Primary Through Advanced Control Setup Methodologies

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Working smarter to achieve results, not harder.
Optimum setup rules-of-thumb for the way you fly

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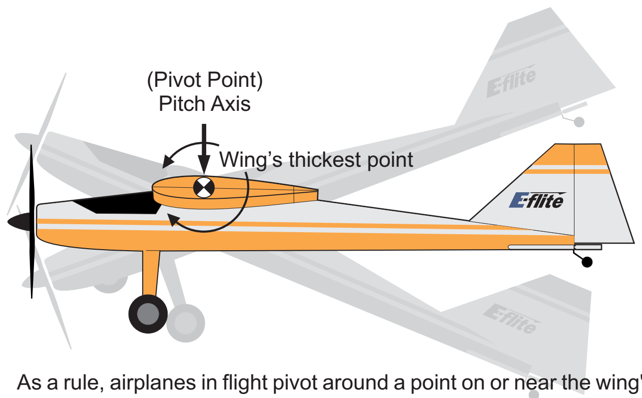
Introduction

There's probably no other subject with more varied opinions than how to best set up an airplane. Yet, if you could rank all the different setup methodologies based on the results obtained within a 4 or 5 day time period, you would quickly discover that certain setups promote faster rates of learning and better results better than others. This article features the setup rules-of-thumb that have proven during 1st U.S. R/C Flight School's solo and aerobatics courses to produce the best overall results in the shortest amount of time.

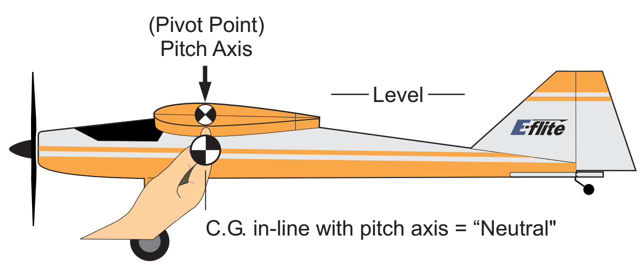
R/C pilots are constantly trying new setups that promise to improve their flying, but if they could objectively evaluate their performance, they would realize that in some cases they actually flew better before. However, instead of returning to what worked best, they hope to overcome the new challenges with more practice. The tricky part of airplane setup is therefore knowing what really helps, what sounds good in theory, but isn't, and what may be applicable to some forms of extreme flying, but would be a detriment to most or all of the flying you do.

Balance

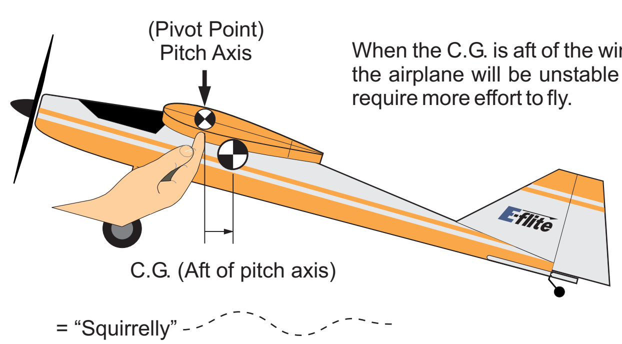
Where you chose to balance your model will have a huge impact on how it handles in the air and how well you fly it. Explained: When an airplane pitches up or down, it pivots around a point on or near the wings thickest point (figure 1). When the center of gravity (C.G.) is located at the wings thickest point (pivot point), the plane tends to be "neutral", i.e., prone to doing only what you tell it to do. When the C.G. is aft of the pivot point (tail heavy), the plane will tend to be unstable. Similar to shooting an arrow backwards, a tail-heavy airplane would be inclined to swap ends in flight if it where not for the tail and the corrective inputs of the pilot. It's true that a tail-heavy condition does increase maneuverability at the extreme ends of the flight envelope, but as a consequence, the airplane requires a lot more effort to fly the rest of the time, especially at slower speeds when the tail forces are less firm. A nose heavy airplane tends to be very stable, less maneuverable, and will behave differently depending on the speed. All things considered, a neutral C.G location at the wing's thickest point provides the best overall handling without restricting maneuverability.



As a rule, airplanes in flight pivot around a point on or near the wing's thickest point.



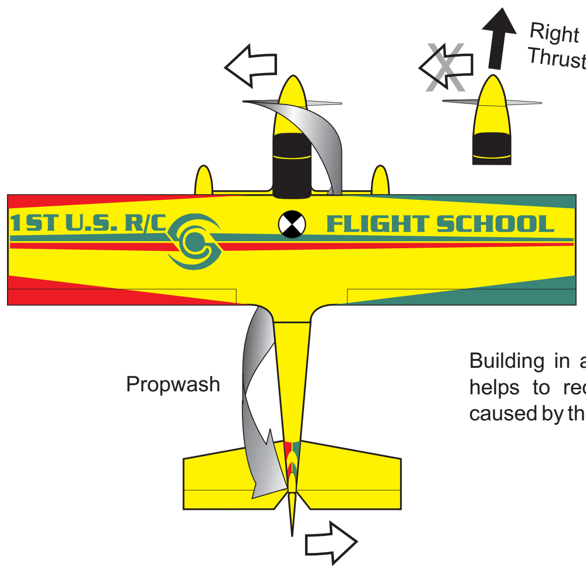
When the C.G. is neither forward nor aft of the wing's thickest point, the airplane neither resists or exaggerates what it is told to do and behaves basically the same at any speed.



When the C.G. is aft of the wing's thickest point, the airplane will be unstable at all speeds and require more effort to fly.

Engine Thrust

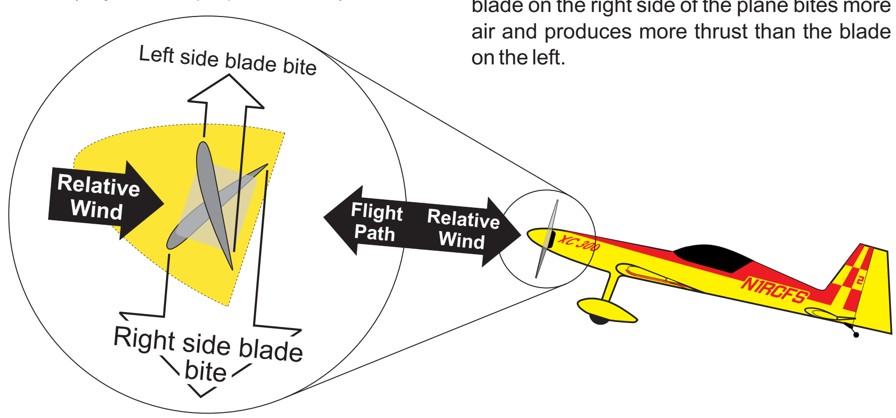
Setting up your airplane with engine right and down thrust will cause it to fly more true. Explained: As the propeller turns, it produces a spiraling slipstream or propwash that ends up striking the left side of the vertical tail and thus tries to yaw the airplane to the left. Propwash is mostly held in-check at higher speeds by the faster airflow over the tail. However, at lower airspeeds with high power, such as during takeoff or approaching the top of a loop, propwash has to be corrected by the pilot. Building in a couple degrees of engine right thrust helps to counter the effects of propwash and therefore reduces the demands on the pilot (figure 2).



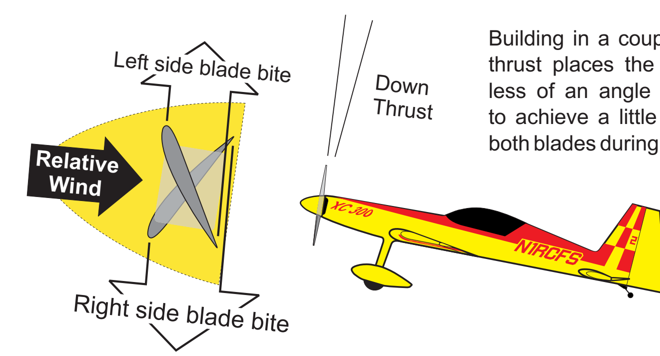
Building in a couple degrees of right thrust helps to reduce the left turning tendency caused by the propeller slipstream/propwash.

P-factor is a left turning tendency that occurs when the airplane is at a positive angle of attack due to the propeller blade of the right side of the plane biting more air and producing more thrust than the blade on the left side (figure 3). Building in a couple degrees of down thrust places the propeller at slightly less of an angle to the relative wind to achieve a more equal bite on both blades during inside (up elevator) maneuvers, thus reducing P-factor and the demands on the pilot. Another benefit of down thrust is providing a down force to counter excess wing lift when an airplane is flying at higher speeds, especially important with flat-bottom wing airplanes.

P-(pitch)-factor
(Asymmetric propeller thrust)



At positive angles of attack, the propeller blade on the right side of the plane bites more air and produces more thrust than the blade on the left.



Building in a couple degrees of down thrust places the propeller at slightly less of an angle to the relative wind to achieve a little more equal bite on both blades during inside maneuvers.

Control Surface Travel Rules-of-Thumb

As a rule, how an airplane responds to control inputs is a function of how fast and how far the control surfaces deflect, regardless of whether the airplane is large, small, high or low performance. Seldom can you go wrong by initially setting up your control surface deflections/travels according to the manufacturers' recommendations. However, don't make the mistake of thinking that those recommendations are what the manufacturer intends you to stay with. To fly your best, you must adjust the control surface travels to suit your immediate skill level. All too often, perfectly good airplanes are faulted or retired because the pilot did not like how the airplane handled, but for one reason or another put it upon himself to get used to it, and then went looking for another airplane when the one he was flying wasn't much fun to fly. This is a case where the solution is so simple that it's sometimes overlooked. Simply by changing the travels to suit your comfort level, you'll immediately start flying with more confidence and begin building on that success, instead of continuing to try to get used to the plane.

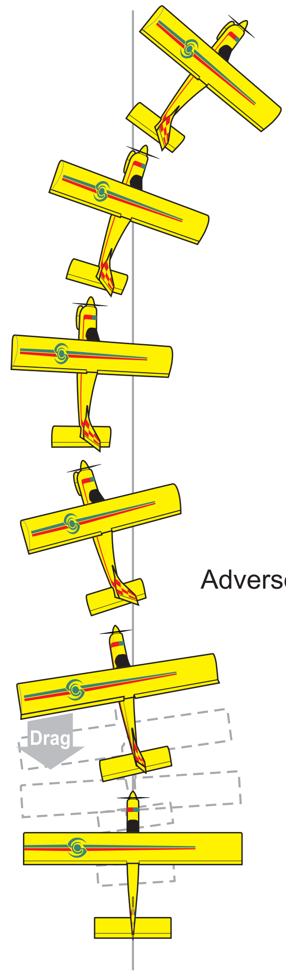
Note: When setting travels using a computer radio, it is vital that you triple check the physical deflections of all the control surfaces in all directions. For a variety of reasons, it is often necessary to program different percentages to achieve the same physical travel of a surface in both directions. Every year, thousands of airplanes are faulted because their owners make certain assumptions based on the "numbers" they read off of the transmitter, but leave out the step of confirming all the physical deflections. They then either end up unhappy with the way their planes handle, or assume that having to make numerous and/or large adjustments later is an indication of a poor design, when other than more left aileron than right for example, the plane is just fine. Remember, transmitter settings should be based on actual deflections and your comfort level, not the numbers read off the radio. Tip: To minimize the need for adjustments and the potential for error, strive to set the neutral position and travel of each surface mechanically, and use the radio only as a last resort to fine tune things.

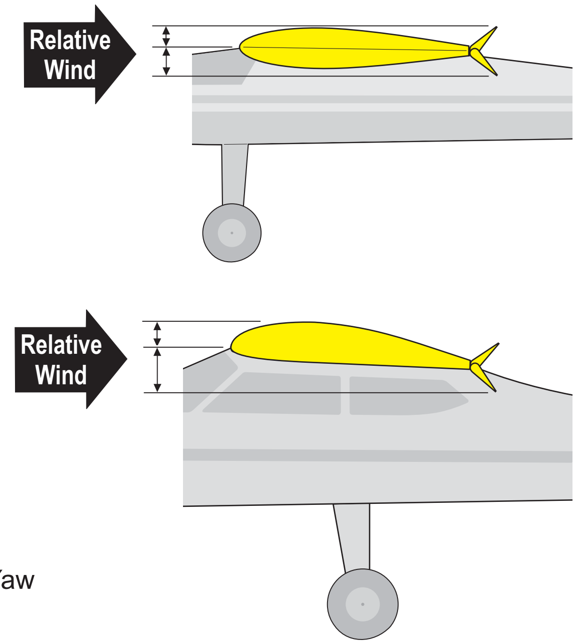
"Balanced" Controls

Another vital component of good flying is achieving balanced control responses. "Balanced controls" describes the ideal condition in which all the controls are equally sensitive. Other than a lack on control stick tension, possibly nothing inhibits progress more than when one of the controls is noticeably more or less sensitive than the others, thus forcing the pilot to remember to use two different control pressures depending on the input. Even a novice pilot can tell when the ailerons are touchier than the elevator for example, so why would you accept one control that is more or less sensitive that the others when a simple control surface travel adjustment is all that's needed to start feeling more comfortable?

Adverse Yaw & Aileron-Rudder Mixing

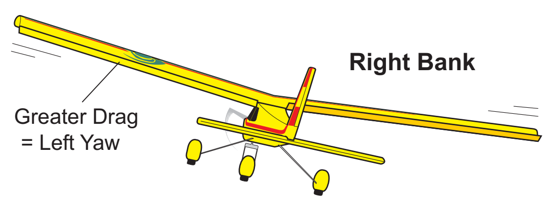
Adverse yaw is an inherent opposite yaw or skid that occurs with aileron deflections. Explained: A positive angle of attack is generally required to produce the wing lift needed to keep an airplane in the air. When the ailerons are deflected at a positive angle of attack, the down aileron presents a wider frontal cross section, thus creating more drag and causing the airplane to yaw in the opposite direction that the ailerons are applied (figure 4). When two aileron servos and the flaperon function are used, adverse yaw can be lessened by programming a small amount of differential aileron travel, i.e., approx. 5 degrees less down aileron than up, thus improving control and producing cleaner axial rolls. The exception is when the airplane has a flat bottom wing. Drag on the side of the down aileron and adverse yaw is so much more pronounced with a flat bottom wing that differential aileron travel has little effect. To eliminate adverse yaw, rudder must be coordinated or mixed in the same direction with the aileron. As a rule, a symmetrical wing plane may require only a 3-5% rudder mix with the aileron to eliminate adverse yaw, whereas a flat bottom wing plane requires nearly as much rudder deflection (in degrees) as aileron (figure 5). Not only does eliminating adverse yaw improve control, pilots who initially learn to fly with Aileron/Rudder mixing are also able to more easily transition into higher performance symmetrical wing airplanes, since they are already accustomed to flying with minimal adverse yaw. Contrast that to those who learn to fly with adverse yaw, and then have to retrain their flying habits when they switch to a symmetrical wing plane with very little adverse yaw.

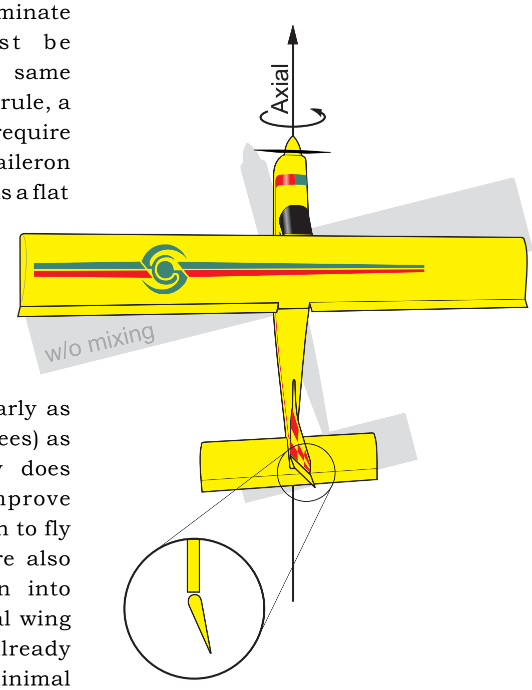




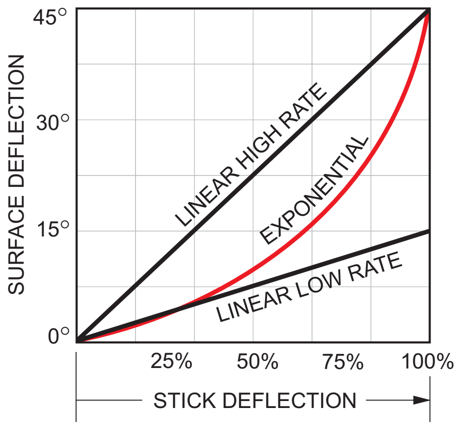
Adverse Yaw

In flight, the down aileron presents a wider cross-section, thus increasing drag and causing adverse yaw, i.e., a yaw in the opposite direction that the ailerons are applied.



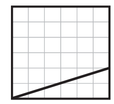


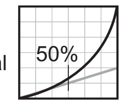
You must coordinate or mix rudder with the aileron in the same direction to eliminate adverse yaw when flying a flat bottom wing airplane.



Sample Travel & Expo Rules-of-Thumb

Aerobatic (Low / Normal) Rates				3D (High) Rates			
Deflection:		Expo:		Deflection:		Expo:	
Aileron	10-15°	Aileron	0-5%	Aileron	30°	Aileron	50%
Elevator	10-15°	Elevator	0-10%	Elevator	45°	Elevator	50%
Rudder	20-30°	Rudder	0-10%	Rudder	45°	Rudder	50%

Linear = Predictable 

Exponential 

Advanced Dual Rate and Expo Rules-of-Thumb

Expert pilots are often asked what their favorite aerobatic airplane is. Frankly, once a person graduates to flying Edges, Extras, Sukhois, and alike, they are all equally capable, and any differences that are not setup related are barely noticeable to all but the most expert flyers. The real question is will your airplane be set up to promote maximum success?

While not necessary for precision aerobatic flying, a computer radio with dual-rates and exponential is required for 3D flying. That's because the large control surface deflections required for 3D maneuvers would cause an airplane to be far too responsive during normal flight. Dual rates allow a pilot to achieve optimal control response for different modes of flight. For example, "high rates" allow maximum travels for 3D flying, whereas "low (normal) rates" provide optimal control for precision aerobatic flying, takeoff and landing (figure 6). To help you stay focused on flying and not on flipping switches, it's recommended that you put all your dual-rate and expo settings on one switch.

On high 3D rates, a plane will be too sensitive and hard to control between maneuvers, thus 30-50% exponential is used to reduce control sensitivity through the first third or half of stick deflection. Expo will therefore allow you to fly with the "feel" of normal rates when the stick inputs are less than half, but then rapidly ramp up beyond that. It's important to note that because of the current dominance of extreme 3D flying, more and more airplane manufacturers are recommending low rates that are low relative to high 3D rates, but are still too much for precision aerobatics, takeoff and landing, and that is why manufacturer's recommend large amounts of expo even on low rates. However, in order to develop the precise timing required to fly aerobatics well, it's important to maintain a close correlation between your inputs and the response of the plane. Therefore, the ideal low/normal rate settings should provide a comfortable control response with minimal use of expo (figure 7). In other words, if the plane is touchy on low rates, before you start adding expo, first try reducing the low rate percentages.

Mixing Rules-of-Thumb

For many reasons, every airplane exhibits some unwanted tendencies while maneuvering. For example, When a large amount of rudder is applied to sustain knife edge flight, most planes tend to gently roll in the direction that the rudder is being held. Therefore, many flyers mix a small amount of opposite aileron with the rudder to cancel out the rolling tendency during knife edge. However, if you're thinking about using computerized mixing to minimize certain unwanted tendencies, you need to first understand that everything in aviation is a tradeoff. A mix that a pilot puts in may help the maneuver for which it is intended, but it may also turn out to be contrary to what's needed during another maneuver, or end up causing a deviation somewhere else that otherwise would not have existed. And that's why you must be very prudent with mixing.

The process of mixing typically unfolds with a pilot detecting some negative tendencies during certain maneuvers that he then attempts to

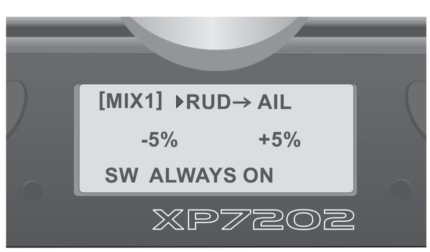
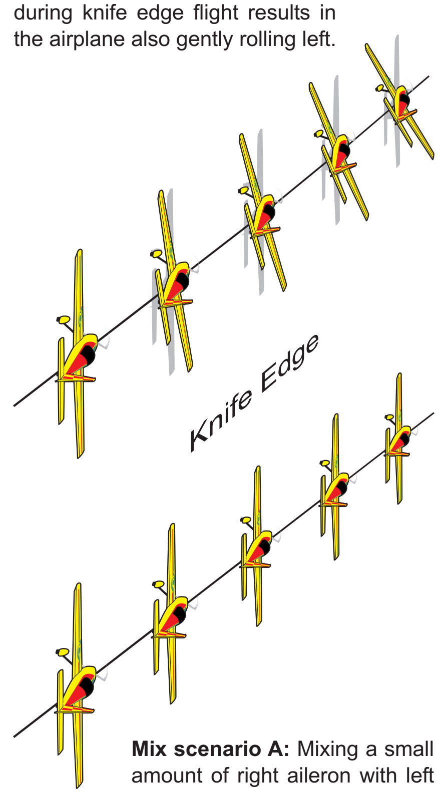
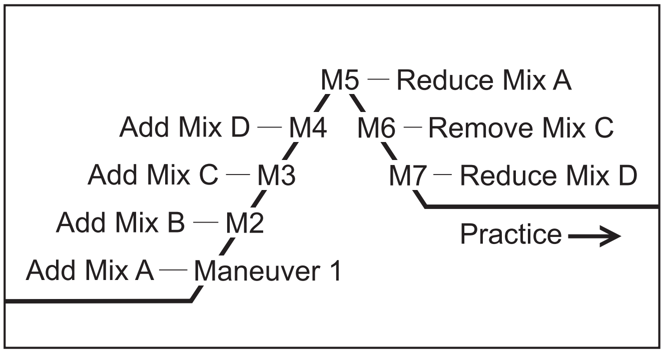


Exhibit A: Holding in left rudder during knife edge flight results in the airplane also gently rolling left.



Mix scenario A: Mixing a small amount of right aileron with left rudder cancels the roll tendency during knife edge.



eliminate with different mixes. As more maneuvers are introduced, the pilot starts running into situations where the deviation that he wants to remove is actually caused by an earlier mix. The process that follows is hours of experimenting to determine which mixes stay, which need to be reduced, which need to be removed or reversed, and when it's time to take the initiative to correct yourself (figure 8). Therefore, unless you intend to only fly a few maneuvers, the most efficient and effective use of programmable mixes is to use the rule-of-thumb of mixing no more than 5-10% (15% max). Limiting your mixes to these percentages will hopefully make your flying easier without having too much impact on other maneuvers or causing you to do a lot of backtracking as you repertoire increases.

Mixing Summary

Many unwanted "tendencies" are held in check at higher speeds, and only show up when the plane is flying slower. Some tendencies show up at higher throttle settings, but not when the throttle is low. A lot of mixes are therefore only appropriate at certain airspeeds and throttle settings. This partly explains while pilots who look to mixing to take the place of developing better flying skills experience little or no improvement over the long term.

Sure, a person could spend a lifetime flipping switches and trying to program complex mixing curves in an attempt to eliminate unwanted tendency, but at a certain point the returns for all that effort are negligible. At some point you will have to settle for being close on your setup and start focusing on improving your flying skills.

Setup Conclusion

One can travel across the country and observe flyers involved in an endless cycle of trying to "dial" into their radios the corrections that they could easily be making--only to have to keep repeating the process each time conditions change, a new maneuver grabs their interest, or a different airplane is flown. Indeed, programming their radios has become their hobby! In many cases it no longer even occurs to people that sometimes the simplest and most effective thing that they could do to improve their flying learn how to make the corrections. Mixes can prove very helpful, but nothing will have more impact on your flying than your flying skills. Happy flying.