few sources that come to mind. Believe it or not, a lot of my FF trimming comes from reading Dean Pappas's FM column on RC aerobatics from years ago- those guys know how to trim an airplane! I think I've probably got some of George Perryman's ideas kicking around too. Good flying buddy Rich Zapf taught me a lot flying indoors, and Tom Nallen's pointers are always welcome. Some of this guide goes back to what are deceptively simple- chuck gliders- and for that, I owe Ed Cattey thanks.

I've been around long enough so I occasionally get asked to help trim an airplane that's reluctant to commit aviation reliably. What's dawned on me is that I've developed a process over the years to help hone in where the problem lies. I have to warn you- this is going to seem intimidating for a raw beginner. If you haven't got a lot of models under your belt, then John Koptonak's 10 Step trimming guide is a pretty good place to start. This guide is for folks who might not be happy with the results of other approaches.

Let's begin with the three phases of flight that our rubber powered craft must go through: climb, cruise, and glide. Let's also go through what are the adjustments that we can do to our models to deal with these various phases: washout (tip), washin/washout (middle of the wing), decalage, rudder, thrustline, and weight. What are the design choices that we also have some control over? Prop, rubber, horizontal stabilizer size, vertical stabilizer size, and dihedral.

For the purposes of trimming in this article though, we're going to restrict the discussion to what we can fix on the field or with a teakettle at home. The first thing that you need to realize is that the various adjustments we do affect differing aspects of the flight regime. Some are pretty obvious, such as you wouldn't need to adjust the thrustline to affect the glide. But the interplay between rudder and thrustline can get pretty challenging, so what I'm going to lay out here is what to look for in a flight pattern and how to improve it. As such, there really aren't a fixed number of steps in this process- it's more of a troubleshooting guide.

Table 1: Adjustment versus Phase of Flight

Adjustment	Glide	Cruise	Climb	Fixes
Washout (tip)	moderate	moderate	strong	Keeps the stall straight ahead
Washin/Washout (middle)	strong	moderate	weak	Prevents the turn from tightening
Decalage	strong	strong	strong	In conjunction with CG, controls the stall. Also controls the climb.
Rudder	weak	moderate	strong	Too much rudder induces a spiral, too little and you walk a very long time.
Thrustline	zero	limited	Strong (few seconds after launch)	Only effective when the airplane has not reached full speed- then rudder and decalage take over.
Weight	strong	moderate	weak	Used to tweak the glide.

Let's go through the adjustments and what they do:

<u>Washout (tip):</u> When someone comes to me with an airplane that they say flies "squirrely", 9 times out of 10, the airplane lacks washout. All airplanes benefit from washout. At the 2022 FAC Nats, I had a nice conversation with Thayer Syme who passed along a discussion he had with some Grumman aerospace engineers.

Their comment was that all full scale aircraft- even with Hershey Bar wings, have washout. Why? Think about the airflow over the wing. Near the root, the flow is parallel to the fuselage, but as you get near the tip, the air begins to flow towards the tip- it's no longer parallel with the fuselage. Since we want the tip to stall last, we need to decrease the angle of attack of the tip relative to the root. Hence, all FF models need washout. Some high wing weenie planes may get away without it, but for a low wing scale ship, it's a really good idea. Elliptical wings have this issue in spades- so Spitfires need LOTS of washout. I've got some photos of my Thunderbolt which needed a fair amount. It's an airplane that has been a bit of a challenge to trim, but who needs another trimming guide based on a Piper Cub? (Actually, another airplane that needs washout with that high aspect ratio wing…)

Look for the "smile in the trailing edge of the port wing- but a straight line in the starboard wing.

The “smile is a bit hard to see in the second shot, but you can clearly see the amount of washout I used to get this airplane to be stable.

Some airplanes with a low enough wing loading will get away without washout- but add more rubber, and you may find that the “gentle” airplane bites you. This issue can be most pronounced in the high power, climbing phase of flight. If you see an airplane climb out, and then wingover back to the ground- odds are what happened was a high speed stall. The lack of washout meant that the airplane did not stall straight ahead- a very desirable characteristic at all times.

Washout/Washin (middle): One of the reasons that I say that building straight is over rated is that most of my low wing airplanes have something of a "smile" in the trailing edge of the port wing. While I'll generally shoot for a straight line trailing edge of the starboard wing-angled to have some washout of course, the port wing often has washin in the middle of the wing along with washout at the tip. The result looks like a smile. Some folks like Gurney flaps- and that can work instead of washin- I've just used washin more often than Gurney flaps. Gurney flaps look very draggy to me but YMMV.

Why is this smile needed? Well, if the airplane has left rudder in it, it's going to want to turn left. As an aside: flying indoors, most of the guys I fly with turn left. Because head on collisions are spectacularly destructive, it's better to turn the same direction as everybody else. Hence, most of my outdoor airplanes turn left too. Airplanes don't know that they're in a turn, and so when you use rudder-which gets more effective the faster the airplane goes- there's a horrible tendency for airplanes to spiral in to the left. From flying indoors, I really like flat skidding turns and I like to see wings level during all phases of flight. Only happens indoors, but you must have some way of keeping the airplane from tightening the left turn induced by the rudder. This is where the washin in the port wing comes in; it counteracts the rudder. If you've flown full scale or even RC, you'll know that when you put the airplane in a banked turn, you need some opposite aileron to prevent the turn from steepening. Well, washin is our opposite aileron. Why not just washin- no washout? Because the airplane is liable to spin in if you don't have it- so you want washout in both tips. Even high wing airplanes will spin in- I had a Rearwin Speedster that flew beautifully until it ran out of turns high up- and spun in.

Decalage: from flying RC, I don't get too hung up on a "perfect" cg. I want a decent cg range because our rubber motors don't necessarily unwind reproducibly. Sometimes you get more knots in the nose and sometimes you get more knots in the tail. The airplane has to be able to cope with both of these conditions, so I want enough positive stability so that the airplane isn't so finicky. What this translates to in decalage is that more decalage increases positive stability, but also drag. Less decalage moves the airplane to neutral stability (goes where you point it- good for RC aerobatics, not so good for FF) but also increasing efficiency. If an airplane stalls and then just continues into the ground- odds are you need more decalage. If the airplane tucks- you definitely want more decalage. (There's an exception here I haven't figure out- some biplanes tuck unpredictably. Haven't figure out why yet.)

If the airplane stalls, but recovers quickly- you've got enough decalage- but you might be able to get rid of some and increase your duration. If the airplane is zooming and needing lots of downthrust on launch- odds are you have too much decalage. The trick is to figure out how little you can get away with and still have a reasonable recovery from a stall. Let me be clear: if an airplane that has a decent glide and begins to get "stally" in the cruise phase, odds are it's not a thrustline issue, but a decalage issue. Only worry about thrustline if it's in the climb phase.

Rudder: Rudder is a high speed surface. When the airplane is flying fast- rudder is most effective, as the airplane slows down, rudder effectiveness falls off. This is why the smile trick works; as the airplane slows down, the washin becomes more effective than the rudder. This will occasionally manifest itself in an airplane that starts turning right in the glide. As long as it doesn't get too sharp, I live with it.
The interplay between rudder and thrustline is tricky. Thrustline only really matters in the couple of seconds after launch. When the airplane is up to speed, both rudder and decalage take over.

Thrustline: we've all heard that once you have a good glide- just use the thrustline for adjustment. Well, there are airplanes where you run out of thrustline adjustment and then you have to retrim the other phases of flight. My suggestion is to only use thrustline for the first couple of seconds of flight and after that- start using the flying surfaces. It is a bit of an art to tell when thrustline adjustment ends and flying surfaces dominate. My guess is that practice will help- as well as a good flying buddy to provide a second set of eyes. One issue you have to be careful of is that if an airplane starts needing more than a few degrees of either down thrust or right thrust, odds are you've got another challenge that needs to be solved. If an airplane goes up too steeply, odds are you've got too much decalage. If the airplane climbs and then curves downward to the left, odds are you've got too much rudder. Only if an airplane burns into the right upon launch have you got too much right thrust. If the airplane only starts climbing after you burn off some turns- you've got too much downthrust.

Weight: yes, I left weight for last because it really only strongly affects the glide- assuming you're sort of in the ballpark. Wildly out of balance airplanes under power generally do something spectacular! You can use weight in two ways- to address a cg issue or to address a turn issue in the glide. Again, I know I'm going to sound like a heretic, but I just want an approximate cg when I start powered flight testing. I may be "borrowing" this idea from Gawgeous Gawge Perryman. He suggested the "magic" 35 winder cranks for the first

powered flights which often works pretty well if you're anywhere close on power setup. The thrustline and decalage will largely control the first part of the powered flight. What I look for is if an airplane begins to stall as the power winds down-that's a cg issue. If the stalls get progressively steeper then the airplane definitely needs noseweight. But if the airplane doesn't climb with lots of power, odds are you may need more decalage.

I don't like adding weight to an airplane, so I'm reluctant to add weight to a wingtip, but if I can't figure out how to stop an airplane from spiraling in during the glide phase- I'll do it. What's beginning to dawn on me by the way, is the need for tip weight is generally driven by an inadequate vertical stabilizer.

This is a pretty good transition point to the issue of design flaws and how to recognize them. Some airplanes will not fly consistently. They'll burn in to the left one time, and burn in to the right the next time. What this means is that the airplane really doesn't have sufficient yaw stability and you'll go nuts trying to trim around a fundamental design flaw of inadequate vertical or horizontal tail volume. You do have to make sure that you haven't got something like a broken wing though! More subtle issues can surface- an airplane that's normally well behaved in calm conditions, has a propensity to spin in – literally! when bounced around. I think I rebuilt the starboard wing on my Thunderbolt at least three times till Rich Zapf told me to enlarge the stab. The airplane flew well when it was calm, but in a little turbulence- would spin in and I'd rebuild. Turns out that given the prop I'm using- I needed to enlarge the fin/rudder as well, which seems to have cured the problem that the airplane in a glide would tighten into a spiral. At Geneseo, the airplane was competitive in the WWII event for the first two rounds even spiraling in at the end, (I added the plastic tab after Nationals of course…) but in the final round, a broken rudder let the airplane spiral in to the right not long after launch.The design flaw is that the cg range is simply too narrow with the tail surfaces shown on the plan and when the airplane runs into turbulence, it can't recover. The solution is larger tail surfaces or stretching the fuselage- or if really desperate- a smaller prop.

Some folks can make airplanes fly with potato chip tail surfaces. I am not one of them. I strongly recommend making sure that potato chips stay out of your stomach and off your airplane! Feed them to political candidates you don't like… Trying to predict the flight pattern of an airplane with a potato chip stab or rudder is an exercise in futility as far as I'm concerned and every time I've rebuilt a potato chip surface and the airplane all of a sudden straightens up and flies right- I think to myself- why did I wait so long?

I haven't really dealt with lack of dihedral in most of my airplanes. I tend to use what I can as while the full scale airplane may not have had dihedral, it had an automatic wing leveling device aka pilot, that our models don't have. I did build a Devastator that lacked dihedral- I got lucky with one flight and broke 20 seconds and then hung the airplane up. It was just too unpredictable otherwise. I learned from that airplane to give up on the idea of scale dihedral or lack thereof. We can't get around the physics of needing to have enough positive stability. I guess biplanes can use curtains- haven't gone that route.

Anyhow, I hope you find this troubleshooting guide helpful.My goal is to help provide a bit more science to the art of trimming a FF airplane…