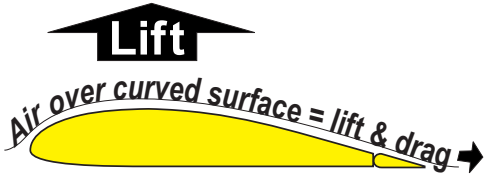
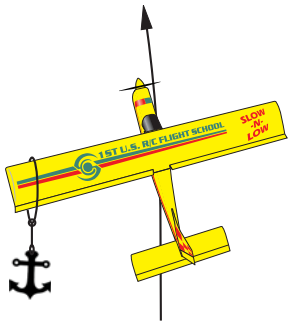
Improving Primary Trainer Airplane Performance



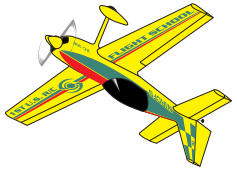
Adverse Yaw



Aileron/Rudder Mixing and Coupling

Building good habits for a better future

ATTENTION: The following section contains information that may not be supported by recreational instructors established in the traditions of their instructors and the instructors before them. If you have reason to believe that the flyer(s) who will be training you is unfamiliar with, and will resist the modern practice of *mixing* aileron and rudder to eliminate *adverse yaw*, skip this section until your abilities allow you to try new things without disturbing those whose help you needed early on.



Improving Primary Trainer Airplane Performance

In this section: B-18 illustrates the cause and effect of *adverse yaw*. As the name implies, adverse yaw is an adverse condition that delays achieving solo abilities.

Struggling and committing to many hours of practice before soloing has been the assumed normal burden of the student until his skills improve. Unknowingly and unnecessarily, novices flying with adverse yaw have been fighting an additional challenge: Most novice pilots assume that a lack of correlation between their control inputs (and intentions) and the plane's response to be strictly the need for more practice, when in fact, adverse yaw is primarily the reason!

B-19 illustrates *coordinating* rudder with the ailerons to eliminate adverse yaw.

B-20 & 21 illustrate the efficient setup of aileron/rudder (A/R) *mixing* or *coupling* that 1st U.S. R/C Flight School uses to automatically coordinate the rudder with the aileron while banking and correcting turns, adjusting course, rolling, etc..

Note: The School's primary purpose mandates taking advantage of all the tools available, including the use of A/R mixing, to ensure every student's ability to safely solo in all kinds of conditions in less than a week — with the experience and knowledge that they will then use that foundation and confidence to continue learning and advancing on their own.

B-22 & 23 illustrate how learning to fly with A/R mixing or coupling instills good habits, promotes sport flying, and accelerates future progress.

B-24 & 25 address some common questions about A/R mixing and coupling, while also explaining some of the misconceptions held by those who have never actually tried either.

KPTR: A/R mixing or coupling accelerate achievement of safe and independent solo abilities. After that, everything else is just practice!

Right Aileron Bank Example

① Lift

Drag

Air over curved surface = lift & drag

A flat-bottom airfoil with a curved top surface produces low-pressure lift as air flows over it. (Ideal on a trainer for sustaining level flight at slower speeds.)

② Lift

Drag

Greater curvature = greater lift & drag

Left wing

The left wing with the lowered aileron generates more low pressure lift as the air flows over the increased curved surface, causing the wing to lift up.

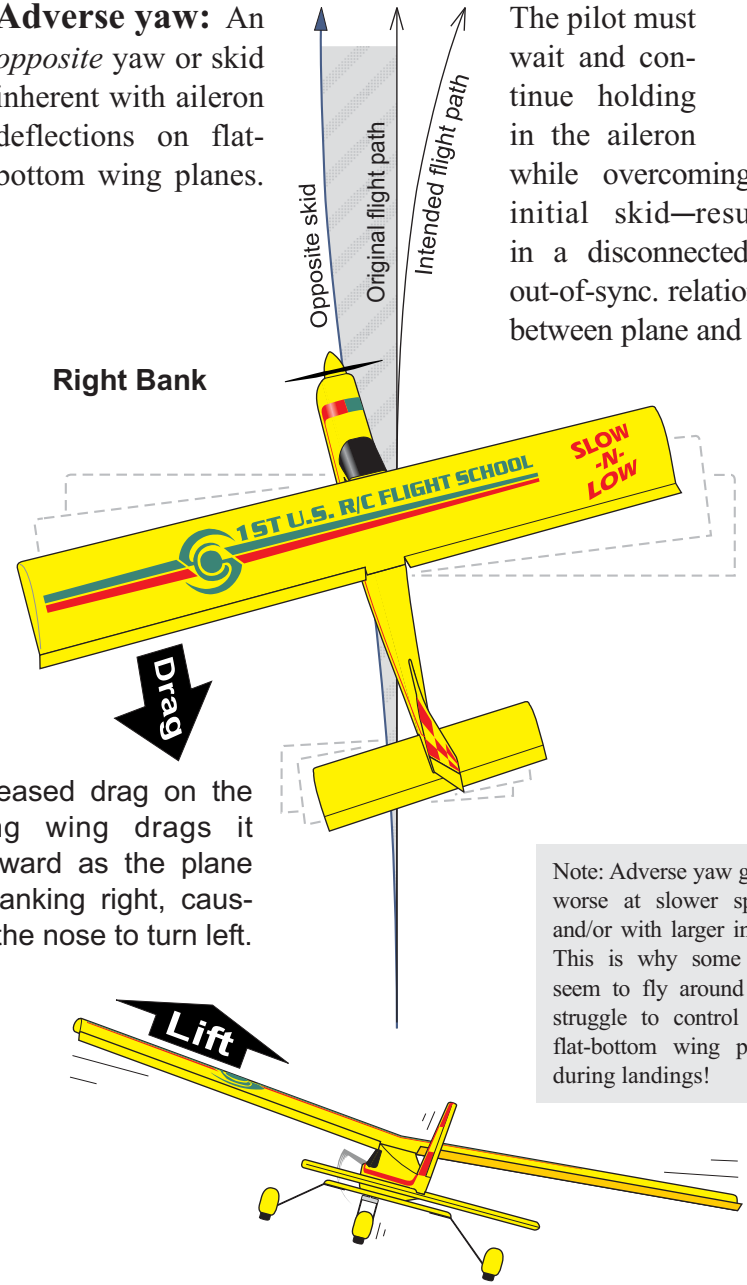
③

Reduced curvature = less lift & drag

Right wing

The raised aileron reduces the effective curvature and lift of the right wing, causing it to lower.

Adverse yaw: An *opposite* yaw or skid inherent with aileron deflections on flat-bottom wing planes.



④ Increased drag on the lifting wing drags it rearward as the plane is banking right, causing the nose to turn left.

The pilot must wait and continue holding in the aileron while overcoming the initial skid—resulting in a disconnected and out-of-sync. relationship between plane and pilot.

Note: Adverse yaw grows worse at slower speeds and/or with larger inputs. This is why some who seem to fly around OK, struggle to control their flat-bottom wing planes during landings!

KPTR: The inherent effects of adverse yaw most adversely effect models with flat-bottom wings.

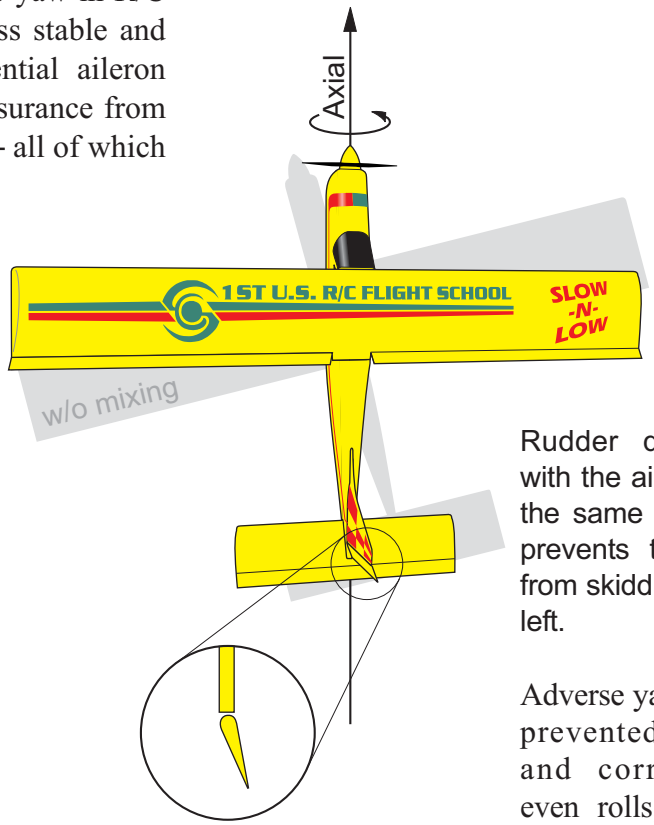
Coordinated Aileron and Rudder

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; accepting it as how trainers fly; and continued reassurance from club members that you will eventually get it with practice — all of which only help to small and varying degrees.

The logical solution to counter adverse (opposite) yaw is with the surface that controls yaw, i.e., the rudder. Coordinated rudder deflections with and in the same direction as the ailerons prevent the plane from skidding in the opposite direction while banking and correcting turns, adjusting course, rolling, etc.. Most importantly, with adverse yaw gone, the plane will conform to match the inputs and intentions of the pilot!

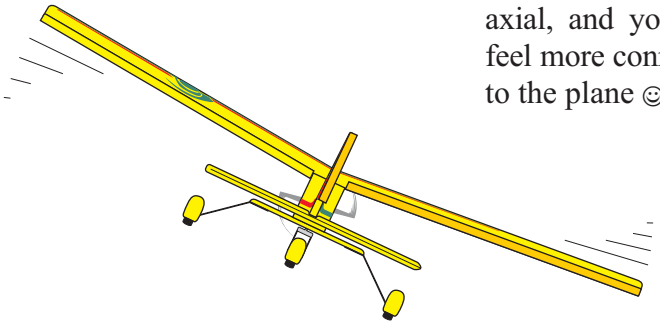
1st U.S. R/C Flight School trains its primary students on planes setup to automatically coordinate the rudder with the aileron by enabling aileron/rudder (A/R) *mixing* in the radio. In fact, radio manufacturers have featured A/R mixing for the purpose of countering adverse yaw since the 1970's, but since most instructors are inclined to keep passing down the way they were taught, it is still not widely used or even understood in R/C.

Another method used by the School, and incorporated into all our students' planes that don't have radio A/R mixing capabilities, is physically *coupling* the aileron and rudder together using a Y-harness connector. Both methods work equally well, however A/R mixing in the radio can make fine tuning the setup a little easier.



Rudder deflecting with the ailerons, in the same direction, prevents the nose from skidding to the left.

Adverse yaw is thus prevented, banks and corrections, even rolls, will be smoother and more axial, and you will feel more connected to the plane ☺



KPTR: The rudder does not turn the plane, but simply keeps the rising wing from sliding back.

Aileron/Rudder Coupling Hookup

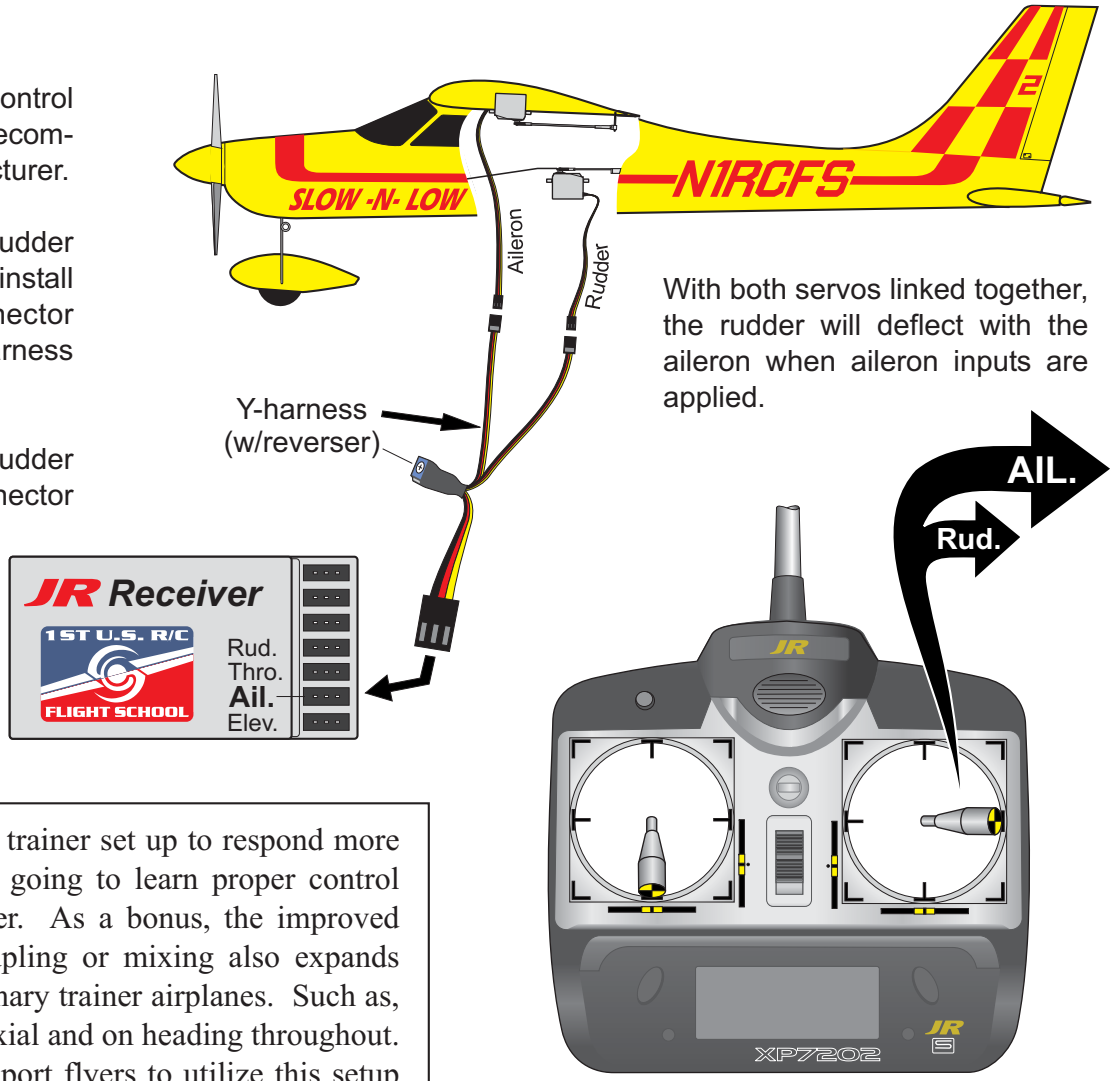
PRIMARY

Flat-bottom wing planes without radio A/R mixing capabilities can achieve the same effect by physically *coupling* the aileron and rudder together using a Y-harness (dual-servo) connector.

Step 1: Install and setup all the control surface deflections (throws) as recommended by the airplane's manufacturer.

Step 2: Unplug the aileron and rudder servos from the receiver, and install a Y-harness (dual-servo) connector into the aileron channel. (Y-harness w/reverser recommended.)

Step 3: Plug the aileron and rudder servos into the two remaining connector plugs.

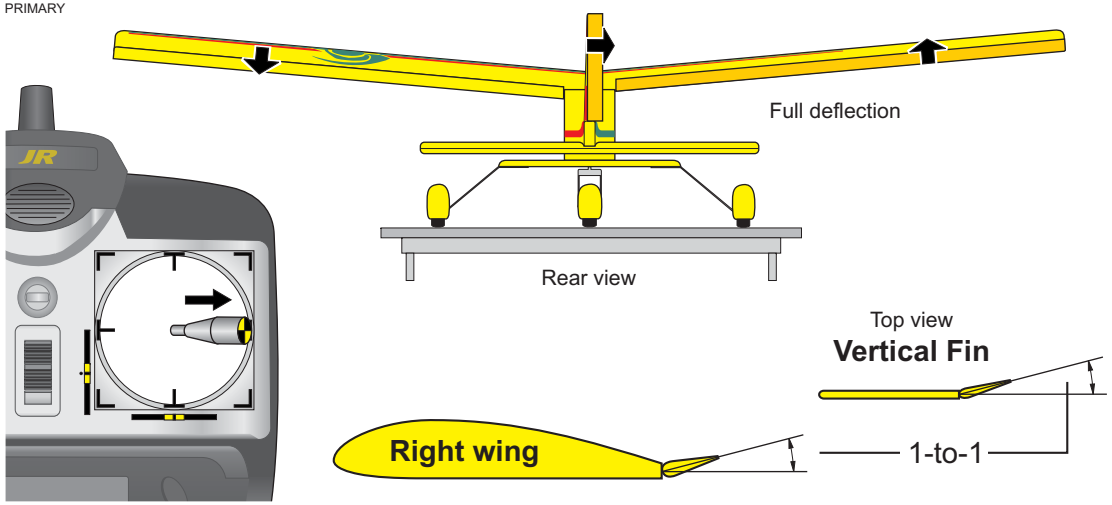


With both servos linked together, the rudder will deflect with the aileron when aileron inputs are applied.

Clearly, one who learns to fly a trainer set up to respond more closely to the control inputs is going to learn proper control and achieve a better solo earlier. As a bonus, the improved control achieved with A/R coupling or mixing also expands the aerobatic capabilities of primary trainer airplanes. Such as, keeping aileron rolls perfectly axial and on heading throughout. This should be motivation for sport flyers to utilize this setup on their flat-bottom wing planes as well.

KPTR: Initially setup the plane according to the model's instructions, then install the Y.

Aileron/Rudder Mixing and Coupling 1-to-1 Setup for Flying



At the School we simply gauge the degree (angle) of aileron deflection visually, and visually match an equal degree of rudder. If for any reason we are unable to set a 1-to-1 relationship, we'll get it as close as we can—knowing from experience that several degrees more or less is not going to make any appreciable difference.

In the event the rudder does not deflect toward the up aileron, the rudder can be reversed in the radio when A/R mixing is used. (Note: Having to reverse a servo does not indicate that anything was done wrong. For any number of reasons, having to reverse at least one control is standard practice setting up a plane.)

If the coupled rudder does not deflect toward the up aileron, reverse the rudder with the Y-harness *reverser*. Confirm proper directions and 1-to-1 deflections.

KPTR: The amount of rudder travel is matched to the aileron in degrees (or deflection angle).

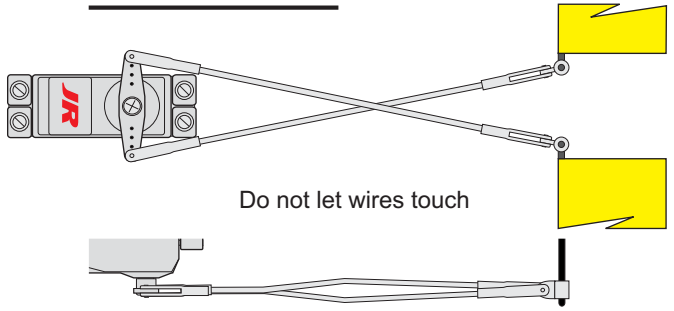
Right input example:

(Rear view) The rudder should deflect to the right toward the up aileron.

A solid rule-of-thumb is to adjust the rudder throw to match the aileron 1-to-1 in degrees of deflection.

Note: Due to the improved control with mixing or coupling, it might befit you to initially set the aileron travel slightly less than the manufacturer's recommendation, say 10% less, and match the rudder to that.

Adverse yaw will be undetectable and the rudder won't skid the plane into turns. Banks, corrections, and rolls will be smooth and axial, and you will feel more connected to the plane when you fly ☺



W/o reverser: Reverse the aileron by crossing the push-rod wires to the ailerons. This is usually simpler than changing both the rudder and nose-gear steering. Again, confirm proper directions.

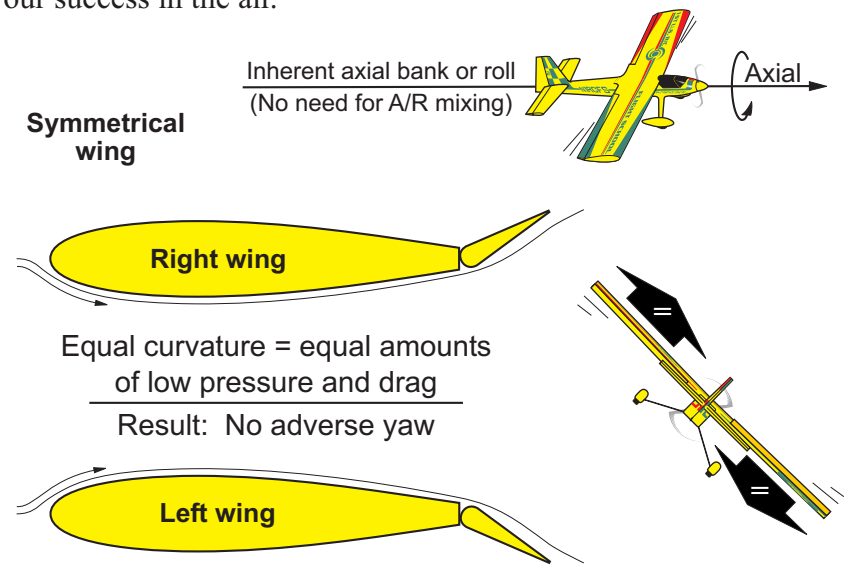
Mixing and Coupling: Investing in a Better Future

1st U.S. R/C Flight School initially began in the 80's without A/R mixing or coupling because it wasn't the norm in R/C at the time (while full-scale aviation has widely applied the use of *yaw damper* (A/R coupling) since the 1950's so pilots are less encumbered while planning and performing more important objectives). When we started coupling our primary trainers, the students' weekly average number of landings leaped from 10-15, to 30-40—an increase of over 200% from installing $10 Y's! The reasons for the increase are simple: 1. Whether a beginning R/C flyer applies his inputs correctly or not, he always has honest results to learn from. 2. The airplane's true representation of the control inputs made leads to an improved understanding of proper control. 3. This enhances his ability to teach himself, with greater retention—thus his practice is overall more consistent, predictable, and extra productive!

The remainder of this section contains somewhat technical information that, if you don't fully grasp, is not going to hinder your success in the air.

Note: When A/R mixing is used, the left-hand stick continues to function conventionally for rudder and nose-gear steering on the ground. The right stick also can be used for ground steering when utilizing A/R mixing, and both approaches are used in the School. When the rudder is physically coupled into the aileron channel, ground steering is controlled by the right stick, and only the throttle control is on the left stick.

IMPORTANT: The aim of A/R mixing or coupling is to get new pilots flying sport planes that don't require coupling using the rudder on the left stick and flying aerobatics, but in hours as compared to months or years! Most new flyers will progress to enjoying the "flying on rails" performance of symmetrical wing sport models. Symmetrical wing airplanes do not require A/R coupling or mixing because adverse yaw is minimal with this type.



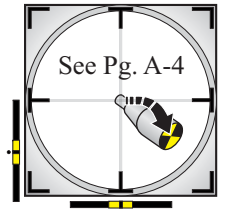
After soloing a *coupled* trainer, the only transitional step advancing to a sport model will be some low-intensity taxi practice to become adept at ground steering on the left stick, and then after taking off, flying with the right-hand stick will resume as usual.

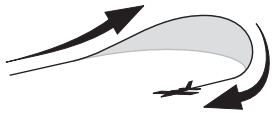
KPTR: An A/R mixed or coupled trainer provides the pilot honest results to learn from, leading to a better understanding of proper control.

Mixing and Coupling: Investing in a Better Future

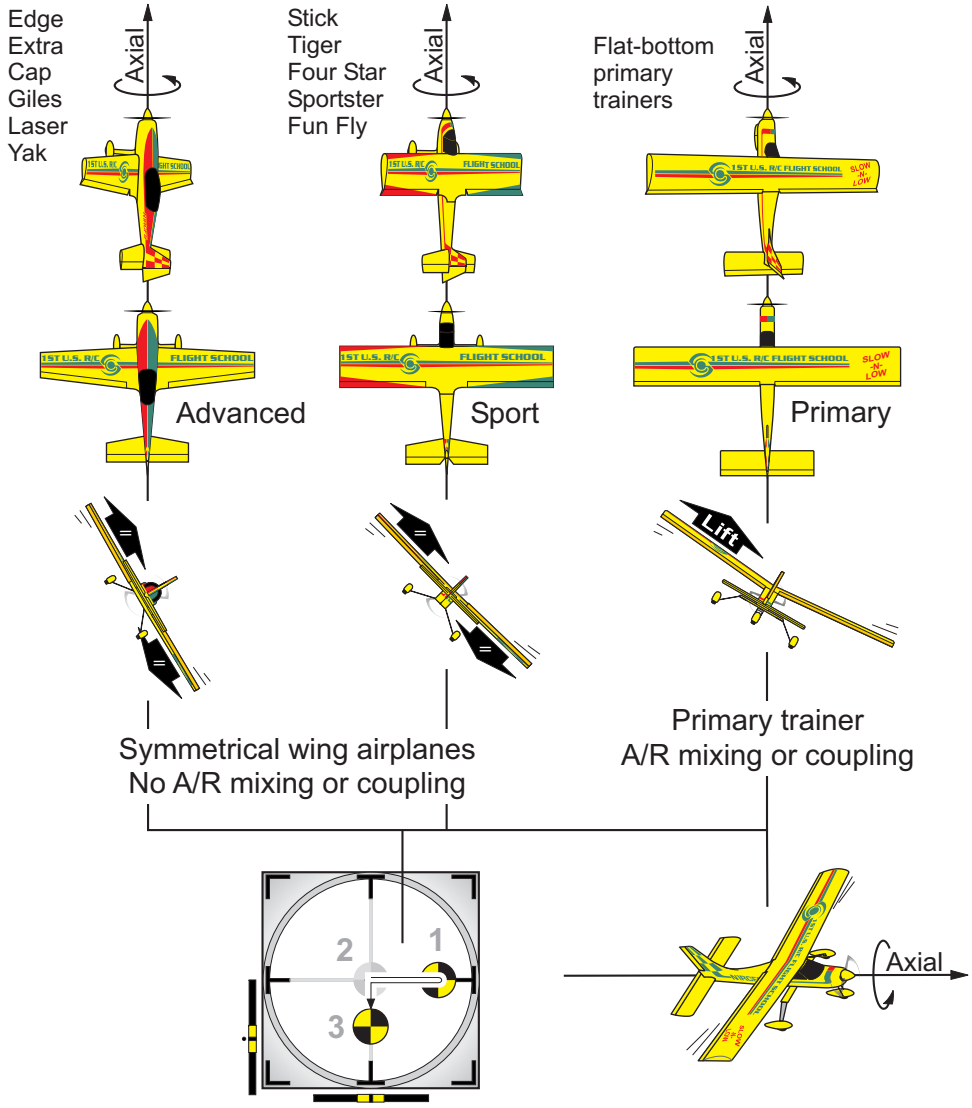
Your transition to a symmetrical wing sport model will prove easier than most, because the control habits you learn flying a coupled trainer will work equally well flying sport models, since in both instances you're flying without adverse yaw. On the other hand, those who learn to fly with adverse yaw (uncoupled) will have to re-train their habits when flying a sport model without adverse yaw.

Those who learn to fly a trainer with adverse yaw find it always necessary to pull up elevator while banking, or the plane will drop due to the skid and subsequent loss of airspeed. This habit will amount to prematurely applying elevator and effecting climbing turns when applied to sport planes that don't skid, and are therefore not as prone to dropping. Sadly, since so many learn with adverse yaw, and climbing turns (with descending finishes) are so common, seldom are these turns even identified as sloppy and the source of some of their inconsistency.





Applying the same turn inputs to all three major airplane types:

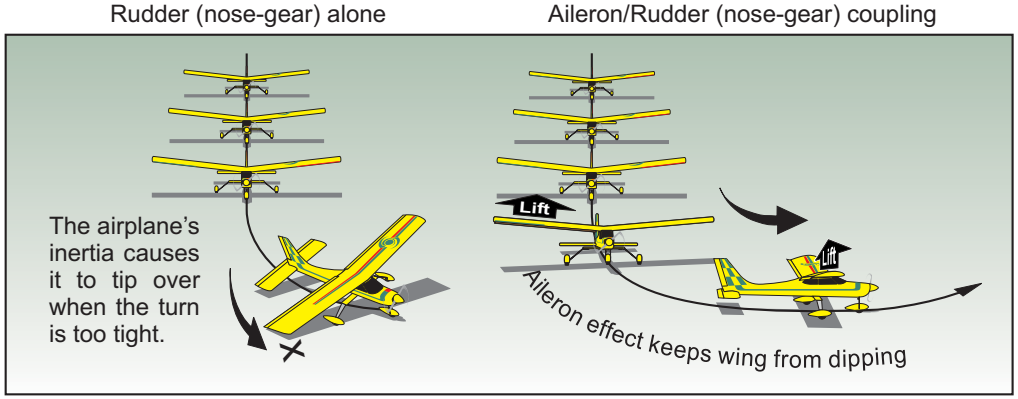


KPTR: Learning to fly with A/R mixing or coupling instills good input habits, making the transition to sport and fun flying easier and faster!

Common Aileron/Rudder Mixing and Coupling Questions

Q. How will A/R coupling influence ground steering? A. It helps.

1. While taxiing, the airplane is not moving fast enough for the ailerons to be effective, thus a wing won't try to lift up while making coupled ground corrections.
2. During takeoff the ground corrections become more effective and therefore smaller as the plane picks up speed. The accompanying aileron deflections are thus too small to affect the wing while still on the ground.
3. In fact, coupling aileron deflections with ground steering helps prevent the plane from flipping over when the ground corrections are over-controlled:



Q. How will it work in wind—especially crosswinds?

A. It helps: You don't counter wind, you fly and guide the *whole plane* regardless of the wind.

1. As a rule, the main challenge of flying in wind is that it exaggerates small deviations and late corrections. A/R mixing and coupling make it possible to immediately and precisely control your corrections before the wind has a chance to take hold of the plane.
2. In fact, the positive control achieved with A/R mixing and coupling permits flying in winds that ground all other trainers. When properly flying in crosswinds, the plane is guided as a *whole*, and the crab angle of the fuselage is not important as long as the *whole airplane* is going where you want it to go. (If the airplane is crabbing in a crosswind approaching to land, most of the time it will straighten out shortly before touching down, due to the crosswind becoming less pronounced over and near the ground's surface. If the plane does touch down while crabbing, it immediately straightens itself out—taking the path of least resistence in the direction the plane was traveling.)

Common Aileron/Rudder Mixing and Coupling Questions

Q. What are the limitations of coupling? A. Some advanced maneuvers can not be performed.
1. The airplane can not be *slipped* (a rarely seen cross-controlled intentional skid requiring highly advanced skills).
2. The airplane can not sustain knife-edge flight. (Trainers do not do a very good knife-edge anyhow.)
In fact, the positive and precise control achieved with A/R coupling or mixing expands the number of maneuvers a trainer can do!

Q. What should I expect when I separate the aileron and rudder?
A. No change with a sport model, or more inputs with a trainer.
1. The confidence instilled after repeated successful solo flights leads many people to fly without A/R mixing or coupling for the first time when they progress to an airplane that does not have a flat-bottom wing and adverse yaw. In this event, there will be little or no difference in how you fly when transitioning into a symmetrical wing plane.
2. When the aileron and rudder are separated on a flat-bottom trainer, your inputs will still work, yet you will need a lot more inputs to overcome the sloppy responses (something you do not want to make a habit of if you plan to fly more responsive sport models in the future).
3. After soloing, if a person is inclined to experiment with flying his trainer without A/R mixing or coupling, he could practice physically coordinating the rudder and aileron together using 1-to-1 movements of both control sticks (although this practice is not applicable to flying sport airplanes).

Q. Why doesn't everyone learn to fly with A/R mixing?
A. Recreational club flyers/instructors/experts don't use it in their own flying.
1. Many R/Cer's were not aware of adverse yaw and A/R mixing when they learned, have never tried it, and are therefore not likely to encourage it when helping others (since it's so easy to assume that all difficulties are just a normal part of learning and can be overcome with more practice)!
2. People (recreational club instructors) who fly semi or fully-symmetrical wing sport models can't relate to why anyone would need it.
3. Some people theorize learning this way will result in difficulty learning to use the rudder later on.
In fact, adding the singular aspect of working the rudder is more easily picked up when everything needed to solo has become routine first—and that is why we use it in the first place!

Summary KPTR: The inputs come first, and the corresponding good turns, adjustments, and straight lines are the results—thanks to A/R mixing or coupling.