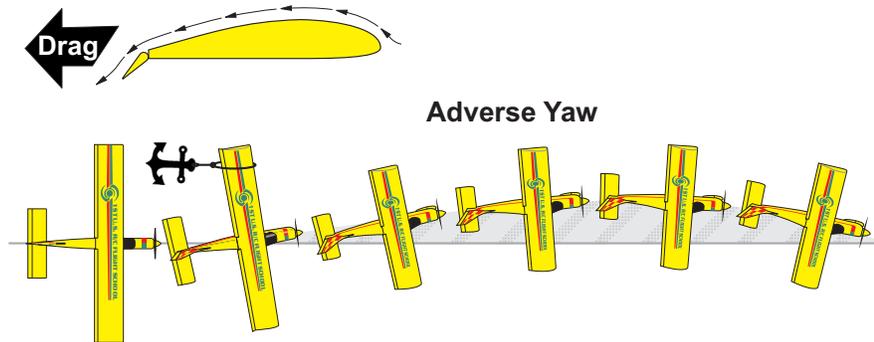


Aileron-Rudder Mixing Explained

“Building Good Habits for a Better Future”

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The following article details the use of programmable Aileron-Rudder mixing to eliminate “adverse yaw”. While primarily aimed at eliminating adverse yaw on a primary trainer, the descriptions and explanations should help cement your grasp of a subject that few in the sport understand, even through all pilots experience the effects of adverse yaw every time they fly.

Introduction

Nearly 100% of computer radios today feature Aileron-Rudder (A/R) mixing to reduce adverse yaw, i.e., the inherent opposite yaw or skid that is especially pronounced during aileron deflections on flat-bottomed wing aircraft, such as those used for primary flight training.

As the name implies, adverse yaw is an adverse or unfavorable condition that, among other things, inhibits progress. Traditionally, struggling and committing to many hours of practice before soloing has been the assumed normal burden of the novice pilot until his or her skills improve. However, they have unknowingly been fighting the additional challenge of flying with adverse yaw as well. Indeed, pilots have always assumed that the lack of correlation between their control inputs/intentions and the response of the plane to be strictly the need for more practice, and sometimes wind, when in fact adverse yaw has been a big reason!

It’s probably safe to say that most of the people reading this learned to fly by trial-and-error or at the side of a recreational flyer/instructor with little

pre-flight preparation. As a result, most pilots learn to fly by “reacting” to what the plane does. Consequently, many pilots naturally think that getting better at making corrections, good reflexes, and more stick-time are the keys to becoming a better flyer. Thus, rarely does adverse yaw or the advantages of A/R mixing when learning to fly ever come up. However, if you were to objectively compare the results achieved training with A/R mixing versus without, you would discover an immediate improvement in consistency and therefore the rate of learning. In fact, as you will soon see, learning to fly with A/R mixing can be credited for helping to instill proper control habits that actually accelerate future progress.

Adverse Yaw

Space does not permit going into all the aerodynamics involved during aileron deflections, so put simply; adverse yaw is caused by the wing with the down aileron generating more lift and therefore more drag than the wing with the raised aileron (figure 1). The drag differential causes the airplane to yaw/skid in the opposite direction that the ailerons are applied while banking into turns, making course corrections, exiting turns, etc.. Pilots therefore have to hold in the aileron longer to overcome the adverse skid, thus increasing the potential for over-controlling, as well as deal with a lack of consistency caused by the out-of-sync relationship between their control inputs and the response of the plane.



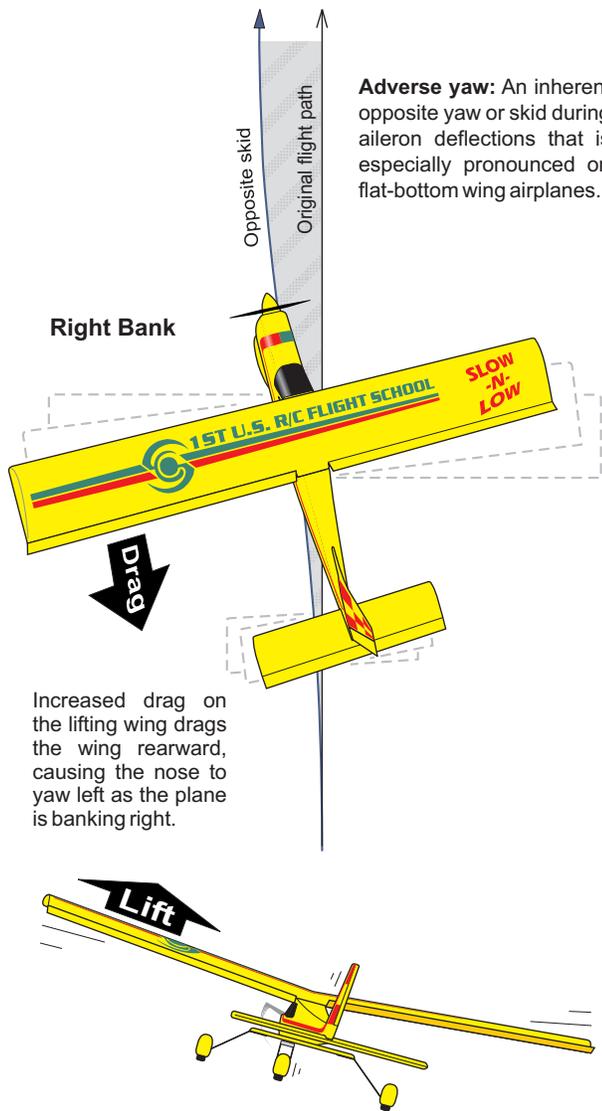
Dave Scott is a champion full-scale aerobatic competitor and airshow pilot. He founded 1st RC Flight School and has professionally training thousands of RC pilots of all skill levels. His groundbreaking training manuals and articles feature the accelerated teaching techniques developed during his 14,000 hours of instruction and experience setting up and test flying over 1000 airplanes at his school. More information about his books and school can be found at www.rcflightschool.com

Adverse yaw is most pronounced on high lift flat-bottom wing aircraft and gets worse at slower airspeeds and/or when making larger aileron inputs. (Adverse yaw is so severe on a scale Piper Cub for example, that when flown near stall speed it will actually turn left when right aileron is applied, and vice-versa.) Also, since the principle effect of wind is exaggerating deviations that would otherwise be minor on calmer days, adverse yaw creates a whole slew of problems when trying to fly a trainer in windy conditions.

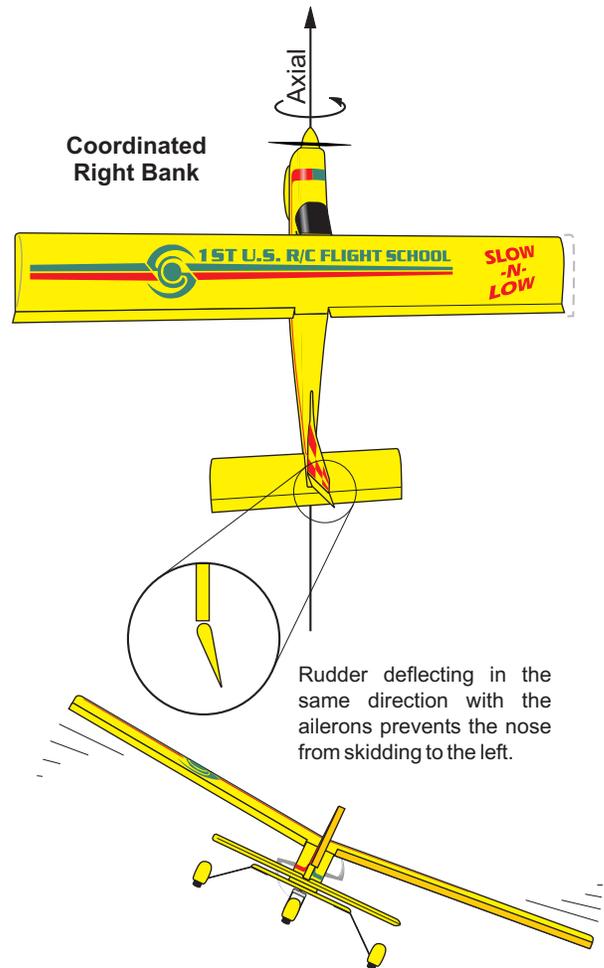
Some common approaches to reduce the effects of adverse yaw in R/C have been: Flying at higher speeds; making the trainer less stable and more maneuverable by lessening wing dihedral; differential aileron travel (more up aileron travel than down); avoiding wind; accepting it as how trainers fly; and continued reassurance from club members that the student will eventually get it with more practice -- all of which only help to small and varying degrees.

Aileron-Rudder (A/R) Mixing

The logical solution to counter adverse yaw is with the surface that controls yaw, i.e., the rudder (figure 2). Coordinated rudder deflections along with and in the same direction as the ailerons prevent the plane from skidding in the opposite direction while banking into and out of turns, making course corrections, rolling, etc.. Most importantly, with adverse yaw eliminated, the airplane response more closely matches the inputs and intentions of the pilot!



A **coordinated** rudder deflection in the same direction as the aileron prevents the nose from yawing in the opposite direction during aileron deflections, thereby keeping banks and rolls axial.



Be clear, the function of the rudder here is not to turn the airplane. Rather, the purpose of the rudder is strictly to prevent adverse yaw in order to achieve a precise “axial” bank and roll response.

1st U.S. R/C Flight School trains its students on planes setup to automatically coordinate the rudder with the aileron through the A/R mixing function in the radio. Radio manufacturers have in fact been providing A/R mixing for the purpose of countering adverse yaw since the 1980’s, but since most people are inclined to keep passing down the way they were taught, it is still not widely used or even understood in R/C.

Those who learn to fly an honest trainer set up to more accurately reflect the control inputs they make are obviously

going to learn proper control earlier. However, as a bonus, A/R mixing also expands the aerobatic capabilities of a primary trainer airplane by helping aileron rolls remain axial and on heading throughout. Furthermore, the improved control achieved with A/R mixing permits flying in winds that would normally ground most trainers. E.g., The main challenge of flying in wind is that it tends to exaggerate deviations, however, the positive control achieved with A/R mixing makes it possible to more precisely and promptly correct deviations before the wind has a chance to exploit them. Thus, even experienced sport flyers have good reasons to utilize this setup on their flat-bottom wing planes.

Of course, when A/R mixing is being used, pilots still have independent

rudder control on the left stick for left-hand ground steering and maneuvers requiring independent rudder. In fact, learning to use independent rudder on the left stick proves easier after learning to fly with A/R mixing because much of the right stick control will have become routine or automatic thanks to the consistency achieved with the mix.

Aileron-Rudder Mixing Setup Rules-of-Thumb

Upon activating A/R mixing, you need to confirm that the rudder moves in the same direction as the aileron (rudder moves toward the up aileron). The rule-of-thumb on a **flat-bottom wing airplane** is to adjust the A/R mixing percentage so that the degree of rudder deflection matches the degree of aileron deflection **1-to-1** (figure 3). At 1st RC Flight School we simply gauge

the degree (angle) of aileron deflection visually, and visually match an equal degree (angle) of rudder. If for some reason we are unable to set a 1-to-1 relationship, we'll get it as close as we can, knowing from experience that a few degrees more or less is not going to make any appreciable difference. We then check the setup by flying the airplane directly at or away from us while banking left and right to confirm that the banks are axial and the fuselage stays pointed in the same direction throughout.

Of course, if you are hesitant to use A/R mixing, you can always start with less, and then keep increasing it until the bank and roll response is finally axial. Although, you can be confident that after applying the 1-to-1 rule-of-thumb to a flat-bottom wing airplane adverse yaw will be virtually undetectable: Banks, corrections, and rolls will be smooth and axial, and you will feel more connected to the plane when you fly. By comparison, adverse yaw is minimal during aileron deflections on fully-symmetrical wing airplanes (except during slow flight), and therefore fully-symmetrical wing airplanes require little or no A/R mix. That means that a semi-symmetrical wing (in-between flat-bottom and fully-symmetrical) requires approx. half as much rudder deflection as aileron to eliminate adverse yaw.

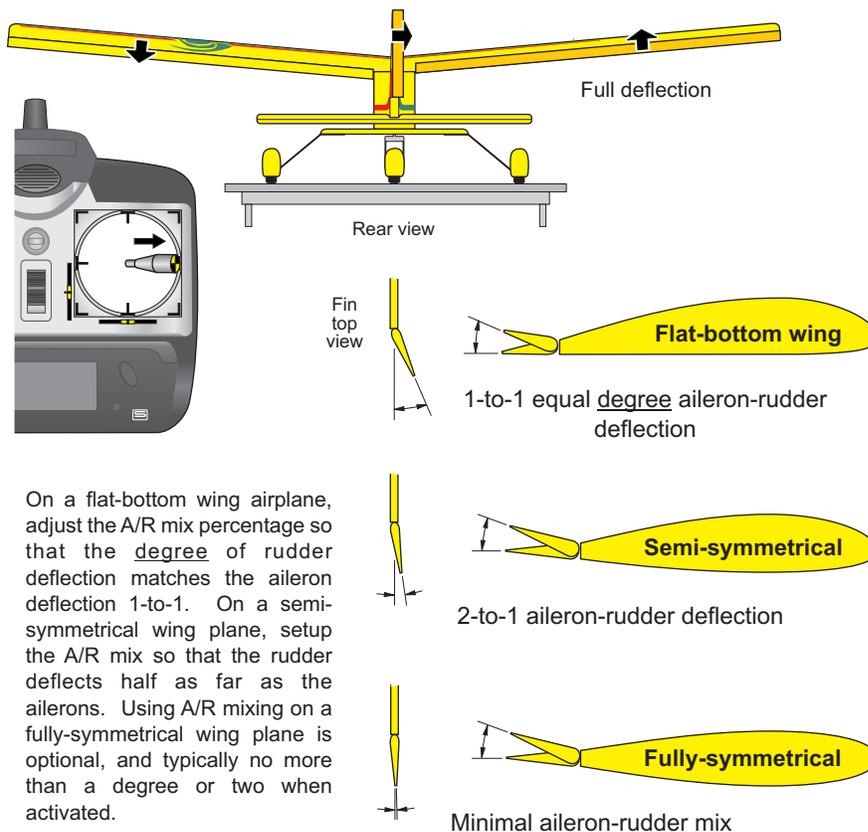
Differential Aileron

If your airplane utilizes 2 aileron servos, you can program a small amount of differential aileron travel (more up aileron deflection than down) to help further reduce the chances of adverse yaw occurring, particularly at slower airspeeds.

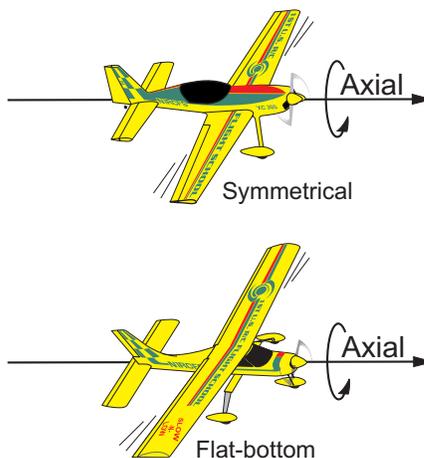
While differential aileron travel is a common practice used to reduce adverse yaw, its effect is slight, and the only way to fully eliminate adverse yaw is with simultaneous rudder. Note that if you did attempt to reduce adverse yaw exclusively with differential, you would end up with so much up aileron travel that the airplane would be unduly prone to dropping at the start of turns and rolls. Thus, a little differential is good, just don't get carried away.

A/R Mixing for the Future

Many new flyers eventually go on to enjoying the "flying on rails" handling and increased capabilities of symmetrical wing aerobatic models.



On a flat-bottom wing airplane, adjust the A/R mix percentage so that the degree of rudder deflection matches the aileron deflection 1-to-1. On a semi-symmetrical wing plane, setup the A/R mix so that the rudder deflects half as far as the ailerons. Using A/R mixing on a fully-symmetrical wing plane is optional, and typically no more than a degree or two when activated.



Symmetrical wing airplanes exhibit minimal adverse yaw and remain almost perfectly axial while banking and rolling (except when the airspeed is low), and thus there is little or no need for A/R mixing with this type.

Flat-bottom wing airplanes exhibit significant adverse yaw and thus require significant A/R mixing to achieve an axial bank/roll response.

In short, learning to fly a flat-bottom wing trainer utilizing A/R mixing leads to learning the same control habits used to fly a symmetrical wing aircraft, thus making the transition easier because pilots are flying without adverse yaw in both cases.

Once again, symmetrical wing airplanes require little or no A/R mixing because adverse yaw is negligible with this type (until slowed).

Those who learn to fly a flat-bottom wing trainer with A/R mixing will actually find the transition into symmetrical wing models easier than most. That's because the control habits learned flying an A/R mixed basic trainer are the same techniques used to fly symmetrical wing airplanes, since in both instances pilots are flying

without adverse yaw and maintaining a direct correlation between their inputs and the response of the plane (figure 4). Conversely, those who learn to fly with adverse yaw (un-mixed) will have to re-train their habits when flying an aerobatic model without much adverse yaw. Thus, the aim of A/R mixing a primary trainer is not only to facilitate learning to fly, but ultimately to compliment the transition into higher performance airplanes that require little or no A/R mixing.

It's important to note that if you're inclined at some point to switch off the A/R mixing on a flat-bottom wing airplane, expect to need a lot more control inputs to overcome the sloppier responses (something that you do not want to make a habit of if you also plan to fly less encumbered aerobatic models). Of course, you could physically coordinate the aileron and rudder control sticks using 1-to-1 movements to eliminate adverse yaw,

but remember that technique only applies to flat-bottom wing airplanes and would not be appropriate when flying symmetrical wing airplanes.

Conclusion

As stated, maintaining a direct correlation between control inputs and the response of the plane is instrumental to developing optimum control habits. Consider that when the initial control inputs are applied correctly, the need for additional

corrections may not even exist. That's when a pilot becomes free to think ahead of the airplane and more efficiently take on new challenges. Thus, by removing the obstacle of adverse yaw, A/R mixing proves to be one of the most effective tools to ensure that pilots learn proper control from the start and therefore continue to enjoy steady advancement and a more successful future. Happy flying!

