The Pilot's Guide

to

Mastering Radio Controlled Flight

By Scott Stoops

2nd Edition Addendum

TIC-TOC

The first time I saw a tic-toc flown, it was by Quique Somenzini in a demonstration video of his new Yak series of aircraft (doesn't it seem that most new 3-D maneuvers find their origins somehow tied to Quique?) From high position over the field, Quique pitched his Yak rapidly from a vertical downline to an upright elevator, then to an inverted elevator. The entire time the model stayed in the same vertical plane, with no roll or yaw. While it looks easy, this is one of the harder maneuvers to fly cleanly due to the excessive yaw forces during the pitch changes! Finally, at the bottom of the maneuver, seemingly out of airspeed and altitude, Quique applied a quick burst of power and transitioned into a harrier rolling circle inches above the ground. Quite the sight to see!

Flying the tic-toc accurately requires a full understanding of gyroscopic precession and the inputs required to counter it when changing pitch attitude rapidly. A good review of gyroscopic precession can be found in the Aerodynamics chapter of Section 2 (Precision Aerobatics). For our purposes here, however, I'll simplify it a touch. Most models will require a left rudder input when pitching up (up elevator) rapidly, and require right rudder when pitching down (down elevator) rapidly. Let's apply that information to the tic-toc.

Begin the tic-toc from around 200-300 feet above the field and at a relatively slow airspeed. Close the throttle and pitch down into a vertical downline. Once established on the downline, and before the airspeed builds too much, apply full up elevator and a touch of power to rapidly pitch the model towards level flight. Along with the throttle and elevator, you will probably need to add left rudder to compensate for gyro precession. Regardless of the direction of rudder needed, apply enough rudder to keep the nose tracking straight and enough aileron to keep the wings level.

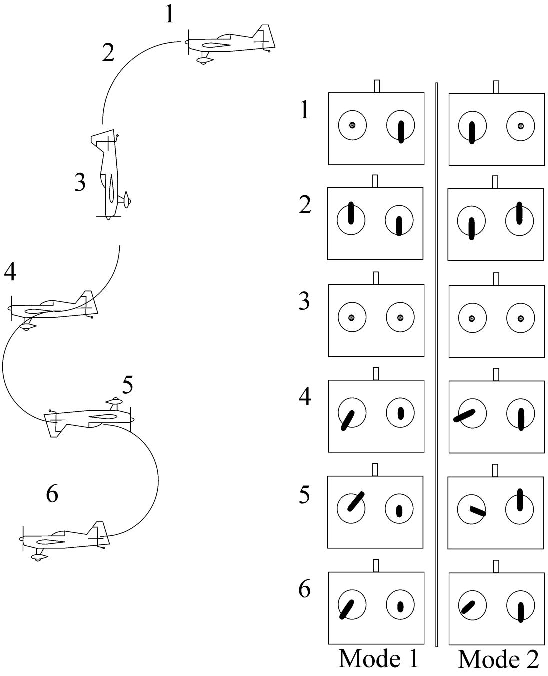
As soon as the model reaches a nearly level position, reverse the elevator control input and pitch the model rapidly through vertical to a level inverted positon. To avoid accelerating during the transition, it may help to pulse the throttle rather than maintain a steady throttle setting. Most models require a burst of power to make the pitch transition through the vertical downline. Again, use an appropriate rudder and aileron input to keep the nose tracking straight and the wings level.

The most common recovery or transition from the tic-toc is into either an upright or inverted harrier from the final tic (or toc). Until you're comfortable with the rate of descent during the tic-toc and subsequent recovery, start them high enough for a full stall or spin recovery.

COMMON MISTAKES

- Inadequate throttle or pitch authority to rapidly transition through vertical to both level and inverted stalled flight.
- Poor rudder coordination to maintain aircraft heading.

Tic-Toc



KNIFE-EDGE ELEVATOR (DEATH SLIDE)

The Death Slide. What a great name. You just knew that I had to have at least one "Monster Truck" type title. I like the dramatic image it provokes. It makes me think of fire breathing monster trucks, Evil Knievel, and flaming hoops! In reality, the slide, as I'll call it in this section, is really just an Elevator done in knife-edge flight. It is one of the harder maneuvers to fly, and requires an enormous rudder and nearly coupling free knife-edge performance. The idea, however, is basically the same as an elevator.

Begin the slide from a decelerating vertical upline. At around 100-150 feet, reduce the throttle to the point that the model stops all vertical motion. As the model slows to a stop, add right rudder to pivot the model into a left wing high knife-edge position. This is very similar to the pivot flown during the hammerhead turn (see, I told you you'd use that precision aerobatic training!). As the model reaches the left wing high knife-edge position, add full left rudder and just a touch of throttle. As the model settles in the knife-edge position, it will accelerate slightly, but the nose should remain slightly above the horizon. With full left rudder and such a high knife-edge AOA, any roll or pitch coupling your model exhibits will be greatly exaggerated. The elevator may be very sensitive, so tread lightly while making pitch adjustments. With just a touch of throttle to ensure rudder effectiveness, the model will settle into the slide.

Some models may not have enough rudder effectiveness or fuselage side area to execute the slide. On those models with full rudder and some power, the nose will fall below the horizon and the model will accelerate dramatically. A perfect slide allows a very smooth and slow descent in the knife-edge position with the nose close to or above the horizon.

As the model descends in the slide, at some point you'll have to either recover or transition into another maneuver. For recovery, one option is to slowly level the wings and add throttle to fly away. You'll need to add enough throttle to transition a harrier attitude. Another option, if your model has exceptional knife-edge capabilities is simply to increase the throttle further and fly away in knife-edge flight.

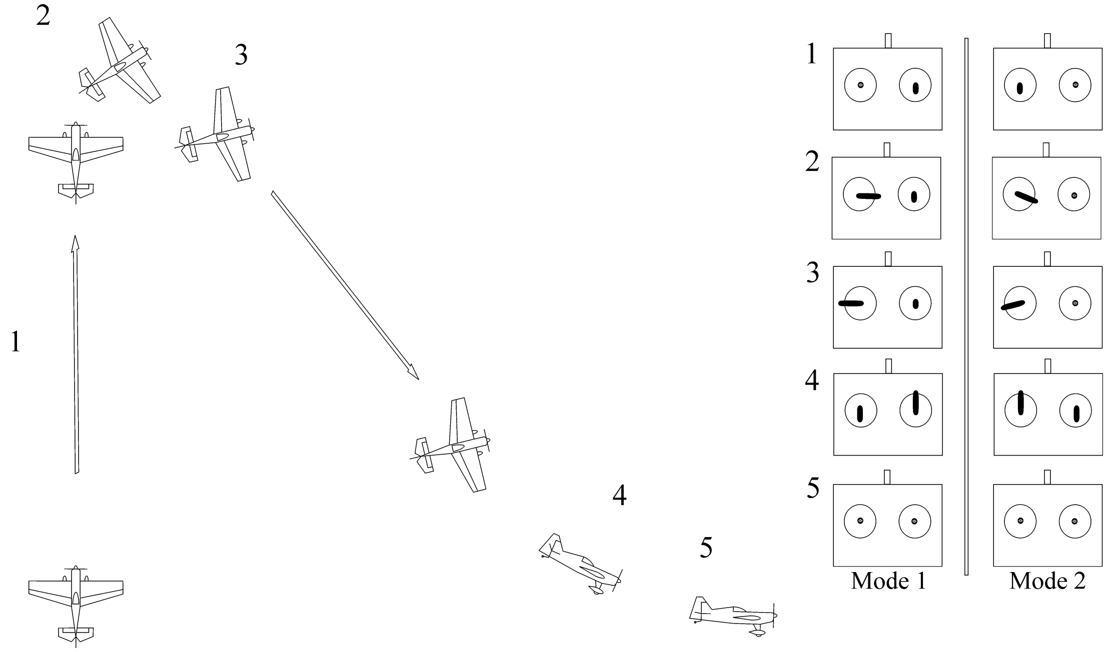
The transition I prefer, however, is into a rolling harrier. As you bottom out of the slide, simply add enough throttle to transition into the harrier attitude and start rolling. The rolling harrier is covered in a later section of this book.

Regardless of the recovery or transition you decide on, be sure to execute it a touch high for your first few attempts. There is always time, once you're comfortable with it, to bring the model down low on the deck.

Common Mistakes

- Insufficient throttle or rudder authority to keep the nose above the horizon.
- Loss of control from excessive control coupling.

Knife-Edge Elevator



ALPHA TRANSITIONS

As the last maneuver or set of maneuvers that I present in this book, alpha transitions are one of the more dramatic 3-D moves that you can add to your repertoire. Used as a transition maneuver between faster precision aerobatic flight and slower high alpha flight, alpha transitions are a clean way to bleed off energy is a dramatic fashion.

While they have been given, in some cases, names like “Aneurism” or “Heart Attack”, I’ve never really latched onto those terms, so I’ll focus on the nature of the figure and simply call them a positive transition and negative transition based on the elevator input used.

POSITIVE TRANSITIONS

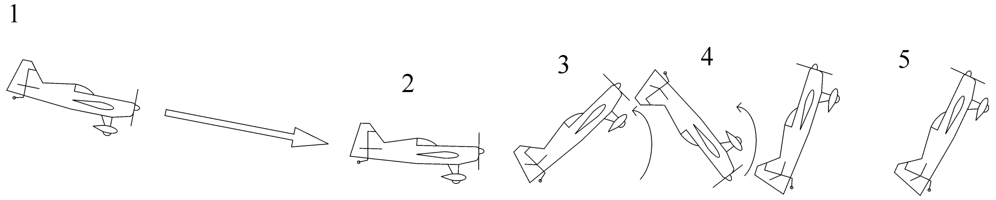
In the most basic sense, alpha transitions are used to smoothly transition the model from high speed to low speed without gaining (or losing) altitude. The first time I saw one flown was by Jason Shulman at an IMAC competition during the freestyle. From the left, his Extra was diving on the field at full throttle and a full head of speed. Assuming he was going to do a very high speed fly-by, knife-edge pass, or point roll, no one in the crowd expected it when the model rapidly snapped and stopped in mid-air, dropping cleanly into a rolling harrier. I don’t know how many G’s that model felt, but that’s not something I intend to try in the full-scale Sukhoi!

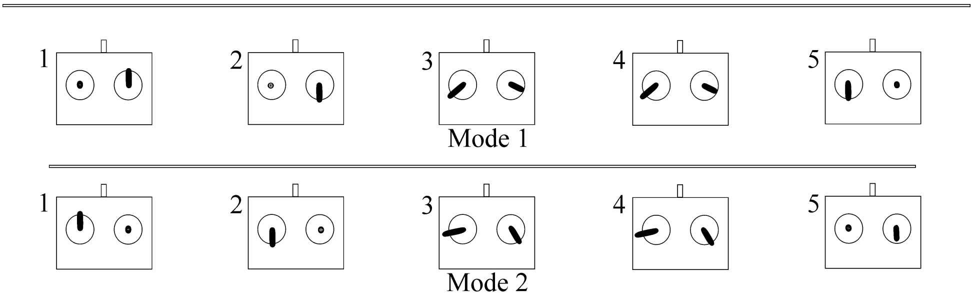
The most common technique for alpha transitions is to use a cross-controlled snap roll to bleed energy quickly. Much like a horizontal blender, when executed correctly the transitions causes the model to dissipate all of its energy instantaneously. Anytime you dissipate energy that quickly, there is going to be a very high load on the airframe, so be careful to ensure your model is strong enough. Additionally, be sure to practice the maneuver high enough that you have room to recover if it goes poorly. Finally, you really need to be very experienced with harrier flight and rolling harriers as that is the recovery from the transition.

Start from around 100 feet above the field from the left and with full power. As you approach mid-field, rapidly close the throttle. With the throttle closed, immediately add full up elevator and left rudder. As the model enters the very deep snap roll, add a touch of throttle and around ½ right aileron. This will cause the upright snap roll to go even deeper and also flatten out (very much like a horizontal flat spin). With the airframe fully exposed to the relative wind, the snap roll will go very deep into the stall and will cause the airspeed to rapidly decay to zero. For most airplanes, two full snap revolutions are required to dissipate all of the models energy. Those two snaps will happen very quickly, however, so it's important to be ready with a burst of throttle to drop into the harrier or inverted harrier.

The most common and easy recovery from the alpha transition is into a harrier, or rolling harrier. When flown with left rudder, the upright alpha transition will be rolling and yawing left, so it works very nicely to simply continue the roll into a left rolling harrier.

Positive Alpha Transition





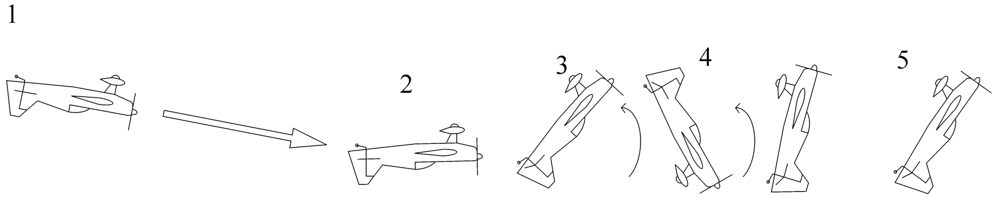
Negative Transition

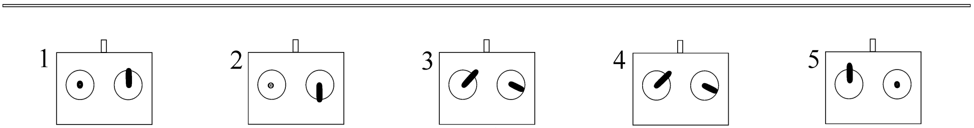
The negative alpha transition uses the exact same control inputs as the blender. For all practical purposes, we are entering a blender from horizontal flight. This maneuver is also commonly called the "aneurism." Definitely an apt name.

I recommend starting your first few negative alpha transitions from inverted flight. They can be flown from upright flight, but often lose altitude if flown from upright flight due to the down elevator input starting the maneuver. If flown from inverted flight, the initial pitch for the snap is away from the ground, which helps to avoid descending.

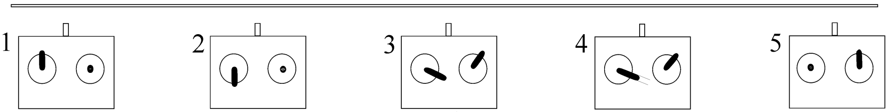
Start from around 100 feet above the field from the left with full power. During the dive, roll the airplane upside down. Approaching mid-field, close the throttle. Immediately add full right rudder and full down elevator. Once the rotation starts, add a burst of throttle and around ½ right aileron. The model will rapidly pitch away from the ground and start a deep negative snap to the right (which rolls left). These are the same input as you flew in the blender. Within 1-2 revolutions the model will have dissipated all of the energy from the diving entry. Remember to add a burst of throttle as the model runs out of energy. Common exits are into an inverted harrier or rolling harrier.

Negative Alpha Transition





Mode 1



Mode 2

Common Mistakes

1. Entering with too slow of an airspeed. You need a head of speed for the violent transition through the deep snap roll.

2. Insufficient throttle to recover into a harrier attitude.

3. Loss of orientation during the recovery. Be comfortable with harriers (both upright and inverted) and rolling harriers.

APPENDIX B – TRIMMING GUIDE

One important aspect of flying precision aerobatics is setting up your aircraft; "trimming" it. This isn't trimming in the general sense of adjusting the elevator, ailerons and rudder to hold level flight, but rather, it is small adjustments to your airframe and radio setup to help your model fly as precisely as possible. In my opinion, this is a step that many pilots overlook or omit in their aerobatic training. While this may seem to be a bit of overkill for a new aerobatic pilot, I find that a nicely balanced and precisely set up model makes learning precision aerobatics much easier. Our goal in this section is to set your model up as true as possible, allowing for the minimum amount of corrections during precision flight.

For starters, I have to assume that your model is straight and square. If not, correct those areas that you can, the rest we'll live with. It should have the appropriate dihedral (if any), wing and tail incidences, and thrust line. It should also initially have the manufacturer's recommended CG. Let's give the manufacturer the benefit of the doubt in the design, and adjust from that starting point.

I also find that most pilots, if they trim the model for aerobatics, tend to either jump ahead or omit steps from this trimming guide. Unfortunately, by jumping ahead they tend to cause more problems than they solve. Each setup item has an effect on the next (except for the last one, which is why it is the last one!), so the order is important. By accomplishing it in this order, I think you'll be satisfied with the results. To help simplify the process, I break it up into several individual adjustments. Below are the steps that we'll follow to get your model set up for precision aerobatic flight.

- Center of gravity
- Thrust line
- Aileron differential
- Sideslip coupling

One item to note: this section is intended for use setting up most sport aerobatic models. It isn't, however, intended as a competition setup guide. We won't cover setting wing and tail incidences, as those aren't adjustable on most small sport aerobatic models. Everything I discuss here is appropriate for setting up sport aerobatic airplanes from your parflyer all the way up to your 40% gas models.

CENTER OF GRAVITY

When deciding on a particular CG for precision flight, a good starting point is the manufacturer's recommended CG position. I have found, however, that many models' recommended CG positions are very, very conservative (as are their recommended control throws), so fine tuning may be appropriate.

As we discussed in the introduction to Section 2, the position of your model's CG affects primarily the pitch axis of the model. A forward CG results in a very stable, yet possibly somewhat less responsive model. An aft CG results in a very pitch sensitive model, and in extreme aft CG positions, too responsive. Our goal is to balance those characteristics, creating a stable yet responsive aerobatic machine.

Start with the manufacturer's recommended CG position. Flying a level inverted line with a neutral elevator position, your model should descend ever so slightly, requiring only a very slight down elevator input to maintain level flight. If the model descends abruptly, adjust the CG aft and repeat the test. If the model holds a perfectly level inverted flight, or climbs inverted with neutral elevator, adjust the CG slightly forward. For precision aerobatics, I recommend a slightly forward CG, allowing the instantaneous snap and spin recovery required for precision aerobatics. This is different from an ideal 3-D CG position. For 3-D flight, I prefer a perfectly neutral model, maintaining perfectly level flight both upright and inverted. In my opinion, this is too far aft for precision aerobatic flight.

A good secondary CG test is vertical downlines with the throttle closed. If the model maintains the vertical downline with a neutral elevator input, both the incidence and CG are very close to perfect. If the model pitches to the landing gear, adjust the CG forward. If the model pitches towards the canopy, adjust the CG aft. Once you've got a CG you're comfortable with, the next step is adjusting your models thrust line.

THRUST LINE

Adjusting your model's thrust is the one change that I feel most modelers overlook when setting their model up for precision aerobatic flight. In fact, I find most simply match the spinner to the cowling, and settle for whatever thrust line that happens to be. Rather than that technique, I advocate that you first set the thrust line, then adjust the cowling to match the appropriate thrust line. On some models, that isn't possible, and on those models, I simply accept the fact that the spinner is offset from the cowl. I'd rather have a precise flying model than one that only looks like it flies well!

I adjust the thrust in two separate steps. We'll start with left/right thrust. Most models have clockwise rotating propellers (when viewed from the cockpit) and as a result of spiral slipstream from the spinning propeller (not torque!), the model tends to yaw to the left under power. To compensate for this, we'll adjust the thrust line to the right slightly. Most modern model manufacturers build some right thrust into their motor mounts, so let's start with what the factory gave us. If your model doesn't have any right thrust, I'd recommend around 2 degrees of right thrust to start.

To test your thrust line, simply fly a vertical upline and watch the nose of the model for a yaw divergence from the vertical line. Make sure that when setting the vertical line that you're actually vertical. Any residual yaw from the pitch up from level on the vertical line will disguise the required thrust line change you need. So, pull to vertical, set the line, and then neutralize any rudder inputs. If the model yaws to the right, reduce your right thrust. If the model yaws to the left, increase the right thrust. I find that most models need around 2-3 degrees of right thrust to adequately compensate for spiral slipstream.

Adjusting down thrust (or up thrust) may be necessary in some models. I find that models with low wings and a high thrust line often require up thrust, and models with a high wing and lower thrust line often require down thrust. A good test for the vertical thrust line is, again, to fly several vertical lines at a steady thrust setting (I use around ¾ throttle). If the model pitches towards the canopy, add some down thrust angle. If the model pitches towards the landing gear, add some up thrust. The actual thrust line setting can be confirmed by flying other lines, including level lines, 45 lines, and inverted lines. With thrust changes, the model should maintain a constant flight path. No thrust line is perfect at every airspeed and attitude, but you can get it very close.

AILERON DIFFERENTIAL

With the CG and thrust lines set, next we'll focus on making your model roll axially. When setting your model's control throws for the first time, we generally recommend symmetrical throws. Some models, however, just won't roll axially with symmetrical throws. With those models, we adjust the control throw end points to help the airplane to roll axially. In other words, we add a differential to the aileron throw. By reducing the throw of one aileron (generally the aileron moving down below the wing), we can eliminate the "barreling" of rolls as a result of the models inherent rolling characteristics.

I find the best way to test for axial rolls is on vertical downlines. With the throttle closed, simply establish a downline and begin a constant roll. Note if the roll barrels at all. If so, start by reducing the throw of the down aileron for that roll direction incrementally. I find that small changes in differential, often just a couple of degrees, are enough. Don't forget to also test the roll in the opposite rolling direction, as it isn't uncommon for the two rolling directions to be different.

One thing to note, I recommend testing for axial rolls only on vertical downlines (i.e. not on level lines). The reason for this is that on vertical downlines there is no "up" or "down" so any non-axial rolling tendencies noticed on the vertical line relate only to the rolling characteristics of the model, not the effects of gravity. Also, unlike level flight where the wing is at some positive AOA, vertical lines are close to zero AOA. At zero AOA, we can truly assess whether the model needs differential to roll axially.

SIDESLIP COUPLING (K.E. COUPLING)

Sideslip coupling (knife-edge coupling) is generally the last trim adjustment I make. Some pilots start making this adjustment right away, but I find that the other adjustments have an effect on sideslip coupling (CG and thrust line), so setting those first, then coming back to sideslip mixing makes the most sense to me.

Any adjustments to the sideslip coupling on your model are done through mixing functions on your transmitter. In reality, all we are doing is mixing in a certain amount of elevator or aileron with rudder deflection to compensate for sideslip coupling.

Before we get to making actual adjustments, let's define what we are actually doing. When you deflect the rudder in your model (in level flight, knife-edge flight, etc…) you're forcing the model into a sideslip condition. The model is flying through the air at an angle, a sideslip angle. As a result of this, most models tend to pitch or roll slightly while in a sideslip. We won't go into how to fix that in the aerodynamic sense, but will cover how to mix it out with your transmitter.

The easiest test to determine the need for a sideslip mix is to simply apply rudder from level flight. If the model pitches or rolls, you'll need to apply a mix with the rudder channel as the master and the correction as the slave. Most aerobatic models tend to pitch to the landing gear and roll one way or the other. I generally start by mixing out the pitch coupling, then focus on roll coupling. As a secondary test, fly a knife-edge line both directions and fine tune your previous adjustments.

One item to note, sideslip coupling is rarely identical from left to right. With one wing high in knife-edge flight, the model may pitch to the landing gear slightly, and with the other wing high may pitch to the canopy. Simply adjust your mixes to whatever your particular model needs.

Finally, I recommend you set up your sideslip mixes to be active during all phases of flight. For precision aerobatics, there are very few instances in which the mix would hamper the precision of your flight, as sideslip coupling applies any time the rudder is used (knife-edge flight, slipping flight, etc…)

Conclusion

I've heard many competition pilots describe the trimming process as a never ending circle. Each additional change you make can force modifications to previous changes. That said, I find that for the average sport aerobatic pilot trimming his model usually only takes one trip through the steps outlined above. By following the basic order of adjustments, you're making the model fly more precisely on its own. This means less to think about, and allows you to focus on flying each figure as precisely as possible. Some look down on electronic mixing, but I find it to be very helpful and also widely accepted as reasonable and necessary to achieve the best possible flying model. Anything you can do to make your model fly precise lines, roll axially, and hold knife-edge with just rudder input is time well spent in my book.