Peter Goldsmiths Trimming Sequence

Condensed from the Model Aviation article under "Scale Aerobatics" Feb & Apr '05 JR Team leader, TOC competitor, IMAC top pilot/judge, and scratch builder Peter Goldsmith offers some of his experience...

Step 1: Relax.

If you consistently win regional IMAC competitions in the Ultimate Class, then there's no reason to read on if you don't want to. Otherwise, forget that you know it all and be objective, listen and be open minded.

Step 2: Follow the sequence in order.

Mr. Goldsmith developed this method of trimming aircraft from years of building, flying in competition and judging aerobatics competitions. He noticed even pilots in "top classes" were chasing their airplanes as a result of not being trimmed well. His approach is systematic and comprehensive. If you aren't fighting your airplane you can concentrate on centering and maneuver geometry. Commit to trimming your plane, it will take a minimum of ten to fifteen flights after you have broken in your engine and chosen your propeller! Changing the prop changes everything. Also, read the whole article before starting the trimming process to get the big picture.

Step 3: Servo and Control Setup.

Decide whether you are going to use your plane for precision, freestyle, or both. Most scale aerobatics events allow a second aircraft for freestyle. If you can afford it…do it! Bias your setup toward precision control if you will use one aircraft for both precision and freestyle.

Precision: Elevator deflection should be somewhere near 12 to 15 degrees. Check your exponential, it shouldn't be more than about 35% which is usually just enough to give the aircraft a "linear feel" (i.e. half stick gives half control response). A precision roll rate of 360 degrees per second rotation at full stick deflection should give you 180 degrees per second rotation at half stick deflection. Servos are rated at oz/in, so using arms longer than one inch reduce the torque delivered to your control surface. Mr. Goldsmith harps extensively on surface blowback. Underpowered surfaces caused by poor geometry or not enough servos will result in the air pushing against your servo and keeping it from full deflection. The results are inconsistent maneuvers and lower scores in competition.

Freestyle: Pay close attention to servo/control arm geometry to make sure you are getting enough power to your surface to prevent blowback! Mr. Goldsmith suggests that it is more important to get correct geometry than to get those crazy throws. He mentions that on his 46% Cap he uses one inch servo arms and 1-1/4 inch double arm on his rudder. He creates a mechanical advantage so his servo is getting even more torque to the surface than it's maximum oz/in rating. He gets 28 degrees aileron, 32 degrees elevator, and 35 degrees rudder maximum deflections, which, he says, is a good balance between precision and freestyle, with a bias toward freestyle. He cites this example: DS8611 = 266 oz/in with a one inch servo arm and 200 oz/in with a 1-1/2 inch servo arm to illustrate this reduces torque available as the servo arm length increases. Good geometry with plenty of power to the control surface will eliminate blowback and flutter.

Step 4: Follow the sequence!

Don't skip ahead. The following sequence will ensure that each subsequent adjustment will have no effect on the previous adjustments. These are the building blocks of a trimmed aircraft in order: center of gravity (CG), dynamic balance (wingtip weight), thrust angle, aileron differential, THEN P-mixing (i.e. knife edge tracking, roll coupling, down-line tracking, etc.). Remember, if you change your propeller, everything changes!

Step 5: Center of Gravity

Is your CG correct? CG is a feel thing, but there are a couple indicators of an excessively forward or aft CG. Does your aircraft take an uncomfortable amount of down elevator to maintain level inverted flight? CG to far forward. If your aircraft climbs on an inverted 45 degree upline your CG is too far back. Mr. Goldsmith recommends at least 10 to 15 flights on a new aircraft before deciding where the CG will be if you're trimming a new model.

Step 6: Dynamic Balance

Wings can weigh the same and still need some weight on one or the other to balance them under flight loads. Here's how to check if you are balanced – from the top of the box dive straight down for three to four seconds at idle, then do a hard pull to the horizontal. Your aircraft should exit wings level, if a wing drops, add weight to the opposite wing. Before adding weight, do the maneuver ten times with an observer to make sure the results are conclusive. Make sure you aren't adding aileron while pulling. Temporarily increase the spring tension on the ailerons if necessary. You did check your elevators to make sure they were identical throughout their travel, didn't you? If everything checks and you have a wing that drops consistently, add weight to the opposite wing and re-test.

Step 7: Thrust Angle

Put aesthetics aside! Although the manufacturer of your aircraft probably got the thrust angle pretty close on the plans or the ARF, having a trimmed aircraft that flies right is more important than having the spinner perfectly lined up with the cowl. Engine and propeller selection make a big difference in thrust angle required. To test for the correct thrust angle fly a straight line, wings perfectly level, and pull up to vertical. Your plane should track straight up to a "top of the box" altitude. As speed changes your trim will be different, so hopefully your aircraft is capable of maintaining forward speed for the required length of your upline. Use rudder trim to compensate for your aircraft veering to the left or right during the upline. Increase (or decrease) your right thrust by half the number of degrees your rudder was deflected. Right rudder = more right thrust, left rudder = less right thrust. Flight test your aircraft and adjust as necessary until you are satisfied with the upline tracking of your aircraft. If you change your propeller size you have to start over. (As a side note, if you read the whole article before you start you might notice a hint about using rudder offset instead of thrust angle in the "Throttle to Rudder Mixing section.)

Step 8: Aileron Differential

Make sure you're not getting surface blowback! Mr. Goldsmith emphasizes this point again in this section. If your roll rates are faster on uplines than on downlines then you are getting surface blowback and your aircraft will be inconsistent. To test for this start a downward vertical dive from the top of the box and roll to the right, pause and roll again to the right. If your first roll was faster than the second roll, you are getting blowback.

Now for the differential…fly a 45 degree upline directly into or down wind and away from you. Roll to the right. If the aircraft "walks" to the right, then you have too much down travel. If it "walks" to the left, then it has too much up aileron travel. Repeat the process to the left and adjust until you are satisfied your aircraft is tracking true in the roll axis. "You'll be amazed at how easy it is to do hesitations on lines," Peter Goldsmith remarks.

Step 9: Throttle to Aileron Mixing

Finally were to the place where everyone starts…the mixing. You'll notice this topic is last in the sequence. Expect to be ready for these mixing steps after 10 to 20 flights or more if you've strictly followed the sequence. Continue to follow the sequence in the recommended order here too.

Most noticeable on downlines throttle to aileron mixing can be checked in two ways and both ways should be used. Fly directly overhead into the wind at a top of the box altitude, 50 to 100 feet past overhead push down into a dive at idle and watch carefully to see if the model is rolling on the downline. Most aircraft will roll slightly to the right. Unknowingly most pilots are carrying a small amount of aileron trim at low throttle. The second way to check is to fly along at a medium height, throttle smoothly back to idle and watch for rolling. Add a throttle to aileron mix at low throttle to compensate for this rolling – make sure it takes effect gradually, starting at around half stick. This is a linear mix.

Step 10: Throttle to Rudder Mixing

Hope to have to only apply a small amount of left rudder at low throttle. To check for this use the same technique as for throttle-to-aileron. Fly directly into the wind overhead at top of box altitude, push down in front of yourself and watch carefully. "You'll be amazed, especially at the start of the downline. Anytime you are using elevator and are off in the yaw axis is a bad day," exclaims Peter. Some fairly experienced modelers use this throttle to rudder theory in reverse. They use little to no right thrust on the engine, but have right rudder mixed in on full throttle. Peter Goldsmith says he hasn't tried this method. For low throttle left rudder mix, Peter likes to have the rudder offset start at least above half and let it progress from there as he reduces throttle. Try to keep the start of the mix well above the idle setting.

Step 11: Rudder to Aileron Mixing

Flat turns are the best way to check for mixing requirements – knife edge flight can be used, but rolling circles appear more frequently in sequences than knife edge flight. If you see inconsistencies at different speeds you may be getting rudder blowback! This should be a linear mix. If your roll mix becomes too much as you reduce your rudder input this is another sign that you could have rudder blowback (insufficient rudder power for full deflection).

Step 12: Rudder to Elevator Mixing

Almost every aircraft will need a rudder to elevator program mix. Start with a flat turn – if your model pitches down add a small amount of up elevator mix, if it pitches up, add a small amount of down elevator. Do this test in both directions. Knife edge flight could be used for this test, but rolling circles are more common in sequences than knife edge flight. This mix is not a linear mix. It will take more elevator at higher degrees of rudder deflection. Mr. Goldsmith says not to panic, most radios used for aerobatic competition these days have the option to program a non-linear mix. At low rudder throw it is possible to have one or two percent mix, but as the throw increases you might need as much as a ten percent mix.

Peter Goldsmith's Tricks of the Trade:

You'll have a hard time beating a person with the same skill but a properly trimmed plane if yours isn't. It took him more than 20 years of competition to figure most of this stuff out. Be patient, observant, and objective. Even if your model isn't perfectly straight you can trim it. Don't fly with your inside wing down five or ten degrees! That is the most common mistake made by all competitors. Get someone to spot you and tell you when you are level – learn to fly level! Flying level will greatly reduce your workload and make all your maneuvers easier and more precise. Spend your money on gas and oil (or glow fuel), trim the plane you have already and practice, practice, practice! "Avoid letting your ego be your only motivation. Be objective, humble, and listen, watch and experiment."