Triangulation Trimming

By Bryan Hebert

Background

In the world of precision competitive flying we are faced with a couple of challenges. First, a reliable set up: whether it be propulsion selection or airframe selection, what we choose to use can make or break us in the heat of competition. We go through enormous amounts of effort to build, install equipment, arrange our schedules to practice, and generally dot every I and cross every T to get ready for the local events and even the Nationals.

We pride ourselves as being the pros at the local clubs when it comes to engine setting, servo selection, and being up to date on all the latest gadgets available for our models. In general, we make great strides to be on top of the hobby except for one area: trimming.

While we are better than most of the sport fliers, some of us lack the devotion to follow the rabbit completely down the hole, so to speak. With our high end radio equipment we have become spoiled with the technology and allowed ourselves to get trapped into quick fixes so we can spend more time flying the sequences – not entirely a bad plan. Some of the top fliers just amaze me with their ability to fly a poorly trimmed model. I have learned a lot working with some of the top fliers in the world today. Anything is possible and there is always more than one way to reach the end goal.

What I will try to do is teach you how to get the most reliable results from your setup no matter what design you are flying. So bear with my rambling at times, and I will do my best to fill you in on what I have learned in the last twenty plus years designing and trimming top shelf pattern designs.

Right now there are so many airplanes to choose, from garage operations to the Naruki ten-thousand-dollar-a-copy machines in Japan. The bottom line is there really is no poor design out there in the “main stream” of pattern. I’m not talking about the pattern look-a-like hobby shop sellers, “it flies just like a pattern plane” types. I’ll stay away from these in this series of articles because there are too many variables. However, the same trim rules apply to these as well. To quote an old friend, Paul Verger, “You may not turn that frog into a Prince but you might make him a Duke.” Keep this in mind for the entry-level airplanes as they are not quite as refined as the top choices out there, but some can be helped with a little TLC and trimming.

Using our modern radios we have learned to satisfy the judges with condition switches for snaps or spins and have convinced ourselves this is the only way it can be done. It’s even crept into the rules and downgrades for the maneuver descriptions. With the conditions switches we can manufacture a fake spin or snap through manipulation of the stick and slight of hand to display

what is accepted as a perfect maneuver instead of trimming the airplane to perform the maneuver without being a Houdini.

Am I against condition switches? No! I do believe they are a great tool, but I hope I can share some insight as to how to get a more consistent result without the need for so much programming by making the airplane as perfect as you can get before we resort to flipping switches.

First I want to start out by saying the number one rule in trim perfection is SET UP SET UP SET UP! I hope I get my point across. The closer you start to perfection the better the outcome. With this in mind, I'm amazed at how many guys don't know what their throws are in degrees or measurements of any kind. This is a must in order to know how to improve or refine your setup in the trimming process, and to record and be able to transfer this information from one airplane to another. I would like to briefly go over my trim method. I call it the Triangulation Trimming Method, because I use three flight angles for feedback to let the airplane tell me what to do. I have refined what I call a "Plus Plus" set up. The wing and the stab are both set positive to the centerline or the desired flight angle that the designer had in mind when he drew the fuse on the plans. This set up goes against the grain of the old accepted way of trimming so my set up rules will not transfer to what I will call the "Zero Zero" method of trimming that came around in the nineteen seventies when guys started experimenting with more streamlined designs – more on this progression later.

Most of the new designs out there have come about from the top FAI pilots so airframes are designed around the hardest schedules in the F3A aresti catalogue. The last few rules cycles have raised the bar for what is expected out of a modern airframe. Who would have thought that a top airframe would have about a three year life span because of constantly evolving technology, building techniques, and schedules? This is all the more reason to get the most out of the airplane for your best competitive results. We just don't get to know our airplanes very well anymore before we have to buy the latest airframe on the market. I can remember some of the old designs staying strong on the market for at least ten years in the eighties; that's not the case anymore. Because our modern airplanes are expected to be able to perform maneuvers we would have only dreamed about just five years ago, the demand for a perfect airframe has gone up exponentially. However, our trimming skills have stayed the same.

Now, I'm going to let you in on a big secret. There are no bad designs out there. There are designs better than the others, but they all have some good points. For the most part we are just bad trimmers. The people who consistently do well are those that have learned how to set their airplanes up for the most durable usage and consistent performance.

Let's Review Some Pattern Design Heritage…

In the old days of retracts we were mostly interested in going as fast as we could for the ease in manipulation of the controls. The less we moved the sticks the less mix was required. To do this,

we installed retracts and had what amounted to pencil like fuselages to keep the drag down. The “Zero Zero” set up was in full swing. The schedules were not very demanding and the only maneuver we had to really worry about, as far as mixing was concerned, was the 4 point roll and a reverse knife edge every once in a while. So, the need for mixing was kept to a minimum because the maneuver demand was not very high or complicated.

Now fast forward this about ten years and Christophe spanked every one at the World Championships with a new airplane and flying style using the more powerful YS Motors. It was throttle management! I can remember a former F3A team member, Bill Cunningham, coming back from the World Championships and telling me, “this kid, Christophe, is the future and I’m not sure he can ever be beat. His style is light years ahead of the rest of the world with this slow and deliberate style of flying.” He set the bar that we still strive for today.

At the same time Dean Koger, Ron Chidgy, and a few others like myself decided to slow an airplane down. We knew we were going to have to build some drag into the airplanes and increase the wing size. Hence, 1150 square inch wings and fixed gear came about. There was only one problem. F3A started using down line and up line snaps, which really made this style of airplane hard to fly. The snaps and reverse spins were especially difficult, because the wings were so hard to stall or keep stalled during the snaps or spins. We all started reducing the wing size, eventually getting down to the 900 or 950 area and even larger fuses for transitional lift. We also needed longer fixed gear for the giant power plants. We now use 22 plus inch props. All this added drag and we became quite happy with ourselves, however there is a down side.

Let me explain briefly. No drag is good, it robs the airplane of efficiency. If the drag does not produce lift, it is a detriment. That’s why you see some taking the gear legs and making them lifting devices. However, our cool user-friendly landing gear is responsible for most of our trimming issues we have today. Remember, we went from 1150 to 950 squares. In essence, we reduced lift and increased drag so as to compensate. A smaller wing produces less lift, therefore requiring more down force (up elevator trim) at the horizontal stab to stay level at the same CG. To make up for this, we started moving our CGs rearward for a more comfortable inverted feel. With these few changes, we increased our workload trimming and setting up an airplane that’s happy through the whole flight envelope.

Here Are The Problems We Encounter…

First, with the CG moved rearward, (it’s usually around 35% of the MAC) it makes the airplane have a left rudder tuck to the belly that’s pronounced mostly on four point rolls, reverse knife edge, stall turns, knife edge loops, etc. Right rudder does not get affected by this unless your CG is really rearward.

Next is an up line pull to the canopy and a down line pull to the canopy. To take care of the upline pull, we increase down thrust. I have seen upwards to 3.5 degrees to correct this problem.

To fix the down line pull, we mix it out with the transmitter.

These band-aids all seem to work and they are commonly accepted as normal correction practices. Some are even proponents of a rudder to throttle mix because they fly so tail heavy. Why is this not just common sense? And we wonder why it's so hard to come up with a common comprehensive trim guide! There is just too much misinformation out there.

Now Let's Talk About Snaps and Spins…

Most of the snaps and spins performed today are just tomfoolery. By that I mean they are set up with condition switches so it appears to be performing the maneuver. We can use stick switched conditions that enable the elevator to come in and out of the maneuver to give the appearance or resemblance of the descriptions required by the rule books while the airplane has never actually snapped or stalled – it just appeared to have done it through slight of hand or trickery. Stalled spin entries are the same, using the famous elevator rate switch from high to low rate to show a nose drop (which looks like a stalled entry) right before the spins is just more of the same and is accepted today as a required setup. WHY? One big setup flaw, CG position.

The T-Cantilizer Phenomenon…

Recently the T-cantilizer phenomenon has come about, touting the end all for rudder mix. While I agree it works for the most part, and I respect Christophe as a World Champion designer, you have just added another surface on the airplane to trim and it is generally another band-aid for a poorly trimmed machine in the first place, not a bad design. Yes, it will reduce rudder mix. This is mainly because the cross section of the gadget is acting as a lifting surface and helping the rudder authority. More authority means less rudder use required, therefore less mix. However, most of the time it creates another issue in the vertical up or down line lines that you have to chase with mixes and can be abusive to the surface it is mounted on, usually the canopy.

I think I have laid a good foundation to help you fundamentally understand where we are coming from and where we need to go to improve your flying and trimming understanding and skills. The method I want to share with you for correcting these issues is something I have developed over the last 20 years. It is an extremely important tool for your advancement in pattern flying and will dramatically increase your chances to advance your understanding in setting up an airplane every time. It is not design exclusive. It's fundamental knowledge that will transcend all designs and classes.

I will teach you how to read the feed back from your airplane and triangulate a correction that will fix more than one thing at a time. When you are done with this article you will walk away understanding more about trimming and setup than you ever though you would want to know.

I will start with the basic foundation to my trimming method next but just wanted to give you a good background of where we came from first. I wanted to describe what you are fighting so you can be assured you know what direction to go in using my methods.

The Nuts and Bolts

First, because this a trimming article aimed at pattern flying, we will assume you have a greater than average understanding of set up, radio installation, and slop free linkages. It is very important to do the shop work and precise radio set up before you even attempt to start flying and trimming. If you haven't already, go read my article on the blog about Basic Aircraft Setup first and then continue here.

Now, I've been doing this long enough and helped enough fliers in trimming their aircraft to know that trimming is an art. Some very good fliers have trouble disciplining themselves to allow the airplane to fly purely, without corrections or cheats, while trying to perform simple tasks in the trimming process. Learning how to trim an airplane and being able to duplicate that trimming procedure with another airplane can be laborious work, but in the end it is worth it. Here is the goal we are trying to achieve and to do it, these rules must be adhered to. What we want is for the airplane to fly itself. Yes, fly itself. You say, "Bryan, what do you mean?" Well, I'm glad you asked. Let me explain.

The airplane, absent our input, should do what we told it to do last, at all times, even in the wind. That is when we know the trimming process is nearly complete. When you pull the airplane into a 45 deg up line you want the airplane to follow that line as long as possible without correction, absent even the elevator. The same holds true with a vertical up line or a 45 degree down line. No input at all should be required to maintain the line. That is why it's important to be absolutely certain that you have hands off trimming on a straight horizontal line of flight. You must be certain that you have no adverse trim effects on any line that requires neutral elevator input. This is an achievable goal and should not be overlooked. It is the most important step in the analysis process.

Let me start by saying you must be as honest with yourself as your skills allow. There is no cheating in aerodynamics. Compromises will always show their ugly heads somewhere down the line and usually where it hurts the most. The greatest percentage of the time it is in snaps and spins. Here is the first unbendable rule; when all else fails you must remember this. A perfect setup will improve every maneuver in our schedule, from Sportsman to F3A, from stall turn to snap roll. So if you think you are finished and you have a couple of maneuvers that are not quite as good as they used to be, or if you are having trouble hitting a particular maneuver,

you either have to tweak your control throw/expo setup (something often overlooked after an adjustment) or you still have something out of whack! A real improvement will correct more than one maneuver. It will usually change, for the better, all maneuvers. So let's get started, shall we?

The Basics

This cannot be stressed enough. You must be as precise as possible in your base setup. You must know where your actual starting point is. You need to be sure of your wing incidence in degrees, down thrust of the motor in degrees, and CG position. Another very important step is to know the exact throw, in degrees, of all control surfaces. What we are talking about here is the actual amount of deflection for every movable surface. We call this the control throw, or just throw, of the surfaces. Now, check, re-check, and duplicate every setting until you can be certain of these parameters every time. One of the biggest problems I encounter while helping pilots trim their airplanes is that they are not aware of the throw and incidence settings of their airplane control surfaces and wings. Many airplanes have been cut and twisted in order to fix a so called bad flying airplane. Some have even been redesigned due to bad diagnosis of an unexpected performance, such as finding that an airplane which will not snap or spin, when the only problems were incorrect throws and incidence or the CG was not correctly set.

Every airplane requires a slightly different amount of control surface throws for spins and snaps. That is why it is so important to set a base line of settings (incidences, throws, and CG) for all non-input flying such as level fight, vertical flight, and single input flight (like knife edge flight and inverted flight). Without these maneuvers being flown hands off, or at least flying with very limited input, it is impossible to have a base upon which to build your inputs for the complex maneuvers.

The small imperfections in trim will turn into big course deflections in the complex maneuvers, requiring large corrective inputs from the pilot. The simple things have to be perfect, just like when trying to assemble a maneuver. If your straight lines are not straight, then you have no foundation upon which to build perfect geometry. The less you have to apply course corrections to the airplane, the less chance you have of making an incorrect input. An error in basic things like alignment or surfaces traveling equally will always manifest itself further down the line, so make sure to pay close attention to every step in your bench setup.

Robart makes a decent analog meter (most people don’t know this but this meter was designed and patented by Al Coomber, the owner of Central Hobbies. It is a great product.) If you have trouble seeing this meter you might want to use a digital inclinometer. However you must be very careful, most of the digital meters I’ve seen are heavy to the point of warping the surfaces, making the readings non-repeatable. If you choose to use one of these meters be certain you can adequately support the surfaces they are mounted upon. Bear in mind, these readings are only a starting point. Such precision is not mandatory, merely the repeatability of the meter. The best analog throw meter I’ve found and have used for years is the CRC meter, designed and built by Frank Capone. I flew against Frank years ago. He always had a well built airplane and a

steady hand. After using his products all these years, I now know why he was so tough to best, it was the high quality workmanship he put into all of his airplanes. Budd Engineering sells one more throw meter of note. This is a laser unit, which can be a little more difficult to set up but is quite accurate. A Budd meter would be a shop tool, but a CRC tool is one that will lend itself to field use as well. For absolute accuracy the Budd meter is probably better, but for ease of use and portability, I use the CRC. Even so, a meter reading is only used as a baseline in order to know where you began and to make adjustments according to what your airplane requires to fly true. In other words, you will need to know where you started before you can make your next move. This will allow you to fix a poorly performing airplane. If you are going to be serious about trimming your airplane, you need both an incidence meter and a throw meter. So if you don't have a meter, call Central Hobbies and purchase a USA built quality product, or acquire another unit of equal quality.

We all get a new airplane, make a flight or two, and say, "This is the best airplane I have ever flown." Then, after about twenty-five flights (once we get settled in), we start becoming more aware of the pesky quirks that the airplane displays. Here is where we need to get busy.

Go home and check the basics again. At this point, pilots sometimes start getting creative with the radio to help "tame that dog". If we look at the airplane surfaces, dissecting the information from the flight and where the surfaces rest, we can decipher what deficiencies are in the set up. Then, we can make improvements from precise repeatable measurements and by using feedback from the maneuvers after we have flown the airplane.

Making Adjustments

So, now, we get to the heart of my setup secrets, learned over twenty-plus years of building and flying. You should know where the zero line is on the airplane. If not, try to find it from the manufacturer or the designer. This is not a must, but it will be the base line for all measurements and you will need to be able to duplicate this zero measurement. It is very helpful. The dynamic between the wing incidence and CG is the most important adjustment in 95% of all trimming, even more than the use of exponential.

The zero line of the airplane is an imaginary line from nose to tail that represents the way the designer intended the fuselage to look in flight. When this line is set perfectly level, the fuselage is in the desired attitude. On my monoplanes I design the zero line into the baseline of the canopy for easy reference. If your airplane does not have a reference, using the stabilizer (with elevators perfectly aligned to it) as a zero line will almost always be adequate. The actual placement of the zero line, within reason, will not affect the trimming process.

The roots of all problems usually start right there. For your initial settings, adjust the wings 0.5 degrees positive to the zero line. Set the motor 0.5 to 1.0 degree negative, or down thrust, from the zero line and set right thrust of the motor 0.5 to 1.0 degrees right of the center line of the fuselage. Now, set the C/G at 25% of the MAC. If it is adjustable, set the stab at 0.0 degrees.

Most likely, when we complete the process of trimming, it will have a slight positive incidence. These are a must to establish a baseline for my triangulation method of trimming. Any other settings and this method will not work completely. Picking and choosing which of these parameters you will follow will sabotage this trimming procedure to the point of confusion.

Because we now use fixed gear, we have more unwanted drag and, as I wrote on the last page, no parasitic drag is good. You can figure that the fixed gear drag causes at least one to two percent of up trim measured from the normal total elevator throw, and this is where most of our trouble begins in the up lines. It is also the reason why the rear C/G is so prevalent on most setups, giving the unwanted effects in any maneuvers where the wing is unloaded (knife-edge and vertical).

The way we overcome this is by increasing positive incidence in the wing. Most of the time, when you increase incidence, you will have to move the C/G forward. The forward CG increases the power and effectiveness of all control surfaces (incidentally, decreasing sensitivity of these surfaces). Since a positive incidence adjustment makes the airplane climb on horizontal lines, this is where we see the effect of the wing adjustment on the airplanes flight. We now need to give some down trim.

This trim adjustment will correct the canopy pull in verticals, up lines, and down lines. However, it can be a frustrating dance to get a perfect pull free down line. Remember this as a foundational rule: the wing is the most powerful and important adjustment. We want the stab and rudder to lift as little as possible. These are not trainers. We are trying to trim the attitude and flying direction of the wing. We want the stab and rudder to steer the wing and fuse not to be a predominant force lifting the tail like the tail of a foamie does (Now you know why a foamie requires so many mixes.

Think about this: take some arrows, remove the weight from the front of these arrows, and shoot a dozen of them. See if you can hit any target or even get them to shoot twice in the same direction. You can't. This is how your airplane acts when the CG is too far rearward. You have to constantly babysit it. That is why you see so many SFG`s (side force generators) on world championships model airplanes, some sport planes, and foamies. You have to add too many flow straighteners to keep the airplane on track with a tail-heavy airplane. Keep this in the back of your mind during the trimming process to keep the C/G from straying towards the tail.

Here are a few quick references to follow while you are trimming. These do not change, no matter what the setup on your airplane is and no matter who tells you otherwise. With these quick reference tips and my base line set up, you will have all you need to trim an airplane. Well, maybe you will need to throw in a little patience too!

- If you need more than 1.0 degree down thrust in the motor to keep your airplane from going to the canopy in the up lines, then you don't have enough positive incidence in the wing.

- If you need more than 1.5 degrees right thrust in the motor to keep the airplane

from pulling left in an up line, your elevator halves are off, your wings pins are loose, or you need to move the CG forward.

- If you make a stab adjustment and it affects the way the airplane flies in the up and down lines, then the CG is too far back.

- If your airplane requires a left rudder to throttle mix your airplane is very tail heavy, your airplane is crooked, or your wing incidence is under 0.3 degrees positive.

- If your airplane goes to the belly on a left rudder knife-edge, move the CG forward. If it goes to the belly on a right rudder knife-edge as well, the same adjustment works.

- If the airplane goes to the canopy on left rudder knife-edge, the CG is too far forward. If it goes to the canopy on right rudder knife-edge, the CG is very far forward.

- If you have to use high rate rudder to do a snap of any kind the CG is too far back.

- If you have to do any snap with no elevator move the CG forward.

- If you have to do your spins with rudder and elevator only the CG is too far back.

- Here's a tricky one. If the airplane continues to rotate when exiting a spin either the CG is too far forward or the rudder rate is too high. However, it is a possibility that the CG is too far rearward. Use information gathered from other indicators to make the determination for a correct adjustment.

- If the airplane does not rotate up onto the main gear during takeoff (common problem) your CG is too far back.

- If the airplane requires a greater amount of rudder and elevator to rotate to and maintain inverted flight, either the CG is too far forward or the wing incidence is less than the baseline setting.

There are many more examples, but we will stop here. It's enough to get you on the right path. If your airplane has just one of these examples listed above, you are not finished and your airplane still needs work. However, I know from experience that if it has one then it's sure to have some others as well. Remember, we said that one correct adjustment would fix more than

one problem so keep this in mind while using this trim process. Also remember that the closer you set the wing incidence to zero degrees, the farther back you can run the CG for normal horizontal flying. Don't forget to keep in mind that a 28-35% of MAC CG setting starts negatively affecting the demanding maneuvers in precision aerobatics, especially snaps and spins, in particular 1.5 snaps.

Conversely, when you move the CG forward it will feel nose heavy. The only way you can move the CG forward is by increasing the incidence in the wing, therefore taking out the up elevator trim induced by the forward center of gravity. It is important to remember that you wont have to use all that expo any more. This is the reason why most guys think they are nose heavy at first.

This is a good place to use less of the capabilities of our fancy radios and reduce your expo. These are guidelines you can use to establish a baseline of settings for your motor position, wing incidence and control surface throws. It comes from many years of designing mix free pattern airplanes. These settings and examples do not waiver on the modern designs we currently fly. The only exception is if you are flying the old style pencil fuses like the Patriot or the Typhoon with retracts or the skinny sport pattern models available for pattern beginners. You can usually fly with the CG at 28% MAC with these airplanes and the wing incidence rarely needs more than 0.5 degrees positive incidence. This is because of the wing sizes and reduced drag from the use of retracts.

With the older planes the snaps and spins require full rudder throw. This is because rudder power comes from the side area of the fuselage. If the airplane has very low side area, it will have very low rudder power. Our modern fuses can do a low rate rudder knife-edge loop, so there is a big difference in that dynamic with the larger side area fuselages.

Time to Fly!

Finally, lets start flight one. Begin by doing multiple trim passes with the airplane in level, upright flight. Make sure it flies from horizon to horizon with no need for any trim. Next, pull to a vertical up line and see if the airplane will go straight up with no input, rudder included.

Next, fly a perfectly straight down line, hands off, and see what the airplane does. After that, and be very precise, fly a left rudder knife-edge flight and a right rudder knife-edge flight. Do this a number of times to be sure you get the correct information. Make a note of what the airplane does, and, if you need to, have a friend record it for you.

This is where the fun begins!

Your airplane probably has these tendencies: the up line is O.K. or maybe pulls to the canopy a little at the very end, the down line has a canopy pull, the right rudder knife-edge flight is dead on, and the left rudder knife-edge flight has a belly tuck (because I know you didn't move the

CG to 25% of the MAC; it was too difficult and you needed to move too much stuff so you were going to try everything else first, just to see! Maybe it was too difficult to adjust the wing incidence, and you did not set it properly.

This is where most airplanes wind up set. I've seen this too many times to mention. Please be patient, and use stick-on weights to get the CG forward if you have to. This step is very important.

If you have an airplane that has wings that cannot have an incidence adjustment, none of these settings will work. Do not even attempt this method. Wing incidence and CG together trumps everything else. Now we have to think about all the dynamics that come into consideration after the flight. Triangulate the information and use an adjustment or two that can fix all the issues. Because the wing is the most important and powerful part of the airplane, it has the most effect on the cause of the problems as well as the most answers for the fixes we are looking for.

We must remember everything else on the airplane is reactionary to what the wing requires and can be a tattletale. This is good! It allows us to use the information to fix an unhappy set up. Because the airplane goes to the canopy on up lines we know we need to adjust more positive incidence into the wings. Then, because the airplane goes to the belly on a left rudder knife-edge, we need to move the CdG forward until we get the tuck to stop.

You will see that moving the CG forward will make the control surfaces react more softly and predictably but more powerfully. It will feel like you added expo but have more control and power around the center.

After you get the airplane pulling a straight vertical line and the left rudder knife-edge is as close as you can to be perfect, only then should you adjust the stabs to match the elevator trims. Adjust the stab incidence until the elevator trim is centered. It will require adjusting then flying, perhaps more than once. You will also see that, with the CG forward, the stab adjustment has no effect on how the airplane trims. It only affects the center position of the elevator halves. Stab position is the least important trim effect in my process. It affects nothing except expo feel inverted.

You have been given all the information you will need to perfectly trim your airplane but it takes time, experience, and patience. We could have examined hundreds more examples, but you have already been given the most important ones with which to start. With this in mind, read and re read what is written here.

All the information here is for rough trimming. Remember that fine tune trimming is a whole other article.

I hope you give this a try in this off-season. It is worth the effort. You will be amazed that you bought in to all the hog wash that has buried itself into the lexicon of the trimming process, and

that it kept you chasing your tail with misinformation and even false information with no improvement in the flight characteristics of your airplane.

Drop me a line and let me know how it worked for you. However, if you don't try it, don't write to let me know it can't work!

Until next time,
Practice with a coach
Bryan Hebert