*The R/C Aircraft Proving Grounds - Aerobatics Setup*

# Set Up for Success by: Douglas Cronkhite

"Aircraft setup is a constant process really. Every

time something is changed, there is the chance it will affect something else. Take your time, and work through it, you'll find yourself fighting the airplane less during a sequence, and that makes it much easier to score well."

Sitting at a recent IMAC contest, Mike Caglia (well known FAI Pattern and 2000 Tournament of Champions Invitational competitor) and I were discussing aircraft setup and both of us came to the conclusion that few people were really setting up their airplanes well. I think much of this is simply due to not knowing how. Much of this article deals with setup before flying the airplane. After basic setup, it will take anywhere from 30 - 50 flights to really dial in an airplane. This seems like a lot but read on, and you'll see why. While this article is based upon the JR PCM-10X radio and it's programming references, the information really is applicable to any modern computer radio. The setup described here is for a precision setup (not 3D or freestyle) but again the same theory can be applied.

## Start With the Right Tools:

Probably the most critical item needed to setup an airplane properly is a control surface throw gauge. I use CRC Throw Meters. You need to accurately determine how much your surface moves. While it's possible to use a ruler or protractor, throw meters make the job much easier.

Throughout this process, you'll be making several flights, and then changing and adjusting. It's important that you change only one thing at a time and then completely retest the airplane each time.

Step 1 - Setup the Airplane First:

The setup of the airplane really starts during the building process. The following is a minimal checklist to start with. You may think of other things you want to add.

Hinges: Hinge lines should be straight and centered on the surface.

Pivot Point of Control Horns: Control horns should be setup such that the pivot point of the horn is exactly on the hinge line to avoid building in a differential.

Servo Arms: The arm on the servo should be exactly parallel to the hinge line. Servo arms should be switched around until you get the spline alignment correct. Always try to avoid using the radio to center the servos whenever possible.

Seal Hinge Lines: Hinge lines should be sealed so no air can pass through. It doesn't matter how tight you think it is, seal it on the bottom with some covering. You want to minimize pushrod slop as much as possible.

Ball Link Attachments: Use high quality ball link attachments and machined aluminum servo arms for the best setup.

Proper Weight and Balance: The model should also be balanced properly before any of the flight trimming starts. Try to find out about other people's experience with your airplane to get the best balance point. The aircraft should also be balanced laterally if possible. Add small amounts of weight to a light wingtip to correct it.

Step 2 - The Radio:

Start With Fresh Memory:

First off, let's start with a fresh model memory (or

reset the current memory) to ensure there isn't anything left over in the airplane. Now setup the reversing switches such that the controls move in the correct direction. The amount they move isn't important right now.

Now you have a fresh, very basic setup. What you want to do now is ensure you're getting the maximum resolution out of your servos. You should have your high rate selected since this is a fresh memory location. Select ATV (code 12) and set all used channels up to 150% in both directions. Don't forget the flap and aux channels if your using multiple aileron or elevator servo setups.

This step allows for the maximum travel out of your servos and therefore maximum servo resolution. Most modern computer radios are 1024 radios, meaning there are 1024 steps of servo resolution for it's full range of travel. By running your ATV up to maximum, you utilize all 1024 steps to command the servos.

Aileron Setup:

Mechanically adjust your linkages so that your ailerons are perfectly centered and get the maximum throw recommended by the manufacturer. You'll probably have to move higher up on the control horn, and closer to the center of the servo arm. Here is where the CRC Throw Meters come in. If all your initial building was straight and true, you should have exactly the same throw in either direction. If they're not exactly equal, mechanically setup the lower of the two to be the correct deflection and reduce the higher direction in the ATV setup screen (code 12) so they're EXACTLY the same. Do this for both ailerons independently of each other. Don't worry about differential just yet.

Elevator Setup:

The procedure for elevator setup is the same as the ailerons. Pay close attention to the center and throw. I setup the maximum throw for precision flying (not 3D or freestyle). Again this is probably going to require long

control horns, and short servo arms. Make sure elevator throw is exactly equal in both directions.

Rudder Setup:

Initially setup the rudder to use its maximum available throw. It's important to setup the rudder with the best mechanical advantage possible to ensure good resolution and power. You might adjust the throw later on, but for now get as much as you can.

Initial Flights:

First flights are sometimes nerve-wracking experiences. Just get the airplane up to some reasonably high altitude and get it trimmed for level flight. Get a feel for the aircraft's control throws. You'll want to adjust these mechanically once you land. Initial trim on the rudder should also be performed now. Fly directly up wind, and straight away from you if possible. With wings level, pull the nose up to the vertical. Note if there is any loss of heading or roll to the airplane. You MUST be wings level to properly evaluate rudder trim. If there are no major heading changes, continue the pitch-up into a series of loops. Do NOT correct them but take note of which direction they fall off center. Add a click or two of rudder trim to correct and try it again. Repeat this several times until you're sure you've got the rudder trimmed as well as possible. Now land.

Ground Trim:

Once you've flown the airplane and got it basically in trim, you need to go back and get everything mechanically neutral again. Write down the trim offset for each control. Now get out your CRC Throw Meters and measure the offset of each surface in degrees. What you want to do now is adjust the linkages such that you have this offset in the surface with the trims centered.

Aileron and rudder trim are really limited in what can be done to solve a problem other than linkage adjustments, lateral balance changes, or SLIGHT thrust adjustments.

For elevator though, we have much more available. If you required some up trim, you can move the CG back, change the incidence in the stab, or just adjust the linkages. For now, stick with either balance or linkage adjustments, as we'll be working on incidence and thrust changes later.

Now that you have the trims centered again. It's time to fly and verify your changes. Again, follow the same procedure and note if any trim changes are needed. If all went well you should have an airplane that is nicely trimmed for straight and level, upright flight with the trims centered.

Before we get too far into flight trimming, I want to emphasize one thing. As you make trim changes, or other adjustments, it is important that you change only one thing at a time, and then fly again and retest. Each change can affect other properties, and multiple changes can only confuse the issue you're trying to fix.

Balance Setup:

Roll the airplane inverted and see how it feels. Did the nose drop dramatically during the roll? Pushing too much elevator to hold level? I use balance to adjust this generally to get the feel I want. Move the CG forward or back and retest. This should be done in SMALL increments, retesting the aircraft after each adjustment. Once you're happy with the way the airplane feels in both upright and inverted level flight, move on to the next phase.

Thrust and Incidence:

You'll hear a lot of different ideas on this, but simply put, thrust controls the vertical up lines. Flying directly into the wind, wings level, smoothly pull to the vertical and let it go. Does it pull to the belly or canopy? Does the nose pull left or right? If it pulls to

the canopy, land and add a slight amount of down thrust. You could also move the CG back slightly as well. If the nose pulls right or left, add side thrust to counteract this tendency.

Note: Left or right thrust requirements can change depending on the prop used. If you change props, you may have to readjust side thrust. This is especially noticeable when changing from a 2 blade to 3 blade prop, which generally require more right thrust due to the increased spiral slipstream.

Once you're getting consistently good, straight up lines, move onto the down lines. Climb the airplane up to 500 feet or so and get into a vertical down line and let go. Does it pull out or tuck under? I generally like to correct slight down line issues with SMALL balance adjustments. If the airplane pulls out of a long down line, move the CG back slightly. This part of setup is a big juggling act, as each change affects something else. It takes awhile, but eventually you'll narrow it down.

Roll Differential Setup:

Any time you roll an airplane, the downward moving aileron generates more drag than the upward moving aileron due to the induced drag caused by the down aileron lifting that wing panel. With modern aerobatic airplanes using fully symmetrical airfoils, this is usually a very small force. When you roll most airplanes, the drag on the down aileron actually pulls the nose offline. So even though you're rolling right, the nose is going left.

From level flight, pull the nose up to 45 degrees and put in full right aileron. Does the nose go offline? Differential can help this. Adjust the differential to about 4% to start with so that the down aileron travels less than the up aileron. Now fly it again and retest. This should also be tested on a vertical up line and down line to make sure the airplane rolls axially.

Knife-Edge Coupling Setup:

Almost all aircraft exhibit some coupling between yaw, pitch, and roll. Basically, we're going to mix for moderate to high-speed flight. Slow speed knife-edge generally isn't encountered in precision aerobatics. The airplane must be properly balanced to get anything useful out of this part of setup. Airplanes like the Cap232, Extra 300S and so forth will generally pitch towards the belly of the airplane with application of rudder, while some mid-wing airplanes like the Extra 260, or Edge 540 may actually pitch to the canopy. You may or may not get some roll coupling as well.

At full throttle, level flight, roll to knife-edge and hold altitude with the rudder. Try to keep the airplane flying straight. Do you have to hold much elevator to keep it straight? What about aileron? Make a mental note of how much input is required. Keep in mind these are for small to moderate rudder inputs. Exaggerated rudder inputs will have to be mixed out differently.
Select the dedicated Rudder - Aileron, Rudder - Elevator mixer (code 64) and deflect the rudder hard over. Now add about 5% up elevator mixing (or down if needed) and re-fly. Does it need more or less? Work on one axis, and one direction at a time. Once you have one rudder direction fixed, move on to the other. We still haven't fixed any roll coupling. Just fly the correction for now, once the airplane will hold a straight knife-edge on either side for the entire length of the field. Work on the roll coupling in the same manner. Start out with a correction of only 2-3% though as aileron isn't usually needed as much as rudder. I leave this mixing on as it's needed in all rudder inputs.

Throttle Setup:

Yep, you read right. Throttle setup is just as important to a smooth flight as anything else. I use the throttle curves (code 18) to make the throttle response as linear as possible. I want to hear an rpm change with every click on the stick. Most gas engines seem to deliver most of the power in the initial 50% of the carb movement, so this requires an initially flat curve,

which then climbs sharply.

It takes some playing to really get it perfect, but when done it makes it SO much easier to get a smooth, constant speed flight. Those of you without dedicated throttle curves can use a programmable point mixer and mix throttle to throttle to get the same effect.

Other Tricks You Can Try:

These are just some slight modifications to the setup that I use as a personal preference. First off, I don't like to push as hard to get good outside performance, so I generally run about 5% more down elevator than up

elevator. I also run about 5% less expo on down elevator as well. For most maneuvers, I run the normal aileron rates, but for rolling circles, I knock that down to about 30-40%. Yes, I'm giving up resolution but this lets me move the stick more making it easier to control the roll rate.

Aircraft setup is a constant process really. Every time something is changed, there is the chance it will affect something else. Take your time, and work through it, you'll find yourself fighting the airplane less during a sequence, and that makes it much easier to score well.